

STANDARD SPECIFICATIONS FOR PUBLIC WORKS CONSTRUCTION

Sponsored and Distributed by:

**Regional Transportation Commission
of Washoe County
Carson City
Churchill County
City of Reno
City of Sparks
City of Yerington
Washoe County**

2012

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FORWARD

To All Proposed Users:

The purpose of this document is to fulfill the need for uniform rules governing public works construction performed in Churchill County, Carson City, the Cities of Reno and Sparks, the City of Yerington, and Washoe County. Uniform specifications help to eliminate conflicts and confusion, lower construction costs, and encourage more competitive bidding by private contractors. The Standard Specifications for Public Works Construction book was first published in 1978 and it has proven to be an invaluable document to its users.

These specifications represent the highest level of professional thinking of representatives from the Public Works Departments. As construction materials and methods are ever changing, however, this document is revised and republished periodically to reflect the changing technology of the industry. A Specifications Revisions Committee has been formed to study and recommend appropriate changes. Interested parties may suggest changes and address questions to the Specifications Revisions Committee, C/O The Regional Transportation Commission of Washoe County. The revisions committee is grateful for the continued support and considerable assistance from local chapters of several organizations, including the American Public Works Association, American Society of Civil Engineers, Associated General Contractors, Builders Association of Northern Nevada, and National Society of Professional Engineers, and other interested parties, including NV Energy and Truckee Meadows Water Authority. The committee also extends special thanks to the Nevada Department of Transportation, for providing information from their Standard Specifications for portions of this document, and to the numerous local consulting engineering and contracting firms whose representatives have provided extensive technical assistance.

In the interest of uniformity, it is hoped that the applicable agencies adopt these standards with as few changes as possible. However, it is recognized that because of charter requirements and other reasons, it may be necessary to modify or supplement certain requirements. The final authority for acceptance of all materials covered in these Specifications is the agency involved and will be so noted on the Construction Plans or Project Solicitation Documents.

The Standard Specifications for Public Works Construction is available online at www.rtcwashoe.com utilizing the Street and Highway link. Copies may be obtained from the Public Works Departments of the various agencies.

It shall be the sole responsibility of all users of this document to remain current with the latest edition, including any addenda.

100.01 DEFINITIONS. Whenever the following abbreviations or terms, or pronouns in place of them, are used in this document or in any documents or instruments in construction operations where the Standard Specifications for Public Works Construction govern, the following terms or pronouns in place of them are used, the intent and meaning shall be interpreted as follows:

100.01.01 ABBREVIATIONS AND CODES.

100.01.01.01 Abbreviations. Whenever the following abbreviations are used in this document or in any documents or instruments in construction operations where the Standard Specifications for Public Works Construction govern, the intent and meaning shall be interpreted as follows:

AAN	–	American Association of Nurserymen
AAR	–	Association of American Railroads
AASHTO	–	American Association of State Highway and Transportation Officials
ABS	–	Acrylonitrile-Butadiene-Styrene
ACI	–	American Concrete Institute
AGC	–	Associated General Contractors of America
AI	–	Asphalt Institute
AIA	–	American Institute of Architects
AISC	–	American Institute of Steel Construction
AISI	–	American Iron and Steel Institute
ANSI	–	American National Standards Institute
APWA	–	American Public Works Association
ARA	–	American Railway Association
AREMA	–	American Railway Engineering and Maintenance of Way Association
ASA	–	American Standards Association
ASCE	–	American Society of Civil Engineers
ASLA	–	American Society of Landscape Architects
ASME	–	American Society of Mechanical Engineers
ASTM	–	American Society for Testing and Materials
AWG	–	American Wire Gauge
AWPA	–	American Wood Preservers Association
AWS	–	American Welding Society
AWWA	–	American Water Works Association
BMP	–	Best Management Practice
CIOD	–	Cast Iron Outside Diameter
CTM	–	California Test Method (Published by the California Department of Transportation, Division of Engineering Services)
EEl	–	Edison Electrical Institute

EIA	–	Electric Industries Association
EPA	–	Environmental Protection Agency
FHWA	–	Federal Highway Administration, Department of Transportation
FSS	–	Federal Specifications and Standards, General Services Administration
ICBO	–	International Conference of Building Officials
IEEE	–	Institute of Electrical and Electronics Engineers
IES	–	Illumination Engineering Society
IAPMO	–	International Association of Plumbing and Mechanical Officials
ISMA	–	International Municipal Signal Association
ISSA	–	International Slurry Surfacing Association
MUTCD	–	Manual on Uniform Traffic Control Devices for Streets and Highways (Published by the Federal Highway Administration)
NAC	–	Nevada Administrative Code
NAQTC	–	Nevada Alliance for Quality Transportation Construction
NDEP	–	Nevada Department of Environmental Protection
NDOT	–	Nevada Department of Transportation
NEMA	–	National Electrical Manufacturers Association
NEV	–	Nevada Test Method (Published by the Nevada Department of Transportation, Materials Division)
NFPA	–	National Fire Protection Association
NOI	–	Notice of Intent
NOT	–	Notice of Termination
NPDES	–	National Pollutant Discharge Elimination System
NRS	–	Nevada Revised Statutes
NSF	–	NSF International: The Public Health and Safety Company
OSHA	–	Occupational Safety and Health Administration
PE	–	Polyethylene
PVC	–	Poly Vinyl Chloride
PSI	–	Pounds per Square Inch
REA	–	Rural Electrification Association
SAE	–	Society of Automotive Engineers
SSPC	–	Steel Structures Painting Council
SWPPP	–	Storm Water Pollution Prevention Plan

UL	–	Underwriters Laboratories, Incorporated
USA	–	Underground Service Alert
USASI	–	United States of America Standards Institute

100.01.01.02 Codes. Whenever the following abbreviations or terms, or pronouns in place of them, are used in this document or in any documents or instruments in construction operations where the Standard Specifications for Public Works Construction govern, the intent and meaning shall be interpreted as follows:

Code	–	NFPA National Electric Code
UBC	–	ICBO Uniform Building Code
UPC	–	IAPMO Uniform Plumbing Code

100.01.02 ADVERTISEMENT. The public announcement as required by law, inviting bids for the work to be performed or materials to be furnished.

100.01.03 AGENCY. The legal entity for which the work is being performed.

100.01.04 BIDDER. An individual partnership, firm, corporation, or any acceptable combination thereof, or joint venture, submitting a bid for the advertised work.

100.01.05 CALENDAR DAY. Every day shown on the calendar, beginning and ending at midnight.

100.01.06 CONTINGENCY ITEM. An item with a quantity which represents no actual estimate, is nominal only, and may be greatly increased or decreased or reduced to zero. The increase or reduction of this quantity, as compared with that set forth in the Bid Schedule, shall not constitute a basis for claim by the Contractor for extra payment or changed conditions. The Agency or Engineer, however, may negotiate a change in unit cost, should the value of the item meet the criteria for a major item as defined by Subsection 100.01.20.

100.01.07 CONTRACT CHANGE ORDER. A written order to the Contractor, executed by both parties to the Contract, which covers changes in the Plans, Specifications or quantities within the scope of the Contract, and establishes the basis of payment and time adjustments for the work affected by the changes.

100.01.08 CONTRACT. The written agreement between the Agency and the Contractor setting forth the obligations of the parties thereunder including, but not limited to, the performance of the work; the furnishing of labor, materials, equipment, and incidentals; and the basis of payment.

The Contract includes the invitation for bids, proposal, Contract form and Contract bond, Standard Specifications, Supplemental Specifications, Special Provisions, general and Detailed Plans, notice to proceed, and any change orders and supplemental agreements that are required to complete the construction of the work in an acceptable manner, including authorized extensions and basis of payment thereof, all of which constitute one instrument.

100.01.09 CONTRACT AMOUNT. The estimated Contract cost computed on the basis of the proposal quantities and Contract unit prices.

100.01.10 CONTRACT ITEM (PAY ITEM). An item of work specifically described for which a price, either unit or lump sum, is provided. It includes the performance of all work and the furnishing of all labor, materials, equipment, and incidentals described in the text of a specific item included in the Contract or described in the Standard Specifications, Supplemental Specifications, or Special Provisions of the Contract.

100.01.11 CONTRACT TIME. The number of work days or calendar days allowed for completion of the Contract, including authorized time extensions. In case a calendar date of completion is shown in the proposal in lieu of the number of working or calendar days, the Contract shall be completed by that date.

100.01.12 CONTRACTOR. The individual, partnership, firm, corporation or any acceptable combination thereof, including joint venture, licensed and qualified by the Nevada State Contractor's Board, undertaking the execution of the work under the terms of the Contract, acting directly or through a duly authorized representative.

100.01.13 DEPARTMENT. The Department of Public Works of the Agency involved.

100.01.14 EMPLOYEE. Any person working on the project mentioned in the Contract of which these Specifications are a part, and who is under the direction and control of, or receives compensation from, the Contractor or Subcontractor.

100.01.15 ENGINEER. The Design Engineer, or other person designated by the Agency, acting either directly or through authorized agents.

100.01.16 EXTRA WORK. An item of work not provided for in the scope of the Contract as awarded.

100.01.17 HOLIDAYS. In the State of Nevada, these occur on:

January 1	–	New Year's Day
Third Monday in January	–	Martin Luther King, Jr. Day
Third Monday in February	–	Presidents Day
Last Monday in May	–	Memorial Day
July 4	–	Independence Day
First Monday in September	–	Labor Day
Last Friday in October	–	Nevada Day
November 11	–	Veteran's Day
Fourth Thursday in November	–	Thanksgiving Day
Day after Thanksgiving	–	Family Day
December 25	–	Christmas Day

or on any day that may be appointed by the President of the United States or by the Governor of Nevada for public fast, thanksgiving or as a legal holiday. If January 1, July 4, November 11, or December 25 falls upon a Sunday, the Monday following shall be observed as a holiday. If January 1, July 4, November 11, or December 25 falls upon a Saturday, the Friday preceding shall be observed as a holiday.

100.01.18 INSPECTOR. An authorized representative of the Engineer assigned to make any or all inspections of the work performed and materials furnished by the Contractor.

100.01.19 LABORATORY. A laboratory accredited by AASHTO in the applicable test methods specified herein or other special laboratory designated by the Agency or Engineer or selected by the Contractor and approved by the Agency or Engineer.

100.01.20 MAJOR ITEM. Any Contract item having a value of 50,000 dollars or 10 percent of the contract, whichever is less.

100.01.21 NOTICE TO CONTRACTORS. The official notice inviting bids for the proposed work.

100.01.22 NOTICE TO PROCEED. A written notice to the Contractor to proceed with the Contract work including, when applicable, the date of beginning of Contract time.

100.01.23 OWNER. The title holder of real property.

100.01.24 PERFORMANCE BOND, AND LABOR AND MATERIAL BOND. The approved securities furnished by the Contractor to guarantee the completion of the work in accordance with the terms of the Contract and to guarantee payment for labor and materials purchased by the Contractor.

100.01.25 PLANS. The approved official drawing of any and every kind, or reproductions thereof that show the work to be done.

100.01.26 PROPOSAL. The offer by a Bidder, on the approved prepared form, to perform the work and to furnish the labor, materials, equipment, and incidentals at the prices quoted.

100.01.27 PROPOSAL GUARANTY. The security furnished with a bid to guarantee that the Bidder will enter into the Contract if the bid is accepted.

100.01.28 SPECIAL PROVISIONS. Additions and revisions to the Standard Specifications covering conditions specific to an individual project.

100.01.29 SPECIFICATIONS. The minute description of details of construction not shown on Plans: general provisions; Special Provisions; technical provisions; applicable reference material therein; a statement of type, quality and quantity of materials to be used; and the method of measurement and payment for work to be performed under the Contract. Whenever the following terms are used in this document, or in any documents or instruments in construction operations where the Standard Specifications for Public Works Construction govern, the intent and meaning shall be interpreted as follows:

100.01.29.01 APWA Standard Specifications. Standard Specifications for Public Works Construction, published by the American Public Works Association, Southern California Chapter, latest edition, except where dated otherwise.

100.01.29.02 Federal Specifications. Federal Specifications and Standards, published by the United States Government, General Services Administration, latest edition, except where dated otherwise.

100.01.29.03 JANS. Joint Army/Navy Specifications, available from the IHS Global International Standards and Specifications Database, latest edition, except where dated otherwise.

100.01.29.04 MIL. Military Specifications and Standards, prepared and/or adopted by the United States Government, Department of Defense, available from the IHS Global International Standards and Specifications Database, latest edition, except where dated otherwise.

100.01.29.05 NDOT Standard Specifications or "Silver Book". Standard Specifications for Road and Bridge Construction, published by the State of Nevada, Department of Transportation, latest edition, except where dated otherwise.

100.01.30 SUBGRADE. That portion of the roadbed upon which the subbase or base course is to be placed.

100.01.31 SUPERINTENDENT. The Contractor's designated representative who is: in responsible charge of the work; present on the work site at all times during progress; and authorized to receive and fulfill instructions from the Engineer and to accept orders for change and extra work.

100.01.32 SUPPLEMENTAL AGREEMENT. A written order to the Contractor, executed by both parties to the Contract, which covers extra work not within the scope of the Contract, and establishes the basis of payment and time adjustments for the extra work.

100.01.33 SURETY. The Corporation, Partnership, or individual, other than the Contractor, executing a bond furnished by the Contractor.

100.01.34 WORK. The furnishing of all labor, materials, equipment, and incidentals necessary or convenient to the successful completion of the project and the carrying out of the duties and obligations imposed by the Contract.

100.01.35 WORKING DAY. A calendar day on which weather and other conditions not under the control of the Contractor will permit construction operations to proceed for at least 5 hours with the normal working force engaged in performing the controlling item or items of work which would be in progress at that time, exclusive, however, of Saturdays, Sundays, State recognized holidays, and any day that is incumbent upon the Contractor, by means of a labor union, to observe as a holiday. However, if the Contractor elects to work on such days, those days will be considered as a working day.

100.02 SECURING DOCUMENTS. Plans; Specifications; Contract document forms; and Proposal forms are available as directed by the Notice to Contractors.

100.03 FILING PROPOSALS. The sealed envelopes containing the proposal shall be: endorsed with the Contractor's name and the date and time to be opened; correctly addressed; and filed in compliance with the Notice to Contractors contained within the Specifications.

100.04 FORM AND CONTENT OF PROPOSAL. Proposals to receive consideration shall be made in accordance with the following instructions:

100.04.01 FORM. Proposals shall be made upon the separate form provided therefor. All items on the proposal form shall be completed. Dollar amounts shall be stated both in words and figures and the signature of all persons signing shall be in writing. The completed form shall be legible. Interlineations, erasures or alterations shall be acknowledged by the initials of the person making said change. In case of discrepancy between the numbers and words, the amount set forth in words shall be taken as correct.

100.04.02 ORAL OR TELEGRAPHIC PROPOSALS OR MODIFICATIONS. Proposals shall contain only the quotations for which the form is prepared. Alternative proposals will not be considered unless necessary. No oral or telephonic proposals or modifications shall be considered. Telegraphic proposals or modifications will be considered contingent upon a written copy of any such telegram being in the hands of the person in charge of the bid opening at the designated time and place of the public bid opening. The Bidder shall assume full responsibility for the accuracy of any such telegraphic proposals and modifications.

100.04.03 SUBCONTRACTORS. Each Bidder shall submit with the bid, on the form provided, the name and address of each Subcontractor, including the principal suppliers of materials, and the portion of the work which each Subcontractor will do. If the Contractor fails to name the Subcontractors in the proposal, the Contractor shall be deemed to have agreed not to subcontract said portion of work without previous permission of the Agency or Engineer.

100.04.04 BIDDER'S BOND. Proposals shall be accompanied by an unconditional check which is: certified by a responsible bank in an amount not less than 5 percent of the aggregate of the proposal; and payable to the order of the Agency, or by a bidder's bond for the said amount and so payable, which is written by a surety company authorized to do business in the State of Nevada. Said check or bond shall be a guarantee that the bidder, if awarded the work, will enter into a Contract within 20-calendar days after receiving notice of said award. In case of refusal or failure to enter into said Contract, the check or bond, as the case may be, shall be forfeited to the Agency, the proceeds therefrom being hereby agreed upon as liquidated damages to the said Agency on account of the delay in the execution of the Contract and required bonds and the performance of the work thereunder, and the necessity of accepting a higher or less desirable proposal resulting from such failure or refusal to execute the Contract and bonds as required. Upon the execution of the Contract and the approval on behalf of the Agency of the accompanying bonds, all bid bonds or certified checks that accompanied proposals and that have not theretofore been returned, will be returned each to its maker. An award of Contract, if an award is made, will occur within 30-calendar days after the opening of bids.

100.05 EXAMINATION OF SITE, DRAWINGS, ETCETERA.

100.05.01 EXAMINATION OF PLANS AND SITE. Each Bidder shall visit the site of the proposed work and become fully acquainted with conditions relating to construction and labor so that the Bidder may fully understand the facilities, difficulties, and restrictions attending the execution of the work under the Contract. Bidder shall thoroughly examine and be familiar with the drawings and Specifications. The failure of any Bidder to receive or examine any form, instrument, addendum or other document or to visit the site and become acquainted with conditions there existing, shall in no way relieve any obligations with respect to the Bidder's proposal or to the Contract.

100.05.02 SUBSURFACE INVESTIGATION. Results of subsurface investigation are presented for the guidance of Bidders. The data has been developed through a program of subsurface investigation directed by the Design Engineer. Presentation of subsurface information does not constitute a guarantee of subsurface conditions.

100.05.03 SECTION COMPLIANCE. The submission of a proposal shall be taken as prima facie evidence of compliance with this section. The accuracy of the interpretation of the facts disclosed by borings or other preliminary investigations is not guaranteed.

100.06 BIDDER INTERESTED IN MORE THAN ONE PROPOSAL. No Contractor shall be allowed to make or file, or be interested in, more than one proposal for the same work, unless alternative proposals are invited. A Subcontractor who has submitted a subproposal to a Bidder, or who has quoted prices on materials to a Bidder is not thereby disqualified from submitting a proposal or quoting prices to other Bidders.

100.07 INTERPRETATIONS OF PLANS AND DOCUMENTS. Should a Bidder find discrepancies in, or omissions from, the Plans or Specifications, or be in doubt as to their meaning, the Bidder shall at once notify the Agency or Design Engineer and, should it be found that the point in question is not clearly and fully set forth, a written Addendum or Bulletin of Instructions will be sent to all Bidders. The Agency or Design Engineer will not be responsible for any oral instructions.

100.08 ADDENDA OR BULLETINS. Any Addenda or Bulletin supplementing the Plans or Specifications and issued prior to the time set for the opening of proposals and/or forming a part of the documents furnished the Bidder for the preparation of the proposal shall be covered in the proposal and shall be made a part of the Contract. An acknowledged copy of the Addenda or Bulletin shall be submitted with the bid.

100.09 WITHDRAWAL OF PROPOSAL. Proposals may be withdrawn by the Bidder prior to, but not after, the time fixed for the opening of the proposals.

100.10 OPENING AND COMPARISON OF BIDS. Proposals will be publicly opened and read at the time indicated in the Notice to Contractors. Contractors, their authorized representatives, and other interested parties are invited to be present.

100.11 AWARD OF CONTRACT OR REJECTION OF PROPOSALS. If award is made, the Agency will award the Contract to the lowest responsive and responsible Bidder or Bidder complying with these instructions and with the provisions of the Instructions to Bidder. The award, if made, will be within 30-calendar days after the opening of bid proposals.

The Agency reserves the right to reject any or all bids. The competency and responsibility of Bidder, as evidenced by the information accompanying the proposals, which will be subject to verification, will be considered in making the award. The proposal may be rejected if the unit prices contained in the proposal are obviously unbalanced, either in excess or below the reasonable cost analysis.

The Agency reserves the right to waive requirements relating to minor irregularities in the bid form when it is deemed to be in the best interests of the Agency to do so.

Before any Contract is awarded, the Bidder may be required to furnish a complete statement of the origin, composition, and manufacture of any or all materials to be used in the construction of the work, together with samples, if required by the Specifications or the Special Provisions to determine their quality and fitness for the work.

100.12 CONTRACT. The Bidder to whom award is made shall execute a written Contract with the Agency within 20-calendar days after the date on which the Contract is awarded. The notice may be hand delivered or sent by mail to the address given in the proposal. The Contract shall be made in the form adopted by the Agency.

If the Bidder to whom award is made fails to enter into Contract as herein provided, the award shall be annulled and an award may be made to the next lowest responsive and responsible bidder, and such Bidder shall fulfill every stipulation embraced herein as if the next lowest bidder were the party to whom the first award was made. The Notice to Contractors, proposal, bonds, instructions to Bidder and General Provisions, and detailed Plans and Specifications shall be considered as incorporated in the Contract. A corporation to which an award is made may be required, before the Contract is finally executed, to furnish evidence of its corporate existence and evidence that the officer signing the Contract and bonds for the corporation is duly authorized so to do.

The Contractor shall not assign, transfer, convey or otherwise dispose of the Contract, or the right, title or interest therein, or the power to execute such Contract, to any other individual, partnership, firm, corporation, or any combination thereof, including joint venture, without previous consent in writing of the Agency.

If any part of the work to be done under this Contract is subcontracted, the subcontract shall be in writing and shall provide that all work to be performed thereunder shall be performed in accordance with the terms of the general Contract. The Agency or Engineer may request certified copies of any or all subcontracts be provided for their review to assure compliance with the subcontract conditions. The subcontracting of any of the work to be done in no way relieves the Contractor of the Contractor's responsibility under the Contract.

The Bidder to whom award is made, shall not subcontract more than 50 percent of the total cost of the project.

100.13 CONTRACT SECURITY. The successful Bidder shall, at the time of signing the Contract, furnish the following listed bonds of a surety company or companies authorized to do business in the State of Nevada and satisfactory to the Agency. The bonds shall be made payable to the Agency.

100.13.01 PERFORMANCE BOND. A bond in an amount equal to 100 percent of the full amount of the Contract, as surety for the faithful performance of the Contract, and for the fulfillment of such other requirements as may be provided by law shall be required. The faithful performance bond shall remain in effect for 1 year after final payment has been accepted by the Contractor.

100.13.02 LABOR AND MATERIAL BOND. A bond in an amount equal to 100 percent of the full amount of the Contract as surety for the payment of materials and labor costs for which the Contractor has obligated himself, will be required.

100.14 INSURANCE. The Contractor shall not commence any work nor permit any Subcontractor to commence work on a project until satisfactory proof has been presented to the Agency that all insurance requirements as outlined below have been met.

100.14.01 LIABILITY INSURANCE. The Contractor shall provide and maintain during the effective life of the awarded Contract, Comprehensive General Liability Insurance covering the Contractor and the Agency. Proof of insurance coverage required shall be by separate policy or Certificate of Comprehensive or commercial general liability insurance furnished to the Agency by the Contractor within 10-calendar days of notification of Contract award.

Notwithstanding any inconsistent statement in the policy or any subsequent endorsement attached thereto, the Agency shall be the insured or named as an additional insured covering all operations of the Contractor, whether liability is attributable to the Contractor or the Agency. The general liability policy shall provide protection from claims set forth below:

- A. Products/Completed Operations;
- B. Blanket Contractual;
- C. Independent Contractors;
- D. Broad Form Property Damage;
- E. Personal Injury; and
- F. Automobile Liability.

The policy shall provide the following limits of coverage:

- A. Bodily Injury & Property Damage: 1,000,000 dollars C.S.L. each occurrence; AND
- B. If the policy contains an "Annual Aggregate" or "Policy Aggregate," the minimum aggregate amount shall be 2,000,000.00 dollars.

All liability insurance policies shall bear an endorsement or shall have attached a rider whereby it is provided that, in the event of nonrenewal of such policies for any reason whatsoever, the Agency shall be notified by registered mail not less than 30-calendar days before expiration or cancellation is effective. This policy is the primary policy with respect to the additional insured, and any insurance held by the additional insured shall be secondary or excess. The cost of this insurance shall be absorbed in the Contractor's bid.

Nothing herein contained shall be construed as limiting in any way the extent to which the Contractor may be held responsible for payment of damages to persons or property resulting from Contractor's operations or the operations of any of the Contractor's subcontractors.

100.14.02 INDUSTRIAL INSURANCE. The Contractor shall comply with NRS Chapters 616 and 617, and within 10-calendar days of notification of award, the Contractor will submit written evidence that the Contractor has obtained for the period of the Contract full worker's compensation insurance coverage for all employees (as defined in NRS Chapter 617) in carrying out the work under this Contract. If the Contractor fails to make any payment for workers compensation insurance, the Agency shall make such payment and subtract the payment amount from any compensation owed to the Contractor.

100.14.03 ACCIDENT PREVENTION AND SAFETY. The Contractor shall at all times exercise reasonable precautions for the safety of employees involved with the Project and all other persons at location of Project activity and shall comply with all applicable provisions of state, federal, and local safety laws, ordinances, rules, regulations and building and construction codes including providing certificates prepared by the Employers Insurance Company of Nevada (formerly S.I.I.S.) or other insurer that shows compliance with NRS Sections 616B.627 and 617.210.

100.14.04 INDEMNITY. The Contractor shall indemnify, hold harmless and defend (assuming any and all costs) the Agency, its officers, agents, et cetera, from all losses and all claims, demands, payments, suits, actions, recoveries and judgements of every nature and description brought or recovered against the Contractor or the Agency by reason of any act, omission, or negligence of the said Contractor, Contractor's agents or employees, in the execution of the work or in the protection of it.

100.15 COMPLIANCE WITH LAWS AND LOCAL LABOR AND MATERIAL REQUIREMENTS. The Contractor shall conduct the work in compliance with all existing state and national laws and county and municipal ordinances and regulations limiting or controlling the work in any manner. Particular attention is called to the following:

100.15.01 PREVAILING WAGE. All workers employed by the Contractor shall be paid a minimum wage at a rate not less than the prevailing wage for the area as determined by the Labor Commissioner of the State of Nevada pursuant to provisions of NRS Chapter 338.

The Contractor shall post prevailing wage schedules at the work site on a weather proof bulletin board or similar display panel at a location approved by the Agency or Engineer.

The Contractor shall forfeit as penalty to the Agency 20 dollars for each working day or portion thereof for each worker paid less than the stipulated prevailing rates for any work done under the Contract by the worker.

100.15.02 EIGHT-HOUR DAY LIMITATION. Eight hours labor shall constitute a day's work, in accordance with the Contract Work Hours Standards Act specified hereinafter. These Standards as set forth in the Special Provisions are under the Labor Standards and shall apply to any worker or mechanic needed to execute the Contract.

100.15.03 REGISTRATION OF CONTRACTORS. Before submitting proposals, the Contractor shall be licensed pursuant to the provisions of NRS Chapter 624 and ordinances of other political subdivisions having jurisdiction over the work.

100.15.04 LABOR DISCRIMINATION. No discrimination shall be made in the employment, upgrading, demotion or transfer, recruitment or recruitment advertising, layoff or termination, rates of pay or other forms of compensation and selection for training, including apprenticeship of persons on public works projects because of race, color, creed, national origin or sex, as provided pursuant to NRS Section 338.125.

100.15.05 PREFERENTIAL EMPLOYMENT. Only citizens or wards of the United States or persons who have been honorably discharged from the military service of the United States shall be employed by the Contractor in the construction of public works pursuant to the provisions of NRS Section 338.130. Preference shall be given to bona fide residents of the area governed by the Agency if they are qualified to perform such work.

100.16 INSPECTION.

100.16.01 RIGHT-OF-ENTRY. Right-of-entry onto the work area shall not be denied the Agency, Engineer, State Health Service representatives, and representatives of utility companies which utilize public right-of-way.

100.16.02 ENGINEER'S AUTHORITY. All work shall be done under the supervision of the Engineer acting on behalf of the Agency. The Engineer shall decide all questions which arise as to the quality and acceptability of materials furnished, work performed, manner of performance, rates of progress, interpretation of the Plans and Specifications, acceptable fulfillment of the Contract and compensation under the Specifications. The Engineer shall have the authority to suspend work wholly or in part due to: the Contractor's failure to correct conditions unsafe for the workers or general public or carry out orders; unsuitable weather; unsuitable conditions for the prosecution of the work; or any other condition or reason determined to be in the public interest. The Engineer shall determine the amount and quality of work performed and materials furnished. The Engineer's estimate shall be "condition precedent" to the right of the Contractor to receive money due the Contractor under the Contract. The Engineer or Inspector does not have authority to authorize changes in the Plans and Specifications, change orders or supplemental agreements without prior written approval of the Agency.

100.16.03 INSPECTION FACILITIES. The Contractor shall furnish the Engineer with every reasonable facility for ascertaining at any time whether or not the work performed and materials used are in accordance with the requirements and intent of the Plans, Specifications and Contract. If the Engineer so requests, the Contractor shall, at any time before final acceptance of the work, remove or uncover such portions of the finished work as may be directed. After examination, the Contractor shall restore said portions of the work to the Standards required by the Specification. Should the work thus exposed or examined prove acceptable, the cost of uncovering or removing and replacing of the covering or replacing parts removed shall be paid for as extra

work, but should the work so exposed or examined prove unacceptable, the cost of uncovering or removing and the replacing of the covering or replacing parts removed shall be at the Contractor's expense. No work shall be done nor materials used without suitable inspection by the Engineer or the designated representative. Any work done or materials used without suitable inspection may, at the option of the Engineer, be ordered removed and replaced at the Contractor's expense. Failure to reject any defective work or materials shall not in any way prevent later rejection when such defect is discovered and such failure shall not obligate the Agency to make final acceptance.

All work which has been rejected shall be remedied, or removed and replaced in an acceptable manner by the Contractor, at the Contractor's own expense, and no compensation shall be allowed for such remedy, removal or replacement. Any work done beyond the lines and grades shown on the Plans or as given, except as herein provided, or any extra work done without written authority, shall be considered as unauthorized and at the expense of the Contractor, and shall not be measured or paid for. Work done in this way may be ordered removed at the Contractor's expense. Upon failure on the part of the Contractor to comply with any order of the Engineer made under the provisions of this article, the Engineer shall have authority to cause defective work to be remedied, or removed and replaced, and unauthorized work to be removed, and to deduct the costs from any monies due or to become due to the Contractor.

100.16.04 FINAL ACCEPTANCE. Upon receipt of written notice to the Engineer from the Contractor of presumptive completion of the project, the Engineer will make an inspection to determine acceptability of same. The Engineer shall respond to the notice in accordance with the Agency's General Provisions, the Contract General Provisions or as follows:

If all work is acceptable, the Engineer will notify the Contractor in writing, which notice shall constitute final acceptance.

If the inspection discloses unacceptable work, the Engineer shall notify the Contractor in writing of same. Upon correction of the unacceptable work items, another inspection will be made which will constitute final acceptance provided all unacceptable work has been satisfactorily corrected. Corrective action shall continue until all unacceptable work items have been satisfactorily corrected at which time final acceptance will occur.

Any failure on the part of the Agency or Engineer to condemn defective work at the time of construction shall not be deemed an acceptance, and the Contractor will be required to correct defective work or material any time before acceptance of final payment and up to 1-year thereafter.

At the option of the Agency, a Notice of Completion may be filed with the County Recorder upon final acceptance of the project.

If, within a period of 10-calendar days after a notice of nonacceptability has been given, the Contractor has not taken steps to complete the work, as outlined by the Engineer, the Engineer may, without further notice and without in any way impairing the Contract, make such other arrangements as the Engineer may deem necessary to have the work completed in a satisfactory manner. The cost of so completing the work shall be deducted from any monies due or which may become due to the Contractor under the Contract.

100.17 MATERIALS AND WORKMANSHIP. Unless otherwise specified or approved by the Agency or Engineer, all materials shall be new and must be of the specified quality and equal to approved samples if samples have been submitted. When requested by the Agency or by the Engineer, the Contractor shall furnish a complete written statement of the origin, compositions and manufacture of any or all materials that are to be used in the work. All samples shall be furnished by the Contractor without cost to the Agency. The Agency may waive sampling and testing if adequate information, properly certified by a Certificate of Compliance, is provided to indicate that materials comply with the terms of the Specifications. Specific testing requirements are specified in the Technical Provisions. All work shall be done and completed in a thoroughly workmanlike manner, notwithstanding any omission from these Specifications or the drawings, and it shall be the duty of the Contractor to call to the attention of the Agency, apparent errors or omissions and request instructions before proceeding with the work. The Engineer for the Agency may, by appropriate instructions, correct errors and supply information relative to omissions, which instructions shall be binding upon the Contractor as though contained in the original Specifications or drawings. Should the Contractor continue to construct items with full knowledge of the discrepancies, but without notifying the Agency of the discrepancies, the Contractor is responsible for all associated changes and related costs that could otherwise have been had the Contractor made such notifications.

Materials shall be stored so as to insure the preservation of their quality and fitness for the work. Stored materials shall be located so as to facilitate prompt inspection. That portion of the right-of-way not required for public travel may be used for storage purposes, and for the placing of the Contractor's equipment, only to the extent that vegetation will not be destroyed nor the landscape marred.

All defective work or materials shall be removed from the premises by the Contractor, whether in place or not, and shall be replaced or renewed in such manner as the Engineer may direct. All material and workmanship of whatever description shall be subjected to the inspection of, and rejection by, the Engineer if not in conformance with the Specifications.

The cost of testing and inspecting the removal and replacement of any defective work or material is the responsibility of the Contractor. Such costs will be deducted from any monies due or which may become due to the Contractor.

Any defective material, equipment, or workmanship, or any unsatisfactory or imperfect work which may be discovered before final acceptance of the work or within 1 year thereafter, shall be corrected immediately at the request of the Engineer, without extra charge, notwithstanding that it may have been overlooked in previous inspections and estimates. Failure to inspect work shall not relieve the Contractor from any obligation to perform sound and reliable work as herein described.

100.18 LOCATION OF THE WORK. The work is to be installed on property owned by, or rights-of-way obtained by the Agency. Limits of rights-of-way are shown on the Plans. Where construction easements are indicated, the Contractor may use the full width of the construction easement for construction activities or for storage of material. Use of construction easements is subject to the Special Provisions of these Specifications.

Any property outside the limits of easements or right-of-way provided by the Agency, that the Contractor may require or desire to use, must be acquired by the Contractor at the Contractor's own expense. Should the Contractor conclude negotiations for temporary use of private property for access to the work, for storage of material or vehicles, or for other purposes related to the construction operations, the terms of such use shall be specifically detailed in a written agreement between the property owner and the Contractor. Copies of said agreement will, upon request, be furnished to the Agency and the Agency shall be specifically exempted in the agreement from any liability incurred from the use of said private property.

100.19 COMMENCEMENT OF WORK. The Contractor shall commence the work covered by the Contract and shall complete the work, after the Contract is fully executed, within the time set forth in the "Special Provisions" therein.

The Contractor shall not commence the work, nor incur any expense in connection therewith, before receiving notification to proceed with the work.

The Contractor will be allowed 20-calendar days after the date on which the Contract is awarded, in which to deliver the Contract with the Contractor's signature affixed thereto, together with the bonds prescribed by law, to the Agency.

The Contractor shall give the Engineer written notice not less than 2-working days in advance of the actual date on which the work will be started. The Contractor shall be entirely responsible for any delay in the work which may be caused by failure to give such notice.

100.20 BASE LINE, BENCH MARKS AND REFERENCE POINTS. A base line, bench marks, construction stakes, and reference points will be established by the Engineer sufficient to enable all construction work to be staked out. The Contractor is liable for the preservation of all such reference lines and points. The Engineer will replace lost or destroyed stakes at the Contractor's expense. The Contractor shall assume full responsibility for dimensions and elevations measured from construction stakes. In all questions arising as to proper location of lines and structures, the Engineer's decision will be final.

100.21 PROGRESS SCHEDULE. After being awarded the Contract, the Contractor shall prepare and submit to the Agency for approval a progress schedule showing the order in which the Contractor proposes to carry out the work within the Contract time and showing the beginning times and completion times for the several salient features of the work provided in the Contract. The progress schedule shall be in the form of an arrow network, precedence diagram, or other similar schedule developed under a critical path method. The schedule shall outline in sufficient detail the proposed operations, the interrelations of the various operations, construction staging limits, and the order of performance so that the progress of the work can be evaluated accurately at any time during the performance of the Contract. The network shall reflect activity durations in a working day time frame and the schedule shall be submitted to the Agency in triplicate at least 10-working days in advance of the commencement of the work. The schedule must be approved by the Agency prior to beginning work.

At a minimum, the progress schedule shall be updated with each pay request.

When, in the judgment of the Agency or Engineer, it is necessary to accelerate any part of the work ahead of schedule, the Contractor shall, when directed, concentrate on such part of the work.

100.22 DELAYS. If any delay is caused the Contractor by specific order of the Agency or Engineer to stop work, or by the performance of extra work ordered by the Agency or Engineer, or by the failure of the Agency to provide the necessary right-of-way or site for installation, or by unforeseen causes beyond the control of the Contractor, such delay will entitle the Contractor to an equivalent extension of time, except as otherwise provided in the paragraphs herein, covering

“Suspension of Work.” Application for extension of time shall be presented in writing to the Agency for approval within 5-working days after such delay. An extension of time shall not release the sureties from their obligations, which shall remain in full force until the discharge of the Contract.

The Contractor shall not be assessed with liquidated damages nor the cost of engineering inspection during the delay in the completion to the work caused by acts of God, the public enemy, fire, floods, epidemics, quarantine restrictions, strikes, freight embargos, or unusually severe weather, or due to such causes, provided that the Contractor shall within 10-working days from the beginning of such delay notify the Engineer in writing of the causes of delay, who shall ascertain the facts and extent of the delay and the Engineer’s findings of the facts thereon shall be final and conclusive.

If delays from any of the above mentioned causes occur after the expiration of the Contract period, no liquidated damages shall occur for a period equivalent to such delay.

100.23 PROVISIONS FOR HANDLING EMERGENCIES. It is possible that emergencies may arise during the progress of the work which may require special treatment or make advisable extra shifts of workers to continue the work for 16, and even 24, hours per day. These emergencies may be caused by damage or possible damage to nearby existing structures or property due to the work under construction, by storm or by accidents or leakage. The Contractor shall be prepared in case of such emergencies to make all necessary repairs and shall promptly execute such work when required by the Engineer.

100.24 CHANGE ORDERS. The Specifications herein contained and drawings herein referred to may be modified and changed as may be agreed in writing between the parties hereto, in any manner not materially affecting the substance thereto, in order to carry out and complete more fully and perfectly the work herein described.

The Agency reserves the right to make alterations by addition to, or exclusion from, the Contract, Specifications or Drawings. Such changes or modifications shall in no way have an effect on or make void other portions of the Contract. The difference in cost of the work affected by such change will be added to or deducted from the amount of said Contract price, in accordance with the Contract unit price schedule. When the change results in increasing or decreasing the original Contract amount of a major item as calculated from the bid quantities by more than 25 percent in accordance with Subection 100.53 – “Increased or Decreased Quantities”, or if no unit price has been established in the Contract, a Contract Change Order, acceptable to both parties to the Contract, shall be executed. The Contract Change Order shall contain fair and reasonable prices, determined in one or more of the following ways:

- A. By the estimate and acceptance of a lump sum price or unit price.
- B. By cost and percentage.
- C. By cost plus a fixed fee.

If none of the above methods are agreed upon, the Contractor, provided an order has been received to make said change, shall proceed with the work on a force account basis. In such case and also under cases B and C above, the Contractor shall keep and present in such form as the Agency or their representative may direct, a record of the correct amount of the net cost of time, labor, equipment, and materials, together with vouchers.

100.24.01 FORCE ACCOUNT. Unless otherwise provided for in the Special Provisions, when payment is to be made on a force account basis, the Contractor shall be compensated as described below, which includes an agreed upon percentage for overhead and profit. The payment of the agreed upon percentage shall be considered full compensation to the Contractor for overhead and profit on the force account work, including all premiums paid on any insurance of any nature which the Contractor may be required, or elects, to carry; and any premiums paid on faithful performance and labor and material bonds, whether required for, or in addition to, the original Contract.

100.24.01.01 Force Account Payment. Work specified and performed on a force account basis shall be paid for as follows:

100.24.01.01.01 Equipment. The Contractor will be paid for any machinery or special equipment (other than small tools), which has been authorized by the Agency or their representative for use, at a rate no higher than the rental rates applicable to, and listed for, such equipment in the latest edition of the Rental Rate Blue Book for Construction Equipment, regardless of ownership and any rental, or other agreement, entered into by the Contractor. If it is deemed necessary by the Agency or their representative to use equipment not listed in this publication, a suitable rental rate for such equipment will be established by the Agency. The Contractor may furnish any cost data that might assist the Agency in establishment of such rental rate.

The Contractor's compensation for equipment will be calculated based on the amount of documented time that the equipment is in operation, on standby, and in transport related to the extra work. Payment will be calculated based on the documented time at the appropriate rate for each activity plus an agreed upon increase up to 15 percent of these costs for overhead and profit. If rental equipment is used intermittently and, when not in use, could be returned to its source at less expense to the Agency than holding it at the work site, it shall be returned, unless the Contractor elects to retain it at the work site at no additional expense to the Agency.

The rental rates paid as provided above shall include the cost of fuel, oil, lubrication, supplies, small tools, necessary attachments, repairs and maintenance of any kind, depreciation, storage, insurance, and all incidentals. All equipment shall be in good working condition, suitable for the purpose for which it is to be used and acceptable to the Agency or its representative.

100.24.01.01.02 Labor. The Contractor will be paid the cost of the labor classifications at the time of the force account work for the type of work (including superintendent when authorized by the Agency or their representative) used in the actual and direct performance of the force account work. The cost of labor, whether the employer is the Contractor, subcontractor, or other forces, will be the sum of the following:

- A. Actual Wages Plus Vacation Pay - The actual wages paid, plus vacation pay, which shall not include any employer payments to, or on behalf of, workers for health and welfare, pension, and similar purposes.
- B. Labor Surcharge -
 - (i) Labor Surcharge: A labor surcharge of 12.5 percent shall be calculated from the actual wages plus vacation pay amount as defined above. This surcharge shall constitute full compensation for all payments imposed by State and Federal laws.
 - (ii) Union Fringe Benefits: All other payments made to, or on behalf of, the workers, as required by collective bargaining agreements will be calculated from the actual wages plus vacation pay amount as defined above.
- C. Subsistence and Travel Allowance - Subsistence and travel allowance paid to such workers as required by collective bargaining agreements.

To the total of the direct costs computed from Subsections A, B and C above, an added markup not to exceed 15 percent of these costs will be allowed.

100.24.01.01.03 Subcontractors. Whenever there is a need to perform originally unanticipated work for which the Contractor is not properly equipped, the Contractor may, upon approval of the Agency or their representative, have the work performed by a Subcontractor who is proficient in the type of work to be performed. The value of the Subcontractor's work shall be determined in accordance with the methods described for the Contractor. The Contractor will be compensated for the value of the Subcontractor's work plus an agreed upon amount up to 10 percent of this cost for the Contractor's overhead. There shall be no further compensation to the Contractor for profit.

When a Subcontractor performs work paid for on a force account basis, the Contractor shall reach agreement with said Subcontractor as to the distribution of the payment made for such work. No additional payment will be made by reason of the performance of the work by a Subcontractor.

100.24.01.01.04 Materials. For materials accepted by the Agency or their representative, and used for the force account work, the Contractor shall receive the actual cost of such material, plus an agreed upon amount up to 15 percent of this cost for overhead and profit. If actual costs are not available, the Agency may establish the cost of an item to be the lowest price which was current at the time of the force account work. The Agency reserves the right to furnish such materials required as it deems expedient, and the Contractor shall have no claim for markup of such materials.

100.24.01.01.05 Supervision and Tools. No additional allowance shall be made for general supervision, the use of small tools or other costs for which no specified allowance is herein provided. Small tools are defined as those having a replacement value of 200.00 dollars or less.

100.24.01.01.06 Records. All force account work shall be recorded daily upon report sheets, furnished to the Agency or their representative by the Contractor and signed by both parties, which daily reports shall thereafter be considered the true record of force account and force account work performed. No force account work shall be performed or change be made except upon a written order from the Agency pursuant to authorization by the Agency, stating that the force account work or change is authorized, and no claim for an addition to the Contract sum shall be valid unless so ordered.

100.24.01.01.07 Documentation.

100.24.01.01.07.01 Labor. No payment will be made for labor performed on force account work until the Contractor furnishes, to the Agency, certified copies of payrolls covering that period when the force account work was performed.

The certified payrolls shall indicate name, classification, dates, daily hours, and hourly rate for each worker.

100.24.01.01.07.02 Equipment, Subcontractors and Materials. Copies of pay vouchers to all vendors for equipment (including transportation charges), subcontracted services, and materials shall be submitted with the Contractor's request for payment. The Agency may request actual invoices if further documentation is required. If materials used on the force account work are not specifically purchased for such work, but are taken from the Contractor's stock, then in lieu of pay vouchers, an affidavit shall be furnished certifying that such materials were taken from the Contractor's stock, that the quantity claimed was actually used and that the price and transportation claimed represent the actual cost to the Contractor.

100.25 EXTRA WORK. In connection with the work covered by the Contract, the Agency or Engineer may at any time during the progress of the work, without notice to the sureties on the Contractor's bonds, order work or material not covered by the Specifications.

The Contractor shall do such extra work and furnish such materials and equipment therefor, as may be required in writing by the Agency or Engineer, but the Contractor shall do no extra work except upon written order from the Agency or Engineer, and in the absence of such written order the Contractor shall not be entitled to payment for such extra work. All bills for such work shall be submitted in writing to the Design Engineer for recommendation regarding payment to the Agency. For such extra work a Supplemental Agreement, acceptable to both parties to the Contract, shall be executed. This Supplemental Agreement shall contain fair and reasonable prices, determined as provided for in Subsection 100.24 – "Change Orders".

100.26 SUSPENSION OF WORK. The Agency reserves the right to suspend the whole or any part of the work herein specified if deemed in its interest so to do, without compensation to the Contractor for such suspension, other than extending the time delayed by such suspension. No allowance by way of damages shall be made for any such delay.

100.27 FAILURE TO PERFORM PROPERLY. If the Contractor should neglect to prosecute the work properly or fail to perform any provision of the Contract, the Agency, after 5-working days written notice to the Contractor may, without prejudice to any other remedy it may have, make good such deficiencies and deduct the cost thereof from the payment then or thereafter due the Contractor.

100.28 DEFAULT AND TERMINATION OF CONTRACT. If the Contractor:

- A. Fails to begin the work under the contract within the time specified in the Notice to Proceed; or
- B. Fails to perform the work with sufficient workers and equipment or with sufficient materials to assure the prompt completion of said work; or
- C. Performs the work unsuitably or neglects or refuses to remove materials or to perform anew such work as may be rejected as unacceptable and unsuitable; or
- D. Discontinues the prosecution of the work; or
- E. Fails to resume work which has been discontinued within a reasonable time after notice to do so; or
- F. Becomes insolvent or is declared bankrupt or commits any act of bankruptcy or insolvency; or
- G. Allows any final judgement to stand against him unsatisfied for a period of 5-calendar days; or
- H. Makes an assignment for the benefit of creditors; or
- I. For any other cause whatsoever, fails to carry on the work in an acceptable manner, the Engineer will give notice in writing to the Contractor and the Contractor's surety of such delay, neglect, or default.

If the Contractor or surety, within a period of 10-working days after such notice, does not proceed in accordance therewith, the Agency or Engineer shall have full power and authority without violating the Contract, to take the prosecution of the work out of the hands of the Contractor. The Agency or Engineer may call upon the surety to complete the work in accordance with the terms of the Contract; or the Agency or Engineer may take over the work, including any or all materials and equipment on the project as may be suitable and acceptable, and may complete the work by force account, or may enter into a new agreement for the completion of said Contract according to the terms and provisions thereof, or use such other methods as, in the Agency's or Engineer's opinion, will be required for the completion of said Contract in an acceptable manner.

All costs and charges incurred by the Agency together with the cost of completing the work under the Contract, shall be deducted from the money due or which may become due said Contractor. In case the expense so incurred by the Agency shall be less than the sum which would have been payable under the Contract if it had been completed by said Contractor, then said Contractor shall be entitled to receive the difference, and in case such expense shall exceed the sum which would have been payable under the Contract, then the Contractor and the Contractor's surety shall be liable and shall pay to the Agency the amount of said excess.

100.29 SPECIFICATIONS AND DRAWINGS. The intent of the Plans and Specifications is to prescribe a complete outline of work which the Contractor undertakes to do in full compliance with the Contract. The Contractor shall perform all trenching; install all piping; construct all structures; perform all excavation and grading; install all base material, curb and gutter, bituminous plantmix pavement, seal and such additional and incidental construction as may be necessary to complete the work to the finished lines, grades and cross sections in a substantial and acceptable manner. The Contractor shall furnish all required labor, materials, equipment, and incidentals, unless otherwise provided in the Contract and shall include the cost of these items in the Contract unit prices for the several units of work. All items of work called for on the Plans or in the Specifications and not included as a separate item in the proposal shall be considered as incidental to the other items of work listed in the proposal and the payment for such incidental items shall be considered as included in the Contract unit prices bid.

The Contractor shall keep on the work site a copy of the Specifications and drawings and shall at all times give the Engineer access thereto. All the drawings accompanying the Specifications shall be regarded as a part thereof and of the Contract. Anything mentioned in these Specifications and not shown on the drawings, or shown on the drawings and not mentioned in these Specifications, shall be of like effect as though shown or mentioned in both.

The Design Engineer will furnish from time to time such detail drawings, Plans, profiles, and information as the Engineer may consider necessary for the Contractor's guidance, unless otherwise provided in the proposal or detail specification. It shall be duty of the Contractor to see that the provisions of these Specifications are complied with in detail, irrespective of the inspection given the work during its progress by the authorized official or designated representatives. Any failure on the part of the Contractor to observe the Specifications will be sufficient cause for rejection of the work.

Upon written request by the Agency, as built Plans will be provided by the Contractor prior to release of retention. The Agency may require these plans to be prepared by an Engineer.

100.30 SHOP DETAILS. When required by the Construction Plans and/or the Contract Documents, the Contractor shall submit at the Contractor's own expense shop details of all fabricated products, equipment, and other appurtenances for the Design Engineer's approval before such items shall be manufactured or used on the work. The approval of all drawings by the Engineer shall apply in general design only, and shall in no way relieve the Contractor from responsibility for errors or omissions contained therein. The time frames for submittal and required number of copies shall be as specified by the Agency.

100.31 DATA TO BE FURNISHED BY THE CONTRACTOR. The Contractor shall furnish the Engineer reasonable facilities for obtaining all information necessary to determine cost of work and material, such as the number of workers employed, their pay and the time worked on the various classes of construction. The Contractor shall also furnish the Engineer copies of all invoices for materials and supplies shipped to or from the project in connection with the work under the Contract, if so requested.

100.32 SUBCONTRACTORS. No subcontractor shall be recognized as such. All persons engaged on the work of construction by the Contractor shall be considered employees of the Contractor and their work shall be subject to the provisions of the Contract. The Agency and its representatives will deal only with the Contractor, who shall be responsible for the proper execution of the entire work.

100.33 PROTECTION OF PERSON AND PROPERTY. The Contractor shall adopt all practical means to minimize interference to traffic and inconvenience or damage to the general public and maintain normal neighborhood services. The Contractor shall protect against damage to any pipes, conduits, or other structures and/or utilities crossing the trenching or encountered in the work or in the proximity and shall be responsible for any damage done to such pipes, structures or property resulting therefrom.

The Contractor shall have the primary responsibility to locate all existing utility structures in accordance with Section 100.41, whether shown on the plans or not, and notify all utility companies for field verification of the location prior to construction. If a Utility is affected, the Utility shall be notified immediately by the Contractor of any damage. The affected Utility shall repair or replace its own facilities with full reimbursement from the Contractor. Any other damaged facilities shall be supported or replaced without delay and without additional compensation and to the satisfaction of the Agency.

100.33.01 MAINTENANCE OF TRAFFIC. While undergoing improvements, during both active construction and temporary suspension periods, the Contractor shall keep the road open to all traffic unless otherwise provided for in the contract documents. If the usable roadway is not sufficient to safely accommodate at least 1 lane of traffic in each direction, the Contractor shall adequately maintain one-way traffic, utilizing flaggers, pilot cars or other means needed for protection of the workers and the travelling public. Wherever controlled traffic is necessary for protection of the work or for the safety of public travel, the Contractor shall provide the Agency with traffic control plans, including any required detours, developed in accordance with the most current edition of the MUTCD. The Contractor shall provide and maintain in a safe condition, temporary approaches to, and crossings or intersections with, trails, roads, streets, businesses, parking lots, and residences. The Contractor is solely responsible for correct placement and proper maintenance of all traffic control devices. All obstructions to traffic shall be guarded by barriers illuminated at night. The Contractor shall be responsible for all damages to persons and property directly or indirectly caused by the Contractor's operations and under all circumstances, the Contractor must comply with all applicable laws and regulations relative to the safety of persons and property and the interruption of traffic and the convenience of the public. Particular attention shall be given to the construction of adequate facilities to permit the passing of emergency vehicles.

100.33.02 EXPLOSIVES. When the use of explosives is necessary for the prosecution of the work, the Contractor or subcontractor shall be properly licensed and comply with the requirements of all applicable codes and regulations pertaining thereto. The Contractor shall submit a work plan for use of explosives, including means of detonation. The Contractor shall be held responsible for and required to make restitution, at the Contractor's own expense, for all damage to persons or property caused by carelessness or neglect on the part of the Contractor or subcontractor or the agent, or employees of either, during the progress of the work and until its final acceptance.

100.33.03 MAILBOXES. The Contractor shall protect all mailboxes and preserve the areas surrounding the mailboxes such that mail service is not interrupted. In the event that construction activities hinder mail service, the Contractor shall relocate any affected mailbox. Temporary mailbox stands shall be located and constructed in accordance with U. S. Postal Service requirements such that mail service is not disrupted. There is no direct payment for this work.

100.34 CHARACTER OF WORKERS; METHODS AND EQUIPMENT. The Contractor shall at all times employ sufficient labor and equipment for prosecuting the several classes of work to full completion in the manner and time required by these Specifications.

All workers shall have sufficient skill and experience to perform properly the work assigned to them. Workers engaged in special or skilled work shall have sufficient experience in such work and in the operation of the equipment required to perform all work properly and satisfactorily.

Any person employed by the Contractor or by any subcontractor who, in the opinion of the Engineer, does not perform the work in a proper and skilful manner or is intemperate or disorderly, shall, at the written request of the Engineer, be removed forthwith by the Contractor or subcontractor employing such person, and shall not be employed again in any portion of the work without the approval of the Engineer.

Should the Contractor fail to remove such person or persons as required above, or fail to furnish suitable and sufficient personnel for the proper prosecution of the work, the Engineer may suspend the work by written notice until such orders are complied with.

All equipment which is proposed to be used on the work shall be of sufficient size and in such mechanical condition as to meet requirements of the work and to produce a satisfactory quality of work. Equipment used on any portion of the project shall be such that no injury to the roadway, adjacent property, or other highway will result from its use.

When the methods and equipment to be used by the Contractor in accomplishing the construction are not prescribed in the Contract, the Contractor is free to use any methods or equipment which can be demonstrated to the satisfaction of the Engineer to accomplish the Contract work in conformity with the requirements of the Contract.

When the Contract specifies that the construction be performed by the use of certain methods and equipment, such methods and equipment shall be used unless others are authorized by the Engineer. If the Contractor desires to use methods or types of equipment other than those specified in the Contract, the Contractor may request authority from

the Engineer to do so. The request shall be in writing and shall include a full description of the methods and equipment proposed to be used and an explanation of the reasons for desiring to make the change. If approval is given, it will be on the condition that the Contractor will be fully responsible for producing work in conformity with Contract requirements. If, after trial use of the substituted methods or equipment, the Engineer determines that the work produced does not meet Contract requirements, the Contractor shall discontinue the use of the substitute method or equipment and shall complete the remaining construction with the specified methods and equipment. The Contractor shall remove the deficient work and replace it with work of specified quality, or take such other corrective action as the Engineer may direct. No change will be made in basis of payment for the construction items involved nor in Contract time as a result of authorizing a change in methods or equipment under these provisions.

100.35 NIGHT WORK. The Contractor may be required to execute the work at night if, at any time, the Agency or Engineer shall deem it necessary for the progress of the work, or if emergencies arise, and the Contractor shall promptly comply with any such requirements made in writing by the Agency or Engineer. The Contractor will also be permitted to work at night if the Agency or Engineer is satisfied of the need therefor, in order to maintain the required progress or protect the work from the elements, and that noise impact considerations have been addressed. If ordered or permitted to work at night, the Contractor shall provide sufficient and satisfactory lighting and other facilities therefor. The Contractor shall receive no extra payment for night work, if performed, but compensation shall be considered as having been included in the price stipulated for the work.

100.36 CLIMATIC CONDITIONS. The Agency or Engineer may order the Contractor to suspend any work that may be subject to damage by climatic conditions. When delay is caused by an order to suspend work, given on account of climatic conditions which, in the opinion of the Agency or Engineer could have been reasonably foreseen and the damage could have been forestalled by diligent and reasonable action on the part of the Contractor, the Contractor will not be entitled to any extension of time or additional compensation on account of such order.

100.37 PROTECTION OF WORK AND CLEANING UP. The Contractor shall be responsible for the care of all work until its completion and final acceptance, and shall, at the Contractor's own expense, replace damaged or lost material and repair damaged parts of the work or the same may be done by the Agency, and the Contractor and the Contractor's sureties shall be liable therefor. The Contractor shall take all risks from floods and casualties and shall make no charge for the restoration of such portions of the work as may be destroyed or damaged by flood or because of danger from flood, or for delays from such causes. The Contractor may, however, be allowed a reasonable extension of time on account of such delays, subject to the conditions hereinbefore specified. The Contractor shall remove from the site, rubbish, unused materials, concrete forms, sheeting or equipment, belonging to, or used under the Contractor's direction during construction, and in the event of the Contractor's failure to do so, the same may be removed by the Agency at the expense of the Contractor and the Contractor and the Contractor's sureties shall be liable therefor.

100.38 ROADS AND FENCES. Streets and roads subject to interference by the prosecution of the work covered by the Contract shall be kept open, and the fences subject to interference shall be maintained by the Contractor until the work is completed.

100.39 FAILURE TO COMPLETE THE WORK IN THE TIME AGREED UPON. Should the Contractor fail to complete the work or any part thereof in the time agreed upon in the Contract, the Contractor will be subject to the liquidated damages as provided in the Contract Documents.

100.40 SANITATION AND SAFETY. The Contractor shall comply with provisions of local, state, and federal regulations as relates to sanitation and sanitary facilities to be provided for use of employees.

100.41 PUBLIC SERVICE EQUIPMENT. The Contractor shall contact USA at 1-(800) 227-2600, at least 2-working days prior to start of construction for utility locations. In case it shall be necessary to remove or relocate any telephone, telegraph or electric power transmission poles, gas pipes, water pipes, electrical conduits or underground structures of any character, or any portion thereof, the Agency will have arranged with the Utility or Owner of said facilities for the removal or relocation of conflicting utilities prior to awarding the Contract.

The Contractor shall not interfere with said facilities until the time agreed to for the relocation of said utilities has expired. In case water service pipe, gas lines, telephone cables, power cables, or any other utilities crossing the line of trenching are cut by the Contractor, the Utility concerned shall be notified immediately of said damage, and the Contractor shall fully reimburse the Utility for any expenses incurred in repairing or replacing the damaged utility. In the event that the Contractor severs a utility service of any kind, whether inadvertently or intentionally, the Contractor shall arrange for the appropriate Utility to perform such work, and shall reimburse said Utility for all costs involved.

Right is reserved to municipal corporations, county authorities, and to water, gas, telephone, telegraph, and electric power transmission utilities to enter upon any public highway or road for the purpose of making repairs and changes that have become necessary by reason of the improvement thereof.

100.42 SUPERVISION. The Contractor shall have a thoroughly experienced and qualified superintendent on the project at all times who shall be in direct charge of the work and readily available for consultation with the Engineer. Failure to do so may be just cause for the suspension of operations until a qualified superintendent is assigned to the project.

100.43 UTILITY SERVICES. All utilities required by the Contractor shall be furnished at the Contractor's own expense. All temporary connections for electricity shall be subject to the approval of the Engineer. In the event electricity is made available by the Agency, the Contractor shall, at the Contractor's own expense, install a meter to determine the amount of current used by him and such electricity shall be paid by the Contractor.

If the Contractor desires to use water from fire hydrants during construction, permission for the use of hydrants shall be obtained from the proper Agency. The Contractor shall use said hydrants in accordance with rules established by the Agency for use of fire hydrants. In the event permission is secured to use fire hydrants, the Contractor shall install flow control valves on the hydrants to allow for full flow to eliminate backwashing from the stop and drain of the hydrants in a partial open position. All tank trucks shall have free flow piping into the top of the tank to assure that siphoning from the tank truck will not contaminate the water distribution system.

100.44 TREES AND SHRUBS. The Contractor shall remove no trees or shrubs without authorization of the Agency or Engineer. The Contractor shall comply with all permitting requirements with regard to removal of trees or shrubs. Serious injuries to trees shall be avoided. The Contractor shall contact the Urban Forester or appropriate authority regarding all trees and shrubs in the public right-of-way.

100.45 GUARANTEE OF STRUCTURES AND EQUIPMENT. The Contractor shall guarantee the work done under this Contract against unsatisfactory conditions due to defective equipment, materials or workmanship for a period of 1 year from the date of the Contractor's acceptance of the final payment under the Contract. Any repair work or replacement required, in the opinion of the Agency or Engineer, shall be done immediately by the Contractor at the Contractor's expense. Should the Contractor fail to repair such defects or to make replacement within 5-working days after written notice, it shall be lawful for the Agency to make such repairs and replacements and charge the Contractor with the actual cost of such necessary labor and materials.

100.46 PAYMENT OF PATENTS AND PATENT INFRINGEMENTS. All fees or claims for any patented invention, article, arrangement or process that may be used upon or in any manner connected with the performance of the work or any part thereof shall be included in the price bid for doing the work, and the Contractor and the Contractor's sureties shall protect and hold the Agency, together with all of its officers, agents, and employees, harmless against any and all demands made for such fees or claims, against any and all suits and claims brought or made by the holder of any invention or patent, or growing out of an alleged infringement of any invention or patent, and before final payment is made on account of the Contract, the Contractor shall furnish acceptable proof to the Agency of a proper release from such fees or claims.

100.47 TRADE NAMES. Whenever any article or any class of materials is specified by a trade name or by the name of any particular patentee, manufacturer or dealer, it shall be and is mutually understood to mean and specify the article or class of materials described, or any other equal thereto in quality, finish and durability, and equally as serviceable for the purpose for which it is intended, subject to the approval and acceptance of the Design Engineer. If the Contractor requests permission to use alternate equipment or materials and its use is permitted, such use will be conditional on the Contractor assuming all responsibility to provide and stand the cost of any changes necessitated thereby and of the engineering design necessary to accommodate the particular equipment or material desired for use. In other words, any deviation from the drawings resulting from the type of equipment or materials to be used, shall not result in, nor be, the basis for any "extra charges" above and in excess of the original bid price for the work.

The Contractor shall, within 10-calendar days following notification by the Agency or Engineer to proceed with the work, submit for approval a complete list of all materials, articles or equipment which are proposed for substitution as the equal, of materials, articles or equipment which are specified by trade names or by the names of any particular patentee, manufacturer or dealer. Failure to submit such list within that time shall be deemed adequate and reasonable ground for refusal by the Engineer to consider any subsequent proposed substitutions. Any items omitted from a duly submitted list may likewise be barred for subsequent consideration.

Complete details of each proposed substitute, including working drawings, catalogs, and tests and other necessary data, shall be furnished in time to permit investigation and approval without delay to the work. No approval shall be valid without the signature of the Design Engineer.

100.48 ARBITRATION. In the event any difference shall arise as to the right or obligation of both parties to the Contract which cannot be adjusted amicably between them, the same shall be submitted to a Board of Arbitrators composed of three competent and disinterested persons, one to be chosen by the Agency, one by the Contractor, and the third to be selected by the two arbitrators so chosen. Either party to the Contract may request that any dispute or difference be arbitrated by appointment of an arbitrator and notifying the other party as to the name of the arbitrator so appointed and requesting that said party appoint their own arbitrator within 10-calendar days after such notification.

Should the party so notified fail or refuse to appoint an arbitrator within the specified time, then the arbitrator who was first appointed shall alone determine and decide the dispute or difference.

Except where one arbitrator alone is acting, a majority of the arbitrators shall constitute the necessary quorum to decide a dispute, and any decision rendered shall be binding and final upon both parties.

The cost of arbitration shall be paid by the party against whom such arbitrator or arbitrators render such decision.

100.49 PERMITS AND LICENSES. The Contractor shall procure at the Contractor's expense all necessary permits, licenses, insurance policies, et cetera, prior to commencement of work and to comply with all applicable Federal, State or local laws and regulations in the performance of the work.

100.49.01 STORM WATER POLLUTION PREVENTION PLAN. It shall be the responsibility of the designated permit holder to provide for the day-to-day operational control of activities that are necessary to ensure compliance with the requirements of the NPDES General Permit for erosion control due to storm water and construction related runoff from construction sites as established under NRS and NAC 445A. This work shall include, but is not limited to, filing the Notice of Intent (NOI) and the Notice of Termination (NOT); and development and implementation of a Storm Water Pollution Prevention Plan (SWPPP), including furnishing materials; constructing; and maintaining permanent and temporary sediment control measures for the duration of construction activities.

The SWPPP shall include descriptions of Best Management Practices (BMP) to be implemented, site-specific diagrams indicating proposed locations of erosion control devices. This plan shall include provisions for installation, maintenance, removal, and disposing of erosion control devices and provide for a means of recording all inspections and maintenance actions. A copy of the NOI, SWPPP, inspection and maintenance records shall be posted at the construction site with other project records and shall be available for public inspection.

100.50 BASIS OF PAYMENT. Payment at the amounts set forth in the proposal and the Contract will be considered to be in full for completed work and will cover labor, materials, equipment, supplies, rental of tools and machinery and all other expenditures incidental to satisfactory compliance with the Contract, unless otherwise specifically provided.

100.51 PARTIAL PAYMENTS. Except as otherwise authorized by NRS Section 338.525, progress payments will be made by Agency once each month based upon a progress invoice submitted by the Contractor and satisfactory to the Agency. The Engineer will, on the first day of each month or as soon thereafter as practicable, make an estimate of the value of the work done by the Contractor during the preceding month including materials delivered but not installed, and on or before the 10th day of the month following the month in which the work was performed for the Contractor's use in preparing the progress invoice. The progress invoice shall be based upon materials on the job site and invoiced, or upon material in place and all labor expended thereon. The Agency shall make payment within 30-calendar days of receipt of a satisfactory progress invoice.

Ten percent of the amount billed will be deducted by Agency until 50 percent of the work has been completed in an acceptable manner. This retention will be held by the Agency in accordance with Section 100.52. After 50 percent of the work has been completed, however, the Agency may, at its discretion, pay any of the remaining progress payments without withholding additional money if, in the opinion of the Agency, satisfactory progress is being made in the work.

The Agency will pay to Contractor, at the end of each quarter, interest earned on the amount withheld under the Contract during the quarter as provided for in Subsection 3 of NRS Section 338.515. Pursuant to NRS Section 338.550, Contractor shall, within 10-calendar days after receipt of the money, pay to each subcontractor or supplier that portion of the interest it receives in direct proportion to the subcontractor's basis in the progress bill or retainage, and any accrued interest thereon.

No interest will be paid on funds withheld for defective work; on funds held as a result of third party claims for failure to make proper payments to Subcontractors for labor, materials or equipment; or for work, materials or equipment still to be furnished or installed.

100.52 FINAL ESTIMATE AND PAYMENT. As soon as practical following completion of the work, the Contractor shall make a written request to the Agency for final inspection and acceptance of the work. Except with respect to payments withheld from a progress payment or retainage reasonably sufficient to pay the expenses Agency expects to incur as a result of the failure of the Contractor to comply with the Contract, applicable billing code, law or regulation, the remaining balance shall be paid within 30-calendar days of:

The occurrence of one or more of the conditions of NRS Section 338.520; or

- A. Contractor submits evidence satisfactory to Agency that all payrolls, bills for material, interest or retention and all other indebtedness connected with the work have been paid; or
- B. No claims, liens or outstanding debts have been filed against the work in response to any 'Notice of Completion' which the Agency may file with the County Recorder. In the event any claims, liens, or outstanding debts are filed against the work, the parties agree that the Agency may continue to hold the retainage until such time as the claims, liens or outstanding debts are resolved.

100.53 INCREASED OR DECREASED QUANTITIES. Whenever the quantity of any item of work as given in the proposal shall be increased or decreased, payment shall be made on the basis of the actual quantity constructed. Payment for such items shall be at the unit price given in the proposal, except that a change order suitable to both parties to the Contract shall be executed when the revised quantity results in a net increase or decrease of more than 25 percent of the original Contract bid quantity for any major item.

200.01 AGGREGATES FOR BASE COURSES.

200.01.01 DESCRIPTION. This Subsection covers the quality and size of mineral materials used as base courses. Portland Cement Concrete or Asphalt Concrete may be crushed or pulverized and mixed with virgin aggregate or used solely as aggregate base, provided the resulting material complies with the requirements of Subsection 200.01.03 for Type 1, Class A or Type 2, Class B Crushed Aggregate Base. Crushed or pulverized Asphalt Concrete, not meeting the requirements of Subsection 200.01.03, utilized at the direction of the *Agency* or *Engineer* as aggregate base, shall comply with the requirements of Subsection 200.01.04 for Type 1 or Type 2 Recycled Asphalt Concrete Base. If asphalt concrete is to be recycled on-site, it shall be pulverized by approved mechanical methods.

200.01.02 TEST SPECIMEN PREPARATION FOR LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS. Unless otherwise directed or approved by the *Engineer* test specimens for determination of the Liquid Limit, Plastic Limit and Plasticity Index shall be prepared in accordance with the Dry preparation method as described in 10.2 of ASTM D4318.

200.01.03 CRUSHED AGGREGATE BASE. Crushed aggregate base shall conform to the applicable requirements of Tables 200.01.03-I and 200.01.03-II.

TABLE 200.01.03-I

Sieve Size	Percentage by Weight Passing Sieve	
	Type 1, Class A	Type 2, Class B
2 inch	100	
1-1/2 inch	90 – 100	
1 inch	80 – 90	100
3/4 inch		90 – 100
No. 4	30 – 65	35 – 65
No. 16	15 – 40	15 – 40
No. 200	2 – 12	2 – 10

TABLE 200.01.03-II

Test	Test Method	Requirements
Sampling Aggregate	ASTM D 75	-
Sieve Analysis	ASTM C 136 and C 117	Table 200.01.03-I
Fractured Faces (percent)	ASTM D 5821	35 Minimum
Liquid Limit	ASTM D 4318 ⁽¹⁾	35 Maximum
Plasticity Index	ASTM D 4318 ⁽¹⁾	10 Maximum
Resistance (R) Value	ASTM D 2844	70 Minimum
Resistance to Wear (percent)	ASTM C 131 ⁽²⁾	45 Maximum

1. Dry Method
2. 500 Revolutions

200.01.04 RECYCLED AGGREGATE BASE. Recycled base shall conform to the applicable requirements of Tables 200.01.04-I and 200.01.04-II.

TABLE 200.01.04-I

Sieve Size	Percentage by Weight Passing Sieve	
	Type 1 (Imported)	Type 2 (Recycled On-site)
2 inch	100	100 ⁽¹⁾
¾ inch	70 – 100	
No. 4	20 – 70	
No. 200	0 – 12	0 – 12

1. Or as directed by the Agency

TABLE 200.01.04-II

Test	Test Method	Requirements
Sampling Aggregate	ASTM D 75	-
Sieve Analysis	ASTM C 136 and C 117	Table 200.01.04-I
Resistance (R) Value	ASTM D 2844	70 Minimum

200.01.05 CEMENT TREATED CRUSHED AGGREGATE BASE. Aggregate for cement treated crushed aggregate base shall conform to Subsection 200.01.01 – “Description” and the requirements of Subsection 200.01.03 for Type 2, Class B Crushed Aggregate Base.

200.01.06 CEMENT TREATED RECYCLED AGGREGATE BASE. Aggregate for cement treated recycled aggregate base shall conform to the requirements of Subsection 200.01.04 “Recycled Aggregate Base”.

200.01.07 SELECT NATURAL BASE. Select natural base shall conform to the applicable requirements of Tables 200.01.07-I and 200.01.07-II.

TABLE 200.01.07-I

Sieve Size	Percentage by Weight Passing Sieve	
	Type 1 (Coarse)	Type 2 (Fine)
1-1/2 inch	100	
1 inch		100
No. 4	55 – 75	70 – 100
No. 16	30 – 75	45 – 90
No. 50	15 – 40	25 – 60
No. 200	3 – 12	3 – 15

TABLE 200.01.07-II

Test	Test Method	Requirements
Sampling Aggregate	ASTM D 75	-
Sieve Analysis	ASTM C 136 and C 117	Table 200.01.07-I
Liquid Limit	ASTM D 4318 ⁽¹⁾	40 Maximum
Plasticity Index	ASTM D 4318 ⁽¹⁾	10 Maximum
Resistance (R) Value	ASTM D 2844	65 Minimum

1. Dry Method

200.01.08 PIT RUN SUBBASE. Pit run subbase shall conform to the requirements of Tables 200.01.08-I and 200.01.08-II.

TABLE 200.01.08-I

Sieve Size	Percentage by Weight Passing Sieve
4 inch	100
2 inch	60 – 100
No. 4	30 – 60
No.100	5 – 20
No. 200	3 – 12

TABLE 200.01.08-II

Test	Test Method	Requirements
Sampling Aggregate	ASTM D 75	-
Sieve Analysis	ASTM C 136 and C 117	Table 200.01.08-I
Liquid Limit	ASTM D 4318 ⁽¹⁾	40 Maximum
Plasticity Index	ASTM D 4318 ⁽¹⁾	12 Maximum
Resistance (R) Value	ASTM D 2844	30 Minimum

1. Dry Method

200.01.09 STRUCTURAL FILL. This Specification covers the minimum quality and size of mineral materials to be placed beneath buildings, concrete slabs, bituminous pavements and all other components subject to structural loading. Materials used for structural fill shall be free of debris and organic matter. The requirements of Tables 200.01.09-I and 200.01.09-II are intended as a guideline to specify a readily available, pre-qualified material. Any adjustments shall be approved in writing by the *Agency* or *Engineer* prior to use.

TABLE 200.01.09-I

Sieve Size	Percentage by Weight Passing Sieve
4 inch	100
3/4 inch	70 – 100
No. 40	15 – 65
No. 200	5 – 20

TABLE 200.01.09-II

Test	Test Method	Requirements
Sampling Aggregate	ASTM D 75	-
Sieve Analysis	ASTM C 136 and C 117	Above (Table 200.01.09-I)
Liquid Limit	ASTM D 4318 ⁽¹⁾	35 Maximum
Plasticity Index	ASTM D 4318 ⁽¹⁾	12 Maximum
Resistance (R) Value	ASTM D 2844	30 Minimum

1. Dry Method

200.01.10 RECREATIONAL SURFACING AGGREGATE. This Specification covers the quality and size of mineral materials for uses such as playgrounds, walking paths and parks. Recreational surfacing aggregate shall conform to the requirements of Tables 200.01.10-I and 200.01.10-II.

TABLE 200.01.10-I

Sieve Size	Percentage by Weight Passing Sieve
3/8 inch	100
No. 4	80 – 100
No. 8	55 – 90
No. 16	40 – 75
No. 30	25 – 50
No. 50	15 – 35
No. 100	10 – 25
No. 200	5 – 20

TABLE 200.01.10-II

Test	Test Method	Requirements
Sampling Aggregate	ASTM D 75	-
Sieve Analysis	ASTM C 136 and C 117	Table 200.01.10-I
Plasticity Index	ASTM D 4318 ⁽¹⁾	3 - 15

1. Dry Method

200.02 AGGREGATES FOR BITUMINOUS COURSES.

200.02.01 DESCRIPTION. This Subsection covers the quality and size of mineral materials used in bituminous courses.

200.02.01.01 RAP. The aggregate shall be the product of crushed, milled, or planed HMA pavement.

200.02.02 TEST SPECIMEN PREPARATION FOR LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS. Unless otherwise directed or approved by the *Engineer* test specimens for determination of the Liquid Limit, Plastic Limit and Plasticity Index shall be prepared in accordance with the Dry preparation method as described in 10.2 of ASTM D4318.

Unless otherwise directed or approved by the *Engineer*, the test specimens shall be obtained from the combined grading materials.

200.02.03 DENSE GRADE PLANTMIX AND ROADMIX AGGREGATE. Dense grade plantmix and roadmix aggregate shall conform to the applicable requirements of Tables 200.02.03-I and 200.02.03-II

TABLE 200.02.03-I

Sieve Size	Percentage by Weight Passing Sieve			
	Type 2	Type 2C ⁽¹⁾	Type 3C	Type 3
1 inch	100	100		
3/4 inch	90 – 100	88 – 95	100	
1/2 inch		70 – 85	90 - 99	100
3/8 inch	63 – 85	60 – 78	70 – 90	85 – 100
No. 4	45 – 65	43 – 60	48 – 65	50 – 75
No. 10	30 – 44	30 – 44	32 – 50	32 – 52
No. 16				
No. 40	12 – 22	12 – 22	12 - 26	12 – 26
No. 200	3 – 8	3 – 8	3 – 8	3 – 8

1. Unless directed or approved by *Agency or Engineer*, Type 2C shall not be used as the final (top) lift of the structural section.

TABLE 200.02.03-II

Test	Test Method	Requirements
Sampling Aggregate	ASTM D75	-
Sieve Analysis	ASTM C136 and C117	Table 200.02.03-I
Fractured Faces (%)	ASTM D5821	
One Face		80 Minimum
Two Faces		50 Minimum
Liquid Limit	ASTM D4318 ⁽¹⁾	35 Maximum
Plasticity Index	ASTM D4318 ⁽¹⁾	6 Maximum
Resistance to Degradation (%)	ASTM C131 ⁽²⁾	37 Maximum
Soundness (% loss)	ASTM C88 ⁽³⁾	
Coarse Aggregate		12 Maximum
Fine Aggregate		15 Maximum
Absorption (%)	ASTM C127	
Coarse Aggregate		4 Maximum

1. Dry Method
2. 500 Revolutions
3. 5 Cycles, Sodium Sulfate

200.02.04 OPEN GRADE AGGREGATE. Open grade aggregate shall conform to the applicable requirements of Tables 200.02.04-I and 200.01.04-II.

TABLE 200.02.04-I

Sieve Size	Percentage by Weight Passing Sieve		
	<i>ATPB</i> ⁽¹⁾	Type 1 (1/2 Inch)	Type 2 (3/8 Inch)
1 inch	100		
3/4 inch	90 - 100		
1/2 inch	35 - 65	100	100
3/8 inch	20 - 45	90 - 100	95 - 100
No. 4	0 - 10	35 - 55	40 - 65
No. 16	0 - 5	5 - 18	12 - 22
No. 200	0 - 2	0 - 4	0 - 5

1. Drainage Layer

TABLE 200.02.04-II

Test	Test Method	Requirements
Sampling Aggregate	<i>ASTM D75</i>	-
Sieve Analysis	<i>ASTM C136 and C117</i>	Table 200.02.04-I
Plasticity Index	<i>ASTM D4318</i> ⁽¹⁾	6 Maximum
Fractured Faces (%)	<i>ASTM D5821</i>	90 Minimum
Resistance to Degradation (%)	<i>ASTM C131</i> ⁽²⁾	37 Maximum
Soundness (% loss)	<i>ASTM C88</i> ⁽³⁾	
Coarse Aggregate		12 Maximum
Fine Aggregate		15 Maximum
Absorption (%)		
Coarse Aggregate	<i>ASTM C127</i>	4 Maximum

1. Dry Method
2. 500 Revolutions
3. 5 Cycles, Sodium Sulfate

200.02.05 CHIP SEAL AGGREGATE. Chip seal aggregate shall conform to the applicable requirements of Tables 200.02.05-I and 200.02.05-II.

TABLE 200.02.05-I

Sieve Size	Percentage by Weight Passing Sieve		
	Type 1 (1/2 Inch)	Type 2 (3/8 Inch)	Type 3 (3/8 Inch, Modified)
1/2 inch	100		
3/8 inch	90 – 100	100	100
No. 4	15 – 35	20 – 45	95 – 100
No. 8			30 – 40
No. 16	0 – 4	0 – 6	4 – 10
No. 30			0 – 5
No. 50			0 – 4
No. 100			0 – 3
No. 200	0 – 2	0 – 2	0 – 2

TABLE 200.02.05-II

Test	Test Method	Requirements
Sampling Aggregate	ASTM D75	-
Sieve Analysis	ASTM C136 and C117	Table 200.02.05-I
Plasticity Index	ASTM D4318 ⁽¹⁾	Non Plastic
Fractured Faces (%)	ASTM D5821	90 Minimum
Resistance to Degradation (%)	ASTM C131 ⁽²⁾	37 Maximum
Stripping Test	Nev. T209	Satisfactory

1. Dry Method
2. 500 Revolutions

200.02.06 SLURRY SEAL AND MICRO-SURFACING AGGREGATE. Slurry seal and micro-surfacing aggregate shall conform to the applicable requirements of Tables 200.02.06-I and 200.02.06-II.

TABLE 200.02.06-I

Sieve Size	Percentage by Weight Passing Sieve			
	Type 1	Type 2	Type 3	Type 4 ⁽¹⁾
1/2 inch				100
3/8 inch		100	100	90 – 99
No. 4	100	90 – 100	70 – 90	65 – 85
No. 8	90 – 100	65 – 90	45 – 70	45 – 70
No. 16	65 – 90	45 – 70	28 – 50	28 – 50
No. 30	40 – 65	30 – 50	19 – 34	19 – 34
No. 50	25 – 42	18 – 30	12 – 25	12 – 25
No. 100	15 – 30	10 – 21	7 – 18	7 – 18
No. 200	10 – 20	5 – 15	5 – 15	5 – 15

1. Unless otherwise directed or approved by the *Engineer* Type 4 shall be combined with an asphalt emulsion conforming to Micro with LMCQS in Table 201.04-III – “Specifications for Latex Modified Emulsion” and used for rut filling and as a scratch course only.

200.02.06 Slurry Seal and Micro-Surfacing Aggregate Continued

TABLE 200.02.06-II

Test	Test Method	Requirements			
		Type 1	Type 2	Type 3	Type 4
Sampling Aggregate	ASTM D75	-			
Sieve Analysis	ASTM C136 and C117	Table 200.02.06-I			
Plasticity Index	ASTM D4318 ⁽¹⁾	Non-Plastic			
Resistance to Degradation (%)	ASTM C131 ⁽²⁾	30 Maximum			
Soundness (% loss)	ASTM C88 ⁽³⁾	10 Maximum			
Absorption	ASTM C128	Provide Results			
Sand Equivalent	ASTM D2419	50 Minimum	60 Minimum	65 Minimum	
Durability Index	ASTM D3744	60 Minimum		70 Minimum	

1. Dry Method
2. 500 Revolutions on gradation D
3. 5 Cycles, Sodium Sulfate

200.02.07 SAND SEAL AGGREGATE AND SAND BLOTTER. Sand seal and sand blotter aggregate shall conform to the applicable requirements of Tables 200.02.07-I and 200.02.07-II.

TABLE 200.02.07-I

Sieve Size	Percentage by Weight Passing Sieve
1/2 inch	100
No. 4	90 – 100
No. 16	30 – 75
No. 200	0 – 12

TABLE 200.02.07-II

Test	Test Method	Requirements
Sampling Aggregate	ASTM D75	-
Sieve Analysis	ASTM C136 and C117	Table 200.02.07-I
Plasticity Index	ASTM D4318 ⁽¹⁾	Non-Plastic
Organic Impurities	ASTM C40	Less Than Plate 3

1. Dry Method

200.03 AGGREGATES FOR BEDDING AND BACKFILL.

200.03.01 DESCRIPTION. This Specification covers the quality and size of mineral materials used in the bedding and backfilling of subsurface improvements.

200.03.02 CLASS A BACKFILL. Class A backfill shall conform to the requirements of Tables 200.03.02-I and 200.03.02-II. In lieu of Class A Backfill, materials meeting the requirements of Section 200.01.03 may also be used as bedding for sewer and storm drain pipes.

TABLE 200.03.02-I

Sieve Size	Percentage by Weight Passing Sieve
3/8 inch	100
No. 4	90 – 100
No. 50	10 – 40
No. 100	3 – 20
No. 200	0 – 15

Test	Test Method	Requirements
Sampling Aggregate	ASTM D 75	-
Sieve Analysis	ASTM C 136 and C 117	Table 200.03.02-I
Plasticity Index	ASTM D 4318 ⁽¹⁾	10 Maximum

1. Dry Method

200.03.03 CLASS B BACKFILL. Class B backfill shall conform to the requirements of Tables 200.03.03-I and 200.03.03-II.

TABLE 200.03.03-I

Sieve Size	Percentage by Weight Passing Sieve
1/2 inch	100
No. 4	0 – 15
No. 200	0 – 3

TABLE 200.03.03-II

Test	Test Method	Requirements
Sampling Aggregate	ASTM D 75	-
Sieve Analysis	ASTM C 136 and C 117	Table 200.03.03-I
Resistance to Wear (percent.)	ASTM C 131 ⁽¹⁾	37 Maximum

1. 500 Revolutions

200.03.04 CLASS C BACKFILL. Class C backfill shall conform to the requirements of Tables 200.03.04-I and 200.03.04-II. Class C backfill need not be washed but shall be free of any organic impurities, clay lumps, or unstable substances.

TABLE 200.03.04-I

Sieve Size	Percentage by Weight Passing Sieve
1 inch	100
3/4 inch	90 – 100
3/8 inch	10 – 55
No. 4	0 – 10

200.03.04 Class C Backfill Continued

TABLE 200.03.04-II

Test	Test Method	Requirements
Sampling Aggregate	ASTM D 75	-
Sieve Analysis	ASTM C 136 and C 117	Table 200.03.04-I
Resistance to Wear (percent)	ASTM C 131 ⁽¹⁾	37 Maximum

1. 500 Revolutions

200.03.05 CLASS D BACKFILL. Class D backfill shall conform to the requirements of Tables 200.03.05-I and 200.03.05-II. The material need not be washed but shall be free of any organic impurities, clay lumps or unstable substances.

TABLE 200.03.05-I

Sieve Size	Percentage by Weight Passing Sieve
2 inch	100
1-1/2 inch	90 – 100
3/4 inch	0 – 15

TABLE 200.03.05-II

Test	Test Method	Requirements
Sampling Aggregate	ASTM D 75	-
Sieve Analysis	ASTM C 136 and C 117	Table 200.03.05-I
Resistance to Wear (percent)	ASTM C 535 ⁽¹⁾	37 Maximum

1. 500 Revolutions

200.03.06 CLASS E BACKFILL. Class E Backfill shall conform to the requirements of Tables 200.03.06-I and 200.03.06-II. The material shall be free of any organic matter.

TABLE 200.03.06-I

Sieve Size	Percentage by Weight Passing Sieve
4 inch	100
3/4 inch	70 – 100
No. 40	10 – 50
No. 200	0 – 35

TABLE 200.03.06-II

Test	Test Method	Requirements
Sampling Aggregate	ASTM D 75	-
Sieve Analysis	ASTM C 136 and C 117	Table 200.03.06-I
Liquid Limit	ASTM D 4318 ⁽¹⁾	40 Maximum
Plasticity Index	ASTM D 4318 ⁽¹⁾	12 Maximum

1. Dry Method

200.03.07 SLURRY BACKFILL. Aggregates for slurry backfill shall conform to the requirements of Tables 200.03.07-I and 200.03.07-II. Mineral materials selected for slurry backfill shall be either commercial quality concrete sand, excavation material, approved imported material, or a combination thereof, which is free of clay, organic material and other deleterious substances.

TABLE 200.03.07-I

Sieve Size	Percentage by Weight Passing Sieve	
	Size No. 8	Size No. 89
1-1/2 inch	100	
1 inch	80 – 100	
3/4 inch	60 – 100	
3/8 inch	50 – 100	
No. 4	40 – 100	
No. 100	2 – 40	
No. 200	0 – 15	

TABLE 200.03.07-II

Test	Test Method	Requirements
Sampling Aggregate	ASTM D 75	-
Sieve Analysis	ASTM C 136 and C 117	Table 200.03.07-I
Plasticity Index	ASTM D 4318 ⁽¹⁾	Non-Plastic

1. Dry Method

200.04 AGGREGATES FOR MORTAR AND GROUT.

200.04.01 DESCRIPTION. This specification covers quality and size of aggregates used in mortar and grout.

200.04.02 MORTAR SAND. Mortar sand shall conform to the requirements of ASTM C 144.

200.04.03 COARSE AGGREGATE FOR GROUT. Coarse aggregate for grout shall conform to the applicable requirements of Tables 200.04.03-I and 200.04.03-II. The *Contractor* may elect to utilize Size No. 8 or No.89.

TABLE 200.04.03-I

Sieve Size	Percentage by Weight Passing Sieve	
	Size No. 8	Size No. 89
1/2 inch	100	100
3/8 inch	85 – 100	90 – 100
No. 4	10 – 30	20 – 55
No. 8	0 – 10	5 – 30
No. 16	0 – 5	0 – 10
No. 30		0 – 5

TABLE 200.04.03-II

Test	Test Method	Requirements
Sampling Aggregate	ASTM D 75	-
Sieve Analysis	ASTM C 136 and C 117	Table 200.04.03-I
Soundness (percent loss) Coarse Aggregate	ASTM C 88 ⁽¹⁾	12 Maximum

1. 5 Cycles, Sodium Sulfate

200.05 AGGREGATES FOR GENERAL STRUCTURAL USE PORTLAND CEMENT CONCRETE.

200.05.01 DESCRIPTION. This Specification covers the quality and size of mineral materials for use in Portland cement concrete for general structural uses not covered in Subsection 200.06.

200.05.02 QUALITY REQUIREMENTS. Aggregates for Portland cement concrete shall conform to ASTM C 33 for normal weight aggregate or ASTM C 330 for lightweight aggregate.

200.05.03 COARSE AGGREGATES. Coarse aggregates for Portland cement concrete shall conform to the applicable requirements of Tables 200.05.03-I and 200.05.03-II.

TABLE 200.05.03-I

Sieve Size	Percentage Passing by Weight Passing Sieve				
	Size No. 4 (1-½" to ¾")	Size No. 7 (½" to No. 4)	Size No. 57 (1" to No. 4)	Size No. 67 (¾" to No. 4)	Size No. 467 (1-½" to No. 4)
2 inch	100				100
1-1/2 inch	90 – 100		100		95 - 100
1 inch	20 – 55		95 – 100	100	
¾ inch	0 – 15	100		90 - 100	35 - 70
½ inch		90 - 100	25 – 60		
¾ inch	0 – 5	40 - 70		20 - 55	10 - 30
No. 4		0 - 15	0 – 10	0 - 10	0 - 5
No. 8		0 - 5	0 – 5	0 - 5	
No. 200	0 – 1.0	0 – 1.0	0 – 1.0	0 – 1.0	0 – 1.0

Note: Size No. 467 shall be split into two sizes and furnished in individual stockpiles or bunkers of Size No. 4 and Size No. 67. The combined grading shall comply with the grading requirements of Size No. 467.

TABLE 200.05.03-II

Test	Test Method	Requirements
Sampling Aggregate	ASTM D 75	-
Sieve Analysis	ASTM C 136 and C 117	Table 200.05.03-I
Resistance to Wear (percent)	ASTM C 131 ⁽¹⁾	50 Maximum
Soundness (percent loss)	ASTM C 88 ⁽²⁾	12 Maximum
Soundness (percent loss)	ASTM C 88 ⁽³⁾	18 Maximum
Clay Lumps and Friable Particles	ASTM C 142	5 Maximum
Cleanness Value	NEV T228	75 Minimum
Potential Reactivity		ASTM C 33, Appendix

1. 500 Revolutions
2. 5 Cycles, Sodium Sulfate
3. 5 Cycles, Magnesium Sulfate

200.05.04 FINE AGGREGATES. Fine aggregates for Portland cement concrete shall conform to the requirements of Tables 200.05.04-I and 200.05.04-II.

TABLE 200.05.04-I

Sieve Size	Percentage by Weight Passing Sieve
3/8 inch	100
No. 4	95 – 100
No. 8	80 – 100
No. 16	50 – 85
No. 30	25 – 60
No. 50	5 – 30
No. 100	0 – 10

TABLE 200.05.04-II

Test	Test Method	Requirements
Sampling Aggregate	ASTM D 75	-
Sieve Analysis	ASTM C 136	Table 200.05.04-I
Material Passing No. 200 Sieve (percent)	ASTM C 117	
Concrete subject to abrasion		3.0 Maximum
All other concrete		5.0 Maximum
Soundness (percent loss)	ASTM C 88 ⁽¹⁾	10 Maximum
Soundness (percent loss)	ASTM C 88 ⁽²⁾	15 Maximum
Clay Lumps and Friable Particles (percent)	ASTM C 142	3 Maximum
Fineness Modulus	ASTM C 125	2.3 – 3.1
Organic Impurities	ASTM C 40	Less Than Plate 3
Sand Equivalent	ASTM D 2419	71 Minimum
Potential Reactivity		ASTM C 33, Appendix

- 1. 5 Cycles, Sodium Sulfate
- 2. 5 Cycles, Magnesium Sulfate

200.06 AGGREGATES FOR SPECIFIC USE PORTLAND CEMENT CONCRETE.

200.06.01 AGGREGATES FOR PORTLAND CEMENT CONCRETE ROADWAY PAVING. Aggregates for Portland cement concrete roadway paving shall be a blend of coarse and fine aggregates conforming to the applicable requirements of Tables 200.05.03-II and 200.05.04-II, proportioned to conform to the requirements of Tables 200.06.01-I and 200.06.01-II.

TABLE 200.06.01-I

Sieve Size	Percentage by Weight Passing Sieve
2 inch	100
1-1/2 inch	90 – 100
1 inch	50 – 86
3/4 inch	45 – 75
3/8 inch	38 – 55
No. 4	30 – 45
No. 8	23 – 38
No. 16	15 – 33
No. 30	8 – 22
No. 50	4 – 13
No. 100	1 – 5
No. 200	0 – 3

200.06.01 Aggregates for Portland Cement Concrete Roadway Paving Continued

TABLE 200.06.01-II

Test	Test Method	Requirements
Sampling Aggregate	ASTM D 75	-
Sieve Analysis	ASTM C 136 and C 117	Table 200.05.05-I
Cleanness Value	NEV T228	75 Minimum

200.06.02 AGGREGATES FOR GUNITE. Aggregates used for gunite shall conform to the quality requirements of *ASTM C33* or *ASTM C330*, as applicable, the combined grading requirements of *ASTM C1436* and the grading requirements of Tables 200.06.02-I and 200.06.02-II.

TABLE 200.06.02-I

Sieve Size	Percentage by Weight Passing Sieve	
	Gradation No. 1	Gradation No. 2
1/2 inch		100
3/8 inch	100	90 – 100
No. 4	95 – 100	70 – 85
No. 8	80 – 100	50 – 70
No. 16	50 – 85	35 – 55
No. 30	25 – 60	20 – 35
No. 50	10 – 30	8 – 20
No. 100	2 – 10	2 – 10

TABLE 200.06.02-II

Test	Test Method	Requirements
Sampling Aggregate	ASTMD75	-
Sieve Analysis	ASTMC136 and C117	Table 200.06.01-I

200.06.03 AGGREGATES FOR SHOTCRETE. Aggregates used for shotcrete shall conform to the quality requirements of *ASTM C 33* and the grading requirements of Tables 200.06.03-I and 200.06.03-II.

TABLE 200.06.03-I

Sieve Size	Percentage by Weight Passing Sieve		
	Gradation No. 1	Gradation No. 3	Gradation No. 3
3/4 inch			100
1/2 inch		100	80 – 95
3/8 inch	100	90 – 100	70 – 90
No. 4	95 – 100	70 – 85	50 – 70
No. 8	80 – 100	50 – 70	35 – 55
No. 16	50 – 85	35 – 55	20 – 40
No. 30	25 – 60	20 – 35	10 – 30
No. 50	10 – 30	8 – 20	5 – 17
No. 100	2 – 10	2 – 10	2 – 10

200.06.03 Aggregates for Shotcrete Continued

TABLE 200.06.03-II

Test	Test Method	Requirements
Sampling Aggregate	ASTM D 75	-
Sieve Analysis	ASTM C 136 and C 117	Table 200.06.03-I

200.07 RIPRAP.

200.07.01 DESCRIPTION. This Subsection covers the quality and size of mineral materials used for riprap.

200.07.02 GENERAL. Stone for riprap shall be angular fractured stone or rounded cobblestone, except that cobblestone shall not be used on slopes steeper than 1 vertical to 2 horizontal or, unless directed by the *Engineer*, where exposed to hydraulic conditions. Stone shall be of such shape to form a stable protection structure for the required section. Flat or elongated shapes will not be accepted unless the thickness of the individual pieces is at least 1/3 of the length.

Stones shall be sound, durable, hard, resistant to abrasion and free from laminations, weak cleavage planes, and the undesirable effects of weathering. It shall be of such character that it will not disintegrate from the action of air, water, or the conditions experienced during handling and placing. All material shall be clean and free from deleterious impurities, including alkali, earth, clay, refuse, and adherent coatings.

Unless otherwise directed or approved by the *Engineer*, for application greater than 200 tons, design parameters, including filter, foundation, and gradation with supporting calculations by a *Professional Engineer*, shall be submitted to the *Engineer* for review at least 30 *Calendar Days* prior to application.

207.07.02.01 Visual Evaluation. Visual evaluation of the source, suitable tests and service records may be used to determine the acceptability of the stone. The *Contractor* shall notify the *Engineer* in writing at least 30 *Calendar Days* prior to use.

200.07.03 LOOSE RIPRAP AND RIPRAP BEDDING GRADING AND QUALITY REQUIREMENTS BY SIZE. Loose stone for riprap designated by size shall conform to the requirements of Tables 200.07.03-I and 200.07.03-II.

TABLE 200.07.03-I

% by Size Passing	Class 150 Bedding	Size (Inches)					
		Class 150/Class 300/400 Bedding	Class 300/Class 550/700 Bedding	Class 400/Class 900 Bedding	Class 550	Class 700	Class 900
100	4	10	20	30	40	48	60
70 – 85		9	18	27	36	45	54
30 – 50	1	6	12	18	24	30	36
5 – 15	¾	2	5	7	12	18	24
0 - 5	#4	1	2	3	6	8	12
D ₅₀ ⁽¹⁾		6	12	16	22	28	35

1. Mean Stone Size

200.07 Riprap (Continued)

TABLE 200.07.03-II

Test	Test Method	Requirements
Resistance to Degradation (%)	ASTM C131 or C535 ⁽¹⁾⁽³⁾	45 Maximum
Absorption (%)	ASTM C127 ⁽³⁾	4 Maximum
Apparent Specific Gravity	ASTM C127 ⁽³⁾	2.5 Minimum ⁽²⁾
Durability	ASTM D3744 ⁽³⁾	52 Minimum

1. 500 Revolutions

2. Riprap with a specific gravity of less than 2.5 may be provided for use outside of channels and major drainage facilities if approved by the *Agency* or *Engineer*.

3. Tests performed on a processed sample of the parent rock.

200.07.04 SLOPE PROTECTION.

200.07.04.01 Color Requirements. Unless otherwise directed or approved by the *Agency*, stone for riprap used for slope protection shall have an earth tone which blends with the surrounding environment. Staining shall be used only with approval of the *Agency*. The *Contractor* shall submit representative samples from source to the *Agency* at least 30 *Calendar Days* prior to use for determination of acceptability of the color.

200.08 TOPSOIL.

200.08.01 DESCRIPTION. This Specification covers the quality and size of materials used for turf and wildflower establishment, sodding or planting.

200.08.02 GENERAL. Topsoil shall be free of refuse, constituents toxic or otherwise deleterious to plant growth, woody vegetation, stumps or roots, brush, stones, and clay lumps. Sod and herbaceous growth such as grass need not be removed, but shall be thoroughly broken up and mixed with the soil.

200.08.03 GRADING AND QUALITY REQUIREMENTS. Unless specifically stated otherwise in the contract documents, topsoil shall conform to the requirements of Tables 200.08.03-I and 200.08.03-II.

TABLE 200.08.03-I

Sieve Size	Percentage by Weight Passing Sieve
1 inch	100
3/8 inch	85 - 100
No. 8	50 - 80
No. 200	0 - 20

TABLE 200.08.03-II

Test	Test Method	Requirements
Sampling Aggregate	ASTM D 75	-
Sieve Analysis	ASTM C 136 and C 117	Table 200.08.03-I
Organic Content	AASHTO T 194	2 - 20
PH	ASTM E 70	5.5 - 7.4

201.01 GENERAL.

201.01.01 DESCRIPTION. This specification covers the quality of asphalt cement, liquid asphalt, and emulsified asphalt.

201.01.02 CERTIFICATE OF COMPLIANCE. A certificate of compliance shall be provided with each load of bituminous material. The certificate shall include, or have attached, results for all applicable tests and the date on which the tests were performed. All tests associated with certificates of compliance shall be performed by a laboratory accredited by AASHTO or other ASTM recognized accrediting organization. The date of each test performed shall be no more than 30 calendar days prior to the date of shipment.

201.01.03 MATERIAL SAFETY DATA SHEET. A Material Safety Data Sheet shall be available for all bituminous materials.

201.02 ASPHALT CEMENTS. These specifications cover viscosity grades: AC-2.5, AC-5, AC-10, AC-20, AC-20P, AC-30, and AC-40 and performance grades PG 64-22, PG 64-28NV, PG 58-34NV, PG 64-28NVTR, and PG 70-22TR. Viscosity grades shall conform to the applicable requirements of Tables 201.02-I and 201.02-II. Performance grades shall conform to the applicable requirements of Tables 201.02-III through 201.02-V. Performance grades containing tire rubber shall conform to the applicable requirements of Tables 202.02-VI and 202.02-VII.

Asphalt cement shall be prepared by the distillation of crude petroleum. The asphalt shall be homogeneous, free from water, and shall not foam when heated to 347 degrees Fahrenheit. Polymer modified asphalts shall be blended at the source of supply (refinery or terminal) and delivered as a finished mixture to the contractors hot plant asphalt storage tank. If asphalt is pumped directly from a tanker truck into the contractors hot mix plant, no in-line blending of polymer will be allowed.

201.03 LIQUID ASPHALTS. These specifications cover medium and slow curing liquid asphalts. Medium curing liquid asphalt are designated by the letters MC and shall conform to the requirements of Table 202.03-I. Slow curing liquid asphalts are designated by the letters SC and shall conform to the requirements of Table 202.03-II.

Liquid asphalts shall be produced by fluxing or blending an asphalt base with suitable petroleum distillates.

201.04 EMULSIFIED ASPHALTS. These specifications cover cationic, anionic and latex modified emulsified asphalts. Emulsified asphalts shall conform to the requirements of Tables 201.04-I, 201.04-II, or 201.04-III for cationic, anionic, or latex modified emulsified asphalts, respectively.

Emulsified Asphalts shall consist of a paving grade asphalt blended with water and a suitable emulsifying agent.

201.05 EMULSIFIED REJUVENATING AGENTS. This specification covers emulsified rejuvenating agents which shall conform to the requirements of Table 201.05-I.

Emulsified Rejuvenating agents shall consist of a paving grade asphalt blended with water and suitable emulsifying and rejuvenating agents.

201.06 RECYCLING AGENTS. This specification covers recycling agents which shall conform to the requirements of Table 201.06-I.

201.07 HOT-APPLIED CRACK FILLER. This specification covers hot-applied crack filler which shall conform to ASTM D 5078.

BITUMINOUS MATERIALS

201.00-2

TABLE 201.02-I
Specifications for Asphalt Cement Graded by Viscosity at 140° Fahrenheit (°F)

Test	Test Method	Requirements						Allowable Tolerance ⁽¹⁾
		AC-2.5	AC-5	AC-10	AC-20	AC-30	AC-40	
Tests on Original Asphalt Cement								
Viscosity @140° F, 300±0.5mm Hg (P)	AASHTO T202	200-300	400-600	800-1200	1600-2400	2400-3600	3200-4800	7 Percent
Kinematic Viscosity @275°F (cSt)	AASHTO T201	125 Min.	175 Min.	250 Min.	300 Min.	350 Min.	400 Min.	2 Percent
Penetration @77°F, 100g, 5 sec (dmm)	AASHTO T49	220 Min.	140 Min.	80 Min.	60 Min.	50 Min.	40 Min.	3 Percent
Flash Point using Cleveland Open Cup (°F)	AASHTO T48	325 Min.	350 Min.	425 Min.	450 Min.	450 Min.	450 Min.	15°F
Solubility in Trichloroethylene (%)	AASHTO T44	99.0 Min.	99.0 Min.	99.0 Min.	99.0 Min.	99.0 Min.	99.0 Min.	0.10
Ductility @39.2°F, 1 cm/min (cm)	AASHTO T51	50 Min.	25 Min.	15 Min.	5 Min.			None
Sieve Test (%)	NEV T730	Pass	Pass	Pass	Pass	Pass	Pass	None
Tests on Residue from Rolling Thin Film Oven (AASHTO T240)								
Viscosity @140° F, 300±0.5mm Hg (P)	AASHTO T202	1000 Max.	2000 Max.	4000 Max.	8000 Max.	12000 Max.	16000 Max.	7 Percent
Average Mass Change (%)	AASHTO T240		1.0 Max.	0.5 Max.	0.5 Max.	0.5 Max.	0.5 Max.	None

1. When tolerances are expressed in terms of percent, the allowable deviation is calculated as the indicated percentage at the upper or lower specification limit, whichever is applicable.

TABLE 201.02-II
Specification for Polymerized Asphalt Cement Graded by Viscosity at 140° Fahrenheit (°F)

Test	Test Method	Requirements	Allowable Tolerance⁽¹⁾
		AC-20P	
Tests on Original Asphalt Cement			
Viscosity @140° F, 300±0.5mm Hg (P)	NEV T727	2100 Minimum	12 Percent
Kinematic Viscosity @275°F (cSt)	NEV T729	475-3000	2 Percent
Flash Point using Cleveland Open Cup (°C)	AASHTO T48	450 Minimum	15°F
Ductility @39.2°F, 5 cm/min (cm)	NEV T746	50 Minimum	None
Toughness @77°F (inch-lbs)	NEV T745	110 Minimum	None
Tenacity @77°F (inch-lbs)	NEV T745	75 Minimum	None
Sieve Test (%)	NEV T730	Pass	None
Tests on Residue from Rolling Thin Film Oven (AASHTO T240)			
Viscosity @ 140° F, 300±0.5mm Hg (P)	NEV T727	3000 Minimum	12 Percent
Ductility @39.2°F, 5 cm/min (cm)	NEV T746	25 Minimum	None
Average Mass Change (%)	AASHTO T240	0.5 Maximum	None

1. When tolerances are expressed in terms of percent, the allowable deviation is calculated as the indicated percentage at the upper or lower specification limit, whichever is applicable.
2. AC20-P shall be blended at the source of supply and delivered as a completed mixture to the job site. AC20-P shall not be transported by railroad car.

BITUMINOUS MATERIALS

201.00-4

TABLE 201.02-III
Specifications for Performance Graded Asphalt Cement

Test	Test Method	Requirements	Limit with Tolerance	Rejection Limit
		PG 64-22		
Tests on Original Asphalt Cement				
Rotational Viscosity @135° C (Pa.s)	AASHTO T316	3.00 Maximum	3.21 Maximum	3.50 Maximum
Flash Point using Cleveland Open Cup (°C)	AASHTO T48	230 Minimum	222 Minimum	163 Minimum
Dynamic Shear, G*/sinδ @64° C, 10 rads/sec (kPa)	AASHTO T315	1.00 Minimum	0.90 Minimum	0.75 Minimum
Solubility (%)	AASHTO T44	99.0 Minimum	98.9	98.6
Tests on Residue from Rolling Thin Film Oven (NEV T728))				
Dynamic Shear, G*/sinδ @64° C, 10 rads/sec (kPa)	AASHTO T315	2.20 Minimum	1.98 Minimum	1.65 Minimum
Average Mass Change (%)	NEV T728	1.00 Maximum	1.00 Maximum	1.01 Maximum
Tests on Residue from Pressure Aging Vessel @100° C (AASHTO R28)				
Dynamic Shear, G* sinδ @25° C, 10 rads/sec (kPa)	AASHTO T315	5000 Maximum	5500 Maximum	6250 Maximum
Flexural Creep Stiffness	AASHTO T313			
Stiffness Modulus, S @ -12° C, 60 sec (MPa)	AASHTO T313	300 Maximum	330 Maximum	375 Maximum
m-value @ -12° C, 60 sec	AASHTO T313	0.300 Minimum	0.290 Minimum	0.245 Minimum

BITUMINOUS MATERIALS

201.00-5

TABLE 201.02-IV
Specifications for Polymerized Performance Graded Asphalt Cement

Test	Test Method	Requirements	Limit with Tolerance	Rejection Limit
		PG 64-28NV		
Tests on Original Asphalt Cement				
Rotational Viscosity @135° C (Pa.s)	AASHTO T316	3.00 Maximum	3.21 Maximum	3.50 Maximum
Flash Point using Cleveland Open Cup (°C)	AASHTO T48	230 Minimum	222 Minimum	163 Minimum
Ductility @4° C, 5 cm/min (cm)	NEV T746	50 Minimum	50 Minimum	29 Minimum
Toughness @25° C (inch-lbs)	NEV T745	110 Minimum	110 Minimum	57 Minimum
Tenacity @25° C (inch-lbs)	NEV T745	75 Minimum	75 Minimum	22 Minimum
Sieve Test (Particulates Retained)	NEV T730	0	1	10
Dynamic Shear, G*/sinδ @64° C, 10 rads/sec (kPa)	AASHTO T315	1.00 Minimum	0.90 Minimum	0.75 Minimum
Tests on Residue from Rolling Thin Film Oven (NEV T728)				
Ductility @4° C, 5 cm/min (cm)	NEV T746	25 Minimum	25 Minimum	4 Minimum
Dynamic Shear, G*/sinδ @64° C, 10 rads/sec (kPa)	AASHTO T315	2.20 Minimum	1.98 Minimum	1.65 Minimum
Average Mass Change (%)	NEV T728	1.00 Maximum	1.00 Maximum	1.01 Maximum
Tests on Residue from Pressure Aging Vessel @100° C (AASHTO R28)				
Dynamic Shear, G*/sinδ @22° C, 10 rads/sec (kPa)	AASHTO T315	5000 Maximum	5500 Maximum	6250 Maximum
Flexural Creep Stiffness	AASHTO T313			
Stiffness Modulus, S @ -18° C, 60 sec (MPa)	AASHTO T313	300 Maximum	330 Maximum	375 Maximum
m-value @ -18° C, 60 sec	AASHTO T313	0.300 Minimum	0.290 Minimum	0.245 Minimum

1. PG 64-28NV shall be blended at the source of supply and delivered as a completed mixture to the job site. PG 64-28NV shall not be transported by railroad car.

BITUMINOUS MATERIALS

201.00-6

TABLE 201.02-V
Specifications for Polymerized Performance Graded Asphalt Cement

Test	Test Method	Requirements	Limit with Tolerance	Rejection Limit
		PG 58-34NV		
Tests on Original Asphalt Cement				
Rotational Viscosity @135° C (Pa.s)	AASHTO T316	3.00 Maximum	3.21 Maximum	3.50 Maximum
Flash Point using Cleveland Open Cup (°C)	AASHTO T48	230 Minimum	222 Minimum	163 Minimum
Ductility @4° C, 5 cm/min (cm)	NEV T746	50 Minimum	50 Minimum	29 Minimum
Penetration @25° C,100 g, 5 sec	AASHTO T49	150 Minimum	150 Minimum	129 Minimum
Sieve Test (Particulates Retained)	NEV T730	0	1	10
Dynamic Shear, G*/sinδ @64° C, 10 rads/sec (kPa)	AASHTO T315	1.00 Minimum	0.90 Minimum	0.75 Minimum
Tests on Residue from Rolling Thin Film Oven (NEV T728)				
Ductility @4° C, 5 cm/min (cm)	NEV T746	25 Minimum	25 Minimum	4 Minimum
Dynamic Shear, G*/sinδ @64° C, 10 rads/sec (kPa)	AASHTO T315	2.20 Minimum	1.98 Minimum	1.65 Minimum
Average Mass Change (%)	NEV T728	1.00 Maximum	1.00 Maximum	1.01 Maximum
Elastic Recovery @ 25° C (%)	AASHTO T301	70 Minimum	70 Minimum	49 Minimum
Tests on Residue from Pressure Aging Vessel @100° C (AASHTO R28)				
Dynamic Shear, G* <i>sinδ</i> @22° C, 10 rads/sec (kPa)	AASHTO T315	5000 Maximum	5500 Maximum	6250 Maximum
Flexural Creep Stiffness	AASHTO T313			
Stiffness Modulus, S @ -18° C, 60 sec (MPa)	AASHTO T313	300 Maximum	330 Maximum	375 Maximum
m-value @ -18° C, 60 sec	AASHTO T313	0.300 Minimum	0.290 Minimum	0.245 Minimum

1. PG 58-34NV shall be blended at the source of supply and delivered as a completed mixture to the job site. PG 58-34NV shall not be transported by railroad car.

TABLE 201.02-VI
Specifications for Polymerized Performance Graded Asphalt Cement with Tire Rubber

Test	Test Method	Requirements	Limit with Tolerance	Rejection Limit
		PG 64-28NVTR		
Tests on Original Asphalt Cement				
Rotational Viscosity @135° C (Pa.s)	AASHTO T316	3.00 Maximum	3.21 Maximum	3.50 Maximum
Flash Point using Cleveland Open Cup (°C)	AASHTO T48	230 Minimum	222 Minimum	163 Minimum
Ductility @4° C, 5 cm/min (cm)	NEV T746	40 Minimum	40 Minimum	19 Minimum
Toughness @25° C (inch-lbs)	NEV T745	110 Minimum	110 Minimum	57 Minimum
Tenacity @25° C (inch-lbs)	NEV T745	75 Minimum	75 Minimum	22 Minimum
Sieve Test (Particulates Retained)	NEV T730	0	1	10
Dynamic Shear, G*/sinδ @64° C, 10 rads/sec (kPa)	AASHTO T315	1.00 Minimum	0.90 Minimum	0.75 Minimum
Solubility (%)	AASHTO T44	97.5 Minimum	97.4 Minimum	97.1 Minimum
Rubber Content (% by Weight)	Note 1	10 Minimum	-	-
Tests on Residue from Rolling Thin Film Oven (NEV T728)				
Ductility @4° C, 5 cm/min (cm)	NEV T746	20 Minimum	20 Minimum	0 Minimum
Dynamic Shear, G*/sinδ @64° C, 10 rads/sec (kPa)	AASHTO T315	2.20 Minimum	1.98 Minimum	1.65 Minimum
Average Mass Change (%)	NEV T728	1.00 Maximum	1.00 Maximum	1.01 Maximum
Tests on Residue from Pressure Aging Vessel @100° C (AASHTO R28)				
Dynamic Shear, G*/sinδ @22° C, 10 rads/sec (kPa)	AASHTO T315	5000 Maximum	5500 Maximum	6250 Maximum
Flexural Creep Stiffness	AASHTO T313			
Stiffness Modulus, S @ -18° C, 60 sec (MPa)	AASHTO T313	300 Maximum	330 Maximum	375 Maximum
m-value @ -18° C, 60 sec	AASHTO T313	0.300 Minimum	0.290 Minimum	0.245 Minimum

1. Certificates of compliance provided for the material shall document that the minimum rubber content is present.
2. PG 64-28NVTR shall be blended at the source of supply and delivered as a completed mixture to the job site. PG 64-28NVTR shall not be transported by railroad car.

TABLE 201.02-VII
Specifications for Performance Graded Asphalt Cement with Tire Rubber

Test	Test Method	Requirements	Limit with Tolerance	Rejection Limit
		PG 70-22TR		
Tests on Original Asphalt Cement				
Rotational Viscosity @135° C (Pa.s)	AASHTO T316	3.00 Maximum	3.21 Maximum	3.50 Maximum
Flash Point using Cleveland Open Cup (°C)	AASHTO T48	230 Minimum	222 Minimum	163 Minimum
Dynamic Shear, G*/sinδ @70° C, 10 rads/sec (kPa)	AASHTO T315	1.00 Minimum	0.90 Minimum	0.75 Minimum
Solubility (%)	AASHTO T44	97.5 Minimum	97.4 Minimum	97.1 Minimum
Rubber Content (% by Weight)	Note 1	10 Minimum	-	-
Elastic Recovery @ 25° C (%)	AASHTO T301	70 Minimum	70 Minimum	49 Minimum
Tests on Residue from Rolling Thin Film Oven (NEV T728)				
Ductility @4° C, 5 cm/min (cm)	NEV T746	20 Minimum	20 Minimum	0 Minimum
Dynamic Shear, G*/sinδ @70° C, 10 rads/sec (kPa)	AASHTO T315	2.20 Minimum	1.98 Minimum	1.65 Minimum
Average Mass Change (%)	NEV T728	1.00 Maximum	1.00 Maximum	1.01 Maximum
Tests on Residue from Pressure Aging Vessel @100° C (AASHTO R28)				
Dynamic Shear, G*/sinδ @28° C, 10 rads/sec (kPa)	AASHTO T315	5000 Maximum	5500 Maximum	6250 Maximum
Flexural Creep Stiffness	AASHTO T313			
Stiffness Modulus, S @ -12° C, 60 sec (MPa)	AASHTO T313	300 Maximum	330 Maximum	375 Maximum
m-value @ -12° C, 60 sec	AASHTO T313	0.300 Minimum	0.290 Minimum	0.245 Minimum

1. Certificates of compliance provided for the material shall document that the minimum rubber content is present.
2. PG 70-22TR shall be blended at the source of supply and delivered as a completed mixture to the job site. PG 70-22TR shall not be transported by railroad car.

BITUMINOUS MATERIALS

201.00-9

TABLE 201.03-I
Specifications for Medium Curing Liquid Asphalt

Test	Test Method	Requirements				Allowable Tolerance ⁽¹⁾
		MC-70	MC-250	MC-800	MC-3000	
Tests on Original Liquid Asphalt						
Kinematic Viscosity @140°F (cSt)	AASHTO T201	70-140	250-500	800-1600	3000-6000	1.5 to 8.9 Percent ⁽²⁾
Flash Point using Tag Open Cup (°F)	AASHTO T79	100 Minimum	150 Minimum	150 Minimum	150 Minimum	15° F
Water in Petroleum Products (%)	AASHTO T55	0.2 Maximum	0.2 Maximum	0.2 Maximum	0.2 Maximum	0.1
Distillation of Cut-Back Asphalt to 680° F (AASHTO T78)						
Percent of total distillate to 437° F to 500° F to 600° F	AASHTO T78	20 Maximum 20-60 65-90	10 Maximum 15-55 60-87	-- 35 Maximum 45-80	-- 15 Maximum 15-75	1.0 1.0 1.0
Volume (percent by difference)	AASHTO T78	55 Minimum	67 Minimum	75 Minimum	80 Minimum	1.0
Tests on Residue from Distillation (AASHTO T78)						
Viscosity @140° F, 300±0.5mm Hg (P)	AASHTO T202	300-1200	300-1200	300-1200	300-1200	7 Percent
Ductility @77°F, 5 cm/min (cm)	AASHTO T51	100 Minimum	100 Minimum	100 Minimum	100 Minimum	30 Percent
Solubility in Trichloroethylene (%)	AASHTO T44	99.0 Minimum	99.0 Minimum	99.0 Minimum	99.0 Minimum	0.1

1. When tolerances are expressed in terms of percent, the allowable deviation is calculated as the indicated percentage at the upper or lower specification limit, whichever is applicable.
2. Below 3000 = 1.5 Percent, 3000 to 6000 = 2.0 Percent, above 6000 = 8.9 Percent

BITUMINOUS MATERIALS

201.00-10

TABLE 201.03-II
Specifications for Slow Curing Liquid Asphalt

Test	Test Method	Requirements				Allowable Tolerance ⁽¹⁾
		SC-70	SC-250	SC-800	SC-3000	
Tests on Original Liquid Asphalt						
Kinematic Viscosity @140°F (cSt)	AASHTO T201	70-140	250-500	800-1600	3000-6000	1.5 to 8.9 Percent ⁽²⁾
Flash Point using Cleveland Open Cup (°F)	AASHTO T48	150 Minimum	175 Minimum	200 Minimum	225 Minimum	15° F
Water in Petroleum Products (%)	AASHTO T 55	0.5 Maximum	0.5 Maximum	0.5 Maximum	0.5 Maximum	0.1
Distillation of Cut-Back Asphalt to 680° F (AASHTO T78)						
Volume (%)	AASHTO T78	10-30	4-20	2-12	5 Maximum	1.0
Tests on Residue from Distillation (AASHTO T78)						
Kinematic Viscosity @140°F (cSt)	AASHTO T201	400-7000	800-10000	2000-16000	4000-35000	1.5 to 8.9 Percent ⁽²⁾
Ductility @77°F, 5 cm/min (cm)	AASHTO T51	100 Minimum	100 Minimum	100 Minimum	100 Minimum	30 Percent
Solubility in Trichloroethylene (%)	AASHTO T44	99.0 Minimum	99.0 Minimum	99.0 Minimum	99.0 Minimum	0.1

1. When tolerances are expressed in terms of percent, the allowable deviation is calculated as the indicated percentage at the upper or lower specification limit, whichever is applicable.
2. Below 3000 = 1.5 Percent, 3000 to 6000 = 2.0 Percent, above 6000 = 8.9 Percent

TABLE 201.04-I
Specifications for Cationic Emulsified Asphalt

Test	Test Method	Requirements								Allowable Tolerance ⁽¹⁾
		Quick Setting	Rapid Setting				Medium Setting		Slow Setting	
Test on Emulsion		CQS-1NV	CRS-1	CRS-2	CRS-2h	CMS-2	CMS-2h	CSS-1	CSS-1h	
Residue (% by mass)	AASHTO T59	57 Min.	60 Min.	65 Min.	65 Min.	65 Min.	65 Min.	57 Min.	57 Min.	1 Percent
Oil Distillate (% by volume of emulsion)	AASHTO T59		3 Max.	3 Max.	3 Max.	12 Max.	12 Max.			None
Particle Charge Test	AASHTO T59	Positive	Positive	Positive	Positive	Positive	Positive			None
Saybolt Furol Viscosity @77° F (sec)	AASHTO T59	20-100						20-100	20-100	None
Saybolt Furol Viscosity @122°F (sec)	AASHTO T59		20-100	150-450	150-450	50-450	50-450			None
Demulsibility (%)	AASHTO T59		40 Min.	40 Min.	40 Min.					5 Percent
Settlement @ 5 days (% difference) ⁽²⁾	AASHTO T59	5 Max.	5 Max.	5 Max.	5 Max.	5 Max.	5 Max.	5 Max.	5 Max.	5 Percent
Cement Mixing Test (%)	AASHTO T59	25 Min. ⁽³⁾						2 Max.	2 Max.	0.2
Sieve Test, Retained on No. 20 (%)	AASHTO T59	0.1 Max.	0.1 Max.	0.1 Max.	0.1 Max.	0.1 Max.	0.1 Max.	0.1 Max.	0.1 Max.	0.03
Storage Stability, 24hr (%)	AASHTO T59		1 Max.	1 Max.	1 Max.	1 Max.	1 Max.	1 Max.	1 Max.	0.5
Dry Aggregate Coating @ Job (%) ⁽⁴⁾	AASHTO T59					80 Min.	80 Min.			None
Wet Aggregate Coating @ Job (%) ⁽⁴⁾	AASHTO T59					60 Min.	60 Min.			None
PH	AASHTO T200							6.7 Max.	6.7 Max.	None
Tests on Residue from Distillation (AASHTO T59)										
Penetration @77° F, 100g, 5 sec (dmm)	AASHTO T49	40-90	100-250	100-250	40-90	100-250	40-90	100-250	40-90	7 Percent
Ductility @77° F, 5 cm/min (cm)	AASHTO T51	40 Min.	40 Min.	40 Min.	40 Min.	40 Min.	40 Min.	40 Min.	40 Min.	10 Percent
Solubility in Trichloroethylene (%)	AASHTO T44	97.5 Min.	97.5 Min.	97.5 Min.	97.5 Min.	97.5 Min.	97.5 Min.	97.5 Min.	97.5 Min.	0.1

1. When tolerances are expressed in terms of percent, the allowable deviation is calculated as the indicated percentage at the upper or lower specification limit, whichever is applicable.
2. The test requirement for settlement may be waived when the emulsified asphalt is used in less than 5 days; or the purchaser may require that the settlement test be run from the time the sample is received until it is used, if the elapsed time is less than 5 days.
3. If the amount of breakage is significant enough to impede the flow of water through the testing screen, thus making it impossible to calculate a result, the test will be considered passing.
4. Calcium carbonate shall not be added to the job aggregate when making samples for the aggregate coating water resistance test.

TABLE 201.04-II
Specifications for Anionic Emulsified Asphalt

Test	Test Method	Requirements					Allowable Tolerance ⁽¹⁾
		Rapid Setting		Medium Setting	Slow Setting		
Tests on Emulsion		RS-1	RS-2	MS-2	SS-1	SS-1h	
Residue by Distillation (% by mass)	AASHTO T59	55 Min.	63 Min.	65 Min.	57 Min.	57 Min.	1 Percent
Saybolt Furol Viscosity @77° F (sec)	AASHTO T59	20-100		100 Min.	20-100	20-100	None
Saybolt Furol Viscosity @122°F (sec)	AASHTO T59		150-450				None
Demulsibility (%)	AASHTO T59	60 Min.	60 Min.				5 Percent
Settlement @ 5 days (% difference) ⁽²⁾	AASHTO T59	3 Max.	3 Max.	3 Max.	3 Max.	3 Max.	5 Percent
Cement Mixing Test (%)	AASHTO T59				2 Max.	2 Max.	0.2
Storage Stability, 24hr, (%)	AASHTO T59	1 Max.	1 Max.	1 Max.	1 Max.	1 Max.	0.5
Sieve Test (Retained on No. 20, %)	AASHTO T59	0.1 Max.	0.1 Max.	0.1 Max.	0.1 Max.	0.1 Max.	0.03
Tests on Residue from Distillation (AASHTO T59)							
Penetration@77°F, 100g, 5 sec (dmm)	AASHTO T49	100-200	100-200	100-200	100-200	40-90	7 Percent
Ductility @77°F, 5 cm/min (cm)	AASHTO T51	40 Min.	40 Min.	40 Min.	40 Min.	40 Min.	10 Percent
Solubility in Trichloroethylene (%)	AASHTO T44	97.5 Min.	97.5 Min.	97.5 Min.	97.5 Min.	97.5 Min.	0.1

1. When tolerances are expressed in terms of percent, the allowable deviation is calculated as the indicated percentage at the upper or lower specification limit, whichever is applicable.
2. The test requirement for settlement may be waived when the emulsified asphalt is used in less than 5 days; or the purchaser may require that the settlement test be run from the time the sample is received until it is used, if the elapsed time is less than 5 days.

TABLE 201.04-III
Specifications for Latex Modified Emulsion

Test	Test Method	Requirements		Allowable Tolerance ⁽¹⁾
		LMCQS-1h	LMCRS-2h	
Tests on Emulsion				
Residue by Evaporation (% by mass)	NEV T756	60 Minimum	65 Minimum	1 Percent
Particle Charge	AASHTO T59	Positive	Positive	None
Saybolt Furol Viscosity @77° F (sec)	AASHTO T59	15 – 90		None
Saybolt Furol Viscosity @122°F (sec)	AASHTO T59		150-450	None
Demulsibility (%)	AASHTO T59		40 Minimum	5 Percent
Settlement @ 5 days (% difference) ⁽²⁾	AASHTO T59	5 Max.		5 Percent
Storage Stability, 24hr (%)	AASHTO T59	1 Max.	1 Max.	0.5
Sieve Test, Retained on No. 20 (%)	AASHTO T59		0.3 Max.	0.03
Tests on Residue by Evaporation				
Penetration @ 77°F, 100g, 5 sec (dmm)	AASHTO T49	40 – 90	40 – 90	7.0 Percent
Ductility @77°F, 5 cm/min (cm)	AASHTO T51	60 Minimum	40 Minimum	10 Percent
Solubility in Trichloroethylene (%)	AASHTO T44	97.5 Minimum		0.10
Torsional Recovery (%)	NEV T757	20 Minimum	18 Minimum	None
Ring & Ball Softening Point, (° F)	AASHTO T53	130 Minimum		None

1. When tolerances are expressed in terms of percent, the allowable deviation is calculated as the indicated percentage at the upper or lower specification limit, whichever is applicable.
2. The test requirement for settlement may be waived when the emulsified asphalt is used in less than 5 days; or the purchaser may require that the settlement test be run from the time the sample is received until it is used, if the elapsed time is less than 5 days.

TABLE 201.05-I
Specifications for Emulsified Rejuvenating Agent

Test	Test Method	Requirements	Allowable Tolerance ⁽¹⁾
Tests on Emulsion			
Residue by Distillation (% by mass)	AASHTO T59	57 Minimum	1.0
Particle Charge	AASHTO T59	Positive	None
pH	AASHTO T200	2 - 7	None
Saybolt Furol Viscosity @77° F (sec)	AASHTO T59	20-400	None
Settlement @5 days (% difference) ⁽²⁾	AASHTO T59	5.0 Maximum	5.0 percent
Sieve Test, Retained on No. 20 (%)	AASHTO T59	0.1 Maximum	0.03
Tests on Residue from Distillation (AASHTO T59)			
Kinematic Viscosity @275°F (cSt)	AASHTO T201	475 – 1500	2 percent
Flash Point using Cleveland Open Cup (°F)	AASHTO T48	450 Minimum	15° F
Solubility in Trichloroethylene (%)	AASHTO T44	97.5 Minimum	1.0
Specific Gravity	AASHTO T228	0.98 Minimum	None
n-Pentene Insoluble (%)	ASTM D2007	15 Minimum	None
Polar Compounds (%)	ASTM D2007	30 Minimum	None
Aromatics (%)	ASTM D2007	15 Minimum	None
Saturates (%)	ASTM D2007	10 Maximum	None

1. When tolerances are expressed in terms of percent, the allowable deviation is calculated as the indicated percentage at the upper or lower specification limit, whichever is applicable.
2. The test requirement for settlement may be waived when the emulsified asphalt is used in less than 5 days; or the purchaser may require that the settlement test be run from the time the sample is received until it is used, if the elapsed time is less than 5 days.

TABLE 201.06-I
Specifications for Recycling Agent

Test	Test Method	Requirements				
		RA-5	RA-25	RA-75	RA-250	RA-500
Tests on Original?						
Viscosity @140° F, 300±0.5mm Hg (P)	AASHTO T202	200 - 800	1000 - 4000	5000 - 10000	15000 - 35000	40000 – 60000
Flash Point using Cleveland Open Cup (°F)	AASHTO T48	400 Minimum	425 Minimum	450 Minimum	450 Minimum	450 Minimum
Saturates (% by weight)	ASTM D2007	30 Maximum	30 Maximum	30 Maximum	30 Maximum	30 Maximum
Tests on Residue from Rolling Thin Film Oven (AASHTO T240)						
Viscosity Ratio ⁽¹⁾		3 Maximum	3 Maximum	3 Maximum	3 Maximum	3 Maximum
Average Mass Change (%)	AASHTO T240	4 Maximum	3 Maximum	2 Maximum	2 Maximum	2 Maximum
Specific Gravity	AASHTO T227 or T228	Report	Report	Report	Report	Report

1. Viscosity Ratio = Viscosity of Residue @ 140° F (determined in accordance with AASHTO T240) divided by the Original Viscosity @140° F.

202.01 GENERAL.

202.01.01 DESCRIPTION. This section covers the quality of cementitious materials, admixtures, fibers, joint materials, bonding systems, curing materials, and other materials related to *PCC* and masonry construction.

202.01.02 SAFETY DATA SHEET (SDS). A *SDS* shall be available for all cementitious and related materials.

202.02 CEMENTITIOUS MATERIALS.

202.02.01 PORTLAND CEMENTS. This specification covers Type II, Type III and Type V, low alkali Portland cements. Type II, Type III and Type V, low alkali Portland cements shall conform to *ASTM C150*, including a 0.60 percent limitation on total alkalis expressed as ($\text{Na}_2\text{O} + 0.658 \text{K}_2\text{O}$) as determined in accordance with *ASTM C114*.

202.02.02 BLENDED HYDRAULIC CEMENT. This specification covers blended hydraulic cement, such as Type IL, Type IP, Type IS and Type IT, which shall conform to *ASTM C595*.

202.02.03 MASONRY CEMENTS. This specification covers Type I and Type II masonry cements which shall conform to *ASTM C91*.

202.02.04 PLASTIC (STUCCO) CEMENT. This specification covers plastic (stucco) cement which shall conform to *ASTM C1328*.

202.02.05 MORTAR CEMENT. This specification covers mortar cement which shall conform to *ASTM C1329*.

202.02.06 SUPPLEMENTAL CEMENTITIOUS MATERIALS (SCM).**202.02.06.01 Pozzolan.**

Raw or Calcined Natural Pozzolan for Use in Portland Cement Concrete. This specification covers raw or calcined natural pozzolan for use as a mineral admixture in concrete. Raw or calcined natural pozzolan shall conform to *ASTM C618*. The supplemental optional chemical and physical properties of Tables 1A and 2A contained in *ASTM C618* shall apply.

Coal Fly Ash for Use in Portland Cement Concrete. This specification covers coal fly ash for use as a mineral admixture in concrete. Coal fly ash shall conform to *ASTM C618*, Class F. The supplemental optional chemical and physical properties of Tables 1A and 2A contained in *ASTM C618* shall apply.

Silica Fume for Use in Cementitious Mixtures. This specification covers silica fume for use in cementitious mixtures which shall conform to *ASTM C1240*.

Slag Cement for Use in Portland Cement Concrete and Mortars. This specification covers slag cement for use in concrete and mortars which shall conform to *ASTM C989*, Grade 100 or 120.

202.02.06.02 Lime.

Hydrated Lime for Structural Purposes. This specification covers hydrated lime for structural purposes which shall conform to *ASTM C141*.

Quick Lime for Structural Purposes. This specification covers quick lime for structural purposes which shall conform to *ASTM C5*.

Hydrated Lime for Finishing Purposes. This specification covers Type N and Type S hydrated lime for finishing purposes which shall conform to *ASTM C206*.

Hydrated Lime for Masonry Purposes. This specification covers hydrated lime for masonry purposes which shall conform to *ASTM C207*.

Hydrated Lime for Soil Stabilization. This specification covers hydrated lime for soil stabilization which shall conform to *ASTM C977*.

Quick Lime for Soil Stabilization. This specification covers quick lime for soil stabilization which shall conform to *ASTM C977*.

202.01.07 RAPID HARDENING CEMENTITIOUS MATERIALS. This specification covers rapid hardening cementitious materials for Portland cement concrete repairs which shall conform to *ASTM C928* with less than - 0.07 percent length change in accordance with *ASTM C157*.

202.03 RELATED MATERIALS.

202.03.01 ADMIXTURES.

202.03.01.01 Chemical Admixtures.

Air-Entraining Admixtures for PCC. This specification covers air-entraining admixtures for *PCC* which shall conform to the requirements of *ASTM C260*.

Chemical Admixtures for Use in Producing Flowable Concrete (Plasticizers). This specification covers chemical admixtures for use in producing flowable concrete (plasticizers) which shall conform to *ASTM C1017*.

Admixtures for Guniting and Shotcrete. This specification covers admixtures for guniting and shotcrete which shall conform to *ASTM C1141*

Other Chemical Admixtures. This specification covers other chemical admixtures. These admixtures shall conform to *ASTM C494* and shall be clearly marked as Type A (Water-Reducing), Type B (Retarding), Type C (Accelerating), Type D (Water-Reducing and Retarding), Type E (Water-Reducing and Accelerating), Type F (Water-Reducing, High Range), Type G (Water-Reducing, High Range, and Retarding) or Type S (Specialty).

Pigment. This specification covers pigment used for integrally colored Portland cement concrete which shall conform to *ASTM C979*.

202.03.02 FIBERS.

202.03.02.01 Alkali-Resistant Glass Fibers. This specification covers alkali-resistant glass fibers which shall conform to *ASTM C1666*.

202.03.02.02 Cellulose Fibers. This specification covers cellulose fibers which shall conform to *ASTM C1116*.

202.03.02.03 Synthetic Fibers. This specification covers synthetic fibers which shall conform to *ASTM C1116*, Type III.

Microsynthetic Fibers.

Monofilament Fibers. This specification covers monofilament fibers which shall conform to *ASTM C1116/C1116M*, Type III and the requirements of *ICC-ES AC308* Section 3.1.1 (plastic shrinkage reinforcement).

Fibrillated Fibers. This specification covers fibrillated fibers which shall conform to *ASTM C1116/C1116M*, Type III and the requirements of *ICC-ES AC308* Section 3.1.1 (plastic shrinkage reinforcement) [and Section 3.1.2 (shrinkage and temperature reinforcement)].

Macrosynthetic Fibers. This specification covers macrosynthetic fibers which shall conform to *ASTM C1116/C1116M*, Type III and the requirements of Section 3.1.2 (shrinkage and temperature reinforcement).

202.03.02.04 Steel Fibers. This specification covers steel fibers which shall conform to *ASTM A820* and *ASTM C1116*.

202.03.03 JOINT MATERIALS.

202.03.03.01 Preformed Expansion Joint Filler.

General. All preformed expansion joint filler shall be punched and/or precut to admit dowels or other shapes as required through the material.

Preformed Expansion Joint Filler for PCC (Bituminous Type). This specification covers preformed expansion joint filler for PCC (Bituminous Type) which shall conform to ASTM D994.

Preformed Expansion Joint Filler for Paving and Structural PCC (Nonextruding and Resilient Bituminous Type). This specification covers preformed expansion joint filler for paving and structural PCC (Nonextruding and Resilient Bituminous Type) which shall conform to ASTM D1751.

Preformed Expansion Joint Filler for Paving and Structural PCC (Sponge Rubber Cork and Recycled PVC Type). This specification covers preformed expansion joint filler for paving and structural PCC (Sponge Rubber Cork and Recycled PVC type) which shall conform to ASTM D1752.

202.03.03.02 Hot Applied Joint Materials.

Hot Applied Joint and Crack Sealants for PCC and Bituminous Pavements. This specification covers hot applied joint and crack sealant for PCC and bituminous pavements which shall conform to ASTM D6690.

202.03.03.03 Cold Applied Joint Materials.

Cold Applied Silicone Joint Sealant for PCC Pavements. This specification covers cold applied silicone joint sealant for PCC pavement which shall conform to ASTM D5893.

202.03.03.04 Bridge Joints.

Preformed Polychloroprene Elastomeric Joint Seals for Bridges. This specification covers preformed polychloroprene elastomeric joint seals for bridges which shall conform to ASTM D3542.

Asphaltic Plug Joints for Bridges. This specification covers asphaltic plug joints for bridges which shall conform to ASTM D6297.

202.03.04 BONDING SYSTEMS. Epoxy-Resin-Base bonding systems shall be used to anchor dowels and tie bars in PCC.

202.03.04.01 Epoxy-Resin-Base Systems. This specification covers epoxy-resin-base systems which shall conform to ASTM C881, Types I, II, IV or V, as specified, Grade 3, Classes A, B, and C. The type and class shall be appropriate for the temperature conditions.

Class	Temperature
A	For use below 40°F surface temperature. The lowest allowable temperature to be defined by the manufacturer of the product.
B	For use between 40° and 60°F surface temperature
C	For use above 60°F. The highest allowable temperature to be defined by the manufacturer of the product.

202.03.05 CURING MATERIALS.

202.03.05.01 Absorptive Cover. This specification covers materials used as absorptive cover which shall conform to ACI 308.

202.03.05.02 Sheet Materials for Curing PCC. This specification covers sheet materials for curing PCC which shall conform to ASTM C171.

202.03.05.03 Liquid Membrane-Forming Compound for Sealing and Curing PCC. This specification covers liquid membrane-forming compounds for sealing and curing PCC which shall conform to ASTM C1315.

202.03.05.04 Liquid Membrane-Forming Compound for Curing PCC.

Interior Slabs-on-grade. This specification covers liquid membrane-forming compounds for curing PCC interior slabs-on-grade. Liquid membrane-forming compounds shall be non-dissipating and be certified by the manufacturer not to interfere with bonding of the floor coverings, if applicable, and conform to ASTM C309, Type 1, Class B (resin-base), with 18 to 25 percent solids.

Exterior Flatwork. This specification covers liquid membrane forming compounds for curing PCC exterior flatwork which shall be dissipating and conform to ASTM C309, Type 2, Class B.

PCCP. This specification covers liquid membrane forming compounds for curing PCC paving which shall conform to ASTM C309, Type 2, Class A (wax-base) or Class B (resin-base).

Colored PCC. This specification covers curing compounds for colored PCC. Curing compounds for colored PCC shall be non-yellowing; dissipating; compatible with the coloring agent; and conform to the requirements of ASTM C309 and the manufacturer of the coloring agent.

202.03.06 OTHER MATERIALS.

202.03.06.01 Non Shrink Grout. This specification covers packaged dry, hydraulic-cement (non shrink grout). Non shrink grout shall conform to ASTM C1107 and ASTM C939, without exhibiting signs of bleeding or segregation when used in applications requiring a fluid consistency.

202.03.06.02. Gunite and Shotcrete.

Materials for Gunite and Shotcrete. This specification covers materials for gunite and shotcrete. Materials for gunite and shotcrete shall conform to ASTM C1436.

202.03.06.03 Masonry

PCC Building Brick. This specification covers PCC building brick to be utilized in masonry construction which shall conform to the requirements of ASTM C55, Grade N or S, Type I or II. The linear change from saturated to cool shall not exceed 0.045 percent. Grade and type shall be as specified by the Engineer. Size, color, and texture shall be as specified on the Plans or as approved by the Engineer.

Solid Load Bearing PCC Masonry Units. This specification covers solid load bearing PCC masonry units to be utilized in masonry construction which shall conform to the requirements of ASTM C90, Grade N or S, Type I or II. The linear change from saturated to cool shall not exceed 0.045 percent. Grade and type shall be as specified by the Engineer. Size, color, and texture shall be as specified on the Plans or as approved by the Engineer.

Hollow Load Bearing PCC Masonry Units. This specification covers hollow load bearing PCC masonry units to be utilized in masonry construction which shall conform to the requirements of ASTM C90, Grade N or S, type I or II. The linear change from saturated to cool shall not exceed 0.045 percent. Grade and type shall be as specified by the Engineer. Size, color, and texture shall be as specified on the Plans or as approved by the Engineer. Concrete masonry units shall be subject to the following requirements:

Solid Load Bearing Clay Masonry Units. This specification covers solid load bearing clay masonry units to be utilized in masonry construction which shall conform to the requirements of ASTM C126. Grade and type shall be as specified by the Engineer. Size, color, and texture shall be as specified on the Plans or as approved by the Engineer.

Sand-Lime Brick. This specification covers sand-lime brick to be utilized in masonry construction. Sand-lime shall conform to the requirements of ASTM C73. Grade and type shall be as specified by the Engineer. Size, color, and texture shall be as specified on the Plans or as approved by the Engineer.

203.01 GENERAL.

203.01.01 DESCRIPTION. This Section covers the quality, manufacture, and fabrication of materials for pressure and non-pressure pipes, appurtenances, fittings and couplings, including hardware for the fittings and couplings, and the related materials used in new construction and rehabilitation.

This Section is for material specifications only and is not intended to be a “qualified products list” and is not intended to encourage or discourage the use of any product. This Section does not address the structural design, installation, and construction requirements that must be taken into account by the Agency or Design Engineer in order to ensure proper application of the individual products and achieve the expected performance of the resulting conveyance system.

The conveyance materials used for each project shall be as determined by the Agency and/or Design Engineer.

203.01.01.01 Definitions. Whenever the following terms are used in this Section, the intent and meaning shall be interpreted as follows:

203.01.01.01.01 Manufacture. Manufacture shall be defined as the mechanical production of the pipe length and/or fittings.

203.01.01.01.02 Fabrication. Fabrication shall be defined as plant alteration of the pipe length.

203.01.01.01.03 Joints.

203.01.01.01.03.01 Soil-Tight. Soil-tight joint shall be defined as a joint that is resistant to infiltration of particles larger than those retained on the No. 200 sieve. Soil-tight joints provide protection against infiltration of backfill material containing high percentage of coarse grain soils.

203.01.01.01.03.02 Silt-Tight. Silt-tight joint shall be defined as a joint that is resistant to infiltration of particles that are smaller than particles passing the No. 200 sieve. Silt-tight joints provide protection against infiltration of backfill material containing a high percentage of fines.

203.01.01.01.03.03 Leak-Resistant. Leak-resistant joint shall be defined as a joint which limits water leakage at a maximum rate of 200 gallons/inch-diameter/mile/day for the pipeline system for the head or pressure as shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.01.01.01.03.04 Watertight. Watertight joint shall be defined as a joint that provides zero leakage of water infiltration and exfiltration for the head or pressure application as shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.01.01.01.03.05 Special Design. Special Design joint shall be defined as a joint requiring special strength in bending or shear; special pull-apart capabilities; or unusual features, including, but not limited to, restrained joints placed on severe slopes, welded joints, or flanged and bolted joints for high pressures, high heads. Special design requirements shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.01.02 CERTIFICATE OF COMPLIANCE. A certificate of compliance with the applicable Specifications contained in this Section shall be provided with each material supplied. Unless waived by the Agency or Design Engineer, the certificate shall include, or have attached, results for all applicable tests and the date on which the tests were performed.

203.01.03 USE OF OTHER MATERIALS. Unless approved by the Agency or Design Engineer, the use of materials and/or fabrication methods other than those shown on the plans or specified in the Special Provisions and/or Special Technical Specifications will not be allowed. The approval shall be in writing; shall state that the Agency or Design Engineer has found the proposed substitution to be acceptable; shall list any necessary modifications to the Special Provisions and/or Special Technical Specifications; and shall be stamped and signed by a registered Professional Engineer licensed by the state of Nevada.

203.01.04 CARE OF PIPE AND MATERIALS. All pipe and related materials shall be manufactured, fabricated, handled, loaded, shipped, unloaded, and stored in such a manner as to be undamaged and in sound condition.

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PIPE AND RELATED MATERIALS

203.01.04.01 Storage.

203.01.04.01.01 Rubber Gaskets. Rubber gaskets shall be stored in a cool, dark place at all times until ready for use.

203.01.04.02 Repairs. This Subsection covers repairs to pipe damaged prior to delivery. Repair of the damaged pipe will be allowed provided the repaired pipe meets all requirements of this Subsection. Unless waived by the Agency or Design Engineer, damaged pipe shall be inspected after preparation for repair and again after repair has been made. Repairs made prior to inspection will be rejected. Unless waived by the Agency or Design Engineer, any repaired pipe shall be tested to demonstrate soundness.

203.02 CORRUGATED METAL PIPE (CMP).

203.02.01 DESCRIPTION. This Subsection covers pipe, pipe-arches, slotted pipe, and spiral rib pipe constructed from corrugated metal; and the related appurtenances, coupling bands and hardware for coupling bands, rivets, bolts and gaskets. Pipe covered by this Subsection is intended for use in drainage applications and other conveyance systems. Pipe covered by this Subsection is not normally used in pressure applications or for the conveyance of sanitary or industrial wastes.

203.02.01.01 Pipe-Arches. Pipe-arches shall consist of metal pipe, with the exception of spiral rib pipe, which has been reformed to a multi-centered pipe, having an arch shaped top with a slightly curved integral bottom. The resulting rise and span dimensions shall conform to the applicable requirements of ASTM, AASHTO and/or AISI standards.

203.02.01.02 Slotted Pipe. Slotted pipe shall be concrete form-type with grate heights of 2-½ or 6 inches, as shown on the plans or specified in the Special Provisions and/or Special Technical Specifications. Where specified, a heel guard shall be attached over the grate.

203.02.01.03 Spiral Rib Pipe. Spiral rib pipe shall consist of metal pipe with a box rib corrugation to provide for a "smooth" interior surface for improved hydraulics.

The material type, gage and/or thickness, nominal diameter and dimensions of the pipe, appurtenances and fittings to be furnished shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.02.01.04 Nominal Diameter. Nominal diameter is defined as the minimum inside diameter of the pipe.

203.02.01.04.01 Pipe-Arches. Nominal dimension (rise and span) for pipe arches shall be defined as the minimum inside dimensions at maximum span and maximum rise of the pipe arch.

203.02.02 IDENTIFICATION. Each section of pipe, appurtenances and fittings shall, at a minimum, be clearly marked such that the manufacturer, material type, gage and/or thickness, heat and/or lot number and all applicable AASHTO and ASTM designations can be readily identified.

203.02.02.01 Corrugated Aluminum Pipe and Pipe-Arches. Corrugated aluminum pipe and pipe-arches shall be clearly marked in accordance with ASTM B 745.

203.02.02.02 Corrugated Steel Pipe and Pipe-Arches. Corrugated steel pipe and pipe-arches shall be clearly marked in accordance with ASTM A 760.

203.02.02.03 Corrugated Aluminized Steel Type 2 Pipe and Pipe-Arches. Corrugated aluminized steel Type 2 pipe and pipe-arches shall be clearly marked in accordance with ASTM A 760.

203.02.03 MATERIALS.

203.02.03.01 Corrugated Aluminum Pipe and Pipe-Arches. Aluminum alloy sheets used in the fabrication of corrugated aluminum pipe and pipe-arches shall conform to ASTM B 744, except as modified by Subsection 203.02.03.01.01.

203.02.03.01.01 Mechanical Properties. The aluminum alloy sheet shall conform to the applicable requirements of Table 203.02.03.01.01-I.

TABLE 203.02.03.01.01-I

Test	Test Method	Requirements	
		Thickness (Inches)	
		0.051 to 0.113	0.114 to 0.249
Tensile Strength (psi)	ASTM B 744	31,000 Minimum	
Yield Strength, at 2 % Elongation (psi)	ASTM B 744	4,000 Minimum	
Elongation, %	ASTM B 744	4 Maximum	5 Maximum

203.02.03.02 Corrugated Steel Pipe and Pipe-Arches.

203.02.03.02.01 Metallic and Polymer Precoated Steel Sheet. Metallic coated and polymer precoated steel sheets used in the fabrication of corrugated steel pipe and pipe-arches shall conform to ASTM A 742.

203.02.03.02.02 Steel. Steel sheets used in the fabrication of corrugated steel pipe and pipe-arches shall conform to ASTM A 929.

203.02.03.02.03 Aluminized Steel Type 2. Aluminized steel sheets used in the fabrication of corrugated steel pipe and pipe-arches shall conform to ASTM A 929.

203.02.04 FABRICATION.

203.02.04.01 Corrugated Aluminum Pipe and Pipe-Arches. Fabrication of corrugated aluminum pipe and pipe-arches for drainage applications and other conveyance systems shall conform to ASTM B 745.

203.02.04.01.01 Corrugations. The corrugations for all corrugated aluminum pipe shall conform to the applicable requirements of Table 203.02.04.01.01-I. The corrugations shall be measured perpendicular to the direction of the corrugation.

TABLE 203.02.04.01.01-I

	Pipe Shape				
	Annular		Helical		
	Pipe Diameter (Inches)		Pipe Diameter (Inches)		
Minimum	15	30	6	12	30
Maximum	27	120	10	72	120
Width (Inches)	2-2/3	2-2/3, 3 or 5	1-1/4	2-2/3	2-2/3, 3 or 5
Depth (Inches) ¹	1/2	1/2 or 1	1/4	1/2	1/2 or 1

1. Minimum

203.02.04.01.02 Hot-Applied Bituminous Coated. When corrugated aluminum pipes are to have a hot-applied bituminous coating, the fabrication requirements specified in ASTM B 745 shall be altered so that the rivet heads inside will be in the valley of corrugations.

203.02.04.01.03 End Finish. When no headwalls or flared end sections are shown on the plans or specified in the Special Provisions and/or Special Technical Specifications, the ends of 0.060 Inch and 0.075 Inch thick corrugated aluminum pipes shall be reinforced. The reinforcement shall consist of an aluminum band of at least 0.135 Inch thickness and at least 6 Inches wide, on at least the outer 1 Foot of the pipe.

203.02.04.02 Corrugated Steel Pipe and Pipe-Arches. Fabrication of corrugated steel pipe and pipe-arches for drainage applications and other conveyance systems shall conform to ASTM A 760.

203.02.04.02.01 Corrugations. The corrugations for all corrugated steel pipe shall conform to the applicable requirements of Table 203.02.04.02.01-I. The corrugations shall be measured perpendicular to the direction of the corrugation.

TABLE 203.02.04.02.01-I

	Pipe Shape				
	Annular		Helical		
	Pipe Diameter (Inches)		Pipe Diameter (Inches)		
Minimum	12	48	6	12	48
Maximum	84	144	10	84	144
Width (Inches)	2-2/3	3 or 5	1-1/2	2-2/3	3 or 5
Depth (Inches) ¹	1/2	1	1/4	1/2	1

1. Minimum

203.02.04.03 Aluminized Steel Type 2 Corrugated Steel Pipe and Pipe-Arches. Fabrication of aluminized steel Type 2 corrugated steel pipe and pipe-arches for drainage applications and other conveyance systems shall conform to ASTM A 762.

203.02.04.03.01 Corrugations. The corrugations for all aluminized steel Type 2 corrugated steel pipe shall conform to the applicable requirements of Table 203.02.04.03.01-I. The corrugations shall be measured perpendicular to the direction of the corrugation.

TABLE 203.02.04.03.01-I

	Pipe Shape				
	Annular		Helical		
	Pipe Diameter (Inches)		Pipe Diameter (Inches)		
Minimum	12	48	6	12	48
Maximum	84	144	10	84	144
Width (Inches)	2-2/3	3 or 5	1-1/2	2-2/3	3 or 5
Depth (Inches) ¹	1/2	1	1/4	1/2	1

1. Minimum

203.02.04.04 Underdrains. Corrugated aluminum, steel or aluminized steel Type 2 for underdrains, shall be of the full-circle type. Perforations in the pipe may be drilled or punched. The perforation may be either in the inside crests or in the flat, tangent portion of the corrugations, but not in both locations in the same length of pipe.

203.02.05 COUPLING BANDS, RIVETS, BOLTS, GASKETS AND NUTS.

203.02.05.01 Coupling Bands for Corrugated Aluminum Pipe and Pipe-Arches. Coupling bands for corrugated aluminum pipe and pipe-arches shall be connected with steel bolts of not less than 1/2 Inch diameter and shall conform to ASTM B 745 and Tables 203.02.05.01-I and 203.02.05.01-II.

TABLE 203.02.05.01-I

Corrugation Size (Inches)	Minimum Width of Coupling Band (Inches)
12 and Greater	12 Minimum
Less than 12	7 Minimum

TABLE 203.02.05.01-II

Corrugation Size (Inches)	Minimum Width of Coupling Band (Inches)
2 2/3 x 1/2	12 Minimum
3 x 1	12 Minimum
5 x 1	12 Minimum

The gage of the coupling bands for corrugated aluminum pipe and pipe-arches may be a maximum of two standard-use thicknesses lighter than that used for the pipe. Minimum thickness shall be 0.060 Inches. The coupling bands shall be fabricated from the same base metal as the base metal of the pipe.

203.02.05.02 Coupling Bands for Corrugated Steel Pipe and Pipe-Arches. Coupling bands for corrugated steel pipe and pipe-arches shall be connected with steel bolts of not less than 1/2 Inch diameter and shall conform to ASTM A 760 and Tables 203.02.05.02-I and 203.02.05.02-II.

TABLE 203.02.05.02-I

Corrugation Size (Inches)	Minimum Width of Coupling Band (Inches)
12 and Greater	12 Minimum
Less than 12	7 Minimum

TABLE 203.02.05.02-II

Corrugation Size (Inches)	Minimum Width of Coupling Band (Inches)
2 2/3 x 1/2	7 Minimum
3 x 1	12 Minimum
5 x 1	12 Minimum

The gage of the coupling bands for corrugated steel pipe and pipe-arches may be a maximum of two standard-use thicknesses lighter than that used for the pipe. Minimum thickness shall be 0.060 Inches. The coupling bands shall be fabricated from the same base metal as the base metal of the pipe.

203.02.05.03 Coupling Bands for Corrugated Aluminized Steel Type 2 Pipe and Pipe-Arches. Coupling bands for corrugated aluminized steel Type 2 pipe and pipe-arches shall be connected with steel bolts of not less than 1/2 Inch diameter and shall conform to ASTM A 762 and Tables 203.02.05.03-I and 203.02.05.03-II.

TABLE 203.02.05.03-I

Corrugation Size (Inches)	Minimum Width of Coupling Band (Inches)
12 and Greater	12 Minimum
Less than 12	7 Minimum

TABLE 203.02.05.03-II

Corrugation Size (Inches)	Minimum Width of Coupling Band (Inches)
2 2/3 x 1/2	12 Minimum
3 x 1	12 Minimum
5 x 1	12 Minimum

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PIPE AND RELATED MATERIALS

The gage of the coupling bands for aluminized steel Type 2 pipe and pipe-arches may be a maximum of two standard-use thicknesses lighter than that used for the pipe. Minimum thickness shall be 0.060 Inches. The coupling bands shall be fabricated from the same base metal as the base metal of the pipe.

203.02.05.04 Coupling Bands for Underdrains. Sleeve-type couplings may be substituted for the coupling bands for underdrains. The couplings shall not distort under normal conditions of use. Minimum thickness for underdrains shall be 0.060 Inches.

203.02.06 COATINGS, LININGS AND PAVINGS. When approved by the Agency or Design Engineer, shown on the plans or specified in the Special Provisions and/or Special Technical Specifications, corrugated aluminum, steel, and aluminized steel Type 2 pipe, coupling bands, and fittings shall be coated, lined, or paved.

203.02.06.01 Coatings. Coatings shall be applied to one or both pipe surfaces. Coupling bands need not be coated on the interior surface. Any appearances of pinholes, blisters, cracks, or lack of bond shall be cause for rejection.

203.02.06.01.01 Hot-Applied Bituminous Coating for Corrugated Metal Pipe and Pipe-Arches. Hot-applied bituminous coating for corrugated metal and pipe-arches shall conform to AASHTO M 190, except that the bituminous material shall be at least 90 percent soluble in cold carbon disulfide.

203.02.06.01.01.01 Corrugated Aluminum Pipe and Pipe-Arches. Hot-applied bituminous coating paving for corrugated aluminum pipe and pipe-arches shall be applied to both surfaces. Minimum coating thickness shall be 0.050 Inches (50 Mil). The thickness shall be measured on the crest of the corrugations.

203.02.06.02 Linings.

203.02.06.02.01 Hot-Applied Bituminous Lining for Corrugated Metal Pipe and Pipe-Arches. Hot-applied bituminous lining for corrugated metal and pipe-arches, shall conform to AASHTO M 190, except that the bituminous material shall be at least 90 percent soluble in cold carbon disulfide.

203.02.06.03 Pavings.

203.02.06.03.01 Hot-Applied Bituminous Paving for Corrugated Metal Pipe and Pipe-Arches. Hot-applied bituminous paving for corrugated metal and pipe-arches shall conform to AASHTO M 190, except that the bituminous materials shall be at least 90 percent soluble in cold carbon disulfide.

203.02.07 JOINTS.

203.02.07.01 Watertight Joints.

203.02.07.01.01 Downdrains. Watertight joints for downdrains shall conform to the applicable requirements of Table 203.02.07.01.01-I.

Table 203.02.07.01.01-I

Test	Test Method	Requirements	
		Pipe Diameter (Inches)	
		0 to 42	48 to 84
Tensile Strength, Pull-Apart (Pounds)	ASTM D 487	5,000 Minimum	10,000 Minimum

203.02.08 REPAIR. This Subsection intentionally left blank.

203.03 This Subsection intentionally left blank.

203.04 STRUCTURAL PLATE PIPE.

203.04.01 DESCRIPTION. This Subsection covers structural plate pipe, pipe-arches, and horizontal and vertical ellipses constructed from corrugated metal plates that are field assembled into their design shape; and the related appurtenances. Pipe covered by this Subsection is intended for use in drainage applications and other conveyance systems.

203.04.01.01 Round Pipe and Pipe-Arches. Pipe and pipe-arches shapes shall consist of metal plates that have been curved to a specific radius resulting with a rise and span dimension that meets the requirements of AASHTO and AISI standards.

203.04.01.02 Horizontal and Vertical Ellipse. Horizontal and vertical ellipse shapes shall consist of metal plates that have been curved with multi-radii resulting with a rise and span dimension that meets the requirements of AASHTO and AISI standards.

203.04.01.03 Underpass. Underpass shapes shall consist of metal plates that have been curved with multi-radii resulting with a rise and span dimension that meets the requirements of AASHTO and AISI standards.

The material type, gage and/or thickness, nominal diameter, rise and span dimensions of the structure, appurtenances and fittings to be furnished shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.04.01.04 Nominal Dimensions. Nominal diameter for round pipe shall be defined as the minimum inside diameter of the pipe. Nominal dimension (rise and span) for multi-radii shapes shall be defined as the minimum inside dimensions at maximum span and maximum rise of the structure.

203.04.02 IDENTIFICATION. Each individual plate shall, at a minimum, be clearly marked such that the manufacturer, material type, gage and/or thickness, heat and/or lot number and all applicable AASHTO and ASTM designations can be readily identified.

203.04.02.01 Corrugated Steel Structural Plate Pipe, Pipe-Arches, Horizontal and Vertical Ellipses, and Underpass Shapes. Each individual steel plate shall be clearly marked in accordance with AASHTO M 167.

203.04.02.02 Corrugated Aluminum Structural Plate Pipe, Pipe-Arches, Horizontal and Vertical Ellipses, and Underpass Shapes. Each individual aluminum plate shall be clearly marked in accordance with ASTM B 746.

203.04.03 MATERIALS.

203.04.03.01 Corrugated Steel Structural Plate Pipe Pipe-Arches, Horizontal and Vertical Ellipses, Field-Assembled. Corrugated steel structural plates used in the fabrication of corrugated steel structural shapes shall conform to the requirements of AASHTO M 167 and shall meet the minimum mechanical properties as shown in Table 203.04.03.01-I.

Table 203.04.03.01-I

Test	Test Specification	Requirements
Tensile Strength (psi)	AASHTO M 167	45,000 Minimum
Yield Point (psi)	AASHTO M 167	33,000 Minimum
Modulus Of Elasticity. (psi)	AASHTO M 167	29 x10 ⁶ Minimum

203.04.03.02 Corrugated Aluminum Structural Pipe Pipe-Arches, Horizontal and Vertical Ellipses, and Underpass Shapes, Field-Assembled. corrugated aluminum structural plate used for the manufacture of corrugated aluminum structural shapes shall conform to ASTM B 746 and shall meet the minimum mechanical properties as shown in Table 203.04.03.02-I.

Table 203.04.03.02-I

Test	Test Specification	Requirements	
		Thickness (Inches)	
		0.100 to 0.175	0.176 to 0.250
Tensile Strength (psi)	AASHTO M 219	35,000 Minimum	34,000 Minimum
Yield Point (psi)	AASHTO M 219	24,000 Minimum	24,000 Minimum
Modulus Of Elasticity. (psi)	AASHTO M 219	10 x 10 ⁶ Minimum	10 x 10 ⁶ Minimum

203.04.04 FABRICATION. Fabrication of the plate shall conform to ASTM B 746, ASTM A 796 or AASHTO M 167 as applicable.

203.04.04.01 Corrugated Steel Plate Structures, Field-Assembled. Fabrication of corrugated steel plate structures which are field-assembled shall conform to ASTM A 796.

203.04.04.01.01 Corrugations. The corrugations for all corrugated steel plate shall conform to the applicable requirements of Table 203.04.04.01-I. The corrugations shall be measured perpendicular to the direction of the corrugation.

Table 203.04.04.01-I

6 Inch x 2 Inch Corrugations				
Gage	Thickness (Inches)	Area (Square Inch/Foot)	Radius of Gyration (Inches)	1 x 1000 (Cubic Inch/Inch)
12	0.111	1.556	0.682	60.411
10	0.138	2.003	0.684	78.175
8	0.168	2.449	0.686	96.163
7	0.188	2.739	0.688	108.000
5	0.218	3.199	0.690	126.922
3	0.249	3.650	0.692	146.172
1	0.280	4.119	0.695	165.836
3/16	0.318	4.671	0.698	190.000
3/8	0.375	5.613	0.704	232.000

203.04.04.02 Corrugated Aluminum Plate Structures, Field-Assembled. Fabrication of corrugated aluminum plate structures which are field-assembled shall conform to ASTM B 746.

203.04.04.02.01 Corrugations. The corrugations for all corrugated aluminum plate shall conform to the applicable requirements of Table 204.04.04.02-I. The corrugations shall be measured perpendicular to the direction of the corrugation.

Table 204.04.04.02.01-I

9 Inch x 2-1/2 Inch			
Thickness (Inches)	Area (Square Inch/Foot)	Radius of Gyration (Inches)	1 x 1000 (Cubic Inch/Inch)
0.100	1.404	0.8438	83.065
0.125	1.750	0.8444	103.991
0.150	2.100	0.8449	124.883
0.175	2.449	0.8454	145.895
0.200	2.799	0.8460	166.959
0.225	3.149	0.8468	188.179
0.250	3.501	0.8473	209.434

203.04.04.03 High Strength Bolts and Nuts. Hot-dipped, specially heat-treated, 3/4 Inch diameter steel bolts conforming to ASTM A 307 shall be used to assemble structural plate (steel and aluminum) plate sections. 3/4 Inch diameter bolt lengths shall conform to the applicable requirements of Table 203.04.04.03-I.

Table 203.04.04.03-I

Normal Bolt Usage		
Plate Gage	Bolt Length (Inches)	
	2 LAP SEAMS	3 LAP SEAMS
12, 10, and 8	1-1/4	1-1/2
7 and 5	1-1/2	1-3/4
3 and 1	1-3/4	2
5/16 and 3/8	2	2-1/2

203.04.05 FITTINGS.

203.04.05.01 Pre-Assembled Fittings. Pre-assembled fittings, including, but not limited to, elbows, skews, and bevels shall be verified for manufacturing limits and shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.04.06 COATINGS, ENCASEMENTS, LININGS AND PAVINGS. This Subsection intentionally left blank.

203.04.07 JOINTS. This Subsection intentionally left blank.

203.05.08 REPAIR. This Subsection intentionally left blank.

203.05 CAST IRON SOIL PIPE (CISP).

203.05.01 DESCRIPTION. This Subsection covers pipe constructed from gray cast iron. Pipe covered by this Subsection is intended for use in drain, waste, vent and drainage applications. This pipe should not be used for any pressure applications. The material type, ASTM designation, strength, and nominal diameter of the pipe to be furnished shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.05.02 IDENTIFICATION. Each section of pipe, appurtenances, and fittings shall, at a minimum, be clearly marked such that the date, manufacturer, plant location, material type, strength designation and nominal diameter can be readily identified.

203.05.03 MATERIALS. Materials used in the manufacture of CISP shall conform to ASTM A 74.

203.05.04 FABRICATION. Fabrication of the pipe shall conform to ASTM A 74.

203.05.05 FITTINGS. Fittings shall include elbows, tees, wyes, plugs, caps, adapters, increasers and reducers.

203.05.01 Hub and Spigot. Hub and spigot fittings shall conform to ASTM A 74.

203.05.02 Hubless. Hubless fittings shall conform to ASTM A 888.

203.05.03 Rubber Gasket. Rubber gasket fittings shall conform to ASTM C 564.

203.05.06 COATINGS, ENCASEMENTS, LININGS AND PAVINGS. All coatings shall be as specified by the applicable Specification or as shown on the plans or specified in the Special Provisions and/or Special Technical Specifications. The coating shall be evenly and smoothly applied to all surfaces except threaded openings.

203.05.07 JOINTS. Joints shall be as required for the application as specified on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.05.08 REPAIR. This Subsection intentionally left blank.

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PIPE AND RELATED MATERIALS

203.06 DUCTILE IRON PIPE (DIP).

203.06.01 DESCRIPTION. This Subsection covers pipe constructed from ductile iron. Pipe covered by this Subsection is intended for use in water distribution and transmission systems, force mains, sanitary sewers, drainage applications, and other conveyance systems. The material type, ASTM or AWWA designation, strength, wall and nominal diameter of the pipe to be furnished shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.06.02 IDENTIFICATION. Each section of pipe, appurtenances, and fittings shall, at a minimum, be clearly marked such that the date, manufacturer, plant location, material type, strength designation, nominal diameter and all applicable AWWA and ASTM designations can be readily identified.

203.06.03 MATERIALS. Materials used in the manufacture of DIP shall conform to AWWA C151 or ASTM A 746, as applicable. Pipe with flexible lining used for sewer mains shall conform to ASTM A 746, as specified on the plans or in the Special Provisions and/or Special Technical Specifications.

203.06.04 FABRICATION. Fabrication of the pipe shall conform to AWWA C151 or ASTM A 746, as applicable.

203.06.05 FITTINGS. Fittings shall include elbows, tees, wyes, plugs, caps, adapters, increasers and reducers. Fittings shall comply with AWWA C110 or AWWA C153 as applicable.

203.06.06 COATINGS, ENCASEMENTS, LININGS, AND PAVINGS. Unless otherwise specified in the Special Provisions and/or Special Technical Specifications, the internal surfaces of all ductile iron water pipe shall be lined with a uniform thickness of cement mortar then sealed with a bituminous coating in accordance with AWWA C104. Coatings and linings shall be specified by the Agency or Design Engineer. All coatings, internal or external, shall be applied per the manufacturer's recommendations. Unlined pipe and fittings shall not be used.

203.06.07 JOINTS. DIP joints shall conform to the applicable requirements of Table 203.06.07-I for the types shown on the plans or in the Special Provisions and/or Special Technical Specifications.

Table 203.06.07-I

Joint Type	Specification
Rubber Gasket Push-On	AWWA C111
Mechanical	AWWA C111
Flanged	AWWA C115

203.06.08 REPAIR. This Subsection intentionally left blank.

203.07 STEEL PIPE.

203.07.01 DESCRIPTION. This Subsection covers pipe constructed from steel plates or steel sheets. Pipe covered by this Subsection is intended for use in water distribution and transmission systems, drainage applications, and other conveyance systems.

The material type, strength designation, nominal diameter of the pipe to be furnished shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.07.02 IDENTIFICATION. Each section of pipe shall, at a minimum, be clearly marked such that the date, manufacturer, plant location, nominal diameter and all applicable AWWA and ASTM designations can be readily identified.

203.07.03 MATERIALS. Materials used in the manufacture of steel pipe shall conform to AWWA C200, ASTM A 238, ASTM A 570, or ASTM A 36 as applicable.

203.07.03.01 Steel Sheets. Sheets used in the manufacture of steel pipe shall conform to ASTM A 570, Grades 30 or 33.

203.07.03.02 Steel Plates. Plates used in the manufacture of steel pipe shall conform to ASTM A 238, Grades C or D, or ASTM A 36.

203.07.04 FABRICATION. Fabricated steel pipe shall conform to AWWA C200. Prior to fabrication, shop fabrication drawings for all pipe, fittings and joints shall be submitted to the Design Engineer for review and comment. Prior to any lining or coatings being applied, each size of pipe being fabricated shall be hydrostatically tested to 75 percent of the specified minimum yield strength of the steel sheets or plates used.

Mill-type steel water pipe shall conform to AWWA C200. Acceptable grades shall be ASTM A 53 Grades A and B, ASTM A 135, ASTM A 139, and ASTM A 134 (steel grade per AWWA C151 only).

203.07.05 FITTINGS. Fittings shall include elbows, returns, tees, reducers, increasers, and crosses. All fittings shall be manufactured from mill-type steel pipe in accordance with ANSI B 16.9 and AWWA C208.

203.07.06 COATINGS, ENCASEMENTS, LININGS AND PAVINGS. The interior and exterior of all steel water pipe and fittings shall be coated by one of the following methods or as shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.07.06.01 Cement-Mortar Lining and Coating. Cement-mortar linings and coatings shall conform to AWWA C05. If a curing compound is used, it shall conform to AWWA C205 and be left on the pipe for a minimum of 7 days.

203.07.06.02 Asphaltic Mastic Coating. Asphaltic mastic coatings shall conform to "Asphaltic Protective Coating for Pipelines" of the Asphalt Institute, Construction series No. 96. Specifications M-2. A Grade 3 system shall be furnished.

203.07.06.03 Coal-Tar Enamel Lining and Coating. Coal-tar enamel linings and coatings shall conform to AWWA C203.

203.07.06.04 Cement-Mortar Lining. Cement-mortar linings shall conform to AWWA C305.

203.07.07 JOINTS. Joints for steel pipe shall be one of the types listed below. All rubber gaskets shall conform to AWWA C200.

203.07.07.01 General.

203.07.07.01.01 Bell And Spigot With Rubber Gaskets.

203.07.07.01.02 Lap Joints For Field Welding.

203.07.07.01.03 Plain Ends Fitted With Butt Straps For Field Welding. Pipe less than 27 Inches in diameter shall be furnished with a 4 Inch diameter hand hole with screw cap or plug for "pointing" the joint.

203.07.07.01.04 Mechanical Coupled Field Joints.

203.07.07.01.05 Plain End With Flanges.

203.07.07.02 Mill-Type Steel Water Pipe. Joints for mill-type steel water pipe shall be one of the types listed below.

203.07.07.02.01 Mechanical Couplings.

203.07.07.02.02 Field Butt-Welded Joint.

203.07.07.02.03 Flanged Joints. Flanges shall conform to ASTM A 181, ANSI B 16.5 and ANSI B 2.1. Class 125 shall be the minimum class flange for water distribution lines.

203.07.08 REPAIR. This Subsection intentionally left blank.

203.08 VITRIFIED CLAY PIPE (VCP).

203.08.01 DESCRIPTION. This Subsection covers pipe, and fittings from fire clay, shale, surface clay, or a combination of these materials that, when formed into a pipe and fired to suitable temperatures, yields a product that conforms to this specification. Pipe covered by this Subsection is intended for use in gravity sanitary sewer, drainage and industrial waste applications.

The material type, strength designation, thickness, nominal diameter and dimensions of the pipe, bends, bevels and fittings to be furnished shall conform to ASTM C 700 and the applicable requirements of Table 203.08.01-I, or as shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

TABLE 203.08.01-I

Nominal Size (Inches)	Minimum Test Loads (Pounds per Linear Foot)	
	Extra Strength	High Strength
4	2000	2200
6	2000	2200
8	2200	2400
10	2400	2600
12	2600	2900
15	3100	3400
18	3600	4000
21	4200	4600
24	4800	5300
27	5200	5700
30	5500	6100
33	5800	6400
36	6300	6900
39	6600	7300
42	7000	7700

203.08.01.01 Nominal Diameter. Nominal diameter is defined as the minimum inside diameter of the pipe.

203.08.02 IDENTIFICATION. Each section of pipe shall, at a minimum, be clearly marked such that the manufacturer, plant location, material type, and strength designation can be readily identified.

203.08.03 MATERIALS. Vitrified clay pipe and fittings shall be manufactured from fire clay, shale, surface clay, or a combination of these materials that, when formed into a pipe and fired to suitable temperatures, yields a product that conforms to this specification.

203.08.03.01 Microtunneling, Sliplining, Pipe Bursting, and Tunnels. Pipe used for microtunneling, sliplining, pipe bursting, and tunnels shall conform to ASTM C 1208.

203.08.04 FABRICATION. This Subsection intentionally left blank.

203.08.05 FITTINGS. Fittings shall include elbows, tees, wyes, plugs, caps, adapters, increasers and reducers.

203.08.06 COATINGS, ENCASEMENTS, LININGS AND PAVINGS. This Subsection intentionally left blank.

203.08.07 JOINTS. Joints for vitrified clay pipe and fittings shall be manufactured in accordance with ASTM C 700 and C 425.

203.08.08 REPAIRS. This Subsection intentionally left blank.

203.09 NON-REINFORCED CONCRETE PIPE.

203.09.01 DESCRIPTION. This Subsection covers pipe constructed from non-reinforced concrete. Pipe covered by this Subsection is intended for use in sanitary sewers, drainage applications, and other conveyance systems.

The material type, strength designation, nominal diameter and dimensions of the pipe to be furnished shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

Strength class of non-reinforced concrete pipe shall be as identified in ASTM C 14, Class 1, Class 2, or Class 3 non-reinforced concrete pipe. Unless otherwise specified, Class 3 non-reinforced concrete pipe shall be used.

203.09.01.01 Nominal Diameter. Nominal diameter is defined as the minimum inside diameter of the pipe.

203.09.02 IDENTIFICATION. Each section of pipe and fittings shall, at a minimum, be clearly marked such that the date, manufacturer, plant location, material type, strength designation, and nominal diameter can be readily identified.

203.09.03 MATERIALS. Materials used in the manufacture of non-reinforced concrete pipe shall conform to ASTM C 14.

203.09.03.01 Cement and Related Materials. Cement and related materials shall conform to Section 202 – “Cement and Related Materials”.

203.09.04 FABRICATION. Fabrication of the pipe shall conform to ASTM C 14.

203.09.04.01 Calcium Chloride. The pipe manufacturer shall certify that no calcium chloride or admixtures containing chloride or calcium chloride has been used in the manufacture of the pipe.

203.09.05 FITTINGS. Fittings shall be fabricated of the same material as the pipe and shall include elbows, tees, wyces, plugs, caps, adapters, increasers, and reducers.

203.09.06 COATINGS, ENCASEMENTS, LININGS, AND PAVINGS. When approved by the Agency or Design Engineer, shown on the plans or specified in the Special Provisions and/or Special Technical Specifications, non-reinforced concrete pipe shall be coated. All coatings, internal or external applications shall be applied per the manufacturer’s recommendations.

203.09.07 JOINTS. The type of joint to be used shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications. If no type is shown or specified, the joint may be any of the types listed below. Only one type of joint shall be used on any run of pipe.

203.09.07.01 Tongue and Groove Mortar Joints. Tongue and groove mortar joints shall be sealed with mortar or grout consisting of one part cement and two parts sand, by volume. The quantity of water in the mixture shall produce a soft workable mortar, but shall not exceed a water-cement ratio of 0.53.

203.09.07.02 Tongue and Groove Mastic Joints. Tongue and groove mastic joints shall be sealed with pre-formed flexible joint sealant conforming to ASTM C 990. The material shall be applied per the manufacturer’s recommendations. A single or double application of joint material may be used. If not specified by the Agency or Design Engineer, a single application is acceptable.

203.09.07.03 Rubber Gasket Joints. Rubber gasket joints shall conform to ASTM C 443 and ASTM C 1619. The gasket may be either a circular or non-circular shape.

203.09.08 REPAIR. This Subsection intentionally left blank.

203.10 REINFORCED CONCRETE PIPE (RCP).

203.10.01. DESCRIPTION. This Subsection covers pipe and elliptical pipe constructed from reinforced concrete. Pipe covered by this Subsection is intended for use in sanitary sewers, drainage applications, and other conveyance systems. Such pipe shall conform to ASTM C 76, ASTM C 506, ASTM C 507 or ASTM C 655, as applicable and except as modified herein.

The material type, strength designation, nominal diameter and dimensions of the pipe to be furnished shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications. Unless otherwise specified, pipe shall be cast, spun or machine-made.

203.10.01.01 Nominal Diameter. Nominal diameter is defined as the minimum inside diameter of the pipe.

203.10.02 IDENTIFICATION. Each section of pipe and fittings shall, at a minimum, be clearly marked such that the date, manufacturer, plant location, material type, strength designation, and nominal diameter can be readily identified.

203.10.03 MATERIALS. Materials used in the manufacture of RCP shall conform to ASTM C 76, ASTM C 506, ASTM C 507 or ASTM C 655, as applicable.

203.10.03.01 Cement and Related Materials. Cement and related materials shall conform to Section 202 – “Cement and Related Materials”.

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PIPE AND RELATED MATERIALS

203.10.04 FABRICATION. Fabrication of the pipe shall conform to ASTM C 76 for round pipe, ASTM C 506 for arch pipe and ASTM C 507 for elliptical pipe.

203.10.04.01 Calcium Chloride. The pipe manufacturer shall certify that no calcium chloride or admixtures containing chloride or calcium chloride has been used in the manufacture of the pipe.

203.10.04.02 Lift Holes. Lift holes (located by the manufacturer) may be installed in each pipe. Lift holes shall be plugged prior to backfilling as specified in the construction method section for reinforced concrete pipe, on the plans or in the Special Provisions and/or Special Technical Specifications. Optional methods of lifting may be used as approved by the Agency or Design Engineer.

203.10.05 FITTINGS. Fittings shall be fabricated of the same material as the pipe and shall include elbows, tees, wyes, plugs, caps, adapters, increasers and reducers.

203.10.06 COATINGS, ENCASEMENTS, LININGS, AND PAVINGS.

203.10.06.01 Coatings. When approved by the Agency or Design Engineer, shown on the plans or specified in the Special Provisions and/or Special Technical Specifications, RCP shall be coated. All coatings, internal or external applications shall be applied per the manufacturer's recommendations.

203.10.06.02 Linings. When required by the Agency or Design Engineer, linings shall be either High Density Polyethylene or Poly Vinyl Chloride, as shown on the plans or specified in the Special Provisions and/or Special Technical Specifications. Liner material properties shall be listed in the Special Provisions and/or Special Technical Specifications.

203.10.07 JOINTS. The type of joint to be used shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications. If no type is shown or specified, the joint may be any of the types listed below. Only one type of joint shall be used on any run of pipe.

203.10.07.01 Tongue and Groove Mortar Joints. Tongue and groove mortar joints shall be sealed with mortar or grout consisting of one part cement and two parts sand, by volume. The quantity of water in the mixture shall produce a soft workable mortar, but shall not exceed a water-cement ratio of 0.53.

203.10.07.02 Tongue and Groove Mastic Joints. Tongue and groove mastic joints shall be sealed with pre-formed flexible joint sealant conforming to ASTM C 990. The material shall be applied per the manufacturer's recommendations. A single or double application of joint material may be used. If not specified by the Agency or Design Engineer, a single application is acceptable.

203.10.07.03 Rubber Gasket Joints. Rubber gasket joints shall conform to ASTM C 443 and ASTM C 1619. The gasket may be either a circular or non-circular shape.

203.10.07.04 Joints for Sanitary Sewer. Joints for sanitary sewer shall be rubber gasket conforming to ASTM C 361 and ASTM C 1619.

203.10.08 REPAIR. This Subsection intentionally left blank.

203.11 This Subsection intentionally left blank.

203.12 REINFORCED CONCRETE PRESSURE PIPE.

203.12.01 DESCRIPTION. This Subsection covers pressure pipe and pressure cylinder pipe constructed from reinforced concrete. Pipe covered by this Subsection is intended for use in supply pipelines, and distribution and transmission systems that carry water under pressure.

The material type, strength designation, nominal diameter and dimensions of the pipe to be furnished shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.12.01.01 Nominal Diameter. Nominal diameter is defined as the minimum inside diameter of the pipe.

203.12.01.02 Pipe Type. This Subsection applies to four types of pipe.

203.12.01.02.01 Reinforced Concrete Steel Cylinder Pipe. Reinforced concrete steel cylinder pipe shall conform to AWWA C 300.

203.12.01.02.02 Prestressed Concrete Steel Cylinder Pipe. Prestressed concrete steel cylinder pipe shall conform to AWWA C301.

203.12.01.02.03 Reinforced Concrete Non-Cylinder Pipe. Reinforced concrete non-cylinder pipe shall conform to AWWA C302.

203.12.01.02.04 Reinforced Concrete Low-Head Pressure Pipe. Reinforced concrete low-head pressure pipe shall conform to ASTM C 361.

203.12.02 IDENTIFICATION. Each section of pipe and fittings shall, at a minimum, be clearly marked such that the date, manufacturer, plant location, material type, strength designation and nominal diameter can be readily identified.

203.12.03 MATERIALS. Materials used in the manufacture of reinforced concrete pressure pipe shall conform to AWWA C300, AWWA C301, AWWA C302, or ASTM C 361 depending upon the pipe type designated on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.12.03.01 Cement and Related Materials. Cement and related materials shall conform to Section 202 – “Cement and Related Materials”.

203.12.04 FABRICATION. Fabrication of the pipe shall be in accordance with AWWA C300 for reinforced concrete steel cylinder pipe, AWWA C301 for prestressed concrete steel cylinder pipe, AWWA C302 for reinforced concrete non-cylinder pipe and ASTM C 361 for reinforced concrete low-head pressure pipe.

203.12.04.01 Calcium Chloride. The pipe manufacturer shall certify that no calcium chloride or admixtures containing chloride or calcium chloride has been used in the manufacture of the pipe.

203.12.04.02 Lift Holes. Lift holes are not allowed in reinforced concrete pressure pipe.

203.12.05 FITTINGS. Fittings shall be fabricated of the same material as the pipe and shall include elbows, tees, wyes, plugs, caps, adapters, increasers and reducers.

203.12.06 COATINGS, ENCASEMENTS, LININGS AND PAVINGS. This Subsection intentionally left blank.

203.12.07 JOINTS. Joints and gaskets shall be as specified in the particular pipe standard that is specified in the plans or specified in the Special Provisions and/or Special Technical Specifications. Minimum bell reinforcement shall be as specified in Table 2 in the Appendix of the U.S. Bureau of Reclamation Standard Specifications for Reinforced Concrete Pressure Pipe.

203.12.08 REPAIR. This Subsection intentionally left blank

203.13 PRECAST REINFORCED CONCRETE BOX (RCB).

203.13.01 DESCRIPTION. This Subsection covers precast RCB. Boxes covered by this Subsection are intended for use in drainage applications and other conveyance systems. The boxes shall conform to the specification designated by the Design Engineer, as specified on the plans or in the Special Provisions and/or Special Technical Specifications.

The material type, specification designation, strength designation (design cover and loading), span and rise dimensions of the box to be furnished shall be as shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

Submittals shall include both overall and individual section layout drawings, wall and slab thicknesses, and structural calculations and designs. The structural calculations and designs shall include specific structural designs for standard sections, shortened sections, skewed sections, any section with an access opening or pipe entry. Details shall be included showing the method of reinforcing extension for any required headwalls, wing walls, and toe walls. All structural calculations shall be sealed by a registered structural engineer appropriately licensed in the State of Nevada. Tables from a standardized reference may be submitted in lieu of structural calculations.

203.13.02 IDENTIFICATION. Each section of box and fittings shall, at a minimum, be clearly marked such that the date, manufacturer, plant location, material type, strength designation (design cover and loading) and nominal span and rise can be readily identified.

203.13.03 MATERIALS. Materials used in the manufacture of the box shall conform to the specification designated by the Design Engineer.

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PIPE AND RELATED MATERIALS

203.13.03.01 Cement and Related Materials. Cement and related materials shall conform to Section 202 – “Cement and Related Materials”.

203.13.04 FABRICATION. Fabrication of the box shall conform to the specification designated by the Design Engineer. Boxes may be manufactured by either the Dri-Cast or Wet-Cast method.

203.13.04.01 Concrete. Concrete shall conform to specification designated by the Design Engineer. Minimum 28 day concrete compressive strength shall be 5,000 psi.

203.13.04.02 Calcium Chloride. The box manufacturer shall certify that no calcium chloride or admixtures containing chloride or calcium chloride has been used in the manufacture of the box.

203.13.04.03 Lift Holes. Lift holes (located by the manufacturer) may be installed in each box. Optional methods of lifting may be used as approved by the Agency or Design Engineer.

203.13.05 FITTINGS. Fittings shall include elbows, tees, wyes, plugs, caps, adapters, increasers and reducers.

203.13.06 COATINGS, ENCASEMENTS, LININGS AND PAVINGS. Coatings may be used on precast reinforced concrete boxes but only when approved by the Agency or Design Engineer. All coatings, internal or external, shall be applied per the manufacturer's recommendation.

203.13.07 JOINTS. Unless otherwise approved or directed by the Agency or Design Engineer, joints shall be sealed with a pre-formed flexible joint sealant conforming to ASTM C 990.

203.13.08 REPAIR. This Subsection intentionally left blank.

203.14 ACRYLONITRILE-BUTADIENE-STYRENE (ABS) PIPE.

203.14.01 DESCRIPTION. This Subsection covers pipe constructed from ABS composite compounds. Pipe covered by this Subsection is intended for use in sanitary sewers and drainage applications and other conveyance systems. The pipe shall conform to ASTM D 2680 (composite pipe) or ASTM D 2751 (solid wall pipe) and as specified on the plans or in the Special Provisions and/or Special Technical Specifications.

The material type, strength designation, nominal diameter and dimensions of the pipe to be furnished shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.14.01.01 Nominal Diameter. Nominal diameter is defined as the minimum inside diameter of the pipe.

203.14.02 IDENTIFICATION. Each section of pipe and fittings shall, at a minimum, be clearly marked such that the production date, manufacturer, plant location, ASTM designation, strength designation, and nominal diameter can be readily identified.

203.14.03 MATERIALS. Materials used in the manufacture of the pipe shall conform to ASTM D 2680 or ASTM D 2235 as applicable. Plastic shall contain polymers or blends of polymers meeting the following requirements listed below. The polymer fraction by weight shall add up to 100 in any specific compound. Additives such as stabilizers, anti-oxidants, lubricants, and colorants, shall not exceed 10 parts by weight per 100 parts of polymer.

203.14.03.01 Acrylonitrile. Pipe shall contain 13 to 35 minimum parts content by weight.

203.14.03.02 Butadiene. Pipe shall contain 8 to 16 minimum parts content by weight.

203.14.03.03 Styrene. Pipe shall contain 40 to 70 minimum parts content by weight.

203.14.04 FABRICATION. Fabrication of the pipe shall conform to ASTM D 2680 or ASTM D 2751 as applicable. Minimum wall thickness of solid wall ABS pipe shall correspond with Standard Dimension Ratio (SDR) 35 requirements.

203.14.04.01 Test Specimens. Unless waived by the Agency or Design Engineer the manufacturer shall prepare test specimens per ASTM D 3641, and test for impact per ASTM D 256, Method A, tensile strength per ASTM D 628 and weight changes per ASTM D 543. Unless waived by the Agency or Design Engineer, testing for elongation at break, ASTM D 412, compression set, ASTM D 395, Method B, and physical requirements after exposure to ozone, ASTM D 1149, will also be required.

203.14.05 FITTINGS. Fittings shall include elbows, tees, wyes, plugs, caps, adapters, increasers and reducers.

203.14.06 COATINGS, ENCASEMENTS, LININGS AND PAVINGS. This Subsection intentionally left blank.

203.14.07 JOINTS. Joints shall be sealed with ABS joint solvent cement supplied by the pipe manufacturer and conforming to ASTM D 2235.

203.14.08 REPAIR. This Subsection intentionally left blank.

203.15 POLYVINYL CHLORIDE (PVC) PRESSURE PIPE.

203.15.01 DESCRIPTION. This Subsection covers pipe constructed from PVC compounds. Pipe covered by this Subsection is intended for use in water transmission and distribution systems, force mains, sanitary sewers, and other conveyance systems.

The material type and nominal diameter of the pipe to be furnished shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.15.01.01 Nominal Diameter. Nominal diameter is defined as the minimum inside diameter of the pipe.

203.15.02 IDENTIFICATION. Each section of pipe and fittings shall, at a minimum, be clearly marked in accordance with AWWA C900 and C905, as applicable.

203.15.03 MATERIALS. Materials used in the manufacture of PVC pipe and fittings shall consist of PVC compounds which conform to ASTM D 1784. The pipe and materials shall be manufactured of PVC compounds having a minimum cell classification of 12454 as defined in ASTM D 1784. Compounds that have different cell classifications than required by ASTM D 1784 which are equal to or exceed this standard are also acceptable as approved by the Agency or Design Engineer.

Pipe and fittings shall meet the requirements of AWWA C900 for cast iron outside diameters (CIOD's) of 4 Inch through 12 Inch or AWWA C905 for CIOD's 14 Inch through 48 Inch.

203.15.03.01 Water Transmission and Distribution. Unless otherwise specified for a higher pressure class designation, PVC pressure pipe shall be a minimum Pressure Class 235 DR 18 meeting the requirements of AWWA C900 for nominal diameters of 4 Inch through 12 Inch and a minimum Pressure Class 235 DR 18 conforming to AWWA C905 for nominal diameters of 14 Inch through 48 Inch.

203.15.03.02 Reclaimed Water. PVC pressure pipe used for reclaimed water shall be colored purple.

PVC pressure pipe shall have been manufactured within the 24 month period prior to installation.

203.15.04 FABRICATION. Fabrication of the pipe shall conform to AWWA C900 or C905, as applicable.

203.15.05 FITTINGS. Unless otherwise specified or shown on the drawings, all fittings to be used with PVC pressure pipe shall conform to either AWWA C110 or AWWA C153.

203.15.06 COATINGS, ENCASEMENTS, LININGS AND PAVINGS. This Subsection intentionally left blank.

203.15.07 JOINTS. Joints shall be watertight per ASTM D 3139 and joined with a gasketed integral bell and spigot joint. Gaskets shall conform to ASTM F 477.

203.15.08 REPAIR. This Subsection intentionally left blank.

203.16 SOLID WALL HIGH DENSITY POLYETHYLENE (SWHDPE) PIPE.

203.16.01 DESCRIPTION. This Subsection covers pipe and fittings constructed from high density polyethylene. Pipe covered by this Subsection is intended for use water transmission and distribution systems, force mains, sanitary sewers, drainage applications, and other conveyance systems. The pipe shall conform to ASTM F 714. Pipe intended for potable water applications shall also meet the requirements of AWWA C901 and AWWA C906 as applicable.

The material type, strength designation, thickness, nominal diameter and dimensions of the pipe to be furnished shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

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PIPE AND RELATED MATERIALS

203.16.01.01 Nominal Diameter. Nominal diameter is defined as the minimum inside diameter of the pipe.

203.16.02 IDENTIFICATION. Each section of pipe and fittings shall, at a minimum, be clearly marked such that the manufacturer, plant location, material type, strength designation, thickness, nominal diameter and weight can be readily identified.

203.16.03 MATERIALS. Materials used in the manufacture of high density polyethylene pipe shall conform to ASTM F 714 and the following requirements:

203.16.03.01 Gravity Pipe. Pipe and fitting material shall conform to ASTM D 3350 with a cell classification of 345464C or 345464E.

203.16.03.02 Pressure Pipe. Pipe and fitting material shall conform to ASTM D 3350 with a cell classification of 445474C or 445574C.

203.16.03.02.01 Potable Water. Pipe and fitting material shall conform to ASTM D 3350, NSF 61-Drinking Water Systems and AWWA C901 and AWWA C906 as applicable.

203.16.04 FABRICATION. Fabrication of pipe shall conform to ASTM D 3261, ASTM F 1055, and ASTM F 2206 as applicable.

203.16.05 FITTINGS. Fittings shall be injection molded, molded butt fusion, electrofusion, fabricated or welded and shall include elbows, tees, manhole adapter rings, plugs, caps, adapters and reducers.

203.16.06 COATINGS, ENCASEMENTS, LININGS AND PAVINGS. This Subsection intentionally left blank.

203.16.07 JOINTS. This Subsection left intentionally blank.

203.16.08 REPAIR. Pipe that does not conform to the referenced standards shall not be used.

203.17 CORRUGATED HIGH DENSITY POLYETHYLENE (CHDPE) PIPE.

203.17.01 DESCRIPTION. This Subsection covers pipe and fittings constructed from CHDPE material. Pipe covered by this Subsection is intended for use in sanitary sewers, drainage applications, and other conveyance systems.

The material type, strength designations, thickness, nominal diameter and dimensions of the pipe to be furnished shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.17.01.01 Nominal Diameter. Nominal diameter is defined as the minimum inside diameter of the pipe.

203.17.02 IDENTIFICATION. Each section of pipe and fittings shall, at a minimum, be clearly marked such that the manufacturer, plant location, material type, strength designation, thickness, nominal diameter and weight can be readily identified.

203.17.03 MATERIALS. Materials used in the manufacture of CHDPE pipe and fittings shall conform to the following requirements:

203.17.03.01 ASTM F 2306. Virgin material for pipe and fittings shall be high density polyethylene conforming with the minimum requirements of cell classification 424220C for 4 Inch to 10 Inch diameters, and 435400C for 12 Inch through 60 Inch diameters, conforming to ASTM D 3350, except that carbon black shall not exceed 5 percent. The 12 Inch through 60 Inch virgin pipe material shall comply with the Notched Constant Ligament-Stress (NCLS) test per ASTM F 2306. Pipe shall be Type S (smooth interior lining) per ASTM F 2306 unless otherwise specified as Type C (corrugated interior) which is available in 4 Inch through 24 Inch only.

203.17.03.02 ASTM F 2648. Material for pipe production shall be an engineered compound of virgin and recycled high-density polyethylene conforming with the minimum requirements of cell classification 424420C (Environment Crack Stress Resistance [ECSR] Test Condition B) for 4 Inch through 10 Inch diameters, and 435420C (ECSR Test Condition B) for 12 Inch through 60 Inch diameters, conforming to ASTM D 3350, except that carbon black content shall not exceed 5 percent.

203.17.04 FABRICATION. Fabrication of pipe shall conform to ASTM F 2306 or F 2648 as applicable. Fabrication of pipe fittings shall conform to ASTM F 2306 and shall be performed by the pipe manufacturer. As

directed by the Agency or Design Engineer or as shown on the plans or specified in the Special Provisions and/or Special Technical Specifications pipe may be perforated.

203.17.05 FITTINGS. Fittings shall be injection molded or welded and shall include elbows, tees, manhole adapter rings, plugs, caps, adapters and reducers. Bell and spigot joints shall use a spun-on or welded bell with valley or saddle gasket meeting the joint requirements in this Subsection.

203.17.06 COATINGS, ENCASEMENTS, LININGS AND PAVINGS. This Subsection intentionally left blank.

203.17.07 JOINTS. Joints shall be watertight per ASTM D 3212 and joined with a gasketed integral bell and spigot joint. Gaskets shall conform to ASTM F 477.

203.17.07.01 Gravity Sewer. CHDPE considered for gravity sanitary sewer applications shall use double gasketed joints only.

203.17.08 REPAIR. Pipe that does not conform to the referenced standards shall not be used.

203.18 GEOCOMPOSITE DRAINAGE PIPE.

203.18.01 DESCRIPTION. This Subsection covers geocomposite drainage pipe and fittings manufactured from corrugated high density polyethylene. Pipe covered by this Subsection is intended for use in subsurface drainage applications. The material type and nominal diameter of the pipe to be furnished shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.18.01.01 Nominal Dimensions. Geocomposite drainage pipe shall be 12 Inch and 18 Inch wide or tall and have a thickness of 1.5 Inches. Slot length shall be 1.125 Inches long and 0.125 Inches wide for 12 Inch geocomposite drainage pipe. Slot length shall be 1.125 Inches long and 0.15 Inches wide for 18 Inch geocomposite drainage pipe.

203.18.02 IDENTIFICATON. Each section of pipe and fittings shall, at a minimum, be clearly marked such that the manufacturer, plant location, material type, strength designation, thickness, nominal dimensions and weight can be readily identified.

203.18.03 MATERIALS. All pipe and fittings shall be manufactured of corrugated high density polyethylene with a minimum cell classification of 424420C as defined in ASTM D 3350. The material shall be made available in long rolls to minimize the use of fittings and joints.

203.18.03.01 Filter Fabric. Geocomposite drainage pipe shall be made available with and without an external geotextile fabric. The use of geotextile fabric shall be as specified by the Agency or Design Engineer. When required, geotextile fabrics shall conform to the applicable requirements of Table 203.18.03.01-I.

TABLE 203.18.03.01-I

Fabric Properties	Test Method	Requirements
Grab Tensile Strength (lbs), Weakest principle direction	ASTM D 4632	120
Grab Elongation (%), Weakest principle direction	ASTM D 4633	60
Trapezoidal Tear (lbs), Weakest principle direction	ASTM D 4533	40
Puncture (lbs)	ASTM D 3786	30
Permittivity	ASTM D 4491	0.7
Apparent Opening Size (US Sieve Size)	ASTM D 4751	60
U.V. Resistance (% Retained)	ASTM D 4355	70

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PIPE AND RELATED MATERIALS

203.18.04 FABRICATION. Fabrication of pipe and fittings shall conform to ASTM D 7001.

203.18.05 FITTINGS. Fittings shall be injection molded or welded and shall include elbows, tees, manhole adapter rings, plugs, adapters and reducers. Other fittings shall be made available including end caps, wyes, end outlets, flat outlets, and side outlets.

203.18.06 COATINGS, ENCASEMENTS, LININGS AND PAVINGS. This Subsection intentionally left blank.

203.18.07 JOINTS. Connection between rolls shall be made with fittings and/or couplings.

203.18.08 REPAIR. Pipe that does not conform to the referenced standards shall not be used.

203.19 POLYPROPYLENE (PP) PIPE.

203.19.01 DESCRIPTION. This Subsection covers profile wall pipe and fittings constructed from polypropylene. Pipe covered by this Subsection is intended for use in sanitary sewer and drainage applications.

The material type, strength designation, thickness, nominal diameter and dimensions of the pipe to be furnished shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.19.01.01 Nominal Diameter. Nominal diameter is defined as the minimum inside diameter of the pipe.

203.19.02 IDENTIFICATION. Each section of pipe and fittings shall, at a minimum, be clearly marked such that the manufacturer, plant location, material type, strength designation, thickness, nominal diameter and weight can be readily identified.

203.19.03 MATERIALS. Materials used in the manufacture of PP and fittings shall be manufactured from virgin material conforming to ASTM D 4101, except as modified herein.

203.19.03.01 Dual Wall Pipe. Dual wall pipe and fittings in diameters 6 Inch through 60 Inch shall have a corrugated exterior and have a smooth interior liner and conform to ASTM F 2736.

203.19.03.02 Triple Wall Pipe. Triple wall pipe and fittings in diameters 30 Inch through 60 Inch shall have a smooth exterior liner, corrugated interior wall and smooth interior liner and conform to ASTM F 2764.

203.19.03.03 Flexible Elastomeric Gaskets. Gaskets shall be manufactured in accordance with ASTM F 477.

203.19.04 FABRICATION. Fabrication of PP pipe and fittings shall conform to ASTM F 2736 and F 2764 and shall be performed by the pipe manufacturer.

203.19.05 FITTINGS. Fittings shall be injection molded or welded polypropylene and shall include elbows, tees, manhole adapter rings, plugs, caps, adapters and reducers. Bell and spigot joints shall use a spun-on or welded bell with valley or saddle gasket meeting the joint requirements in this section. Fittings may also be SDR 35 PVC upon request for diameters up to 30 Inch. Gaskets shall conform to ASTM F 477. As directed by the Agency or Design Engineer or as shown on the plans or specified in the Special Provisions and/or Special Technical Specifications pipe may be perforated.

203.19.06 COATINGS, ENCASEMENTS, LININGS AND PAVINGS. This Subsection intentionally left blank.

203.19.07 JOINTS. Joints shall be watertight per ASTM D 3212 and joined with a single or dual gasketed integral bell and spigot joint. Gaskets shall conform to ASTM F 477.

203.19.07.01 Gravity Storm Sewer. Gravity storm sewer applications shall use either a single or dual gasket.

203.19.07.02 Gravity Sanitary Sewer. Gravity sanitary sewer applications shall use a double gasketed joint and have a minimum strength of 46 pounds per inch diameter.

203.19.08 REPAIR. Pipe that does not conform to the referenced standards shall not be used.

203.20 PVC GRAVITY PIPE.

203.20.01 DESCRIPTION. This Subsection covers pipe constructed from PVC compounds. Pipe covered by this Subsection is intended for use in sanitary sewers, drainage applications and other conveyance systems.

The material type, nominal diameter and wall thickness dimension ratio (SDR) of the pipe, appurtenances and fittings to be furnished shall be in accordance with the applicable ASTM designation and as shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.20.01.01 Nominal Diameter. Nominal diameter is defined as the minimum inside diameter of the pipe, including allowable manufacturing tolerances.

203.20.02 IDENTIFICATION. Each length of pipe shall, at a minimum, be clearly marked by such that the ASTM designation, nominal pipe size, pipe stiffness, resin cell classification, manufacturer's name and manufacturer's production code with the date of manufacture can be readily identified.

203.20.03 MATERIALS. Materials used to manufacture profile wall PVC pipe and related fittings and appurtenances shall be PVC compounds having a minimum cell classification as listed below based on pipe type as defined and described in ASTM D 1784. Pipe and fittings shall conform to ASTM D 3034 SDR 35 or greater for nominal diameters of 4 Inches through 15 Inches. Pipe and fittings shall conform to ASTM F 679 for nominal diameters of 18 Inches through 36 Inches.

The pipe and materials shall be manufactured of PVC plastic having a minimum cell classification of 12454 as defined in ASTM D 1784. Compounds that have different cell classifications because one or more properties are superior to those of the specified compounds are also acceptable as approved by the Agency or Design Engineer.

203.20.03.01 PVC Solid Wall Gravity Pipe. Pipe and fittings shall conform to ASTM D 3034 SDR 35 or greater for nominal diameters 4 Inch through 15 Inch. Pipe and fittings shall conform to ASTM F 679 for nominal diameters 18 Inch through 48 Inch.

Minimum "pipe stiffness" ($F/\Delta y$) at 5 percent deflection shall be 46 psi for SDR 35 and 115 psi for SDR 26 for all sizes when tested in accordance with ASTM D 2412.

203.20.03.02 Profile Wall PVC Pipe shall conform to ASTM F 949. Profile Wall PVC Pipe and fittings shall be homogeneous throughout and free from visible cracks, holes, foreign inclusions or other injurious defects.

203.20.03.03 Type 46 Pipe. Pipe shall be manufactured to a stiffness of 46 psi when tested in accordance with 3ASTM D 2412. There shall be no evidence of splitting, cracking or breaking when the pipe is tested. Pipe shall have a minimum cell classification of 12454 as defined in ASTM D 1784.

203.20.03.04 Type 115 Pipe. Pipe shall be manufactured to a stiffness of 115 psi when tested in accordance with ASTM D 2412. Pipe shall have a minimum cell classification of 12454 as defined in ASTM D 1784.

203.20.03.05 PVC Ribbed Or High Profile Gravity Pipe. Pipe and fittings shall be manufactured from PVC compounds as defined and described in ASTM D 1784. Pipe and fittings shall conform to ASTM F 949/ASTM F 794 or AASHTO M 304.

The pipe and materials shall be manufactured of PVC compounds having a minimum cell classification of 12454 or 12364 as defined in ASTM D 1784. Compounds that have different cell classifications because one or more properties are superior to those of the specified compounds are also acceptable as approved by the Agency or Design Engineer.

Minimum pipe stiffness ($F/\Delta y$) at 5 percent deflection shall be 46 psi when tested in accordance with ASTM D 2412.

203.20.04 FABRICATION. Perforated pipe shall be as shown on the plans or specified in the Special Provisions and/or Special Technical Specifications. For slotted and standard perforated pipe, the perforation dimensions shall conform to ASTM F 949. Instead of slots, round holes 1/4 Inch in diameter may be used for 15 Inch and 18 Inch diameter pipe and 3/8 Inch diameter for 21 Inch through 48 Inch diameter pipe.

203.20.05 FITTINGS. All fittings for profile wall PVC pipe shall conform to ASTM F 949. To insure compatibility, the pipe manufacturer shall provide all fittings. Fittings for Type 46D pipe shall conform to ASTM F 949.

203.00-22

PIPE AND RELATED MATERIALS

203.20.06 COATINGS, ENCASEMENTS, LININGS AND PAVINGS. This Subsection intentionally left blank.

203.20.07 JOINTS. Pipe shall be configured such that it can be joined on the project site with integrally-formed bell and spigot gasketed connections. The manufacturer shall provide documentation showing no leakage when gasketed pipe joints are tested in accordance with ASTM D 3212. Elastomeric seals (gaskets) shall conform to ASTM F 477. Gaskets shall have a double fluted cross section. Gaskets shall be protected from damage during shipping, handling and storage. Appropriate lubricant shall be supplied by the manufacturer.

203.20.08 REPAIR. Pipe that does not conform to the referenced standards shall not be used.

203.21 CENTRIFUGALLY CAST FIBERGLASS REINFORCED POLYMER MORTAR (CCFRPM) PIPE.

203.21.01 DESCRIPTION. This Subsection covers pipe constructed from fiberglass reinforced polymer mortar. Pipe covered by this Subsection is intended for use in sanitary sewers, drainage applications, and other conveyance systems. CCFRPM pipe conforming to ASTM D 3262, or as modified herein, may be used for direct bury installation, jacking installation, and sliplining installation in gravity service applications. CCFRPM pipe conforming to ASTM D 3754, or as modified herein, may be used in pressure applications.

The material type, strength designation, nominal diameter and dimensions of the pipe to be furnished shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications. Unless otherwise specified, pipe shall be manufactured by the centrifugal casting process.

203.21.01.01 Nominal Diameter. Nominal diameter is defined as the minimum inside diameter of the pipe which shall be within plus or minus 5% of the specified diameter.

203.21.02 IDENTIFICATION. Each section of pipe and fittings shall, at a minimum, be clearly marked such that the date, manufacturer, plant location, material type, strength designation and nominal diameter can be readily identified.

203.21.03 MATERIALS. Materials used in the manufacture of CCFRPM shall conform to ASTM D 3262, and ASTM D 3754 and shall have a minimum cell class 123 (Type 1, Liner 2 and Grade 3).

203.21.03.01 Resin Systems: Only isophthalic polyester resin systems with a proven history of performance in this particular application shall be used. A reference list of projects constructed in the United States with a combined minimum total footage total of 3,500,000 lineal foot of pipe with a diameter of 36 Inches or greater conveying gravity sanitary and/or storm flow shall be provided as part of the submittals.

203.21.03.02 Glass Reinforcement: The reinforcing glass fibers used shall be of the highest quality commercial grade E-glass filaments with binder and sizing compatible with impregnating resins.

203.21.03.03 Silica Sand: Sand shall be minimum 98% silica with a maximum moisture content of 0.2%.

203.21.03.04 Additives: Resin additives, such as curing agents, pigments, dyes, fillers, and thixotropic agents, when used, shall not detrimentally affect the performance of the product. No dyes and or fillers are allowed in the liner resin. Liner should be free of colorants to allow for field inspection by the owner representative.

203.21.04 FABRICATION. Fabrication of the pipe shall conform to ASTM D 3262 with Cell Limits Type 1, liner 2, Grade 3 and Pipe Stiffness Class C or higher. CCFRPM pipe shall have been fabricated within the six month period prior to installation.

203.21.04.01 Interior Corrosion Barrier. CCFRPM pipe liner shall be a non-reinforced layer of nominal 0.040 Inches flexibilized polyester resin with minimum 50% elongation. No fiberglass material in the form of glass fabrics, glass veils or tapes shall be allowed in the construction or reinforcement of the liner layer.

203.21.04.02 Exterior UV Protection Layer. The layer shall be comprised of a 90% sand and 10% resin by volume without any fiberglass surface tapes placed over or within the UV layer.

203.21.05 FITTINGS. Fittings shall be capable of withstanding all operating conditions when installed. They may be contact molded or manufactured from mitered sections of pipe joined by glass-fiber-reinforced overlays. Properly protected standard ductile iron, fusion-bonded epoxy coated steel and stainless steel fittings may also be used.

203.21.06 COATINGS, ENCASEMENTS, LININGS AND PAVINGS. When approved by the Agency or Design Engineer, coatings may be used on CCFRPM pipe. All coatings, internal or external applications shall be applied per the manufacturer's recommendations.

203.21.07 JOINTS. The type of joint to be used shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.21.07.01 Direct Bury – Gravity Service. The joint shall be field connected with fiberglass sleeve couplings which use built-in double-fin elastomeric sealing gaskets made of Ethylene Propylene Diene Monomer (EPDM) rubber compound. The joints shall conform to ASTM D 4161. The joint shall withstand 200 feet of external head pressure.

203.21.07.02 Jacking – Gravity Service. The joint shall be field connected with fiberglass sleeve couplings or bell-spigot joints which use elastomeric sealing gaskets made of EPDM. The joints shall conform to ASTM D 4161.

203.21.07.03 Sliplining – Gravity Service. The joint shall be field connected with low-profile, fiberglass bell-spigot joints or flush fiberglass bell-spigot joints which use elastomeric sealing gaskets made of EPDM. The joints shall conform to ASTM D4161.

203.21.07.04 Pressure Service. The joints shall be field connected with fiberglass sleeve couplings which use elastomeric sealing gaskets made of EPDM rubber compounds. All gaskets shall act as the sole means to maintain joint watertightness. The joints shall conform to ASTM D 4161.

203.21.08 REPAIR. This Subsection intentionally left blank.

203.22 STEEL REINFORCED HIGH DENSITY POLYETHYLENE (SRHDPE) PIPE.

203.22.01 DESCRIPTION. This Subsection covers pipe, fittings, gaskets and related appurtenances manufactured from galvanized steel reinforced, high density polyethylene. SRHDPE pipe is intended for sanitary sewer, drainage applications, and other conveyance systems.

The material type, joint designation, nominal diameter, and dimensions of the pipe, appurtenances and fittings to be furnished shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.22.01.01 Nominal Diameter. Nominal diameter is defined as the minimum inside diameter of the pipe with allowance for manufacturing tolerance per ASTM F 2562.

203.22.02 IDENTIFICATION. Each length of pipe shall, at a minimum, be clearly marked such that the ASTM designation, nominal pipe size, pipe stiffness class, manufacturer's name, manufacturer's production code and date of manufacture can be readily identified.

203.22.03 MATERIALS. Materials used in the manufacture of SRHDPE pipe and fittings shall conform to the following requirements:

203.22.03.01 ASTM D 3350. SRHDPE pipe and fittings shall be manufactured from virgin, high density polyethylene, stress-rated resins conforming to the minimum requirements of cell classification 345464 C as defined in ASTM D 3350.

203.22.03.02 ASTM F 2562. SRHDPE Pipe and fittings shall be manufactured and/or fabricated in accordance with ASTM F 2562. Galvanized steel ribs shall be completely encased within the polyethylene profile. SRHDPE pipe shall have a smooth waterway wall and ribbed exterior profile.

203.22.04 FABRICATION. Pipe fittings shall be welded from SRHDPE pipe components or solid wall high density polyethylene pipe components. Pipe fittings shall conform to ASTM F 2562. Perforated pipe shall be as designated on the plans, Special Provisions and/or Special Technical Specifications.

203.22.05 FITTINGS. All fabricated fittings and couplings shall be fabricated to ensure no loss of structural integrity or watertightness at welded seams and joints for watertight applications. Only those fittings supplied by or recommended by the manufacturer shall be used. Pipe fittings shall conform to ASTM F 2562.

203.22.06 COATINGS, ENCASEMENTS, LININGS AND PAVINGS. This Subsection intentionally left blank.

203.00-24

PIPE AND RELATED MATERIALS

203.22.07 JOINTS. Pipe shall be configured such that it can be joined on the project site using bells and spigots especially designed for SRHDPE pipe. Both the bell and the spigot shall conform to ASTM D 3212 and shall be watertight. Steel reinforcement within the bell and spigot shall be an integral part of the manufacturing process.

203.22.07.01 Gaskets. Gaskets shall be those designed for SRHDPE pipe and shall conform to ASTM F 477.

203.22.08 REPAIR. Pipe that does not conform to the referenced standards shall not be used.

203.23 CURED-IN-PLACE PIPE (CIPP)

203.23.01 DESCRIPTION. This Subsection covers sewer pipe rehabilitation using cured-in-place pipe (CIPP) conforming to ASTM F 1216 and/or ASTM F 1743 as applicable and as specified on the plans or in the Special Provisions and/or Special Technical Specifications.

The material type, ASTM designation, wall thickness, nominal diameter and dimensions of the pipe to be furnished shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.23.02 IDENTIFICATION. Each section of fabric tubing shall, at a minimum, be clearly marked such that the internal circumference, length, and all applicable ASTM numbers can be readily identified.

203.23.03 MATERIALS. Materials used in the manufacture of CIPP shall conform to the requirements of ASTM F1216 and/or ASTM F1743, as applicable.

203.23.03.01 Resin. Resin shall be compatible with the CIPP system used and resistant to high hydrogen sulfide environment. Resin shall be an unsaturated polyester and tinted for adequate visibility suitable for internal inspection and provide positive indication of adequate liner wet-out.

203.23.04 FABRICATION. Fabrication of the pipe shall be in accordance with ASTM F1216 and/or ASTM F1743 as applicable.

203.23.05 FITTINGS. This Subsection intentionally left blank.

203.23.06 COATINGS, ENCASEMENTS, LININGS, AND PAVINGS. This Subsection intentionally left blank.

203.23.07 JOINTS. Joints at pipe ends (end seal) and connections shall use epoxy sealing or connection liner material compatible with the liner.

203.23.08 REPAIR. Pipe that does not conform to the referenced standards shall not be used.

203.24 STEEL RIBBED POLYETHYLENE (SRP) PIPE.

203.24.01 DESCRIPTION. This Subsection covers pipe, fittings, gaskets and related appurtenances manufactured from zinc coated galvanized steel sheets with an exterior polymer film polyethylene liner. Pipe covered by this Subsection is intended for use in sanitary sewer, drainage applications, and other conveyance systems.

The material type, joint designation, nominal diameter, and dimension of the pipe, appurtenances and fittings to be furnished shall be shown on the plans or specified in the Special Provisions and/or Special Technical Specifications.

203.24.01.01 Nominal Diameter. Nominal diameter is defined as the minimum inside diameter of the pipe with allowance for manufacturing tolerance per ASTM A 978.

203.24.02 IDENTIFICATION. Each length of pipe, appurtenances, and fittings shall, at a minimum, be clearly marked such that the ASTM designation, the nominal pipe size, the pipe stiffness class, the manufacturer's name, the manufacturer's production code, and the date of manufacture can be readily identified.

203.24.03 MATERIALS. Materials used in the manufacture of SRP pipe and fittings shall conform to ASTM A 978.

203.24.04 FABRICATION. Fabrication of the pipe shall conform to ASTM A 978 and as required by the Special Provisions and/or Special Technical Specifications.

203.24.05 FITTINGS. All fabricated fittings and couplings supplied by the manufacturer shall be fabricated to ensure no loss of structural integrity or watertightness at welded seams and joints for watertight applications. Only those fittings supplied by or recommended by the manufacturer shall be used. Pipe fittings shall conform to ASTM A 978.

203.00-26

PIPE AND RELATED MATERIALS

203.24.06 COATINGS, ENCASEMENTS, LININGS, AND PAVINGS. This Subsection intentionally left blank.

203.24.07 JOINTS. Joints shall be watertight.

203.24.08 REPAIR. This Subsection intentionally left blank.

204.00-1

MANHOLES AND CATCH BASINS

204.01 DESCRIPTION. This section covers the quality of materials used in the construction of manholes and catch basins, both precast and cast-in-place.

204.02 CONSTRUCTION. Except for precast sections, manholes, manhole bases, and catch basins shall be constructed in accordance with all the requirements of Section 311 – “Concrete Structures and Masonry Structures.”

204.02.01 Manhole Bases. Manhole bases shall be cast-in place, except that precast manhole bases may be used with the approval of the Engineer.

- a) Inverts. Invert channels shall be smooth and accurately shaped as detailed on the drawings. Invert channels may be formed directly in the freshly poured concrete, or may be constructed by laying the pipe through the manhole and breaking out the top of the pipe. All concrete shall be troweled smooth to prevent obstruction of the waterway channel. All working areas shall be medium broom finish.
- b) Precast Bases. When approved by the Engineer, precast bases manufactured in accordance with ASTM C 478 may be used.

204.02.02 Manhole Shafts. Manhole shafts shall be constructed from:

- a) Precast Shafts. Precast shafts may be constructed of precast concrete riser sections manufactured in accordance with ASTM C 478. Precast riser section joints shall be sealed with preformed mastic joint sealants in accordance with these Specifications.
- b) Cast-in-Place. Cast-in-place manholes shall be constructed in accordance with Section 311 – “Concrete Structures and Masonry Structures.”

204.02.03 Cast Iron Frame and Cover. Manhole cast iron frames shall be set in full concrete beds unless otherwise shown on the Plans. Frames shall be set such that the cover or grate will set accurately to the final elevations as indicated on the Plans.

204.02.04 Cleaning. All manholes and catch basins shall be thoroughly cleared of any accumulation of silt, debris, or foreign matter of any kind, and shall be clear of such accumulations at the time of final acceptance.

204.03 MATERIALS

204.03.01 All concrete for manholes and catch basins shall be constructed of Portland Cement Concrete with materials conforming to Section 202 – “Portland Cement Concrete.”

204.03.02 Precast Manhole Components. All precast concrete manhole and catch basin components shall conform to the requirements of ASTM C 478.

204.03.03 Cast Iron Frame and Cover. Gray iron frame and cover castings shall conform to ASTM designation A48, Class 35B. The cover and frame shall be machined so that the cover may be rotated to any position in the frame and maintain a satisfactory seat. Manhole frames and covers shall be traffic rated 24 inch cast iron frame and cover No. A-1032 for vented application or No. A-1024 for non-vented application, both as provided by D&L Supply, Provo, Utah, or approved equal, unless otherwise specified in the project documents.

204.03.04 Catch Basin Castings. Gray iron catch basin castings shall conform to Section 204.03.03 above, with the following exceptions: frames and grates shall be constructed in a manner provided the interchanging of frame and grate castings without having to perform any grinding or other work to prevent working of the grate as it rests in the frame.

MANHOLES AND CATCH BASINS

204.00-2

204.03.05 Steps. Steps shall be required as directed by the Engineer. Steps shall be M.A. Industries, Peachtree, Georgia, polyethylene coated and steel reinforced, or approved equal, or as indicated in the project documents. Steps shall meet the minimum specification requirements of ASTM C 478.

204.04 MEASUREMENT OF QUANTITIES AND BASIS OF PAYMENT. Work shall be compensated for in accordance with the unit prices per each or per vertical foot as established in the Contract Documents, unless otherwise specified.

205.01 DESCRIPTION. This section describes the quality of water necessary for the construction of earth embankments, preparation of cement concrete or soil-cement mixtures, and for wetting backfill, subgrade, and gravel base and surfacing courses.

205.02 MATERIALS REQUIREMENTS. All water for embankments, backfill, subgrade, landscaping, gravel base and surface courses, cement concrete curing, and concrete shall be clean and free from excessive amounts of acids, alkali, oil, vegetable matter, and other deleterious substances and shall be subject to the approval of the Engineer.

Additionally, all water for use in concrete shall meet the requirements of the Nevada State Highway Department, Standard Method of Test for Quality of Water to be used in Concrete Test Method No. Nev. T506. Water which is suitable for drinking or ordinary household use may be accepted for use without being tested.

206.01 DESCRIPTION. This section covers the quality of bar steel, fabricated reinforcement, and welded steel wire used in the reinforcement of concrete for street and highway structures.

206.02 REQUIREMENTS

206.02.01 Defects. Metal reinforcement, except prestressing steel, with rust, mill scale, or a combination of both shall be considered as satisfactory, provided the minimum dimensions, including height of deformations and weight of a hand wire brushed test specimen, are not less than the applicable ASTM specification requirements.

206.03 MATERIALS, PHYSICAL PROPERTIES AND TESTS

206.03.01 Bar Steel Reinforcement. This steel shall conform to the applicable following requirements:

Test	Test Method	Requirements
Deformed Billet-Steel Bars for Concrete Reinforcement	ASTM A 615	Grade 40, 60
Axle-Steel Deformed Bars for Concrete Reinforcement	ASTM A 617	Grade 40, 60
Spiral Reinforcement	ASTM A 615	Grade 60

206.03.02 Fabricated Steel Bar or Rod Mats Reinforcement. This steel shall conform to the requirements of ASTM A 184.

206.03.03 Welded Steel Wire Fabric Reinforcement. This steel shall conform to the requirements of ASTM A 185.

206.03.04 Prestressing Steel. Prestressing steel shall be high-tensile wire conforming to ASTM Designation A421, high-tensile wire strand conforming to ASTM Designation A416 or uncoated high-strength steel bars conforming to the following requirements:

	Plain Bars		Deformed Bars
	Grade 145	Grade 160	Grade 150
Ultimate tensile strength, p.s.i.	145,000	160,000	150,000 ⁶
Yield Strength, p.s.i.	130,000 ²	140,000 ²	120,000 ^{1,6}
Elongation, min. percent	4 ³	4 ³	7 ⁴
Reduction in area, min. percent	20 ⁵	20 ⁵	20 ^{6,7}
Modulus of Elasticity at 70 percent of guaranteed ultimate strength, min. p.s.i.	25x10 ⁶	25x10 ⁶	25x10 ⁶

1. Measured at 0.2 percent offset.
2. Measured at 0.7 percent extension under load method.
3. Measured at 20 bar diameters.
4. Measured in 10 bar diameters or 8 inch minimum.
5. Based on nominal area.
6. Based on effective area which is determined from the bar weight less 31/2 percent for the ineffective weight of the deformations.
7. For deformed bars, the reduction of area shall be determined from a bar from which the deformations have been removed. Such a bar shall be machined no more than necessary to remove the deformations over a length of 12 inches, and reduction will be based on the area of the machined portion.

Dimensions and Weights of High Strength Bars

Nominal Diameter Inch ¹	Nom. Wt. Lb./ft.	Nom. Area In. ²	Nom. Wt. Lb./ft.	Eff. Area In. ²
5/8			0.98	0.28
3/4	1.50	0.44	1.49	0.42
7/8	2.04	0.60		
1	2.67	0.78	3.01	0.85
1 1/8	3.38	0.99		
1 1/4	4.17	1.23	4.49	1.25
1 3/8	5.05	1.48	5.56	1.58

1. The maximum variation in diameter of a plain bar shall not exceed +0.030, -0.010 inch from the nominal diameter.
2. The maximum variation in weight for deformed bars shall not exceed +3.0 percent or -2.0 percent of the nominal weight for the respective bar size.

Both plain and deformed bars shall show no evidence of cracking after being bent 90 degrees around a pin. For bars 5/8 inch diameter through 1 1/8 inch diameter, the pin diameter shall be six times the bar diameter. For 1 1/4 inch and 1 3/8 inch diameter bars the pin diameter shall be eight times the bar diameter.

The bend test shall be made when the steel is between 60 degrees and 80 degrees F. The bending apparatus shall provide a continuous and uniform application of force throughout the duration of the bending operation, unrestricted movement of the specimen at the points of contact, and close wrapping of the specimen around the pin or mandrel during the bending operation.

All bars in any individual member shall be of the same grade, unless otherwise permitted by the *Engineer*.

When bars are to be extended by the use of couplers, the assembled units shall have a tensile strength of not less than the manufacturer's minimum guaranteed ultimate tensile strength of the bars. Failure of any one sample to meet this requirement will be cause for rejection of the heat of bars and lot of couplers. The location of couplers in the member shall be subject to approval by the *Engineer*.

Wires shall be straightened, if necessary, to produce equal stress in all wires or wire groups or parallel lay cables that are to be stressed simultaneously or when necessary to insure proper positioning in the ducts.

Where wires are to be button-headed, the buttons shall be cold formed symmetrically about the axis of the wires. The buttons shall develop the minimum guaranteed ultimate tensile strength of the wire. No cold forming process shall be used that causes indentations in the wire. Button-heads shall not contain wide open splits, more than two splits per head, or splits not parallel with the axis of the wire.

Sampling and testing shall conform to the specifications of ASTM Designation A 416 and ASTM Designation A 421 and as specified below.

Samples from each size and each heat of prestressing bars, from each manufactured reel of prestressing steel strand, from each coil of prestressing wire, and from each lot of anchorage assemblies and bar couplers to be used shall be furnished for testing if required by the *Engineer* or Contract Documents. With each sample of prestressing steel wires, bars, or strands furnished for testing, there shall be submitted a certification stating the manufacturer's minimum guaranteed ultimate tensile strength of the sample furnished.

All materials for testing shall be furnished by the *Contractor* at his expense. The *Contractor* shall have no claim for additional compensation in the event his work is delayed awaiting approval of the materials furnished for testing.

All bars of each size from each mill heat, all wire from each coil, and all strand from each manufactured reel to be shipped to the site shall be assigned an individual lot number and shall be tagged in such a manner that each such lot can be accurately identified at the job site. Each lot of anchorage assemblies and bar couplers to be installed at the site shall be likewise identified. All unidentified prestressing steel, anchorage assemblies or bar couplers received at the site will be rejected.

The following samples of materials and tendons, selected by the *Engineer* from the prestressing steel at the plant or job site, shall be furnished by the *Contractor* to the *Engineer* well in advance of anticipated use:

- a) For wire, strand, or bars, one 5 foot long sample of each size shall be furnished for each heat and pack or reel.
- b) If the prestressing tendon is to be prefabricated, one completely fabricated prestressing tendon 5 feet in length for each size of tendon shall be furnished, including anchorage assemblies. If the prestressing tendon is to be assembled at the job site, sufficient wire or strand and end fittings to make up one complete prestressing tendon 5 feet in length for each size of tendon shall be furnished, including anchorage assemblies.
- c) If the prestressing tendon is a bar, one 5-foot length complete with one end anchorage shall be furnished and in addition, if couplers are to be used with the bar, two 4-foot lengths of bar equipped with one coupler and fabricated-to-fit coupler shall be furnished.

Before being allowed to use, the proposed prestressing system must have prior approval by the *Engineer*. Approval of new prestressing systems will be contingent on prequalification testing by the *Contractor*, at his expense, of complete tendon assemblies as proposed for the use and the submittal of written information as may be requested by the *Engineer*.

For prefabricated tendons, the *Contractor* shall give the *Engineer* at least 10 days notice before commencing the installation of end fittings installations and wire headings while such fabrication is in progress at the plant and will arrange for the required testing of the material to be shipped to the site.

No prefabricated tendon shall be shipped to the site without first having been released by the *Engineer*, and each tendon shall be tagged before shipment for identification purposes at the site. All unidentified tendons received at the site will be rejected.

Job site or site, as referred to herein, shall be considered to mean the location where members are to be manufactured whether at the bridge site or a removed casting yard.

The release of any material by the *Engineer* shall not preclude subsequent rejection if the material is damaged in transit or later damaged or found to be defective.

206.03.05 Cold Drawn Steel Wire for Spiral Reinforcement. This steel shall conform to the requirements of ASTM A 82.

207.01 DESCRIPTION. This specification covers the quality of structural steel used in highway structures.

207.02 REQUIREMENTS

207.02.01 Defects. Finished rolled material shall be free from cracks, flaws, injurious seams, laps, blisters, ragged and imperfect edges, and other defects. It shall have a smooth, uniform finish and shall be straightened in the mill before shipment.

Material shall be free from loose mill scale, rust pits, or other defects affecting its strength or durability.

The Engineer reserves the right to reject material which he deems unsuitable for the purpose intended even though the material meets the requirements of mill tolerances.

207.02.02 Charpy V-notch Test. All steels used in and designated as main load carrying members subject to tensile stress, shall comply with all the requirements specified for charpy v-notch test in the various AASHTO designations for the steels involved. Sampling and testing procedures shall be in accordance with the requirements of the applicable AASHTO Temperature Zone Designation as shown on the Contract Documents, but not less than the requirements of Zone 2.

207.03 MATERIALS, PHYSICAL PROPERTIES ,AND TESTS

207.03.01 Structural Steel

- a) Standard Steel. All steel for use in miscellaneous structures, unless otherwise noted, shall conform to the requirements of ASTM A 36.
- b) High Strength Low Alloy Columbium-Vanadium Steel. This steel shall conform to the requirements of ASTM A 572, Grade 50, and shall be other than rimmed or capped steel.
- c) High Strength Bolts. All bolts, nuts, and washers to be used in high-strength connections shall conform to the requirements of ASTM A 325.
- d) Stainless Steel Bolts. This steel shall conform to the requirements of ASTM A 276.
- e) Welded Seamless Steel Pipe. This steel shall conform to the requirements of ASTM A 53, Grade B.
- f) Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes. This steel shall conform to the requirements of ASTM A 500, Grade B.
- g) Shear Stud Connectors. Shear stud connectors shall conform to the requirements of ASTM A 108, Grade 1015 or 1020. Flux retaining caps shall be low carbon grade suitable for welding and shall conform to the requirements of ASTM A 109.
- h) Pins and Rollers. Pins and rollers 9 inches or less in diameter shall be formed and heat treated or cold finished carbon-steel shafting. Pins or rollers more than 9 inches in diameter shall be forged and heat treated in accordance with the requirements of ASTM A 235.
- i) Bolts. All bolts, nuts, and washers not intended for high-strength connections shall conform to ASTM A 307.

- j) Structural Steel. Unless otherwise noted on the Plans, all structural steel for use in main load carrying members of bridge structures shall conform to the requirements of ASTM A 36. Bridge elements typically not considered as main load carrying members include: crossframes, diaphragms, wind bracing, stiffeners, gusset plates, bearing plates, and expansion assemblies.
- k) High Strength Low Alloy Steel. This steel shall conform to the requirements of ASTM A 588.
- l) High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding. This steel shall conform to the requirements of ASTM A 514
- m) High-Yield-Strength, Alloy Steel Plates, Quenched and Tempered for Pressure Vessels. This steel shall conform to the requirements of ASTM A 517.

208.01 TIMBER

208.01.01 Description. This section covers the quality requirements for structural timber, lumber, guardrail posts, markers, and miscellaneous items.

208.01.02 Grades. Grades furnished shall be as noted on the Plans or in the Special Provisions.

208.01.03 Certificates of Inspection. Inspection certificates shall be furnished without extra charge with each shipment of timber. These certificates shall be issued by the inspection agency under whose rules the material was manufactured and graded.

208.01.04 Species. The standard commercial and botanical names recognized by these Specifications are described as follows:

<u>Standard Commercial Name</u>	<u>Botanical Name</u>
Cedar, Port Orford	Chamaecyparis lawsoniana
Fir, Douglas (coast)	Pseudotsuga taxifolia (coast type)
Fir, Douglas (inland)	Pseudotsuga taxifolia (inter-mountain type)
Hemlock, West Coast	Tsuga Heterophylla
Larch	Larix Occidentalis
Redwood, California	Sequoia sempervirens

208.01.05 Grades. Structural timber and lumber shall meet the requirements for the numerical stress shown on the Plans, or as may be otherwise specified, when graded by rules developed in accordance with AASHTO M168, or the grading rules of any other lumber grading agency approved by the Engineer. Any commercial grading rules that will provide material of an equal or greater stress value may be used.

The West Coast Lumber Inspection Bureau and the Western Wood Products Association grading rules shall be included as grading rules which may be used. Grading rules in effect of the date of advertisement of bids shall govern.

Guardrail posts and blocks shall meet the following requirements:

Douglas fir or Western Larch shall conform to the requirements for "No. 1 Structural" grade as set forth in paragraph 131(b) of the grading rules of the West Coast Lumber Inspection Bureau of paragraph 80.11 of the grading rules of the Western Wood Products Association.

208.02 PRESERVATIVE TREATMENTS FOR TIMBER

208.02.01 General. This work shall consist of preservative treatment for lumber, timber, and piles as herein specified.

208.02.02 Materials. The materials used shall be those prescribed for the several items which constitute the finished work and shall comply with all the requirements for such materials as set forth in these Specifications.

208.02.03 Treatment. All structural timber, piling, and other lumber shall be thoroughly seasoned or conditioned before treatment by air seasoning, kiln drying, steaming, or heating in the preservative, either at

atmospheric pressure or under a vacuum, or by a combination thereof that will not cause damage. The moisture remaining in the wood prior to treatment shall be reduced so that the injection and proper distribution of the required amount of preservative will be obtained. The method of seasoning, conditioning and treating used shall conform to the requirements of the American Wood Preservers Association or ASTM D 1760.

208.02.04 Amount of Preservative. The minimum amount of preservative retained per cubic foot of timber, lumber, or piling shall conform to the minimum specification requirements of the American Wood Preservers Association or ASTM D 1760.

Unless otherwise specified, material treated with pentachlorophenol shall have a minimum retention of 8 pounds unless it is to be painted, then 6 pounds will be the minimum retention.

Material to be treated with Ammoniacal Copper Arsenite shall have a net retention of dry salts of not less than 0.3 pound.

209.01 DESCRIPTION. This section covers the quality and types of materials used in the construction of fencing. All fencing materials shall be new and undamaged. All fencing materials shall comply with the current applicable standards, types, classes, sizes, and other related citations and supplemental requirements of this section and the corresponding drawings unless specifically otherwise required in the Bid Documents. All ferrous fencing materials shall be galvanized or have other coatings specified herein.

209.02 WIRE FENCING. This portion describes the requirements for materials necessary for wire fencing, including barbed wire (Type BW) and wire mesh (Type WM) fencing. These fence types are similar, with the exception of the fence fabric.

209.02.02 Metal Posts. Metal line posts for Type BW and Type WM fencing shall be “T “ type posts with anchor plate and clip type wire fasteners, conforming with either ASTM Designation A 702, Class B steel, or with Federal Specification RR-F-221/3. T-posts shall weigh not less than 1.3 pounds per lineal foot plus 0.67 pound for the anchor plate. Metal brace panel, end corner, and gate posts, when specified, shall be tubular steel posts conforming with Federal Specification RR-F-191/3 Class 1 Steel Pipe, Grade A or B. In addition, Class 1 Steel pipe Grade B shall be manufacturer certified to meet the following minimum performance criteria when subjected to salt spray testing in accordance with ASTM B 117:

- 1) Exterior – 1,000 hours exposure with maximum 5 percent red rust
- (2) Interior – 600 hours exposure with maximum of 5 percent red rust.

See Section 207.03.01 for additional requirements. Unless specified in the Plans, metal fence post colors are optional except that all posts on a project must be the same color.

209.02.03 Wood Posts and Braces. Round posts and braces shall be peeled to remove all outer bark and all inner cambium bark, except that occasional strips of inner bark may remain if not over 1/2 inch wide or 3 inches long. All knots shall be trimmed flush with the sides, spurs and splinters removed, and ends cut square. All dimension requirements shall exclude bark.

Line and brace posts shall have small end diameters between 3 1/2 and 6 inches, a maximum taper of 2 1/2 inches, and a minimum mid-length diameter of 4 inches. The maximum deflection in any plane on the long axis of a post shall be 2 inches. Sawn square posts shall have a minimum dimension of 3.5 inches and a maximum of 6 inches. Sawn posts shall be Grade No. 2 or better.

WOOD POST LENGTHS

<u>Nominal Height Top Wire Above Ground</u>	<u>Nominal Post* and Brace Length</u>
42 inches	78 inches
50 inches	84 inches

*Post lengths shall be not more than 1 inch less nor 2 inches more than nominal. The average length shall not be less than nominal.

209.02.03.01 Untreated Wood Posts. Untreated wood posts and braces shall be Juniper, Redwood, or Western Red Cedar.

209.02.03.02 Treated Wood Posts. Treated wood posts and braces shall be Douglas Fir, Hem-Fir, Yellow Pine, Lodge Pole Pine, or Larch, except that Lodge Pole is acceptable for line posts only.

Warning: Designers and Contractors are cautioned that all of the following specified alternate treatment materials are currently classified as either possible carcinogens or carcinogens. All are classified as “Restricted

Use Pesticides." Certain health risks exist for handlers and installers, other persons, and birds and animals, dependent on levels of exposure. EPA Report PD-4 elaborates. Product-specific consumer information sheets summarize site use and handling precautions. Designers and Contractors are directed to familiarize themselves and comply with current regulations and bulletins prior to specifying use and/or handling of these products.

All treatment shall conform with Federal Specification FS-TT-W-00571 in addition to specific citations. All treated posts shall either have a treatment plant stamp identifying the species, grade, and treatment, or load specific AWPAs approved treatment plant certification of compliance with applicable standards herein.

- a) Creosote. The creosote method is acceptable only for butt-end treatment of split Western Red Cedar, unless otherwise stated on the drawings. Grade 1 coat tar creosote (conforming to AWPAs P2) shall be applied in accordance with Federal Specification No. YY-W-00571, Table I and Parts 3 and 4, and AWPAs C5 minimum net retention of preservative shall be 6 pounds per cubic foot, using the empty-cell pressure treating process.
- b) Pentachlorophenol. Five percent pentachlorophenol solution (conforming to AWPAs P8) in petroleum (conforming to AWPAs P9 Type A) shall be applied as prescribed in Federal Specification No. TT-W-00571, Table II and Parts 3 and 4, and AWPAs C5. Minimum net retention of preservative shall be 0.3 pound per cubic foot by assay using the empty-cell pressure treating process.
- c) Ammoniacal Copper Arsenate. Ammoniacal Copper Arsenate (conforming to AWPAs P5) shall be applied as prescribed in Federal Specification No. TT-W-00571. Minimum net retention of dry salts shall be 0.3 pound per cubic foot or wood.
- d) Chromated Copper Arsenate. Chromated Copper Arsenate waterborne preservative (conforming to Types A, B, and C in AWPAs P5) shall be applied as prescribed in Federal Specification No. TT-W-00571, Table I and Parts 3 and 4. Minimum net retention of solid preservative shall be 0.4 pound per cubic foot (gauge only) using the full-cell pressure treating process.

209.02.04 Wire and Miscellaneous Fasteners

209.02.04.01 Fence Wire

- a) Barbed Wire. Barbed wire shall conform to ASTM Designation A 121, Class 1 coating. It shall consist of two strands of 12 1/2 gauge (0.010 inch) wire, twisted with 2-point, 14 gauge barbs at not more than 4 inch intervals.
- b) Barbless Wire. Barbless wire for wildlife accommodation (normally top and/or bottom stands are to be used only when and where specifically required on the Plans. Used for Type BW and Type WM fences, this wire consists of 2-strand twisted, 12 1/2 gauge (0.010 inch) galvanized wire. Wire shall be zinc coated with not less than 0.3 ounces of zinc per square foot or coated surface area (Class 1 coating) and have a minimum tensile breaking strength of 950 pounds force. Wire shall conform with Federal Specification RR-F-221/1.

209.02.04.02 Woven Wire Mesh. Galvanized woven wire shall conform to the requirements of ASTM A116, Class 1 or better coating, No. 12 1/2 farm. Heights shall be specified, except that where unspecified, it shall be designation 832-06 12 1/2 (32 inch height, 6 inch wide mesh.)

209.02.04.03 Miscellaneous Fasteners. Miscellaneous accessories including spikes, nails, and staples shall be galvanized.

- a) Staples shall be made from No. 9 gauge (0.148 inch) galvanized wire, U-shaped (stronghold) type, and length shall be not less than 1 3/4 inches.

- b) Nails shall be galvanized 40 d to 60 d, dependent on installation application.
- c) Steel dowels, 3/8 inch x 4 inch length, may be fabricated from steel rebar or rod stock and need not be galvanized.
- d) Miscellaneous wire applications including optional (nonbarbed) diagonal brace wire, deadman anchors, and other related uses shall be smooth galvanized 9 gauge steel wire meeting Federal Specification RR-F-221/1, Type I, Class I, with not less than 0.4 ounce zinc per square foot of coated surface.
- e) Fence wire stays shall be single member twisted smooth 9 gauge galvanized steel wire manufactured specifically for this application.
- f) Wire fasteners shall be galvanized steel wire clip style as normally furnished with T-Type steel fence posts (see Section 207.02.02) and manufactured for the specific purpose. The nominal gauge is 11 (0.120 inch).
- g) Miscellaneous gate hardware. All metal gate hinges, latches, and related accessories, shall be galvanized at not less than 1.2 ounces zinc per square foot coated surface. All gate latches shall be outfitted to permit padlocking with common commercial grade padlocks. Swing driveway gates shall have semi-automatic outer latches to secure the gate in an open position. All wire gates (Missouri type unframed) shall be fitted with galvanized or rust inhibiting painted mechanical lever/latch style closures with high leverage and low release impact potential. Submittals are required.
- h) Gate Reflectors. Gate reflectors shall be circular and a minimum of 4 inches in diameter. The reflective surface shall be red glass or plastic. The reflectors shall be designed for exterior use and rated for extended sunlight (UV) exposure and SAE approved. The reflectors shall have holes or other attachment configurations permitting secure attachment to barbed and barbless fence wire, wire mesh and chain link fence fabric. Fasteners shall be not less than two hog rings, 11 gauge galvanized tie wire, or equivalent. Submittals are required.

209.02.04.04 Electrical Grounding

- a) Ground Rods. Grounding rods shall be copper coated rods, 8 feet in length, and a minimum of 1/2 inch in diameter, manufactured for this purpose. Ground wire shall be Number 6 solid copper wire or 5 gauge steel wire.

209.03 CHAIN LINK FENCING. This portion describes the requirements for chain link fencing materials.

209.03.01 Metal Posts, Rails, and Braces. All metal posts, rails, and braces shall meet the following requirements. Federal Specification RR-F-191/3 Class 1, Steel Pipe, Grade A or B; Class 3 Formed Steel Sections; or Class 4, Steel H-sections. In addition, Class 1, Steel Pipe, Grade B, shall be manufacturer certified to meet the following minimum performance criteria when subjected to salt spray testing in accordance with ASTM B 117:

- 1) Exterior – 1,000 hours exposure with maximum 5 percent red rust;
- (2) Interior – 600 hours exposure with a maximum 5 percent red rust.

For slatted chain link fence 72 inches and less in height use 2.38 inch O.D. x 3.65 pounds for line posts and 2.88 inch O.D. x 5.79 pounds for end, corner, slope and gate posts (6 foot or shorter gate leaves) and 1.62 inch O.D. x 2.27 pound top rail and braces.

STEEL POSTS, RAIL AND BRACES

<u>Use</u>	Nominal Type & Size <u>Inches</u>	Actual O.D. <u>Inches</u>	<u>Grade A</u>		<u>Grade B</u>	
			Weight <u>lb/LF</u>	Wall Tnkns <u>Inches</u>	Weight <u>lb/LF</u>	Wall Tnkns <u>Inches</u>
Fences 72 inches or less in height; line posts for fences 72 inches or less in height	1 1/2 inch Pipe 1.88 inch x 1.62 inch H 1.88 inch x 1.62 inch FS	1.90	2.72 2.80 2.40	0.148	2.28	0.120
End, corner, slope and gate posts for single gates 6 feet or less in width and double gates 12 feet or less in width for fences 72 inches or less in height	2 inch Pipe 3.5 inch x 3.5 inch FS	2.375 5.10	3.65	0.157	3.12	0.130
Fences higher than 72 inches; line posts for fences higher than 72 inches	2 inch Pipe 2.25 inch x 1.88 inch H 2.25 inch x 1/70 inch FS	2.375 –	3.65 3.43 2.78	0.157 –	3.12 –	0.130 –
End, corner, slope and gate posts for single gates 6 feet or less in width and double gates 12 feet or less in width for fences higher than 72 inches	2 1/4 inch Pipe 3.5 inch x 3.5 inch FS	2.875 5.10	5.79	0.207	4.64	0.160
All fence heights top rails and braces	1 1/4 inch Pipe 1.52 inch x 1.25 inch H	1.660 –	2.27 2.20	0.143 –	1.83 –	0.11 –

STEEL POSTS, RAIL AND BRACES (cont)

<u>Use</u>	Nominal Type & Size <u>Inches</u>	Actual O.D. <u>Inches</u>	<u>Grade A</u>		<u>Grade B</u>	
			Weight <u>lb/LF</u>	Wall Tnks <u>Inches</u>	Weight <u>lb/LF</u>	Wall Tnks <u>Inches</u>
Gate posts for single swing gates over 6 feet but not over 13 feet in width and double swing gates over 12 feet but not over 26 feet in width or for all slide gates with leaves larger than 6 feet	3 1/2 inch Pipe	4.0	9.11	0.231	—	—
	3 inch Pipe	3.5	—	—	5.71	—
Gate posts for singleswing gates over 13 feet but not over 18 feet in width and double swing gates over 26 feet but not over 36 feet in width	6 inch Pipe	6.625	18.97	0.286	—	—
Frames for gates and stiffeners for gates	1 1/2 inch Pipe	1.900	2.72	0.148	2.28	0.120

Note: "H" identifies steel H-section; "FS" identifies formed steel section.

209.03.02 Chain Link Fencing Fabric. All chain link fencing fabric shall meet the following requirements: Federal Specification RR-F-191/1 Type I, zinc coated, or ASSHTO Designation M 181, Type I with Class A coating. Fence with fabric height of 72 inches or less shall be 11 gage. Fabric heights over 72 inches shall be 9 gage. The fabric edges shall be knuckled on top and barbed on bottom edges, unless otherwise specified, except that fencing for schools and playgrounds shall be knuckled on both selvages.

PVC coated steel chain link fence fabric shall meet or exceed ASTM F 668, Class 2. The color shall be medium green unless otherwise specified. The core wire shall be the same as required for normal galvanized wire for the height required.

Slatted chain link fence fabric shall have either plastic or wood slats, depending on the Plans requirements. Plastic slats shall be virgin high density polyethylene with UV inhibitors, adequate color base for opacity, and tensile strength of 3500 p.s.i. or more in accordance with ASTM D 638. Slats shall fit the fabric adequately to firmly retain their position with an effective locking system. Installed slats shall not generate noise when exposed to wind. Slats shall be single members and lengths shall be slightly shorter than the fabric to preclude interference with top rails and fasteners. Slats shall be guaranteed/warranted for 20 years or more against color fade and brittle fracture. Wood slats shall be sound single members meeting the same fit criteria. Wood slats shall be stapled securely to fabric. Slat colors shall be forest green for plastic and rustic Redwood stain for wood slats unless otherwise specified. For plastic slats, wire gauge and mesh shall be the same as otherwise required for the application. Wood slats shall be provided only in 9 gauge chain link fabric with a mesh size of approximately 3 x 5 inches. When slats are required, all posts and braces shall be upgraded to the next larger equal quantity pipe size.

209.03.03 Miscellaneous Fittings and Appurtenances

Note: Some entries are identified as alternatives or options. Refer to the project Plans.

209.03.03.01 Fittings. All fittings shall be pressed steel or malleable or cast steel conforming with ASTM F 626 and Federal Specification RR-F-191/4 including galvanizing. Vinyl coating is required only when specified in the Plans. When required, vinyl coated quality and color shall match that specified for fence fabric.

- a) Post Caps. Galvanized pressed steel, malleable or cast steel and designed to fit snugly over posts to exclude moisture. Supply cone-type caps for terminal posts and loop-type for line posts.
- b) Rail and Brace Ends. Galvanized pressed steel or malleable or cast steel and cup-shaped to receive rail and brace ends.
- c) Top Rail Sleeves. Galvanized steel sleeves, equal in thickness to the top rail, not less than 6 inches to 7 inches long, expansion type. Swedged ends are acceptable also.
- d) Brace Brands. Galvanized pressed steel, 12 gauge (0.105 inch) thickness x 3/4 inch wide.

209.03.03.02 Truss Rods. Truss rods shall be galvanized steel 3/8 inch diameter rods, fitted with an equivalent strength turn buckle designed and manufactured for this application.

209.03.03.03 Tension Bars. Galvanized steel strip, not less than 5/8 inch wide x 3/16 inch thick.

209.03.03.04 Tension Bands. Galvanized pressed steel, not less than 14 gauge (0.080 inch) thickness x 3/4 inch wide.

209.03.03.05 Tension Wire. The bottom tension wire shall be at least 7 gauge (0.177 inch) coil spring steel of good commercial quality and shall be galvanized in accordance with the provisions of ASTM Designation A 116, Coating Class 3.

209.03.03.06 Tension Cable. Top tension cable shall be 3/8 inch diameter galvanized seven strand cable, conforming to the requirements of ASTM Designation A 475, common grade. Tension cable is required only when top rail is not utilized.

209.03.03.07 Hog Rings and Tie Wire. Hog rings and tie wire shall be not less than 11 gauge (0.120 inch) steel wire galvanized in conformance with ASTM Designation A 116, Class 3 coating or 9 gauge 1100 H4 aluminum alloy or better.

209.03.03.08 Security Fence

- a) Security Top Arms. Galvanized arms shall securely fasten to post tops and angle at 45 degrees from vertical, in the direction directed by the Engineer. Each arm shall be fabricated from pressed steel or malleable or cast steel, and include clips/slots necessary to rigidly attach three equally spaced double strand barbed wires. Each arm shall be capable of supporting a vertical load of 250 pounds at the outer barb attachment point without permanent deflection. All gates and posts shall be extended in height to permit equal level barbed wire attachment.
- b) Barbed Wire. Barbed wire shall conform to ASTM Designation A 121, Class 1 coating. It shall consist of two strands of 12 1/2 gauge wire, twisted with 4-point 14 gauge barbs at not more than 5 inch intervals.

209.03.04 Gates. Chain link gates shall conform with the requirements shown in the Standard Details and the project plans.

209.03.05 Portland Cement Concrete Post Anchorage. Portland Cement Concrete for post footings and anchorage shall conform with Section 202.12 – “Freeze-Thaw Environments” – with 3/4 inch maximum size aggregate and a compressive 28 day strength of not less than 4000 p.s.i. Commercial premixed rapid setting non-shrink post grouts are permitted for post anchorage and required for posts placed in drilled holes in rock or concrete.

210.01 DESCRIPTION. This section describes the quality of materials used for timber piles, precast or cast in place concrete piles, sheet piling and steel piles.

210.02 TIMBER PILES. Timber piles shall conform to the requirements of ASTM D 25 for Class B piles.

210.03 STEEL SHELL PILES. Steel shall conform to the requirements of ASTM A 252, Grade 2.

210.04 STEEL "H" PILES AND SHEET PILING. Steel "H" piles and sheet piling shall conform to the requirements of ASTM A 36.

210.05 PRECAST CONCRETE PILES OR CAST IN PLACE PILES. Materials for concrete shall conform to Subsection 200.05 – "Concrete Aggregates," – Section 206 – "Reinforcing Steel," – and 207 – "Structural Steel" – of these Specifications.

211.01 DESCRIPTION. This section covers the quality and kind of materials used in the construction of culvert markers and guide posts.

211.02 CERTIFICATES. Without expense to the Agency, two certificates covering each order of material (plates, reflectors, and posts) shall be furnished by the manufacturer, certifying that the product complies with the Specifications. Certificates shall be delivered to the Engineer in charge at the job site at the time of, or prior to, delivery of the order.

For steel used in posts, the Contractor shall furnish two certified copies of mill test reports showing the chemical and physical characteristics from each heat.

211.03 PHYSICAL PROPERTIES AND TESTS

211.03.01 Metal Posts. Posts shall be steel conforming to ASTM Designation A 570, Grade C or ASTM Designation A 526, 12 or 13 gage.

Metal posts shall be galvanized in accordance with Section 213, – “Galvanizing,” – or in accordance with the requirements of ASTM Designation A 525, coating Designation G 210.

211.03.02 Target Plates

- a) Base Metal. Base metal for the target plates shall be zinc coated steel sheet or aluminum sheet.

The zinc coated steel shall comply with Federal Specification QQ-S-775 Steel Sheet, carbon, zinc coated Type 1, Classes D and E, except that the zinc coated surface shall withstand a 180 degree bend on itself at room temperature without flaking the coating. The zinc coated surface shall be prepared for painting by the application of phosphate coating. Surface preparation shall conform to the following requirements:

The phosphatizing process shall be accomplished without damaging or removing the galvanized coating from the steel base metal;

Any evidence of damage or removal of the zinc coating shall be cause for rejection of the entire lot.

The aluminum sheet shall be prepared for painting with chemical conversion coating conforming to the requirements of Federal Specification MIL-C-5541. The coating shall be applied in accordance with the manufacturer’s specifications and recommended sequence of operation. Two copies of certified mill tests of the aluminum sheets shall be furnished to the Engineer.

Target plates shall be fabricated from 20 gauge steel sheet of 0.050 inch thick aluminum sheet, alloy 3005-H14.

Fabrication of all metal parts shall be accomplished in a uniform and workmanlike manner. Plates shall be cut to size and shape and the holes punched for mounting bolts and reflectors in accordance with the details shown on the Plans or as specified in the Special Provisions. Surfaces and edges of the plates shall be free from defects resulting from fabrication.

- b) Paint. Target plates shall have satisfactory paint adherence. Paint properties and application shall be in accordance with Section 214 – “Paint,” – and Section 324 – “Painting, Pavement Striping and Marking.”

At the Contractor’s option, metal reflector plates for metal guide posts may be furnished with one or both sides coated with a black, baked enamel finish. If only one side is coated, the coated side shall face oncoming traffic.

The plates shall be coated with baked enamel conforming to the following provisions:

The enamel finish coat for plates shall comply in all respects with the requirements of Federal Specification TT-E-489, Class B baking type enamel, with the added requirement that the yellowness index of the white enamel shall not exceed 0.08 when tested in accordance with Federal Test Method Standard No. 141, Method 6131.

Application of the baking enamel may be by spray, roller, or dip at the option of the manufacturer. Other methods may be used provided they are approved prior to use. The dry film thickness of the baked enamel coating on the galvanized steel plates shall be not less than 2 mils on both front and back surfaces. The dry film thickness on both front and back surfaces of the aluminum plates shall be not less than 1.5 mils on each side if enamel is applied by spray or dip method and not less than 1 mil if enamel is applied by continuous roller coat method.

The coating shall be uniform throughout and shall be smooth and free from flow lines, streaks, blisters, or other surface imperfections.

The finished plates shall be free from dents and defects. The maximum surface deviation from a horizontal plane on which the finished plate lies shall not exceed 0.25 inch.

211.03.03 Reflectors. Metal guide posts shall be equipped with reflective sheeting conforming to the requirements of Subsection 215.03.01 – “Reflective Sheeting” – of these Specifications for Type I.

The size of the sheeting shall be as indicated on the Plans. The color of the sheeting shall be as indicated in the MUTCD Manual.

212.01 DESCRIPTION. This section covers the quality and kind of material used in the construction of guardrail.

212.02 CERTIFICATES. Two certified copies of mill test reports showing the chemical and physical characteristics from each heat from which metal is used shall be furnished by the Contractor.

Certificates for wood posts shall be furnished in accordance with Subsection 208.01.03 – “Certificates of Inspection.”

212.03 PHYSICAL PROPERTIES AND TESTS

212.03.01 Rail Members. The beam-type members comprising rail members and end or terminal pieces, shall be formed from one open-hearth, basic oxygen, or electric-furnace steel sheets, galvanized after fabrication, or two aluminum alloy sheets as the Contractor may elect.

The thickness of steel sheets before galvanizing, and thickness of aluminum sheets shall not be less than 0.100 inch nominal 12 gauge and allowing for tolerances. The metal in the members shall meet the minimum requirements of the following table as determined by testing in accordance with ASTM Designation A 525.

Strength Requirements for Beam-Type Rail Members, Rail End Piece

	<u>Rail</u>	<u>Terminal Section</u>
Ultimate Tensile Strength	67,000 p.s.i.	–
Yield Point Strength	–	25,000 p.s.i.
Elongation in 2 inch Gauge Section	12 percent	–
Total Ultimate Strength at Splices	80,000 lbs.	80,000 lbs.

Steel members shall be galvanized in accordance with Section 213 – “Galvanizing.”

Workmanship shall be equivalent to commercial practice and all edges, bolt holes and surfaces shall be free of torn metal, burrs, sharp edges, and protrusions.

Railing parts furnished under these Specifications shall be interchangeable with similar parts regardless of source.

When paint is specified on the Plans, the materials should conform to the Subsection 214.03.01 – “Paint (Other than Traffic Paint).”

212.03.02 Fittings. All bolts, nuts, washers, and other fittings for beam-type guardrail shall be steel and of a quality adequate to develop the specified strength of rail splices and to provide a post connection withstanding a 5,000 pound side pull in either direction.

All bolts, nuts, and washers shall be 5/8 inch size. Bolts shall be buttonhead style and nuts shall be coarse-threaded (11 per inch), with nuts tapped oversize not to exceed 1/32 inch. Outside dimensions of boltheads, nuts, and washers shall have the following minimums: boltheads 1 1/4 inches; nuts, 15/16 inch; and washers, 1 1/2 inches. Splice bolts shall be 1 1/4 inches in length, and post connection bolts shall be of lengths required to fit the post dimension and extend beyond the tightened nuts thereon within limits of 1/4 to 1/2 inch. Washers, 1/8 inch thick, shall be provided for use under nuts on all post bolts, and under any nut which has a width of less than 1 1/16 inches.

All fittings shall be galvanized in accordance with Section 213, – “Galvanizing.”

Bolts, nuts, and other fittings shall be interchangeable with similar parts regardless of source.

212.03.03 Wood Posts. Wood posts shall conform to the Specifications set forth in Subsection 208.01.05 – “Grades.”

212.03.04 Reflector Plates. Reflector plates shall be fabricated from 11 gauge steel sheet or 0.148 inch thick aluminum sheet alloy 6061-T6. Nails for fastening reflector plates to the guardrail post shall be either galvanized metal or aluminum. Steel reflector plates shall be galvanized. Reflectorized material for reflector plates shall conform to the requirements of Subsection 211.03.03 – “Reflectors.”

213.01 DESCRIPTION. This section covers the quality and thickness of galvanize used on various material when called for on the Plans or designated in the Specifications.

213.02 REQUIREMENTS

213.02.01 Products One-Eighth (1/8) Inch Thick And Thicker. Galvanizing of products fabricated from rolled, pressed, and forged steel shapes, plates, bars, and strip shall conform to the requirements of ASTM Designation A 123.

213.02.02 Rail Elements. All rail elements shall be galvanized in accordance with AASHTO Designation M 180, Type 1.

213.02.03 Hardware. Bolts, nuts, washers, and fastenings shall be galvanized in accordance with the requirements of ASTM Designation A 153.

213.02.04 Mechanical Galvanizing. In lieu of hot-dipped galvanizing as specified in these Specifications, ferrous metals may be mechanically galvanized in accordance with ASTM Designation B 695. Regardless of the method chosen, the coated product shall conform to the coating thickness, adherence, and quality requirements of ASSHTO Designation M 232.

214.01 DESCRIPTION. This section covers the following items:

214.01.01 Paint (Other than Traffic Paint). The quality, color, and number of applications of paint (other than Traffic Paint) used in painting various materials.

214.01.02 Traffic Paint. The quality requirements of ready mixed traffic line paint to be applied to either asphaltic or Portland Cement Concrete pavements.

214.01.03 Traffic Beads. The quality requirements of glass spheres to be embedded into traffic paint.

214.01.04 Pavement Marking Film. The quality requirements for permanent pavement marking film and thermoplastic paint.

214.01.05 Thermoplastic Paint. The quality requirements for thermoplastic paint to be applied to either asphaltic or Portland Cement Concrete pavements.

Attention is directed to Section 213 – “Galvanizing” – for galvanizing coating.

214.02 REQUIREMENTS

214.02.01 Paint (Other Than Traffic Paint)

214.02.01.01 Certificates. The Contractor shall furnish the Engineer with written certification that all required tests have been satisfactorily completed and that the materials thereof comply with all the requirements. Samples will be taken when required by the Engineer.

214.02.02 Traffic Paint

214.02.02.01 General. Paint shall be free from foreign materials such as dirt, sand, fibers from bags, or other material capable of clogging screens, valves, pumps, or other equipment used in a paint striping apparatus. The paint pigment shall be well ground and shall be properly dispersed in the vehicle. The dispersions shall be of such nature that the pigment does not cake or thicken in the container, and does not become granular or curdled. Any settlement of pigment in the paint shall be a thoroughly wetted, soft mass permitting the complete and easy vertical penetration of a paddle. Settled pigment shall be easily redispersed, with minimum resistance to the sidewise manual motion of the paddle across the bottom of the container to form a smooth uniform product of the proper consistency.

The specified amounts and materials used in each formula for achieving satisfactory pigment wetting and suspension may be varied or changed to suit the vendor’s method of manufacture. Paint made with any deviations in anti-settling, wetting agents, or stabilizers shall still be required to conform to the characteristics of the finished paint and all other requirements of these Specifications.

214.02.02.02 Packaging. All manufactured paint shall be prepared at the factory ready for application. The addition of thinner or other material to the paint after the paint has been shipped will not be permitted unless otherwise specified in the Contract Special Provisions.

All shipping containers must comply with Department of Transportation Code of Federal Regulations, Hazardous Materials Regulations Board, Reference 49CFR. The containers must be lined, if necessary, so as to prevent attack by the paint or agents in the air space above the paint. The lining must not come off the container of lid as skins.

All containers shall be properly sealed with suitable gaskets and shall show no evidence of leakage.

All containers of paint shall be labeled showing the exact title of the Specification, manufacturer's name, date of manufacture, and manufacturer's batch number.

Precautions concerning the handling and application of paint shall be shown on the label of the paint container.

The lining of the containers shall be of such character as to resist the solvent of this paint and to permit no skins being loosened into the body of the paint.

214.02.03 Traffic Beads

214.02.03.01 General. The glass spheres shall lend themselves readily to firm embedment in the traffic paint when dropped on a freshly placed paint line. The embedment shall be of such character as to provide a highly reflectorized surface on the paint film with reserve reflectorizing capacity in the lower sections of the paint film. The reflection shall be effectively manifest to the operator of a motor vehicle when the headlights of the vehicle are played on the markings.

All glass beads shall have a moisture proof overlay consisting of water repellent material applied during the process of bead manufacture. The beads so treated shall not absorb moisture in storage, shall remain free of clusters and lumps, and shall flow freely from dispensing and testing equipment.

214.02.04 Pavement Marking Film

214.02.04.01 Certificates. A Certificate of Compliance for the pavement marking film shall be furnished to the Engineer. The certificates shall be signed by the manufacturer of the material. A Certificate of Compliance must be furnished with each lot of material delivered to the work and the lot so certified be clearly identified in the certificate.

All materials used on the basis of a Certificate of Compliance may be sampled and tested at any time. The fact that material is used on the basis of a Certificate of Compliance shall not relieve the Contractor of responsibility for incorporating material in the work which conforms to the requirements of the Plans and Specifications and any such material not conforming to such requirements will be subject to rejection whether in place or not.

214.02.05 Thermoplastic Paint

214.02.05.01 Certificates. Certificates shall conform to Subsection 214.02.01.01 – "Certificates."

214.03 PHYSICAL PROPERTIES AND TESTS

214.03.01 Paint (Other Than Traffic Paint)

214.03.01.01 Iron and Steel Use Items. The Contractor may choose from SSPC (Steel Structures Painting Council) Alkyd Paint Systems 2.00 or Phenolic Paint System 3.00 when metal rail, bridge, or pedestrian rail and guardrail are specified to receive paint or when painting structural steel, miscellaneous iron and steel standards. The color of paint shall be as shown on the Plans or specified in the Special Provisions. The use of lead base paint will not be allowed.

The Contractor shall submit to the Engineer for approval a letter indicating his choice of system, accompanied by certificates attesting that the ingredients chosen meet the applicable specifications and requirements prior to application of any paint.

214.03.01.02 Aluminum Use Items. Aluminum bridge railing and posts specified to receive paint shall be prepared for painting with a chemical conversion coating conforming to the requirements of Federal Specification MIL-C-5541. The coating shall be applied in accordance with the manufacturer's specifications and recommended sequence of operations.

The Contractor may use any of the paint systems specified for use on iron or steel in Subsection 214.03.01.01 – "Iron and Steel Use Items" – for painting aluminum, and shall submit to the Engineer for approval a letter indicating his choice of system as required for iron or steel.

214.03.01.03 Timber Items. Paint for cattle guard wings, bridge railings, right-of-way markers, sign posts, and miscellaneous timber structures shall conform to the following:

<u>Purpose</u>	<u>Number of Coats</u>	<u>Color</u>	<u>General Type</u>	<u>Formula or Specification</u>
Prime	1	White	Mixed Pigment exterior Wood Primer	*TT-P-25 *TT-P-25
Intermediate (first coat after primer)	1	Cream	Titanium Zinc Oxide	*TT-P-102 Class B
Finish (second coat after primer)	1	White	Titanium Zinc Oxide	*TT-P-102 Class B
Trim Lettering and Indications (used when indicated on plans)	1	Black	Titanium Zinc Oxide	*TT-P-61

*Federal Specifications

214.03.01.04 Concrete Items. Paint for concrete end posts (bridges), raised traffic bars, and miscellaneous concrete shall conform to the following:

<u>Purpose</u>	<u>Number of Coats</u>	<u>Color</u>	<u>General Type</u>	<u>Formula or Specification</u>
Finish	1	White	Water Thinned	Acrylic Resin or Synthetic Latex Alkyd Emulsion

214.03.02 Traffic Paint

214.03.02.01 Sampling and Testing. Samples will be taken after delivery. The Agency reserves the right to have an inspector present to observe the manufacturing process. The vendor shall furnish a complete formulation record of his manufacturing process to the Engineer.

All tests shall be performed according to ASTM, Federal Test Method Standards No. 141a and methods designated by the Agency.

214.03.02.02 Fast Dry Traffic Paint Materials. The raw materials for use in the paint formula shall conform to the Specifications designated by federal serial number or paint material code number hereinafter specified. Subsequent amendments to the Specifications quoted shall apply to all raw materials and finished products.

Paint shall also comply with the following requirements:

214.03.02.02 (a) Composition Requirements. All percentages specified are by weight.

214.03.02.01 (b) Pigment Composition. Percent by weight of total pigment:

	<u>White</u>	<u>Yellow</u>
Titanium Dioxide, Anatase (ASTM D 476, Type I 94 percent min. TiO ₂)	24.0-26.0	7.0-9.0
Medium Chrome Yellow (ASTM D 211, Type III, 87 percent min. PbCrO ₄)		15.0-17.0
Zinc Oxide (ASTM D 79, American Process-Type)	7.5-9.5	7.0-9.0
Magnesium Silicate (ASTM D 605)	26.0-38.0	35.0-37.0
Calcium Carbonate (ASTM D 1199, Type GC, Grade I or II)	28.0-30.0	31.0-33.0
Antisettling Agent (Bentone 34 or Clayton 40)	Note 1	Note 1

Note 1. Sufficient dispersing and suspending agent shall be added to prevent excessive settling as required in 2.2 and 2.4

214.03.02.02 (c) Vehicle Composition. Percent by weight of vehicle:

	<u>White and Yellow</u>
Alkyd Resin Solution (See Note 2)	21.3 min.
Chlorinated Rubber (Parlon S20 or Allopren X20)	16.4 min.
Chlorinated Paraffin (Federal Specification MIL-C 429C, Type I)	11.3-13.3
Lead Drier 24 percent (ASTM D 600, Class B)	0.2-0.4
Cobalt Drier 6 percent (ASTM D 600, Class B)	0.05-0.25
Antiskinning Agent (Exkin or Equivalent)	Note 3

White and Yellow (cont)

Stabilizer (Propylene Oxide) (See Note 4)	0.45-0.55
Toluene (ASTM D 62)	26.1 Max.
Heptane (Technical Grade)	6.5-8.5
Methyl Ethyl Ketone (ASTM D 740)	14.7 min.
Methanol (ASTM D 152)	0.2-0.4

Note 2. Alkyd Resin Solution: The medium oil soya-modified alkyd resin shall be supplied as 59 to 61 percent nonvolatile solids in VM & P Naphtha (TT-N95b, Type I). The resin solids shall contain an oil acid content of 48 to 55 percent, a phthalic anhydride content of 33 to 37 percent and an acid number of 8 maximum. The alkyd resin solution shall have a maximum color of 9 (Gardner). The alkyd resin solution, reduced to 45 percent solids with VM & P Naphtha, shall have a viscosity of D to G (Gardner-Holdt). No rosin will be permitted. The oil fatty acids shall be of vegetable origin, either alkali refined soya bean oil or the fatty acids of soya bean oil having a minimum iodine number of 115. No recovered oil marine or soya food fatty acid derivatives shall be used. The alkyd resin solution must tolerate a 500 percent by weight dilution with VM & P Naphtha. A solution containing alkyd resin solution, chlorinated rubber, methyl ethyl ketone, toluene, and heptane in the proportions given in the vehicle composition shall be clear, transparent, and show no separating after storage of 24 hours in a 3/4 full test tube at 26.7 degrees plus or minus 2.8 degrees Centigrade (80 degrees plus or minus 5 degrees Fahrenheit).

Note 3. Sufficient antiskinning agent shall be used to prevent skinning as required in **3.3. Material** shall be added at the proper time during the manufacturing of the paint so as to minimize losses due to volatilization and maximum retention in the package.

Note 4. Other approved stabilizers: Styrene Oxide – 3 pounds per 100 gallons of paint; Thermolite 813 – 0.5 pounds per 100 gallons of paint.

214.03.02.02 (d) Manufacturing Formulations. Typical formulas which may serve as a guide for the paint manufacturer are as follows (yields are approximately 100 gallons.):

	Pounds	
	<u>White</u>	<u>Yellow</u>
Titanium Dioxide	150	50
Medium Chrome Yellow	—	100
Zinc Oxide	50	50
Magnesium Silicate	225	225
Calcium Carbonate	175	200
Antisettling Agent (Claytone)	4	4
Methanol	2	2
Alkyd Resin Solution (60 percent nonvolatile)	130	130
Chlorinated Rubber (Parlon S-20)	100	100
Chlorinated Paraffin	75	75

	Pounds (cont)	
	<u>White</u>	<u>Yellow</u>
24 percent Lead Drier	2	2
6 percent Colbalt Drier	1	1
Antiskinning Agent (Exkin)	3	3
Stabilizer (Propylene Oxide)	3	3
Toluene	160	160
Heptane	45	45
Methyl Ethyl Ketone	<u>90</u>	<u>90</u>
	1215	1240

214.03.02.03 Quantitative Requirements of Mixed Paint

	<u>White</u>	<u>Yellow</u>
1. Pigment. Percent by weight	49.0-51.0	50.0-52.0
2. Total Solids. Percent by weight, min.	68.87	69.48
3. Nonvolatile Vehicle. Percent by weight vehicle, min.	38.96	38.96
4. Consistency. Krebs-Stormer Shearing rate 200 r.p.m., Grams	140 to 190	140 to 190
5. Weight per Gallon. Pounds, min.	12.05	12.25
6. Fineness of Grind. Hegman gage, North Standard Scale, min.	2	2
7. Drying Time. Minutes, max.	10	10
8. Directional Reflectance, min.	80	50
9. Uncombined Water. Percent by weight of paint, max.	1.0	1.0
10. Coarse Particles and Skins. Retained on a No. 325 mesh sieve, percent by weight or pigment, max.	1.0	1.0

214.03.02.04 Qualitative Requirements of Fast Dry Traffic Paint

214.03.02.04 (a) Color of Yellow Paint. The color of the yellow paint shall visually match color chip No. 33538 of Federal Standard 595a when tested as **specified in 4.1.5**. In case of dispute, the color shall be within the green and red tolerance limits when compared with the standard colorships of "Highway Yellow Color Tolerance Chart," U.S. Department of Commerce, Bureau of Public Roads PR Color No. 1, June 1965.

214.03.02.04 (b) Condition in Container. The paint shall not show excessive settling in a freshly-opened full can and shall be easily redispersed with a paddle to a smooth homogeneous state. The paint shall show no curdling, livering, caking, gelling, or thixotropic properties, lumps, skins, or color separation. [see 214.03.02.04 (c) and 214.03.02.04.(d)].

214.03.02.04 (c) Skinning. The paint shall not skin within 48 hours in a 3/4 filled, tightly closed container.

214.03.02.04 (d) 3.4 Storage Stability. When stored for 12 months the paint must be usable; the drying time shall be as specified and the consistency range shall be 70 to 85 Krebs units.

214.03.02.04 (e) Flexibility and Adhesion. The paint shall show no cracking, flaking or loss of adhesion when tested as **specified in 4.1.2.**

214.03.02.04 (f) Water Resistance. The paint shall show no softening, blistering, loss of adhesion, or other evidence of deterioration other than a slight loss in gloss when tested as specified in 214.03.02.04 (b).

214.03.02.04 (g) Dilution Stability. The thinned paint shall be uniform and show no separation, curdling, or precipitation after reduction in the proportions of eight parts by volume of the packaged material with not more than one part by volume of the appropriate thinner for each type of paint.

214.03.02.04 (h) Spraying Properties. The paint as received or diluted no more than as specified herein shall have satisfactory spraying properties when applied (and held in a horizontal position) to tinplate or aluminum surfaces at a wet film thickness of approximately 0.015 inch.

214.03.02.04 (i) Appearance. The sprayed film [see 214.03.02.04 (h)] shall dry to a smooth uniform finish free from roughness, grit, unevenness, and other surface imperfections. The paint shall show no streaking or separation when placed on clean glass.

214.03.02.04 (j) Bleeding. The paint shall show a minimum rating of six when tested as specified in **4.1.4.**

214.04 TEST PROCEDURES

214.04.01 Test Procedures. The tests indicated in Table I shall be conducted in accordance with Federal Test Method Standard No. 141a or ASTM method as indicated.

TABLE I

TEST METHODS

<u>Test</u>	<u>Section of Federal Test Method Standard No. 141a or ASTM Method</u>	<u>Section of this Specification Giving Requirements</u>	<u>Section of this Specification with Further Reference</u>
Percentage of Pigment	4021	2.1	...
Nonvolatile in Vehicle	4051	1.2	214.03.02.03 #3
Consistency, Krebs-Stormer	4281	214.03.02.03 #4	...
Weight per Gallon	4184	214.03.02.03 #5	...
Water Resistance	6011		4.1.3

TABLE I (cont)

TEST METHODS

<u>Test</u>	<u>Section of Federal Test Method Standard No. 141a or ASTM Method</u>	<u>Section of this Specification Giving Requirements</u>	<u>Section of this Specification with Further Reference</u>
Condition in Container	3011.1	3.2	...
Dilution Stability	4203	3.7	...
Skinning	3021	3.3	...
Fineness of Grind, Hegman	4411	2.2.6	...
Directional Reflectance	6121	2.2.8	...
Uncombined Water	4081	2.2.9	...
Coarse Particles and Skins	4091	2.2.10	...
Phthalic Anhydride	7021	2.1.2	...
Oil Acids	7031	2.1.2	...
Rubber Base Precipitate	5211.1	2.1.2	...
Iodine Number of Oils and Fatty Acids	5061	2.1.2	...
Flexibility and Adhesion	6221	3.5	4.1.2
Appearance of paint	3011.1	3.9	...
Color of Pigmented Coatings	4250	3.1	4.1.5
Drying Time	ASTM D 711	2.2.7	...
Bleeding	ASTM D 969	3.10	4.1.4

4.2 Flexibility and Adhesion. Apply a wet film thickness of 0.005 inches with a film applicator to a 3 by 5 inch panel weighing 0.39 to 0.51 lbs./sq. ft., previously cleaned with benzene and lightly buffed with steel wool. Dry the paint film at 70 degrees to 80 degrees Fahrenheit in a horizontal position for 18 hours, then bake in an oven at 122 degrees plus 4 degrees Fahrenheit 47.8 degrees Centigrade to 52.2 degrees Centigrade for two hours, cool to room temperature for at least 1/2 hour and bend over 1/2 inch diameter rod and examine, without magnification, as specified in 3.5.

4.3 Water Resistance of Paint. Apply a wet film thickness of 0.015 inches with a film applicator to a clean glass plate. Let dry in a horizontal position at room temperature (70 to 80 degrees Fahrenheit) for 72 hours. Immerse one-half the painted plate in distilled water at room temperature for 18 hours as specified in Method 6011 of Federal Test Method Standard No. 141, allow to air dry for two hours and examine as specified in 3.6.

4.4 Bleeding. The bleeding characteristics shall be determined in accordance with ASTM D 969. The test panels shall be evaluated according to ASTM D 868, and the degree of resistance to bleeding shall have a numerical rating as specified in 3.10.

4.5 Color of Yellow Paint. Apply a wet film of 0.015 inch to a tin panel; let dry for 24 hours and compare color as required in 3.1.

214.03.03 Traffic Beads

1.0 Requirements. A minimum of 85 percent of all the beads by count shall be colorless, true spheres, free of dark spots, milkiness, air inclusions, and surface scratches which involve a substantial part of any individual sphere.

When tested according to ASTM D 1214 the beads delivered shall conform to the following gradation requirements:

<u>Sieve No.</u>	<u>Percent Passing</u>
30	100
50	20-60
70	5-20
100	0-7

The Index of Refraction shall be a minimum of 1.5 by the oil immersion method utilizing tungsten light at 25 degrees Centigrade.

After refluxing a 50 gm. sample of beads in a Soxhlet Extractor for 8 hours with distilled water there shall be no more than a very slight reduction in luster or reflecting power of the beads.

The beads shall have a specific gravity of 2.44 to two and 2.56 at 25 degrees Centigrade.

The moisture content shall not exceed 0.01 percent when tested at 105 degrees Centigrade for three hours.

Two pounds of beads are added to a reserved unbleached cotton bag approximately 10 1/2 inches by 17 1/2 inches thread count 48 by 48. The sample is then immersed in distilled water at room temperature for 30 seconds or until the spheres are completely covered. The sample is then removed and excess water removed by twisting the neck of the bag. After two hours with the bag suspended at room temperature the sample is thoroughly mixed and transferred to a clean dry funnel 150 mm. top diameter, 120 mm. depth and 9 to 10 mm. stem i.d. The entire sample shall flow through the funnel with light tapping of the stem permissible only at the start of the test to initiate flow.

214.03.04 Pavement Marking Film

1.0 Permanent Pavement Markings Film. The film shall conform to the following requirements:

- a) Composition. The permanent pavement marking film shall be pliant polymer and shall consist of a mixture of polymeric materials, pigments and glass beads uniformly distributed throughout its cross-sectional areas and with a reflective layer of beads bonded to the top surface. These materials shall be composed as follows:

	<u>Minimum by Weight</u>
Resins and Plasticizers	20%
Pigments	30%
Graded Glass Beads	30%

- b) Glass Beads. The glass beads shall be colorless and have a minimum index of refraction of 1.5 when tested using the liquid oil immersion method.
- c) Reflectance. These markings shall have the following initial average reflectance value at 0.2 degrees and 0.5 degree observation angles and 86 degrees entrance angle as measured in accordance with the testing procedures of Federal Test Method Standard No. 370.

	<u>White</u>	<u>Yellow</u>
Observation Angle	0.2	0.2
Specific Luminance	550 380	410 250

- d) Thickness. The nominal thickness, excluding adhesive, shall be 0.06 inch.
- e) Tensile Strength. The film shall have a minimum tensile strength of 40 pounds per square inch of cross section when tested according to ASTM D 638-76. A sample 6 inches by 1 inch by 0.06 inch shall be tested at a temperature between 70 degrees Fahrenheit and 80 degrees Fahrenheit, using a jaw speed of 12 inches per minute.
- f) Elongation. The film shall have a minimum elongation of 75 percent when tested according to ASTM D 638-76, using a jaw speed of 12 inches per minute.
- g) Plastic Pull Test. A test specimen made the same size as in paragraph (b) shall support a dead weight of 4 pounds for not less than 5 minutes at a temperature between 70 degrees Fahrenheit and 80 degrees Fahrenheit.
- h) Pigmentation. The pigments shall be selected and blended to provide a marking film which is white or yellow conforming to standard highway colors through the expected life of the film.
- i) Effective Performance Life. The Permanent Pavement Marking Film, when applied according to the recommendations of the manufacturer, shall provide a neat, durable marking that will not flow or distort due to temperature, if the pavement surface remains stable. Although reflectivity is reduced by wear, the pliant polymer shall provide a cushioned resilient substrate that reduces bead crushing and loss. The film shall be weather resistant, and, through normal traffic wear, shall show no appreciable fading, lifting, or shrinkage throughout the useful life of the marking, and shall show no significant tearing, roll back, or other signs of poor adhesion.

These materials shall be capable of being adhered to asphaltic and/or Portland cement concrete by means of a pressure sensitive pre-coated adhesive or a liquid contact cement which is applied at the time of installation. Application shall be made according to the manufacturer's recommendation.

214.03.05 Thermoplastic Paint. Thermoplastic traffic line paint shall be a reflectorized thermoplastic permanent striping material applied to the road surface in a molten state by mechanical means. It shall have a surface application of glass spheres which, upon cooling to normal pavement temperatures, will produce an adherent reflectorized stripe of the specific thickness and width, and will be resistant to deformation by traffic. The material shall contain at least 20 percent by weight of glass spheres in the white and yellow paints and at least 12 percent by weight titanium dioxide in the white paint. The material, when applied at a temperature of 400 to 425 degrees Fahrenheit and a thickness of 125 mils (1/8 inch) to 188 mils (3/16 inch) shall set to bear traffic in not more than two minutes when the air temperature is 50 degrees Fahrenheit and not more than 10 minutes when the air temperature is 90 degrees Fahrenheit.

215.01 MATERIALS COVERED. This Specification covers the kind and quality of materials used in the construction and fabrication of "Construction Signs," "Temporary Signs," and "Permanent Signs."

215.02 REQUIREMENTS

215.02.01 General. The following materials shall conform to the requirements as noted:

Portland Cement Concrete	Section 202
Reinforced Steel	Section 206

215.02.02 Certificates. It shall be the Contractor's responsibility to ascertain that all required tests have been made by qualified testing laboratories as approved by the Department. The Contractor shall furnish the Engineer with a written certification that all required tests have been satisfactorily completed and that materials and fabrication thereof comply with all the requirements.

All materials shall be approved prior to use.

215.03 PHYSICAL PROPERTIES AND TESTS

215.03.01 Reflective Sheeting. The reflective sheeting shall consist of spherical lens elements embedded within a transparent plastic having a smooth, flat outer surface (Type I), or spherical lens elements adhered to a synthetic resin and encapsulated by a flexible, transparent, weatherproof plastic having a smooth outer surface (Type III). All sheeting shall be weather resistant and shall have a protected, precoated adhesive backing.

Color tolerance shall be within the limits of the FHWA Color Tolerance Charts. The instrumental testing restrictions noted on the FHWA Color Tolerance Charts relative to retroreflective materials may be disregarded to the following extent:

As an alternative to visual testing, instruments providing a system of diffuse illumination and unidirectional viewing may be used as a preliminary means of establishing that the colors meet the required CIE limits. In the event of any dispute concerning the results of instrumental testing, the visual test shall prevail.

The diffuse day color of the reflective sheeting shall conform to the requirements of the CIE Chromaticity Coordinate Limits hereinafter specified and shall be determined in accordance with ASTM Designation E97 "Standard Method of Test for 45 Deg. Directional Reflectance of Opaque Specimens by Filter Photometry." (Geometric characteristics must be confined to illumination incident within 10 degrees of and centered about a direction 45 degrees from the perpendicular to the test surface; viewing is within 15 degrees of and centered about the perpendicular to the test surface. Conditions of illumination and observation must not be interchanged.) The standards to be used for reference shall be the Munsell Papers. Papers must be recently calibrated on a spectrophotometer.

The test instrument shall be one of the following:

- a) Gardner Multipurpose Reflectometer,
- b) Gardner Model AC-2a Color Difference Meter,

- c) Meeco Model V Colormaster,
- d) Hunterlab D25 Color Difference Meter.

The reflective sheeting shall include a precoated pressure sensitive adhesive or a tack free, heat activated adhesive, either of which shall be applied exactly as specified by the sheeting manufacturer to recommended, properly prepared flat surfaces without necessity of additional coats on the reflective sheeting or application surface.

Type I Reflective Sheeting

- a. Photometric Requirements. The reflective sheeting shall have the following minimum brightness values at 0.2 degrees and 0.5 degrees and 1.5 degrees divergence expressed as average candlepower per foot - candle per square foot (candelas per lux per square meter) of material. Measurements shall be conducted in accordance with standard testing procedures for reflex-reflectors of Federal Specification L-S-300A, "Sheeting and Tape, Reflective, Nonexposed Lens Adhesive Backing," paragraph 4.47, or as amended.
- b. Wet Performance. Wet performance measurement shall be conducted in accordance with standard rainfall test specified in Federal Specification L-S-300A and the brightness of the reflective sheeting, totally wet by rain, shall not be less than 90 percent of the above values.
- c. Color. The diffuse day color of Type III reflective sheeting shall conform to the following:

Div. Ang. Inc. Ang.	Silver-White #1			Silver-White #2			Yellow		
	.2°	.5°	1.5°	.2°	.5°	1.5°	.2°	.5°	1.5°
-4°	70	30	4	80	41	4	50	25	5
40°	14.5	8.5	1.5	16.5	9.5	2	11.5	7	1.5

Div. Ang. Inc. Ang.	Red			Blue			Green			Orange		
	.2°	.5°	1.5°	.2°	.5°	1.5°	.2°	.5°	1.5°	.2°	.5°	1.5°
-4°	14.5	7.5	1	4	2	0.6	9	4.5	1	25	13.5	1.5
40°	3	1.5	0.3	0.9	0.4	0.08	1.8	1.5	0.2	1	0.8	.1

Type III - CIE Chromaticity Coordinate Limits

Color	x	y	x	y	x	y	x	y	(Y) Reflectance Limit		Ref. Std. Munsell Papers
									Min.	Max.	
Silver-White	.302	.289	.286	.306	.324	.344	.342	.327	30.0		5PB7/0.7
Green	.152	.523	.211	.395	.172	.372	.105	.503	3.0	8.0	9.0G3.3/9.5
Yellow	.483	.352	.510	.490	.560	.440	.534	.414	16.0	32.0	1.25Y6/12
Red	.608	.288	.700	.298	.644	.352	.608	.352	4.0	8.0	8R3.2/13

Type III - CIE Chromaticity Coordinate Limits (Cont'd)

Color	x	y	x	y	x	y	x	y	(Y) Reflectance Limit		Ref. Std. Munsell Papers
									Min.	Max.	
Orange	.535	.375	.535	.399	.582	.417	.607	.393	19.8	30.0	2.5Y5.5/14.0

- d. Lens Elements. The reflective sheeting shall possess stable and durable spherical lens elements which, following extraction, shall show no deterioration following submersion in a 5N solution of sulfuric acid (H2SO4) for 30 minutes at 72 degrees Fahrenheit (23 degrees Centigrade).
- e. Adhesive. The reflective sheeting shall include a precoated pressure sensitive adhesive or a tack free, heat activated adhesive, either of which shall be applied exactly as specified by the sheeting manufacturer to recommended, properly prepared flat surfaces without necessity of additional adhesive coats on the reflective or application surface.

The protective liner attached to the adhesive shall be removed by peeling without soaking in water or other solvents and shall be easily removed after accelerated storage for 4 hours at 150 degrees Fahrenheit (65 degrees Centigrade) under weight of 0.25 pounds per square inch (0.18 kg. per square cm.).

The adhesive shall form a durable bond to smooth, corrosion and weather resistant surfaces. The reflective sheeting, applied to cleaned and etched aluminum test panels shall adhere securely, 48 hours after application, at all normal application temperatures up to 150 degrees Fahrenheit (93 degrees Centigrade) after the panels are conditioned for 24 hours at minus 10 degrees Fahrenheit (minus 35 degrees Centigrade). The adhesive bond shall be sufficient to render the applied sheeting vandal-resistant and show no cracking when the surface of the reflective sheeting is exposed to the impact of a 2 pound (0.9 kg.) weight with a 5/8 inch (15.9 mm.) rounded tip dropped from a 10 inch pound (11.4 cm. kg.) setting on a Gardner Variable Impact Tester, IG-1120M. The sheeting shall resist peeling from the application surface when a 5 lb./in. width (2.27 kg. per 2.54 cm. width) force is applied as outlined in ASTM Designation D 903.

- f. Film. The reflective sheeting shall have sufficient strength and flexibility so that it can be handled, processed, and applied according to the recommendations of the sheeting manufacturer without appreciable damage. Following liner removal, the reflective sheeting shall not shrink more than 1/64 inch (0.4 mm.) in 24 hours in any dimension per 9 inch (22.9 cm.) square at 72 degrees Fahrenheit (23 degrees Centigrade) and 50 percent RH.

The sheeting with liner removed, conditioned for 24 hours at 72 degrees Fahrenheit and 50 percent RH, shall be sufficiently flexible to show no cracking when bent around a 1/8 inch (3.18 mm.) mandrel with adhesive side contacting mandrel. Note: For ease of testing, spread talcum powder on adhesive to prevent sticking to mandrel.

- g. Surface. The sheeting surface shall be smooth and facilitate cleaning and wet performance, and exhibit 85 degrees gloss meter rating of not less than 50 (ASTM Designation D 523). The surface of the sheeting with the heat activated adhesive shall be readily processed in accordance with recommendations of the sheeting manufacturer, compatible with recommended transparent and opaque process colors and show no loss of the color coat with normal handling, cutting, and application.

The sheeting shall permit cutting and color processing at temperatures of 60 degrees, minus 100 degrees, Fahrenheit (15 degrees, minus 39 degrees, Centigrade) and relative humidities of 20 to 80 percent. The sheeting surface shall permit cleaning by wiping with a clean soft rag dampened in V.M.&P. Naptha or mineral spirits.

- h. Impact Resistance. The sheeting, applied according to manufacturer's recommendations to cleaned, etched, 0.4 inch by 3 inch by 5 inches (1 mm. by 7.6 cm. by 12.7 cm.) aluminum (6061-T6) and conditioned for 24 hours at 72 degrees Fahrenheit (23 degrees Centigrade) and 50 percent humidity, shall show no cracking when face of panel is subjected to impact of a 2 pound (0.9 kg.) weight with 5/8 inch (15.9 mm.) rounded tip at 10 inch pound (11.4 cm. kg.) setting on a Gardner Variable Impact Tester (IG-1120).
- i. Durability. Reflective sheetings, processed, applied to approved sign base materials, and cleaned, in accordance with manufacturer's recommendations for their use on traffic control signs, shall be capable of performing satisfactorily for the number of years stated in Table II if the sheetings have not deteriorated due to natural causes to the extent that: (1) the sign is ineffective for its intended purpose when viewed from a vehicle, or (2) the average nighttime reflective brightness is less than that specified in Table II.

TABLE II (Type III)

<u>Sheeting</u>	Average min. candlepower per foot candle <u>per sq. ft. at 0.2 incidence</u>	Satisfactory <u>Life</u>
Silver-White	200	10
Green	24	10
Yellow	120	10
Red	28	5
Orange	48	3

215.03.02 Aluminum Sign Panels. Sheet aluminum for sign panels shall be of 0.125 inch aluminum alloy alclad 5052-H38 or 6061-T6 and shall conform to specifications for ASTM Designation B 209.

Sign panel sections shall be fabricated of standard width aluminum sheets not less than 4 feet wide, except that not more than two sheets for any one sign may be cut not less than 18 inches in width, so as to provide sign widths to nearest 6 inch increments. Panel sections shall run from the top edge to the bottom edge of the sign without horizontal joints.

The aluminum shall be free of all corrosion, white rust, and dirt. All sign dimensions, metal gage, and bolt holes shall conform to the requirements set forth on the Plans and in these Specifications. Metal degreasing will be required on all sheet aluminum and shall be performed by one of the following methods:

- a. Vapor degreasing. Signs shall be completely immersed in a saturated vapor of trichlorethylene or perchlorethylene. Trademark printing shall be removed with lacquer thinner or a controlled alkaline cleaning system, and rinsed thoroughly with running water.
- b. Alkaline degreasing. Signs shall be completely immersed in a tank containing alkaline solutions controlled and titrated to the solution manufacturer's specification. Immersion time shall depend upon the amount of soil to be removed. Signs shall then be thoroughly rinsed with running water.

Whenever reflective sheeting is required on the sign, the aluminum shall be etched by one of the following methods:

1. Acid etch. The aluminum shall be well-etched in a 6 to 8 percent phosphoric acid solution at 100 degrees Fahrenheit and rinsed thoroughly with running cold water, followed with a hot water tank rinse.
2. Alkaline etch. Etch well the precleaned aluminum in all alkaline etching material that is controlled by titration. Time, temperature, and concentration shall be as specified by the solution manufacturer. Smut shall be removed with an acidic, chromium compound-type solution as specified by the solution manufacturer and the sign then rinsed thoroughly.
3. The surface etch shall provide a clean, mat, nonshine or nonglare finish suitable for the application of paint or sheeting and for the unpainted back or reverse side of highway signs. After the degreasing and etching process, the aluminum shall be dried by use of a forced air drier.

Metal shall not be handled, except by device or clean canvas gloves between all cleaning operations and the application of the sign background material. There shall be no opportunity for the aluminum to come in contact with greases, oils, or other contaminants prior to the application of the background material.

Fabrication of all metal parts shall be accomplished in a uniform and workmanlike manner. All fabrication, including cutting, shall be cut to size and shape and shall be free of buckles, warp, dents, cockles, burrs, and other defects resulting from fabrication. The surface of all sign panels shall be a plane surface.

215.03.03 Overhead Sign Structures and Sign Frames. The materials used in the fabrication of overhead sign structures and footings shall conform to the following requirements:

- a. Sign names. Bars, plates, and shapes shall be structural steel conforming to the specifications of ASTM Designation A 36.
- b. Sign pipe posts. Pipe posts shall be welded or seamless steel pipe conforming to the specifications of ASTM Designation A 53, Grade B. At the option of the Contractor, posts may be fabricated from structural steel conforming to the specifications of ASTM Designation A 36 or of ASTM Designation A 283, Grade D, except that plates more than 1 inch in thickness shall be structural steel conforming to the specifications of ASTM Designation A 373.
- c. Sign steel walkway gratings. Steel walkway gratings shall be furnished and installed in accordance with details shown on the Plans and the following provisions:
 1. Gratings shall be the standard product of an established grating manufacturer.
 2. Material for gratings shall be structural steel conforming to the specifications of ASTM Designation A 36.
 3. For welded type gratings, each joint shall be full resistance welded under pressure to provide a sound, completely beaded joint.

4. For mechanically locked gratings, the method of fabrication and interlocking of the members shall be approved by the Engineer, and the fabricated grating shall be equal in strength to the welded type.
 5. After fabrication, gratings shall be hot-dip galvanized.
 6. Gratings shall be accurately fabricated and free from warps, twists, or other defects affecting their appearance or serviceability. Ends of all rectangular panels shall be square. The tops of the bearing bars and cross members shall be in the same plane. Gratings distorted by the galvanizing process shall be straightened.
- d. Bolts, Nuts, and Washers. High-strength steel bolts, nuts and washers shall conform to the specifications of ASTM Designation A 325. All other bolts and nuts, including anchor bolts and nuts for sign foundations, shall conform to the specifications of ASTM Designation A 307, and shall be furnished with commercial quality washers. Bolted connections shall conform to the provisions in Subsection 326.03.08 – “Bolts and Bolted Connections.”
 - e. Bearing plates and gusset or stiffener plates shall be of the sizes and dimensions shown on the Plans and shall be galvanized after fabrication. Steel shall conform to ASTM Designation A 36. Galvanizing shall conform to ASTM Designation A 123. All welding shall conform to the requirements set forth in Subsection 326.03.18 – “Welding.”
 - f. Anchor bolts, nuts and washers shall be of structural carbon steel conforming to Section 207 – “Structural Steel,” and shall be galvanized in accordance with ASTM Designation A 165 Type TS. The top portion of anchor bolts shall be galvanized or cadmium plated to such extent that the galvanized or cadmium plate portion will extend at least 2 inches into concrete. Anchor bolts shall be of the size, shape, and length as shown on the Plans.
 - g. All bolts, nuts, clamps, and metal washers not otherwise noted shall be galvanized or cadmium plated. Cadmium plating shall conform to the specifications of ASTM Designation A 165, minimum thickness as prescribed for grade Type TS, and galvanizing shall conform to the requirements of ASTM Designation A 153.
 - h. Steel sign panels shall be mounted using 1/4 inch by 20 inch flat head, brass, machine screws with a No. 14 brass, nickel plates, asbestos backed, finishing washer and one brass nut with a flat brass washer and lock washer for each machine screw. Lock washers shall be plain phosphor bronze or beryllium copper, shake-proof and externally toothed. Where obstructions prevent the normal installation of nuts, the frame shall be drilled and tapped to accept the screw. The exposed portion of fastening hardware on the face of the sign panels shall be painted out using commercial quality touch-up enamel that matches the background.

The following type fasteners may be used in lieu of those specified above:

Either a silicone bronze or an aluminum alloy 5052 or 5056, self-plugging blind rivet with a nominal diameter of 9/32 inch. The rivet head shall be not less than 0.7 inch nor more than 0.8 inch in diameter and shall be undercut to make deburring of the mounting hole unnecessary. The rivet shall develop a clamping force of not less than 350 pounds.

- i. Supporting frame shall be manufactured in accordance with the Plans and in accordance with the requirements herein specified. All metal parts shall be galvanized after fabrication, in accordance with the provisions of Section 213. When permission is granted by the Engineer to zinc coat a surface by means other than hot-dip galvanizing, the metalizing process shall be used to place the zinc. Metalizing shall be performed in accordance with the AWS Specifications and the thickness of the sprayed zinc coat shall be at least 5 mils.

- j. Truss frames shall be fabricated to the largest practical sections prior to galvanizing. Splice locations shall be submitted to the Engineer for approval and the Contractor shall not commence fabrication until such splice locations are approved.
- k. All welding in the fabrication of the structure shall be done in accordance with the requirements of Section 326. No field welding on any part of the structural assembly will be permitted.

Note: Before fabrication is started, five sets of shop drawings for each overhead sign structure shall be submitted to the Engineer for approval.

215.03.04 Sign Hardware and Related Materials. Bearing plates and gusset or stiffener plates shall be of the sizes and dimensions shown on the Plans and shall be galvanized after fabrication. Steel shall conform to ASTM Designation A 36. Galvanizing shall conform to ASTM Designation A 123. All welding shall conform to the requirements set forth in Section 326.

All bolts, nuts, clamps, and metal washers shall be of structural, carbon steel conforming to Section 207 and may be galvanized or cadmium plated as hereinafter stated.

Anchor bolts, nuts, and washers shall be of structural carbon steel conforming to Section 207, and shall be galvanized in accordance with ASTM Designation A 153, or cadmium plated in accordance with ASTM Designation A 165, Type TS. The top portion of anchor bolts shall be galvanized or cadmium plated to such extent that the galvanized or cadmium plated portion will extend at least 2 inches into concrete. Anchor bolts shall be of the size, shape, and length as shown on the Plans.

Aluminum alloy tubular stiffeners shall be schedule 40 pipe fabricated of 6061-T6 aluminum alloy and shall conform to the specifications of ASTM Designation B 241.

Steel pipe for posts shall conform to the specifications of ASTM Designation A 120 and shall be galvanized.

Galvanized steel pipe posts shall be of the diameter and length shown on the Plans. The top of the posts shall be fitted with a cover. Posts showing damage shall be repaired or rejected.

The straps, bars, and braces used on single support signs shall be of aluminum alloy 6061-T6 and shall conform to ASTM Designation B 209.

Stringers for horizontal supporting structural members shall be of 6061-T6 or 6062-T6 aluminum alloy and shall conform to ASTM Designation B 308, Alloy GS11A.

All bolts, nuts, clamps, and metal washers in contact with aluminum shall be cadmium plated. All other bolts, nuts, clamps and metal washers shall be galvanized or cadmium plated. Cadmium plating shall conform to the specifications of ASTM Designation A 165, minimum thickness as prescribed for grade Type TS and galvanizing shall conform to the requirements of ASTM Designation A 153.

Wood posts and braces for sign supports shall be constructed of Douglas Fir, West Coast Hemlock, or any other equivalent stress rated wood material, at the option of the Contractor. Said wood material shall be construction grade, free of heart center, minimum stress rating of 1200f, and shall be graded in accordance with the provisions contained in Section 208. Sweep shall not exceed 0.08 feet in 10 feet.

The expansion assembly for fastening the aluminum tubing to the aluminum Z-bars shall be manufactured of a zinc die casting alloy which contains copper, aluminum, and magnesium. The anchor bolt for the expansion assembly shall be cadmium plated and shall conform to the specifications of ASTM Designation A 165, minimum thickness as prescribed for grade Type TS.

Square sign posts and anchors shall conform to the following requirements:

Material. Steel posts shall conform to ASTM Designation A 446 or A569. Steel posts shall have a minimum yield of 40,000 p.s.i. after fabrication with certification being required.

Shape. The cross section of post shall be a square tube formed of ten 0.135 inch (U.S.S. gauge) or twelve 0.105 inch (U.S.S. gauge) steel carefully rolled to size and welded. The cross section of the sign post anchor and sleeve used with the 2 inch post will be same as for the sign posts. The cross section of the sign post anchor used with the 2 1/2 inch post shall be a square tube formed of 3/16 inch steel carefully rolled to size and welded.

Fabrication. The furnished members shall be straight and shall have a smooth uniform finish. All holes and cut off ends shall be free from burrs.

Finish. All posts shall be weather protected. Posts made from material conforming to ASTM A446 shall be formed from steel which has been zinc coated in accordance with ASTM A525, Designation G-90.

Posts made from material conforming to ASTM A569 shall be coated in accordance with the applicable provisions of AASHTO M181 for Class 2 posts, except as hereinafter modified.

AASHTO M181 is hereby modified as follows:

- a) Article 8.2.2.2. The weight of zinc coating on the exterior surface of posts shall be a minimum of 0.45 ounce per square foot as determined from the average results of two or more specimens and not less than 0.40 ounce per square foot on an individual sample.
- b) Article 8.2.2.4. The weight of chromate conversion coating on posts shall be a minimum of 5 micrograms per square inch.

Size. Sizes shall conform to those shown on the Plans or as approved when used as an alternate. Channel sign posts and base posts shall conform to the following requirements:

Material. Posts shall be rolled form high strength hot rolled steel conforming to ASTM Designation A 499 modified to 60,000 p.s.i. minimum yield and 90,000 p.s.i. minimum tensile or equal.

Shape. Posts shall be of a uniform channel shape. The dimensions of these posts shall be as noted on special detail sheets in the Contract Plans.

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Weight. The weight of each base post and each sign post before holes are punched shall be 2.75 and 4 pounds per foot for base posts and 2.5 and 4 pounds per foot for sign posts. The 2.75 pound base post shall be used with 2.5 pound sign post and the 4 pound base post with the 4 pound sign post.

Fabrication. The furnished members shall be straight and have a smooth uniform finish. All holes and cut off ends shall be free of burrs.

Finish. All posts shall be weather protected by galvanizing. This galvanizing shall conform to ASTM Designation A 123.

Size. Sizes shall conform to those shown on Plans or as approved when used as an alternate.

The pipe, wyes, tees and elbows used to construct Rent Construction Barricades (Type III B) shall be made of polyvinyl chloride (PVC) plastic pipe. The PVC pipe shall conform to the requirements of ASTM Designation D 2241 for PVC 1120 or 1220, SDR 21, pressure rating 200 p.s.i. The PVC wyes, tees, and elbows shall conform to the requirements of ASTM Designation D 2466, Type II, Grade 1. At the Contractor's option, pipe, wyes, tees and elbows may be acrylonitrile-butadiene-styrene (ABS) conforming to the requirements of ASTM Designation D 2751. Combinations of PVC and ABS pipe and fittings will be permitted. All joints shall be slip-fit and shall not be threaded or cemented.

216.01 DESCRIPTION. This Specification covers the quality and kind of materials used in the construction of monuments.

216.02 MATERIALS. Materials used in the construction of survey monuments shall conform to the following requirements:

216.02.01 Survey Markers. Survey markers shall be bronze as manufactured by Servco (No. 286), or approved equal. The top surface shall be flat and machined, and the shank shall be corrugated and flattened to prevent removal or turning once the marker has been set. The marker shall be cast of virgin metal, in one piece, free from casting imperfections. Marker size shall be 2 inch diameter top, 3/4 inch by 2 1/2 inch corrugated and flattened shank.

In the event that the Contractor desires to use a survey marker without a corrugated and flattened shank, the shank shall be either 6 inches in length (minimum) and bent to insure non-removal once set, or manufactured with a split shank, each side of which shall be bent, or flared, so that the marker cannot be removed after it is set.

216.02.02 Concrete. Concrete used for the construction of survey monuments shall contain not less than six sacks of Type II cement per cubic yards of concrete, a 1 inch maximum aggregate size, and shall obtain a compressive strength of not less than 3,000 p.s.i. after 28 days.

216.02.03 Street Wells. Street wells, or "pots" used in the construction of survey monuments shall be Pinkerton Foundry assembly A 257 or approved equal. The "pot" shall be cast iron, and the cover shall have the word "Survey" in raised letters indicated on its top surface.

216.02.04 Drain Rock. Drain rock used in the construction of survey monuments shall consist of either a 3/4 inch maximum aggregate mixture or a 3/8 inch pea gravel.

217.01 DESCRIPTION. This Section covers the quality of materials and operating requirements necessary for fire hydrant installation.

217.02 TYPE OF HYDRANT AND CHARACTER OF SERVICE. All hydrants shall conform to the American Water Works Association Standard C-502-54 (AWWA Standard for Fire Hydrants for Ordinary Water Works Service), and shall be subject to controls set forth by the Agency.

217.02.01 Pressure. All hydrants shall be designed for a working pressure of 150 p.s.i. and a hydrostatic test pressure of 300 p.s.i..

217.02.02 Valve Opening. All hydrants shall be of the compression type with the main valve opening against the pressure and closing with the pressure.

217.02.03 Dry Top Design. Hydrants shall be of the dry top design; the operating threads shall be completely sealed away from the water at all times, whether or not the valve is open or closed. Hydrants having operating threads located in the waterway are not acceptable.

217.02.04 Operating Nut. Hydrants shall be opened by turning to the left (counter clockwise) and shall have a 1 3/16 inch pentagonal bronze operating nut. On high profile model fire hydrants (such as the Mueller 107), a corrosion-resistant stainless steel screw pin shall secure the combined cap and nut to the operating screw.

217.02.05 Packing Gland. The packing gland located in the bonnet shall be solid bronze with double "O" ring seals in lieu of a conventional stuffing box.

217.02.06 Nozzles. Hydrants shall have at least two, 2 1/2 inch nozzles with threads conforming to the National Standard Dimensions (7 1/2 threads per inch), and one, 4 1/2 inch pumper connection with an outside diameter of 5 7/16 inches and four threads per inch.

An exception to the above Specification is in the Incline Village area, where a 4 1/2 inch pumper connection with a National Standard Thread will be acceptable.

217.02.07 Traffic Models. All hydrants shall be of the traffic model type so that the main valve will remain closed in the event the hydrant is broken off or destroyed. The barrel section and operating mechanism shall be designed with a breakable safety flange.

217.02.08 Bottom Flange Location. The bottom flange on the hydrant barrel must be between 4 and 12 inches above finished grade elevations at the hydrant location.

217.02.09 Main Valve Facing. The main valve facing shall be made of rubber with the main valve opening 5 1/4 inches in diameter.

217.02.10 Drain Valves. Hydrants shall be of the dry barrel type and shall have a minimum of two positive acting, non-corrosive drain valves that shall drain the hydrant completely by opening as soon as the main valve is closed, and by closing when the main valve is opened. Drain valves operated by springs or gravity flow will not be acceptable.

217.02.11 Main Valve Seat. The main valve seat shall be bronze with a bronze cap nut on bottom stem threads to prevent corrosion.

217.02.12 Inlet Connection. Hydrants shall have a 6 inch inlet and be connected to the main by means of a flanged, asbestos cement, or mechanical joint shoe, depending on the type of pipe specified.

217.02.13 Interchangeable Parts. All like parts of hydrants of the same size and model produced by the same manufacturer shall be interchangeable.

217.02.14 Features. All hydrants must be non-freezing and self-draining, and must have an independent shutoff valve.

217.02.15 Hydrant Capacity. Hydrants must have sufficient capacity to deliver 600 gallons per minute with a friction loss not exceeding 2 1/2 p.s.i. in the hydrant, and a total friction loss not exceeding 5 p.s.i. between the street main and outlet.

217.02.16 Flush Hydrants. Flush hydrants will not be acceptable.

217.02.17 Hydrant Color. Hydrant color shall be as per instruction of the Agency.

217.02.18 Hydrant Types. High profile hydrants (such as the Mueller 107) shall be installed in industrial and mercantile areas except when specified otherwise by the Agency. Low profile hydrants shall be installed in all residential areas and areas other than industrial and mercantile areas except when specified otherwise by the Agency.

217.02.19 Hydrant Footpiece. The hydrant footpiece, after installation, shall bear on concrete. The minimum bearing area shall be 4 square feet.

217.02.20 Drain Valve Openings. Hydrant drain valve opening shall, after installation, be surrounded by a gravel sufficiently coarse so that no foreign substance may enter the drain valve and impair its operation.

217.03 MATERIALS. All materials designated hereinafter shall, when used in hydrants produced under this Specification, conform to the requirements designated below for each material listed. When reference is made to the American Society of Testing and Materials (ASTM), the American Standard Association (ASA), or other standards, it is understood that the latest revision thereof shall apply.

Whenever hydrant components are to be made in conformance with ASTM, ASA, or other standards, all test requirements or testing procedures specified therein shall be met by the hydrant manufacturer. The records of such tests shall, if required by the Agency, be made available to him.

217.03.01 Cast Iron. All cast iron shall conform to ASTM A 126 Class B (Gray Iron Castings for Valves, Flanges, and Pipe Fittings).

217.03.02 Steel. Steel shall conform to ASTM A 107 (Hot Rolled Carbon-steel Bars). Stainless steel shall conform to ASTM A 276.

217.03.03 Brass or Bronze. Brass or bronze shall be Grade 1, conforming to ASTM B 62.

217.03.04 Body Bolts and Nuts. Body bolts and nuts shall conform to ASTM A 307 (Grade B). Bolts and nuts shall be either cadmium plated or zinc coated (ASTM A123), or rust-proofed by some other process (Parkerizing, Sherardizing, or the like) disclosed to and acceptable to the Agency. Body bolt studs shall conform to the physical and threading requirements of ASTM A 307 (Grade B).

Safety flange coupling bolts shall intentionally have a lower breaking point than the rest of the unit. The stainless steel coupling pins shall conform to Section 216.03.02 – “Steel” of these Specifications.

217.03.05 Gasket Material. Gasket material shall be sheet asbestos, rubber composition, or paper free from corrosive ingredients, either alkaline or acid.

217.03.06 Paint. Paint used in coating the hydrant shall conform to the requirements of Federal Specification TT-V-51a asphalt varnish or Army-Navy Specification JAN-P-450. Exterior coating above the ground line shall conform to Federal Specification TT-P-86a (Type IV) or consist of one coat of 14-V-40 Neutral Orange Rust inhibitive primer and one coat of 49-9-28 Quick Dry Brushing Enamel, unless otherwise specified by the Agency.

217.04 DESIGN

217.04.01 Cast Iron. The parts where cast iron may be used are the footpiece or elbow, the barrel or standpipe, the frost jacket if used, the bonnet, the packing plate, the gates, the nozzle caps, and small miscellaneous parts where the use of cast iron will conform to good practice.

217.04.02 Bronze. Bronze may be used for drain valve parts, glands, bolts, bolt nuts, bushings, nozzles, stems or threaded portions of stems, and valve seats or valve seat rings.

217.04.03 Main Valve Facing. The main valve facing of the hydrant shall be faced with a suitable yielding material, such as rubber, leather, balata, or composition, where it bears on metal seats. The material shall be clamped so that the valve will not leak at the stem. The bottom stem threads may be protected by a suitable cap nut.

217.04.04 Hydrant Wall Thickness. The thickness of the wall of the barrel shall not be less than the thickness specified for Class 250 pit-cast iron water pipe of like diameter produced in accordance with ASA A-212 (American Standard for Cast Iron Pit Cast Pipe for Water or Other Liquids) and Table 2.3 thereof. The wall thickness of barrels of fractional-inch diameter shall be that for the next larger diameter.

Variations in hydrant wall thickness shall not exceed those permitted for pit-cast cast iron pipe of like diameter as recorded in Section 2-11(b) of ASA A-21.2.

217.04.05 Waterway. Changes in the shape or size of the waterway shall be accomplished by means of easy curves. The junctions of hose and pumper nozzles with the barrel shall be rounded to ample radii. Exclusive of the main valve opening, the net area of the waterway of the barrel and footpiece at the smallest part shall not be less than 120 percent of that of the net opening of the main valve.

217.04.06 Inlet and Connection. The base of the hydrant, known as the footpiece or elbow, shall have a side or bottom inlet provided with a bell, a flange, or other type of connection as specified or approved by the Agency for connecting the hydrant to the branch from the main. In a hydrant provided with bell type connections, the bell dimensions shall conform to those shown in Standard for Cast Iron Pressure Fittings — AWWA C-100 (Class D). In a hydrant provided with flange type connections, the flange dimensions shall conform to ASA B16.1 (Cast Iron Pipe Flanges and Flanged Fittings, Class 125). When a hydrant is to be connected to mechanical joint pipe, the dimensions shall conform to Table 11.1 of ASA A-21.11 (American Standard for a Mechanical Joint for Cast Iron Pressure Pipe and Fittings).

217.04.07 Lugs. Lugs, if required, for harnessing the hydrant to the connecting pipe from the street main shall be provided on the bell of the elbow.

217.04.08 Nozzles. Hose nozzles shall be of Grade I bronze and shall be fastened into the barrel by a fine thread or by leading. If lead is used, an adequate recess shall be provided for the lead. All nozzles shall be safeguarded against blowing out. For screwed-in nozzles, a pin or other approved method shall be employed to prevent the nozzle from turning or backing out.

217.04.09 Nozzle Caps. Nozzle caps shall be cast iron and shall be provided for all outlets. The threads shall conform to those of the nozzle. The cap nut shall have dimensions similar to those of the operating nut. Caps shall be securely chained to the barrel with a metal non-kinking chain having links made from stock not less than 1/8 inch in diameter, or of equivalent cross sectional area. A recess shall be provided at the inner end of the threads to retain a gasket.

217.04.10 Access to Moveable Parts. The hydrant shall be so designed that when it is in place, no excavation will be required to remove the main valve and the moveable parts of the drain valve.

217.04.11 Valve Seats or Seat Rings. Valve seats or seat rings shall be made of Grade 1 bronze.

217.04.12 Operating Threads. The operating threads of the hydrant shall be so designed as to avoid the working of any iron or steel parts against either iron or steel. Either the operating stem or its threaded stem nut (or sleeve) shall be of non-corrosive metal. If the threaded portion of the operating stem is bronze, it shall be made of Grade I material. If the threaded stem nut is bronze, it shall be made of Grade I material. The operating stem and nut shall have Acme threads unless specified otherwise by the Agency. The design factor of safety of the operating mechanism shall be five and shall be based on the foot-pounds torque required for the closing and opening of the individual hydrant at 150 pounds per square inch working water pressure. Hydrants shall be capable of being subjected to an operating torque of 200 foot-pounds applied at the operating nut. The torque requirements apply only to hydrants of 5 foot bury and under.

217.04.13 Operating Mechanism. The operating mechanism, particularly the lead of the thread of the operating stem, shall be so designed that when the operating nut is turned at the fastest possible rate using a 15 inch wrench to shut off the flow of water, the resulting pressure in the system shall not exceed twice the static pressure if the static pressure averages 60 p.s.i. or greater. If the static pressure averages less than 60 p.s.i., the pressure shall not be raised more than 60 p.s.i. above the static.

217.04.14 Hydrant Top. The hydrant top or bonnet shall be of cast iron, and shall be free-draining and of a type that will maintain the operating mechanism in readiness to use under freezing conditions. It shall be so designed as to make tampering difficult and shall be provided with convenient means to afford lubrication to insure ease of operation and the prevention of wear and corrosion.

217.05 MARKING. All hydrants shall have permanent markings identifying the manufacturer by name, initials, or abbreviations in common usage, and designating the size of the main valve opening and the year of manufacture. An arrow and the word "OPEN" shall be cast in relief, so as to be clearly visible, on the top of the hydrant to designate the direction of opening. Markings shall be so placed as to be readily discernible and legible after hydrants have been installed.

217.06 WORKMANSHIP. All foundry and machine work shall be done in accordance with standard good practices for the class of work involved. When assembled, hydrants manufactured in accordance with this Specification shall be well fitted, smooth operating and watertight.

217.06.01 General. All parts shall conform to the required dimensions and shall be free from defects which will prevent proper functioning of the hydrant.

217.06.02 Machined Parts. All machined parts shall be made to template or gauge.

217.06.03 Joints. All joints shall be faced true and shall be watertight when subjected to the water pressure for which the hydrant is designed.

217.06.04 Iron Parts and Bronze Mounting. All iron parts receiving bronze mounting shall be made true and smooth, and the bronze mounting shall be finished to fit.

217.06.05 Castings. All castings shall be clean and sound, without defects which will impair their service. No plugging, welding, or repairing of such defects will be allowed.

217.07 HYDROSTATIC TEST. Hydrants shall be subjected, after assembly, to two tests under a hydraulic pressure of 300 p.s.i. One test shall be made with the whole interior of the hydrant under pressure; and another with the main valve closed and the footpiece under pressure from the inlet side. Under the above test procedure, there shall be no leakage through the main valve, or stuffing box, nor through the castings or the joints of the assembled hydrant. Leakage or other imperfections found in either test shall be corrected before the hydrant is accepted.

300.01 DESCRIPTION. This Section covers the construction methods involved in the clearing and grubbing operation.

300.02 LIMIT OF WORK. Clearing and grubbing shall consist of removing all natural and artificial objectionable materials from construction areas. This work shall be performed in advance of grading operations and in accordance with the requirements herein specified, subject to erosion control requirements.

300.02.01 Scope. The natural ground surface shall be cleared of all organic growth, such as sod, trees, logs, upturned stumps, roots of downed trees, brush, grass, weeds, and all other objectionable materials within the limits of construction.

Grubbing shall extend to the outside excavation and fill slope lines, except that where slopes are to be rounded, the areas shall extend to the outside limits of slope rounding. Within the limits of clearing, all stumps, roots 1 1/2 inches in diameter or larger, buried logs, and all other objectionable material shall be removed 3 feet below the existing ground surface or subgrade, whichever is deeper.

Existing signs and the like within the construction limits shall be removed, salvaged and reinstalled as directed by the Engineer. If existing traffic control signs are removed (i.e. stop, yield signs) the Contractor shall install temporary signs of the same designation as close as possible to the original position immediately.

Existing mailboxes within the construction limits shall be removed, salvaged, and reinstalled as close to the original position as possible after construction in the area is completed. Mail service shall not be interrupted at any time due to construction activities.

300.02.02 Work Outside Stated Limits. No payment will be made to the Contractor for clearing and grubbing outside the stated limits, unless such work is authorized by the Engineer.

300.02.03 Protection of Plants. Trees and plants that are not to be removed shall be fully protected from injury by the Contractor at his expense. Trees shall be removed in such a manner as not to injure standing trees, plants, and improvements which are to be preserved.

Tree branches which hang within 13 1/2 feet above finished roadway grade or within 9 feet above finished sidewalk or parkway grade shall be cut off close to the boles in a workmanlike manner. The Contractor shall remove additional tree branches under the direction of the Engineer, in such a manner that the tree will present a balanced appearance. Scars resulting from the removal of branches shall be treated with a heavy coat of an approved tree sealant.

300.03 REMOVAL OF MATERIALS. All materials removed shall be hauled from the site at the Contractor's expense, unless otherwise specified. The construction area shall be left with a neat and finished appearance.

300.04 PROTECTION OF UTILITIES AND UNDERGROUND FACILITIES. The Contractor shall inform himself of the exact location of all conduits, ducts, cables, pipe systems, or other underground facilities and shall protect all utilities encountered in the process of construction. The Contractor shall contact Underground Service Alert (USA) at least 48 hours prior to any construction activity. Any damages to underground facilities shall be immediately repaired by the Contractor at his own expense, except for damage to utilities, in which case the Contractor shall immediately notify the proper Utility. Unless cleared by the Utility, the Contractor shall be responsible for reimbursing said Utility for any and all work required to repair or replace damaged facilities.

300.05 BASIS OF PAYMENT. The lump sum price or the price per acre bid for clearing and grubbing shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all the work involved in clearing and grubbing as shown on the Plans and as specified in these Specifications, or as specified otherwise and as directed by the Engineer, including the removal and disposal of all the resulting materials.

When the contract does not include a pay item for clearing and grubbing as above specified, full compensation for any necessary clearing and grubbing required to perform the construction operations specified shall be considered as included in the price bid for other items of work and no additional compensation will be allowed therefor.

There will be no direct payment for the salvaging of signs, installation of temporary traffic control signs, mailboxes and the like and for the removal of trees smaller than 6 inches in diameter, measured 3 feet above the original ground line. The cost of this work shall be included in the price bid for other items of work.

There will be no direct payment for the reinstallation of salvaged mailboxes. The cost of this work shall be included in the price bid for other items of work.

301.01 DESCRIPTION. This Section covers the construction methods involved in removing existing improvements.

301.02 LIMIT OF WORK. The removal of existing improvements shall conform to the following requirements.

301.02.01 Demolition. Demolition of buildings and structures shall be included as part of the removal of existing improvements unless specified otherwise.

301.02.02 Bituminous Pavement. Bituminous pavement shall be removed to clean straight lines by saw cutting where the removal of existing improvements does not include the total amount of paving encountered. Saw cutting shall be utilized whenever a pavement joint is to be made. Where only the surface of existing bituminous pavement is to be removed by rotomilling or by other approved methods, a minimum laying depth of twice the maximum aggregate size of new pavement material shall be provided at the joint line. Where bituminous pavement adjoins a trench, the edges adjacent to the trench shall be trimmed to neat straight lines at least 9 inches wider than the trench on each side, before resurfacing, to insure that all areas to be resurfaced are accessible to the rollers used to compact the subgrade or paving materials. Where new pavement is to adjoin existing asphalt or concrete pavements, the existing pavement shall be saw cut or blade cut to straight lines at a 45° angle.

301.02.03 Concrete Pavement. Concrete pavement shall be removed to neatly sawed edges. Saw cuts shall be made to a minimum depth of 1 1/2 inches. If a saw cut in concrete pavement falls within 3 feet of a construction joint, cold joint, expansion joint, crack, or edge, the concrete shall be removed to the joint, crack, or edge. The edges of existing concrete pavement adjacent to trenches where damage subsequent to the original saw cutting of the pavement has occurred shall again be saw cut to neat straight lines for the purpose of removing the damaged pavement areas. Such saw cut shall be either parallel to the original saw cuts or shall be cut on an angle which departs from the original saw cut by not more than 1 inch in each 6 inches.

301.02.04 Concrete Curb, Sidewalks, Gutters, Cross Gutters, Driveways, and Alley Intersections. Concrete shall be removed to neatly sawed edges with saw cuts made to a minimum depth of 1 1/2 inches. Concrete sidewalk or driveway to be removed shall be neatly sawed in straight lines either parallel to the curb or at right angles to the alignment of the sidewalk. No section to be replaced shall be smaller than 30 inches in length. If the saw cut in sidewalk or driveway falls within 30 inches of a construction joint, expansion joint, crack, or edge, the concrete shall be removed to the joint, or edge, except that where the saw cut would fall within 12 inches of a score mark, the saw cut shall be made in and along the score mark. Curb and gutter shall be sawed to a depth of 1 1/2 inches on a neat line at right angles to the curb face.

301.03 REMOVAL OF MATERIALS. All materials removed shall be hauled from the site at the Contractor's expense, unless otherwise specified. The construction area shall be left with a neat and finished appearance.

301.04 PROTECTION OF ITEMS NOT REMOVED

301.04.01 Protection. Existing improvements, adjacent property, utilities and other facilities, and trees and plants that are not to be removed shall be protected from injury or damage resulting from the Contractor's operations.

301.04.02 Responsibility. Any existing improvements, adjacent property, utilities, sprinkler systems, signs, other facilities or appurtenances, including trees and plants which are damaged or displaced as a result of the Contractor's operation, shall be replaced or restored to the original position and condition prevailing prior to the start of his operations at the Contractor's own cost and expense, unless otherwise directed by the Engineer. In addition, removal of existing improvements shall be done in accordance with the provisions of Section 300.04 – Protection of Utilities and Underground Facilities.”

301.05 BASIS OF PAYMENT. Unless specified otherwise, removal of existing improvements shall be compensated for by a unit price established for each item. This unit price shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in the removal of existing improvements as shown on the Plans and as specified in these Specifications or as specified otherwise, and as directed by the Engineer, including the removal and disposal of all the resulting materials.

When the contract does not include a pay item for removal of existing improvements as above specified, full compensation for any necessary removal of existing improvements required to perform the construction operations specified shall be considered as included in the price bid for other items of work and no additional compensation will be allowed therefor.

302.01 DESCRIPTION. This Section covers the preparation of natural, filled, or excavated material prior to the placement of additional fill and/or improvements.

302.02 PREPARATION OF SUBGRADE. Scarifying and cultivating will be required for dry soils which are impervious to the penetration of water, for soils which contain excessive amounts of moisture which may result in unstable foundations, for soils which are non-uniform in character which may result in non-uniform relative compactions and subsequent differential settlements of finished surfaces, or when pavement is to be placed directly on the roadbed material. Cemented soils are exempt from scarification, moisture conditioning, and recompaction, if allowed by the Engineer. Unsuitable material found below the processing depth or subgrade specified herein shall be treated in accordance with Subsection 302.05 – “Unsuitable Material.”

After rough grading has been completed when scarifying and cultivating are required, the subgrade shall be loosened to a depth of at least 6 inches. The loosened material shall then be worked to a finely divided condition and all rocks larger than 4 inches in diameter shall be removed. The moisture content shall be brought to sufficiently near optimum by the addition of water, by the addition and blending of dry suitable material, or by the drying of existing material to allow densification to the specified minimum relative compaction.

Uniform pervious soils that allow the immediate penetration of water, or uniform impervious soils which will allow the penetration of water to a depth of at least 6 inches after the addition of suitable wetting agent, will not require scarifying and cultivating unless a condition previously set forth in this subsection requires such processing. When scarifying and cultivating are not required, the moisture content of the top 6 inches of the subgrade material shall be brought to sufficiently near optimum by moisture conditioning to allow densification to the specified minimum relative compaction.

302.03 RELATIVE COMPACTION. Unless specified otherwise, all subgrade shall be densified to a relative compaction of not less than 90 percent for a minimum depth of 6 inches, in accordance with test procedures set forth in ASTM D 1557. Subgrade beneath full depth asphalt pavements shall be densified for a depth of at least 6 inches to a minimum 95 percent relative compaction.

302.04 SUBGRADE TOLERANCES. Native subgrade or imported subbase shall not vary more than 0.1 foot from the specified grade and cross section. Variations within the above specified tolerances shall be compensating so that the average grade and cross section specified are met.

302.05 UNSUITABLE MATERIAL. Any unstable material encountered in the subgrade preparation, such as organic, fine grain, oversized, or expansive material which is unsuitable subgrade or cannot be properly graded and compacted, shall be disposed of off the site. Any such material which is encountered below finished grade shall be removed, disposed of, and replaced with an approved material as directed by the Engineer.

302.06 WET MATERIAL. If required excavated material is unsatisfactory for the specified use on the project solely because of high moisture content, the Contractor may be directed by the Engineer to either process the material to reduce the moisture content to an optimum condition, or to remove the material and replace it with suitable material. If such high moisture content is not the result of any action on the part of the Contractor, or inaction in protecting the work during the course of the contract, the work involved will be paid for in accordance with Subsection 100.24 – “Change Orders.” Otherwise, the Contractor shall submit to the Engineer for approval a plan for drying or removing and replacing the wet material, and such work and material shall be at the expense of the Contractor.

302.07 BASIS OF PAYMENT. Payment for preparing a subgrade will be considered as included in the item of work for which the subgrade is prepared.

303.01 DESCRIPTION. Unclassified excavation shall consist of all excavations, unless separately designated.

303.02 LIMIT OF WORK. The limits of the excavation shall be shown on the Plans or as may be required by these Specifications.

303.02.01 UNCONTROLLED FILL. Uncontrolled fill lying in structural areas shall be removed. Uncontrolled fill is any fill material that has not been placed properly, compacted lifts under the construction observation, and material testing program of a Nevada licensed engineer and cannot be verified by the Engineer as to its competency to support the proposed structural improvements. Uncontrolled fill may be reused as structural or nonstructural fill only if of suitable quality as determined by the Engineer. If the Engineer concludes the uncontrolled fill is unsuitable, the material shall be disposed of in accordance with Subsection 303.02.02 – “Unsuitable Material”. Fill to be used beneath buildings, concrete slabs, asphalt pavements, and all other structural loading shall conform to the requirements of Subsection 304.03 – “Structural Fill”.

303.02.02 UNSUITABLE MATERIAL. Material that is unsuitable for the planned use shall be excavated and disposed of as directed by the Engineer.

The removal and disposal of such unsuitable material will be paid for as unclassified excavation for the quantities involved if the removal of such material is shown in the Plans or specified in the Special Provisions.

If the removal of unsuitable material is not shown on the Plans or specified in the Special Provisions, the removal and disposal of such unsuitable materials will be paid for at the contract price for unclassified excavation. However, if due to the character of the work, the removal and disposal of the unsuitable material is not properly compensable at the contract prices for unclassified excavation, the work may be paid for in accordance with Subsection 100.24 – “Change Orders”.

303.02.03 WET MATERIAL. If wet material is encountered during the excavation process and the material is found to be unsatisfactory for the specified use on the project, solely because of high moisture content, the Contractor may be directed by the Engineer or Agency to either process the material to reduce the moisture content to an optimum or otherwise acceptable condition or to remove the material and replace it with suitable material. If such high moisture content is a result of any action by the Contractor or any inaction in protecting the work during the course of the Contract, the Contractor shall submit to the Engineer or Agency for approval a plan for drying or removing and replacing the wet material at the expense of the Contractor. However, if such high moisture content is a result of forces beyond the Contractor’s control or was not present at the time of bidding, the Contractor may request additional compensation by Change Order as specified in Subsection 100.24 – “Change Orders.” It will be assumed that the Contractor is reasonably familiar with the condition of the soil at the site during the time of bidding and that no additional compensation will be paid to the Contractor because of his failure to disclose any obvious soil conditions.

303.02.04 OVERSHOOTING. Excessive blasting will not be permitted. Material outside the authorized cross section which may be shattered or loosened because of blasting shall be removed at the Contractor’s expense. The Contractor shall discontinue any method of blasting which leads to overshooting, is hazardous to the public, or is destructive to property or natural features.

303.02.05 SLIDES AND SLIPOUTS. Material outside the planned excavation limits which is unstable and constitutes a potential slide as determined by the Engineer, material which has come into the planned excavation limits, and material which has slipped out of new or old fills, shall be excavated to designated lines or slopes either by benching or in such manner as directed by the Engineer. Such material may be used in the construction of an unclassified fill or disposed of as directed by the Engineer.

The removal and disposal of slide and slipout material not resulting from any act, or failure to act, on the part of the Contractor will be paid for at the contract prices for unclassified excavation for the quantities involved.

However, if due to the character of the work, the removal and disposal of such material is not properly compensable at the contract prices for unclassified excavation, the work may be paid for as provided in Subsection 100.24 – “Change Orders.”

Payment will be made only for those quantities of slide or slipout material which are actually removed as ordered by the Engineer.

303.02.06 SLOPES. Excavation slopes shall be finished in conformance with the lines and grades shown on the Plans. All debris and loose material shall be removed. When completed, the average plane of the slopes shall conform to the slopes indicated on the Plans and no point on the completed slopes shall vary from the designated plane by more than 6 inches measured at right angles to the slope. Where excavation is in rock, no point shall vary more than 2 feet from the designated plane of the slope. In no case shall any portion of the slope encroach so as to interfere with the planned use of the facility.

The tops of excavation slopes and the ends of excavations shall be rounded, and these quantities will not be included in the quantities to be paid for as excavation. This work will be considered as a part of finishing slopes and no additional compensation will be allowed therefor.

303.02.07 SURPLUS MATERIAL. Unless otherwise shown on the Plans or specified in the Special Provisions, no surplus excavated material may be disposed of within the project limits or within rights-of-way. The Contractor shall make all arrangements for disposal of the material at off-site locations and shall, upon request, file with the Engineer the written consent of the Owner of the property upon which he intends to dispose of such material.

Quantities of surplus material, if shown on the Plans or in the Special Provisions, are approximate only. The Contractor shall satisfy himself that there is sufficient material available for the completion of the fills before disposing of any indicated surplus material inside or outside the limits of the project or right-of-way. Any shortage of material caused by premature disposal of the indicated surplus material by the Contractor shall be replaced by him and no compensation will be allowed for such replacement.

303.02.08 SELECTED MATERIAL. Selected material encountered in excavation within the project limits shall be used as shown on the Plans as specified in the Special Provisions, or as directed by the Engineer. Topsoil excavated within the limits of the project may be considered as a selected material only for the purpose of backfilling areas to be planted or other areas as designated by the Engineer.

303.02.09 STRUCTURE EXCAVATION. Structure excavation shall consist of removal of material for the construction of foundations for bridges, retaining walls, head walls, culverts, or other structures. Structure excavation shall include the furnishing of all materials and equipment, the construction or installation of all cofferdams and other facilities which may be necessary to perform the excavation, and the subsequent removal of such facilities as may be necessary or required.

When footing concrete or masonry is to rest upon rock, the rock shall be fully uncovered and the surface thereof shall be removed to a depth sufficient to expose sound rock. The rock shall be roughly leveled off or cut to approximate horizontal and vertical steps and roughened. Seams in the rock shall be grouted under pressure or treated as the Engineer may direct, and the cost thereof will be paid for as extra work unless indicated otherwise by the Plans or Specifications.

Whenever any structure excavation is completed, the Contractor shall notify the Engineer so that an inspection can be made of the foundation. No concrete or masonry shall be placed until the Engineer has inspected the foundation and has given approval to proceed or has given approval without making an inspection.

303.03 PROTECTION OF UTILITIES AND UNDERGROUND FACILITIES. All unclassified excavation shall be done in conformance with the provisions of Subsection 300.04 – “Protection of Utilities and Underground Facilities.”

303.04 BASIS OF PAYMENT.

303.04.01 GENERAL EXCAVATION. The lump sum price, or the price per cubic yard, bid for excavation shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all work as shown on the Plans or as specified in these Specifications, or as specified otherwise, and as directed by the Engineer.

Unless otherwise specified, the quantity of excavation will be measured on a volume basis by cross sectioning the area to be excavated and computing neat lines for end area. The average end area method will be used with no allowance made for curvature. If, for any reason, it is impossible or impractical to measure quantities by average end areas, the Engineer will compute the quantities by a method which, in his opinion, is best suited to obtain an accurate determination.

When the contract does not include a pay item for necessary excavation required to perform the construction operations specified, full compensation shall be considered as included in the price bid for other items of work and no additional compensation will be allowed therefor.

303.04.02 STRUCTURE EXCAVATION. Unless otherwise provided in Special Provisions or Bid Proposal, no payment will be made for structure excavation as such. Full compensation shall be considered as included in the price bid for construction or installation of the items to which such excavation is incidental or appurtenant.

The quantity of structure excavation, whether paid for as a separate item or not, shall be that volume in place included between a vertical plane 3 feet outside of and parallel with the outermost horizontal dimensions of the structure and between the surface of the existing ground and the footing subgrade.

304.01 DESCRIPTION. Unclassified fill shall consist of all filling unless separately designated. Construction of unclassified fill includes preparing the area on which fill is to be placed, and the depositing, conditioning, and compacting of fill material.

304.02 PREPARATION OF FILL AREAS.

304.02.01 PREPARATION OF EXISTING GROUND. Areas over which fills are to be placed shall first be cleared and grubbed in accordance with Section 300 – “Clearing and Grubbing” – and prepared in accordance with Section 302 – “Subgrade Preparation.”

304.02.02 BENCHING. When fill is to be placed on existing slopes that exhibit a slope in excess of 5:1, the existing slope shall be horizontally benched to insure an adequate bond between the fill and original ground. Original ground shall be stripped to sufficient depth to remove all loose superficial soils. Horizontal benches shall be excavated in equipment-wide swaths.

304.03 STRUCTURAL FILL. Fill to be placed beneath buildings, concrete slabs, asphalt pavements, and all other structural loading shall conform to the requirements of Subsection 200.01.09 – “Structural Fill”.

304.04 PLACING MATERIALS FOR FILLS.

304.04.01 LAYERS. Fill material shall be placed in horizontal layers of depths compatible to the material being placed and the type of equipment being used. Each layer shall be evenly spread and moistened or aerated, as necessary. Unless otherwise approved by the Engineer, each layer spread for compaction shall not exceed 8 inches of compacted thickness.

Unless otherwise permitted by the Engineer, each layer of fill material shall cover the length and width of the area to be filled before the next higher layer of material is placed. The top surface of each layer shall be approximately level, but with a crown or crossfall of at least 1 foot in 50 feet, but no more than 1 foot in 20 feet, to provide adequate drainage at all times during the construction period.

304.04.02 ROCK FILL. When fill material contains by volume over 30 percent of rock larger than 3/4 inch in greatest dimension, the fill below a plane 3 feet from finished grade may be constructed in layers of a loose thickness before compaction, up to the maximum size of rock in the material, but not exceeding 18 inches in thickness. The interstices around the rock in each layer shall be filled with soil and compacted. Rock larger than 12 inches in greatest dimension shall not be allowed without approval of the Engineer. Rock larger than 6 inches shall not be placed in the upper 1 foot of structural fill.

304.04.03 CONSTRUCTION DEBRIS. Broken Portland Cement Concrete and bituminous pavement obtained from the project excavations may be permitted in the fill with the following limitations:

1. The maximum dimension of any piece used shall be 6 inches.
2. Pieces larger than 4 inches shall not be placed within 12 inches of any structure.
3. Pieces larger than 3 inches shall not be placed within 12 inches of the subgrade for paving.
4. “Nesting” of pieces will not be permitted.

304.05 APPLICATION OF WATER. At the time of compaction, the moisture content of fill material shall be such that the specified relative compaction will be obtained in accordance with test procedures set forth by ASTM D1557, and the fill will be firm, hard, and unyielding. Fill material which contains excessive moisture shall not be compacted until the material is dry enough to obtain the required relative compaction.

304.06 COMPACTION. Unless otherwise specified, each layer of earth fill shall be compacted to a relative compaction of at least 90 percent in accordance with ASTM D1557, applicable method.

304.06.01 SLOPES. Fill slopes shall be finished in conformance with the lines and grades shown on the Plans. When completed, the average plane of the slopes shall conform to the slopes indicated on the Plans and no point on the completed slopes shall vary from the designated plane by more than 6 inches measured at right angles to the slope.

304.07 STRUCTURE BACKFILL.

304.07.01 PLACEMENT. Structure backfill shall not be placed until the structure footings or other portions of the structure or facility have been inspected by the Engineer and approved for backfilling. No backfill shall be placed until the concrete has developed a strength of not less than 3,000 pounds per square inch in compression as determined by test cylinders cured under conditions similar to those prevailing at the site. The above curing requirement may be waived if the structure is of such a nature that the backfilling procedure will not be harmful to the curing concrete or will not create a hazardous condition.

The backfill material and its placement and compaction shall comply with the requirements of Sections 304.03 through 304.06 of these Specifications, inclusive.

304.07.02 PONDING OR JETTING. Ponding and jetting of structural backfill may be permitted upon approval of the Engineer when the backfill material and adjacent native material are free draining having a sand equivalent of at least 30.

304.08 MEASUREMENT OF QUANTITIES. Unless otherwise specified, the fill quantity will be measured on a volume basis by cross sectioning the area to be filled and computing neat lines for an end area. The average end area method will be used with no allowance made for curvature. If for any reason it is impossible or impractical to measure quantities by average end areas, the Engineer will compute the quantities by a method which, in his opinion, is best suited to obtain an accurate determination.

304.09 BASIS OF PAYMENT. Unclassified Fill will be paid for by either the cubic yard unit price or by the lump sum bid in the unit Bid Schedule. Such payment shall include all labor, equipment, materials, watering, placement, spreading, processing, compaction, and all other items and activities necessary for fill placement.

Unless otherwise provided in the Special Provisions or Bid Proposal, no payment will be made for structure backfill as such. Full compensation will be considered as included in the bid price for construction of the items to which such backfill is incidental or appurtenant.

305.01 DESCRIPTION. This work shall consist of furnishing all materials, equipment, and labor for excavating, trenching, and backfilling of all work delineated as trenchwork on the Plans, in these Specifications, or as directed by the Engineer.

For the purpose of shoring or bracing, a trench is defined as an excavation in which the depth is greater than the width of the bottom of the excavation.

Excavations for appurtenant structures, such as but not limited to manholes, transition structures, junction structures, vaults, valve boxes, catch basins, thrust blocks, and boring pits shall, for the purpose of shoring and bracing, be deemed to be in the category of trench excavation.

Excavations shall include the removal of all water and materials of any nature which interfere with the construction work. Removal of ground water to a level below the structure subgrade shall be accomplished as necessary.

Excavation for conduits shall be by open trench unless otherwise specified or shown on the Plans. However, should the Contractor elect to tunnel or jack any portion not so specified, he shall first obtain approval from the Engineer. Payment for such work will be made as though the specified methods of construction had been used.

305.02 MAXIMUM LENGTH OF OPEN TRENCH. Except by permission of the Engineer, the maximum length of open trench where prefabricated pipe is used shall be 500 feet, or the distance necessary to accommodate the amount of pipe installed in a single day, whichever is the greater. The distance is the collective length at any location that has not been temporarily resurfaced, and includes open excavation pipe laying, and appurtenant construction and backfill.

Except by permission of the Engineer, the maximum length of open trench in any one location where concrete structures are cast in place will be that which is necessary to permit uninterrupted progress. Construction shall be pursued as follows: excavation, setting of reinforcing steel, placing of floor slab, walls, and cover slab or arch. Each shall follow the other without any one operation preceding the next nearest operation by more than 200 feet. Failure by the Contractor to comply with the limitations specified herein may result in an order to halt the work until such time as compliance has been achieved.

305.03 TRENCH WIDTH. For pipe, the minimum and maximum width of trench permitted shall be as indicated on the Plans, and shall be of such a width to allow placement and compaction of bedding and backfill.

If the maximum trench width is exceeded, the Contractor shall provide additional bedding, another type of bedding, or a higher strength of pipe, as shown on Plans or approved by the Engineer, at no additional cost to the Agency.

Additional payments or deductions from the Contract price for trench excavation for conduits will be based upon a calculated or measured lineal distance. The width used in calculating the volume of excavation for prefabricated conduit will be the maximum width of trench shown on the Plans and measured at the top of the pipe. In the case of sewers or storm drains formed and cast in place, such volume will be based upon the outside width of the structure being constructed plus 3 feet.

Additional payment or deductions from Contract price for trench resurfacing will be based upon an area determined by the maximum width of trench as specified herein.

305.04 LADDERS. Safe and suitable ladders which project 2 feet above the top of the trench shall be provided for all trenches over 5 feet in depth. One ladder shall be provided for each 100 feet of open trench, or fraction thereof, and be so located that workmen in the trench need not move more than 50 feet to a ladder.

305.05 REMOVAL OF EXISTING FACILITIES. Bituminous pavement, concrete pavement, curbs, sidewalks or driveways removed in connection with construction shall be removed and reconstructed in accordance with Subsection 305.07 – "Trenches Under Pavement or Structures."

305.06 SHORING. The manner of bracing excavations shall be as set forth in the rules, orders, and regulations of the United States Department of Labor Occupational Safety and Health Administration (OSHA).

A detailed plan showing the design of shoring, bracing or sloping of all trenches 5 feet deep or deeper must be submitted and approved by the Engineer prior to commencing any such trenching operations. If the submitted plan varies from the standards established by the OSHA, the plan shall be prepared by a registered Civil or Structural Engineer.

Should the bracing system utilize steel H-beams or piles or other similar vertical supports, driving of said vertical supports will not be permitted except for the last 4 feet. The vertical supports shall be placed in holes drilled to a depth of 4 feet above the proposed bottom of pile, except where this procedure is impracticable. The vertical support may then be driven to the required depth, not to exceed 4 feet. During the drilling and driving operations, the Contractor shall take care to avoid damage to utilities.

At locations where the drilling of such holes is impracticable because of the existence of rocks, running sand, or other similar conditions, and provided said impracticability is demonstrated to the satisfaction of the Engineer by actual drilling operations by the Contractor, the Engineer may, upon request of the Contractor, approve the use of means other than drilling for the purpose of placing the vertical support. Such other means, however, must be of a nature which will accomplish, as nearly as possible, the purpose of the drilling, namely, the prevention of damage to existing surface or subsurface improvements, both public and private. All costs for this work shall be included in the prices bid for the items involved.

If sheeting is used to support the excavated trench, the sheeting shall be removed by the Contractor, and no such sheeting will be permitted to remain in the trench. When field conditions, the type of sheeting, or methods of construction used by the Contractor are such as to make the removal of sheeting impracticable, the Engineer may permit portions of the sheeting to be cut off to a specified depth and remain in the trench.

305.07 TRENCHES UNDER PAVEMENT OR STRUCTURES. All materials removed shall be disposed of by the Contractor at his expense. The roadway and adjacent areas shall be left with a neat and finished appearance.

The removal of existing improvements shall conform to the following requirements:

305.07.01 REMOVAL OF BITUMINOUS PAVEMENT. Removal of bituminous pavement shall be done in accordance with Subsection 301.02.02 – “Bituminous Pavement.”

305.07.02 REMOVAL OF CONCRETE PAVEMENT. Removal of concrete pavement shall be done in accordance with Subsection 301.02.03 – “Concrete Pavement.”

305.07.03 CONCRETE CURB, SIDEWALKS, GUTTERS, CROSS GUTTERS, DRIVEWAYS, AND ALLEY INTERSECTIONS. Removal of concrete curb, sidewalks, gutters, cross gutters, driveways, and alley intersections shall be in accordance with Subsection 301.02.04 – “Concrete Curb, Sidewalks, Gutters, Cross Gutters, Driveways, and Alley Intersections.”

305.07.04 REPLACEMENT OF MATERIALS REMOVED. Bituminous pavement, concrete pavement, concrete curb, sidewalks, gutters, cross gutters, driveways, and alley intersections shall be replaced with materials equal to or better than the surrounding material. Replacement shall include compacted subgrade and base material.

305.08 BEDDING. Bedding shall be defined as that material supporting, surrounding, and extending to 1 foot above the top of the pipe. Where concrete is specified to cover the pipe, the top of the concrete shall be considered as the top of the bedding.

If soft, spongy, unstable, or other similar material is encountered upon which the bedding material or pipe is to be placed, this unsuitable material shall be removed to a depth ordered by the Engineer and replaced with bedding material suitably densified. Additional bedding so ordered, over the amount required by the Plans or Specifications, will be paid for as provided in the Contract Documents or the Special Provisions. If the necessity for such additional bedding material has been caused by an act or failure to act on the part of the Contractor, the Contractor shall bear the expense of the additional excavation and bedding.

Bedding material shall first be placed so that the pipe is supported for the full length of the barrel with full bearing on the bottom segment of the pipe equal to a minimum of 0.4 times the outside diameter of the barrel. Then the remainder of the bedding shall be placed. Alternate methods of pipe laying which are recommended by the pipe manufacturer may be used if approved by the Engineer.

Except where otherwise specified, bedding material shall conform to Subsection 200.03 – “Aggregates for Bedding and Backfill”. Bedding shall be densified to at least 90 percent relative compaction (ASTM D 1557).

Unless otherwise specified, concrete used for bedding shall contain four sacks of Type II cement per cubic yard of concrete, shall have a maximum aggregate size no greater than 1 1/2 inches, and shall obtain a minimum compressive strength of at least 2,000 pounds per square inch in 28 days.

In cases where native free-draining granular material is suitable for use as bedding, the trench may be excavated to a point above the invert grade and the trench bottom hand-shaped so that the bottom segment of the pipe is firmly supported on undisturbed material.

Unless otherwise specified, special pipe bedding will not be required for steel or cast iron water pipe, and the trench bottom need not be shaped to the outside diameter of the pipe. However, the trench bottom shall provide firm and uniform bearing.

305.09 BACKFILL AND DENSIFICATION. Backfill shall be considered as starting 1 foot above the pipe or conduit, or at the top of concrete bedding over the pipe or conduit. All material below this point shall be considered as bedding.

Backfill, or fill, as the case may be, for cast-in-place structures such as, but not limited to, manholes, transition structures, junction structures, vaults, valve boxes, and reinforced concrete box conduits shall start at the subgrade for the structure.

Except where the pipe must remain exposed for force main leakage tests and subject to the provisions herein, the Contractor shall proceed as soon as possible with backfilling operations. Care shall be exercised so that the conduit will not be damaged or displaced. If the pipe is supported by concrete bedding placed between the trench wall and the pipe, the remainder of any bedding material shall be placed to 1 foot over the top of the conduit. The backfill above the bedding shall not be placed nor sheeting pulled until at least 40 hours after the placement of concrete bedding. Such backfill may be placed and sheeting pulled after 24 hours if the early strength of the bedding is increased.

Unless otherwise specified, the periods of time set forth in the following table after which the Contractor may place fill or backfill against or over the top of any cast-in-place structures are predicated on the use of concrete to which no admixture has been added for the purpose of obtaining a high early strength:

<u>Operation</u>	<u>Location</u>	
	Against Sides of Structures <u>(days)</u>	Over Top of Structures <u>(days)</u>
Placement of Loose Backfill	5	21
Densification of Backfill	7	28

The Engineer may permit the use of admixtures or the use of additional cement in various parts of the structure in accordance with Section 202 – “Cement and Related Materials.”

Rocks greater than 4 inches in any dimension will not be permitted in backfill placed 2 feet above any pipe or box wherever the trench width is 4 feet or narrower. Wherever trench widths are greater than 4 feet, rocks larger than 4 inches but less than 12 inches in any dimension will be permitted as backfill no closer than 2 feet from the top of pipe or box and 2 feet below finished pavement subgrade or within 2 feet of risers, valves, manholes, or other structures, providing the following conditions are met:

1. Backfill materials shall be screened or "grizzled" prior to being used as backfill.
2. Rocks shall be mixed with sufficient volume of suitable soil so as to eliminate nesting of rock and voids.
3. Trenches shall be at least 4 feet wide if a compactor on the end of a track excavator boom is utilized, or at least 8 feet wide if a full sized roller is used. A full sized roller shall consist of a sheepsfoot or drum roller having metal drums or shells not less than 4 feet in diameter. Hand tamping compactors or rollers will be used to obtain compaction within 2 feet of risers, valves, manholes, or other structures, and will be used to assist in obtaining compaction along the edges of the trenches. However, they will not be permitted to be used in lieu of the equipment specified if rock larger than 4 inches in any dimension is used as backfill.
4. The Contractor shall demonstrate to the Engineer and the testing agency that adequate compaction can be obtained with the materials, equipment, and procedures to be used.
5. Compacted lift thickness shall not exceed 12 inches.
6. If, in the opinion of the Engineer and testing agency, the backfill soils cannot be satisfactorily tested to determine if compaction criteria is met, the testing agency and Engineer, at their option, may direct the Contractor to modify his materials and procedures so that testing can be performed or may use a method specification based on the equipment and materials being used to verify that adequate compaction is obtained.

Rocks larger than 12 inches in any dimension shall not be permitted without authorization of the Engineer and only after a satisfactory method of obtaining adequate compaction has been developed and agreed to.

Where rocks are included in the backfill, they shall be mixed with suitable excavated materials so as to eliminate voids.

Broken Portland Cement Concrete and bituminous type pavement obtained from project excavations will be permitted in the backfill subject to the same limitations as rocks, except that bituminous materials recycled as backfill will not be allowed within 5 feet of the ground water table.

Where it becomes necessary to excavate beyond the limits of normal excavation lines in order to remove boulders or other interfering objects, the voids remaining after the removal of the boulders shall be backfilled as specified herein, or as otherwise approved by the Engineer:

- a. Where the void is below the subgrade for bedding conduits or structure, backfill shall be:
 1. Suitable material, as approved by the Engineer, and densified to not less than 90 percent relative compaction in accordance with ASTM D1557 in all structural areas including buildings and streets, and not less than 85 percent relative compaction in non-structural areas.
 2. Concrete containing five sacks of Type II cement per cubic yard of concrete, 1 1/2 inch maximum size aggregate, and a minimum compressive strength of 2,000 pounds per square inch in 28 days.
 3. Thoroughly densified bedding material as specified by the Engineer.
- b. Where the void is in the side of the trench, it shall be backfilled with suitable material and densified as approved by the Engineer.

It shall be understood that the removal of all boulders or other interfering objects and the backfilling of voids left by such removals shall be at the expense of the Contractor and no direct payment for the cost of such work will be made. The cost of such work shall be included in the prices bid for the various items of work.

Voids left by the removal of sheeting, piles, and similar sheeting supports shall be immediately backfilled with clean sand which shall be jetted into place to assure dense and complete filling of the voids.

After the placing of backfill has been started, the Contractor shall proceed as soon as practicable with densification.

305.10 MECHANICALLY COMPACTED BACKFILL. Backfill shall be mechanically compacted by means of tamping rollers, sheepsfoot rollers, pneumatic tire rollers, vibrating rollers, or other mechanical tampers. All such equipment shall be of a size and type approved by the Engineer. Impact-type pavement breakers (stompers) will not be permitted over clay, asbestos cement, cast iron, or non-reinforced concrete pipe.

Permission to use specific compaction equipment shall not be construed as guaranteeing or implying that the use of such equipment will not result in damage to adjacent ground, existing improvements, or improvements installed under the contract. The Contractor shall make his own determination in this regard.

Material for mechanically compacted backfill shall be placed in lifts which, prior to compaction, shall not exceed the thickness specified below for the various types of equipment:

- a. Impact, free-fall, or stomping equipment maximum lift thickness of 1 foot.
- b. Vibratory equipment, including vibratory plates, vibratory smooth-wheel rollers, and vibratory pneumatic tired rollers maximum lift thickness of 1 foot.
- c. Rolling equipment, including sheepsfoot (both vibratory and non-vibratory), grid, smooth-wheel (non-vibratory), pneumatic tired (non-vibratory), and segmented wheels - maximum lift thickness of 1 foot.
- d. Hand-directed mechanical tampers - maximum lift thickness of 8 inches.

Mechanically compacted backfill shall be placed in horizontal layers of thickness (not exceeding those specified above) compatible to the material being placed and the type of equipment being used. Each layer shall be evenly spread, moistened (or dried, if necessary), and then tamped or rolled until at least 90 percent relative compaction has been attained in all structural areas and at least 85 percent in non-structural areas in accordance with ASTM D 1557.

305.11 WATER DENSIFIED BACKFILL. Water densified backfill shall be employed only if authorized by the Engineer.

As used in these Specifications, flooding shall mean the inundation of backfill with water puddled with poles or bars to insure saturation of the backfill material for its full depth. Jetting shall be accomplished by the use of a jet pipe to which a hose is attached carrying a continuous supply of water under pressure.

Unless flooding is specified or otherwise authorized by the Engineer, all backfill to be densified by water shall be jetted.

Bedding shall be carefully placed by hand to a depth of 1 foot over the top of the pipe 24 inches in internal diameter or smaller, and placed by an applicable method to the same depth for pipe 27 inches in internal diameter or larger. The backfill shall be placed, flooded, or jetted as specified in this Subsection.

305.11.01 RESTRICTIONS. Densification by flooding or jetting shall be subject to all of the following requirements:

- a. Application of Water. The Contractor shall apply water in a manner, quantity, and at a rate sufficient to thoroughly saturate the thickness of the lift being densified. Jetting shall be done in accordance with Subsection 304.07.02 – “Ponding or Jetting.”

- b. Use of Vibration. Where densities are required which cannot be attained by jetting or flooding alone, the Engineer may direct the Contractor to supplement the jetting or flooding process with the application of vibrating compacting equipment to the backfill.
- c. Lift Thickness. The lift of backfill shall not exceed that which can be readily densified by the jetting or flooding procedure, but in no case shall the undensified lift exceed 10 feet for flooding or 15 feet for jetting.
- d. Character of Material. Water densified backfill shall have a minimum sand equivalent of 30 (ASTM D2414). Where the nature of the material excavated from the trench is generally unsuitable for densification by water, the Contractor may, at no cost to the Agency, import suitable material for flooding or jetting, or densify the excavated material by other methods. If water densification methods are employed in such cases, the Contractor shall, at his expense, provide free-draining bedding material under the pipe and all structures to permit the unimpeded movement of excess water to the downstream end of the construction where the Engineer may require the Contractor to provide a sump and pump to remove the accumulated water.
- e. Damage to Adjacent Improvements. The Contractor shall make his own determination that the use of flooding or jetting methods will not result in damage to existing improvements. Permission to use such methods in densifying backfill shall not be construed as guaranteeing or implying that adjacent ground and improvements will be unaffected.

305.12 BACKFILL IN NARROW TRENCHES. A narrow trench is defined as being 3 feet wide or less at the surface of the ground.

305.13 BACKFILL IN WIDE TRENCHES. A wide trench is defined as being wider than 3 feet at the surface of the ground.

Backfill in wide trenches in State Highways may not be placed and densified by jetting unless specifically permitted by the Special Provisions or encroachment permit. Otherwise, backfill shall be placed and densified to the specified relative compaction by mechanical compaction methods.

305.14 DENSIFICATION OF BACKFILL. Backfill of trenches beneath streets, buildings, concrete slabs, asphalt pavements, and any structural loading shall be densified to a relative compaction of at least 90 percent when tested in accordance with ASTM D 1557 by mechanical or water densified means approved by the Engineer. Backfill in non-structural areas shall be densified to at least 85 percent relative compaction.

305.15 IMPORTED BACKFILL. If the Contractor elects to import material from a source outside the project limits for use as backfill, said materials shall be clean soil, free from organic material, trash, debris, rubbish, or other objectionable substances.

Whenever the Contractor elects to use imported material for backfill, he shall deliver a sample of the material to the Engineer not less than 10 days prior to intended use. The sample shall have a minimum dry weight of 100 pounds and shall be clearly identified as to source, including street address and community of origin. The Engineer will determine the suitability, the minimum relative compaction to be attained, and the placement method.

Should the imported material not be substantially the same as the approved sample, it shall not be used for backfill and shall be removed from the job-site at the Contractor's expense.

The densification method for imported material authorized by the Engineer will be dependent upon its composition, the composition of the in-place soil at the point of placement, and the relative compaction to be obtained.

The Contractor may, at his option and with the Engineer's approval, transport or back-haul material to be used as backfill material from any portion or line of a project to any other portion or line of the same project, or from any project being constructed under one Contract to any other project being constructed under that same contract. Such transported material shall be clean soil, free from organic material, trash, debris, rubbish, or other objectionable substances.

305.16 SLURRY BACKFILL. At the option of the Contractor, slurry backfill may be used as structural backfill for pipe culverts, except that slurry backfill shall not be used as such for aluminum or aluminum coated pipe culverts. Slurry backfill may be used as a substitute for aggregate base with the approval of the Engineer or Agency. Slurry backfill may be used as bedding for private utilities with approval of the utility company.

When slurry backfill is used as structural backfill, the width of the excavation shown on the plans may be reduced so that the clear distance between the outside of the pipe and the side of the excavation, on each side of the pipe, is a minimum of six inches for pipes up to and including 42 inches in diameter or span and one foot for pipe over 42 inches in diameter or span.

Slurry backfill shall be placed only for the portion of the structural backfill below the original ground or the grading plane or the type of embankment placed prior to excavating for the culvert pipe. Where necessary, earth plugs shall be compacted as required by the project specifications at each end of the pipe prior to placing slurry backfill in a manner that will completely contain the slurry backfill in the pipe trench.

Slurry backfill shall be placed in a uniform manner that will prevent the development of voids in or segregation of the slurry backfill, and will not shift or float the pipe culvert. Foreign materials which fall into the trench prior to or during the placement of the slurry backfill shall be immediately removed.

The placement of any material over the slurry backfill shall not commence until at least four hours after the slurry backfill has been placed, except that when concrete sand is used for the aggregate and the in-place material is free draining, backfilling may commence as soon as the surface water is gone.

Slurry backfill used for intersections and long trenches in roadways shall be allowed to set for at least four hours before supporting vehicular traffic. The Contractor is permitted to place slurry backfill to pavement grade and leave exposed until such time as the Contractor excavates out the pavement depth and commences paving.

305.17 TEMPORARY RESURFACING. Unless permanent pavement is placed immediately, temporary bituminous resurfacing 2 inches thick shall be placed and maintained at locations determined by the Engineer wherever excavation is made through pavement, sidewalk, or driveways. In sidewalk areas the temporary bituminous resurfacing shall be at least 2 inches thick. At major intersections and other critical locations, a greater thickness may be ordered. Temporary resurfacing shall be placed as soon as the condition of the backfill is suitable to receive it and shall remain in place until the condition of the backfill is suitable for permanent resurfacing.

305.18 JACKING OPERATIONS. Before starting excavation, the Contractor shall submit drawings of jacking pit bracing, casing (or conduit), and jacking head proposed to be used.

Unless otherwise specified, the methods and equipment used in jacking casing or conduit shall be optional with the Contractor, provided that the proposed method is approved by the Engineer. Such approval, however, shall in no way relieve the Contractor of the responsibility for making a satisfactory installation meeting the criteria set forth herein. Only workmen experienced in jacking operations shall be used in performing the work.

The leading section of conduit shall be equipped with a jacking head securely anchored thereto to prevent any wobble or variation in alignment during the jacking operation.

The driving ends of the conduit shall be properly protected against spalling and other damage, and intermediate joints shall be similarly protected by the installation of sufficient bearing shims to properly distribute the jacking stresses. Any section of conduit showing signs of failure shall be removed and replaced with a new section of precast conduit, or with a cast-in-place section, which is adequate to carry the loads imposed upon it.

Excavation shall not be made in excess of the outer dimensions of the conduit being jacked unless approved by the Engineer. Every effort shall be made to avoid any loss of earth outside the jacking head. Excavated material shall be removed from the conduit as excavation progresses, and no accumulation of such material within the conduit will be permitted.

Once the jacking operation has commenced, it shall be continued uninterrupted around the clock until the conduit has been jacked between the specified limits.

Upon completion of the jacking operations, all voids around the outside face of the conduit shall be filled by grouting.

Grouting equipment and material shall be on the job-site before jacking operations and drilling of grout holes are completed in order that grouting around the jacked conduit may be started immediately after the jacking operations have finished.

Should appreciable loss of ground occur during the jacking operation, the voids shall be back-packed promptly to the extent practicable with soil cement consisting of a slightly moistened mixture of one part cement to five parts granular material. Where the soil is not suitable for this purpose, the Contractor shall import suitable material at his expense. The soil cement shall be thoroughly mixed and rammed into place as soon as possible after the loss of ground.

305.18.01 JACKING REINFORCED CONCRETE PIPE. It shall be understood when pipe is specified to be jacked into place, the design of such pipe is based upon the superimposed loads and not upon the loads which may be placed upon the pipe as a result of the jacking operations. Any increase in pipe strength in order to withstand jacking loads shall be the responsibility of the Contractor.

Where pipe 60 inches or greater in inside diameter is to be jacked for a distance greater than 32 feet, a pilot tunnel shall be constructed first to insure accuracy of grade and alignment. The dimensions and support of the pilot tunnel will be optional with the Contractor, subject to approval of the Engineer. Such approval shall in no way relieve the Contractor of the responsibility for damage of any nature which might occur as a result of the method used.

Supports for pilot tunnels shall be removed as jacking progresses.

Unless the Contractor submits an alternate proposal to the Engineer for approval, the following method shall be used for supporting and guiding the pipe:

After the pilot tunnel has been constructed, a concrete cradle shall be placed true to line and grade and conforming to the outside radius of the pipe. The cradle shall be of such dimensions as to adequately and uniformly support the pipe under the lower 60 degree sector measured on the outside of the pipe. The curved surface shall be formed or accurately screeded to the proper dimensions. It shall be reinforced with not less than 0.3 percent of longitudinal steel and not less than 0.5 percent of transverse steel shall be bent on a radius equal to the radius of the outside of the pipe plus 2 inches and shall extend to within 1 inch of the edge of the cradle.

In lieu of the concrete cradle specified above, the Contractor may, subject to the approval of details by the Engineer, set steel rails in the concrete base slab to true line and grade.

The Contractor shall place grout holes, pipe, and fittings in the pipe invert on centers not greater than 5 feet and shall perform such pressure grouting as is necessary to fill voids and to secure uniform bearing between the cradle and the pipe. The grout shall be neat cement grout.

Grouting pressures shall be as determined in the field by the Engineer.

All costs involved in the performance of the work of constructing pilot tunnels and tunnels and cradles shall be included in the price bid for jacking pipe.

305.18.02 JACKING STEEL CASING. Unless otherwise specified on the Plans or in the Special Provisions, the size and wall thickness of the casing to be jacked to accommodate the Contract pipeline shall be at the Contractor's option, except that the casing thickness shall be not less than 3/8 inch, and he shall be fully responsible for the sufficiency of the casing provided.

The joints of sections of casing to be jacked shall be welded with a continuous circumferential weld. It shall be the Contractor's responsibility to provide stress transfer across the joints which is capable of resisting the jacking forces involved.

All clay pipe installed in a jacked casing shall have mechanical compression joints. The pipe shall be braced or filled to prevent shifting or flotation during backfilling operations.

Backfill shall be gunite and sand, gunite concrete, or pressure concrete at the Contractor's option, except where specified otherwise in the Plans, Special Provisions, or directed by the Engineer. Pressure concrete shall not be placed until the mix design, placement method, and equipment have been approved by the Engineer.

If the pressure concrete mix cannot be readily pumped or placed by the placing equipment, additional water may be added, provided the water-cement ratio of the approved mix design is not exceeded.

Where gunite sand backfill is used, the pipe shall be laid on a concrete sub-base or on gravel bedding where shown on the Plans or approved by the Engineer.

Where gunite concrete or pressure concrete backfill is to be used, the pipe shall be laid on concrete sub-base at least 5 1/2 inches thick at the centerline containing five sacks of Type II cement per cubic yard of concrete, a maximum aggregate size of 1 1/2 inches and a compressive strength of 2,000 pounds per square inch in 28 days.

The pipe barrels shall rest upon concrete support blocks with the pipe socket clearing the concrete sub-base by at least 1/2 inch.

In addition to submitting details of the jacking pit bracing, casing, and jacking head, the Contractor shall submit to the Engineer for approval details of the following in advance of the proposed jacking operation: concrete support blocks, bracing to prevent pipe shifting or flotation, and pressure concrete mix design, placement method, and equipment.

305.18.03 LINE AND GRADE. Concrete conduit shall be jacked true to line and grade and the Contractor shall modify the manner in which he is conducting the jacking operation to correct any deviation. Unless otherwise shown on the Plans or indicated in the Special Provisions, when a pilot tunnel is required to be constructed in connection with jacking reinforced concrete pipe or box sections, the Contractor will be permitted a tolerance from exact grade or alignment of 1 inch per 100 feet.

305.19 TUNNELING OPERATIONS. Pipe tunnel locations, lengths, and details may be shown on the Plans or, alternatively, tunnels may be constructed at the Contractor's option in lieu of trench construction. In the latter case, for continuous tunnels greater than 20 feet in length, the Contractor shall submit his proposed plan of tunnel operations which shall include drawings showing details of the following:

- a. Tunnel shaft bracing and dimensions
- b. Tunnel supports
- c. Method of back-packing tunnel supports
- d. Method of transporting pipe in tunnel
- e. Bracing to prevent pipe shifting and flotation
- f. Pressure concrete mix design, placement method, and equipment.

The approval of the Engineer will not be required for tunnels less than 20 feet in continuous length which the Contractor may elect to construct in lieu of trenching.

All provisions regarding back-packing and backfilling shall apply to such tunnels except that if the roof of any such tunnel, or portion thereof, is sloped upward toward the ends of the tunnel for the full width of the excavation at an angle of 45 degrees or greater with the horizontal, the backfill within the sloped portion of the tunnel may be made with material removed from the excavation and densified by flooding or jetting, or mechanically compacted to a minimum relative compaction of 85 percent in accordance with ASTM D1557.

If the supporting base of any substructure is distributed or any sewer or storm drain is exposed or partially exposed, it shall be supported with a concrete wall.

305.19.01 EXCAVATIONS. Access shafts or portals shall be located where shown on the Plans or designated in the Special Provisions. Where no such locations are given, the Contractor shall have the option of determining such locations subject to approval by the Engineer. In general, access shafts or portals will not be permitted within street intersections.

The Contractor shall excavate all materials encountered in the tunnel within the width and height necessary to install tunnel supports, place pipe, make joints, properly place backfill to fill all void space around the pipe, and do whatever else is necessary to complete the pipe installation in the tunnel.

Clearances shown on the tunnel details on the Plans are minimum and no encroachment within the dimensions shown will be permitted. The spring line clearances shown shall be increased by 3 inches for any tunnel to be constructed on a curve with a centerline radius of less than 300 feet.

All drill and blasting shall be performed in such a manner as to avoid undue shattering or loosening of material which is likely to fall or appears dangerous to workmen or the work. The fact that such removal may enlarge the excavation beyond the required limits shall not relieve the Contractor from the necessity of performing such work, and the Contractor will not be entitled to any additional compensation by reason of such tunnel enlargement.

Loose material in the invert shall be removed to a reasonably clean rock surface or undisturbed foundation prior to placing pipe bedding and installing pipe. Deep depressions may be filled with suitable material approved by the Engineer. The work of removing loosened invert material and filling the resulting depressions or enlargement of the tunnel from overshooting or over-excavating shall be considered a part of tunnel excavation and no additional compensation will be allowed therefor.

305.19.02 DEWATERING. All water encountered in constructing the tunnel shall be disposed of by the Contractor in such a manner as will not damage public or private property or create a nuisance or health menace. The Contractor shall furnish, install, and operate pumps, pipes, appliances, and equipment of sufficient capacity to keep all tunnel excavations and accesses free from water until the tunnel is backfilled, unless otherwise authorized by the Engineer. The Contractor shall provide all means or facilities necessary to conduct water to the pumps. Water, if odorless and stable, may be discharged into an existing storm drain, channel, or street gutter in a manner approved by the Engineer. When required by the Engineer, a means shall be provided for desilting the water before discharging it.

305.19.03 TUNNEL SUPPORTS. Unless otherwise shown in the Plans or indicated in the Special Provisions, the materials used for tunnel supports may be timber, metal, concrete, or a combination thereof at the option of the Contractor. Steel liner plates, if used, shall be provided with grout connections sufficient in number to permit back-packing by means of grout, should such action prove necessary. All tunnel supports shall conform to the requirements set forth. Except for short tunnels 20 feet or less in length, the Contractor shall submit drawings of tunnel supports proposed to be used. Such drawings shall include full details of the proposed tunnel supports (including connections), longitudinal and transverse bracing and foot blocks, the proposed method of pipe installations, the proposed method of back-packing tunnel supports, and other pertinent details.

The tops of foot blocks shall be installed below the pipe barrel a distance of $1/6$ the pipe diameter or a minimum of 4 inches, whichever is greater. Transverse timber struts, spreads, and footings will be permitted only where necessary to support horizontal thrust from the tunnel sides. Timber bracing, where necessary, may be left in place, provided it lies entirely below the bottom of the pipe the distance specified herein for foot blocks and does not occupy more than 15 percent of the bottom area of the tunnel.

Vertical and horizontal clearance dimensions between pipe sockets and the inside of continuous tunnel supports, lagging, spiling, or steel liner plates as specified herein or as shown on the Plans will be considered minimum dimensions. The clearance dimensions between pipe sockets and such intermittent timbers and steel members as timber sets or steel rib sets are also minimum dimensions and no encroachment within the dimensions specified will be permitted. It shall be the responsibility of the Contractor to increase tunnel dimensions where necessary in order to provide adequate room for workmen and equipment and such space shall be at no increase in cost to the Agency.

Unless otherwise specified or shown on the Plans, the minimum clearances shall be as follows:

For tunnels to be backfilled with pressure concrete, the minimum side clearance at the spring line of pipe sockets to continuous steel or timber shall be 12 inches, and to intermittent sets or ribs shall be 10 inches. The minimum overhead clearance from pipe sockets to nearest inside face of any steel or timber member shall be 10 inches.

For tunnels to be backfilled with gunite concrete or gunite sand, the minimum side clearances at the spring line of pipe sockets shall be as for pressure concrete backfill specified above, but the minimum overhead clearance shall be increased to 18 inches.

The minimum side and top clearances prescribed herein shall be increased by 3 inches for pipe without projecting sockets or collars and shall apply to the barrel of the pipe.

No exterior work will be required on the following types of joints:

- a. Socket and spigot pipe with rubber gasket or mechanical compression joints
- b. Pipe 21 inches or larger in internal diameter
- c. Steel-ring-and-gasket type reinforced concrete pipe for sewers, if the tunnel backfill and bedding under the pipe are concrete; or where the tunnel backfill is concrete and the bedding material under the pipe is granular and the Contractor beds the pipe for 4 inches on each side of the joint in fresh mortar at least 3 inches thick and extending 2 inches above the top of the granular bedding material.

The Contractor will be required to do such reconstruction of tunnel supports at his expense as may be necessary to meet the foregoing requirements. The Engineer may make minor revisions in the horizontal tunnel alignment where possible in sections at least 50 feet long to minimize the extent of such reconstruction. Similar changes in vertical alignment will generally not be approved.

All timber collar braces and, to the extent practicable, timber supports, lagging, and blocking shall be removed prior to backfilling tunnels, except where such removals would be hazardous to persons or the structure. Material to remain in place shall be cleaned of adhering tunnel muck or other material not suitable for backfill.

305.19.04 SUBGRADE AND BEDDING. Pipe shall be placed and bedded as shown on the Plans specifying the methods of laying and bedding pipe in trenches.

Concrete base shall consist of an invert slab if placed separately. Where a slab is placed separately, it shall be poured to the full width of the tunnel. Concrete shall contain five sacks of Type II cement per cubic yard of concrete, have maximum aggregate size of 1 1/2 inches, and shall obtain a compressive strength of 2,000 pounds per square inch in 28 days. Concrete shall not be placed until placement method and equipment have been approved. The slab, when placed separately, shall be cured for at least 5 days prior to the application of heavy loading.

Payment for rock, or other base material required to the extent shown on the Plans for pipe bedding in trenches, shall be considered as included in the price paid for pipe complete in place and no additional compensation will be made therefor.

All rock required to fill voids caused by over-excavation, or to maintain the tunnel supporting members or to control water throughout the period of tunnel excavation shall be furnished and placed by the Contractor and the cost thereof shall be included in the price paid for pipe complete in place and no additional compensation will be made therefor.

When ordered by the Engineer, rock in addition to that required by the Plans for bedding shall be placed by the Contractor.

305.19.05 BACK-PACKING TUNNEL SUPPORTS. Voids behind all temporary or permanent tunnel support systems, including overbreak, cave-ins, and chimneys, shall be back-packed as specified herein. Back-packing shall be placed progressively as soon as practicable after placement of tunnel supports. When ordered by the Engineer, the Contractor shall place back-packing immediately. The non-back-packed length of tunnel shall be held to the minimum practicable for the method of back-packing utilized by the Contractor.

Tunnels in rock supported by the timber lagging steel liner plate, or bolted steel plate tunnel lining shall be back-packed either with pressure grout or soil cement, except that tunnel spoil may be used to mid-height of the tunnel. When voids 1 cubic foot in size or larger exist behind lagging or sheeting in tunnels so supported in soil, the Contractor shall back-pack behind such supports with either pressure grout or tunnel spoil when ordered by the Engineer.

Tunnels in rock or soil and supported by timber or steel sets with partial timber or metal lagging may be back-packed to the mid-height of the tunnel with tunnel spoil.

All spaces not filled with such back-packing shall be filled at the time of, and with material selected for, tunnel backfilling around the pipe.

Tunnel spoil used for back-packing shall be selected from the better spoil material available, and shall contain sufficient fines to fill all voids. Such material shall be rammed into place. Soft or wet clay may be used only if satisfactory compaction can be obtained. Otherwise, the Contractor will be required to import granular material for back-packing at no additional cost to the Owner.

Soil cement for back-packing lagged or fully lined tunnels shall consist of a slightly moistened mixture of one part cement to five parts of granular material selected from the tunnel spoil when such material is suitable. Otherwise, granular material shall be imported at the Contractor's expense. The soil cement shall be thoroughly mixed and rammed into place immediately following placement of tunnel supports. The placement interval shall not exceed three rings of liner plate or the distance between tunnel sets. Mechanically or pneumatically operated tampers shall be used to ram the soil cement into place unless another placing method is approved by the Engineer.

305.19.06 TUNNEL BACKFILL. Pipe laying operations in tunnels shall not precede tunnel backfill by more than 150 feet without the approval of the Engineer. Longer reaches may be approved if tunnel clearances are increased from the minimums shown in order to obtain additional working space around the pipe.

The space between the tunnel supports and the pipe shall be completely backfilled with the materials and methods specified herein. The backfill material shall be forced or packed into all the crevices and around all timber sets or steel ribs from the tunnel invert to its crown. The Contractor shall provide whatever wedging or bracing is needed to insure against pipe movements during placement of backfill.

Backfill for tunnels in rock shall be limited to pressure concrete or gunite concrete.

The approval of the use of gunite concrete for backfill is contingent upon the prior back-packing of tunnel supports with acceptable materials other than gunite concrete.

Unless the Plans for tunnels to be constructed in soil require the use of pressure concrete or gunite concrete for backfill, the Contractor may use gunite sand for backfill.

Gunite sand shall be placed with a pneumatic gun in accordance with the requirements for placing gunite concrete, except that no Portland Cement need be added. The Contractor may add up to 100 pounds of cement per cubic yard to improve placement stability at his option and expense. In either case, water sufficient to saturate the material and insure proper packing and minimize rebound shall be added to the mixture. The nozzleman shall operate in the immediate vicinity of the backfill face to insure compaction and complete filling of voids.

At least 30 days prior to backfilling operations, the Contractor shall submit to the Engineer for approval his proposed mix design and method of placing concrete, including placing equipment. No pressure concrete backfill shall be placed until mix design, placement method, and equipment have been approved. If the approved mix cannot be readily pumped or placed by the Contractor's placing equipment, additional water may be added, provided the water-cement ratio of the approved mix design is not exceeded.

The pressure concrete shall be placed by methods capable of forcing it into crevices and filling all void spaces in the tunnel. Unless otherwise provided on the Plans, the concrete backfill shall be placed under pressure by means of a "slick" line and pneumatic or positive displacement pumps.

The combined length of the slick line and delivery line shall not exceed the recommendation of the manufacturer of the concrete pump or, if no manufacturer's performance data is available, 150 feet. The discharge end of the slick line shall be rigid conduit with a minimum length of 10 feet. It shall be kept buried in at least 5 feet of fresh concrete during concrete placement. Concrete shall be pumped continuously during withdrawal of the slick line to eliminate voids.

305.19.07 PRESSURE GROUTING OF VOIDS. Where the Engineer has reasonable doubt that the tunnel void spaces are completely filled, the Contractor shall pressure grout such locations as ordered through grout pipes to be installed either from the ground surface or from within the conduit. At least two grout holes will be required at each location to permit escape of air. The location of surface grout pipes may be adjusted as may be required, dependent upon traffic requirements on overhead streets.

Grout for filling voids shall be low pressure grout (less than 10 pounds per square inch). Neat cement grout shall be used, except that large voids shall be filled with pressure concrete or grout containing sand.

Grout shall be placed by means of pumps of positive displacement or pneumatic type and capable of placing grout at pressures up to 100 pounds per square inch, unless otherwise approved by the Engineer. Grout shall be placed at pressures which are requisite for the conditions encountered, and will ordinarily be less than 10 pounds per square inch, except in cases where large cave-ins or other adverse conditions may require higher pressures.

Regardless of the materials or methods of backfilling or filling voids used, the Engineer shall reserve the right to require filling of void spaces known to remain by additional grouting. Such work will be deemed to have resulted from the Contractor's operation and shall be done at his expense.

305.20 MEASUREMENT OF QUANTITIES AND BASIS OF PAYMENT. All quantities shall be measured in lineal footages, unless indicated otherwise in the Contract Documents.

305.20.01 TRENCHWORK. No direct payment shall be made for trenchwork done as a result of pipe, conduit, or utility installation. Trenchwork for pipe, conduit, or utility installation shall be included in the unit price per lineal foot bid for the particular underground facility, unless indicated otherwise in the Contract Documents.

305.20.02 JACKING. The price per foot of jacked conduit shall include full compensation for furnishing all labor, materials, tools, and equipment and doing all the work involved in constructing the jacked conduit complete in place, including all excavation; furnishing and installing conduit, including all work involved in jacking the conduit; constructing, supporting and removing pilot tunnels and constructing reinforced concrete cradles where required; providing grout holes, grout and grouting where necessary; and doing whatever else is appurtenant to jacking conduit within the limits shown on the Plans and as specified herein.

Except when a bid item is provided for jacking casing, the cost of furnishing and jacking casing in place shall be included in the unit price per linear foot bid for the portion of the pipeline or conduit to be installed within the casing.

When a section of reinforced concrete pipe conduit is specified to be constructed by jacking methods, the specified limits for jacking may be increased by the Contractor with the approval of the Engineer. Such increased limits may require an increase in the strength of the pipe to be jacked. When reinforced concrete pipe conduit is specified to be constructed by open trench method, the Contractor may construct said conduit by jacking methods, with the approval of the Engineer. Such methods may require an increase in strength of the pipe.

It shall be understood that, when a change in construction method or an increase in jacking limits as specified herein is requested by the Contractor and authorized by the Engineer, payment for the work will be based on the Contract prices as though the specified method had been used.

305.20.03 TUNNELING. Unless the Contract Documents provide for unit prices for individual work items included in tunnel work, the lump sum or unit price per linear foot for tunneling as set forth in the proposal shall include full compensation for furnishing all labor, materials, tools, and equipment and for doing all the work involved in making tunnel excavation; de-watering, furnishing, installing, back-packing, and maintaining tunnel supports; placing tunnel backfill, low pressure grouting, providing access shafts of portals including excavation, backfill and replacement of surface or other improvements; furnishing and installing pipe, and doing whatever else is appurtenant to tunnel construction with the limits shown on the Plans and as specified herein. Unless otherwise specified, payment for tunnel excavation shall include the excavating of any type of material encountered. High pressure grouting required by the Engineer, and not resulting from an act or failure to act on the part of the Contractor, will be paid for as extra work.

306.01 DESCRIPTION. This work shall consist of the furnishing of trenching, bedding, pipe material and appurtenances, and compacted backfill for gravity storm drains, culverts, and sanitary sewers.

306.02 MATERIALS. Materials shall be in conformance with Section 203 – “Non-Pressure and Pressure Pipes”, and as modified in this Section.

306.03 TRENCHWORK. Trenchwork shall be in conformance with Section 305 – “Trench Excavation and Backfill”.

306.04 GRAVITY LINES. Gravity pipe lines for storm drains, culverts, and sanitary sewers shall be constructed in accordance with the following Specifications, where applicable:

306.04.01 GENERAL. Pipe will be carefully inspected in the field before and after laying. If any cause for rejection is discovered in a pipe after it has been laid, it shall be subject to rejection. Any corrective work shall be approved by the Engineer and shall be at no cost to the Owner.

When connections are to be made to any existing pipe, conduit, or other appurtenances, the actual elevation or position of which cannot be determined without excavation, the Contractor shall excavate and expose the existing improvement before trenching for or laying any pipe or conduit on the project. Any adjustments in line or grade which may be necessary to accomplish the intent of the Plans will then be made.

Pipe shall be laid upgrade with the socket or collar ends of the pipe upgrade unless otherwise authorized by the Engineer.

Concrete pipe with elliptical reinforcement shall be laid with the minor axis of the reinforcement cage in a vertical position.

Corrugated metal pipe shall be laid with the external laps of the circumferential seams toward the inlet end.

Before backfilling around circular corrugated metal pipes 48 inches in diameter and larger, the full length of pipe shall be elongated vertically. When specified in the Special Provisions, circular pipes smaller than 48 inches in diameter shall also be elongated vertically.

Pipes shall be vertically elongated from a true circle to provide an increase in the vertical diameter of approximately 5 percent for the full length.

Pipes may be vertically elongated at the fabricating shop by any of the following methods:

- a. By fabricating the plates so that the vertical elongation is obtained after assembly.
- b. By mechanical pressure sufficient to introduce a permanent vertical elongation in the pipe.

Pipes may be vertically elongated in the field. The method of vertical elongation shall be subject to the approval of the Engineer.

Pipe shall be laid true to line and grade, with uniform bearing under the full length of the barrel of the pipe. Suitable excavation shall be made to receive the socket or collar, which shall not bear upon the subgrade or bedding. Any pipe which is not in true alignment or shows any undue settlement after laying shall be taken up and relaid at the Contractor's expense.

Pipe sections shall be laid and joined in such a manner that the offset of the inside of the pipe at any joint will be held to a minimum at the invert. The maximum offset at the invert of pipe shall be 1 percent of the inside diameter of the pipe or 3/8 inch, whichever is smaller.

In joining, socket and spigot of each pipe shall be so seated in the socket of the adjacent pipe as to give a minimum of 3/8 inch annular space all around the pipe in the socket. Unavoidable offsets shall be distributed around the circumference of the pipe in such a manner that the minimum offset occurs at the invert.

When pipe is laid in a sheeted trench, all sheeting against which a concrete cradle is to be placed shall be faced with at least one thickness of building paper and the sheeting shall be withdrawn without displacing or damaging the cradle.

After the joints have been made, the pipe shall not be disturbed in any manner.

Test for watertight joints shall conform to the requirements of Section 336.

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At the close of work each day, or whenever the work ceases for any reason, the end of the pipe shall be securely closed, unless otherwise permitted by the Engineer.

306.04.02 FIELD JOINTING OF CLAY PIPE. Unless otherwise indicated on the Plans, any of the following joints may be used for sewers constructed of clay pipe.

a. Type "C" Joints (Couplings For Plain End Clay Pipe). Pipe joints shall be made with sewer pipe couplings. Each coupling shall be sealed with Class "C" mortar which shall be sufficiently fluid to insure free flow in the annular space between the housing and the sleeve.

Steel bands on couplings shall be tightened as soon as pipe is placed. No joint shall be sealed with mortar until the next two adjoining pipes are in place.

b. Type "D" Joints (Rubber Sleeve Coupling For Plain End Clay Pipe). Unless otherwise specified, pipe shall be delivered to the job site with the rubber sleeve applied at the factory on one end of the pipe or fitting. The spigot end of the pipe to be joined shall be inserted in the sleeve and the steel compression band shall be tightened sufficiently to achieve the test results as specified herein.

c. Type "E" Joints (Polyvinyl Chloride Compression Joints). Type "E" joints shall be as specified in Subsections 307.08.05 – "Joint Assembly" – and 307.08.06 – "Solvent-Welded Joint Assembly". Upon installation, the meeting surfaces shall be wiped clean of dirt and foreign matter, then an approved lubricant shall be applied to the joint surfaces. The spigot shall be positioned inside the socket and the joint shoved home. For large diameter pipe, a lever attachment or bar cushioned with a wooden block shall be used to shove the joint into place.

In no case shall a bar be used on an unprotected joint surface. Mating surfaces shall be in tight contact with each other upon completion of the joint installation.

d. Type "F" Joints (Polyurethane Compression Joints). The method of installation of Type "F" joints shall be as Type "E" Polyvinyl Chloride joints. Type "F" joints may be permitted for use on curves, provided that the radius of curvature is not less than shown on the Plans unless beveled pipe or shorter lengths are provided.

306.04.02.01 Straight Non-beveled Pipe on Curves. Straight nonbeveled pipe with Type "D" or "G" joints is permitted for pipelines on curves, provided the radius of curvature is not less than that shown in the following table. For radius of curvature less than that shown, beveled pipe or shorter lengths shall be provided.

STRAIGHT PIPE ON CURVES — TYPE "D" & "G" JOINTS

(All deflections are based on ASTM C425)

D Pipe Size (Inches)	For Pipe Length (Feet)	Min. Radius of Curvature (Feet)	Max. Deflection Per Joint (Degrees)	Max. Deflection Per Length (Inches)
6 to 12	5	120	2.4	2 1/2
	5 1/2	132	2.4	2 3/4
	6	144	2.4	3
15 to 24	5	160	1.8	1 7/8
	5 1/2	176	1.8	22 1/16
	6	192	1.8	2 1/4
	7 1/2	240	1.8	2 13/16
27 to 36	5	240	1.2	1 1/4
	5 1/2	264	1.2	1 3/8

STRAIGHT PIPE ON CURVES — TYPE “D” & “G” JOINTS, continued
(All deflections are based on ASTM C425)

D Pipe Size	For Pipe Length	Min. Radius of Curvature	Max. Deflection Per Joint	Max. Deflection Per Length
39 to 42	6	288	1.2	1 1/2
	7 1/2	360	1.2	1 7/8
	5	320	0.9	15/16
	5 1/2	352	0.9	1 1/16
	6	384	0.9	1 1/8

306.04.03 FIELD JOINTING OF REINFORCED CONCRETE PIPE. (Mortar Type Joints for Reinforced Concrete Pipe.)

- a. General. All joints shall be cleaned with a wire brush and wetted before mortaring. All mortar shall conform to the applicable provisions of Subsection 203.16 – “Polyethylene Pipe.”
- b. Tongue and Groove Self-Centering Joints. Pipe used on curves shall have one or both ends beveled or shall be pulled to provide a smooth curve. If the resulting space between the extremities (outermost elements) of adjacent pipe is more than 1/8 inch, #4 reinforcement steel shall be placed circumferentially on 3 inch centers in the gap between the lip of one pipe and the seat of the other, and the space filled with mortar (or concrete) for the full thickness of the barrel of the pipe. If the space is greater than 1 inch as defined herein, a reinforced concrete collar shall be provided as directed by the Plans.

When pipe is under 21 inches in diameter, the joints shall be made by filling the outer joint space completely and the lower half of the inner joint space with mortar.

When the pipe is 21 inches or greater in diameter, jointing shall be made by completely filling both inner and outer joint spaces with mortar. No backfill shall be placed until joint mortar is allowed to thoroughly set.

- c. Collar Joints. Pipe with collar joints shall be laid with the collar end up-grade. The pipes shall be tightly butted together and uniform caulking space left between the pipe and the collar. When the entering pipe has been placed and checked for line and grade, the body of the pipe shall be backfilled with earth on both sides to hold the pipe firmly in place. The caulking space then shall be completely filled with stiff increments by means of caulking tool and hammer.
- d. Gasket-Type Joints for Reinforced Concrete Pipe.
 1. The ends of the pipe shall be so formed that, when the pipes are laid together and joined, they shall make a continuous and uniform line of pipe with a smooth and regular surface.

Joints shall be water-tight and flexible. Each joint shall contain a solid gasket of neoprene or other material approved by the Engineer, which shall be the sole element responsible for water-tightness of the joint. This gasket shall be of circular cross section, unless otherwise approved by the Engineer. The length and cross sectional diameter of the gasket, and all other joint details shall be such as to produce a water-tight joint. The slope of the longitudinal gasket contact surfaces of the joint with respect to the longitudinal axis of the pipe shall not exceed 2 degrees.

2. Under ordinary laying conditions, the work shall be scheduled so that the socket end of the pipe faces in the direction of laying. Prior to placing the spigot into the socket of the pipe previously laid, the spigot groove, the gasket, and the inside of the socket shall be thoroughly cleaned. Then the spigot groove, the gasket, and the first 2 inches of the inside surface of the socket shall be lubricated with a soft vegetable soap compound. The gasket, after lubrication, shall be uniformly stretched when placing it in the spigot groove so that the gasket is distributed evenly around the circumference.

For pipe in which the inside joints are to be pointed, suitable spacers shall be placed against the inside shoulder of the socket to provide the proper space between abutting ends of the pipe.

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After the joint is assembled, a thin metal feeler gauge shall be inserted between the socket and the spigot and the positions of the gasket checked around the complete circumference of the pipe. If the gasket is not in the proper position, the pipe shall be withdrawn, the gasket checked to see that it is not cut or damaged, the pipe relaid, and the gasket position again checked.

Where steel joint rings are used, a suitable cloth, plastic or paper band shall be placed around the outside and centered over the joint to prevent dirt from entering the joint recess. The joint band shall be bound to the pipe by the use of steel box strapping or by an equivalent method, and shall completely and snugly encase the outside joint except for an opening near the top where grout is to be poured into the joint recess. Grout shall be poured and allowed to set before densification of bedding and backfill materials by jetting or flooding methods. In any case, joints shall be grouted before backfill is placed over the top of the pipe. With the jointing band properly secured, the joint recess shall be moistened with water and then filled with mortar. The mortar grout shall completely fill the outside annular space between the ends of the pipe and around the complete circumference. After the recess has been filled, the jointing band shall be replaced over the opening left for pouring and the mortar allowed to set. After the bedding and backfill have been densified, the inside joint recess shall first be moistened, then filled with stiff mortar. The finished joint shall be smooth and flush with the adjacent pipe surfaces.

306.04.04 FIELD JOINTING OF NON-REINFORCED CONCRETE

- a. Tongue and Groove Joints. The grooved end of the pipe shall be buttered with a stiff mixture of mortar prior to jointing pipe. The pipe joint shall then be carefully wiped on the inside.
- b. Socket and Spigot Mortar Joints. In making the joints, the entire annular space shall be completely and compactly filled with mortar.

Mortar placed in the joint to assist in the assembling and centering of the pipe shall not be considered as filling that portion of the joint in which it is placed. The mortar shall be beveled on a 1:1 slope from the outer edge of the socket, and the interior of the pipe cleaned of surplus mortar or other foreign material.

When approved by the Engineer, a narrow gasket of oakum or lead may be caulked into each joint in wet trenches, after which the joint shall be thoroughly mortared. Interior joints in pipe shall be neatly wiped on the inside.

- c. Socket and Spigot Gasket Joints. The outside of the spigot and the inside of the socket of the pipe shall be thoroughly cleaned prior to laying. The gasket and the socket interior shall be lubricated with a soft vegetable soap compound before the pipes are jointed.

306.04.05 FIELD JOINTING OF CAST IRON PIPE. Unless specified otherwise, all cast iron pipe shall be jointed in accordance with Subsection 203-05 – “Cast Iron Soil Pipe”, with the exception that synthetic rubber rings shall be used.

306.04.06 FIELD JOINTING OF CORRUGATED METAL PIPE. The pipe shall be laid so that the seams are not on the bottom. The inside circumferential seams shall be placed pointing downstream. Care shall be taken to insure that dirt or other particles do not get between the outside of the pipe and the pipe coupling. Paved inverts shall be placed and centered on the bottom of the trench. Any damage to the protecting lining and coating shall be repaired prior to the backfilling around the pipe.

The spigot end shall be inserted to the proper depth of the socket as indicated by the home mark.

306.04.09 FIELD JOINTING OF INJECTION SEALED PVC PIPE. Injection seal jointing of PVC pipe shall be in accordance with the approved manufacturer's printed instructions, which shall be furnished to the Engineer.

The spigot end shall be inserted to the full depth of the socket as indicated by the home mark and driven into the locking taper as recommended by the manufacturer.

The ports in the socket end shall be positioned so as to allow observance of flow of the adhesive from the exhaust port. The adhesive compound shall be injected until air is no longer observed to bubble from the exhaust port. Escape of adhesive compound beyond the retainer ring shall be cause for rejection of the joint.

306.04.10 Field JOINTING OF HDPE PIPE. Jointing of High Density Polyethylene Pipe shall be in accordance with the approved manufacturer's printed instructions. Joints will be Bell and Spigot type with gaskets made of a properly cured high grade elastomeric compound meeting the requirements of ASTM F 477.

The spigot end shall be inserted to the proper depth of the socket as indicated by the home mark.

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306.04.11 FIELD JOINTING OF PRECAST CONCRETE BOX CULVERTS. Jointing of box culverts shall be according to manufacturer's recommendations using a pre-formed joint material meeting AASHTO M 198 Type B. A double application of joint material shall be used; one application shall be applied to the tongue and the other to the groove. The minimum size of joint material shall be 1 1/4 inches. Any joint material extruding from the interior of the joint shall be removed flush with the box culvert.

For multiple box installations, a space of 3 inches shall separate each line of boxes. The space between the box lines shall be filled solidly with grout. The grout shall be a workable mix suitable for pumping without segregation and shall be thoroughly mixed. The grout shall be placed by pumping or an approved alternate method. The grout shall be consolidated by mechanical vibration or rodding during placing. The grouting shall be done in a continuous pour in lifts not exceeding 6 feet. Vertical grout barriers may be used to control the flow of grout horizontally. The grout shall attain a minimum compressive strength of 2,500 pounds per square inch in 28 days when tested in accordance with Test Method No. Nev. T475.

306.05 CULVERTS.

306.05.01 DESCRIPTION. This work shall consist of furnishing and installing pipe culverts, siphons, end sections, head walls, etc., as may be required to complete the work shown on the Plans or established by the Engineer.

306.05.02 BEDDING. The pipe shall be bedded in accordance with the Plans, the Special Provisions, and the requirements of Section 305 – "Trench Excavation and Backfill".

Where pipes are to be installed in new embankments on a steep slope or in a difficult location, the height of new embankments may be varied as directed by the Engineer before installing pipes.

When headwalls are not required and granular materials are used for backfilling, the fill at the ends of the structure shall be sealed against the infiltration of water by bedding the ends of the structure in well tamped clay as shown on the Plans.

306.05.03 HEADWALLS. Where shown on the Plans, inlet and outlet headwalls shall be constructed or installed in connection with culvert pipes. Where such headwalls are constructed or installed, the ends of pipes shall be placed flush or cut off flush with the headwall face, unless otherwise permitted by the Engineer. Headwalls are to be constructed to conform to the applicable requirements of Section 311 – "Concrete Structures and Masonry Construction."

306.05.04 END SECTIONS. The bed for the end section shall be excavated to the required width and grade. For metal end sections with plates, a trench shall be excavated for the toe plate in a manner to permit the toe plate being against the inner face of the trench when the end section is in its final position. After end sections have been properly secured to the pipe, this trench shall be backfilled and firmly compacted.

Precast concrete end section shall be placed with its tongue (or groove) fully entered in the groove (or tongue) of the pipe.

306.05.05 EXTENDING EXISTING CULVERTS. Where shown on the Plans or directed by the Engineer, existing culverts shall be extended in accordance with the provisions for installing new culverts and the following additional provisions. Existing headwalls shall be demolished and removed and disposed of or moved to the extended location as indicated on the Plans or ordered by the Engineer.

A headwall that is not to be reset shall be demolished without injury to the existing culvert and removed and disposed of. If shown on the Plans or ordered by the Engineer, a new concrete headwall shall be constructed in accordance with the provisions of Section 311 – "Concrete Structures and Masonry Construction" or a flared end section shall be attached.

306.06 STRUCTURAL STEEL AND ALUMINUM PLATE PIPE AND ARCHES.

306.06.01 DESCRIPTION. This work shall consist of furnishing and installing structural plate pipe and pipe arch culverts conforming to the requirements of these Specifications, and of the sizes and dimensions required in the Plans, and installing such structures at locations designated in the Plans or established by the Engineer, and in conformity with the lines and grades established by the Engineer. The work shall also include the reinstallation of salvaged structural plate pipe and pipe arch culverts.

Plates for a pipe arch shall form a cross section made up of four circular arcs tangent to each other at their junctions and symmetrical about the vertical axis. The top shall be an arc of not more than 180 degrees nor less than 155 degrees. The bottom shall be an arc of not more than 50 degrees nor less than 10 degrees. The top shall be joined at each end to the bottom by an arc having a radius between 16 and 21 inches and of not more than 87 1/2 degrees nor less than 75 degrees.

306.06.02 MATERIALS. Structural plate pipe and pipe arches shall conform to the requirements of Subsection 203.03 – “Corrugated Steel Pipe and Pipe Arches”.

If called for in the bid schedule, plates for pipes and pipe arches shall be bituminous coated in accordance with AASHTO M 190, Type A, B, or C.

When bituminous coating is applied to plates for structural steel plate pipe, arches and pipe arches, each plate shall have the thickness painted on the inner surface so that the plate thickness can be readily identified.

All portions of all nuts and bolts used for assembly of bituminous coated structural steel plate pipes, arches, and pipe arches projecting outside the pipe shall be bituminous coated after installation. The portion of the nuts and bolts projecting inside the pipe need not be bituminous coated.

Damaged bituminous coating shall be repaired by the Contractor by applying bituminous material conforming to the provisions of AASHTO M 190 or other approved material.

The bottom plates of structural plate pipes and arches shall be one gauge heavier than the gauge specified in the bid schedule, which will apply to top and side plates. When gauge one is specified, the bottom plates shall also be gauge 1.

Plates shall be shipped and handled in such a manner as to prevent bruising, scaling, or breaking of the spelter coating. Damaged spelter coating, in lieu of the requirements of AASHTO M 36, may be repaired by thoroughly wire brushing the damaged area and removing all loose and cracked spelter coating, after which the cleaned area shall be painted with two coats of zinc oxide-zinc dust paint conforming to the requirements of Federal Specification MIL-P-15145. The paint shall be properly compounded in a suitable vehicle in the ratio of one part zinc oxide to four parts zinc dust by weight.

Planned lengths and sizes are approximate. The Contractor shall not order and deliver the plates until a list of sizes and lengths is furnished to him by the Engineer.

306.06.03 PLATE DESCRIPTION. Plates shall consist of structural units of galvanized corrugated metal structural steel or aluminum. Single plates shall be furnished in standard sizes to permit structure length increments of 2 feet. (Plates have approximately a 2 inch lip beyond each end crest, which results in the actual length of a given structure being approximately 4 inches longer than the nominal length, except when skewed or beveled.)

The plates at longitudinal and circumferential seams shall be connected by bolts. Joints shall be staggered so that not more than three plates come together at any one point. Each plate shall be curved to one or more circular arcs.

306.06.04 FABRICATION. Plates shall be formed to provide lap joints. The bolt holes shall be so punched that all plates having like dimensions, curvature, and the same number of bolts per foot of seam shall be interchangeable. Each plate shall be curved to the proper radius so that the cross sectional dimensions of the finished structure will be as specified.

Unless otherwise specified, bolt holes along those edges of the plates that will form longitudinal seams in the finished structure shall be staggered in rows 2 inches apart, with one row in the valley and one in the crest of the corrugations. Bolt holes along these edges of the plates that will form circumferential seams in the finished structure shall provide for a bolt spacing of not more than 12 inches. The minimum distance from center of hole to edge of plate shall be not less than 1 3/4 times the diameter of the bolt. The diameter of the bolt holes in the longitudinal seams shall not exceed the diameter of the bolt by more than 1/8 inch.

Burnt edges shall be free from oxide and burrs and shall present a workmanlike finish. Damaged spelter on the surface of the plates and the edges of cuts shall be repaired within 24 hours after the cuts are made. Each cut plate shall be legibly identified to designate its proper position in the finished structure.

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306.06.05 FIELD INSPECTION. The Engineer shall be furnished with an itemized statement of the number and length of the plates in each shipment by the manufacturer. Each plate included in a shipment shall conform to the requirements of these Specifications. If 25 percent or more of the plates in any shipment fail to conform to the requirements, the entire shipment may be rejected.

306.06.06 ASSEMBLING. The structural plate structures shall be assembled in accordance with the manufacturer's assembly instructions. The unsupported edges of all plates shall extend far enough to support the plate above until the first complete ring has been assembled. A sufficient number of bolts shall be progressively installed to hold the plates in position. Bolts shall not be tightened until tightening will not interfere with the adjustment and matching of additional plates and sections. Special care shall be exercised in the use of drift pins or pry bars to prevent chipping or injury to the galvanized or other protective coating, and such injury shall be repaired at the Contractor's expense. After all plates are in place, the bolts shall be progressively and uniformly tightened from one end of the structure and the tightening operation repeated to be sure that all bolts are tight. Bolts shall be tightened to a minimum of (a) 100 foot-pounds of torque for plates of seven gauge and lighter, and (b) 150 foot-pounds of torque for plates of five gauge and heavier, and shall be rechecked and retightened as necessary just prior to backfilling.

The elliptical-shaped pipes shall be installed with their long diameter vertical, and pipe arches shall be installed with their span width horizontal.

306.06.07 STRUTTING. When specified, structural plate pipes which are not fabricated out of round before erection shall be timber strutted vertically before placement of the embankment.

The pipe shall be deformed to the required degree by means of suitable jacks. The method of jacking shall meet with the approval of the Engineer. A tolerance of 25 percent above or below the specified elongation will be permitted.

The method for distorting plates in the field shall conform to details shown on the Plans. The vertical diameter throughout that portion of the pipe between outer shoulder lines of the roadway shall be increased to the approximate percentages listed in the following table:

Pipes using 0.280 inches or 0.249 inches top and side plates	1 percent
Pipes using 0.218 inches or 0.188 inches top and side plates	2 percent
Pipes using 0.168 inches, 0.138 inches, or 0.109 inches top & side plates	3 percent

Between the outer shoulder lines of the roadway and the outer ends of the pipe, the distortion may be decreased uniformly to zero.

The struts shall be left in place until the embankment is complete and compacted, unless otherwise ordered by the Engineer.

In lieu of strutting structural plate pipe, the Contractor may furnish structural plate pipe with the vertical axis fabricated out of round 5 percent of the nominal diameter from end to end of the pipe. A tolerance of 25 percent above or below the specified elongation will be permitted. The elongation shall be made by approved shop methods, and any coating damaged or destroyed shall be repaired or replaced satisfactorily.

306.06.08 WORKMANSHIP. It is the essence of these Specifications that, in addition to compliance with the details of construction, the completed pipe shall show careful, finished workmanship in all particulars. Structural plates on which the spelter coating has been bruised or broken, or which shows defective workmanship, shall be rejected, except as herein otherwise specified. The requirement applies not only to the individual plates, but to the shipment on any contract as a whole. Among others, the following defects are specified as constituting poor workmanship and the presence of any or all of them in any individual culvert plate, or in general in any shipment, shall constitute sufficient cause for rejection:

- a. Uneven laps.
- b. Variation from a straight center line.
- c. Ragged edges.
- d. Loose, unevenly lined or spaced bolts.
- e. Bruised, scaled or broken spelter coating.
- f. Dents or bends in the metal itself.

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306.06.09 HEADWALLS. Where shown on the Plans, inlet and outlet headwalls shall be constructed or installed in connection with structural plate pipe. Where such headwalls are constructed or installed, the ends of pipes shall be placed flush or cut off flush with the headwall face, unless otherwise permitted by the Engineer. Headwalls are to be constructed to conform to the applicable requirements of Section 311 – “Concrete Structures and Masonry Construction.”

306.06.10 EXTENDING EXISTING STRUCTURAL PLATE PIPE AND PIPE ARCH CULVERTS. In case the Plans provide for the extension of any old or existing structural plate pipe or pipe arch culverts, the connection of the old and new sections shall be made by punching any necessary bolt holes, furnishing bolts, nuts and washers, changing location of individual plates on pipe arches, and any other work required in the completion of the connection in a workmanlike manner. In all cases where an existing headwall is in place, the concrete shall be completely removed.

307.01 DESCRIPTION. This work shall consist of furnishing of all labor, equipment, and materials necessary to construct and complete the installation of a workable domestic water or irrigation system, as indicated on the Plans and in these Specifications.

307.02 MATERIALS. All materials used in the construction of domestic water and irrigation systems shall be in accordance with Section 203 – “Non-Pressure and Pressure Pipe and Joint Materials” – of these Specifications.

307.03 TRENCHING AND BACKFILL. Trenching and backfill procedures shall be in accordance with Section 305 – “Trench Excavation and Backfill” – of these Specifications.

307.04 LOWERING OF WATER MAIN MATERIAL INTO TRENCH. Proper implements, tools, and facilities satisfactory to the Engineer shall be provided and used by the Contractor for the safe and convenient performance of the work. All pipe, fittings, valves, and hydrants shall be carefully lowered into the trench piece by piece by means of a derrick, ropes, or other suitable tools or equipment, in such a manner as to prevent damage to water main materials and protective coatings and linings. Under no circumstances shall water main materials be dropped or dumped into the trench.

If damage occurs to any pipe, fittings, valves, hydrants, or water main accessories in handling, the damage shall be immediately brought to the Engineer's attention. The Engineer shall prescribe corrective repairs or rejection of the damaged items.

307.05 INSPECTION BEFORE INSTALLATION. All pipe and fittings shall be carefully examined for cracks and other defects while suspended above the trench immediately before installation in final position.

307.06 UNSUITABLE CONDITIONS FOR LAYING PIPE. Pipe shall not be laid when, in the opinion of the Engineer, trench conditions are unsuitable.

307.07 DUCTILE IRON PIPE. Ductile iron pipe shall be handled and installed in accordance with the requirements of Sections 1, 2, and 3 of AWWA C-600, the recommendations of the pipe manufacturer, and these Specifications.

Pipe shall be laid with bell ends facing in the direction of laying, unless directed otherwise by the Engineer. Where pipe is laid on a grade of 10 percent or greater, the laying shall start at the bottom and shall proceed upward with the bell ends of the pipe upgrade.

Flame cutting of pipe by means of an oxyacetylene torch will not be allowed.

Whenever it is necessary to join ductile iron pipe to pipe of a dissimilar metal, the connection shall be made with an insulating coupling approved by the Engineer.

Concrete for thrust blocks shall have a 28 day compressive strength of no less than 3000 p.s.i.

307.08 POLYVINYL CHLORIDE PIPE (PVC). PVC pipe shall be handled and installed in accordance with the requirements of Uni-Bell Standard UNI-B-3, the recommendations of the pipe manufacturer, and these Specifications.

Pipe shall be laid with bell ends facing in the direction of laying, unless directed otherwise by the Engineer. Where pipe is laid on a grade of 10 percent or greater, the laying shall start at the bottom and shall proceed upward with the bell ends of the pipe upgrade.

Concrete for thrust blocks shall have a 28 day compressive strength of not less than 3000 p.s.i.

307.09 SETTING HYDRANTS

307.09.01 LOCATION AND POSITION. Hydrant location shall be established or approved by the Agency. Hydrant position in respect to fences, walls, intersections, and any other confining structure shall be in accordance with requirements of the Agency.

All hydrants shall stand plumb and shall have their nozzles parallel with or at right angles to the curb with the pumper nozzle facing the curb, except that hydrants having two-hose nozzles 90 degrees apart shall be set with each nozzle facing the curb at an angle of 45 degrees.

307.09.02 CONNECTION TO MAIN. Each hydrant shall be connected to the main with a 6 inch ductile iron or PVC branch controlled by an independent 6 inch gate valve, unless otherwise specified.

307.09.03 Hydrant Drainage. Whenever a hydrant is set in soil that is pervious, drainage shall be provided at the base of the hydrant by placing coarse gravel or crushed stone mixed with coarse sand from the bottom of the trench to at least 6 inches above the waste opening in the hydrant and to a distance of 1 foot around the elbow.

Wherever a hydrant is set in clay or other impervious soil, a drainage pit 2 feet in diameter and 3 feet deep shall be excavated below each hydrant and filled compactly with coarse gravel or crushed stone mixed with coarse sand under and around the elbow of the hydrant and to a level of 6 inches above the waste opening. No drainage pit shall be connected to a sewer.

307.09.04 ANCHORAGE. The bowl of each hydrant shall be well braced against unexcavated earth at the end of the trench with a concrete thrust block or it shall be tied to the pipe with suitable restrained joints, as directed by the Engineer.

Concrete for thrust blocks shall have a 28 day compressive strength of not less than 3000 p.s.i. Thrust blocks shall be placed so that the pipe and fitting joints will be accessible for repair.

307.10 DISINFECTING OF DOMESTIC WATER SYSTEM. Before the pipeline is placed in service and before certification of completion by the Engineer, all new water systems, extensions to existing systems, valved sections of extensions, replacements in existing systems, and any exposed section of the existing system shall be disinfected in accordance with AWWA C-651, "Disinfecting Water Mains." Following disinfecting, the pipeline shall be flushed within 24 hours. Chlorinated water shall be disposed of legally. The Contractor shall furnish all equipment, chemicals, water, and connections necessary for disinfecting and flushing of pipelines.

307.10.01 TESTING. All newly laid pipe or any valved section therefore shall be subjected to a hydrostatic pressure test as specified in Section 336 – "Inspection and Testing."

307.11 IRRIGATION SYSTEMS

307.11.01 AUTOMATIC CONTROLLERS. When called for on the Plans, the Contractor shall furnish and install on a utility panel with a concrete base automatic controllers as herein specified. They shall be an electrically timed device for automatically opening and closing control valves for predetermined periods of time and mounted so that all normal adjustments will be conveniently located for use by the operation. Controllers shall be enclosed in a weatherproof casing with hasp and lock or locking device. All locks or locking devices shall be master keyed and three sets of keys provided. Operating features shall include the following, unless specified otherwise:

- a. Each valve in the circuit shall be of adjustable setting to remain open for any desired period of time - from 1 minute or less to at least 90 minutes - with automatic starts up to three per program per day.
- b. The controller shall operate on 110-117 volts and shall be equipped with a circuit breaker or fusible connection to protect the controller from overloads.
- c. Controller shall have a battery back up system for power failure to maintain the program for 7 days.
- d. The controller shall have a master on-off switch to turn all stations off without disturbing the clock settings or automatic timing sequences.
- e. Controls shall allow any position to be operated manually both on or off whenever desired.
- f. Controls shall provide for resetting the start of the irrigation cycle at any time and advancing from one position to another.

307.11.02 SPRINKLER HEADS. Sprinkler heads shall be of the type, pattern, and coverage of the Plans. Heads are to be installed flush with grade, mounted on a triple swing joint consisting of threaded SCH 80 elbows with a minimum of 3 inch threaded nipples or be premanufactured assemblies. All heads in turf areas are to have rubber covers.

307.11.03 GATE VALVES. Valves 2 1/2 inches and smaller shall be of the same size as the pipes on which they are placed unless otherwise indicated on the Plans. Service rating for non-shock cold water shall be 200 p.s.i. These valves shall be all bronze, split wedge type, with rising stem and union bonnet.

Packing shall be teflon impregnated asbestos and the valve shall be capable of being repacked under pressure. Handwheels shall be malleable iron. Valves 2 1/2 inches and smaller shall be the threaded type and installed with a union on either side of the valve.

Gate valves 3 inches and larger shall be iron body, bronze mounted, double disc, parallel seat type with "O" ring seals and shall comply with AWWA Standards. These valves shall have a working pressure of 200 p.s.i. and a test pressure of 400 p.s.i. A shut-off rod, 6 feet in length that will fit a 2 inch wrench nut, shall be furnished by the Contractor.

307.11.04 CONTROL VALVES. Manual control valves shall be straight or angle pattern globe valves of all brass or bronze construction with replaceable compression disks. Manual control valves shall be of the same size as the pipes on which they are placed unless otherwise indicated on the Plans, and shall be provided with a union connection. Manual control valves shall be capable of withstanding a cold water working pressure of 150 p.s.i.

Electric control valves shall be of the diaphragm type, normally closed, 24 volt, 60 cycle. The valve solenoids shall operate with 18 to 30 volts of power. The solenoid shall be completely encapsulated for positive waterproofing. The valve body and bonnet shall be of solid brass, flange or threaded type. If threaded type is used, it shall be provided with a union connection. The time interval between opening and closing the valve shall not be less than 5 seconds. The solenoid plunger shall be spring loaded so the valve may operate when installed in any position and shall be constructed of stainless steel with neoprene seat. Valve bonnet shall have a bleed screw for manual operation and a manual flow control adjustment. Electric control valves shall be capable of withstanding a non-shock cold water working pressure of 150 p.s.i.

Each solenoid control valve shall be placed in a rectangular green plastic valve box with valve box extensions allowing at least 6 inches clear on all sides of the valve. The control wires shall have an additional 3 feet of wire coiled up for each wire in the valve box. All valve wiring splices shall be inside the valve box using DBY connectors or in a 9 inch round box.

307.11.05 QUICK COUPLER VALVES. The quick coupler valve shall be of brass or bronze construction with 3/4 inch female iron pipe bottom connection. The valve shall be of two piece construction with removable upper body. The valve body shall be designed with a single slot to receive hose swivel elbow. The Contractor shall provide one valve key and hose swivel elbow for every quick coupler in the construction contract.

307.11.06 VALVE BOXES. Valves boxes shall be reinforced fiberglass or plastic, with one piece bolt-down (not hinged) lids. The lid is to be clearly marked with "Irrigation" impregnated into the lid. Control valves and irrigation boxes are to be grouped as indicated and valve boxes are to be located in flat areas, if possible. If they have to be located on a slope, the top of the box must be flush with the grade and at the same slope. Wells or depressions in the slope to make the top of the valve boxes level are not permitted. Valve boxes shall have extensions as necessary to reach the depth indicated. Extensions shall be of the same material as the valve box. Valve boxes shall not rest directly on the pipe. One inch or greater clear space is required between the pipe and the valve box or valve box extension.

307.11.07 BACKFLOW PREVENTERS. The irrigation system is to be isolated from domestic water by a reduced pressure principal backflow prevention device. Double check or pressure vacuum breakers are not permitted for landscape use under the Uniform Plumbing Code. Backflow preventer shall be a minimum of 12 inches above grade. All pipes closer than 24 inches to the surface connecting to the backflow device shall be galvanized pipe. A galvanized union shall be placed on both sides of the backflow preventer. All galvanized pipe below the ground surface shall be taped to prevent electrolysis per the Uniform Plumbing Code. A 1 cubic foot minimum concrete thrust block shall be placed at each elbow and riser. A manual drain valve shall be placed on the main line on both sides of the backflow preventer.

All potable water lines for drinking fountains, rest rooms, etc., shall be provided a separate service line upstream of the backflow preventer. The potable water line shall have a manual shut off valve at the point of connection to the main line, and a manual drain valve on the service line.

307.11.08 DRAIN VALVES

a. Manual Drain Valves. Drain valves are to be metallic manual globe valves located at all low points in all main and submain irrigation lines under constant pressure. Each drain valve is to be placed in a 9 inch diameter round valve box with extensions or a 4 inch schedule 40 sleeve inside the round valve box extending to the valve. If a sleeve is used, the top of the sleeve shall be a minimum of 3 inches below the bottom of the valve box cover. The bottom of the sleeve shall have 1 inch vertical clearance above the main line so the sleeve does not rest directly on the main line pipe.

A gravel sump consisting of 3 cubic foot minimum gravel conforming to the requirements for Class B backfill as specified in Subsection 200.03.03 – "Bedding and Backfill Material" – shall be placed below each drain valve with filter fabric placed over the gravel sump.

b. Automatic Drain Valves. Automatic ball check drain valves shall be installed at all low points in lateral lines. Ball checks shall be spring loaded and shall close under pressure of 2 to 4 p.s.i. Valves shall be installed with a gravel sump as described above.

307.11.09 PIPING. All live pressure lines shall be located a minimum of 30 inches below grade. All lateral lines shall be a minimum of 24 inches below grade. All flexible drip lines shall be made of algae resistant PVC and placed a minimum of 8 inches below grade. Pipes shall be snaked in the trench. All pipes located in the same trench shall be laid at the same elevation and laterally spaced a minimum of 3 inches apart. Control wires and caps common wires are to be taped to the bottom of the mainline with PVC tape in 10 foot intervals. All pipe runs shall be continuous full length pieces with no splices, except at either end of a branch lateral or at a tee for an irrigation head.

During assembly of pipe joint, all pipe cuts shall be reamed out with a pipe reaming tool to restore the full inside diameter.

PVC Primer and PVC Solvent Cement shall be as approved by the PVC pipe manufacturer. All excess cement shall be wiped off the pipe at time of assembly. A concrete thrust block shall be placed at all bends in pressure main lines and at all lateral bends where lateral pipe diameter is larger than 2 1/2 inches.

All piping under pavement shall be installed in a SCH 40 PVC sleeve a minimum of 1 inch larger than the pipe. Sleeves shall be installed 24 inches below finish grade and extend 18 inches past the edge of pavement.

307.11.10 CONTROLLER WIRING. All control and common wires shall be direct-burial rated. All continuous wire runs under 500 feet shall be continuous with no splicing permitted. When splicing is required outside of a valve box, a 9 inch round valve box shall be installed for the splice. Each wire to be spliced shall have a 3 foot coil of extra wire. All splices shall use a waterproof splice similar to a DBY connector. When the wire follows a main or irrigation line that has a 90 degree bend, 3 feet of excess wire shall be provided and buried at each elbow.

307.11.11 DRIP IRRIGATION LINES. All algae resistant PVC flexible lines shall be buried a minimum of 8 inches deep. All drip emitter taps and spaghetti lines shall be made with the tool manufactured by the emitter manufacturer. All drip lines shall be terminated with a flushing end plug in a 9 inch diameter valve box. Enough excess pipe shall be provided in the box so the flushing end plug can be directed outside the box when flushing.

307.11.12 DRIP EMITTERS. The gallon output shall be as shown on the Plans. For each plant, provide the following number of emitters per size as follows:

1-2 Gallon Shrub	1 Emitter
5 Gallon Shrub/Tree	2 Emitters
15 Gallon Tree	3 Emitters
24 Inch Box Tree	4 Emitters

Emitters are to be placed equally around the plant approximately 6 inches outside of the rootball. All drip distribution centers shall have a visible at grade cap/marker or valve box.

307.11.13 INSTALLATION. Piping layout indicated on drawings is diagrammatic. Route around structures or obstacles.

Trench for sprinkler system to insure proper grades and slopes to drain points.

Keep trenches free of debris, material, or obstructions that may damage pipe.

Care shall be exercised by the Contractor when excavating trenches near existing trees. Where roots are 2 inches and greater in diameter, except in the direct path of the pipe, the trench shall be hand excavated and tunneled. Trenches dug by machines adjacent to trees having roots 2 inches and less in diameter shall have the sides hand trimmed, making a clean cut of the roots. Trenches having exposed tree roots shall be backfilled within 24 hours unless adequately protected by moist burlap or canvas.

Where piping is installed in an open trench, excavation and backfill shall conform to the provisions in Section 305 – "Trench Excavation and Backfill." The bottom of the trench shall be graded and prepared to provide a firm and uniform bearing throughout the entire length of the pipe. During backfilling operations, the pipe shall be rigidly supported so that no movement of or damage to the pipe or joints will result.

Install piping, valves and controls, and sprinklers in accordance with the manufacturer's written instructions.

Solvent welded joints shall be made with solvent supplied by the manufacturer of the pipe. Care shall be exercised to clean both pipe and fitting to be joined. After the joint is made, excess solvent shall be wiped from the pipe and fitting, and the joint shall not be moved for a period of 15 minutes. No water shall be introduced into the system for a period of 12 hours.

Piping shall be installed to provide drainage. Slope exterior piping to drain toward drain valves.

On all plastic threaded connections, Permatex No. 2 silicone tape, or equal, shall be applied to the male thread.

Fittings shall be used on all bends in excess of 20 degrees. Where fittings are not used on lesser bends, the trench shall be of sufficient width to allow for an even bend.

Plastic pipe shall be laid to allow for expansion and contraction. Caution shall be exercised to support all plastic fittings and connections.

Where pipe is to be installed through existing paved areas, the subbase, base, and paving removed shall be replaced with material of equal quality. All pipe shall be cut straight and true. After cutting, the ends shall be reamed out to the full inside diameter of the pipe.

Foreign material shall be prevented from entering the irrigation system during installation. Immediately prior to assembly, all pipes, valves, and fittings shall be cleaned. All unattached ends of pipe, fittings, and valves shall be plugged or capped pending attachment of additional pipe or fittings. All lines shall be thoroughly flushed out prior to attachment of terminal fittings. Use threaded Schedule 80 nipples for risers to each outlet to facilitate easy replacement.

After piping is installed and before sprinkler heads are installed and backfilling commences, open valves and use full head of water to flush out system. Backfill sprinkler system using sand to a depth of 3 inches (75 mm) over piping. Fill remainder of trenches to top of subgrade elevation with sub-soil.

Set sprinkler heads and box covers to finish grade. Adjust all heads for proper water flow at completion of work. Replace plantings or structure damaged by installation of sprinkler system.

307.11.14 FLUSHING AND TESTING. All main supply lines shall be flushed completely of foreign particles before placing section control valves, quick coupler valves and hose bibs. After flushing, and when valves are in place, all main supply lines shall be tested at 100 p.s.i. with valves closed. Pressure shall be maintained for a period of 2-consecutive hours. All joints showing leaks shall be cleaned, remade, and tested.

After installation of lateral lines, the piping shall be completely flushed of foreign particles before attaching sprinkler heads and drain valves. After flushing, section lines shall be tested with risers capped and drain valves closed. The test shall be made at maximum operating pressure for a period of 1 hour. Any pipe, fittings or joints showing leaks will not be accepted. All joints showing leaks shall be cleaned, remade and retested. Piping shall be flushed for 5 minutes before connection with the control valves.

Automatic controllers shall be tested by actual operation for a period of two weeks under normal operating conditions. Should adjustments be required, the Contractor shall do so according to manufacturer's direction and he shall test the system until operation is satisfactory.

307.11.15 ADJUSTING SYSTEM. Before final inspection, the Contractor shall adjust and balance all sprinklers to provide adequate and uniform coverage. Spray patterns shall be balanced by adjusting individual sprinkler heads with the adjustment screws or replacing nozzles to produce a uniform pattern. Unless otherwise specified, sprinkler spray patterns will not be permitted on pavement, walks, or structures.

307.11.16 CLEANING. Upon completion of work, remove excess debris, materials, equipment, apparatus, tools, and the like and leave premises clean, neat, and orderly.

307.11.17 SUBMITTALS. Provide Owner with complete Operation and Maintenance manuals with instructions covering full operation care and maintenance of system and controls with manufacturer's parts catalogs.

Instruct owner's designated maintenance personnel in proper operation of system.

307.12 MEASUREMENT OF QUANTITIES. The materials to be measured for payment under these Specifications will be listed in the contract items by size, class, type, gage, or whatever information is necessary for identification.

The quantity of pipe to be measured for payment will be the actual number of lineal feet of the type specified, complete and in place. Pipe bends, wyes, tees, and other branches will be measured along centerlines to the point of intersection.

The quantity of sprinklers, couplers, heads, valves, hose bibs, valve boxes, valve assemblies, riser assemblies, etc., will be measured per each of the type and size specified, complete and in place.

307.13 BASIS OF PAYMENT. The accepted quantities of pipe measured will be paid for at the contract unit price bid per lineal foot for the types and sizes specified.

The accepted quantity of all other attachments measured will be paid for at the contract unit price bid per each for the types and size specified, unless these items are bid as included in the unit price per lineal foot of the piping.

Payment per lineal foot of pipe involved shall be full compensation for furnishing and installing pipe, bedding and backfilling, caps, markers, and incidentals necessary to install the pipe, complete and in place.

The above payment will be full compensation for furnishing all the material and labor necessary to install the system. Such payment shall include excavation, backfill, restoring sidewalk, curb, gutter, pavement, and appurtenances damaged or destroyed by construction and making all required tests.

308.01 DESCRIPTION. This work shall consist of furnishing, placing, and compacting aggregate base courses constructed in accordance with the requirements hereinafter set forth and in reasonably close conformity with the lines, grades, thicknesses, and cross sections shown on the Plans, indicated in the Special Provisions, or established by the Engineer.

308.02 MATERIALS. The quality and size of all materials shall conform to the requirements of Subsection 200.01 – “Base Aggregates”.

308.03 PLACING AND SPREADING. The approved material shall be placed uniformly on the approved subgrade by means of a hauling vehicle with or without spreading devices.

Spreading shall be done in such a manner as to prevent segregation of the different sizes of material and any such segregation, unless satisfactorily corrected, shall be cause for rejection at the discretion of the Engineer.

Where the required thickness is 6 inches or less, the base materials may be spread in one layer. Where the required thickness is more than 6 inches, the base material shall be spread for compaction in each layer not to exceed 6 inches. When large compaction equipment is utilized, base materials can be spread for compaction in 8 inch lifts if it can be demonstrated that adequate compaction can be attained.

308.04 WATERING AND MIXING. Water shall be applied immediately prior to and during all blading operations, until a uniform mixture is obtained which is approved by the Engineer. The material shall be moistened sufficiently to prevent segregation of the fine and coarse particles. Water shall be applied during the compaction and maintenance stages in sufficient amounts to assist in compaction and to prevent raveling.

308.05 COMPACTION. The base course shall be compacted to at least 95 percent maximum dry density at optimum moisture content as determined by procedures set forth in ASTM D 1557. The surface of any layer shall be maintained in its finished condition until the succeeding layer is placed. The base shall be properly drained at all times. Any loss of density in the upper portions of the material due to the elements, or because of a lapse of time, or for other reasons, shall require recompaction to the specified density prior to placement of any subsequent course with no additional compensation for such recompaction.

Recycled base mixtures shall be densified either as specified above, or by the number of passes established by measurement of peak wet density in a rolling pattern, providing the in-place moisture content is within 2 percent of optimum as determined by ASTM D 1557.

308.06 TOLERANCE. Waves, corrugations, and ruts will not be allowed to form and the base shall be bladed as often as necessary, rewatered, and recompacted to maintain a true cross section. When a 12 foot straightedge is laid in any direction, the finished surface shall not deviate at any point more than 0.05 foot from the bottom of the straightedge or from plan grade.

308.07 BASIS OF PAYMENT. The lump sum or unit contract price shall be full compensation for furnishing all material, hauling, placing, spreading, watering, mixing, compacting, and maintaining of the base material including the furnishing of all incidentals necessary to complete the work.

309.01 DESCRIPTION. This work shall consist of constructing one or more courses of mixture of aggregate and Portland Cement on a prepared surface in accordance with these Specifications in reasonably close conformity with the lines, grades, thicknesses, and typical cross sections shown on the Plans or established by the Engineer.

309.02 COMPOSITION OF MIXTURES. A mix design shall be performed and submitted to the Engineer in accordance with Subsection 337.01 "Mix Design" and the applicable requirements of Subsections 337.02 – "Cement Treated Crushed Aggregate Base" or 337.03 – "Cement Treated Recycled Aggregate Base" to determine the composition of the mixture. No cement treated base shall be placed without approval by the Engineer of a mix design. Immediate control of the cement content shall be accomplished by testing the fresh, moist cement-aggregate mixture by Test Method No. Nev. T239.

309.03 CONSTRUCTION.

309.03.01 MIXING — ROADMIX METHOD.

a. Depositing Untreated Aggregate. Untreated aggregate shall be deposited on the prepared area by means of spreader boxes equipped with a readily adjustable strike-off device resulting in a uniform windrow or a uniform spread, to provide the required width and surface tolerance specified in Subsection 309.03.06 – "Finished Surface." Aggregate to be treated shall not be mixed with roadbed material that is not to be treated.

b. Mixing. Cement treated base may be mixed either on the roadbed or at a location off the roadbed by the roadmixed method or the plantmixed method, as the Contractor may elect.

If the Contractor elects to use the plantmix method, all the requirements in Subsection 309.03.02 – "Mixing - Plantmix Method" – will apply, except the following:

The 0.4 of a percentage point variation in the cement content as provided in Subsection 309.03.02 – "Mixing - Plantmix Method" – will be increased to 0.6 of a percentage point as specified in this Subsection.

If the Contractor elects to use the roadmix method, the roadmixing machine shall be of the pugmill or auger type, or other type meeting the approval of the Engineer. The machine shall be designed to pick up the material to be mixed from the windrow or blanket, so that during at least 50 percent of the mixing cycle all the material is picked up and mixed while separated from the mixing table.

Cement to be mixed with aggregate may be furnished in sacks or in bulk. If sacked cement is used, the sacks shall be distributed on the aggregate at the required intervals and then be emptied by hand methods, following which the cement from each sack shall be distributed in a layer of uniform thickness. If the cement is furnished in bulk, it shall be spread by mechanical equipment. Each load in the spreading equipment shall be calibrated so the average rate of spread can be determined by the Engineer. The rate of cement spread per lineal foot of windrow or blanket shall not vary more than 10 percent from the designated rate. The tops of windrowed aggregate shall be flattened or slightly trenched to receive the cement. The distance which cement may be spread upon the aggregate ahead of the roadmixing operations will be determined by the Engineer.

The roadmixing machine shall have provisions for introducing water at the time of mixing, through a metering device or by other approved methods. The water shall be applied by means of controls that will supply the correct quantity of water to produce a completed mixture with a uniform moisture content. Leakage of water from equipment will not be permitted. Care shall be exercised to avoid the addition of any excessive water. The quantity of water added to the mixture will be determined by the Engineer.

Where the material is to be spread and compacted in two or more layers, material for each layer shall be mixed separately.

The resulting mixture shall be uniform and more than one pass of the mixer through the material may be required. If equipment is used that requires more than one pass of the mixer, at least one pass shall be made before any water is added to the material.

At the time mixing is completed, the moisture content of the mixture shall not be in excess of 3 percent over optimum as determined by Test Method No. Nev. T-236.

The cement content of samples taken from time to time from the product of the roadmixing machine, or from mixtures spread on the roadbed, shall not have a variation above or below the cement content designated by the Engineer or more than 0.6 of a percentage point based on the weight of the aggregate as determined by Test Method No. Nev. T239.

The lengths of treated sections shall be regulated to permit completion within the time requirements provided in Subsection 309.03.06 – “Time Requirements.”

Should the Contractor elect to perform roadmixing operations off the roadbed, the provisions specified in this Subsection for mixing on the roadbed shall apply.

309.03.02 MIXING — PLANTMIX METHOD.

General. Cement treated base shall be mixed at a central mixing plant by either batch mixing using revolving blade or rotary drum mixers or continuous mixing at the option of the Contractor. The aggregate and cement may be proportioned either by weight or volume.

In all plants, the water shall be proportioned by weight or volume and there shall be means by which the Engineer may readily verify the amount of water per batch or the rate of flow for continuous mixing. The time of the addition of water, or the points at which it is introduced into the mixer, shall be determined by the Engineer. The quantity of water added to the mixture will be determined by the Engineer.

At the time mixing is completed, the moisture content of the mixture shall not exceed optimum as determined by Test Method No. Nev. T236.

In all plants, cement shall be added in such a manner that is uniformly distributed throughout the aggregates during the mixing operation.

The charge in a batch mixer, or the rate of feed to a continuous mixture, shall not exceed that which will permit complete mixing of all of the material. Dead areas in the mixer, in which the material does not move or is not sufficiently agitated, shall be corrected by either a reduction in the volume of material or by other adjustment.

In all plants, the proportioning of materials designated by the Engineer shall be within the following tolerances:

Aggregate weights or rate of feed	±5.0 percent
Cement content of the completely dry mixture	±0.4 percent
Moisture content of the completed mixture	±1.0 percent

Batch Mixing. In batch-type mixers, the mixer shall be equipped with a timing device which will indicate by a definite audible or visual signal the expiration of the mixing period. The device shall be accurate to within 2 seconds. The plant shall be equipped with a suitable automatic device for counting the number of batches.

Mixing shall continue until a homogeneous mixture of uniformly distributed and properly coated aggregates of unchanging appearance is produced.

Cement for each batch shall be weighed on scales separate and distinct from the aggregate batching scales.

If volumetric proportioning is used, means shall be provided for accurately calibrating the amount of material in each measuring bin.

Continuous Mixing. If the continuous-type mixture is used, the correct proportion of each aggregate size introduced into the mixer shall be drawn from the storage facility by an approved type of feeder, which will continuously supply the correct amount of aggregate in proportion to the cement, and so arranged that the proportion of each aggregate size can be separately adjusted. The plant shall be equipped with metering devices of an approved type that will introduce the cement and water into the mixer in specified proportions. The metering devices and feeder shall be interlocked and so synchronized as to maintain a constant rate of cement and water to the aggregate. When storage bins are used, they shall be equipped with overflow chutes for each compartment. A positive signal system shall be provided that will automatically close down the plant when the level of material in any bin approaches the strike-off capacity of the feed gate. The plant shall not be permitted to operate unless the signal system is in good working condition. The feeder for the aggregate shall be mechanically or electrically driven. Aggregate feeders that are mechanically driven or electrically driven shall be directly connected with the drive on the cement feeder. The plant shall be equipped with facilities satisfactory to the Engineer for calibrating gate openings and metering devices by weighing check samples. Aggregated feeders that are electrically driven shall be actuated from the same circuit that serves the motor driving the cement feeder.

Mixing shall continue until a homogenous mixture of uniformly distributed and properly coated aggregates of unchanging appearance is produced.

The cement feeder shall be equipped with a device by which the rate of cement feed can be determined while the plant is in full operation.

The drive shaft of the cement feeder shall be equipped with a revolution counter reading to 1/100 of a revolution, and of sufficient capacity to register the total number of revolutions in a day's run.

309.03.03 SPREADING.

General. The area to be covered with cement treated base shall be prepared and compacted to the grade and cross section for the bottom surface of the cement treated base. Any material cut away in trimming for such grade and cross section shall be disposed of in a manner satisfactory to the Engineer.

Materials mixed at a location off the roadbed shall be protected against moisture loss while being transported to the spreading site, with a method approved by the Engineer, and shall be spread without segregation. Immediately prior to spreading, the area to be covered shall be moistened and kept moist, but not excessively wet.

Where the required thickness is 6 inches or less, the mixture may be spread and compacted in one layer. Where the required thickness is more than 6 inches, the mixture shall be spread and compacted in two or more layers of approximately equal thickness and the maximum compacted thickness of any one layer shall not exceed 6 inches. Work on each layer shall be performed in a similar manner, and the surface of the compacted material shall be kept moist or prevented from drying by some method approved by the Engineer until covered with the next layer.

Cement treated base to be placed in inaccessible areas may be spread by approved methods in one course. After spreading, the material shall be thoroughly compacted to the required lines, grades, and cross section by means of pneumatic tampers or with other compacting equipment which consistently obtains equal or better compaction than that provided in Subsection 309.03.05 – "Compaction."

Plantmix Method. The mixture shall be deposited on the roadbed at a uniform quantity per lineal foot, which quantity will provide the required compacted thickness without resorting to spotting, picking up, or otherwise shifting the mixture.

The mixture shall be spread in one operation with a self-propelled mechanical spreader ready for compaction without further shaping. Segregation shall be avoided and the base shall be free from pockets of coarse or fine material. Equipment not propelled by the unloading vehicle will be considered self-propelled. The spreader shall be provided with a screed that strikes off and distributes the material to the required cross section. Screed action includes any cutting, oscillating or other practical motion that produces a finished surface texture of uniform appearance. If the spreader leaves ridges, indentations, or other objectionable marks in the surface that cannot be eliminated by rolling, or prevented by adjustments in operation, its use shall be discontinued.

Except as otherwise provided in this Subsection, the use of motor graders will not be permitted during spreading and compacting operations, except that motor graders may be used to trim the edges and surface of the cement treated base after compaction in order to finish the base within the tolerances specified.

A motor grader will be considered to be a self-propelled mechanical spreader if it has been equipped with end wings on the blade, and with cross slope and automatic grade controls.

The mixed materials shall be spread for the full planned width, either by one spreader or by several spreaders operating in a staggered position across the subgrade, unless otherwise permitted by the Engineer or if traffic conditions require part width construction. Should permission be granted or part width construction be required for the use of one spreader operating alternately on contiguous lanes, not more than any 1 hour shall elapse between the time of placing material in adjacent lanes at any location. If longitudinal construction joints are necessary, they shall fall on lane lines.

309.03.04 COMPACTION. The provisions contained in this Subsection apply to both plantmix and roadmix methods.

Compacting equipment shall produce the required compaction within the operation time limit specified in Subsection 309.03.06 – "Time Requirements."

Initial rolling of cement treated bases shall be performed with steel-tired rollers.

Rolling shall be performed in such a manner that bumps and irregularities will be eliminated and finished surface shall be true to the required grade and cross section within the surface tolerances specified in Subsection 309.03.05 – “Finished Surface Tolerances.”

Water shall be applied without driving equipment over the uncompacted material.

Rolling shall commence by completely covering the outer edge of the material. Subsequent rolling shall lap at least 25 percent of previously compacted material.

Pneumatic-tired rollers conforming to the provisions in Subsection 319.03.04 – “Rollers” – shall be used following completion of initial rolling.

Areas inaccessible to rollers shall be compacted to the required compaction by other means.

The density of compacted cement treated bases shall not be less than 95 percent of the maximum density as determined by test procedures set forth by ASTM D 558. Test procedures set forth in ASTM D 1556, ASTM D 2922, Method B, or ASTM D 3017 may be used to determine the in-place density.

309.03.05 FINISHED SURFACE TOLERANCES. The finished surface of cement treated base shall be uniform and shall not deviate at any point more than 0.05 foot from the bottom of a 12 foot straightedge laid in any direction.

The surface of the finished cement treated base at any point shall not vary more than 0.05 foot above or below the grade established by the Engineer, except that when Portland Cement Concrete pavement is to be placed on cement treated base, the surface of the finished cement treated base at any point shall not extend above the grade established by the Engineer.

When the finished surface of cement treated base is outside the specified tolerances, and before placing any course of material thereon, all high spots on the finished surface shall be trimmed off to within the specified tolerance. The excess material shall be removed and disposed of in a manner approved by the Engineer immediately after trimming and no loose material shall be left on the base and the area shall then be rolled again. Full compensation for trimming high spots and disposing of the trimmed material shall be considered as included in the prices paid for the contract items involved in constructing the cement treated base and no additional compensation will be allowed therefor.

Cleated equipment shall not be allowed on new cement treated base unless street pads are used on cleats.

309.03.06 TIME REQUIREMENTS. Any mixture of aggregate, cement, and water that has not been compacted shall not be left undisturbed for more than 30 minutes. Not more than 2 hours shall elapse between the time water is added to the aggregate and cement and the time of completion of initial rolling. Not more than 3 hours shall elapse between the time water is added to the aggregate and cement and the time of completion of final compaction after trimming.

309.03.07 CONSTRUCTION JOINTS. At the end of each day's work and when cement treated base operations are delayed or stopped for more than 2 hours, a construction joint shall be made in thoroughly compacted material, normal to the centerline of the roadbed with a vertical face. Additional mixture shall not be placed until the construction joint has been approved by the Engineer.

Where cement treated base has cured for at least 1 hour, longitudinal joints shall be constructed. Longitudinal joints shall be constructed by cutting vertical lines into the existing edge for a depth of approximately 3 inches. The material cut away may be disposed of in the adjacent lane to be constructed. The face of the cut joints shall be moistened in advance of placing the adjacent base section.

309.03.08 PROTECTION AND CURING. The surface shall be kept moist at all times until the curing seal is applied. Water equipment shall be of a type which will apply moisture in a fog or mist type application free of pressure at the surface being treated.

The completed cement treated base shall be covered with a bituminous curing seal as protection against drying. Curing seal will be required only for the top layer of cement treated base. The curing seal shall be applied as soon as possible, but not later than 24 hours after the completion of final rolling. The surface shall be kept moist until the seal is applied. Curing seal shall be Asphalt Emulsion Type SS-1, unless otherwise specified, and shall be applied at a rate of between 0.15 gallon and 0.25 gallon per square yard of surface. The exact amount is to be determined by the Engineer. The curing seal shall be applied in accordance with the requirements of Section 317 – “Seal Coats” – and in sufficient quantity to provide a continuous membrane over the base. At the time of application of the curing seal, the surface shall be tightly knit, free from all loose material, and shall contain

sufficient moisture to prevent excessive penetration of the asphalt. If necessary to insure sufficient moisture content, sufficient water to fill the surface voids shall be applied immediately before the asphalt is applied.

Equipment or traffic shall not be permitted on the cement treated base during the first 3 days after applying the curing seal, unless otherwise permitted by the Engineer. After traffic is allowed on the cement treated base, and there is danger of excessive surface abrasion, sand blotter may be required as determined by the Engineer.

When equipment or traffic is permitted on the cement treated base and such permission is granted for the sole convenience of the Contractor, he shall protect the curing seal at his expense.

All loose sand shall be completely removed from the cement treated base before any surfacing material is placed thereon. Full compensation for furnishing, spreading, and removing sand, as specified above, shall be considered as included in the contract price paid for sand blotter and no additional allowance will be made therefor.

309.03.09 WEATHER LIMITATIONS. Cement treated base shall not be mixed or placed while the atmospheric temperature is below 35 degrees Fahrenheit, or when conditions indicate that the temperature will fall below 35 degrees Fahrenheit for a sustained period of 4 hours. Cement treated base shall not be placed on frozen ground and all material shall be protected from freezing and frost for a period of 5 days after placing.

309.04 MEASUREMENT OF QUANTITIES. The quantity of cement treated base to be measured for payment will be the number of square yards conforming to all the requirements in the completed work. Mixing, hauling, spreading, and compacting cement treated base will be included for payment by the square yard. The area will be determined from horizontal measurement of the finished surface of the base.

The quantities of liquid asphalt used for curing seal and sand blotter to be measured for payment will be determined as provided in Section 317 – “Seal Coats.”

309.05 BASIS OF PAYMENT. The accepted quantity of materials measured as provided in Subsection 309.04 – “Measurement of Quantities” – will be paid for at the contract unit price bid per square yard for cement treated base.

The above prices shall be full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all the work involved in constructing cement treated base, complete in place, as shown on the Plans and as directed by the Engineer.

The accepted quantities of liquid asphalt used for curing seal will be paid for in accordance with Section 317 – “Seal Coat and Surface Treatment” – if it is not included in the unit price bid per square yard for cement treated base as specified herein.

310.01 DESCRIPTION. This work shall consist of aggregate and bituminous material mixed in a central plant and spread and compacted on a prepared surface in accordance with these Specifications and typical cross sections shown on the Plans or established by the Engineer.

The requirements of Section 320 – “Plantmix Bituminous Pavement” shall be applicable to this work, except as hereinafter specified.

310.02 CONSTRUCTION.

310.02.01 DESCRIPTION. The construction requirements shall conform to the requirements as specified in Subsections 320.03.01 through 320.05.03, inclusive, of Section 320 – “Plantmix Bituminous Pavement” with the following exceptions:

310.02.02 ROLLERS. There shall be operating with each paver three rollers meeting the requirements of Subsection 320.03.04 – “Rollers.”

310.02.03 SPREADING AND FINISHING. Unless otherwise specified, bituminous base shall not be placed in courses exceeding 4 inches in compacted thickness. When more than one course is placed, the courses shall be approximately equal thickness.

310.02.04 SURFACE TOLERANCES. The completed surfacing shall be thoroughly compacted, smooth and free from ruts, humps, depressions, or irregularities. When a straightedge 12 feet long is laid on the finished surface and parallel with the centerline of the highway, the surface shall not vary more than 0.02 foot from the lower edge of the straightedge. The transverse slope of the finished surface shall be uniform to a degree such that no depressions greater than 0.02 foot are present when tested with a straightedge 12 feet long laid in a direction transverse to the centerline and extending from edge to edge of a 12 foot traffic lane.

Any ridges, indentations, or other objectionable marks left in the surface of the bituminous mixture by blading or other equipment shall be eliminated by rolling or other means. The use of any equipment that leaves ridges, indentations, or other objectionable marks in the bituminous mixture shall be discontinued and other acceptable equipment shall be furnished by the Contractor.

310.03 MEASUREMENT OF QUANTITIES. Plantmix bituminous base will be measured as specified in Subsection 320.08 – “Measurement of Quantities.”

310.04 BASIS OF PAYMENT. The quantity of materials measured will be paid for at the Contract unit price bid per Contract item.

The Contract unit price bid per Contract item shall be full compensation for all work involved in constructing plantmix bituminous base, as shown on the Plans or established by the Engineer, including, but not limited to, furnishing all the material; mixing; loading; hauling; placing; and compacting.

311.01 GENERAL.

311.01.01 DESCRIPTION. This Section covers the design, production, preparation for placement, and placement of *PCC*. The Section covers, the design, provisions, excavation, preparation for placement, placement and backfilling of monolithic precast reinforced concrete (*RC*) box intended for use in drainage applications and other conveyance systems.

Conventional *PCC* shall conform to the applicable Subsections of this section – Section 311 – “Concrete/ Structures/ Monolithic Precast RC Box/ Segmented Box”. All other structures shall conform to Section 502 – “Concrete Structures” and Section 503 – “Prestressed Concrete and Precast Members” of the *Silver Book* or other applicable references.

Segmented *RC* Box covered by this Subsection is intended for use in drainage applications or other conveyance systems. The boxes shall conform to the ASTM C1786 or as shown on the *Plans* or specified in the *Special Provisions* and/or *Special Technical Specifications*.

311.01.01.01 Abbreviations and Terms. Abbreviations and terms shall be in accordance with Subsection 100.01.01 – “Abbreviations and Codes”, except as modified herein.

Terms.

Production. Production shall be defined as furnishing, proportioning, combining and mixing all materials in accordance with approved *PCC* mix design(s).

Ready-mix. Ready-mix shall be defined as *PCC* that is manufactured in a fixed location batch plant and transported to the Site of Work.

Placement. Placement shall be defined as transferring, consolidating, finishing to a specified line and grade, and curing of the *PCC*.

Acceptable Crack. A crack width less than 0.1 inch and located in a non-corrosive environment (pH>5.5).

Monolithic. A structure cast in one-piece from and transported as a complete structure.

Slabbing. The separation of *PCC* from the reinforcing steel.

Spalling. The peeling, popping-out and flaking off of a *PCC* surface.

Segmented. A structure comprised of two or more individually cast components which are assembled at the *Site of Work* to form a complete structure.

311.01.02 DESIGN. This Subsection does not address the complete design requirements that must be taken into account by the *Engineer* in order to achieve the expected performance of the *PCC* improvement. The *Engineer* shall show specific design requirements on the *Plans* or specify these requirements in the *Special Provisions* and/or *Special Technical Specifications*.

This section does not address the complete design requirements that must be taken into account by the *Engineer* in order to achieve the expected performance of the resulting pipe and pipe system. Design requirements shall be shown on the *Plans* or specified in the *Special Provisions* and/or *Special Technical Specifications*. If details are not provided by the *Agency*, the *Engineer*, shall adhere to the standard installations in accordance with the applicable Article in Section 12⁽¹⁾ – “Buried Structures and Tunnel Linings” of the *AASHTO LRFD Bridge Design Specifications*.

1. Section as designated in the 7th Edition published in 2014. Section designations may change with the publication of subsequent editions. The *Current* edition shall be used.

311.01.02.01 PCC.

Composition of Mixtures. A mix design shall be submitted to the *Engineer* in accordance with Subsection 337.01 - “Mix Design”. The compressive strength at 28 *Days*, slump, target air content, aggregate gradation and type of cementitious material shall be shown on the *Plans* or specified in the *Special Provisions* and/or *Special Technical Specifications*.

**CONCRETE/ STRUCTURES/ MONOLITHIC PRECAST RC BOX/
SEGMENTED BOX**

MONOLITHIC PRECAST RC BOX. The Mix Design shall comply with *ASTM C1433* or *ASTM C1577*. The comprehensive strength at 28 *Days*, slump, target air content, aggregate gradation and type of cementitious material shall be shown on the *Plans* or specified in the *Special Provisions* and/or *Special Technical Specifications*.

SEGMENTED RC BOX. The Mix Design shall comply with *ASTM C 1786*. The compressive strength at 28 *Days*, slump, target air content, aggregate gradation and type of cementitious material shall be shown on the *Plans* or specified in the *Special Provisions* and/or *Special Technical Specifications*.

311.01.02.02 Forms. Forms shall be of suitable material and of a type, size, shape, quality, and strength to ensure construction as designed and, unless otherwise directed or approved by the *Agency*, shall conform to *ACI 347* – “Guide to Formwork for Concrete”.

311.01.02.03 Box Design Verification. Box design verification shall be performed when there is a change to material suppliers, materials, mix design, equipment or manufacturing operation, but no less than once every 12 months for each size box. Monolithic boxes shall conform to *ASTM C1433* or *C1577* (as applicable, Section 5).

Design verification records shall be maintained by the manufacturer and made available upon request.

311.01.03 SAFETY. The *Contractor* shall be responsible for safety in accordance with Subsections 100.33 – “Protection of Persons and Property” and 100.37 – “Protection of Work and Cleaning Up”.

311.01.03.02 Trenches. Unless otherwise directed or approved by the *Engineer*, *Trenches* shall not be excavated until immediately before installation of pipe and other appurtenances.

311.01.04 STRENGTH CLASS. The strength class required for a project is dependent on the bedding and backfill material, the depth of cover and the loading conditions. The bedding and backfill requirements used by the *Engineer* to determine the class of pipe required should be shown on the *Plans* or specified in the *Special Provisions* and/or *Special Technical Specifications*.

The *Engineer* may refer to the standard installations, as defined in Section 12⁽¹⁾ – “Buried Structures and Tunnel Linings” of the *AASHTO LRDF Bridge Design Specifications*, which provide flexibility in selecting the installation that best meets the projects unique combination of site conditions, available backfill materials and desired construction and inspection materials. Once the type of installation is selected the correct strength class of *RC* pipe can be determined.

1. Section as designated in the 7th Edition published in 2014. Section designators may change with the publication of subsequent editions. The Current edition shall be used.

311.02 MATERIALS. The materials used shall be accepted by the *Engineer*. The *Contractor* shall ensure that the materials have been accepted by the *Engineer* prior to transport and prior to performing subsequent *Construction Activities*.

311.02.01 INSPECTION OF MATERIALS. The *Contractor* shall accommodate inspection and sampling of the materials in accordance with Subsections 100.16 – “Inspection” and the applicable Subsections of Section 336 – “Inspection and Testing”.

311.02.02 CARE OF MATERIALS. The box and/or box components shall be supported so as not to create a concentrated point loading situation.

311.02.02.01 Material Storage. Materials shall be stored in accordance with Subsection 100.17 – “Materials and Workmanship.” except as modified herein.

Aggregates. Sufficient storage space shall be provided for the aggregate required. The storage yard shall be maintained neatly and orderly and separate aggregate stockpiles shall be readily accessible for sampling.

Aggregates shall be stored at *SSD* or above moisture condition.

Process Control Plan. A written process control plan shall be required from any aggregate *Supplier*. This written plan shall be provided to the *Engineer* upon request. The *Agency* and/or *Engineer* shall have the option to inspect aggregate processing facilities and/or request representative samples of processed aggregate for properties verification.

Process Control Testing. A summary of the results of all process control test data shall be included with the process control plan.

Cementitious Materials. Cementitious materials shall be stored in a sealed, waterproof environment to prevent wind damage and moisture intrusion. Unless otherwise directed or approved by the *Engineer*, cementitious materials used in *PCC* shall not have been stored for more than 750 *Calendar Days* after date of manufacture.

311.02.03 USE OF OTHER MATERIALS. The *Contractor* shall not use other materials and/or methods.

311.02.04 READY-MIX PCC. Ready-mix *PCC* shall conform to *ASTM C94*.

311.02.05 AGGREGATES. Aggregates shall conform to Section 200 – “Aggregates”.

311.02.06 CEMENTITIOUS MATERIALS. Cementitious materials shall conform to Subsection 202.02 – “Cementitious Materials”.

311.02.07 ADMIXTURES. Admixtures shall conform to Subsection 202.03.01 – “Admixtures”.

311.02.08 FIBERS. Fibers shall conform to Subsection 202.03.02 – “Fibers”.

311.02.09 CURING MATERIALS. Curing materials shall conform to Subsection 202.03.05 – “Curing Materials”.

311.02.10 WATER. Water shall conform to Section 205 – “Water”.

311.02.11 REINFORCING STEEL. Reinforcing steel shall conform to Section 206 – “Reinforcing Steel”.

311.02.12 FORMS. Forms shall be of suitable material and of a type, size, shape, quality, and strength to ensure construction as designed and, unless otherwise directed or approved by the *Agency*, shall conform to *ACI 347* – “Guide to Formwork for Concrete.”

311.03 CONSTRUCTION.

311.03.01 SUBMITTALS.

311.03.01.01 Certificate of Compliance. The *Contractor* shall provide a certificate of compliance for each material in accordance with Subsection 100.17 – “Materials and Workmanship”, except as modified herein.

Required Information.

- A. A statement that the individual responsible for the affirmation has the legal authority to bind the *Supplier* or manufacturer and/or fabricator;
- B. Quantity of pipe shipped; and
- C. The size, class and quantity of pipe shipped.

A certificate shall be sent with each shipment. The *Contractor* shall ensure that the *Certificates of Compliance* have been reviewed and accepted by the *Engineer* prior to unloading the associated material at the *Site of Work*.

311.03.01.02 PCC. The *Contractor* shall submit, in writing, the *PCC* mix design at least 14 *Calendar Days* prior to placement, for acceptance by the *Engineer*. Written comments regarding the submittal shall be provided to the *Contractor* within 7 *Calendar Days* of the submittal. The *Contractor* shall ensure that the mix design has been reviewed and accepted by the *Engineer* prior to providing the *PCC*.

Quality Control Program. Unless otherwise directed or approved by the *Engineer*, a written Quality Control Program shall be required for ready-mix production. This written plan shall be provided to the *Engineer* upon request. The *Agency* and/or *Engineer* shall have the option to inspect production facilities and/or request representative samples of mixture components or produced *PCC* for properties verification.

The overall plan shall address the individual elements which affect the quality of the *PCC* including, but not limited to, mix design; aggregate gradation; quality of materials; stockpile management; proportioning; mixing; and transporting.

Manufacturer shall maintain a quality control program which is certified annually. At the time of this publication *ACPA Q-Cast* and *NPCA* are the most widely recognized national certification programs. A comparable internal certification program may be submitted to the *Agency* for review and approval.

Salvage of Existing Systems. Boxes, in general, cannot be reused or salvaged. Items such as vault frames and manhole covers may be salvaged and reused at the discretion of the *Engineer*.

311.03.01.03 Forms. When requested by the *Engineer*, the *Contractor* shall submit detailed plans of formwork for examination by the *Engineer*. If such plans are not satisfactory to the *Engineer*, the *Contractor* shall make such changes as may be required, but it is understood that the *Engineer's* concurrence in the use of the Plans as submitted or corrected shall in no way relieve the *Contractor* of responsibility in obtaining satisfactory results.

311.03.02 INSPECTION AND TESTING. Inspection and testing shall be performed in accordance with Subsection 100.16 – “Inspection” and the applicable Subsections of Section 336 – “Inspection and Testing”.

311.03.03 LIMIT OF WORK. The limit of work shall be in accordance with Subsection 100.18 – “Location of Work”.

311.03.04 SCHEDULING OF WORK. The *Contractor* shall prepare and provide to the *Engineer*, for review, a baseline schedule, weekly work agenda and monthly updates.

311.03.05 EXISTING IMPROVEMENTS AND SYSTEMS. Removal of existing improvements and systems shall be performed in accordance with Section 301 – “Removal of Existing Improvements”. The *Contractor* shall protect items not removed in accordance with Section 301.04 – “Protection of Items Not Removed”, except as modified herein.

311.03.05.01 Aggregate Base. Aggregate Base shall be prepared in accordance with Section 308 – “Aggregate Base Courses” or Section 309 – “Cement Treated Base” as applicable.

311.03.06 CONSTRUCTION EQUIPMENT. The *Contractor* shall provide all equipment, tools, and machinery in accordance with Subsection 100.34 – “Character of Workers; Methods and Equipment”, except as modified herein.

311.03.06.01 Batch Plant and Delivery Fleet. Unless otherwise directed or approved by the *Engineer* plants used for the ready-mix production of *PCC* shall be of sufficient capacity and coordinated to adequately handle the proposed construction. The plant, including the delivery fleet, shall hold a current *NRMCA* certification.

Information regarding certification, including a complete list of the related tests, and an electronic directory of *NRMCA* certified plants are available at www.nrmca.org.

The plant shall include satisfactory equipment or use other methods which will meet local conditions, city, county, state, and federal laws pertinent to air pollution.

311.03.07 CONSTRUCTION LOADS. The *Contractor's* operations shall not produce a surcharge which would impact stability of adjacent improvements. Any proposed construction loads that were not specifically identified in the design process shall be reviewed and approved by the *Engineer*.

311.03.08 SUBGRADE PREPARATION. *Subgrade* preparation shall be performed in accordance with Section 302 – “*Subgrade* Preparation”, except as modified herein.

311.03.08.01 Ground Water. Ground water shall be kept below *Subgrade* until the concrete has set.

311.03.08.02 Moisture Conditioning. Prior to *PCC* placement, the *Subgrade* shall be thoroughly dampened with water. Standing water shall not be permitted.

311.03.08.03 Bedrock. When *PCC* is to be placed on *Bedrock*, the surface shall be removed to a depth sufficient to expose the solid material. *Bedrock* shall be roughly leveled off or cut to approximately horizontal and vertical steps. Loose or deleterious material shall be removed from the prepared *Bedrock* surface. Seams in the *Bedrock* shall be grouted under pressure or otherwise treated as directed or approved by the *Engineer*.

311.03.09 EXCAVATING. Excavating shall be performed in accordance with Section 303 - "Unclassified Excavation", except as modified herein.

311.03.09.01 Cover Limits. The box cover height should be determined during the design phase. In no instance shall the cover limits of the box be exceeded.

311.03.09.02 Trench Width. For pipe, the minimum and maximum width of *Trench* permitted shall be as shown on the *Plans* or *Standard Details* or specified in the *Special Provisions* and/or *Special Technical Specifications*, and shall be of such a width to allow placement proper construction of joints and compaction of bedding and backfill. Unless otherwise directed or approved by the *Engineer*, trenches shall be excavated to a width that will provide adequate working space for mechanical compaction equipment, but not less than required by Article in Section 12⁽¹⁾ – "Buried Structures and Tunnel Linings" of the *AASHTO LRDF* Bridge Design Specifications.

1. Section as designated in the 7th Edition published in 2014. Section designators may change with the publication of subsequent editions. The Current edition shall be used.

Trench walls shall not be undercut.

If the maximum *Trench* width is exceeded, the *Contractor* shall provide additional bedding, another type of bedding, or a higher strength of pipe, as directed by the *Engineer*, at no additional cost to the *Agency/Owner*.

Narrow trenches. Narrow trenches may be allowed by the *Engineer* provided the clearance between the pipe and *Trench* wall is adequate to allow compaction of the backfill..

The minimum trench width shall be wide enough (between the box and trench wall) to permit the proper construction of joints and compaction of backfill around the box, but shall be at least equal to the trench width required under *AASHTO* Section 27 for Concrete Culverts.

If special circumstances exist, narrower trench widths may be used as approved by *Engineer*.

311.03.09.03 Trench Foundation. The *Foundation* shall be accurately graded to provide uniform bearing and support for each section of the pipe at every point along its entire length, except for portions of the pipe where it is necessary to excavate for bells and for proper sealing of the pipe joints.

When connections are to be made to any existing pipe, conduit, or other appurtenances, the actually elevation or position of which cannot be determined without excavating, the *Contractor* shall excavate and expose the existing improvement before trenching for or laying any pipe or conduit on the project. Any adjustments in line or grade which may be necessary to accomplish the intent of the *Plans* will then be made.

Oversize Material or Bedrock. Unless otherwise directed or approved by the *Engineer*, rocks larger than 4 inches in any dimension or *Bedrock*, exposed by excavating, shall be removed to a minimum depth of 6 inches below the *OD* of the pipe. The *Contractor* shall replace the removed materials as directed or approved by the *Engineer*.

If information regarding oversize materials or *Bedrock* was not available and no provisions for removal and replacement were included in the *Contract Documents*, the *Contractor* may request

additional compensation. The *Contractor* shall submit any request for increase to the *Contract Amount* in accordance with Subsection 100.24 – “Change Orders”.

Unsuitable Material. The *Contractor* shall remove any material unsuitable for pipe support to the depth directed by the *Engineer*.

If information regarding unsuitable materials was not available and no provisions for removal and replacement were included in the *Contract Documents*, the *Contractor* may request additional compensation. The *Contractor* shall submit any request for increase to the *Contract Amount* in accordance with Subsection 100.24 – “Change Orders”.

311.03.10 PLACING OF MATERIALS.

311.03.10.01 Forms. The *Contractor* shall ensure that the surface has been accepted by the *Engineer* prior to placing forms for *PCC*. Unless otherwise directed or approved by the *Engineer* forms shall be constructed in accordance with *ACI 347* – “Guide to Formwork for Concrete”.

PCC Placed Without Forms.

PCC Placed Against Excavation Surfaces. When *PCC* is placed directly against the faces of the excavation, the faces must be firm, compact, able to stand without sloughing, and must be outside the concrete lines shown on the *Plans* at all points. The entire faces of excavation, against which concrete is to be placed without the use of outside forms, shall be gunited to sufficient thickness to prevent raveling of the exposed earth faces during the placing of reinforcing steel, forms, and concrete.

PCC Placed Against Sheeting. When *PCC* is placed against sheeting, such sheeting shall be closely fitted on all points outside the concrete lines shown on the *Plans*. Those surfaces against which the *PCC* is to be placed shall be faced with building paper. Except as otherwise specified herein, all sheeting shall be removed, but not until at least 7 *Days* after placing concrete, or until the concrete has attained a strength in compression of 2,000 *PSI*.

Care shall be used in removing sheeting so as to avoid damaging the concrete. When field conditions or the type of sheeting or methods of construction used by the *Contractor* are such that the removal of sheeting is impracticable, that portion of the sheeting against which *PCC* has been placed may be left in place.

311.03.10.02 *PCC Temperature.* The temperature of the *PCC* at delivery shall not exceed 90°F.

311.03.10.03 *Foundation and Bedding.* The *RC Box* strength class for a project is dependent on the bedding and backfill material and compaction. The bedding and backfill requirements used by the *Engineer* to determine the strength of box required should be called out on the project plans and specifications or the plans and specifications may refer to the local agency standard plan sheets that govern the design.

311.03.10.04 *Backfill.* Backfill above the top of the box shall conform to Subsection 200.03.06 – “Class E Backfill” with a relative compaction of at least 90 percent of the maximum dry density, within 2 percent of optimum moisture content, determined in accordance with *ASTM D1557* or slurry backfill when specified in the project plans or specifications.

Mechanically Compacted Backfill. Mechanically compacted backfill shall be layered in 12” maximum lifts. Avoid usage of impact tampers directly above the box until the full loose layer backfill depth above the box is obtained.

Slurry Backfill. If slurry backfill is specified the slurry backfill shall conform to Subsection 337.08.01 – “Slurry Backfill”, Type A (Excavatable). The slurry backfill shall be placed around the box from the foundation bedding to the springline.

311.03.10.05 *Box Installation.* Installation shall be per *ASTM C1675* unless noted otherwise in this specification or in the project plans and specifications.

Ensure that no rocks greater than 3 inches or other rigid or jagged material is present in the bedding material where the box may be laid directly on the material.

Prior to placing backfill material, all lifting holes in concrete culverts shall be completely filled with grout.

311.03.10.06 Connections. All junctions of laterals with a main line or junctions of 2 or more main lines, which are not made in a manhole or concrete junction structure, shall be made by either grouting the lateral in to a fabricated reinforced opening, connecting the lateral with an approved Cast in Place field collar, or in a manufactured wye or tee. The wye or tee shall be of the same material as the conduits to which they are joined, and shall have the same or greater strength as the box.

Connections should be detailed in the project plan sheets or sent as part of the submittal package for approval of the *Engineer* prior to fabrication.

311.03.10.07 Joints. Joints for precast RC box shall meet the requirements of ASTM C990.

Precast RC box shall be supplied with a T&G joint.

T&G joints may be sealed using cement mortar or mastic material in the joint gap.

The precast RC box and T&G joint shall be constructed by following method:

T&G Joints

Mortared Joints. Use only an approved mortar (or non shrink grout).

Compose mortar of 1 part Portland cement and 2 parts mortar aggregate by volume. Add only enough water to permit placing and packing of the soft workable mortar. The water-cement ratio shall not exceed 0.53. After the ends of the sections of box are cleaned and wetted, place mortar firmly into the lower half of the groove end of the previously laid section. Firmly place mortar on the top half of the tongue end of the section to be jointed. Snugly insert the tongue end into the groove end of the section previously laid. Use enough mortar to completely fill the joint.

311.03.10.08 Grout.

Composition of Materials. Grout shall consist of one part by volume of Portland cement and three parts of clean sand and shall contain only sufficient moisture to permit packing.

Brush or point the interior joint. Trowel or brush smooth the inside joints and remove excess mortar from the interior box joint. Fill the outside joint recesses with mortar. Firmly fill the external space between the ends of the jointed box from the outside with laying mortar.

Backfill of the box trench may be completed while the joint mortar is still plastic. Should the joint mortar become set before backfilling, do not backfill until 16 hours after jointing the box sections. When the box is not backfilled while the mortar is plastic, cure the mortar using a method approved by the *Engineer*. Do not allow free water to come in contact with the boxline until the mortar in the joints has set at least 24 hours.

Mastic Joints. Wrap mastic joint sealant around the tongue and snugly insert tongue end into the groove end of the section previously laid. Alternately, *Contractor* may place mastic firmly into the lower half of the groove end of the previously laid section and firmly place mastic on the top half of the tongue end of the section to be jointed. Snugly insert the tongue end into the groove end of the section previously laid.

Joint Gaps. The *Contractor* should make every effort to pull the box completely home. Should gapping occur due to changes or corrections in horizontal or vertical alignment or radius turns, the gaps should not exceed the gap tolerance listed below.

The recommended joint gap is one that does not exceed 1/2 of the T&G joint length. If this gap is exceeded, the *Contractor* shall submit, for approval by the *Engineer*, methods to properly seal the joint.

**CONCRETE/ STRUCTURES/ MONOLITHIC PRECAST RC BOX/
SEGMENTED BOX**

Joint Material. In lieu of mastic material conforming to Section 203, the following extruded cellular rubber gaskets may be used for soil tight applications:

Extruded Cellular Rubber Gaskets.

- A. Gaskets shall be manufactured from extruded closed cellular rubber, and meeting the physical requirements of ASTM D1056, Class 2C1. Each gasket shall be a single continuous part, conforming to the joint size and shape. The outer surface shall be completely covered with a smooth, impermeable natural skin of the same material.
- B. Gasket cross-sectional diameters and installation practices, to include maximum and minimum joint gaps, shall be in accordance with the manufacturer's installation instructions.
- C. Do not use this type of gasket when the pipe is installed by jacking or boring methods.

311.03.10.09 ACCPETANCE.**Damaged Work.**

Repair. Cracks in boxes (both longitudinal and circumferential) that are less than 0.10 inch in width in a non-corrosive environment (pH>5.5) are generally considered non-structural flaws and need not be repaired.

Cracks that are equal to or exceed 0.10 inch in width shall require an evaluation by a *Professional Engineer*.

Damaged end, chips or cracks which do not pass through the wall can be patched using an approved concrete placing material.

311.03.11 WEATHER LIMITATIONS.

311.03.11.01 Surface Moisture. PCC shall not be placed on a grade which is frozen or which has a moisture content which would be detrimental to the quality of the PCC.

311.03.11.02 Temperature.

Cold Weather. PCC shall not be mixed or placed while the ambient temperature is below 35°F, or when conditions indicate that the temperature may fall to 35°F within 24 hours of placement unless adequate means are employed to heat the aggregates and water, and satisfactory provisions have been made for protecting the work. Placement of concrete in cold weather conditions shall be performed in accordance with ACI 301, and the recommendations of ACI 306.

Protection. PCC shall be protected from freezing or frost for a period of 5 *Calendar Days* after placing.

Hot Weather. PCC shall not be mixed or placed while the ambient temperature is above 115°F unless adequate means are employed to cool the aggregate and water and satisfactory provisions have been made for protecting the work. Placement of concrete in hot weather conditions shall be performed in accordance ACI 301, and the recommendations of ACI 305.

Evaporation. When the evaporation rate at the fresh PCC surface exceeds 0.15 pounds per square foot per hour, mitigation measures shall be implemented in accordance with ACI 305. If plastic shrinkage cracking is observed after mitigation measures have been utilized, PCC placement shall be suspended until resumption is approved by the *Engineer*.

Precipitation. PCC placement shall be stopped when precipitation is sufficient to cause damage to the work.

311.03.12 MAINTENANCE OF TRAFFIC. Maintenance of traffic shall be performed in accordance with Section 338 – "Maintenance of Traffic".

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311.03.13 PROTECTION OF WORK AND CLEANING UP. Protection of work and cleaning up shall be in accordance with Section 100.44 – “Protection of Work and Cleaning Up” except as modified herein.

311.03.13.01 Protection. Protect concrete from direct rays of sun or drying effect of wind.

Cold Weather Concreting. Placement of concrete in cold weather conditions shall be performed in accordance with, and the recommendations of ACI 306.

Hot Weather Concreting. Placement of concrete in hot weather conditions shall be performed in accordance, and the recommendations of ACI 305.

311.04 ACCEPTANCE. *PCC* shall be accepted based on the following criteria:

- A. Compressive strength;
- B. Air Content;
- C. Unit Weight;
- D. Surface tolerance; and
- E. Documentation of placement, finishing, curing and protection in accordance with Subsections 311.03.10 – “Placing of Materials” and 311.03.11 – “Weather Limitations”.

Any *PCC* which is defective or damaged shall be repaired or replaced by the *Contractor* with no additional compensation.

312.01 GENERAL.

312.01.01 DESCRIPTION. This Section covers the design, production, preparation for placement, and placement of *PCC*.

Any Subsection designations which are omitted within this Section shall be interpreted to be intentionally left blank. *PCC* flatwork, curbs, ditches and slope paving shall conform to the applicable Subsections of Section 311 – “*CONCRETE/STRUCTURES/MONOLITHIC PRECAST RC BOX/SEGMENTED BOX*”, except as modified herein.

312.01.02 DESIGN.

312.01.02.01 Thickness. Unless otherwise shown on the *Plans* and/or specified in the *Special Provisions* and/or *Special Technical Specifications*, the minimum *PCC* thickness for sidewalks shall be 4 inches. Where sidewalk is to be constructed across driveways the *PCC* thickness shall be a minimum of 6 inches.

312.02 COMPOSITION OF MATERIALS.

A mix design shall be performed and submitted to the Engineer in accordance with Subsection 337.01.01 “Mix Design” and the applicable requirements of Subsection 337.10 – “General Structural Use Portland Cement Concrete” to determine the composition of the mixture. No *PCC* shall be placed without approval by the Engineer.

312.03 CONSTRUCTION.

312.03.01 INSPECTION AND TESTING. Inspection and testing shall be performed in accordance with Subsection 100.16 – “Inspection” and the applicable Subsections of Section 336 – “Inspection and Testing”.

312.03.02 PLACING OF MATERIALS.

312.03.02.01 Drainage Outlets. The *Contractor* shall provide suitable outlets through new curb and/or sidewalks for any existing building drains conflicting with new construction. The *Contractor* shall place similar outlets opposite any low area on adjacent property such that the drainage of the adjacent property will not be affected by the new work.

The full depressed curb opening at driveway entrances shall be a minimum of 1 inch above gutter flow line at the curb face. The top of the fully depressed portion of the curb shall be finished to a transverse 1/2 inch drop toward the gutter.

312.03.02.02 Finishing. Finishing of the *PCC* shall be performed in accordance in with the *PCA's* Concrete Finisher's Guide. No water shall be added during finishing. Steel finishing tools, with the exception of edging tools, shall not be used. **All air entrained *PCC* for exterior improvements placed January 1, 2018 and after shall be by, or under the direct supervision of a Superintendent who is certified by the ACI as a Concrete Flatwork Finisher.**

Information regarding certification including a complete list of the related tests, and an electronic registry of *ACI* Concrete Flatwork Finishers is available at www.concrete.org.

Face and Top of Curb. The front forms may be stripped as soon as the concrete has set sufficiently.

The face and top of the curb shall then be carefully finished to a smooth and even finish, the top with a transverse slope of 1/4 inch toward the gutter, and both edges rounded to a radius of 3/4 inch. The surface shall be finished as prescribed.

Sidewalk Surface. When a 10 foot straightedge is placed on the sidewalk, the surface shall not vary more than 1/8 inch from the edge of the straightedge, except at grade changes.

Edging and Jointing. Edging and jointing should not be done until all bleed water and excess moisture have left or have been removed from the surface.

Isolation Joints. Unless otherwise shown on the *Plans* and/or specified in the *Special Provisions* and/or *Special Technical Specifications*, isolation joints shall be constructed in curbs, sidewalks, and gutters. Such joints shall be filled with premolded joint filler, conforming to the requirements of Subsection 202.03.03 – “Joint Materials”.

PCC FLATWORK, CURBS, GUTTERS, WALKS, DRIVEWAYS, AND ALLEYS

Placement. The joint filler shall be placed with the top edge 1/4 inch below the surface and shall be held in place by means of steel pins driven into the base course and spaced sufficiently close to prevent warping of the filler during floating. Upon completion of floating, the pins shall be removed and, when finishing operations have been completed, the joint shall be edged with an edging tool with a radius of 1/2 inch.

Curb and Gutter Joints. Isolation joints 1/2 inch wide shall be located in curbs and gutters at each side of structures, and at the ends of all curb returns, and abutting hardened in-place curbs and gutters, except that isolation joints shall not be installed within 20 feet of an island nose. Isolation joints shall be 1/2 inch thick, shaped to the cross section of the curbs and gutters, and shall be constructed at right angles to the curbs and gutters.

Sidewalk Isolation Joints. Transverse isolation joints 1/2 inch wide shall be constructed at all sidewalk returns, opposite isolation joints in adjacent curbs, and as shown on *Plans*. Isolation joints shall be installed around all structures. Isolation joints shall be filled with joint filler strips 1/2 inch thick.

Weakened Plane Joints. Weakened plane joints shall be straight. Headers shall be marked to locate the weakened plane for final joint finishing, which shall be accomplished with a jointer tool having a depth of 1/2 inch and a radius of 1/4 to 1/2 inch. The finished joint opening shall not be wider than 1/8 inch.

Sidewalks. Weakened plane joints shall be located at regular intervals not exceeding 1.2 times the width and no more frequently than 0.8 times the width, but in no case shall regular intervals of weakened plane joints in either direction exceed 10 feet.

Texturing. After edging and jointing operations, the surface shall be slightly roughened by brooming, with the exception of the flow line of the gutter which should be left smooth.

312.03.02.03 Curing. Unless otherwise directed or approved by the *Engineer*, curing compound conforming to the requirements of Subsection 202.03.05 shall be used. The curing compound shall be uniformly applied to all fresh *PCC* surfaces in accordance with the manufacturer's recommendations. The curing compound shall be applied immediately after completion of final finish or texturing.

312.03.03 PROTECTION OF WORK AND CLEANING UP. Protection of work and cleaning up shall be in accordance with Section 100.37 – "Protection of Work and Cleaning Up"

No equipment causing jarring of the concrete shall be permitted adjacent to concrete curbs, gutters, or alley intersections until the fourth day following placement of concrete. The placement of bituminous pavement adjacent to concrete curbs, gutters, or alley intersections shall not be permitted until the seventh day following the placement of concrete, nor shall concrete paving operations be permitted until the seventh day where placing or finishing equipment will ride on the previously placed concrete.

313.01 GENERAL.

313.01.01 DESCRIPTION. This Section covers the design, production, preparation for placement, and placement of specialized *PCC*.

Any Subsection designations which are omitted within this Section shall be interpreted to be intentionally left blank. Specialized *PCC* shall conform to the applicable Subsections of Section 311 – “CONCRETE/STRUCTURES/MONOLITHIC PRECAST RC BOX/SEGMENTED BOX”, except as modified herein.

313.02 PERVIOUS CONCRETE.

313.02.01 DESCRIPTION. This Section covers the design, production, preparation for placement, and placement of Portland cement pervious concrete pavement for streets, parking and pedestrian areas.

Abbreviations and Terms. Abbreviations and terms shall be in accordance with Subsection 100.01.01 – “Abbreviations and Codes”, except as modified herein.

Terms.

Pervious Concrete. Concrete paving containing little or no fine aggregate, creating an open matrix that allows water to pass through it.

Raveling. Contiguous dislodging of the surface layer of aggregate.

313.02.02 MATERIALS.

313.02.02.01 Aggregates. Aggregates shall conform to Section 200 – “Aggregates”, except as modified herein.

Aggregate shall have a minimum specific gravity of 2.60, a minimum rodded void content of 36 percent in accordance with *ASTM C29*, and a maximum absorption rate of 3 percent. The aggregate size shall not exceed 1/2 inch nominal.

313.02.02.02 Reinforcing Steel. Reinforcing steel shall not be utilized.

313.02.02.03 Filter Fabric. The filter fabric shall conform to *ASTM D6767*.

313.02.03 CONSTRUCTION.

The pervious paving *Contractor/Subcontractor* shall employ one or more NRMCA Certified Pervious Concrete Craftsman or three or more NRMCA Certified Pervious Concrete Installers, who shall be onsite, actively guiding each placement crew during pervious concrete placement.

Information regarding certification, including a complete list of the related tests, and an electronic directory of NRMCA certified pervious concrete paving contractors are available at www.nrmca.org.

313.02.03.01 Scheduling of Work.

Pre-Activity Meeting. Before commencement of pile construction, a pre-activity meeting shall be scheduled by the *Engineer* a time and place satisfactory to the *Contractor*. At a minimum, the pre-activity meeting shall be attended by the *Contractor*, pervious paving *Subcontractor's Superintendent* and NRMCA Certified Craftsman or Installer and the *Engineer*. Pile construction shall not be commenced until all action items resulting from the pre-activity meeting have been satisfactorily addressed.

313.02.03.02 Placing of Materials.

Internal vibration of the mixture is prohibited.

PCC shall not be pumped.

Water addition is permitted at mixing drum to maintain wet metallic sheen.

Edging and Jointing.

Transverse Construction Joints. Transverse construction joints shall be installed whenever placing is suspended for 20 minutes or whenever concrete is no longer workable.

Dowels. Do not dowel longitudinal joints between successive placements.

Isolation Joints. Isolation joints shall be used when abutting fixed structures. Place isolation material before concrete is placed and to the depth of the pavement section.

Control Joints. Control (contraction) joints shall be installed at regular intervals not to exceed 20 feet, or two times the width of the placement. The control joints shall be installed at 1/4 to 1/3 the depth of the thickness of the pavement.

Saw cutting after the *PCC* has hardened will not be permitted due to potential joint raveling.

313.02.03.03 Weather Limitations.

Temperature.

Cold Weather. Unless otherwise directed or approved by the *Engineer*, *PCC* shall not be mixed or placed while the ambient temperature is below 45°F, or when conditions indicate that the temperature may fall to 32°F within 48 hours of placement.

Hot Weather. *PCC* shall not be mixed or placed while the ambient temperature is above 95°F.

313.02.03. FIELD QUALITY CONTROL

313.02.03.01 Infiltration Rate. Average infiltration rate shall be 250 inches per hour or more, with no single test less than 100 inches per hour.

Infiltration Test. Per ASTM C1701. One test for every 10,000 sq. ft. minimum, but not less than three tests. Test locations shall be on clean, level pavement. Testing shall be performed after curing but before opening pavement to traffic. Test results shall be averaged.

313.02.03.02 Pressure Wash Resistance. Pavement shall withstand pressure washing with no more than 2 percent raveling.

Pressure Wash Test. Minimum of three locations equal to 1 percent of total Project area of pervious concrete pavement shall be tested. Pressure wash at 3000 psi and 2.4 gpm with zero-degree nozzle no more than 3 inches from concrete surface. Nozzle shall be moved at slow but steady rate across test surface.

313.02.03.03 Compressive Strength. Compressive strength testing is not used for pervious concrete.

313.03 ROLLER COMPACTED CONCRETE PAVEMENT (*RCC*).

313.03.01. GENERAL.

313.03.01.01 SCOPE. The scope of work shall consist of furnishing all materials, tools, equipment, and batching, or batching and mixing plant for producing roller compacted concrete (also referred to as *RCC*); and performing all labor for producing, transporting, forming, placing, compacting, curing, finishing and testing of *RCC*. The constructed *RCC* pavement shall conform to lines, grades, thickness, and cross section, as shown on the plans, or otherwise established by these specifications.

313.03.01.02 DESCRIPTION. Roller-compacted concrete shall consist of Portland cement, possibly supplementary cementing materials (for example fly ash or ground granulated blast furnace slag), aggregates, water, and chemical admixtures proportioned to produce the required formability (adequate to the method of consolidation by vibratory rollers) and strength.

313.03.02. SUPERINTENDENCE.

As part of the bid package and prior to Project award, the prime *Contractor* must have on their payroll, or be under contract with, either a consultant or subcontractor that will provide a *RCC* Superintendent for the project and provide documentation of such agreement. The *RCC* Superintendent shall be present at the job site during all items relating to Roller Compacted Concrete. Additionally, the *Contractor* shall submit, as part of the bid package, the *RCC* Superintendent's resume. At a minimum, the *RCC* Superintendent's resume shall include the following:

- A. *RCC* Superintendent must have experience with the equipment required of the work including pugmills and high density pavers.
- B. *RCC* Superintendent must have a minimum of 3 years *RCC* pavement experience.
- C. *RCC* Superintendent must have completed at least 3 *RCC* pavement projects with a minimum of 2,000 CY each, using the required equipment.
- D. Three *RCC* project references, including photographs that are representative of the projects, must be included.
- E. Prime *Contractor* or *RCC* Superintendent must have completed at least 5 public roadway projects that included asphalt, PCC and/or *RCC* paving. Project references are required including photographs that are representative of the projects.

As part of their duties, the *RCC* Superintendent will be required to perform the following items:

- A. *RCC* Superintendent must submit and conduct (or appropriately broker) an *Agency* approved pre-construction *RCC* training program agenda and training for the *Contractor*, the paving crew, and *Agency* staff involved with the *RCC* portion of the project. The training must be repeated if the *Contractor* or paving crew staff changes.
- B. *RCC* Superintendent must oversee the performance of at least one 1,500 SY *RCC* paving test section specific to this project, prior to paving.

313.03.03. MATERIALS.

313.03.03.01 Moisture Control. One of the following admixtures, or an approved equal, is allowed for use of controlling moisture. Please refer to the manufacturer's recommendations for dosage rates.

ACEiT Plus Manufactured by ACEiT Industries

V-MAR VSC500 Manufactured by Grace Concrete Products

313.03.03.02 Troweling. The following admixture, or approved equal, is required when surface troweling is performed. Please refer to the manufacturer's recommendations for dosage rates.

ACEiT Blue Manufactured by ACEiT Industries

313.03.04 EXECUTION.

313.03.04.01 Preconstruction Laboratory Mix Design Studies. An independent testing laboratory shall proportion *RCC* to meet the specified requirements for strength and *Contractors* requirements for consistency and formability. The laboratory shall demonstrate its compliance with the requirements of ASTM C1077. The mix design backup information shall show the moisture-density curve with associated maximum dry density, wet density and optimum moisture content, details of cementitious materials, 3-day, 7-day and 28-day, or 42-day compressive strengths, including strength gain curve for the proposed mix. The mix design shall identify the quantity and gradation of aggregates, the optimum moisture content, and the amount of Portland cement, other cementitious material(s) and the total cementitious materials required per cubic yard of the concrete. The mix design shall specify the proportions of each material (aggregate, cement, water, and admixtures) in the mix in terms of pounds per cubic yard based on saturated surface dry weights. Any changes to the mix design shall be approved by the *Engineer*. Should a change in material source be proposed, the *Engineer* must approve a new mix design.

Proportioning of *RCC* shall be performed in general compliance and in the sequence recommended by ACI 327R-14, Chapter 6 "Mixture Proportioning."

313.03.04.02 Field Evaluation of Production Mix. The proposed production mix shall be evaluated by field testing using the production equipment, batching and mixing procedures. *RCC* shall be sampled and tested for compressive strength at 3, 7, 28, and 42 days, 5 cylinders per each age of testing. For *RCC* paving on Hickory, sample testing shall also be completed at 1 and 2 days. In order to be qualified the mix shall demonstrate the average compressive strength at the final specification age exceeding the minimum required one by at least 750 psi. No individual cylinder shall demonstrate strength exceeding the minimum specified one by less than 650 psi. Aggregates shall be tested for content of free moisture by direct moisture evaporation. Batch weights of materials shall meet the tolerances specified in ASTM C94 or C685, depending on the method of production. Aggregates shall be also sampled and tested for compliance with gradation and cleanliness requirements of these specifications.

313.03.05 RCC PRODUCTION AND DELIVERY.

313.03.05.01 Storage of Materials. Portland cement and supplementary cementing materials shall be stored in weather tight bins or silos that protect them from dampness and contamination and provide easy access for inspection and identification of each shipment. *RCC* supplier shall assure that properties of materials will not change during storage and handling operations.

The supplier is required to have separate stockpiles (bunkers) for different aggregate sizes, which should be arranged in a manner preventing intermixing of different aggregate sizes, and their contamination by foreign materials. If stockpiles are located immediately next to each other, they have to be physically separated. Stockpiles shall be arranged on hardened surfaces.

Procedure for forming stockpiles shall preclude segregation of aggregates (Reference: Recommendations for forming stockpiles, excluding segregation of aggregates, are provided in ACI 304).

For temperature adjustment during hot weather periods of time, stockpiles for coarse aggregates are recommended to be shaded and provided with water sprinklers.

Silos for hydraulic cements and supplementary cementitious materials should be completely weather-tight. Chemical admixtures shall be stored and handled in a manner protecting them from contamination.

313.03.05.02 Batching, Mixing and Transporting of *RCC*. The *Engineer* shall approve the mixing plant before the *Contractor* begins producing *RCC*. The mixing plant shall follow ACI 327R-14.

The plant shall be capable of producing an *RCC* mixture in the proportions defined by the final approved mix design and within the specified tolerances. The capacity of the plant shall be sufficient to produce a uniform mixture at a rate compatible with the placement equipment. The minimum homogeneous production rate of any acceptable plant shall be 300 tons per hour. For batch mixers, the volume of *RCC* material in the mixing chamber shall not be more than the rated capacity for dry concrete mixtures. Multiple plants shall not be used to supply *RCC* material to the paver. The *Engineer* can halt operations if the plant is unable to produce the *RCC* mixture sufficiently in quality or quantity, until a plant meeting all requirements is obtained.

A pugmill plant is required and shall match that listed during the prequalification process unless a substitution is made which meets these specifications and is approved by the *Engineer*. It shall be a central plant with a twin shaft pugmill mixer, capable of batch or continuous mixing, equipped with synchronized metering devices and feeders to maintain the correct proportions of aggregate, cement, mineral admixture, and water. Other pugmill plant requirements are as follows:

Aggregate Storage. The aggregate and sand must be furnished in 2 or more stockpiles. If previously blended aggregate is furnished, storage may be in a stockpile from which it is fed directly to a conveyor feeding the mixer. If aggregate is furnished in two or more size groups, aggregate separation must be provided at the stockpiles.

Aggregate Bin. Aggregate bins shall have a feed rate controlled by a variable speed belt, or an operable gate calibrated to accurately deliver any specified quantity of material. If two or more aggregate size stockpile sources are used, the feed rate from each bin shall be readily adjustable to change aggregate proportions, when required. Feed rate controls must maintain the established proportions of aggregate from each stockpile bin when the combined aggregate delivery is increased or decreased.

Plant Scales. Plant scales for any weigh box or hopper shall be either of beam or springless-dial type, and be sensitive to 0.5 percent of the maximum load required. Beam-type scales shall have a separate beam for each aggregate size, with a single telltale actuated for each beam, and a tare beam for balancing hopper. Belt scales shall be of an approved design. Standard test weights accurate to plus or minus 0.1 percent shall be provided for checking plant scales.

Cement and Mineral Admixture Material Storage. Separate and independent storage silos shall be used for Portland cement and mineral admixture. Each silo must be clearly identified to avoid confusion during silo loadings. If the *Contractor* chooses to preblend the cementations material he must employ blending equipment acceptable to the *Engineer* and demonstrate, with a testing plan, the ability to successfully produce a uniform blended material meeting the mix design requirements. Testing of the preblended cementations material shall be done on a daily basis to assure both uniformity and proper quantities.

Cement and Mineral Admixture Feed Unit. Satisfactory means of dispensing Portland cement and mineral admixture, volumetrically or by weight, shall be provided to assure a uniform and accurate quantity of cementations material enters the mixer.

Water Control Unit. The required amount of water for the approved mix shall be measured by weight or volume. The unit shall be equipped with an accurate metering device. The water flow shall be controlled by a meter, valve or other approved regulating device to maintain uniform moisture content in the mixture.

Surge Hopper. For continuous operating pugmills, a surge hopper attached to the end of the final discharge belt shall be provided to temporarily hold the *RCC* discharge to allow the plant to operate continuously. No other stockpiling shall be permitted. For batch mixers, discharge all material in the mixing chamber before recharging.

Alternative Mixing Equipment. Other types of batching and mixing equipment and configurations other than twin shaft pugmill mixers may not be used. This includes but is not limited to dry batch plants, central mix tilt drum plants, ready mix truck mixers, volumetric concrete trucks and trailers.

The mixing time shall be pre-established by uniformity studies conducted, as provided in ACI 327R-14, Section 8.2 "Roller-compacted concrete mixing plants."

Locate the mixing plant within 30 minutes hauling time from the construction site, when non-agitating vehicles are used for delivery. The supplier may request a longer hauling time not exceeding 60 minutes, provided the documentation is submitted evidencing that properties of fresh *RCC* are suitable and allow for convenient and proper placement and consolidation.

Prior to commencement of *RCC* production, the *Contractor* shall carry out a complete and comprehensive calibration of the plant in accordance with the manufacturer's recommended practice. All scales, containers and other items necessary to complete the calibration shall be provided by the *Contractor*. After completion of the initial calibration, the plant shall be recalibrated as directed by the *Engineer*.

The transportation of the *RCC* to the areas to be paved, with the exception of concrete mixed in truck mixers, shall be in dump trucks fitted and equipped, when necessary, with retractable protective covers for protection from rain or excessive evaporation. The trucks shall be dumped clean with no buildup or hanging of *RCC* material. The dump trucks shall deposit the *RCC* material directly into the hopper of the paver or into a secondary material distribution system which deposits the material into the paver hopper. Dump truck delivery must be scheduled so that *RCC* material is spread and compacted within the specified time limits. Access routes shall be clearly marked over the area to be constructed. Haul time should not exceed 20 minutes without addition of admixtures which have proven to successfully maintain moisture content levels in *RCC*.

313.03.05.03 General Requirements. Method of production of *RCC* shall assure that concrete proportions comply with the design quantities of ingredients, as provided by the approved statement of concrete mix design, and that concrete is mixed uniformly. For central batch plants mixing time shall be established by uniformity testing per the procedure provided in *ASTM C94*.

313.03.05.04 Accuracy of Batching, Tolerances. Accuracy of batching (namely weights of cementing materials and aggregates, weight or volume of water, and volumes of liquid chemical admixtures) comply with tolerances specified in *ASTM C94* or *C685*, as applicable.

The *Contractor* shall supply daily plant records of production and quantities of materials used that day to the *Engineer*.

313.03.05.05 Change of Material Source. If the type or source of cementing materials, or aggregates, or type of chemical admixtures changes, the production of *RCC* must be suspended, and a new mix design shall be developed, tested, and submitted for approval.

313.03.05.06 Pavement Test Section. Construct a 150-foot long test section prior to starting construction. Construct the test section using the proposed mixture design, the staff that will be completing the work, and the materials and equipment that are listed in the pavement construction plan and approved by the *Engineer*. If the pavement placement requires more than one pass of the paver, construct the test section a minimum of two paver widths wide. If the pavement placement requires more than one lift, construct the test section to the required number of lifts. If the pavement placement requires more than one day of paving or longitudinal cold joints, construct the test section over two days and begin paving from a longitudinal cold joint on the second day. Place the test section in a location approved by the *Engineer*. The test section will not be incorporated into the final project.

The *Engineer* shall evaluate the following criteria from the test section:

- A. Adequacy of the production method and equipment to meet productivity requirements and produce uniform *RCC*.
- B. Maximum density directly behind the paver prior to roller compaction.
- C. Suitability of the proposed lift thickness.
- D. Sequence of primary/secondary roller passes (with and without vibration).
- E. Maximum density following roller compaction.
- F. Texture and surface finish acceptability.
- G. Integrity of both fresh and cold joints (vertical and horizontal).
- H. Compressive strength of *RCC* based on molded cylinders and extracted cores tested at 3-days, 7-days, and 28-days.
- I. Procedures for troweling and finishing *RCC* surface to meet specification.
- J. Process for applying curing compound at appropriate rate and coverage.
- K. Process for installing saw cuts in pavement.

Construction (Cold) Joint Edges. The *Contractor* shall establish the maximum angle for edges to be used in joint faces of construction (cold) joints.

If the test area does not meet acceptance requirements, the *Contractor* shall remove and reconstruct a new test section with corrected procedures at no additional cost to the City. The *Contractor* will be required to provide new test sections, for which no additional compensation will be allowed, until an acceptable, reproducible test section is achieved.

313.03.05.07 Placement.

Condition of the Subgrade/Subbase. Prior to *RCC* placement, the surface of the subgrade/subbase shall be clean and free of foreign material, ponded water and frost prior to the placement of the *RCC* pavement mixture. The subgrade/subbase must be uniformly moist at the time of *RCC* placement. If sprinkling of water is required to remoisten certain areas, the method of sprinkling shall not be such that it forms mud or pools of free-standing water. Prior to placement of *RCC*, the subgrade/subbase shall be checked for proper density and soft or yielding areas and these areas shall be corrected per these specifications.

Jointing Plan. Prior to placement of the *RCC*, joint locations shall be marked by the *Contractor* in the field to insure cold joints will align with the jointing plan. Following *RCC* placement, and before sawcutting the joints, the jointing plan shall be marked on the *RCC* by the *Contractor* with a temporary marking material to demonstrate to the *Engineer* that the sawcuts are being placed per the plan.

Paver Requirements. *RCC* shall be placed with an approved paver as noted in these specifications and shall meet the following requirements:

The quantity of *RCC* material in the paver shall not be allowed to approach empty between loads. The material shall be maintained above the auger shaft at all times during paving.

The paver shall operate in a manner that will prevent segregation and produce a smooth continuous surface without tearing, pulling or shoving. The spread of the *RCC* shall be limited to a length that can be compacted and finished within the appropriate time limit under the prevailing air temperature, wind, and climatic conditions.

The paver shall proceed in a steady, continuous manner. Paver speed during placement operations shall not exceed the speed necessary to ensure that minimum density requirements are met and surface distress is minimized.

The surface of the *RCC* pavement once it leaves the paver shall be smooth, uniform and continuous without excessive tears, ridges or aggregate segregation.

Lift Thickness. Place *RCC* in lifts between 4 inches and 9 inches thick. Multiple lifts are not allowed for pavements less than 9 inches thick. For multiple lift placements, compact the bottom layer to the minimum specified wet density before placing the next lift. No lift shall be less than 4 inches.

Adjacent Lane Placement. All longitudinal joints must be considered a cold joint and shall be prepared in accordance with "Cold Vertical Joints" section found elsewhere in these specifications. Fresh joints will only be allowed under special circumstances at the *Engineer's* discretion. In that case, the adjacent paving lane shall be placed within 30 minutes and additional precautions may be necessary to avoid excessive moisture loss at the joint such as the use of set retarding admixtures, water misting, and blankets.

Hand Spreading. Broadcasting or fanning the *RCC* material across areas being compacted shall not be permitted. Additions of material may only be done immediately behind the paver and before any compaction has taken place. Any segregated coarse aggregate shall be removed from the surface before rolling.

Segregation. If segregation occurs in the *RCC* during paving, operations shall cease until the cause is determined and corrected.

Placement. *RCC* placement shall be done in a pattern so that the curing water from the previous placements will not pose a runoff problem on the fresh *RCC* surface or on the subbase layer.

Paving Inaccessible Areas. Areas inaccessible to either paver or roller shall be placed with cast-in-place concrete with a minimum compressive strength of 4,000 psi or as specified by the *Engineer*. In areas that may be subjected to high load transfer, the *Engineer* may require the cast-in-place concrete to be doweled into the *RCC*.

Expansion Joints. Expansion Joints shall be placed at all longitudinal cold joints, where concrete pavements abut asphalt concrete pavements, and at intersections of concrete pavement streets.

313.03.05.08 Compaction.

Compaction shall begin immediately behind the placement process and shall be completed within 60 minutes of the start of mixing cementing materials with water. The time may be increased or decreased at the discretion of the *Engineer* depending on use of set controlling admixtures, initial concrete temperature, and/or ambient weather conditions (temperature, wind velocity and humidity).

Rolling. Apply the sequence and number of passes by vibratory and non-vibratory rolling to obtain the specified density proposed in the paving construction plan and verified during construction of the test section. Do not run rollers on adjacent *RCC* that was placed less than 7-days prior. Do not operate rollers in the vibratory mode while stopped. Use steel drum rollers in static mode and/or rubber-tire rollers for final compaction.

Rolling Longitudinal and Transverse Joints. If a cold joint is planned, the complete lane shall be rolled and cold joint procedures shall be followed per these specifications. If the *Engineer* approves fresh joint construction, the roller shall not operate within 24 inches of the edge of a freshly placed lane until the adjacent lane is placed. Then both edges of the two lanes shall be rolled together within the allowable time.

Longitudinal joints shall be given additional rolling as necessary to produce the specified density for the full depth of the lift in order to achieve a tight smooth transition across the joint. Any uneven marks left by vibrating rolling shall be smoothed out by non-vibrating or rubber tire rolling. The surface shall be rolled until a relatively smooth, flat surface, reasonably free of tearing and cracking is obtained. For freshly placed *RCC* next to an existing cold joint, roll the complete lane, taking extreme care not to bridge the roller drum between the new unconsolidated fresh material and a previous cold joint edge. Such bridging of roller drum over cold joint edges, especially in vibratory mode, can significantly degrade the cold joint edge.

Speed. Speed of the rollers shall be slow enough at all times to avoid displacement of the *RCC* pavement. Displacement of the surface resulting from reversing or turning action of the roller shall be corrected immediately.

Tight Space Compaction. Compact areas inaccessible to large rollers with small drum rollers, walk-behind vibratory rollers or plate tampers. Cast-in-place, conventional concrete meeting the same strength requirements as specified for *RCC* may be used in these areas as a replacement for *RCC*.

313.03.05.09 Formation of Joints.

Fresh Vertical Joints. Fresh longitudinal joints will only be allowed under special circumstances under the approval of the *Engineer*. A vertical joint shall be considered a fresh joint when an adjacent *RCC* lane is placed within 30 minutes of the batch time of the previous lane. This time may be reduced depending on ambient conditions, as well additional precautions may be necessary to avoid excessive moisture loss at the joint such as the use of evaporation retarders, fogging, and curing mats.

Fresh longitudinal joints shall be constructed prior to placement of an adjacent lane by leaving the outer 24 inches of the freshly placed lane uncompacted during rolling. Then both edges of the two lanes shall be rolled together within the allowable time.

Adjacent lanes shall be placed such that the new lane abuts tightly against the incomplete edge of the prior lane.

The joint formed by both lanes shall be compacted by centering the roller drum over the joint and compacting both edges simultaneously.

Extra passes of the roller may be required at the joint to achieve the required density.

Cold Vertical Joints. Any planned or unplanned construction joints that do not qualify as fresh joints shall be considered cold joints and shall be treated as follows:

Longitudinal and Transverse Cold Joints. Formed joints that do not meet the minimum density requirements and all unformed joints shall be cut vertically for the full depth or produced using an edging shoe. The vertical cut shall be at least 6 inches from the exposed edge and located on a joint identified on the jointing plan. Do not perform this operation any sooner than 2 hours after final compaction. Demonstrate to the *Engineer* that saw cutting will not cause significant edge raveling and remove all slurry and excess material from the cutting operation.

If the *Contractor* can demonstrate that he can construct a cold vertical joint that can meet the minimum joint density requirements using an "edge shoe," then the use of the edge shoe in lieu of cutting a cold vertical joint is allowed. The edge shoe should be as close to vertical as possible with the maximum allowable positive edge angle being of 10 degrees from vertical.

Cold joints cut after two hours of placement shall be saw-cut 1/4 to 1/3 depth of the *RCC* pavement with the rest removed by hand or mechanical equipment. Any modification or substitution of the saw cutting procedure must be demonstrated to and accepted by the *Engineer*. All excess material from the joint cutting shall be removed.

Prior to placing fresh *RCC* mixture against a compacted cold vertical joint, the joint shall be thoroughly cleaned of any loose or foreign material. The vertical joint face shall be wetted and in a moist condition immediately prior to placement of the adjacent lane.

Uneven surfaces or slopes greater than as determined for "Cold Joint Edges" shall be cut vertically for the full depth of the *RCC*.

The rollers shall pass over the end of the freshly placed *RCC* mixture when a vertical cold joint is to be made. Unless the *RCC* cold joint has been formed by an edging shoe, the edge of the previously placed *RCC* pavement shall be cut back to expose an even vertical surface for the full thickness of the course without disturbance of the *RCC* that is to remain in place. Uneven areas and raveling shall be corrected.

The top layer shall be placed so that longitudinal joints in that layer will coincide with joints in the lower layers of the pavement. Transverse joints in the top layer shall coincide with transverse joints in the lower layers of the pavement.

Place expansion joint at all transverse cold joints.

Fresh Horizontal Joints. For multi-layer construction, a horizontal joint shall be considered a fresh joint when a subsequent *RCC* lift is placed within 30 minutes of the batch time of the previous lift. This time may be adjusted at the discretion of the *Engineer* depending on use of retarders or ambient weather conditions. Fresh joints do not require special treatment other than cleaning the surface of all loose material and moistening the surface prior to placement of the subsequent lift.

Horizontal Cold Lift Joints. For horizontal cold joints the surface of the lift shall be kept continuously moist and cleaned of all loose material prior to placement of the subsequent lift. The use of a cement slurry or mortar grout between lifts is required. If supplementary bonding materials are used, they shall be applied immediately prior to placement of the subsequent lift.

RCC Pavement Joints at Structures. The joints between *RCC* pavement and concrete structures shall be treated as isolation vertical joints.

Control Joints. Control joints shall be constructed in the *RCC* pavement to induce cracking at pre-selected locations. Joint locations shall be as shown on the Plans or as directed by the *Engineer*. Early entry saws shall be utilized as soon as possible behind the rolling operation and set to manufacturer's recommendations. Saw crack control joints to the interval specified on the plans. The depth of the crack control joints shall be equal to 1/3 of the thickness of *RCC* pavement. The width of the crack control joints shall be 1/8". Extend all crack control joints the entire width of paving. When sawing crack

control joints, begin as soon as the *RCC* cuts without excessive raveling along the saw cut and finish before conditions induce uncontrolled cracking, regardless of the time or weather. Control joints shall be sprayed with curing compound or water depending on the curing method.

Isolation Joints. Line the perimeter of fixed structures such as manholes, valves, trench drains, and with strips of fiberboard or other approved isolation joint material, as noted in the plan details, prior to paving. Joint filler for isolation joints must be preformed expansion joint filler for concrete (bituminous type) in compliance with *ASTM D 994*.

Expansion Joints. Install expansion joints to the details, dimensions and locations shown on the Plans. If the plans do not include details and conditions warrant expansion joints, propose a plan and install expansion joints in the pavement, with approval of the *Engineer*. Include width, filler, sealing material, location and/or spacing recommendations in the expansion joint plan, considering thermal effects, regional climatic conditions, *RCC* coefficient of thermal expansion and expected daily temperature ranges at the time of placement.

313.03.05.10 Finishing. Where indicated on the plans and as directed by the *Engineer*, the *RCC* pavement shall be troweled and broom finished.

Use self-propelled machine trowels.

Determine the number of machine trowels required to perform the work at a rate equal to the concrete delivery rate. When the time from concrete placement to machine trowels finishing exceeds 30 minutes, stop concrete delivery. When machine trowels are in proper position, you may resume concrete delivery and paving.

Trowels must be equipped with devices that adjust the underside to a true flat surface.

Perform texturing with a broom device that produces striations parallel to the centerline.

313.03.06 CURING.

313.03.06.01 General. Immediately after final rolling, compaction testing, and finishing use an approved curing method outlined below. Water cure or curing compound shall be applied vertically from above the pavement. Application shall not be allowed from the side of the pavement. During this work the *Contractor* shall control the work such that it does not result in visible water or curing compound particulate migration. Reapply curing compound to sawcuts and disturbed areas.

313.03.07 ACCEPTANCE.

313.03.07.01 Thickness Requirements. Determine the pavement thickness from cores by average caliper measurements in accordance with *ASTM C174*. Extract one core for each lot of *RCC* pavement per Table *RCC-1*. For pavement placement units consisting of less than one lot of *RCC* pavement, include the pavement with the previous or next placement unit.

As an option, use alternative or additional thickness determination methods to satisfy the requirements of Table *RCC-1*, with the *Engineer's* approval. Such alternate thickness determination procedures can include surveying, GPS devices, and/or LIDAR.

Mitigation. A pay adjustment will be considered for *RCC* pavement that does not fully meet the specification for thickness and surface texture. These adjustments will be applied to each area of proposed pavement. Limits of area subject to pay factor to be determined by the *Engineer*. *Contractor* shall be responsible for taking additional samples to assist the *Engineer* in determination of limits of deficient area. If a core is found to be deficient in thickness, two additional cores shall be taken at the *Contractor's* expense to determine the extent of the deficiency. Limits of deficient areas are to be determined by the *Agency or Owner*.

Inches	Payment %
0.00 to 0.24	100
0.25 to 0.49	90
0.50 or greater	Remove and replace

313.03.07.02 Density Requirements.

In-Place Wet Mat Density Determination. Determine the in-place wet mat density on pavement that is at least 24 inches from any joint in accordance with ASTM C1040 direct transmission mode at 75% of total RCC pavement depth for each lot of RCC pavement per Table RCC-1. For pavement placement units consisting of less than one lot of RCC pavement, include the pavement with the previous or next placement unit.

Table RCC-1

Item	Method	Frequency/Lot Size	Acceptance
RCC Moisture Content	ASTM C566	Sample at mixing plant or point of placement from initial truck load and as required	±1.0% of optimum moisture content per ASTM D1557
In-place Wet Mat Density	ASTM C1040 direct transmission mode	At beginning of placement immediately behind the paver and within 30 minutes of final compaction; One Test per lot	At least 98% of the maximum laboratory wet density by ASTM D1557 based on an average of four consecutive tests with no test below 96%
In-place Wet Joint Density	ASTM C1040 direct transmission mode	One Test per lot and within 30 minutes after final compaction	At least 96% of the maximum laboratory wet density by ASTM D1557 based on an average of four consecutive tests with no test below 94%
Cylinders for Compressive Strength	ASTM C1435 for molding cylinders ¹⁷ ; ASTM C31 for curing and handling cylinders; and ASTM C39 for testing cylinders	One set of three cylinders for every for every lot of paving, or one day of production, whichever is less.	Average strength equal to 100% of the specified strength per these specifications, no single result below 90%.
Surface Smoothness	See Acceptance Criteria	One Test per lot	See Acceptance Criteria
Thickness	ASTM C42	One core for every two lots, or one day of production, whichever is less.	See Acceptance Criteria

In-Place Wet Joint Density Determination. Determine the in-place wet joint density on joints at a distance 12 inches or greater for free edge and 6 inches or greater for a confined edge in accordance with ASTM C1040 direct transmission mode for each lot of RCC pavement per Table RCC-1. For pavement placement units consisting of less than one lot of RCC pavement, include the pavement with the previous or next placement unit.

Mitigation. For in-place wet mat density and in-place wet joint density, full payment will be made for pavement based on the acceptance criteria in Table RCC-1. Pavement lots that have density that is less than the required density are subject to further evaluation. Take an additional test within a 5 to 8 foot radius, of the original test (within the same placement unit). If this test is below the acceptance criteria in Table RCC-1, additional roller passes shall be made across the full lane width between the last testing location that produced an acceptable reading and the paver. If the additional roller passes do not correct the problem, or causes the density to decrease, the paving operation shall be discontinued until corrections can be made to assure that the specified density can be achieved.

313.03.07.03 Strength Requirements.

Strength Determination. Determine the compressive strength for cylinders prepared in accordance and for each lot of RCC pavement per Table RCC-1. For pavement placement units consisting of less than one lot of RCC pavement, include the pavement with the previous or next placement unit.

Mitigation. Full payment will be made for cylinders meeting the requirements of the mix design, whose average strength equal to 100% of the specified strength, with no single result below 90%.

Pavement lots that have strength that are less than the required strength are subject to further evaluation.

Extract three cores at random locations in the suspect area after the *RCC* pavement is at least 28 days old. Remove, handle and test the compressive strength of the three cores according to *ASTM C42*.

Determine the average and standard deviation of the compressive strength of the three cores. If the average of the three cores exceeds 85% of the minimum specified compressive strength, the *RCC* in the subplot is acceptable and is subject to full payment and acceptance. If the average strength of the three cores is less than 85% of the specified compressive strength, the *RCC* is not acceptable and requires removal.

Removal and Replacement. Areas determined to have strength deficiencies that are not resolved through referee testing, as noted above, require removal and replacement. After the referee period or at least seven days, remove the hardened *RCC* material by full depth saw cutting the perimeter of the deficient area along joint lines. Repair the area using an air-entrained cast-in-place concrete meeting the strength requirements per these *Specifications* or as directed by the *Engineer*. The new concrete shall be doweled into the existing *RCC* layer using dowel bars or as directed by the *Engineer*.

313.03.07.04 Surface.

Smoothness for *RCC* Pavements. The *RCC* pavement shall conform to the concrete pavement smoothness approved by the *Engineer*.

Mitigation. When the surface smoothness is outside the specified surface tolerance the *Contractor* shall grind the surface to within the tolerance by use of self-propelled diamond grinders, provided grinding does not create deviation from other tolerances. Milling of the final surface is not acceptable, unless it is for the removal of the pavement. After correction, verify the corrective work by measuring the smoothness as noted in the above section.

Surface Texture. The final surface texture after rolling and curing shall be smooth and uniform over the entire area of pavement and will reasonably match the surface condition of the test strip. The surface area shall be free of rips, bird baths, areas of loose aggregate, surface pitting, voids or indentation, pockmarks, surface tears greater than 1/4" inch depth and ¼ inch width, check cracking, segregation or rock pockets, pumped areas, aggregate drag marks, and areas where fines have been washed away during the curing process.

Mitigation. Correct surface texture deficiencies using an approved grinding device, or removal and replacement.

314.01 GENERAL.

314.01.01 DESCRIPTION. This Section covers the production, provision, preparation for placement, and placement of *PCCP*.

Any Subsection designations which are omitted within this Section shall be interpreted to be intentionally left blank. *PCCP* shall conform to the applicable Subsections of Section 314 – “Portland Cement Concrete Pavement (PCCP)”, unless modified herein.

314.01.02 DESIGN.**314.01.02.01 PCC.****Composition of Mixtures.**

Specified Strength. To ensure that the *PCC* produced will meet or exceed the acceptance criteria for the specified strength; the mix design average strength must be higher than the specified strength. The amount of the overdesign necessary to meet specification requirements depends on the producer’s standard deviation of flexural test results and the accuracy which that value can be estimated from historic data for the same or similar materials.

314.02 MATERIALS.**314.02.01 Material Storage.**

314.02.01.01 Lubricants. Lubricant shall be stored at a temperature between 50 °F and 80 °F, and shall be used within 270 *Calendar Days* after date of manufacture.

314.02.02 AGGREGATES. Aggregates shall conform to Subsection 200.06 – “Aggregates for *Specific Use Portland Cement Concrete*”

314.02.03 CURING MATERIALS. Curing materials shall conform to Subsection 202.03.05.04– “*PCCP*”.

314.02.04 REINFORCING STEEL. Reinforcing steel shall be deformed steel bars conforming to Subsection 206.03.01 – “Bar Steel Reinforcement”.

314.02.05 DOWEL BARS. Dowel bars shall be plain steel bars conforming to *ASTM A615*, *ASTM A616*, or *A617*, and shall be free from burring or other deformation restricting slippage in the concrete. High strength dowel bars shall conform to *ASTM A714*, Class 2, Type S Grade I, II, or III, Bare Finish, XS. Before delivery to the construction site, each dowel bar shall be epoxy-coated. Coated dowels shall conform to *AASHTO M 254*.

314.02.06 TIE BARS. Tie bars shall be deformed steel bars conforming to the *ASTM A 615*, *ASTM A616*, or *ASTM A617*, except that rail steel bars, Grade 50 and 60, shall not be used for tie bars that are to be bent or re-straightened during construction. Tie bars designated as Grade 40 in *ASTM A615* can be used for construction requiring bent bars.

314.02.07 EPOXY RESIN. Epoxy-resin used to anchor dowels and tie bars in *PCCP* shall conform to *ASTM C881*, Type I, Grade 3, Class C. Class A or B shall be used when the surface temperature of the hardened *PCCP* is below 60 °F.

314.02.08 JOINT SEALER. Joint filler shall conform to Subsection 202.03.03.03 – “Cold Applied Joint Materials”.

314.03 CONSTRUCTION.**314.03.01 CONSTRUCTION EQUIPMENT.**

314.03.01.01 Spreading. *PCC* shall be spread, screeded, shaped and consolidated by one or more self-propelled machines. These machines shall perform in a manner so that the completed pavement will conform to the required cross section with a minimum of handwork.

314.03.01.02 Pump Trucks. The end of the boom on the pump truck shall have a device to prevent *PCC* from falling at the highest point of the boom.

314.03.02 PLACING OF MATERIALS.**314.03.02.01 Forms.**

The forms and/or the underlying surface shall be sprinkled with water immediately before placing the *PCC*.

314.03.02.02 Joint Devices. All joint devices shall be approved by the *Engineer*. The top of an assembled joint device shall be set at the proper distance below the pavement surface and the elevation shall be confirmed. The devices shall be set to the required position and line and shall be securely held in place by stakes or other means to the maximum permissible tolerances during the placing and finishing of the *PCC*.

Premolded Joint Filler. Premolded joint filler for each joint shall be furnished in a single piece for the full depth and width required for the joint, unless otherwise directed or approved by the *Engineer*. When the use of more than one piece is required for a joint, the abutting ends shall be fastened securely and held accurately to shape by stapling or other positive fastening means satisfactory to the *Engineer*.

Premolded joint material shall be placed and held in a vertical position; if constructed in sections, there shall be no offsets between adjacent units. Premolded joint filler shall be securely fastened via large washer and nail or other approved means, to adjacent hardened PCCP panel prior to pouring fresh PCCP.

The *Contractor* shall ensure that the installation of joint devices has been accepted by the *Engineer* prior to placing the *PCC*.

314.03.02.03 Dowel Bar Placement. Dowel bars or other load-transfer units of an approved type shall be placed across joints in the manner as shown on the plans. They shall be of the dimensions and spacing as shown on the *Plans* and held rigidly in the middle of the slab depth in the proper horizontal and vertical alignment by an approved assembly device to be left permanently in place. The dowel or load-transfer and joint devices shall be rigid enough to permit complete assembly as a unit ready to be lifted and placed into position. A lubrication bond breaker shall be provided for the epoxy-coated steel dowels except when approved pullout tests indicate it is not necessary. Where butt-type joints with dowels are designated, the exposed end of the dowel shall be oiled.

The *Contractor* shall submit the proposed method of using wire basket supports including shop drawings with proposed method of anchoring the baskets for acceptance by the *Engineer* prior to placement. The proposed method of establishing the assembly locations on the subgrade shall be submitted for acceptance as well.

The sleeves for dowel bars used in isolation joints shall be metal or other type of and approved design to cover 2 to 3 inches of the dowel, with a closed end and with a suitable stop to hold the end of the bar at least 1 inch from the closed end of the sleeve. Sleeves shall be of such design that they will not collapse during construction.

The position and alignment of the dowel bars and assemblies shall be confirmed by the *Engineer*. During the *PCC* placement operation, placement of plastic *PCC* directly on dowel assemblies immediately prior to passage of the paver will maintain dowel position and alignment within maximum permissible tolerances.

Dowel bar assemblies are not allowed in construction joints. The *PCC* shall be struck flush and dowels/tie bars shall be placed into holes drilled into the hardened *PCC*. Holes approximately 1/8 inch to 1/4 inch greater in diameter than the dowel or tie bar shall be drilled with rotary-type core drills that must be held securely in place to drill perpendicularly into the vertical face of the pavement slab. Rotary-type percussion drills may be used provided that spalling of concrete does not occur. Any damage of the *PCC* shall be repaired by the *Contractor* in a method approved by the *Engineer*. Dowels or tie bars shall be bonded in the drilled holes using an epoxy resin material. Installation procedures shall be adequate to ensure that the area around dowels is completely filled with epoxy grout. Drilled holes shall be cleaned with oil-free compressed air. Epoxy shall be injected into the back of the hole and displaced by the insertion of the dowel bar. Bars shall be completely inserted into the hole and shall not be withdrawn and reinserted creating air pockets in the epoxy around the bar. The *Contractor* shall furnish a template for checking the position and alignment of the dowels.

314.03.02.04 PCC.

Limitations on Mixing and Placing. PCC shall not be mixed, placed, or finished when the natural light is insufficient, unless an adequate and approved artificial lighting system is operated. All PCC shall be placed at times that ensure sawing is completed on the same day of placement.

Finishing. The surface of the pavement shall be finished with a broom, burlap drag or artificial turf finish as shown on the *Plans* or specified in the *Special Provisions* and/or *Special Technical Specifications*.

Brush or Broom Finish. If the pavement surface texture is to be a type of brush or broom finish, it shall be applied when the water sheen has practically disappeared. The equipment shall operate transversely across the pavement surface, providing corrugations that are uniform in appearance and approximately 1/16 of an inch in depth. It is important that the texturing equipment not tear or unduly roughen the pavement surface during the operation. Any imperfections resulting from the texturing operation shall be corrected.

Burlap Drag Finish. If a burlap drag is used to texture the pavement surface, it shall be at least 15 ounces per square yard. To obtain a textured surface, the transverse threads of the burlap shall be removed approximately 1 foot from the trailing edge. A heavy building of grout on the burlap threads produces the desired wide sweeping longitudinal striations of the pavement surface. The corrugations shall be uniform in appearance and approximately 1/16 of an inch in depth.

Artificial Turf Finish. If artificial turf is used to texture the surface, it shall be applied by dragging the surface of the pavement in the direction of concrete placement with an approved full-width drag made with artificial turf. The leading transverse edge of the artificial turf drag will be securely fastened to a lightweight pole on a traveling bridge. At least 2 feet of the artificial turf shall be in contact with the concrete surface during dragging operations. A variety of different types of artificial turf are available and approval of any one type will be done only after it has been demonstrated by the Contractor to provide a satisfactory texture. The corrugations shall be uniform in appearance and approximately 1/16 of an inch in depth.

Tining. If tining is used to texture the surface, it shall be performed in accordance with the applicable requirements of Section 409.03.11 "Finishing" of the *Silver Book*.

Protection of Fresh Surface. The finished surfaces of the freshly placed PCC shall be kept damp by applying a water-fog or mist with approved spraying equipment until the pavement is covered by the curing medium. If necessary, wind screens shall be provided to protect the concrete from an evaporation rate in excess of 0.15 PSF per hour as determined in accordance with Figure 2.1.5 in ACI 305R, Hot Weather Concreting, which takes into consideration relative humidity, wind velocity, and air temperature.

When conditions are such that problems with plastic cracking can be expected, and particularly if any plastic cracking begins to occur, the Contractor shall immediately take such additional measures as necessary to protect the pavement surface. Such measures shall consist of wind screens, more effective fog sprays, and similar measures commencing immediately behind the paver. If these measures are not effective in preventing plastic cracking, paving operations shall be immediately stopped.

Curing. Curing shall be accomplished immediately after the final finishing operation. The PCC shall not be left exposed for more than 30 minutes during the curing period. The use of fly ash or set retarding admixtures can delay the occurrence of bleed water. Curing should be applied after bleed water is gone from the surface. Curing materials shall be applied in accordance with Table 314.03.02.04-I.

314.03.02.04-I Curing Requirements

Evaporation Rate (lbs/ft ² /hr) ⁽¹⁾	Curing Requirement
less than 0.2	Single coat membrane.
0.2 - 0.4	Two coat membrane.
0.4 - 0.6	Continuous water fogging until cotton mats are applied and maintained wet.
greater than 0.6	Paving operations shall be terminated or not be initiated if conditions are anticipated.

1. Figure 2.1.5 from ACI 305R, "Hot Weather Concreting", shall be used in determining the Evaporation Rate regardless of ambient temperature.

314.03.02.05 Joints.

Sawing. Joint sawing shall be accomplished as soon as the pavement can support the sawing equipment to permit cutting without chipping, spalling, or tearing and before uncontrolled shrinkage cracking of the pavement occurs. Sawing shall be carried on until completion at the required spacing, consecutively in sequence of the PCC placement. If an insert material is used, the installation and edge finish shall be according to the manufacturer's instructions. The groove shall be finished or cut clean so that spalling will be avoided at intersections with other joints. Sawing shall produce a slot at least .01 feet wide, but not to exceed .02 feet wide and to the depth shown on the plans.

Construction Joints.

Longitudinal. Longitudinal construction joints shall be slip-formed or formed against side forms as shown on the joint layout plans.

Transverse. Transverse construction joints shall be installed at the end of each day's placing operations and at any other points within a paving lane when concrete placement is interrupted for more than 30 minutes or it appears that the concrete will obtain its initial set before fresh concrete arrives. The installation of the joint shall be located at a planned contraction or expansion joint. If placing of the concrete is stopped, the Contractor shall remove the excess concrete back to the previous planned joint.

314.03.02.06 Joint Sealing. Joints shall be sealed as soon after completion of sawing and before the pavement is opened to traffic, including construction equipment. The pavement temperature shall be above 40° F at the time of installation of the preformed joint seal.

Immediately before sealing, the joints shall be thoroughly cleaned of all laitance, curing compound, and other foreign material. Cleaning shall be accomplished by sandblasting, wire brushing, or high pressure water blast. Upon completion of cleaning, the joints shall be blown out with compressed air. The joint faces shall be surface dry when the seal is applied.

Joints shall be inspected for proper width, depth, alignment, and preparation, and shall be accepted by the *Engineer* before sealing is allowed. A qualified installer representing the preformed sealant company shall be present during the initial stages of sealing until such time that the *Engineer* is satisfied that the installation is being performed according to the manufacturer's directions.

Preformed joint sealer shall be placed using equipment capable of installing the sealer in the upright position, without cutting, nicking, distorting, or otherwise damaging the seal. Hand placing of preformed joint sealer will not be allowed. Lubricant shall be applied to the concrete or the preformed seal, or both, and the seal shall be installed in a substantially compressed condition and at the depth below the surface of the pavement as shown in the plans.

The method of installation shall be such that the joint sealer will not be stretched more than 5 percent of the minimum theoretical length, or compressed more than 2 percent. The method of installation shall be checked for stretching or compression, using transverse joint sealer. The check shall consist of installing sealer in five joints of at least 25 feet in length, removing the sealer immediately after installation, and checking the length. This check may be modified by premarking or precutting the sealer to length prior to installation if this is compatible with the equipment being used. If the measured length of any of these five sealers indicated that the sealer is stretched or compressed beyond these limits, the installation shall be modified to correct the situation.

Once satisfactory sealing operations have started, one joint length per every hundred shall be removed and checked. If the limits are exceeded, the joint sealers on either side shall be removed until the condition disappears. The affected joints shall be resealed in a satisfactory manner at no cost to the owner, and the method of installation shall be checked again for satisfactory procedure. The seal shall be installed in the longest practicable lengths in longitudinal joints and shall be cut at the joint intersections for continuous installation of the seal in the transverse joints. After placing, all sealant shall be poured with neoprene cement at intersections of joint materials to produce a waterproof joint intersection.

If the joint as sawed is oversized, the joint shall be resawn to a uniform width and a wider joint seal installed at no cost to the Owner. The width of the sawcut joint shall be adjusted for each increment of 10° F deviation from 60° F as per the manufacturer's recommendation. The joint and corresponding joint material widths required shall be in accordance with Table 314.03.02.06-I

Table 314.03.02.06-I. Joint Material Width Requirements

Joint Width (Inches)	Joint Material Width (Inches) @ 60 °F
0.35 to 0.47	9/16
0.48 to 0.59	13/16
0.60 to 0.75	1
0.76 to 0.97	1-1/4
<0.97	1-5/8

Silicone sealants shall be installed in accordance with the manufacturer’s recommendation.

314.03.02.07 Repair, Removal and Replacement.

General. New pavement slabs that are broken or contain cracks shall be removed and replaced or repaired, as specified hereinafter at no cost to the *Owner*. Spalls along joints shall be repaired as specified. Removal of partial slabs is not permitted. Removal and replacement shall be full depth, shall be full width of the slab, and the limit of removal shall be normal to the paving lane and to each original transverse joint. The *Engineer* will determine whether cracks extend full depth of the pavement and may require cores to be drilled on the crack to determine depth of cracking. Such cores shall be 4 inches diameter, shall be drilled by the *Contractor* and shall be filled by the *Contractor* with a well consolidated *PCC* bonded to the walls of the hole with epoxy resin, using approved procedures. Drilling of cores and refilling holes shall be at no expense to the *Owner*. All epoxy resin used in this work shall conform to *ASTM C881*, Type V.

Shrinkage Cracks. Shrinkage cracks, which do not exceed 4 inches in depth, shall be cleaned and then pressure injected with epoxy resin, Type IV, Grade 1, using procedures as approved. Care shall be taken to assure that the crack is not widened during epoxy resin injection. All epoxy resin injection shall take place in the presence of the *Engineer*. Shrinkage cracks, which exceed 4 inches in depth, shall be treated as full depth cracks in accordance with Subsections “Full Depth Cracks Present, Original Joint Not Opened” and “Full Depth Cracks Present, Original Joint Also Cracked”.

Slabs with Cracks through Interior Areas. Interior area is defined as that area more than 6 inches from either adjacent original transverse joint. The full slab shall be removed and replaced at no cost to the *Owner*, when there are any full depth cracks, or cracks greater than 4 inches in depth, that extend into the interior area.

Cracks Close To and Parallel To Joints. All cracks essentially parallel to original joints, extending full depth of the slab, and lying wholly within 6 inches either side of the joint shall be treated as specified hereinafter. Any crack extending more than 6 in from the joint shall be treated as specified in Subsection “Slabs With Cracks Through Interior Area.”

Full Depth Cracks Present, Original Joint Not Opened. When the original uncracked joint has not opened, the crack shall be sawed and sealed, and the original joint filled with epoxy resin as specified below. The crack shall be sawed with equipment specially designed to follow random cracks. The reservoir for joint sealant in the crack shall be formed by sawing to a depth of 3/4 in, plus or minus 1/16 in, and to a width of 1/4 in, plus or minus 1/8 in. Any equipment or procedure which causes raveling or spalling along the crack shall be modified or replaced to prevent such raveling or spalling. The joint sealant shall be a liquid sealant as specified. Installation of joint seal shall be as specified for sealing joints or as directed. If the joint sealant reservoir has been sawed out, the reservoir and as much of the lower saw cut as possible shall be filled with epoxy resin, Type IV, Grade 2, thoroughly tooled into the void using approved procedures.

If only the original narrow saw cut has been made, it shall be cleaned and pressure injected with epoxy resin, Type IV, Grade 1, using approved procedures. If filler type material has been used to form a weakened plane in the transverse joint, it shall be completely sawed out and the saw cut pressure injected with epoxy resin, Type IV, Grade 1, using approved procedures. Where a parallel crack goes part way across paving lane and then intersects and follows the original joint which is cracked only for the remainder of the width, it shall be treated as specified above for a parallel crack, and the cracked original joint shall be prepared and sealed as originally designed.

Full Depth Cracks Present, Original Joint Also Cracked. At a joint, if there is any place in the lane width where a parallel crack and a cracked portion of the original joint overlap, the entire slab containing the crack shall be removed and replaced for the full lane width and length.

Removal and Replacement of Full Slabs. Where it is necessary to remove full slabs, unless there are keys or dowels present, all edges of the slab shall be cut full depth with a concrete saw. All saw cuts shall be perpendicular to the slab surface. If keys, dowels, or tie bars are present along any edges, these edges shall be sawed full depth 24 inches from the edge if only keys are present, or just beyond the end of the dowels or tie bars if they are present. These joints shall then be carefully sawed on the joint line to within 1 inch of the depth of the dowel or key.

The main slab shall be further divided by sawing full depth, at appropriate locations, and each piece lifted out and removed. Suitable equipment shall be used to provide a truly vertical lift, and approved safe lifting devices used for attachment to the slabs. The narrow strips along keyed or doweled edges shall be carefully broken up and removed using light, hand-held jackhammers, 30 lb. or less, or other approved similar equipment.

Care shall be taken to prevent damage to the dowels, tie bars, or keys or to concrete to remain in place. The joint face below keys or dowels shall be suitably trimmed so that there is not abrupt offset in any direction greater than 1/2 inch and no gradual offset greater than 1 inch when tested in a horizontal direction with a 12 ft. straightedge.

No mechanical impact breakers, other than the above hand-held equipment shall be used for any removal of slabs. If underbreak between 1-1/2 and 4 inch deep occurs at any point along any edge, the area shall be repaired as directed before replacing the removed slab. Procedures directed will be similar to those specified for surface spalls, modified as necessary.

If underbreak over 4 inches deep occurs, the entire slab containing the underbreak shall be removed and replaced. Where there are no dowels, tie bars, or keys on an edge, or where they have been damaged, dowels of the size and spacing as specified for other joints in similar pavement shall be installed by epoxy grouting them into holes drilled into the existing concrete using procedures as specified. Original damaged dowels or tie bars shall be cut off flush with the joint face. Protruding portions of dowels shall be painted and lightly oiled. All 4 edges of the new slab shall thus contain dowels or original keys or original tie bars.

Placement of *PCC* shall be as specified for original construction. Prior to placement of new *PCC*, the underlying material (unless it is stabilized) shall be re-compacted and shaped. The surfaces of all four joint faces shall be cleaned of all loose material and contaminants and coated with a double application of membrane forming curing compound as bond breaker. Care shall be taken to prevent any curing compound from contacting dowels or tie bars. The resulting joints around the new slab shall be prepared and sealed as specified for original construction.

314.03.02.08 Repairing Spalls Along Joints. Where directed, spalls along joints of new slabs, and along parallel cracks used as replacement joints, shall be repaired by first making a vertical saw cut at least 1 inch outside the spalled area and to a depth of at least 2 inches. Saw cuts shall be straight lines forming rectangular areas. The concrete between the saw cut and the joint, or crack, shall be chipped out to remove all unsound concrete and at least 1/2 inch of visually sound concrete. The cavity thus formed shall be thoroughly cleaned with high-pressure water jets supplemented with compressed air to remove all loose material. Immediately before filling the cavity, a prime coat of epoxy resin, Type III, Grade I, shall be applied to the dry cleaned surface of all sides and bottom of the cavity, except any joint face. The prime coat shall be applied in a thin coating and scrubbed into the surface with a stiff-bristle brush. Pooling of epoxy resin shall be avoided. The cavity, depending on volume, shall be filled with low slump *PCC* or with a polymeric concrete patch or elastomeric concrete matching the color of the *PCC* when cured (as manufactured by D.S. Brown). Concrete shall be used for larger spalls, generally those more than 1/2 cu. ft. in size and polymeric or elastomeric shall be used for the smaller ones. Any spall less than 0.1 cu. ft. shall be repaired only with polymeric or elastomeric material. Portland cement concrete mixtures shall be proportioned as directed and shall be mixed, placed, consolidated, and cured as directed. Polymeric and elastomeric materials shall be mixed and placed as recommended by the manufacturer, and as approved by the engineer. These materials shall match the color of *PCC* when cured. Mechanical vibrators and hand tampers shall be used to consolidate the concrete or patching material. Any repair material on the surrounding surfaces of the existing concrete shall be removed before it hardens. Where the spalled area abuts a joint, an insert or other bond-breaking medium shall be used to prevent bond at the joint face. A reservoir for the joint sealant shall be sawed to the dimensions required for other joints, or as required to be routed for cracks. The reservoir shall be thoroughly cleaned and sealed with the sealer specified for the joints. If any spall penetrates half the depth of the slab or more, the entire slab shall be removed and replaced as previously specified.

314.03.02.09 Opening to Traffic. Based upon minimum opening strength requirements and other specified requirements herein, the *Engineer* shall determine when the traffic or other vehicles will be allowed on the *PCC* pavement. The *Engineer* shall sample each subplot from the plastic *PCC* delivered to the job site. Sampling locations shall be determined by the *Engineer* in accordance with random sampling procedures contained in *ASTM D3665*. For each subplot one beam and one cylinder shall be tested at a time determined by the *Contractor* for the means of verifying a flexural strength of 550 *PSI*, as determined by Test Method *ASTM C78*. No pavement will be opened to mixed traffic until the average of the lot has attained 550 *PSI* with no single subplot specimen less than 500 *PSI*.

Prior to opening to traffic, the pavement shall be cleaned by flushing with water until all dirt and dust are removed from the pavement surface. It shall be the *Engineer's* sole discretion if the pavement surface is clean enough to be opened up to traffic.

315.01 DESCRIPTION. This work shall consist of preparing and treating an existing surface with bituminous material, and blotter material if required, in accordance with these Specifications.

315.02 MATERIALS.

315.02.01 Bituminous Material. The type and grade of bituminous material will be either MC-70 or MC-250 liquid asphalt as specified in the Contract. SS-1 or SS-1h asphalt emulsion can be utilized with permission of the Engineer or Agency.

The bituminous material shall meet the applicable requirements of Section 201 – “Bituminous Materials.” The bituminous material may be conditionally accepted at the source.

315.02.02 Sand Blotter. Sand blotter shall meet the requirements of Subsection 200.02.07 – “Sand Seal Aggregate or Sand Blotter.”

315.03 CONSTRUCTION.

315.03.01 EQUIPMENT. The Contractor shall provide equipment for heating and applying the bituminous material for applying blotter material. The equipment shall meet the requirements of Subsection 319.03.02 – “Distributors.”

315.03.02 WEATHER LIMITATIONS. Bituminous material shall not be applied on a wet surface when the atmospheric temperature is below 50 degrees Fahrenheit or when weather conditions, in the opinion of the Engineer, would prevent the proper construction of the prime coat.

315.03.03 PREPARATION OF SURFACE. The surface upon which the bituminous prime coat is to be placed shall conform to the established lines and grades, shall be reasonably smooth and uniform, and shall be compacted to the required density. If the required density deteriorates from the time the gravel course was compacted originally and the time the prime coat is placed, for any reason whatsoever, then the surface shall be recompacted to the required density at the expense of the Contractor. When required by the Engineer, an application of water shall be applied immediately before bituminous application.

315.03.04 APPLICATION OF BITUMINOUS MATERIAL. Bituminous material shall be applied to the width of the section to be primed by means of a pressure distributor in a uniform, continuous spread. When traffic is maintained, not more than 1/2 of the width of the section shall be treated in one application. Care shall be taken that the application of bituminous material at the junctions of spreads is not in excess of the specified amount. Excess bituminous material shall be “squeegeed” from the surface. Excess prime shall not exist at the time of paving. Skipped areas or deficiencies shall be corrected.

When traffic is maintained, one-way traffic shall be permitted on the untreated portion of the roadbed. As soon as the bituminous material has been absorbed by the surface and will not pick up, traffic shall be transferred to the treated portion and the remaining width of the section shall be primed.

The bituminous material shall be uniformly applied at a rate of 0.15 to 0.25 gallons per square yard unless called for otherwise on the Plans, in the Special Provisions, or ordered by the Engineer.

The temperature requirements pertaining to the application of liquid asphalts and asphaltic emulsions shall conform to the applicable requirements of Tables 315.03.04-I and 315.03.04-II.

TABLE 315.03.04-I

Grade and Type MC and SC	Distributor Spraying Temperature °F		Pugmill Mixing Temperature °F of Liquid Asphalts MC and SC ⁽¹⁾	
	Minimum	Maximum	Minimum	Maximum
70	120	180	95	140
250	165	220	135	175
800	200	255	165	205
3000	235	290	200	240

1. The maximum spraying temperature may be used if the aggregate is not heated.

TABLE 315.03.04-I

Grade of Asphalt Emulsion	Distributor Spraying Temperature °F		Pugmill Mixing Temperature °F of Emulsion and Aggregates ¹	
	Minimum	Maximum	Minimum	Maximum
RS-1, CRS-1	75	130	(Not used for Mixing)	
RS-2, CRS-2	110	160	(Not used for Mixing)	
SS-1, CSS-1	75	130	50	130
SS-1h, CSS-1h	75	130	50	130
CMS-2S	100	160	60	140

1. The maximum spraying temperature may be used if the aggregate is not heated.

315.03.05 APPLICATION OF BLOTTER MATERIAL. If, after the application of the prime coat, the bituminous material fails to penetrate within 3 to 6 days and the roadway must be used by traffic, blotter material shall be spread and removed if excessive in the amounts required to absorb any excess bituminous material. When necessary for traffic, blotter material may be spread prior to 3 days penetrating time.

315.04 MEASUREMENT OF QUANTITIES. The quantity of bituminous material to be measured for payment will be the number of tons, square feet, or square yards conforming to all the requirements in the completed work. The quantity of blotter sand measured for payment will be the number of tons or cubic yards conforming to all the requirements in the completed work. If provided for in the Bid Documents or Special Provisions, no direct payment may be offered for blotter.

315.05 PAYMENT. The accepted quantity of materials measured as provided in Subsection 315.04 – “Measurement of Quantities” will be paid for at the contract unit price bid per ton bituminous material and per ton or cubic yard for blotter sand, or for the square footage or yardage of bituminous material, including blotter, as indicated in the Bid Documents or the Special Provisions.

The above prices shall be full compensation for furnishing the material, mixing, loading, hauling, placing, and incidentals necessary for doing all the work involved in placing prime coat and sand blotter, as shown on the Plans, indicated in the Special Provisions, or established by the Engineer.

316.01 DESCRIPTION. This work shall consist of preparing and treating an existing bituminous or concrete surface in preparation for an overlay with bituminous material in accordance with these Specifications, and as shown on the Plans, or established by the Engineer.

316.02 MATERIALS. The type and grade of bituminous material will be SS-1, SS-1h, CSS-1 or CSS-1h asphalt emulsion unless specified otherwise in the Contract.

The bituminous material shall meet the applicable requirements of Section 201 – “Bituminous Materials.” The bituminous material may be conditionally accepted at the source.

Asphaltic emulsion used as a Tack Coat between the courses of plantmix surface or over an existing surface shall be of the type and grade specified and prepared for application as follows:

The emulsion shall be diluted by water. Water shall be added in the quantity of 50 percent of the emulsion by weight. To accomplish this mixing, the distributor shall be partly filled with water, and the correct proportion of emulsified asphalt shall then be added, and the remaining water to be added shall be sprayed in the tank under pressure and then thoroughly circulated within the distributor.

316.03 CONSTRUCTION

316.03.01 EQUIPMENT. The Contractor shall provide equipment for heating and applying the bituminous materials. This equipment shall meet the requirements of Subsection 319.03.02 – “Distributors.”

316.03.02 WEATHER LIMITATIONS. Application of bituminous material will not be permitted when the surface to be treated is damp or wet or when weather conditions are unsuitable or when the atmospheric temperature or aggregate temperature is below 40 degrees Fahrenheit.

316.03.03 PREPARATION OF SURFACE. The existing surface shall be patched and cleaned and be free of irregularities to provide a reasonably smooth and uniform surface to receive the treatment. The edges of existing pavements, which are to be adjacent to new pavement, shall be cleaned to permit the adhesion of bituminous materials.

Where the Contractor is applying tack upon a previously constructed course under the contract, patching, cleaning, repairing, etc., will be at the Contractor’s expense, unless otherwise provided.

316.03.04 APPLICATION OF BITUMINOUS MATERIALS. The bituminous material shall be uniformly applied at a rate of 0.08 to 0.13 gallon per square yard, depending upon the texture of the surface, unless otherwise called for on the Plans, specified in the Special Provisions, or ordered by the Engineer. When asphaltic emulsion is used, the temperature at the time of application shall conform to the applicable requirements in Table I of Subsection 315.03.04 – “Application of Bituminous Material.”

The tack coat shall be applied in such a manner as to offer the least inconvenience to adjacent traffic. The tack coat shall break before subsequent paving operations.

316.04 MEASUREMENT OF QUANTITIES. The quantity of bituminous material to be measured for payment will be the number of tons, square feet, or square yards conforming to all the requirements in the completed work.

Bituminous material diluted as prescribed shall be measured in tons, square feet, or square yards of the diluted mixture acceptably applied to the surface.

316.05 BASIS OF PAYMENT. The accepted quantity of bituminous material measured will be paid for at the contract unit price bid per ton, square foot, or square yard, unless the application of tack coat is included in the overall paving scope, when no direct payment will be offered.

The above prices shall be full compensation for furnishing the material, mixing, loading, hauling, placing, and incidentals necessary for doing all the work involved in placing tack coat, as shown on the Plans or established by the Engineer.

317.01 DESCRIPTION. This work shall consist of an application of bituminous material on a compacted and bonded bituminous surface, and blotter material or a cover of screenings, in accordance with these Specifications and Plans, or as established by the Engineer. All new pavements including overlays shall receive a fog seal unless otherwise specified.

317.02 MATERIALS.

317.02.01 BITUMINOUS MATERIAL. The following bituminous materials shall be utilized for seal coats unless modified by the Agency:

Fog Seal	SS-1 or SS-1h Asphalt Emulsion
Sand or Chip Seal	Latex Modified CRS-2H, Asphalt blended with 2.5 percent latex rubber

The bituminous material shall meet the applicable requirements of Section 201 – “Bituminous Materials.” The bituminous material may be conditionally accepted at the course.

317.02.02 SAND SEAL OR SAND BLOTTER. Aggregates utilized in Sand Seal or Sand Blotter shall meet the requirements of Subsection 200.02.07 – “Sand Seal Aggregate or Sand Blotter.” The material may be accepted in stockpile at the source.

317.02.03 CHIP SEAL AGGREGATE. Chip seal aggregate shall meet the applicable requirements of Subsection 200.02.05 – “Chip Seal Aggregate”.

317.03 CONSTRUCTION.

317.03.01 EQUIPMENT. The Contractor shall provide equipment for heating and applying the bituminous material for applying the sand blotter material or the screenings, in accordance with the Specifications and as shown on the Plans.

317.03.01.01 Distributors. The distributor shall meet the requirements of Subsection 319.03.02 – “Distributors.”

317.03.01.02 Aggregate Spreader. For seal coat aggregates, the aggregate spreader shall be self-propelled and supported by at least four wheels equipped with pneumatic tires on two axles. The aggregate spreader shall be equipped with positive control so that the required amount of material will be deposited uniformly over the full width of the bituminous material.

317.03.01.03 Rollers. For chip seal aggregate there shall be operating with each aggregate spreader one pneumatic-tire roller and one steel-wheel roller. The pneumatic-tired roller shall meet the requirements of Subsection 319.03.04b – “Rollers.” The steel-wheel roller shall weigh not more than 6 tons.

317.03.02 WEATHER LIMITATIONS. Bituminous material shall not be spread when weather conditions are unsuitable, or when the atmospheric temperature is below the following:

- a. Below 65 degrees Fahrenheit or the pavement temperature is below 80 degrees Fahrenheit for chip seal aggregate.
- b. Below 50 degrees Fahrenheit or when weather conditions, in the opinion of the Engineer, would prevent the proper construction of the fog seal or sand seal coat and additional sand blotter, if required.

317.03.03 PREPARATION OF SURFACE. Immediately before applying the bituminous material, the surface to be sealed shall be thoroughly cleaned of all dirt and loose material by sweeping with vacuum power brooms supplemented by hand brooms if necessary. The process of cleaning shall continue until dirt and loose material is removed from the entire width of the surfacing.

317.03.04 MAINTAINING TRAFFIC. Where public is being routed over a surface upon which a surface treatment is to be applied, the surface treatment shall not be applied to more than 1/2 the width of the traveled way at a time and the remaining 1/2 width shall be kept free of obstructions and open for use by public traffic at all times until the surface treatment first applied is ready for use by traffic.

317.00-2**SEAL COATS (FOG SEAL, SAND SEALS, AND CHIP SEALS)**

Traffic will not be allowed on the newly placed bituminous material and screenings until, in the opinion of the Engineer, the screenings and bituminous material have sufficiently set and bonded to prevent displacement by such traffic.

When the newly completed surface treatment is open to traffic, the traffic shall be controlled by use of flagmen and a pilot car for a period of 4 hours or for such time as deemed necessary by the Engineer as follows:

- a. A flagger shall be stationed at the beginning of each newly completed section open to traffic to stop oncoming traffic preparatory to piloting operations and shall be kept on duty during the entire control period.
- b. Traffic control as described above shall be moved ahead progressively as the newly completed surface is open to traffic.

317.03.05 APPLICATION OF BITUMINOUS MATERIAL. Bituminous material shall not be spread later in the day than will permit the stopping of traffic control prior to darkness. Bituminous material shall be applied to only one designated traffic lane at a time and the entire width of the lane shall be covered in one operation.

The bituminous material shall be uniformly applied at the rates specified in Table 317.03.05-I or as called for on the Plans, indicated in the Special Provisions, or ordered by the Engineer. Bituminous material shall be applied by means of a pressure distributor in a uniform, continuous spread over the section to be treated. The temperature of the bituminous material shall conform to the applicable requirements of Section 315 – “Prime Coat.” If the texture of the surface is such that bituminous material penetrates too rapidly, a preliminary application of from 0.05 to 0.10 gallon per square yard of surface may be required.

TABLE 317.03.05-I

Application	Application Rate (Gallons per Square Yard)
Fog Seal	0.07 – 0.12 (Diluted Emulsion)
Sand Seal	0.15 – 0.20
Chip Seal	0.25 – 0.35

The distributor, when not spreading, shall be parked so that the spray bar or mechanism will not drip bituminous materials on the surface of the traveled way.

When the surface treatment includes screenings, a strip of building paper at least 3 feet in width, and with a length equal to that of the spray bar of the distributor plus 1 foot, shall be used at the beginning of each spread. If the cutoff is not positive, the use of paper may be required at the end of each spread. The paper shall be removed and disposed of in a satisfactory manner. The distributor shall be moving forward at proper application speed at the time the spray bar is opened. Any skipped areas or deficiencies shall be corrected. Junctions of spreads shall be carefully made to assure a smooth riding surface.

317.03.06 APPLICATION OF AGGREGATE. Immediately following the application of the bituminous material, aggregate shall be spread at the rate per square yard shown in Table 317.03.06-I.

TABLE 317.03.06-I

Application	Application Rate (Pounds per Square Yard)
Sand Seal	10 - 15
Chip Seal	20 - 25

In order to avoid building a longitudinal joint when spreading aggregate on the first width of bituminous material, no aggregate shall be applied within 6 inches of the edge adjacent to the next application of bituminous material.

Bituminous material and aggregate shall not be spread over a greater distance than can be rolled and finished within 1 day's operation.

In order to eliminate dust film, aggregate shall be moistened with water before being applied. In spreading the screenings, the equipment used shall be so operated that the fresh bituminous material will be covered before equipment wheels come upon it.

Asphalt emulsion applied to the road surface shall be covered with aggregate before setting or breaking occurs.

After the aggregates have been spread upon the bituminous material, any piles, ridges, or uneven distribution shall be carefully removed with flat bottom shovels, or other approved methods, to insure against permanent ridges or bumps in the completed surface. Additional aggregate shall be spread by hand in whatever quantities required to prevent picking up at the rollers or traffic.

After the application of the aggregate, the surface, where specified, shall be lightly broomed or otherwise maintained as directed for a period of 4 days or as directed. Maintenance of the surface shall include the distribution of screenings over the surface to absorb any free bituminous material and cover any area deficient in screenings. The maintenance shall be conducted so as not to displace embedded material. Excess material shall be swept at the time determined by the Engineer.

All sand and chip seals shall be placed in the presence of the Agency or Engineer. The Contractor shall notify the Agency or Engineer at least 24 hours prior to construction of sand or chip seals. The Contractor shall supply the on-site inspector with an asphalt sample taken directly from the distributor truck and provide asphalt certification before proceeding.

317.03.07 ROLLING OF AGGREGATE. Rollers shall always include pneumatic rollers. In addition, a steel drum roller shall be utilized on the second course of a double chip seal and shall be operational on a single chip seal. Rolling shall follow immediately behind spreading screening to properly embed the screenings in the soft bituminous material, and rolling shall commence at the outer edges and proceed toward the inner edge of each spread of bituminous material and screenings, and shall be continued until the aggregates are thoroughly set. Roller speed shall be less than 5 miles per hour and shall not displace aggregate.

317.03.08 CLEANUP OF AGGREGATE. The Contractor shall broom excess aggregate from the roadway within 24 to 72 hours of application and before opening to any full speed traffic. Excess aggregate shall be removed from the project site.

317.04 MEASUREMENT OF QUANTITIES. The quantity of bituminous material to be measured for payment will be the number of tons, square feet, or square yards conforming to all the requirements in the completed work. The quantity of screenings measured for payment will be the number of tons or cubic yards conforming to all the requirements in the completed work, unless it is indicated in the bid documents that the unit price bid for seal coat or surface treatment includes screening.

317.05 BASIS OF PAYMENT. The accepted quantity of materials measured as provided will be paid for at the contract unit price bid per ton, square foot, or square yard for bituminous material and per ton or cubic yard for screenings, unless it is indicated in the bid documents that the price of screenings is included in the unit price established for seal coat or surface treatment.

The above prices shall be full compensation for furnishing the material, mixing, loading, hauling, placing, rolling, sweeping, and incidentals necessary for doing all the work involved in placing bituminous material and screenings, as shown on the Plans or established by the Engineer.

318.01 DESCRIPTION. The work covered by this specification includes the mixing, application, testing, construction, and quality control required for the proper application of an emulsified asphalt slurry seal surface in accordance with these Specifications and Plans, or as established by the Engineer.

318.02 COMPOSITION OF MIXTURES. A mix design shall be performed and submitted to the Engineer in accordance with Subsections 337.01 "Mix Design" and 337.07 – "Slurry Seal and Microsurfacing" to determine the composition of the mixture. No slurry seal shall be placed without approval by the Engineer of a mix design.

318.03 EQUIPMENT.

318.03.01 GENERAL. All equipment, tools, and machines used in the performance of this work shall be maintained in satisfactory working order at all times.

318.03.02 SLURRY MIXING EQUIPMENT. The slurry seal mixing equipment shall be a continuous flow mixing unit, either an individual unit that returns to the stockpile for reloading or a continuous run unit that is resupplied on the job.

All units must have suitable means of accurately metering each individual material being fed into the mixer. All feeding mechanisms must be continuous feed and proportioning must remain constant at all times. The units shall be equipped with approved devices so that the machine can be accurately calibrated, and the quantities of materials used during any one period can be estimated. In the event these metering devices stop working, the slurry unit(s) will stop the application process until they are mixed.

The mixer shall thoroughly blend all materials to form a homogeneous mass before leaving the mixer.

318.03.03 SLURRY SPREADING EQUIPMENT. The spreader box shall be equipped to prevent loss of slurry seal from all sides and with a flexible rear strike-off. It shall be capable of producing a uniform surface its full width. It shall have suitable means for side tracking to compensate for deviations in pavement geometry. Any type drag used shall be approved by the Engineer or Agency and kept in a completely flexible condition at all times. The box shall be kept clean, and build-up of asphalt and aggregate shall not be permitted.

318.03.04 AUXILIARY EQUIPMENT. Suitable crack and surface cleaning equipment, barricading equipment, hand tools, and any support equipment should be provided as necessary to perform the work.

318.04 MACHINE CALIBRATION AND VERIFICATION.

318.04.01 CALIBRATION. Each slurry mixing unit to be used in performance of the work shall be calibrated in the presence of the Engineer or Agency prior to construction. Previous calibration documentation covering the exact materials to be used may be accepted provided they were made during the calendar year. The documentation shall include an individual calibration of each material at various settings, which can be related to the machine's metering device(s). No machine will be allowed to work on the project until the calibration has been completed and/or accepted.

318.04.02 VERIFICATION. Test strips will be made by each machine after calibration and prior to construction. Test strips shall be a portion of the project. Samples of the slurry seal will be taken and verification made as to mix consistency and proportioning. Verification of rate of application will also be made. Upon failure of any of the tests, additional test strips, at no cost to the Owner or Agency, will be required until each unit is authorized to work. Any unit failing to pass the tests after the third trial will not be permitted to work on the project. Test strips must be accepted or rejected within 24 hours after application.

318.05 RATE OF APPLICATION, AND TOLERANCES.

318.05.01 RATE OF APPLICATION. The slurry seal mixture shall be of proper consistency at all times so as to provide the amount of mixture required by the surface condition. The application rate as measured by the Engineer shall be 6-10 pounds per square yard for Type 1 Aggregate, 10-15 pounds per square yard for Type II Aggregate, and 15-25 pounds per square yard for Type III Aggregate.

318.05.02 TOLERANCES. Tolerances for individual materials as well as the slurry seal mixture are as follows:

- a. After the designed residual asphalt content is determined, a plus or minus 1 percentage point variation will be permitted.
- b. The percent of aggregate passing each sieve shall not vary more than ± 4.0 percent from the mix design.
- c. The percent of aggregate passing shall not go from the high end to the low end of the specified range of any two successive sieves.
- d. The slurry consistency shall not vary more than ± 05 cm from the mix design after field adjustments.

318.06 LIMITATIONS.

318.06.01 WEATHER. The slurry seal shall not be applied unless both the pavement and air temperature are 55 degrees Fahrenheit (15 degrees C) and rising. No slurry seal shall be applied when there is danger that the finished product will freeze before 24 hours. The mixture shall not be applied when weather conditions prolong opening to traffic beyond a reasonable time.

318.07 SURFACE PREPARATION.

318.07.01 SURFACE PREPARATION. Immediately prior to applying the slurry seal, the surface shall be cleared of all loose material, silt spots, vegetation, oil spots, and other objectionable material. Any standard cleaning method will be accepted. If water is used, cracks shall be allowed to dry thoroughly before slurry sealing. Manholes, valve boxes, drop inlets, and other service entrances shall be protected from the slurry seal by a suitable method. The Engineer or Agency shall approve the surface preparation prior to sealing.

318.07.02 TACK COAT. If required by the Plans, the Contractor shall apply a tack coat consisting of one part asphalt emulsion and three parts water. Tack coats are necessary only on very smooth surfaces or on concrete. The same asphalt emulsion to be used in the slurry seal shall be used. The equipment used to apply the tack coat shall be capable of applying the dilution at a rate of 0.5 to 0.10 gal/sq. yd. (0.15 to 0.35 lit/sq. m.).

318.08 APPLICATION.

318.08.01 GENERAL. The surface should be pre-wetted by fogging ahead of the slurry box when required by local conditions. Water used in pre-wetting the surface shall be applied such that the entire surface is damp with no apparent flowing water in front of the slurry box. The rate of application of the fog spray shall be adjusted during the day to suit temperatures, surface texture, humidity, and dryness of the pavement surface.

The slurry mixture shall be of the desired consistency upon leaving the mixture and no additional materials shall be added. A sufficient amount of slurry shall be carried in all parts of the spreader at all times so that a complete coverage is obtained. Overloading of the spreader shall be avoided. No lumping, balling, or unmixed aggregate shall be permitted.

No streaks, such as those caused by oversized aggregate, will be left in the finished surface. If excess oversize develops, the job will be stopped until the Contractor proves to the Engineer or Agency that the situation has been corrected.

318.08.02 JOINTS. No excessive buildup, uncovered areas, or unsightly appearance shall be permitted on longitudinal or transverse joints. An excessive overlap will not be permitted on longitudinal joints. The Contractor shall provide suitable width spreading equipment to produce a minimum number of longitudinal joints throughout the project. When possible, longitudinal joints shall be placed on lane lines. Half passes and odd width passes will be used only in minimum amounts. If half passes are used, they shall not be the last pass of any paved area.

318.08.03 MIX STABILITY. The slurry mixture shall possess sufficient stability so that premature breaking of the slurry seal in the spreader box does not occur. The mixture shall be homogeneous during and following mixing and spreading, it shall be free of excess water or emulsion, and free of segregation of the emulsion and aggregate fines from the coarser aggregate.

318.08.04 HAND WORK. Areas which cannot be reached with the slurry seal machine shall be surfaced using hand squeegees to provide complete and uniform slurry seal coverage. The area to be handworked shall be lightly dampened prior to mix placement and the slurry worked immediately. Care shall be exercised to leave no unsightly appearance from handwork. The same type finish as applied by the spreader box shall be required. Handwork shall be completed during the machine applying process.

318.08.05 LINES. Care shall be taken to insure straight lines along curbs and shoulders. No runoff on these areas will be permitted. Lines at intersections will be kept straight to provide a good appearance.

318.08.06 CLEAN-UP. All areas such as manways, gutters, and intersections shall have the slurry seal removed as specified by the Engineer or Agency. On a daily basis, the Contractor shall remove any debris associated with the performance of the work.

318.09 MEASUREMENT. The quantity of slurry seal to be measured for payment will be based on the Contract unit, as indicated in the Bid Proposal, conforming to all the requirements for the completed work.

If paid by the weight of aggregate and emulsion, the Contractor shall submit to the Engineer or Agency a certified affidavit and delivery tickets which show tonnage of each material delivered to the job site and used on the project.

318.10 BASIS OF PAYMENT. The quantity of materials measured will be paid for at the Contract unit price bid per Contract item.

The Contract unit price bid per Contract item shall be full compensation for all work involved in placing slurry seal, as shown on the Plans or established by the Engineer, including, but not limited to, furnishing all materials and for all preparation, mixing and applying these materials, and for all labor, equipment, tools, test design, and clean-up.

Full compensation for furnishing and applying bituminous material or asphalt emulsion as provided for in Subsection 318.07.02 – “Tack Coat”– shall be considered as included in the Contract unit price bid for the principal items involved and no further compensation will be paid.

319.01 DESCRIPTION. This work specification covers the construction of one or more courses of roadmix bituminous pavement on a prepared base or road surface in accordance with this Subsection and typical cross section shown on the Plans or established by the Engineer.

The mineral aggregate and bituminous material may be mixed in place in the prepared roadbed, or mixed off the roadbed by either roadmix or plantmix methods.

319.02 COMPOSITION OF MIXTURES. A mix design shall be performed and submitted to the Engineer in accordance with Subsections 337.01 "Mix Design" and 337.04 – "Bituminous Plantmix" to determine the composition of the mixture. The type and gradation of aggregate and type and grade of bituminous material will be specified in the Contract in the Special Technical Specifications. No roadmix bituminous mixture shall be placed without approval by the Engineer of a mix design.

319.03 CONSTRUCTION EQUIPMENT.

319.03.01 MOTOR GRADERS. Motor graders for spreading, shaping, and finishing mixture shall be of the self-powered type with blades not less than 12 feet long and wheel bases of not less than 17 feet.

319.03.02 DISTRIBUTORS. The distributor shall be so designed, equipped, maintained, and operated that bituminous material at even heat may be applied uniformly on variable widths of surface up to 14 feet at readily determined and controlled rates from 0.05 to 2 gallons per square yard, with uniform pressure, and with an allowable variation from any specified rate not to exceed 0.02 gallon per square yard. Distributor equipment shall include a tachometer, pressure gages, accurate volume measuring devices or a calibrated tank, and a thermometer for measuring temperatures of tank contents. Distributors shall be equipped with a power unit for the pump and full circulation spray bars adjustable laterally and vertically.

319.03.03 MIXING PLANTS. Traveling or stationary mixing plants or other equipment of proven performance may be used by the Contractor in lieu of the Specified equipment, if approved. Traveling mixing plants shall have positive controls for applying asphalt.

319.03.04 ROLLERS. Rollers used shall conform to the requirements of Subsection 320.03.04 – "Rollers."

319.03.05 WEATHER LIMITATIONS. The mixing, spreading, and compacting of roadmix bituminous pavement shall be carried on only when the surface on which the materials to be placed is dry and when the atmospheric temperature is above 50 degrees Fahrenheit, and has not been below 40 degrees Fahrenheit during the preceding 24 hours.

319.03.06 PREPARATION OF EXISTING SURFACE. Before spreading materials for roadmixing, the surface of the base or road surface on which the roadmix is to be placed shall be conditioned as specified in Section 320 – "Bituminous Plantmix."

After a prime coat is applied, it shall be left undisturbed not less than 24 hours. The Contractor shall maintain the primed surface until the roadmix material has been placed. This maintenance shall include the spreading of sand or other material, if necessary, to prevent adherence of the prime coat to the tires of vehicles using the primed surface and patching any breaks in the primed surface with additional bituminous material. Any area of primed surface that has become damaged shall be repaired before the roadmix material is placed.

319.03.07 PLACING AGGREGATES. Mineral aggregate shall be deposited upon the prepared subgrade, or mixing area, by the use of spreader boxes, or from the vehicles equipped, or supplemented with suitable spreading devices.

The mineral aggregate shall contain sufficient material to construct the roadmix surfacing as planned, including sufficient material for surfacing special features off the traveled way. The aggregate shall not be mixed with earth or other deleterious matter.

If the surface moisture of the aggregate is more than 2 percent of the dry weight of the aggregate, except when the bituminous material is emulsified asphalt, the aggregate shall be turned by blades or disc harrows or otherwise aerated until the moisture content is reduced to 2 percent or less. The aggregate shall be spread smoothly and uniformly over half the road or other convenient width of the surface ready for the application of bituminous material, except that when a traveling mixing plant is used the aggregate shall be formed into a uniform cross section.

In lieu of aerating and drying the aggregate, the Contractor may use an approved additive. The additive shall permit suitable coating of the wet aggregate and shall prevent the bituminous coating from stripping in the presence of water.

319.03.08 APPLICATION OF BITUMINOUS MATERIAL. The bituminous material shall be uniformly distributed in successive applications, in such amounts and at such intervals as directed. The temperature of the bituminous material shall conform to the applicable requirements of Section 315 – “Prime Coat.” The mixing equipment shall follow immediately behind the distributor after each application of bituminous material. No more bituminous material shall be applied per day than can be mixed with the aggregate on the same day it is applied.

319.03.09 MIXING. The materials may be mixed upon the roadbed, or upon some other approved area of the roadbed by roadmixing methods, or the material may be mixed at a central mixing plant by plantmix methods as specified below, whichever the Contractor elects.

a. Roadmixing Methods. Prior to applying the bituminous material, the prepared aggregate shall be spread smoothly and uniformly over 1/2 the mixing area or some other convenient width. The first application of bituminous material shall then be applied and partially mixed with the aggregate. The remaining applications of bituminous material with a partial mixing after each application shall follow in like manner. After the last application of bituminous material and partial mixing, the entire mass of bituminous material and aggregate shall be windrowed on the mixing surface and then thoroughly mixed and combined by the mixing units specified by blading the mix from side to side of the mixing surface, or by manipulation producing equivalent results, until all particles are coated with bituminous material and the whole mass has uniform color and the mixture is free from spots containing an excess or deficiency of bituminous material, balls, or uncoated particles. During the mixing operations, care shall be taken to avoid cutting into the underlying course or contaminating the mixture with earth or other extraneous matter. When so directed by the Engineer, the mixing process shall be confined to part of the width or area of the roadbed so as to allow a convenient passage for traffic.

Prior to spreading and compacting, should the mixture show an excess or deficiency of bituminous material, or an uneven distribution thereof, the condition shall be corrected by adding mineral aggregate or bituminous material, as the case may be, and then remixing to produce a satisfactory mixture. If necessary, all compressed masses of mixed materials shall be broken up.

When the mineral aggregate consists of the existing material on the roadbed and an allowance for additional mineral aggregate has not been provided for on the Plans, additional mineral aggregate may be obtained by scarifying material from the roadbed as directed by the Engineer or, in lieu thereof, the Contractor may import suitable material. No additional compensation will be allowed for conforming to the above requirements, except that additional materials imported and added to that in place will be paid for at the unit price bid.

The amount of material mixed in any 1 day shall not be more than can be spread and compacted on the following day, provided, however, that when directed by the Engineer, mixed material may remain in the windrow for a longer period.

In lieu of mixing the material as above specified, a roadmixing machine or any equipment other than that required above may be employed which will produce the completed mixture equal to that which would be produced by the means above specified. The Agency reserves the right to order the use of any equipment discontinued which, in the opinion of the Engineer, fails to produce a satisfactory mixture.

The roadmixing machine shall be of the pugmill or auger type which picks up the loose material from the mixing area, or it may be of the type which cuts a true plane in material at a specified depth, leaving no loose material in either case. Either type shall introduce the bituminous material through a metering device at the time of mixing. The machine shall be equipped to provide for a positive control of the amount of bituminous material introduced into the mix, which can be readily adjusted to the changes required.

The rate of movement of the roadmixing machine, the amount of the material mixed, and the amount of mixing shall be so regulated that a mix satisfactory to the Engineer will result. The materials shall be mixed until a uniform mixture of unchanging appearance is obtained and all particles of aggregate are thoroughly coated with bituminous materials. Before mixing, the loose materials shall be placed in windrows or in a blanket of uniform cross section and of such size that all the material in the windrow or blanket can be passed through the mixing machine at each mixing operation.

Materials mixed off the roadbed shall be uniform in character and equal in all respects to that which would be produced by mixing on the roadbed as above specified.

b. Plantmixing Method. Should the Contractor elect to mix the materials at a central mixing plant by the plantmix method, the mineral aggregate shall be dried, proportioned, and mixed with the bituminous material in accordance with the applicable requirements of Section 320 – “Bituminous Plantmix”– of these Specifications with the following modifications: When the moisture content of the mineral aggregate does not exceed 2 percent by weight of the dry aggregate and laboratory tests indicate that such increased moisture content will not produce an unstable mixture, mixing of the materials without passing the aggregate through a dryer will be permitted.

Unless otherwise specified in the Special Provisions, separation of the mineral aggregate into required sizes and storing in separate bins will not be required.

319.03.10 SPREADING, COMPACTING, AND FINISHING. Before the finished mixture is spread for compaction, a triangular cut shall be made with a motor grader at each edge of the base course to provide for a thickened edge of bituminous mixture. The cut shall be approximately 2 inches deep at the outer edge and slope to zero 2 feet in toward the center. In making a cut, the excavated material shall be thrown to the edge of the roadbed in a small windrow against which the mixture shall then be spread.

After roadmixing operations have been completed and the mixture has been approved by the Engineer, the mixture shall be uniformly spread over the area to be surfaced to the proper width and to such depth as will compact to the required thickness. The mixture shall be spread by means of a motor grader meeting the requirements of Subsection 319.03.01 – “Motor Graders.”

Segregation of coarse or fine particles shall be avoided and the mixture shall be free from lumps or pockets of coarse and fine material after spreading.

After the mixture has been spread as above specified, approximately the top 1/2 of the material shall be removed by motor graders and placed into a windrow on one side. The windrow shall be so placed that earth or other extraneous materials will not become intermixed with the windrowed material. The exposed area not occupied by the windrow shall then be thoroughly rolled. Rolling shall be continuous throughout the spreading operations. The windrowed material shall then be respread over the entire surface by alternating the windrow from one side of the roadbed to the other and to the center, and gradually decreasing the amount of material moved until the entire surface has uniform texture and is smooth and true to cross section and grade and is uniformly compacted. During blading and rolling, all lumps and loose stones shall be moved to the outside of the surface area and disposed of.

All rolling, except the final finish rolling, shall be done with pneumatic-tired rollers. The finish rolling shall be done with steel-tired tandem or three wheeled rollers commencing at the lower edge, progressing toward the highest portion. Under no circumstances shall the highest portion be rolled first.

319.03.11 SURFACE TOLERANCES. The surface will be tested by the Engineer using a 12 foot straightedge at selected locations. The variation of the surface from the testing edge of the straightedge between any two contacts with the surface shall at no point exceed 0.03 foot. All humps or depressions exceeding the Specified tolerance shall be corrected by removing defective work and replacing it with new material as specified.

319.04 MEASUREMENT OF QUANTITIES. The quantity of roadmix bituminous surface aggregate to be measured for payment will be based on the Contract unit, as indicated in the Bid Proposal, conforming to all the requirements for the completed work.

When the mixture is mixed at a central mixing plant by the plantmix method, and the quantity is measured in tons, the number of tons will be determined by weighing the completed mixture of aggregate and bituminous material, which conforms to all the requirements for the completed work, and deducting from this weight the weight of the bituminous material.

When mixing and compacting is to be paid for as a Contract item on a lineal foot basis, the quantity will be determined from measurements taken along the centerline of the roadway to be the nearest 1 foot length. No extra allowance will be made for mixing widened sections and shoulder dikes, unless otherwise provided in the Special Provisions

The quantity of bituminous mixture, the placing of which is to be paid for as a Contract item on an area basis in addition to the Contract prices paid for the bituminous mixture, will be determined from measurements of the quantity compacted in-place, which conforms to all the requirements for the completed work, measured based on the Contract unit, as indicated in the Bid Proposal.

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ROADMIX BITUMINOUS SURFACE

319.05 BASIS OF PAYMENT. The quantity of materials measured will be paid for at the Contract unit price bid per Contract item.

The Contract unit price bid per Contract item shall be full compensation for all work involved in constructing roadmix bituminous surface, as shown on the Plans or established by the Engineer, including, but not limited to, furnishing all the material; scarifying; mixing; loading; hauling; placing; and compacting.

Mineral aggregate consisting of material-in-place on the roadbed will not be measured and paid for.

Full compensation for furnishing and applying bituminous material or asphalt emulsion as provided for in Subsection 319.03.06 – “Preparation of Existing Surface”– shall be considered as included in the Contract unit price bid for the principal items involved and no further compensation will be paid.

320.01 DESCRIPTION. This specification covers the construction of one or more courses of bituminous plantmix pavement on a prepared base or road surface in accordance with this Subsection and typical cross section shown on the Plans or established by the *Engineer*.

320.02 COMPOSITION OF MIXTURES.

320.02.01 Composition of Mixtures. A mix design shall be prepared in accordance with Subsection 337.01 - "Mix Design". The blows per side, target air voids, aggregate gradation and type and grade of asphalt shall be shown on the *Plans* or specified in the *Special Provisions* and/or *Special Technical Specifications*.

320.02.02 HMA. For *HMA* containing 15 percent or less of *RAP* by dry weight of aggregate, the mix design shall be performed in accordance with Subsection 337.04 – "*Bituminous Plantmix/HMA*".

320.02.03 HMA with Greater Than 15 Percent RAP. For *HMA* containing greater than 15 percent of *RAP* by dry weight of aggregate, the mix design shall be performed in accordance with Subsection 337.05 – "*Bituminous Plantmix/HMA with Greater Than 15 Percent RAP*."

320.03 CONSTRUCTION.

320.03.01 SUBMITTALS.

320.03.01.01 Materials. The materials used shall be accepted by the *Engineer*. The *Contractor* shall ensure that the materials have been accepted by the *Engineer* prior to transport.

Certificate of Compliance. The *Contractor* shall submit to the *Engineer* a *Certificate of Compliance* for each material and manufactured and/or fabricated product for which the *Specifications* require that such a certificate be furnished. Unless otherwise specified, the *Contractor* shall submit the certificate at least 30 *Calendar Days* prior to providing the material or product for *Acceptance* by the *Engineer*. Written comments regarding the submittal shall be provided to the *Contractor* within 14 *Calendar Days* of the submittal. The *Contractor* shall ensure that the certificate has been reviewed and accepted by the *Engineer* prior to transport. Unless approved by the *Engineer*, materials without acceptance of the certificate by the *Engineer* shall be removed and replaced at no additional cost to the *Agency/Owner*.

All tests associated with the certificate shall be performed by an *Accredited Laboratory* as defined in Subsection 100.01.19 – "LABORATORY." Unless otherwise specified, the date of each test performance shall be no more than 365 *Calendar Days* prior to the acceptance of the material or product.

Required Information. Unless waived by the *Engineer*, the certificate shall include, or have attached, the following information:

- A. The project name;
- B. The legal name, address, and phone number of the material supplier or product manufacturer and/or fabricator;
- C. A description of the material or product;
- D. The specifications being affirmed;
- E. An affirmation that the material or product conforms in all respects to the cited specifications;
- F. The date of the affirmation; and
- G. The name, title, and signature of the individual responsible for the affirmation.

When requested by the *Engineer*, the *Contractor* shall furnish a complete written statement of the origin, compositions and manufacture of any or all materials that are to be used in the work.

SDS. A SDS shall be available for all applicable materials.

USE OF OTHER MATERIALS. Unless otherwise directed or accepted by the *Engineer*, the *Contractor* shall not use materials and/or installations other than those shown on the *Plans* or specified in the *Specifications*.

Materials Specified by Trade Names. Whenever any article or any class of materials is specified by a trade name of any particular patentee, manufacturer or dealer, it shall be mutually understood to mean and specify the article or class of materials described, or any other equal thereto in quality, finish and durability, and equally as serviceable for the purpose for which it is intended, subject to *Acceptance* of the *Engineer*. If the *Contractor* requests permission to use alternate equipment or materials and its use is permitted, such use will be conditional on the *Contractor* assuming all responsibility to provide any changes to the *Plans* and/or *Specifications* necessary to accommodate the particular equipment or material desired for use at no additional cost to the *Agency/Owner*. The *Contractor* shall, with 10 *Calendar Days* following the *Notice to*

Proceed, submit for *Acceptance* a complete list of all materials, articles or equipment which are proposed for substitution as the equal, of materials, articles or equipment which are specified by trade names or by the names of any particular patentee, manufacturer or dealer. Failure to submit such list within that time shall be deemed adequate and reasonable ground for refusal by the *Engineer* to consider any subsequent proposed substitutions. Any items omitted from a duly submitted list may likewise be barred for subsequent consideration.

The *Contractor* shall provide all details of each proposed substitute needed by the *Engineer* to evaluate the substitution.

Acceptance. The *Acceptance* shall be in writing; shall state that the *Engineer* has found the proposed substitution to be acceptable; shall list any necessary modifications to the *Specifications*; and shall be stamped and signed by a *Professional Engineer*.

MATERIAL STORAGE. The *Contractor* shall safely and securely store materials and shall ensure the preservation of their quality. Stored materials shall be located to facilitate inspection.

Asphalts and Additives. The date of each test performed shall be no more than 30 *Calendar Days* prior to the date of shipment to the hot plant.

320.03.01.02 HMA. The *Contractor* shall submit, in writing, the *HMA* mix design at least 14 *Calendar Days* prior to placement, for acceptance by the *Engineer*. Written comments regarding the submittal shall be provided to the *Contractor* within 7 *Calendar Days* of the submittal. The *Contractor* shall ensure that the mix design has been reviewed and accepted by the *Engineer* prior to providing the *HMA*.

320.03.01.03 Quality Control Program. Unless otherwise directed or approved by the *Engineer*, a written Quality Control Program shall be required for the *HMA* production process. This written plan shall be provided to the *Engineer* upon request. The *Agency* and/or *Engineer* shall have the option to inspect production facilities and/or request representative samples of mixture components or produced *HMA* for properties verification.

The overall plan shall address the individual elements which affect the quality of the *HMA* including, but not limited to, mix design; aggregate gradation; quality of materials; stockpile management; proportioning; mixing; transporting; and placing and compaction.

Processing and Stockpiling RAP for incorporation in HMA. *RAP* incorporated into *HMA* shall be processed and stockpiled in such a manner to produce a uniform *RAP* product. Layer placing or alternate approved methods shall be used to prevent coning or segregation of component sizes. The stockpile shall be maintained in a loose and uncompacted state. To prevent premature consolidation, *RAP* shall not be stored in confined metal bins or hoppers unless slated for immediate processing.

Immediately prior to feeding the *RAP* into the mixing plant, the material shall first pass through an apparatus which eliminates oversize material.

Process Control Plan. A written Process Control Plan shall be required from any construction material producer processing *RAP* to be incorporated in any percentage as a blend material during the production of *HMA*. This written plan shall be provided to the *Engineer* upon request. The *Agency* and/or *Engineer* shall have the option to inspect *RAP* processing facilities and/or request representative samples of processed *RAP* for properties verification.

The process control plan shall include a brief narrative for each location or facility where *RAP* processing occurs that describes procedures implemented during initial handling of unprocessed *RAP* materials. In an effort to optimize consistency of *RAP* to be incorporated in *HMA*, measures shall be described to minimize inclusion of undesirable materials such as lightweight aggregate, organics, dirt, concrete, and trash into the finished *RAP* product.

Process Control Testing. Process control testing shall be performed in conformance with Subsection 336.03.04. A summary of the results of all process control test data shall be included with the Process Control Plan.

320.03.01.04 Haul Route. Unless waived by the *Engineer*, the *Contractor* shall submit to the *Engineer* a document designating the route to be used for transporting of materials. The *Contractor* shall ensure that the document has been reviewed and accepted by the *Engineer* prior to proceeding with the related *Construction Activity*.

320.03.02 INSPECTION AND TESTING. Inspection and testing shall be performed in accordance with Subsection 100.16 – “Inspection” and the applicable Subsections of Section 336 – “Inspection and Testing”.

320.03.03 LIMIT OF WORK. The limit of work shall be in accordance with Subsection 100.18 – “Location of Work”.

320.03.04 SCHEDULING OF WORK. The *Contractor* shall prepare and provide to the *Engineer*, for review, a baseline schedule, weekly work agenda and monthly updates in accordance with Subsection 100.21 – “Progress Schedule”.

320.03.05 EXISTING IMPROVEMENTS AND SYSTEMS. Removal of existing improvements and systems shall be performed in accordance with Section 301 – “Removal of Existing Improvements”. The *Contractor* shall protect items not removed in accordance with Section 301.04 – “Protection of Items Not Removed”, except as modified herein.

320.03.05.01 Preparation of Existing Surface. When the surface of the existing bituminous pavement or old base is irregular, it shall be brought to uniform grade and cross section established. Tack coat shall be applied in accordance with Section 315 – “Prime Coat” and Section 316 – “Tack Coat”.

When shown on the *Plans* or specified in the *Special Provisions* and/or *Special Technical Specifications*, all longitudinal and transverse joints and all cracks shall be sealed by the application of the specified joint sealing compound before spreading the *HMA* on an existing bituminous pavement or *PCC* surface. All excess bituminous material shall be removed from joints and cracks prior to spreading the *HMA*.

Contact surface of existing curbing, gutters, manholes, and other structures shall be painted with a thin, uniform coating of asphalt emulsion prior to the *HMA* being placed against them in accordance with Section 315 – “Prime Coat” and Section 316 – “Tack Coat”

325.03.05.02 Temporary Resurfacing. The *Contractor* shall maintain all temporary resurfacing in a safe, rideable condition.

320.03.06 CONSTRUCTION EQUIPMENT. The *Contractor* shall provide all equipment, tools, and machinery in accordance with Subsection 100.34 – “Character of Workers; Methods and Equipment”, except as modified herein.

320.03.06.01 Hot Plant. Plants used for the preparation of *HMA* shall be of sufficient capacity and coordinated to adequately handle the proposed construction. Equipment shall be capable of heating to mixing temperatures in accordance with the manufacturer’s recommendations.

The plant shall be equipped with a suitable thermometric instrument placed at the discharge chute of the drier to automatically register or indicate the temperature of the heated aggregates.

The plant shall include satisfactory precipitation devices or use other methods which will meet local conditions, city, county, state, and federal laws pertinent to air pollution.

The maximum temperature of the *HMA* when leaving the plant shall be 350° F. The permissible moisture content of the *HMA* shall not exceed 1.0 percent as determined by AASHTO T 329. Should the aggregate contain excessive moisture when heated within temperature limits, the *Contractor* shall take satisfactory corrective action before resuming *HMA* operations.

Asphalt. Asphalt shall be measured or gauged and introduced into the mixer in the amount(s) specified by the job mix formula. The asphalt material shall be heated in a manner that will avoid local overheating and provide a continuous supply of asphalt to the mixer at a uniform temperature at all times.

An armored thermometer of adequate range in temperature reading shall be fixed in the asphalt feed line near the discharge valve.

Storage. Tanks for the storage of asphalt shall be equipped to heat and hold the material at the required temperatures. The heating shall be accomplished by steam coils, electricity, or other approved means so that no flame shall be in contact with the tank. The circulating system for asphalt shall be designed to assure proper and continuous circulation during the operating period. Provision shall be made for measuring the asphalt in the storage tanks.

Aggregates.

Heating and Drying. The plant shall include a drier or driers which continuously agitate the aggregate during the heating and drying process.

RAP. The plant shall be modified such that the combination of *RAP* and virgin aggregate can be heated to a temperature needed for a resultant mix temperature. The *RAP* shall be introduced into the plant in such a manner as to ensure uniform proportioning and to protect the material from direct contact with the burner flame.

Proportioning.

Batch Plant. Aggregates proportioned immediately after the heating and drying process shall be screened into a minimum of two fractions in the case where minus 1/2 Inch aggregate is used, and into a minimum of three fractions when larger sized aggregate is used. The screened material shall be conveyed to separate compartments ready for proportioning and mixing with asphalt material.

The dried aggregate shall be combined in the mixer in the amount of each fraction of aggregates required to meet the Job-Mix Formula (*JMF*).

Drum Plant. Aggregates proportioned prior to the heating and drying process shall be separated into at least three bins. Each portion of the material shall be stored separately. When moving the aggregate from storage to compartment bins, any method may be used which will not cause segregation, degradation, or combinations of aggregate which fail to meet the specified gradation requirements.

Lime Treatment.

Marination Method. Lime marinated aggregates shall be prepared in accordance with the Marination Method described in Subsection 401.03.08 – “Preparation of Aggregates”, of the *Silver Book*.

Dry Lime. The moisture content of the aggregate shall be a minimum of 4 percent prior to introduction of dry lime at the plant. The dry lime shall be delivered to the combined aggregates from the silo to a calibrated metering device which is interlocked with the aggregate control (electrically driven feeder actuated from the same circuit). When the aggregates and the lime have been combined, the entire mass shall be mixed until a uniform coating has been achieved.

Batch Plant. In batch plants, dry lime introduced at the plant shall be added to the aggregate prior to drying.

Drum Plant. In continuous mix and/or drum dryer plants, dry lime introduced at the plant shall be added to the aggregate after the aggregate is proportioned.

Mineral Filler. Mineral filler shall be drawn from a storage facility in which the mineral filler is agitated by air or other means to keep it in a uniform free flowing condition. The mineral filler for delivery to the mixer shall be from a vane-type metering device which is interlocked (electric driven feeders shall be actuated from the same circuit) to the flow of each aggregate feeder. The drive shaft on the mineral filler vane feeder shall be equipped with a revolution counter reading to 1/10 of a revolution, and a means for varying the rate.

Job Control Grading Band. During construction, test properties of the *HMA* furnished shall conform to Table 320.03.06.01-I.

TABLE 320.03.06.01-I

Test Property	Job Control Grading Band <i>Job-Mix Formula (JMF)</i>
Aggregate passing the No. 4 sieve and larger (%)	<i>JMF</i> Target Value ± 7
Aggregate passing the No. 8 to 100 sieves (%)	<i>JMF</i> Target Value ± 4
Aggregate passing the No. 200 sieve (%)	<i>JMF</i> Target Value $\pm 2^{(1)}$
Asphalt (%)	<i>JMF</i> Target Value $\pm 0.5^{(2)}$
Laboratory Air Voids (%)	<i>JMF</i> Target Value ± 1.5

1. Not to exceed 8%.
2. By total weight of the mix

Additives. Additives shall be measured or gauged and introduced into the mixer in the amount(s) specified by the *JMF*. Additives, when used, shall be controlled and handled in accordance with the manufacturer's recommendations.

320.03.06.02 Transport. Trucks used for hauling *HMA* shall have tight, clean, smooth metal beds which have been thinly coated with an asphalt release agent to prevent the *HMA* from adhering to the beds. Do not use diesel or kerosene. Tarps shall be used if the haul distance or hauling time results in cooling of the *HMA* to below temperature specified for placement at the work site.

320.03.06.03 Placement. Pavers shall be self-contained, power-propelled units, provided with an activated screed or strike-off assembly, heated if necessary and capable of spreading and finishing layers of *HMA* in lane widths applicable to the specified typical section and thicknesses shown on the *Plans*. Pavers used for shoulders and similar construction shall be capable of spreading and finishing layers of *HMA* in widths shown on the *Plans*.

Pavers shall be equipped with a receiving hopper having sufficient capacity for a uniform spreading operation. The hopper shall be equipped with a distribution system to place the *HMA* uniformly in front of the screed.

The screed or strike-off assembly shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the *HMA*.

Hydraulic strike-off screed extensions shall only be used for tapered sections and odd shaped areas. The *HMA* pavement for all uniform roadway sections shall be placed, spread, and compacted only by that portion of the paver equipped with a vibratory screed which is equipped with screed heaters.

Unless otherwise directed or approved by the *Engineer*, the paver shall be equipped with a leveling device which facilitates smooth transition between grade changes.

320.03.06.04 Finishing. The *Contractor* shall provide a minimum of two steel wheel rollers and one pneumatic roller, unless otherwise approved by the *Engineer*. All rollers shall have an operational reversing mechanism so that the roller is capable of changing directions smoothly.

Rollers shall be equipped with a system that prevents *HMA* from sticking to the wheels. A release agent may be used provided it does not damage the *HMA* or impede the bonding of layers.

Breakdown Rollers. Breakdown rollers shall be a two axle tandem weighing not less than 10 tons and capable of rolling with or without vibration.

Pneumatic Rollers. Pneumatic-tired rollers shall be equipped with pneumatic tires of equal size and diameter mounted on two axles attached to a rigid frame equipped with a loading platform or body suitable for ballast loading, so that the total operating weight of the roller is not less than 10 tons.

The tires on the rear axle shall be so spaced that the entire gap between adjacent tires on the front axle will be covered by one tread of the following tires. The tires shall be uniformly inflated so that the air pressure in the several tires will not vary more than 5 psi. The inflation pressure shall be in accordance with the tire manufacturer's recommendation. Minimum tire size shall be 7.50 by 15 Inches, four ply.

Finish Rollers. The finish roller shall be a two axle tandem steel wheel roller weighing not less than 8 tons.

320.03.07 CONSTRUCTION LOADS. The *Contractor's* operations shall not produce a surcharge which would impact stability of adjacent improvements.

320.03.08 SUBGRADE PREPARATION. *Subgrade* preparation shall be performed in accordance with Section 302 – “*Subgrade Preparation*”.

320.03.09 EXCAVATING. Excavating shall be performed in accordance with Section 303 - “*Excavating*”.

320.03.10 PLACING OF MATERIALS. The *Contractor's* operations shall not create dust hazard or other nuisance. The *Contractor* shall immediately remove and dispose of any nuisance material and/or spillage within the *Site of Work* and/or any routes used for transport of materials.

320.03.10.01 Spreading and Compacting. The *Contractor* shall ensure that the surface has been accepted by the *Engineer* prior to placing the *HMA*.

Tack Coat. Unless otherwise directed or approved by the *Engineer* tack coat shall be applied to the surface of *HMA* courses that are not constructed in the same shift. Tack coat shall be applied in accordance with Section 315 – “Prime Coat” and Section 316 – “Tack Coat”.

The *HMA* shall be spread and struck off to grade, and elevation established. Pavers shall be used to distribute the *HMA* either over the entire width or over such partial width as may be feasible.

Only in areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impracticable, the *HMA* may be spread by other means to obtain the specified lines, grades and cross sections. Use a pneumatic tamper, plate compactor, or equivalent, to achieve thorough compaction.

Lift Thickness. In no case shall the compacted thickness of a single lift be less than 3 times the nominal maximum particle size of the mix being placed, defined as one sieve size larger than the first sieve to retain more than 10% of the JMF, unless otherwise approved by the *Engineer*. In no case shall the compacted thickness of a single lift exceed 4 inches.

The paver(s) shall move at a uniform rate with a minimum amount of stopping. Placing of the *HMA* shall be as continuous as possible.

Unless otherwise directed or approved by the *Engineer*, the minimum temperature entering the paver shall be 250 °F.

Windrow Placement. At the *Contractor's* option, *HMA* base or surface material may be placed in a windrow in front of the paver. When used, the windrow shall be properly sized to insure the delivery of the correct amount of material to the paver at all times. The *HMA* shall be transferred from the windrow to the paver in such a manner that the materials in the paver will be uniform. The base, upon which the windrow was formed, shall not be disturbed during pickup of the *HMA*. There shall be no excess paving material remaining on this base between the pickup device and the paver.

320.03.10.02 Rolling. The *Contractor* shall use a rolling pattern which ensures satisfactory compaction. Unless otherwise directed or approved by the *Engineer*, initial rolling shall commence at the lower edge and shall progress toward the highest portion of the roadbed.

The breakdown roller shall immediately follow the paver and shall completely cover the *HMA* mat. The pneumatic roller shall follow the breakdown roller and shall completely cover the *HMA* mat. The pneumatic rolling shall be performed at a suitable temperature to ensure that *HMA* does not stick to the pneumatic tires. The finish roller shall follow the pneumatic roller and shall completely cover the *HMA* mat.

All rolling shall be performed in such a manner that cracking, shoving, or displacement will be avoided. The roller shall be kept in continuous motion while rolling so that all parts of the pavement shall receive equal compression. The motion of the roller shall be slow enough at all times to avoid displacement and cracking of the pavement. Any displacement occurring as result of reversing the direction of the roller, or from any other cause, shall be corrected immediately.

Unless otherwise directed or approved by the *Engineer*, rollers shall not pass over the unprotected edges of a freshly laid *HMA*.

Unless otherwise directed or approved by the *Engineer*, the finish rolling shall be completed while the temperature of the *HMA* is at or above 140°F.

320.03.10.03 Joints.

Longitudinal. Longitudinal joints shall be constructed only on the shoulders or edge of travel lanes. Longitudinal joints in *HMA* pavement shall be located to coordinate with the striping plan. Longitudinal joints shall be spaced in such a manner that joints in succeeding layers will overlap the joint of the preceding layer by at least 6 Inches horizontally.

When the temperature of the adjacent mat is less than 130°F, a tack coat shall be applied in accordance with Section 315 – “Prime Coat” and Section 316 – “Tack Coat” to the contact surface of longitudinal joints prior to placement of additional *HMA* against the previously rolled material.

Transverse. Transverse joints exposed to traffic shall be finished with a 25 horizontal to 1 vertical transition to the existing surface. The transition joint material shall be removed prior to placement of additional *HMA* by exposing the full depth of the mat and removing the excess material.

When the temperature of the adjacent mat is less than 130°F, a tack coat shall be applied in accordance with Section 315 – “Prime Coat” and Section 316 – “Tack Coat” to the contact surface of transverse joints prior to placement of additional *HMA* against the previously rolled material.

320.03.11 WEATHER LIMITATIONS.

320.03.11.01 Surface Moisture. *HMA* base layer or surface layer shall not be placed on a grade which is frozen or which has a moisture content which would be detrimental to the compaction or quality of the *HMA*.

320.03.11.02 Temperature. Dense grade *HMA* base layer or surface layer shall not be placed unless the both the ambient and surface temperatures conform to Table 320.03.11.02-I.

Table 320.03.11.02-I

Compacted Thickness	Ambient Temperature °F	Surface Temperature ⁽¹⁾ °F
Greater than 2 Inches	40 Minimum	40 Minimum
2 Inches or Less	45 Minimum	45 Minimum

1. Shall be measured on surface that is to be paved.

320.03.11.02.03 Open Grade. Unless otherwise directed or approved by the *Engineer*, open grade plantmix surface shall be placed only when the ambient and surface temperature is above 60 ° F.

320.03.12 MAINTENANCE OF TRAFFIC. Maintenance of traffic shall be performed in accordance with Section 100.33.01 – “Maintenance of Traffic”.

320.03.13 PROTECTION OF WORK AND CLEANING UP. Protection of work and cleaning up shall be in accordance with Section 100.44 – “Trees and Shrubs” and Section 100.37 – “Protection of Work and Cleaning Up”.

320.04 ACCEPTANCE. *HMA* pavement shall be accepted based on the following criteria:

- A. Surface tolerance;
- B. In place relative compaction; and
- C. Thickness.

320.04.01 SURFACE TOLERANCE. The surface of the compacted *HMA* pavement shall be smooth and free from irregularities due to placement operation, ruts, humps, depressions. Any ridges, indentations, or other objectionable marks left in the surface of the *HMA* by blading or other equipment shall be eliminated by rolling or other means. The use of any equipment that leaves ridges, indentations, or other objectionable marks in the mat surface shall be discontinued and other acceptable equipment shall be furnished by the *Contractor*.

Unless otherwise directed or approved by the *Engineer*, when a straightedge 12 feet long is laid on the surface of the compacted mat and parallel with the centerline of the roadway, the surface shall not vary more than 1/8 Inch from the lower edge of the straightedge. The transverse slope of the finished surface shall be uniform to a degree such that no depressions greater than 1/4 Inch are present when tested with a straightedge 12 feet long laid in a direction transverse to the centerline and extending from edge to edge of a 12 foot traffic lane. The finished grade of the pavement surface shall vary no more than 5/8 Inch from design finished grade in both profile and cross section.

320.04.01.01 Mitigation. Compacted *HMA* pavement surfaces which do not conform to Subsection 320.04.01 – “Surface Tolerance” shall be mitigated by grinding with an application of a surface seal. The seal shall be recommended by the *Engineer* and accepted by the Public Works Department of the maintaining *Agency* prior to application by the *Contractor* at no additional cost to the *Agency/Owner*.

320.04.02 RELATIVE COMPACTION. Relative compaction of the compacted layer shall be based on the *Theoretical Maximum (Rice) Specific Gravity* and determined in accordance with Subsection 336.18 – “*HMA*”. Each lot of compacted *HMA* shall have a *Rice Relative Compaction* between 97% and 92% for mixes with a target air void content of 4% and 98% and 93% for mixes with a target air void content of 3%.

320.04.02.01 Mitigation. Compacted *HMA* pavement which do not conform to Subsection 320.04.02 – “Relative Compaction” shall be evaluated for acceptance and mitigation by the *Engineer* in accordance with Tables 320.04.02.01-I for mixes with a target air void content of 4% or Table 320.04.02.01-II for mixes with a target air void content of 3%.

Table 320.04.02.01-I – 4% TARGET AIR VOID CONTENT

Introduction: This process is provided to assist in assessing compacted pavement for conformance with Subsection 336.03.04.02 – “Relative Compaction” and, if recommended for acceptance, providing recommendations for any mitigation measures needed to achieve the design service life of the pavement. The process requires sound engineering analysis and judgment. The *Engineer/Engineer of Record* shall evaluate all relative parameters, including mix properties; location within the pavement section and roadway cross section; environmental considerations; and future maintenance, and provide the recommendation regarding acceptance and any needed mitigation measures. The recommendation shall be stamped and signed by a *Professional Engineer* and provided to the Public Works Department of the maintaining *Agency* for determination of the acceptability of the recommendation. The *Engineer/Engineer of Record* shall include documentation from the Public Works Department of the maintaining *Agency* that any mitigation measures have been accepted with the letter of verification regarding the adequacy of the improvements. The *Contractor* shall comply with any mitigation measures at no additional cost to the *Agency/Owner*.

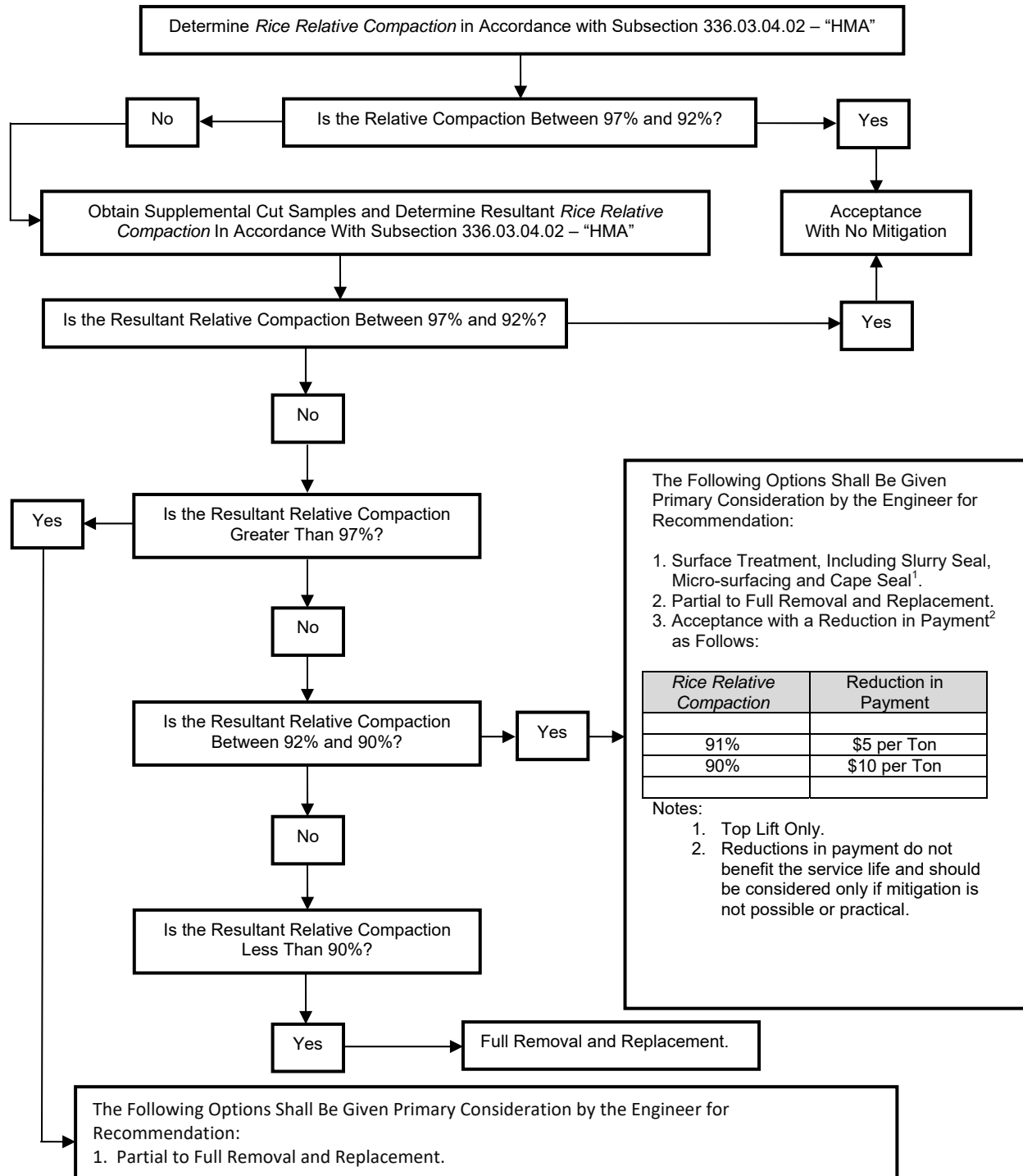
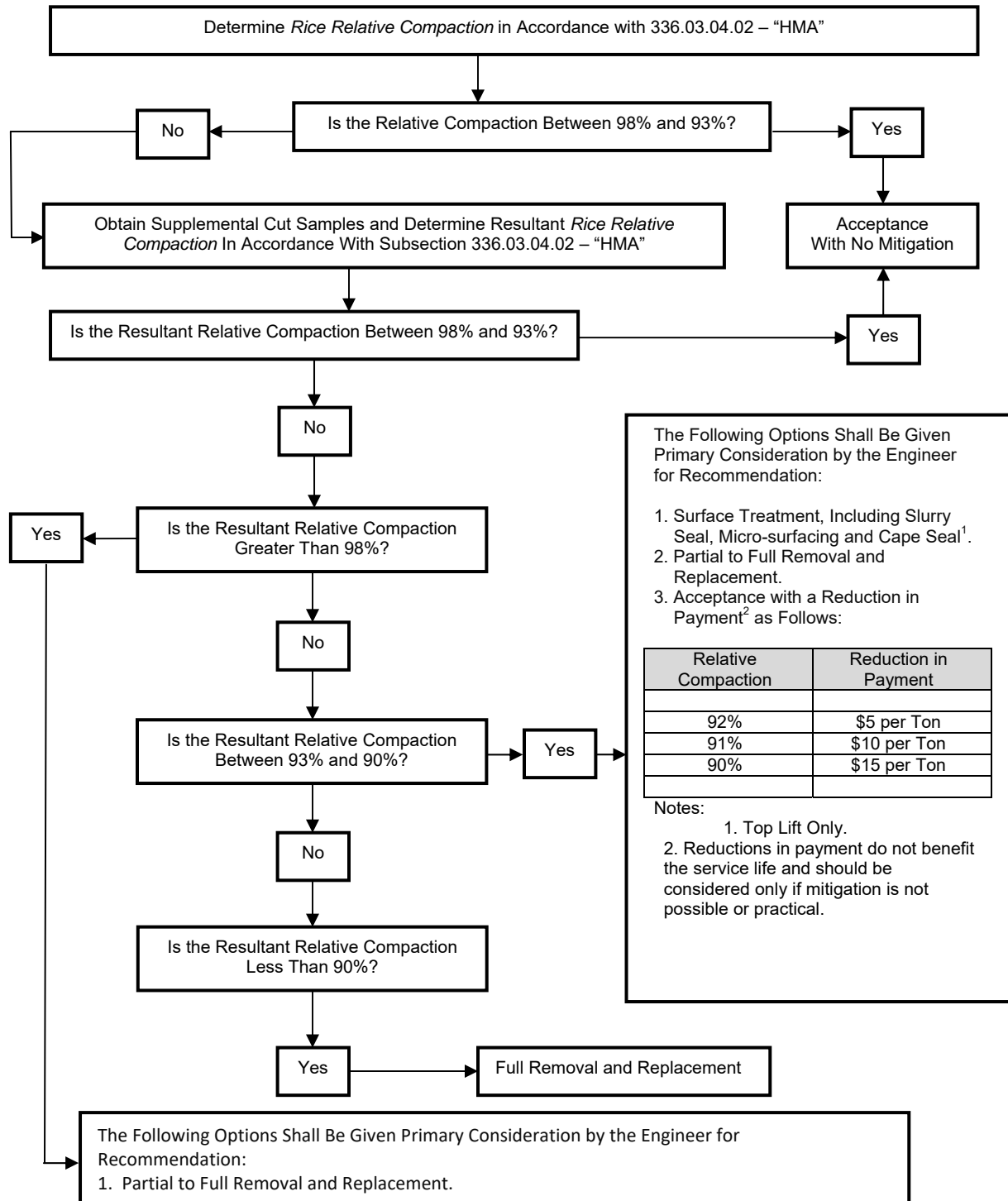


Table 320.04.02.01-II – 3% TARGET AIR VOID CONTENT

Introduction: This process is provided to assist in assessing compacted pavement for conformance with Subsection 336.03.04.02 – “Relative Compaction” and, if recommended for acceptance, providing recommendations for any mitigation measures needed to achieve the design service life of the pavement. The process requires sound engineering analysis and judgment. The *Engineer/Engineer of Record* shall evaluate all relative parameters, including mix properties; location within the pavement section and roadway cross section; environmental considerations; and future maintenance, and provide the recommendation regarding acceptance and any needed mitigation measures. The recommendation shall be stamped and signed by a *Professional Engineer* and provided to the Public Works Department of the maintaining *Agency* for determination of the acceptability of the recommendation. The *Engineer/Engineer of Record* shall include documentation from the Public Works Department of the maintaining *Agency* that any mitigation measures have been accepted with the letter of verification regarding the adequacy of the improvements. The *Contractor* shall comply with any mitigation measures at no cost to the *Agency/Owner*.

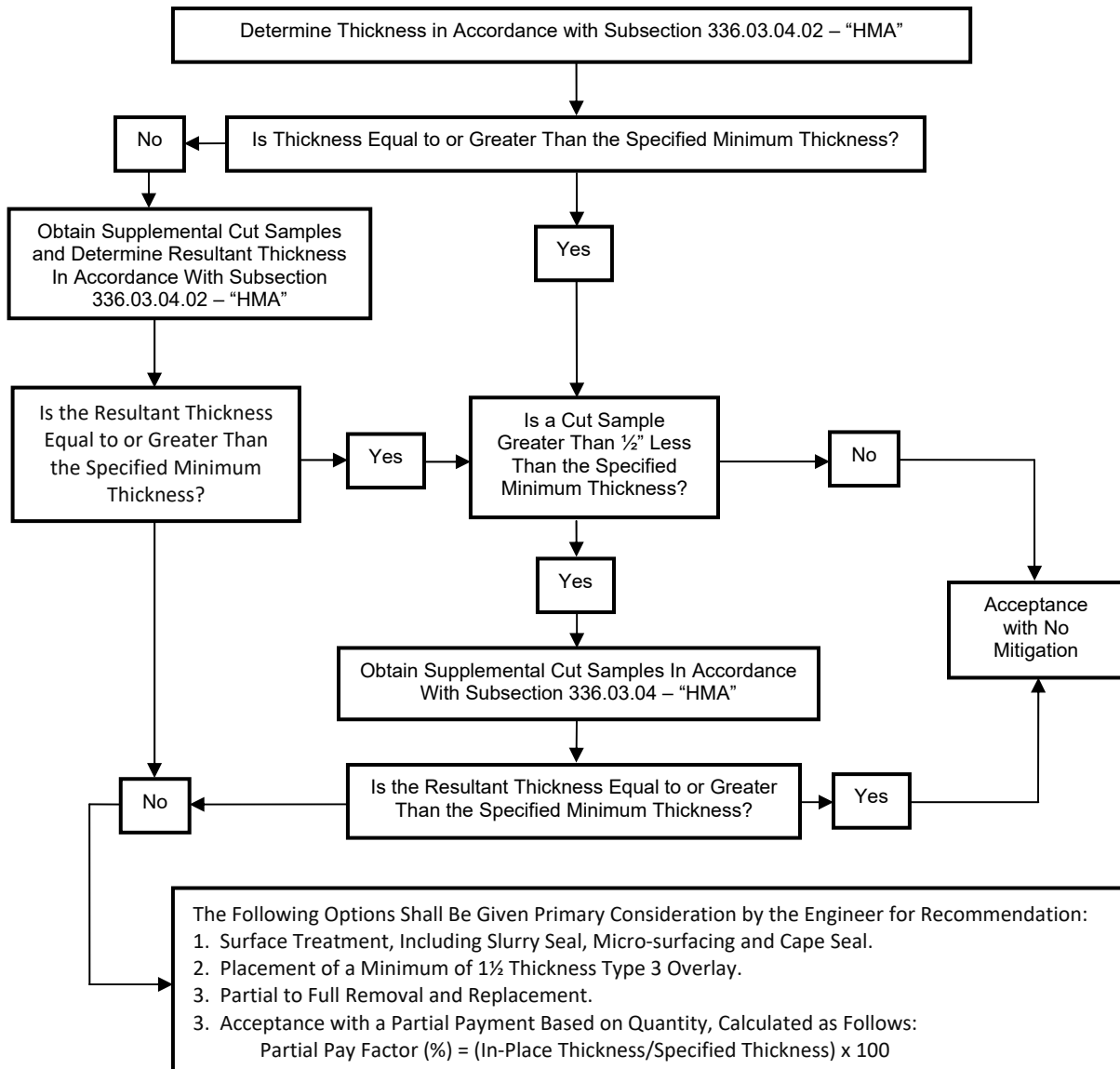


320.04.03 THICKNESS. Cut samples taken in accordance with Section 336.03.04.02 – “HMA” shall be used to determine conformance with thickness specifications. The average thickness of cut samples shall be at least equal to the specified minimum thickness of the *HMA* pavement per each lot sampled with no single core greater than ½” less than the specified minimum thickness.

320.04.03.01 MITIGATION. Compacted *HMA* pavement which does not conform to Subsection 320.04.03 – “Thickness” - shall be evaluated by the *Engineer* in accordance with Table 320.04.03.01-I.

Table 320.04.03.01-I

Introduction: This process is provided to assist in assessing compacted pavement for conformance with Subsection 336.04.03 – “Thickness” and, if recommended for acceptance, providing recommendations for any mitigation measures needed to achieve the design service life of the pavement. The process requires sound engineering analysis and judgment. The *Engineer/Engineer of Record* shall evaluate all relative parameters, including location within the pavement section and roadway cross section; environmental considerations; and future maintenance, and provide the recommendation regarding acceptance and any needed mitigation measures. The recommendation shall be stamped and signed by a *Professional Engineer* and provided to the Public Works Department of the maintaining *Agency* for determination of the acceptability of the recommendation. The *Engineer/Engineer of Record* shall include documentation from the Public Works Department of the maintaining *Agency* that any mitigation measures have been accepted with the letter of verification regarding the adequacy of the improvements. The *Contractor* shall comply with any mitigation measures at no additional cost to the *Agency/Owner*.



321.01 DESCRIPTION. This specification covers the placement of open-grade bituminous plantmix pavement in one course in accordance with this Subsection and in reasonably close conformity with the lines, grades, thickness, and the typical cross sections shown on the Plans or established by the Engineer.

The requirements of Section 320 - "Bituminous Plantmix" – shall be applicable to this work, except as hereinafter specified.

321.02 COMPOSITION OF MIXTURES. A mix design shall be performed and submitted to the Engineer in accordance with Subsections 337.01 "Mix Design" and 337.04 – "Bituminous Plantmix" to determine the composition of the mixture. The type and gradation and type and grade of bituminous material will be specified in the Contract in the Special Technical Specifications. No open-grade bituminous plantmix pavement shall be placed without approval by the Engineer of a mix design.

321.03 CONSTRUCTION. The construction requirements shall conform to the requirements as specified in Section 320 - "Bituminous Plantmix" – with the exceptions contained in the following four Subsections:

- A. Rollers. Contractor shall provide a minimum of two steel wheel rollers unless otherwise directed by the Engineer or Agency. There shall be operating with each paver two tandem rollers weighing not less than 8 nor more than 10 tons. When two pavers are paving in echelon, within 400 feet of each other, then two rollers may be used for both pavers.
- B. Joints. Longitudinal joints shall be constructed only on the shoulders, or at the edge of travel lanes. Whenever possible, longitudinal joints in open-grade pavement shall be located to coordinate with the striping plan.
- C. Tolerances. The completed surfacing shall be thoroughly compacted, smooth, and free from ruts, humps, depressions, or irregularities. When a straightedge 12 Feet long is laid on the finished surface and parallel with the centerline of the highway, the surface shall not vary more than 0.02 Foot from the lower edge of the straightedge. The transverse slope of the finished surface shall be uniform to a degree such that no depressions greater than 0.02 Foot are present when tested with a straightedge 12 feet long laid in a direction transverse to the centerline and extending from edge to edge of a 12 Foot traffic lane.

Any ridges, indentations, or other objectionable marks left in the surface of the bituminous mixture by blading or other equipment shall be eliminated by rolling or other means. The use of any equipment that leaves ridges, indentations, or other objectionable marks in the bituminous material shall be discontinued and other acceptable equipment shall be furnished by the Contractor.
- D. Weather Limitations. Open-grade plantmix surface shall be placed only when the pavement temperature in the shade is above 60 degrees Fahrenheit.

321.04 MEASUREMENT OF QUANTITIES. The quantity of open-grade bituminous plantmix pavement to be measured for payment will be the quantity compacted in-place which conforms to all the requirements for the completed work, measured in the field based on the Contract unit, as indicated in the Bid Proposal.

321.05 BASIS OF PAYMENT. The quantity of materials measured will be paid for at the Contract unit price bid per Contract item.

The Contract unit price bid per Contract item shall be full compensation for all work involved in constructing open-grade bituminous plantmix pavement, as shown on the Plans or established by the Engineer, including, but not limited to, furnishing all the material; mixing; loading; hauling; placing; and compacting.

Full compensation for furnishing and applying bituminous material or asphalt emulsion as a tack coat as required by the Plans and/or Specifications and/or as directed by the Engineer, in accordance with the applicable requirements of Section 316 – "Tack Coat" shall be considered as included in the Contract unit price bid for the principal items involved and no further compensation will be paid.

322.01 DESCRIPTION. This specification covers incorporation of reclaimed asphalt pavement (RAP) in bituminous plantmix.

The policy of the State of Nevada, enacted in 2012, is to encourage and promote the use of recycled aggregate, recycled bituminous pavement and recycled rubber from tires in the construction, reconstruction, improvement, maintenance and repair of public roads in the State of Nevada.

Recycled Bituminous Plantmix conforming to the requirements specified herein may be substituted at the Contractor's option for any lift of conventional bituminous pavement mixtures. The Agency or Design Engineer shall ensure the use of RAP is not restricted unless scientific evidence clearly indicates that the use of RAP compromises the structural integrity of the pavement.

The requirements of Section 320 – "Bituminous Plantmix" – shall be applicable to this work, except as herein specified.

322.01.01 PROCESSING AND STOCKPILING RAP FOR INCORPORATION IN RECYCLED BITUMINOUS PLANTMIX. RAP for incorporation in recycled bituminous plantmix shall be processed and stockpiled in such a manner to produce a uniform RAP product. RAP for Type 2 bituminous plantmix shall be sized so that 100 percent of that product passes a 3/4" sieve. RAP for Type 3 bituminous plantmix shall be sized so that 100 percent of that product passes a 1/2" sieve. It shall be the materials producers' option to determine whether individual RAP products shall be further fractionated.

322.01.02 PROCESS CONTROL PLAN. A written Process Control Plan shall be required from any construction material producer processing RAP to be incorporated, in any percentage, as a blend material during the production of recycled bituminous plantmix. This written plan shall be submitted for approval by the Agency or Design Engineer prior to production and placement of any recycled bituminous plantmix containing RAP. The Agency and/or Design Engineer shall have the option to inspect RAP processing facilities and/or request representative samples of processed RAP for properties verification.

The process control plan shall include a brief narrative for each location or facility where RAP processing occurs that describes procedures implemented during initial handling of unprocessed RAP materials. In an effort to optimize consistency of RAP to be incorporated in recycled bituminous plantmix, measures shall be described to minimize inclusion of undesirable materials such as lightweight aggregate, organics, dirt, concrete, and trash into the finished RAP product.

322.01.02.01 Process Control Testing. Process control testing shall be performed in conformance with Subsection 336.03.04.06 – "Recycled Bituminous Plantmix". The sample location for the process control testing shall be the finished RAP stockpile. A summary of the results of all process control test data shall be included with the Process Control Plan submittal.

322.02 COMPOSITION OF MIXTURES. The RAP stockpile shall be produced and tested prior to the performance of a mix design. The mix design, specific to the RAP stockpile, shall be performed and submitted to the Engineer in accordance with Subsections 337.01 "Mix Design" and 337.05 – "Recycled Bituminous Plantmix" to determine the composition of the mixture. The type and gradation of aggregate and type and grade of bituminous material will be specified in the Contract in the Special Technical Specifications. No bituminous plantmix using RAP shall be placed without approval by the Engineer of a mix design. If the original mix design stockpile is supplemented during the one year approval period of the mix design, testing of the supplemented RAP shall be conducted in accordance with Subsection 322.01.02.01 – "Process Control Testing".

322.02.01 JOB CONTROL GRADING BAND. During construction, the gradation and asphalt cement content of the mixture furnished shall be maintained within the job control grading band. The job control grading band shall be developed by applying the maximum tolerances contained in Table 322.02.01-I to the job mix formula.

TABLE 322.02.01-I

Constituent	Maximum Tolerance
Aggregate passing the No. 4 sieve and larger	Plus or Minus 7 Percent
Aggregate passing the No. 8 to 100 sieves	Plus or Minus 4 Percent
Aggregate passing the No. 200 sieve	Plus or Minus 2 Percent
Asphalt Cement	Plus or Minus 0.5 Percent ⁽¹⁾

1. By total weight of the mix

In no case shall the resulting job control grading band exceed the limits of the specification grading band of Table 200.02.03-I.

322.02.02 MIXING AND COMPACTING TEMPERATURES. The mixing and compacting temperatures of plantmix bituminous mixtures with asphalt cement shall conform to the requirements of the mix design.

322.03 CONSTRUCTION. The construction requirements shall conform to the requirements of Subsection 320.03 – “Construction”, except as modified herein.

322.03.01 BITUMINOUS MIXING PLANT. The plant shall meet all of the requirements of Subsection 320.03.01 – “Construction”. In addition, the control and handling of the recycling agent shall be in a manner similar to that specified for the bituminous material.

If the batch plant is used, the plant shall be modified so that the virgin aggregate can be superheated to a temperature required to produce a resultant mix temperature as specified in Subsection 320.02.02 – “Mixing and Compacting Temperatures”, after adding the ambient temperature RAP. The plant shall also be modified to feed the RAP to the aggregate weight hopper in a manner to insure uniform proportioning.

If a dryer drum is used, the plant shall be modified to produce the required resultant mix temperature, or the combination of RAP and virgin aggregate can be heated to a temperature needed for a resultant mix temperature as specified in Subsection 320.02.02 – “Mixing and Compacting Temperatures”. The RAP shall be introduced into the plant in such a manner as to insure uniform proportioning and to protect the material from direct contact with the burner flame.

Regardless of the type of bituminous mixing plant used, the air pollution requirements as set forth by owner and state law shall apply to the manufacture of recycled bituminous pavement.

322.03.02 PREPARATION OF AGGREGATES. Virgin aggregates shall be prepared as specified in Subsection 320.04.02 – “Aggregates”.

The RAP stockpiling area shall be graded and compacted so a firm, smooth, well drained area can be maintained at all times. Layer placing or alternate approved methods shall be used to prevent coning or segregation of component sizes. The stockpile shall be maintained in a loose and uncompacted state. To prevent premature consolidation, RAP shall not be stored in confined metal bins or hoppers unless slated for immediate processing.

Immediately prior to feeding the RAP into the mixing plant, the material shall first pass through an apparatus which eliminates oversize material.

322.04 ACCEPTANCE. Pavement utilizing recycled bituminous plantmix shall be accepted in accordance with Subsection 320.06 – “Acceptance”.

322.05 MITIGATION OF UNACCEPTABLE RECYCLED BITUMINOUS PLANTMIX PAVEMENT. Pavement utilizing recycled bituminous plantmix shall be mitigated in accordance with Subsection 320.06 – “Mitigation of Unacceptable Bituminous Plantmix Pavement”.

322.06 MEASUREMENT OF QUANTITIES. Pavement utilizing recycled bituminous plantmix shall be measured as in accordance with Subsection 320.08 – “Measurement of Quantities”.

322.07 BASIS OF PAYMENT. Pavement utilizing recycled bituminous plantmix shall be paid in accordance with Subsection 320.09 – “Basis of Payment”.

323.00-1**ADJUSTMENT OF NEW AND EXISTING MANHOLES,
CATCH BASINS, VAULTS, WATER AND GAS
VALVES, AND MONUMENTS TO FINAL GRADES**

323.01 DESCRIPTION. This work shall consist of all labor, equipment, and materials necessary to adjust new and existing manholes, catch basins, vaults, water and gas valves, monuments, and similar structures to final grade.

323.02 GENERAL. Frames, covers, or grates of existing manholes, inlets, monument boxes, or other facilities shall be adjusted to grade with new material similar in character to those in the original structure and in accordance with the provisions of these Specifications and the Special Provisions or as directed by the Engineer.

After the existing cover or grate frame has been removed, the top of the structure to be raised shall be trimmed to provide a suitable foundation for the new material.

323.03 ASPHALT CONCRETE WORK. On asphalt concrete paving projects, final adjustment of castings shall be commenced at such time as there is sufficient street paving to allow a reasonable progressive program of adjusting. Where a number of castings exist in the area, their adjustment shall be programmed as the Engineer directs so that traffic will be permitted to use the street in a reasonable, efficient, and safe manner.

The Contractor shall be required to patch around all castings owned by the Agency, the cost of which will be incidental to the cost of the works.

The Contractor shall reference all manholes before resurfacing. After the asphalt concrete surfacing top or wearing course has been placed, the manholes shall be located from reference points and pavement over and around the castings removed to allow adjustment as outlined in the previous Sections.

New manholes being constructed shall be constructed to grades as shown on the Plans.

Existing manholes shall be remodeled as shown on the Plans in accordance with the Specifications and the Special Provisions.

All manholes that are to be lowered shall be removed as directed by the Engineer to an approximate depth of 3 feet below finished grade and shall then be reconstructed with the proper taper to the finished grade.

323.04 ABANDONMENT OF EXISTING STRUCTURES. When existing manholes or drop inlets are to be abandoned, all pipes entering the manhole or inlet shall be securely closed by a tight fitting plug or wall of cement concrete not less than 6 inches thick, or by a tight brick wall not less than 8 inches thick with cement mortar joints. The manhole or inlet shall be demolished to an elevation of 3 feet below finished grade and backfilled with suitable backfill material.

323.05 UTILITY MANHOLES AND VAULTS. Utility manholes and vault frames and covers shall be adjusted to grade in conformance with the requirements of the appropriate Utility or as directed by the Engineer. Appropriate Utilities shall be notified by the Contractor of his intentions prior to the commencement of work.

323.06 MONUMENTS, GAS VALVES, AND WATER VALVES. Monuments, gas valves, and water valves shall be constructed and/or adjusted to grade in the same manner as manholes.

323.07 MEASUREMENT OF QUANTITIES AND BASIS OF PAYMENT. Unless specified otherwise in the Contract Documents, no direct payment shall be made for the adjustment of the above utilities to final grade. On paving or resurfacing projects, the work shall be considered a part of the paving or resurfacing work. New frames and structures to be adjusted shall be considered a part of the work required for the structure.

324.01 DESCRIPTION. This work shall consist of the preparation of surfaces to be painted, pavement to be striped or marked, and the application, protection, and drying of the required number of coats of paint of the kinds and at the points specified or ordered by the Engineer.

324.02 MATERIALS. All materials shall be in accordance with Section 214 – “Paint,” – of these Specifications and shall meet or exceed the minimum standards hereinafter set forth:

324.02.01 Raw Materials. American Society for Testing Materials (ASTM) and Federal Specifications.

324.02.02 Prepared Paints. Federal Specifications are specified to designate the type of material and standard of quality. Manufacturer’s standard, first grade materials meeting or exceeding these requirements may be used if approved by the Engineer. Materials not bearing manufacturer’s identification as a standard, first grade product of his regular line will not be considered.

324.02.03 Proprietary Materials. Proprietary materials when specified hereinafter by the manufacturer’s trade name designate the standard of quality or type of material required. When the quality or type of material required is not specified, the Contractor shall apply for directions as to selection of materials and receive approval thereof from the Engineer before proceeding; only the best quality of such materials shall be used, as determined by the Engineer.

324.02.04 Materials List. Materials lists shall be submitted to the Engineer for approval and none shall be used until such approval has been obtained. All materials proposed for use shall be delivered to the site in original containers, seals unbroken, stored where directed, and none may be used until approved by the Engineer. Materials that are not approved must be immediately removed from the job site.

324.02.05 Number of Coats. Unless otherwise required in the Contract Documents, the number and kinds of coats of paint shall be as set forth in Section 214 – “Paint.”

324.03 CONSTRUCTION

324.03.01 Weather Limitations. Paint shall be applied only on thoroughly dry surfaces and during periods of favorable weather. Except as provided below, painting will not be permitted when weather conditions during applications are such that the atmospheric temperature is at or below 40 degrees Fahrenheit or when freshly painted surfaces may become damaged by rain, wind, dust, or condensation, or when it can be anticipated that the atmospheric temperatures will drop below 40 degrees Fahrenheit during the drying period. If fresh paint is damaged by the elements, it shall be replaced by the Contractor at his expense.

Subject to the approval of the Engineer in writing, the Contractor may provide suitable enclosures to permit painting during inclement weather. Provisions must be made to control atmospheric conditions artificially inside the enclosures within the limits suitable for painting throughout the painting operation. The cost of providing and maintaining such enclosure shall be considered as included in the prices paid for the various contract items of work and no additional payment will be made therefor.

324.03.02 Workmanship. All work shall be done by painters and finishers of established status and reputation for executing their work by the very best methods for each kind or type. Painting shall not be done except when the surface is dry and when weather conditions are satisfactory as set forth above.

Strict adherence to these Specifications and the recommendations of the manufacturer whose materials are used shall be followed in the application. The Contractor shall use such skills, equipment, materials, and give his thorough attention to details as will provide thoroughly workmanlike and satisfactory results throughout.

Work which shows carelessness, lack of skill and execution, or which is defective due to any other cause shall be removed and refinished or repainted as directed without additional cost to the Owner. On all surfaces which are inaccessible for brushing, the paint shall be applied by sheepskin daubers especially constructed for the purpose, or by other means approved by the Engineer.

If spray methods are used, the operator shall be thoroughly experienced. Runs, sags, thin areas in the paint coat, or skips and holidays shall be considered as evidence that the work is unsatisfactory and the Contractor may be required to apply the remainder of the paint by brush.

Mechanical mixers shall be used to mix the paint. The paint shall be mixed a sufficient length of time, prior to use, to thoroughly mix the pigment and vehicle together. Paint shall be kept thoroughly mixed while being applied to keep the pigments in suspension.

Paint specified or formulated shall be ready for application and thinning will be allowed only on direction of the Engineer.

The Contractor shall protect all parts of the structure being painted against disfigurement by splatters, splashes, and smudges of paint or paint materials. When paint is being applied on structures carrying public traffic, the Contractor shall be responsible for any damage caused by his operations to passing vehicles or persons and may be required to use canvas shields or other protective means to guard against such damage.

Paint stains which result in an unsightly appearance shall be removed by the Contractor at his own expense.

324.03.03 Surface Preparation of Steel Surfaces. The following methods of surface preparation apply to steel surfaces. Unless otherwise specified, the sandblasting method shall be used.

- a. Sandblasting. All visible oil, grease, dirt, mill scale, rust, old paint, and other foreign material shall be removed from steel surfaces by an approved blast cleaning apparatus. Blast cleaning shall be sufficient to meet the requirements of Steel Structures Painting Council, SSPC Specifications SP-10, Photo Vis: C Sa 2 1/2 Near-White.

Abrasives used for such blast cleaning shall be either clean dry sand, mineral grit, steel shot, or steel grit, at the option of the Contractor, and shall be a grading suitable to produce satisfactory results. The use of abrasives other than those specified herein will not be permitted unless approved in writing by the Engineer.

When sandblasting is being performed on structures open to traffic, the Contractor shall provide suitable protective devices to prevent damage to traffic.

When sandblasting is being performed near machinery, all journals, bearings, motors, and moving parts shall be sealed against entry of sand dust before sandblasting begins.

Unless otherwise authorized by the Engineer, sandblasted surfaces shall be primed or treated the same day sandblasting is done. If cleaned surfaces rust before painting is accomplished, they shall be recleaned by the Contractor.

- b. Washes. Rust-inhibitor chemical washes shall be applied to freshly sandblasted steel surfaces prior to the application of the first undercoat of paint, except whenever the first undercoat of paint is applied to the cleaned surfaces within a 4 hour period after cleaning, washes will not be required. Washes shall be applied in not more than 4 hour intervals. If in the opinion of the Engineer, atmospheric conditions are such that corrosion products form on freshly sandblasted surfaces in less than 4 hours, treatment may be required at more frequent intervals.

Rust-inhibitor chemical washes may be applied by brush or spray, and they shall be applied in a careful manner to insure that all surfaces are covered.

During the application of the rust-inhibitor chemical wash, no sandblasting will be permitted to the areas being treated.

No paint shall be applied until after the treated surfaces have thoroughly dried.

The first undercoat of paint shall be applied to the treated surfaces the same day that cleaning and washing have been done.

- c. Steam Cleaning. All dirt, grease, loose chalky paint, or other foreign material which has accumulated on the previously painted surfaces shall be removed with an approved steam cleaning apparatus which shall precede all other phases of cleaning.

It is not intended that sound paint be removed by this process. Subsequent painting shall not be performed until the cleaned surfaces are thoroughly dry and in no case in less than 24 hours after cleaning.

A detergent soap consisting of 45 percent sodium metasilicate, 43 percent sodium sesquiosilicate, 10 percent sodium tetraphosphate, and 2 percent Naccanol shall be added to the feed water of the steam generator at the approximate rate of 1 pound of detergent per 200 pounds of water.

Any residue which may accumulate on cleaned surfaces shall be removed by flushing with fresh water, but washing down the cleaned surfaces will not otherwise be required.

- d. Hand Cleaning. All dirt, loose rust, and mill scale, dead paint, or paint which is not firmly bonded to the metal surfaces shall be removed by wire brushes, either hand or powered, hand scraping tools or sandpaper.

Pneumatic chipping hammers will not be allowed unless authorized in writing by the Engineer. Hand cleaning shall be sufficient to remove all loose material which would prevent the bond of succeeding coats of paint.

Hand cleaning will be permitted as an alternative to sandblasting on all steel except bridge girders. Bridge girders shall be cleaned by method (a) – “Sandblasting” – supplemented by minor amounts of hand cleaning as determined by the Engineer.

324.03.04 PAINTING STEEL SURFACES

- a. Paint. The paint to be applied to the steel surfaces shall conform to the requirements of Section 214 – “Paint,” – of these specifications. A minimum of three coats of paint shall be required. The prime coat shall consist of a minimum dry film thickness of 2 mils. The intermediate coat shall consist of a minimum dry film thickness of 1 and 1.5 mils. The intermediate coat of paint shall be of such shade as to contrast with both the prime and finish coats. The finish coat shall consist of a minimum dry film thickness of 1 and 1.5 mils. The total thickness of all coats shall not be less than 5 mils.

Excessively thick coats of paint will not be permitted. The thickness of each coat shall be limited to that which will result in uniform drying throughout the paint film.

Prior to erection, all new structural steel shall be cleaned and painted with the prime coat of paint.

- b. Field Cleaning. Unless otherwise specified in the Contract Documents, after erection and riveting or welding, all surfaces of unpainted structural steel which will be exposed to air, shall be sandblasted in accordance with the requirements of Subsection 324.03.03 – “Surface Preparation of Steel Surfaces.”

Any damage resulting from the Contractor's operations to **sound** paint on areas not designated for treatment shall be repaired to the satisfaction of the Engineer.

- c. Painting. Painting of structural steel prior to erection will be limited to surface preparation and one undercoat of paint. Any deficiencies in the first coat of paint shall be corrected to the satisfaction of the Engineer, prior to the application of succeeding coats of paint.

Surfaces exposed to the atmosphere which would be inaccessible for painting after erection shall be painted the full number of coats prior to erection.

The surface of the paint coat being covered shall be free from moisture, dust, grease, or any other deleterious material which would prevent the bond of the succeeding paint coats. In spot painting, any old paint which lifts after application of the first spot coat shall be removed by scraping and the area repainted before application of the next coat.

The application of the finish coat will not be permitted until the required total film thickness of the undercoats of paint as described in Subsection 324.03.04 (a) – “Paint” – (above) is obtained.

Open seams at contact surfaces of built-up members which would retain moisture shall be caulked with red lead paste before applying the second undercoat of paint.

Metal surface to be embedded in concrete need not be painted.

- d. Machine Finished Surfaces. With the exception of abutting chord and column splices, and column and truss shoe bases, machine finished surfaces shall be coated with a rust inhibitor which can be easily removed. Surfaces of iron and steel castings which have been machine finished shall be painted with a coat of shop paint.
- e. Frames and Grates. Prior to installation, all surfaces of frames and grates exposed to the atmosphere shall be painted with two coats of paint. Unless otherwise specified in the Contract Documents, the exposed surfaces shall be painted after installation with one finish coat as specified for structural steel.

324.03.05 Painting Timber. All new timber requiring painting shall be painted with three coats of paint. The paint used for various coats will be as specified in these Specifications or in the Contract Documents.

- a. Preparation of Surfaces. All cracked or peeled paint, loose chalky paint, dirt, and other foreign matter shall be removed by wire brushing, scraping, or other approved means immediately prior to painting. Unpainted timber shall be thoroughly dry before paint is applied.
- b. Painting. When permitted in writing by the Engineer, the first coat of paint may be applied prior to erection.

After the first coat has dried and the timber is in place, all cracks, checks, nail holes, etc., shall be puttied flush with the surface and allowed to dry before the second coat is applied.

Skips, holidays, thin areas, or other deficiencies in any one coat of paint shall be corrected to the satisfaction of the Engineer before the succeeding coat is applied.

The surface of the paint coat being covered shall be free of any deleterious material before any additional paint is applied.

324.04 PAVEMENT STRIPING AND MARKINGS. The Contractor shall apply all traffic striping, marking, and all other directional information on the surfaces of highways, streets, detour roads, parking lots, median strips, and curbing only when required by the Contract Documents.

Should the Contractor elect to alter the existing traffic stripes and markings, or to divert the flow of traffic on construction projects for his own convenience and there are no specific pavement markings or lane delineations shown on the Plans or in the Special Provisions, he shall, with the approval of the Engineer, provide the necessary temporary striping in accordance with the M.U.T.C.D. at no expense to the Contracting Agency.

When not otherwise shown on the Plans, detour transitional traffic line striping shall have a minimum taper of 20:1 for temporary striping and 30:1 for permanent striping. Temporary traffic lanes shall be at least 10 feet wide and no lane shall encroach within 5 feet of an open excavation or within 2 feet of a longitudinal curb.

All traffic stripes (except black stripes) shall be beaded on the final finish coat in accordance with Subsections 214.03.03 – "Traffic Beads" – and 324.08 – "Reflective Material."

The Contractor shall furnish all equipment, materials, labor, and supervision necessary for painting traffic lanes, directional arrows, guide lines, curbs, parking lanes, crosswalks, and other designated markings in accordance with the Plans, or for approved temporary detours essential for safe control of traffic through and around the construction site. The Contractor shall remove by wet sandblasting (or by other approved methods) all existing or temporary traffic markings and lines that may confuse the public. When temporary detour striping or markings are no longer required, they shall be removed prior to painting the new traffic stripes or markings.

324.04.01 Weather Limitations. All paint shall be applied within the temperature range specified by the Engineer or as recommended by the paint manufacturer. Paint shall be applied only when the pavement surface is dry and clean, when the air temperature is above 40 degrees Fahrenheit, and when the weather is not windy, foggy, or humid.

324.04.02 Equipment. All equipment required to perform the work shall be approved in advance by the Engineer and shall include such apparatus as brushes, brooms, compressors, air blowers to properly clean the pavement surface, a mechanical marking machine, a suitable device for heating the paint to the specified temperatures, a bead dispensing device, and auxiliary hand spray paint equipment, paint rollers, or other equipment as may be necessary to satisfactorily complete the work.

The striping machine shall be an approved spray-type marking machine suitable for applying traffic paint at the temperatures specified in Subsection 324.04.01 for the particular paint or as recommended by the paint manufacturer. It shall have sufficient paint capacity for each color with adequate air pressure to perform the work satisfactorily without excessive stopping. The machine shall produce a uniform thickness and cross section at the required coverage and shall produce markings with clean-cut edges without running or spattering. It must be capable of being guided within the straightness tolerances set forth in these Specifications. The machine shall have suitable adjustments for painting the line width specified and, when required, shall be equipped with an automatic cycling device to produce intermittent (skip) lines. A standard Skip-line pattern is normally a 24 foot cycle of which 9 feet are painted and 15 feet are unpainted. However, the machine shall be equipped to produce a variable skip pattern, including simultaneous paint of a broken line on one side and a solid line on the other side of a multiple stripe. An acceptable tolerance in the skip pattern is plus or minus 6 inches.

The striping machine shall be capable of three gun applications consisting of one black and two yellow spray guns operating simultaneously or individually. The equipment shall also be capable of operating two white guns simultaneously.

The striping machine shall have a wheel base of sufficient length to produce a straight line to meet the straightness tolerance specified. The machine must also be capable of producing curved lines without abrupt breaks, in accordance with approved layouts.

Provisions shall be made for a dispenser capable of applying glass beads at the required rates.

Equipment for applying molten thermoplastic material shall readily extrude the material between 400-425 degrees Fahrenheit to produce a continuous line 1/8 inch to 3/16 inch thick, of uniform cross section, and having clear sharp dimensions.

Thermoplastic material may also be applied by an approved machine that flame sprays the material onto clean road surfaces. This machine shall be capable of applying a coat 10 mils thick which will dry to "no pick up" in accordance with ASTM D 711. The equipment shall produce a smooth continuous line having clear sharp dimensions.

Word markings, letters, numerals, and symbols shall be applied using suitable spray equipment together with stencils and templates.

The Contractor shall provide a wet sandblasting machine with sufficient sand, water, and air capacity to completely remove all existing or temporary traffic striping or markings that may be confusing to the public. This machine shall meet all requirements of the air pollution control district having jurisdiction. All sand used in wet sandblasting shall be removed from the pavement without delay as the sandblasting operation progresses. Removal of striping by high velocity water jet may be permitted when approved by the Engineer.

324.04.03 Geometry, Stripes, and Traffic Lanes. Permanent and temporary striping and marking shall be in accordance with the M.U.T.C.D. manual and the Nevada Control manual.

324.05 SURFACE PREPARATION. Existing markings and striping, either permanent or temporary, which are to be abandoned or obliterated shall be removed by wet sandblasting or other approved methods. Dry sandblasting may be used in selected areas only with the permission of the Engineer and with approval of the air pollution control authority having jurisdiction over the area in which the work will be performed. Alternate methods of paint removal require prior approval of the Engineer. Obliteration of traffic striping with black paint or light emulsion oil shall be done only with the prior approval of the Engineer.

Before applying paint, the existing pavement surface shall be cleaned by washing, sweeping, blowing, or vacuuming as necessary to remove moisture, dirt, grease, oils, acids, laitance, or other foreign matter which would reduce the bond between the paint and the pavement. Areas which cannot be satisfactorily cleaned shall be scrubbed with a water solution of tri-sodium phosphate (10 percent Na₂ PO₄ by weight) or other approved cleaning solution. After cleaning, the surface shall be rinsed with water and dried before painting.

324.06 CONTROL POINTS. When necessary, the Engineer will furnish the necessary control points for all required pavement striping and markings. The Contractor shall establish all traffic striping between these points by stringline or other method to provide striping that will vary not more than 1/2 inch in 50 feet from the specified alignment.

When no previously applied figures, markings, or traffic striping are available to serve as a guide, suitable layouts shall be spotted in advance of the permanent paint application. Traffic lines may be spotted by using a rope as a guide for marking spots every 5 feet, by using a marking wheel mounted on a vehicle, or by any other means satisfactory to the Engineer.

The Contractor shall stripe or otherwise delineate the traffic lanes per the M.U.T.C.D. manual in the new roadway or portion of roadway, or detour before opening it to traffic if it is required by the Contract Documents.

The Contractor shall provide an experienced technician to supervise the location, alignment, layout, dimensions, and application of the paint.

324.07 APPLICATION. Traffic striping and marking shall be applied at locations and to the dimensions and spacing indicated on the approved Plans or as provided in the Special Provisions. Where temporary traffic striping and marking is required, it shall not be applied until the layouts, alignments, sequencing, and condition of the existing surface have been approved.

Paint shall be mixed in accordance with the manufacturer's instructions. It shall be mixed thoroughly and applied to the surface at the proper temperature, at its original consistency without the addition of any paint thinner. If the paint is applied in two coats, the first coat shall be thoroughly dry before the second coat is applied. Before applying thermoplastic paint on concrete surfaces, there shall be a prime coat consisting of either a two component epoxy or a 15 percent solution of buna N rubber in methyl-ethyl ketone applied 1/2 hour before application of the thermoplastic paint.

Traffic striping shall be applied in one application.

If the paint is applied in two coats, beads will be required only in the second coat. The first coat shall be thoroughly dry before the second coat is applied. On open-graded surfaces, the second coat shall follow no sooner than 14 calendar days after initial application.

Ten days shall elapse between the application of a bituminous seal coat and the permanent traffic marking. The paint shall not bleed, curl, or discolor when applied to bituminous surfaces. If bleeding or discoloring occurs, the unsatisfactory areas shall be given an additional coat of paint.

Straight strips deviating more than 1/2 inch in 50 feet shall be obliterated by sandblasting and the markings corrected. The width of markings shall be as designated, within a tolerance of 4 percent. When existing striping and markings are to be repainted, they shall be repainted so as to completely cover the old markings within 1/4 inch. Stripe repainting shall be retraced with a longitudinal tolerance of 6 inches plus or minus at the end of each stripe. Abrupt breaks in striping alignment will not be allowed. The striping shall be a continuous operation except where crossovers are required to complete painted medians.

All painting shall be performed by competent and experienced equipment operators and painters using proper equipment, tools, stencils, templates, and shields in a workmanlike manner.

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Difficulties normally experienced in cool weather shall be minimized by heating the traffic paint to provide for a uniform flow of material.

Reflective material shall be applied to traffic stripes and markings, in accordance with Subsection 324.08 – “Reflective Material” – and 214.03.03 – “Traffic Beads.”

Temporary striping and marking shall be renewed when the stripes and markings have lost 50 percent of their original visual effectiveness.

All paint materials shall be tested before application to verify that they meet the Specification requirements. The Engineer shall be notified upon delivery of the paint to permit inspection and sampling. When required by the Engineer, the Contractor shall furnish a notarized certificate signed by either an authorized employee of the manufacturer or test laboratory or both stating that the paint conforms to the specified requirements. This certificate shall not be interpreted as final approval of paint.

324.08 REFLECTIVE MATERIAL. Reflective material shall consist of glass beads in conformance with Subsection 214.03.03 – “Traffic Beads” – of these Specifications. Reflective material shall be added to the surface of the final coat of paint prior to setting so that beads will have proper adhesion. Special care shall be taken with rapid dry paint and thermoplastic materials.

Reflective material (glass beads) shall be applied at a rate of 6 to 8 pounds of beads per gallon of paint. Glass beads shall be applied to pavement markings, curbs, and crosswalks by use of a dispensing device developed for this purpose or other methods approved by the Engineer.

The Engineer may authorize the use of paint containing premixed glass beads. The type, gradation, quantity, and quality of the premixed glass beads shall be approved prior to the manufacture of the paint. In addition to the specified premixed beads, 2 to 3 pounds of beads per gallon of paint shall be mechanically applied when the paint is applied.

If thermoplastic paint is required, glass beads may be added directly to the combined pigment, filler, and resin. Prior to setting, all thermoplastic paint surfaces shall receive an additional application of at least 1 pound of glass beads per gallon of paint.

324.09 TEMPORARY PAVEMENT STRIPING TAPE

324.09.01 Description. This work shall consist of furnishing, locating, placing, maintaining, and removing continuous temporary pavement striping tape and temporary pavement striping tape (pilot line).

324.09.02 Materials. Temporary striping tape shall be yellow or white of any combination thereof as directed by the Engineer and shall conform to the following requirements:

“Temporary Striping Tape,” “Temporary Striping Tape (Pilot Line),” and “Temporary Arrows” may be either Type 1 or Type 2 tape. The Contractor will have the option as to which type is used.

Type 1 tape is more readily removable from the surface and is recommended for use on surfaces which are not designated to be covered or removed and on temporary areas where traffic patterns are to be altered.

Type 2 tape is much more difficult to remove from the surface and is recommended for use on surfaces which are to be covered or removed, in which case removal of the tape will not usually be required.

Should the Contractor elect to use either Type 1 or Type 2, it shall be his responsibility for its removal when required and removal shall be to the satisfaction of the Engineer.

Type 1 tape shall conform to the following requirements:

Composition. The removable preformed pavement marking film shall consist of a white or yellow mixture of high quality of polymeric materials, pigments, and glass beads, with a reflective layer of beads bonded to the top surface. A nonmetallic medium coated with a pressure sensitive adhesive shall be incorporated to facilitate removal. The white and yellow materials shall have the following initial average reflectance values at 0.2 degree and 0.5 degree observation angles and 86 degrees entrance angle, as measured in accordance with the testing procedures of Federal Test Method Standard 370:

	<u>White</u>		<u>Yellow</u>	
	0.2°	0.5°	0.2°	0.5°
Observation Angle	0.2°	0.5°	0.2°	0.5°
Specific Luminance	1770	1270	1310	810

Removability. The marking film shall be completely removed from asphalt and Portland Cement Concrete either manually or with a roll-up device, at temperatures above 40 degrees Fahrenheit (4 degrees C.) without use of heat, solvents, grinding, or sand blasting.

Type 2 tape shall conform to the following requirements:

Composition. The metallic backed striping tape shall consist of a white or yellow reflective film on a conformable metallic backing, precoated with a pressure sensitive adhesive.

324.09.03 Construction. Temporary Striping Tape (Pilot Line) shall be 4 inch by 12 inch sections and shall be placed on traffic lane lines at 40 foot intervals, with the longer side parallel to traffic. Lane lines and 40 foot intervals shall be located by the Contractor as approved by the Engineer. Prior to the end of a working day, a temporary pilot line shall be placed on each new lift of bituminous surfacing over which public traffic is directed. The exception to the foregoing is that the State shall be responsible for placing pilot line on the final open graded surface using State furnished labor, materials, and equipment.

Continuous temporary striping tape shall be furnished, located, applied, maintained, and removed by the Contractor at locations indicated on the Plans or determined by the Engineer.

The surface to which the tape (pilot line or continuous) is applied shall be dry, free of oils, grease, dust, and dirt. The tape shall be tamped down immediately after application in order to obtain a proper bond, and shall be removed from final pavement surface and where necessary to reroute public traffic as directed by the Engineer.

It should be considered normal and expected that portions of the temporary striping tape shall have to be replaced during the life of the contract. The locations and extent of these replacements shall be determined by the Engineer.

324.10 PROTECTION OF WORK. The Contractor shall use proper and sufficient directional signs, warning devices, barricades, pedestals, lights, traffic cones, flagmen, or other devices to protect the work, workmen, and the public.

All markings and striping shall be protected from injury and damage of any kind while the paint is drying. All adjacent surfaces shall be protected from disfiguration by splatter, splashes, spillage, and ripping of paint or other material.

324.11 SCHEDULING OF WORK. In areas of high traffic volume, the Contractor shall schedule his work to paint traffic lines and markings in off-peak traffic hours or on weekends.

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324.12 UNACCEPTABLE WORK. Any work or material not conforming to the Plans or Specifications shall be unacceptable and shall be redone, removed, replaced, or made satisfactory to the Engineer at the sole expense of the Contractor.

324.13 MEASUREMENT OF QUANTITIES AND BASIS OF PAYMENT

324.13.01 Painting. No direct measurement of quantities or payment shall be made for painting, cleaning structural steel, or preparing surfaces for painting unless indicated in the Contract Documents or directed by the Engineer. Compensation for this work shall be considered as included in the contract unit prices bid for the particular item requiring painting, unless indicated otherwise.

324.13.02 Traffic Striping and Marking. The quantity of traffic striping and marking shall be measured by one or more of the following methods: lineal footage, the area in square feet, or one lump sum item complete in place.

The lump sum or unit prices established shall include full compensation for furnishing all labor, materials, tools, and equipment, and for doing all work involved in, or appurtenant to, the painting of all traffic striping or markings as shown on the Plans, indicated in the Special Provisions, or as directed by the Engineer.

All costs for temporary pavement painting for the convenience of the Contractor, including costs for sandblasting of existing lines and markings, shall be at his sole expense.

325.01 DESCRIPTION

325.01.01 General. Electrical work shall consist of furnishing and installing, modifying or removing one or more traffic signals, flashing beacon systems, highway lighting systems, sign illumination systems, traffic count stations, electrical equipment in structures, falsework lighting, partial installations for future systems, or combinations thereof, all as shown on the Plans, and as specified in these Specifications and the Special Provisions.

The locations of signals, beacons, standards, lighting fixtures, signs, controls, services, and appurtenances shown on the Plans are approximate and the exact locations will be established by the Engineer in the field.

The materials shall be manufactured, handled, and used in a workmanlike manner to insure complete work in accordance with the Plans, Specifications, and Special Provisions.

All systems shall be complete and in satisfactory operating condition at the time of acceptance of the project.

Where an existing system is to be modified, the existing material shall be reused in the revised system, removed, salvaged, and stockpiled or abandoned as shown on the Plans, as specified in the Special Provisions or as directed by the Engineer.

325.01.02 Regulations and Code. All electrical equipment shall conform to the standards of the National Electrical Manufacturers Association (NEMA), the Underwriters Laboratories, Inc., (ULI), or the Electronic Industries Association (EIA), wherever applicable. In addition to the requirements of the Plans, these Specifications, and the Special Provisions, all materials and workmanship shall conform to the requirements of the National Electrical Code, hereinafter referred to as the Code; Rules for Overhead Electrical Line Construction, the Public Service Commission; Standards of the American Society for Testing and Materials (ASTM); American National Standards Institute (ANSI); International Municipal Signal Association (IMSA); Illumination Engineering Society (IES); Rural Electrification Association (REA); and any local ordinances which may apply.

Wire sizes shall be based on American Wire Gauge (AWG).

325.01.03 Equipment List and Drawings. Unless otherwise permitted in writing by the Engineer, the Contractor shall, within 15 days following approval of the Contract, submit to the Engineer for approval, a list of equipment and materials which he proposes to install. The list shall be complete as to name of manufacturer, size, and identifying number of each item. The list shall be supplemented by such other data as may be required, including scale drawings of cabinets showing location and spacing of shelves, terminal blocks and equipment, including dimensioning. All of the above data shall be submitted in triplicate for review. Where electrical equipment is constructed as detailed on the Plans, the submission of detailed drawings and diagrams will not be required.

Where a basic controller cabinet wiring diagram is provided, circuit diagrams for detector plug connections, peripheral equipment, and external solid-state logic shall be provided.

The Contractor shall furnish to the Engineer for transmittal to the maintaining agency five reproducible film positives with silver base, and five copies thereof, of the cabinet schematic wiring diagram for each controller cabinet furnished. The diagrams shall show the location of the installation and shall list all equipment installed in each cabinet. In addition, for each signal installation, the Contractor shall furnish an intersection sketch showing poles, detectors, field wire connection terminals and phasing as shown on the Plans. One copy of the controller cabinet diagram and the intersection and phase diagram as reviewed by the Engineer shall be placed in a heavy duty plastic envelope with side opening, and attached to the inside of the door of each controller cabinet.

All schematic wiring diagrams of the controllers and auxiliary equipment, all cabinet diagrams, and all operation manuals shall be submitted at the time the controllers are delivered for testing or, if ordered by the Engineer, previous to purchase. This diagram shall show in detail all circuits and parts. Such parts shown thereon shall be identified by name or number and in such manner as to be readily interpreted.

325.01.04 Warranties, Guarantees, and Instruction Sheets. Manufacturers' warranties and guarantees furnished for materials used in the work, and instruction sheets and parts lists supplied with materials shall be delivered to the Engineer prior to acceptance of the project.

325.01.05 Maintaining Existing and Temporary Electrical Systems. Existing electrical systems (traffic signal, ramp metering, highway and street lighting, flashing beacon, and sign illumination), or approved temporary replacements thereof, shall be kept in effective operation for the benefit of the traveling public during the progress of the work, except when shutdown is permitted to allow for alterations or final removal of the systems. The traffic signal shutdowns shall be limited to periods during normal working hours, or shall be as specified in the Special Provisions. Lighting system shutdowns shall not interfere with the regular lighting schedule, unless otherwise permitted by the Engineer. The Contractor shall notify the Engineer prior to performing any work on existing systems.

The local traffic enforcement agency and the traffic signal maintenance agency shall be notified prior to any operational shutdown of a traffic signal system.

State or local forces will continue operation and maintenance of existing electrical facilities. The State or local authorities will furnish electrical energy for operation and will repair or replace damaged facilities.

Where damage is caused by the Contractor's operations, the Contractor shall, at his expense, repair or replace damaged facilities promptly in accordance with these Specifications. Should the Contractor fail to perform the required repairs or replacements, the cost of performing such repairs or replacements will be deducted from any moneys due, or to become due, the Contractor.

The exact location of existing conduit runs and pull boxes shall be ascertained by the Contractor before using equipment that may damage such facilities or interfere with any system.

Where roadways are to remain open to traffic and existing lighting systems are to be modified, the lighting systems shall remain in operation and the final connection to the modified circuit shall be made so that the modified circuit will be in operation by nightfall of the same day.

Temporary electrical installations shall be kept in effective operation until the temporary installations are no longer required for the traveling public. Removal of temporary installations shall conform to the Provisions in Subsections 325.06.01, 325.06.02, and 325.06.03 — "Salvaging and Reinstalling or Stockpiling Electrical Equipment."

These Provisions will not relieve the Contractor in any manner of his responsibilities as provided in Subsection 117.00 — "Materials and Workmanship."

A temporary overhead cable system may be used for the existing signal system circuitry in lieu of maintaining the underground installations during construction.

Where an existing system is being modified, work not shown on the Plans or specified in the Special Provisions, and which is considered by the Engineer as necessary to keep all or any part of the existing system in effective operation, shall be considered as included in the prices paid for the systems, or units; therefor, no additional compensation will be allowed.

325.01.06 Scheduling of Work. Work shall be so scheduled that each traffic signal, highway lighting, and sign illumination system shall be completed and ready for operation prior to opening the corresponding section of the roadway to traffic.

Traffic signals shall not be placed in operation for use by public traffic without the energizing of street lighting at the intersection to be controlled if street lighting exists or is being installed in conjunction with the traffic signals.

Traffic signals shall not be placed in operation until the roadways to be controlled are open to public traffic unless otherwise directed by the Engineer.

Highway lighting and traffic signals shall not be placed in operation, including flashing operation, prior to commencement of the functional test period specified in Subsection 325.02.13 – “Field Tests” – unless ordered otherwise by the Engineer.

Conductors shall not be pulled into conduit until pull boxes are set to grade, crushed rock sumps installed, mortar placed around conduit, concrete bottom of pull boxes placed, and metallic conduit bonded.

Unless otherwise directed by the Engineer, traffic signals at new locations shall be placed on flashing operation for a minimum of 24 hours prior to normal operation.

In vehicular undercrossings, soffit lights shall be placed in operation as soon as practicable after falsework has been removed from the structure. Lighting for pedestrian structures shall be placed in operation prior to opening the structure to pedestrian traffic.

If the Engineer orders soffit lights or lighting for pedestrian structures placed in operation before permanent power service is available, the cost of installing and removing temporary power service will be paid for as extra work as provided in Section 125.00 – “Extra Work.”

325.01.07 Safety Precautions. Before starting work on existing series street lighting circuits, the Contractor shall obtain daily a safety circuit clearance from the serving utility. Bypass-switch plugs shall be pulled and “MEN AT WORK” signs posted at switch boxes before any work is done.

325.01.08 Definitions. The following definitions pertain only to Section 325 – “Traffic Signals and Street Lighting.”

Actuation. The operation of any type of detector.

Clearance Interval. The interval(s) from the end of the right of way of one phase to the beginning of a conflicting phase.

Controller. The complete electrical mechanism for controlling the operation of a traffic signal. A controller consists of a controller unit and all auxiliary equipment housed in a weatherproof cabinet.

Controller Unit. The basic timing unit of a traffic signal controller with its manually variable sequence and timing controls.

Detector for Traffic Actuation. A device by which vehicles or pedestrians are enabled to register their presence with a traffic actuated signal controller.

Magnetic Vehicle Detectors. A detector installed in or near the roadway, capable of being actuated by the induced voltage caused by the passage of a vehicle through the earth’s magnetic field.

Magnetometer Vehicle Detector. A detector installed in or near the roadway, capable of being actuated by the magnetic disturbance caused by the passage or presence of a vehicle.

Inductive Loop Detector. A detector installed in the roadway capable of being actuated by the change of inductance caused by a vehicle passing over or standing over the loop.

Pedestrian Detector. A detector, usually of the push button type, installed near the roadway and capable of being operated by hand.

Pressure-Sensitive Vehicle Detector. A detector installed in the roadway capable of being actuated by the pressure of a vehicle passing over its surface.

Electrolier. The complete assembly of pole, mast arm, luminaire, ballast, and lamp.

Extensible Portion. That portion of the green interval on an actuated phase following the initial portion, which may be extended, for example, by traffic actuation.

Extension Limit. The maximum time for which actuations on any traffic phase may retain the right of way after actuation on an opposing traffic phase, after the initial portion has been timed out.

Flashing Feature. A device which, when operated, discontinues normal signal operation and causes the flashing of any predetermined combination of signal lights.

Initial Portion. The first part of the green interval which is timed-out or separately controlled by a traffic-actuated controller before the extendible portion of the interval takes effect.

Interval. Any one of the several divisions of the time cycle during which signal indications do not change.

Interval Sequence. The order of appearance of signal indications during successive intervals of a time cycle.

Luminaire. The assembly which houses the light source and controls the light emitted from the light source. Luminaires consist of hood, (including socket) reflector, glass globe or refractor, and ballast.

Lighting Standard. The pole and mast arm which supports the luminaire.

Major Street. The roadway approach or approaches at an intersection normally carrying the major volume of vehicular traffic.

Manual Operation. The operation of a signal controller by means of a hand-operated switch.

Minimum Period. In semi-traffic-actuated controllers, the shortest time for which the right of way shall be given to the approaches not having detectors.

Minor Street. The roadway approach or approaches at an intersection normally carrying the minor volume of vehicular traffic.

Passage Period. The time allowed for a vehicle to travel at a selected speed from the detector to the nearest point of conflicting traffic.

Pedestrian Phase. A traffic phase allocated to pedestrian traffic which may provide a right of way pedestrian indication either concurrently with one or more vehicular phases, or to the exclusion of all vehicular phases.

Preemption. The transfer of normal control of signals to a special signal control mode.

Pre-timed Controller Unit. An automatic control device for supervising the operation of traffic control signals in accordance with a pre-timed cycle and divisions thereof.

Recall Switch. A manual switch in a traffic-actuated controller which will cause the automatic return of the right of way to a street regardless of the absence of actuation on that street.

Rest. The interval portion of a phase when present timing requirements have been completed.

Right of Way. The privilege of the immediate use of the highway.

Signal Face. That part of a signal head provided for controlling traffic in a single direction and consisting of one or more lenses. Turning indications may be included in a signal face.

Signal Head. An assembly containing one or more signal faces.

Signal Indication. The illumination of a traffic signal lens or equivalent device, or of a combination of several lenses or equivalent devices, at the same time.

Split. A division of the cycle length allocated to each of the various phases (normally expressed in percent).

Time Cycle. The number of seconds required for one complete revolution of the timing dial or complete sequence of signal indications.

Traffic-Actuated Controller Unit. A controller assembly for supervising the operation of traffic control signals in accordance with the varying demands of traffic as registered with the controller by detectors.

Traffic Phase (Traffic Movement). Those right of way and clearance intervals in a cycle assigned to any independent movement(s) of traffic.

Unit Extension. The minimum time, during the extendible portion, for which the right of way must remain on any traffic phase following an actuation on that phase, but subject to the extension limit.

Vehicle. Any motor vehicle normally licensed for highway use by the State of Nevada.

Visor (Hood). The part of a signal section which protects the lens face from direct ambient light.

325.02 MATERIALS AND INSTALLATION

325.02.01 General. Where existing systems are to be modified, the existing materials shall be incorporated in the revised system, salvaged or abandoned as specified.

325.02.02 Foundations. Foundations for posts, standards, pedestals and controller bases shall be Portland Cement Concrete, have a 28-day compressive strength of 3000 p.s.i., 1 to 4 inch slump, and 4 to 7 percent air. Portland Cement Concrete shall conform to the Provisions in Section 202 – “Portland Cement Concrete.”

Foundations shall be placed "in the solid" and monolithic where practicable. For posts, standards, and pedestals not on structures, the top 2 inches of the concrete foundation shall be placed after the post, standard, or pedestal is in proper position. The exposed portions of the foundation shall be formed to present a neat appearance.

After each post, standard, or pedestal on structures is in proper position, grout shall be placed under the base plate. The exposed portions shall be formed to present a neat appearance. Grout shall consist of one part by volume of Portland Cement and three parts of clean sand, shall contain only sufficient moisture to permit packing, and shall be cured by keeping it damp for 3 days.

Forms shall be true to line and grade. Tops of foundations for posts and standards, except special foundations, shall be finished to curb or sidewalk grade or as directed by the Engineer. Forms shall be rigid and securely braced in place. Conduit ends and anchor bolts shall be placed in proper position and to proper height, and shall be held in place by means of a template until the concrete sets.

Anchor bolts, anchor bars, or studs and nuts shall conform to the Specifications of ASTM Designation A307 and shall be provided with two nuts and two washers each. Anchor bolts, nuts, and washers shall be galvanized in accordance with the requirements of ASTM Designation A153.

Plumbing of standards shall be accomplished by adjusting nuts before grouting or before the foundation is finished to final grade. Shims or other similar devices for plumbing or raking of posts, standards, or pedestals will not be permitted.

Both forms and ground which will be in contact with the concrete shall be thoroughly moistened before placing concrete. Forms shall not be removed until the concrete has thoroughly set.

Ordinary surface finish, as specified in Subsection 311.14.01 – "Ordinary Surface Finish" – shall be applied to exposed surfaces of concrete.

Where obstructions prevent the construction of a planned foundation the Contractor shall construct an effective foundation satisfactory to the Engineer.

The foundations shown on the Plans shall be extended if conditions require additional depth, and such additional work, if ordered by the Engineer, will be paid for as extra work as provided in Section 125.00 – "Extra Work."

Unless otherwise shown on the Plans, all standards to be relocated shall be provided with new foundations and anchor bolts of the proper type and size.

Posts, poles, standards, and pedestals, except concrete pedestals cast in place, shall not be erected until the foundation has set at least 72 hours, and shall be plumbed or raked, as directed by the Engineer.

In unpaved areas, a raised pad of Portland Cement Concrete of the size shown on the Plans shall be placed in front of each controller cabinet.

When a foundation is to be abandoned in place, the top of foundation, anchor bolts, and conduits shall be removed to a depth of 0.5 foot below the surface of sidewalk or unimproved ground. The resulting hole shall be backfilled with material equivalent to the surrounding material.

325.02.02A Excavating and Backfilling. The excavations required for the installation of conduit, foundations, and other appurtenances shall be performed in such a manner as to avoid any unnecessary damage to street, sidewalks, landscaping, and other improvements. The trenches shall not be excavated wider than necessary

for the proper installation of the electrical appurtenances and foundations. Excavation shall not be performed until immediately before installation of conduit and other appurtenances. The material from the excavation shall be placed in a position that will not cause damage or obstruction to vehicular and pedestrian traffic nor interfere with surface drainage.

The excavations shall be backfilled in conformance with the Provisions in Section 305 – “Trench Excavation and Backfill.”

Excavations after backfilling shall be kept well filled and maintained in a smooth and well-drained condition until permanent repairs are made.

All excavations shall be filled, and sidewalks, pavement, and landscaping restored at each intersection prior to excavating at any other intersection, unless otherwise permitted by the Engineer.

Excavations in the street or highway shall be performed in such a manner that not more than one traffic lane is restricted in either direction at any time.

325.02.03 Removing and Replacing Improvements. Improvements such as sidewalks, curbs, gutters, Portland Cement Concrete and asphalt concrete pavement, base material, lawns, and plants, and any other improvements removed, broken, or damaged by the Contractor's operations, shall be replaced or reconstructed with the same kind of material as found on the work or with materials of equal quality. The new work shall be left in a serviceable condition satisfactory to the Engineer.

Whenever a part of a square or slab of existing concrete sidewalk or driveway is broken or damaged, the entire square or slab shall be removed and the concrete reconstructed as above specified.

The outline of all areas to be removed in Portland Cement Concrete sidewalks and driveways and in pavements shall be cut to a minimum depth of 1 1/2 inches with an abrasive type saw prior to removing the sidewalk, driveways, and pavement material. The cut for the remainder of the required depth may be made by a method satisfactory to the Engineer. Cuts shall be neat and true with no shatter outside the removal area.

325.02.04 Standards, Steel Pedestals, and Posts. Standards for traffic signals and highway lighting and steel pedestals for cabinets and other similar equipment shall be located as shown on the Plans. Workmanship and finish shall be equal to the best general practice of metal fabrication shops. All welding shall conform to AWS D2.0 – “Specifications for Welded Highway and Railway Bridges” – and to the requirements in this section.

Standard pipe shall conform to the Specifications of ASTM Designations A53 or A120.

All ferrous metal parts of standards, 15 feet and longer, shall conform to the details shown on the Plans and the following requirements:

Standard shall be fabricated from (a) sheet steel conforming to the Specifications of ASTM Designation A611, Grade C or ASTM Designation A570, Grade C, or from (b) sheet steel of weldable grade. If alternative (b) is used, the steel, after fabrication, shall have a minimum yield of 48,000 p.s.i.

Standards with luminaire arms only shall be fabricated of not less than No. 10 U.S. standard gauge steel, except that when material conforming to alternative (b) above is used, the gauge shall not be less than No. 11 U.S. Standard Gauge steel.

Standards may be fabricated of full length sheets or shorter sections. Each section shall be fabricated from not more than two pieces of sheet steel. Where two pieces are used, the longitudinal weld seams shall be directly opposite one another. When the sections are butt welded together, the welded seams on adjacent sections shall be placed to form continuous straight seams from base to top of standard.

Standards shall be straight, with a permissive variation not to exceed 1 inch measured at the midpoint of a 28.5, 30, or 35 foot standard and not to exceed 3/4 inch measured at the midpoint of an 18, 20, or 25 foot standard.

The butt-welded, transverse joints shall be strengthened by inseting a metal sleeve at each joint. The sleeve shall be No. 10 U.S. Standard Gauge steel and made from steel having the same chemical composition as the steel in the standard. The metal sleeve shall have a minimum length of 1 inch. The sleeve shall be centered at the joint and have the same taper as the standard with the outside of the sleeve in full contact with the inside of the standard throughout the sleeve length and circumference.

All welds shall be continuous.

The weld metal at the transverse joint shall extend to the sleeve, making the sleeve an integral part of the joint.

All longitudinal welds shall be performed by the submerged arc process.

All exposed welds, except fillet welds, shall be ground flush with the base metal.

All exposed edges of the plates which make up the base assembly shall be finished smooth and all exposed corners of such plates shall be neatly rounded to 1/8 inch radius, unless otherwise shown on the Plans. Shafts shall be provided with slip-fitter shaft caps.

Handholes in the base of standards shall conform to the details shown on the Plans.

Push button posts and guard posts shall be pipe conforming to the Specifications of ASTM Designations A53 or A120.

Holes left in the shafts of existing standards, due to removal of equipment or mast arms, shall be repaired by welding in a suitable disk, grinding smooth, and painting as provided for repairing damaged galvanized surfaces in Section 213 – “Galvanizing.”

When directed by the Engineer, existing standards to be relocated or reused in place shall be repaired prior to repainting or regalvanizing. Large dents shall be removed, shafts shall be straightened, and portions which are in poor condition, due to corrosion or damage, shall be replaced. Extent of repairs or replacements will be determined by the Engineer and said repairs or replacements ordered by the Engineer will be paid for as extra work as provided in Section 125.00 – “Extra Work.”

Anchor bolts and nuts required for relocating existing standards will be furnished by the Contractor.

New standards, posts, and other ferrous materials shall be galvanized as provided in Section 213.02.14 – “Galvanizing.”

325.02.05 Conduit. All conductors shall be run in conduit except for overhead and temporary installations, and where conductors are run inside poles.

Conduit shall be of the sizes shown on the Plans, as specified in this subsection or in the Special Provisions. In addition, the Contractor may, at his option and expense, use conduit of a larger size than that shown or specified provided the larger size is used for the entire length of the run from outlet to outlet. Reducing couplings will not be permitted.

- a. Material. Conduit and fittings shall be the rigid, metal-type manufactured of mild steel conforming to UL Publication UL 6 for Rigid Metallic Conduit, or at the option of the Contractor, conduit to be installed underground may be rigid nonmetallic type conforming to the requirements of the UL Standard for Rigid Nonmetallic Conduit (Publication UL 651).

A Certificate of Compliance conforming to the Specifications shall be submitted by the manufacturer with all rigid metallic conduit and all rigid nonmetallic conduit.

Where rigid metallic conduit is used underground, it shall be either tarred and wrapped or shall be spirally wrapped with a corrosion protection polyvinyl chloride or polyethylene pressure sensitive tape, applied with a suitable primer. The wrap shall have a nominal thickness of 20 mils, consisting of either one layer of 20 mil tape or two separate layers of 10 mil tape. A single wrap of 10 mil tape with a half lap will not be acceptable.

- b. Use. Conduit to be installed on the surface of poles or structures or other exposed locations shall be the rigid metal type and shall be unpainted except that exposed conduit installed on a painted structure shall be painted the same color as the structure.

Where nonmetallic conduit is to be installed, the conduit run between the pole base and the nearest pull box and the conduit in structures may be of the nonmetallic type.

Where existing rigid metal conduit systems are to be modified or extended, rigid metal conduit only shall be installed.

Where a pull box is installed adjacent to the base of an electrolier, conduit installed from the pull box to the standard shall not be less than 1 1/2 inches in diameter.

Where pull boxes are installed adjacent to the base of a signal standard or controller pedestal, conduit installed between pull boxes and the standard or pedestal shall not be less than 2 inches in diameter, unless otherwise shown on the Plans.

Conduit for detector runs shall be not less than 1 inch in diameter. All conduit not otherwise specified shall be 1 1/2 inches in diameter.

Conduit running from a pull box to soffit, wall, or other lights or fixtures below the grade of the pull box shall be installed in the end of the pull box with the centerline of the conduit terminus a minimum of 5 inches above the bottom of the pull box.

On conduit runs that contain signal cable exceeding 50 feet in length, PVC factory coated rigid metallic bends shall be used. On conduit runs 50 feet or less, the Contractor may use PVC factory coated rigid metallic bends or PVC Schedule 40 conduit bends.

- c. Installation. Conduit shall be installed in conformance with the codes and regulations listed in Subsection 325.01.02 – "Regulations and Code."

Conduit runs shown on the Plans may be changed to avoid underground obstructions with written approval by the Engineer.

The ends of all conduits, whether shop or field cut, shall be reamed to remove burrs and rough edges. Cuts shall be made square and true so that the ends will but or come together for the full circumference thereof. Slip joints or running threads will not be permitted for coupling conduit. When a standard

coupling cannot be used for coupling metal type conduit, an approved threaded union coupling shall be used. The threads on all ferrous metal conduit shall be painted with rust preventive paint before couplings are made up. All couplings for metal type conduit shall be tightened until the ends of the conduits are brought together, providing a good electrical connection throughout the entire length of the conduit run. Where the coating on metal conduit has been damaged in handling or installing, such damaged places shall be painted with rust preventive paint. Nonmetallic type conduit shall be cut with a hacksaw or other approved tool. Nonmetallic type conduit connections shall be of the solvent weld type. Exposed ungalvanized threads on metal conduit resulting from field cuts shall be painted with rust preventive paint.

All metal type conduit ends shall be threaded and shall be capped with standard pipe caps until wiring is started. When caps are removed, the threaded ends shall be provided with conduit bushings. Nonmetallic type conduit ends shall be capped until wiring is started. Nonmetallic conduit fittings for connecting nonmetallic conduit to rigid metal conduit shall be threaded on the metal conduit side.

Conduit bends, except factory bends, shall have a radius of not less than six times the inside diameter of the conduit. Where factory bends are not used, conduit shall be bent, without crimping or flattening, using the longest radius practicable.

A nylon pull string shall be installed in all conduits which are to receive future conductors. At least 5 feet of pull string slack shall be coiled up at each termination.

Existing underground conduit to be incorporated into a new system shall be cleaned with a mandrel or cylindrical wire brush and blown out with compressed air.

Conduit shall be laid to a depth of not less than 18 inches below the curb grade in sidewalk areas and curbed paved median areas, 24 inches below highway pavement grade in road areas and finished grade in all other areas, except that conduit may be laid on top of the existing pavement within new curbed medians being constructed on top of said pavement.

Conduit runs parallel to curbs shall be placed adjacent to back of curb, except where in conflict with existing facilities.

Conduit stubs from electrolier bases shall extend at least 6 inches from face of foundation and at least 18 inches below top of foundation.

Rigid metal conduit shall be placed under existing pavement by approved jacking or drilling methods. Pavement shall not be disturbed without permission from the Engineer. In the event obstructions are encountered, upon approval of the Engineer, small test holes may be cut in the pavement to locate obstructions. jacking or drilling pits shall be kept 2 feet clear of the edge of any type of pavement wherever possible. Excessive use of water such that pavement might be undermined or subgrade softened, will not be permitted.

Rigid nonmetallic type conduit shall not be used for drilling or jacking, Installation of rigid nonmetallic type conduit under existing pavement will be permitted if a hole larger than the conduit is predrilled and the conduit installed by hand. Bottom of trenches for rigid nonmetallic conduit shall be relatively free of sharp irregularities which would cause pinching and excessive bending of the conduit. The trench shall be excavated to 4 inches below the invert grade of the conduit and backfilled with a granular material with 100 percent passing the 3/8 inch size sieve except where backfilled with concrete. A cradle shall be shaped in the granular material cushion to support the conduit. The first 6 inches of backfill over the top of the conduit shall be of this granular material. The top 6 inches shall be backfilled and compacted as shown on the Plans or as directed by the Engineer.

Conduit to be placed beneath railroad tracks shall comply with the following:

The conduit shall be rigid metal type, 1 1/2 inches minimum size and shall be placed to a minimum depth of 3 feet below bottom of tie. The near side of each conduit jacking pit shall be constructed not less than 12 feet from the centerline of track. When the jacking pit is to be left overnight it shall be covered with substantial planking.

Conduit terminating in standards or pedestals shall extend not more than 2 inches vertically above the foundation and shall be sloped towards the handhold opening. Conduit entering through the side of nonmetallic pull boxes shall terminate not more than 2 inches inside the box wall and not less than 2 inches above the bottom, and shall be sloped toward the top of the box to facilitate pulling of conductors. Conduit entering through the bottom of a pull box shall terminate 1 to 2 inches above the bottom and shall be located near the end walls to leave the major portion of the box clear. At all outlets, conduits shall enter from the direction of the run.

Conduit for future use in structures shall be threaded and capped. Conduit leading to soffit, wall, or other lights or fixtures below the grade of the pull box shall be sealed by means of a sealing fitting and sealing compound, except that sealing fitting and sealing compound will not be required where conduit terminates in a structure pull box.

Conduits in bridge superstructures shall be supported as shown on the Plans, in conformance with the following:

Cast-in-place metal inserts for hangers or brackets shall be capable of developing 20,000 p.s.i. in tension on the net section of the bolt or threaded rod.

Openings for conduits through bridge superstructure concrete shall be formed or may consist of pipe sleeves.

Where conduits pass through the abutment concrete, the conduits shall be wrapped with two layers of 10 pound asphalt-felt building paper, securely taped or wired in place.

The space around conduits through bridge abutment walls shall be filled with Portland Cement mortar conforming to the Provisions in Subsection 311.14 – “Patching” – except that the proportion of cement to sand shall be 1 to 3.

When the bridge superstructure is to be prestressed the space around conduits through abutments shall not be filled until the prestressing has been completed.

Conduit run on the surface of structures shall be secured with galvanized malleable iron clamps spaced not more than 5 feet apart.

Attention is directed to Subsection 325.02.10 – “Bonding and Grounding.” Where pull boxes are placed in conduit runs, the conduit shall be fitted with threaded bushings and bonded.

The location of ends of all conduits in structures, or terminating at curbs, shall be marked by a “Y” at least 3 inches high cut into the face of curb, gutter, or wall, directly above the conduit and above grade line.

325.02.06 Pull Boxes. Pull boxes shall be installed at the locations shown on the Plans.

Plastic and concrete pull boxes placed in the roadway or containing interconnect cable and located outside of sidewalk sections shall have steel covers fitting over entire pull box. All concrete boxes not requiring steel covers shall have cast iron lids. Plastic pull boxes not requiring steel covers may have approved plastic lids.

- a. Materials. Pull boxes, covers, and extensions for installation in the ground or in sidewalk areas shall be of the sizes and details shown on the Plans and shall be precast reinforced concrete, except that alternative materials and designs may be used if units of equal strength, without excessive deflection, will be provided. Material shall be self-extinguishing when tested in accordance with ASTM Designation D635, and shall show no appreciable change in physical properties with exposure to the weather. Where a ballast or transformer is to be placed in a nonmetallic pull box, the box shall be provided with recesses for a hanger as shown on the Plans.

Plastic pull boxes shall be of sufficient rigidity that when a designated concentrated force is applied perpendicularly to the midpoint of one of the long sides at the top while the opposite long side is supported by a rigid surface, it shall be possible to remove the cover without the use of tools. The designated concentrated force shall be 150 pounds for a No. 3 1/2 pull box and shall be 100 pounds for a No. 5 or No. 7 pull box.

When a vertical force of 1,500 pounds is applied, through a 1/2 inch by 3 inch by 6 inch steel plate, to a plastic cover in place on a pull box, the cover shall not fail and shall not deflect more than 1/4 inch. The steel plate shall be centered on the cover with its longitudinal axis coinciding with the longitudinal axis of the cover.

Pull boxes and covers for installation in structures shall be of the sizes and details shown on the Plans. In lieu of the structure pull box shown on the Plans, the Contractor may use a telescoping steel pull box, with interior dimensions, conduit entrances, and cast iron cover conforming to the details shown on the Plans. Design of the steel pull box shall be submitted to the Engineer for review prior to fabrication.

Covers shall be secured with 3/8 inch bolts, capscrews, or studs, and nuts which shall be of brass, stainless steel, or other noncorroding material. Stainless steel hold-down bolts, capscrews, or studs, and nuts and washers shall have a chromium content of not less than 18 percent and a nickel content of not less than 8 percent. Nuts shall be recessed below surface of cover.

Junction boxes for installation in structures shall conform to the details shown on the Plans.

Junction boxes which are to be placed in concrete barrier rails as indicated on the Plans, shall have covers installed in a manner that will result in the cover conforming to the contours of, and flush with the exterior of the barrier rail.

All ferrous metal parts shall be galvanized in accordance with the Provisions in subsection 325.02.14 – “Galvanizing.”

- b. Cover Marking. Covers for pull boxes shall be marked as follows:
1. “Traffic Signal.” Where pull box contains traffic signal conductors with or without street lighting conductors.
 2. “Street Lighting.” Where pull box contains street lighting conductors only. “HIGH VOLTAGE” shall be inscribed below where street lighting voltage is above 600 volts.
 3. “Communication.” For pull boxes where communication conduit enters the pull box.
 4. “Sprinkler Control.” For pull boxes where sprinkler control conduit enters the pull box.

5. "Count Station." For pull boxes where traffic count station conduit enters the pull box.
6. "Ramp Meter." For pull boxes where ramp metering conduit enters the pull box.

Marking shall be clearly defined and uniform in depth and may be placed parallel to either the long or short sides of the cover.

Marking letters shall be between 1 and 3 inches high.

Marking shall be applied to each steel or cast iron cover prior to galvanizing by one of the following methods:

- a. Cast iron strips, at least 1/4 inch thick, with the letters raised a minimum of 1/16 inch.

Strips shall be fastened to covers with 1/4 inch flathead stainless steel machine bolts and nuts. Bolts shall be peened after tightening.

- b. Sheet steel strips, at least 22 gauge with the letters raised a minimum of 1/16 inch above the surrounding surface of the strips. Strips shall be fastened to covers by spot welding, tack welding, or brazing, or with 1/4 inch roundhead stainless steel machine bolts and nuts. Bolts shall be peened after tightening.
- c. Bead welding the letters on the covers. The letters shall be raised at least three 3/32 inch.
- c. Installation and Use. Pull boxes shall be installed at the locations shown on the Plans or, in long runs, they shall be spaced at not over 200 foot intervals. The Contractor may, at his expense, install additional pull boxes to facilitate his work.

The tops of pull boxes installed in the ground or in sidewalk areas shall be flush with the surrounding grade or top of adjacent curb. Where practical, pull boxes shown in the vicinity of curbs shall be placed adjacent to the back of curb, and pull boxes adjacent to a standard shall be placed along the side of foundations as shown on the Plans.

The bottoms of pull boxes installed in the ground or in sidewalk areas shall be bedded in crushed rock as shown on the Plans and shall be grouted prior to the installation of conductors. A layer of roofing paper shall be placed between the grout and the crushed rock sump. A 1 inch drain hole shall be provided in the center of the pull box through the grout and the roofing paper.

325.02.07 Expansion Fittings. Expansion fittings, as detailed on the Plans, shall be installed where the conduit crosses an expansion joint in the structure. Each expansion fitting shall be provided with a copper bonding jumper having the amperage required by the Code.

Expansion-deflection fittings shall consist of a molded neoprene sleeve with a bonding jumper passing through a separate waterproof compartment and two silicon bronze couplings. Fittings shall permit a minimum of 3/4 inch expansion and contraction and a 3/4 inch deflection without deformation.

325.02.08 Conductors. Conductors shall consist of solid or stranded copper of the gauge shown on the Plans unless specified otherwise.

Copper wire shall conform to the Specifications of ASTM Designations B3 and B8.

- a. Traffic Signal and Multiple Lighting Conductors. Conductors for traffic signal, flashing beacon and multiple lighting installations shall be UL listed and rated for 6000 volt operation. The insulation for No. 16 or smaller conductors shall be Type TF. The insulation for No. 14 and larger conductors shall be one of the following:

1. Type TW polyvinyl chloride conforming to the requirements of ASTM Designation D2219.
2. Type THW polyvinyl chloride.
3. Type XHHW or Type RHW cross-linked polyethylene.

Minimum thickness of any of the above insulations shall be 45 mils for conductor sized No. 14 to No. 10, inclusive, and 60 mils for No. 8 to No. 2, inclusive.

Within steel posts and arms only, insulation for No. 10, 12, and 14 conductors may be Type UF, 60 mils.

All conductors used in controller cabinet wiring shall be No. 22 AWG or larger. Conductors smaller than No. 14 AWG shall conform to Military Specification MIL-W-1687D, Type B, Vinyl-Nylon Jacket, 600 volt, 115 degrees Centigrade. Conductors No. 14 AWG and larger shall be as specified above.

All conductors in controller cabinets subject to flexing during opening and closing of the cabinet door or on removal of equipment from the cabinet shall be stranded. Conductors No. 14 AWG through No. 10 AWG, inclusive, shall be 19 strand and conductors No. 16 AWG shall be 26 strand.

Conductors in traffic actuated controller cabinets between service terminals and the "AC+" terminals on external light relays (including connections to the police panel switches), the signal light neutral and all conductors in the highway lighting circuit within the controller cabinet shall be No. 10 AWG or larger. All other conductors in the signal light circuits shall be No. 14 AWG.

Conductors in pre-timed controller cabinets between the service terminals and "AC+" common bus to signal light circuits (including switches, radio interference suppresser, flasher relays, and harness conductors to the controller shall have an amperage of 20 amperes at 160 degrees Fahrenheit.

Conductors for wiring flush wall luminaires shall be Type SA stranded copper, insulated with silicone rubber and asbestos braid for use at temperatures up to 125 degrees Centigrade.

Overhead lighting conductors shall be No. 8 AWG or larger medium hard drawn copper with weatherproof covering.

Vehicle detector conductors and lead-in cable are specified in subsection 325.02.32 – "Vehicle Detectors."

- b. Traffic Signal Cable. Individual signal cable shall be installed between the controller cabinet and the terminal block in the pole mounted signal head for each mast arm signal pole.

Individual signal conductors shall only be used between the terminal block and each signal head and to poles without mast arms. Cable shall conform to IMSA Specification No. 20-1 and shall be sized as indicated on the Plans.

Interconnect cable shall be REA Specification PE 39 unless otherwise noted on the Plans.

Opticom detector cable shall be 3 conductor, No. 20 cable and shall be either 3M Model 138 or Belden No. 87223 types.

- c. Conductor Identification. All signal conductors and cables shall have clear, distinctive and permanent markings on the outer surface throughout the entire length showing the manufacturer's name or trademark, insulation type-letter designation, conductor size, voltage rating, and the number of conductors if a cable.

Conductor insulation shall be of a solid color or of basic colors with a permanent continuous colored identification stripe as detailed in the "Conductor Table" unless otherwise specified.

CONDUCTOR TABLE						
Circuit	Signal Phase or Function	Insulation Colors		Identification		Size AWG
		Base	Stripe (Note 1)	Band Symbols (Note 6)		
Vehicle Signals	A.....	Red, Yellow, Green	Black	Band only special (A ₁) and overlap (A ₁ + C ₁) phases.		14
	B.....	Red, Yellow, Green	White			14
	C.....	Red, Yellow, Green	None	Simple phases such as A, B, C, or D do not require banding.		14
	D.....	Red, Yellow, Green	Orange			14
Pedestrian Signals	Aw	Red, Green	Black	Aw	(Note 2)	14
	Bw	Red, Green	White	Bw	(Note 2)	14
	Cw	Red, Green	None	Cw	(Note 2)	14
	Dw	Red, Green	Orange	Dw	(Note 2)	14
Pedestrian Push Buttons	Aw	Blue	Black	P-A	(Note 2)	14 or larger
	Bw	Blue	White	P-B	(Note 2)	
	Cw	Blue	None	P-C	(Note 2)	
	Dw	Blue	Orange	P-D	(Note 2)	
Traffic Signal Controller Lighting	Ungrounded between Service Switch and Controller	Black	None	CON		10 or larger
	Pull box to Luminaire.....	Black	None	No band required		14
Multiple Highway Lighting (Note9)	Ungrounded-Line 1.....	Black	None	ML 1		10 or larger
	Ungrounded-Line 2.....	Red	None	ML 2		
Lighting Control	Ungrounded to P.E.C. unit	Black	None	C-1		14
	Switching leg from P.E.C. unit or SM transformer.....	Red	None	C-2		14
Multiple Service	Ungrounded-Line 1 (Signals)	Black	None	(No band required except per Note 5)		8 or larger
	Ungrounded-Line 2 (Lighting).....	Red	None			
Sign Lighting (Note 8)	Ungrounded between transformer or Service Switch and Ballasts.....	Black	None	SL		12 or larger

Flashing Beacons (Note 7)	Ungrounded between Red or Flasher and beacons..... Yellow Detectors and Pedestrian Push Buttons	White	None	F-Location No. (Note3)	14 or larger
		Black	Black	No band required	12 or 14
	Signals and Multiple Lighting.....	White	None	No band required	10 or larger
Neutral and Common (Note 4)	Flashing Beacons and Sign Lighting.....	White	None	No band required	12
	Lighting Control	White	None	C-3	14
	Multiple Service	White	None	No band required	8 or larger
	Common.....	White	None	I	larger
Railroad Preemption Spares	.....	Black	None	R	14
	.....	Black	None	No band required	14

Notes:

1. On overlaps, insulation is striped for first phase in designation, for example, a phase (A₁ + C₁) conductor is striped as for phase A.
2. Stamp for overlap and special phases as required.
3. Flashing beacons having separate service do not require banding.
4. A single No. 12 common shall be used for pressure sensitive detectors and pedestrian push buttons. A single No. 14 AWG common shall be used when only pedestrian push buttons are connected.
5. "S" if circuit is switched on line side of service equipment by utility.
6. Band conductors in each pull box and near ends of termination points. On signal light circuits, a single band shall be placed around two or three ungrounded conductors comprising a phase.
7. Ungrounded conductors between service switch and flasher mechanism shall be black and stamped as indicated in this column.
8. Conductors between ballasts and sign lighting lamps shall be No. 16 and color shall correspond to that of the ballast leads.
9. Both conductors between ballast and lamp shall be black.
10. Conductors for inductive loop detectors are specified in Subsection 325.02.32 – "Vehicle Detectors."

325.02.09 Wiring. Wiring shall be done in conformance with the regulations and code listed in Subsection 325.01.02 – "Regulations and Code" – and the following additional requirements:

- a. Circuitry. Sufficient signal light conductors shall be provided to perform the functional operation of the signal system and, in addition thereto, three spare conductors of a size equal to the largest signal light conductor in the run, except neutral, shall be provided throughout the signal light system, unless shown otherwise on the Plans.

All signal light conductors, except branch neutrals, shall be run continuously without splices from a terminal block located in a cabinet, compartment, or signal head, to a similarly located terminal block. Signal light conductors shall not run to a terminal block on a standard unless they are to be connected to a signal head that is mounted thereon.

Connection to each terminal of a pedestrian push button shall be by a single conductor.

The neutral for pedestrian push button circuits shall be separate from the signal light circuit neutral.

- b. Installation. Powdered soapstone, talc, or other UL approved inert lubricant shall be used in placing conductors in conduit.

Conductors shall be pulled into conduit by hand and the use of winches or other power actuated pulling equipment will not be permitted.

When new conductors are to be added to existing conductors in a conduit, all conductors shall be removed; the conduit shall be cleaned as provided in subsection 325.02.05C – “Installation” –; and both old and new conductors shall be pulled into the conduit as a unit.

Where signal conductors or cable are run in lighting standards containing high-voltage series street lighting conductors, either the signal conductors or the lighting conductors shall be encased in flexible or rigid metal conduit, to a point where the two types of conductors are no longer in the same raceway. Where telephone circuits are installed adjacent to signal and lighting circuits, the telephone conductors shall be encased in UL approved flexible metal conduit.

Temporary conductors less than 10 feet above grade shall be enclosed in flexible or rigid metal conduit.

At least 1 foot of slack shall be left for each conductor at each signal or lighting standard, or combined standard, and at least 3 feet of slack at each pull box.

At least 3 feet of slack shall be left for each conductor at each splice.

Ends of spare conductors shall be taped.

Conductors within fixtures or cabinets shall be cabled together with self-clinching nylon cable ties, waxed lacing or other method permitted by the Engineer.

Wiring within controller cabinets shall be neatly arranged and laced, or enclosed in plastic tubing or raceway.

Small permanent identification bands shall be marked as detailed in the conductor table following subsection 325.02.08 – “Conductors.” The bands shall be securely attached to each conductor in each pull box and near the end of each conductor where conductors are terminated. Where circuit and phase are clearly indicated by conductor insulation, bands need not be used. Permanent identification bands shall be embossed aluminum foil tape with pressure-sensitive, oil resistant backing. Tape shall be of a type such that embossed symbols contrast with the background color.

- c. Connectors and Terminals. Conductors shall be joined by the use of connectors or other methods permitted by the Engineer.

All splices, with or without connectors shall be soldered by the pouring or dipping method, except that soldering of pressure connectors and terminals may be omitted provided the connectors and terminals are applied with the proper type tool as recommended by the manufacturer of the connector or terminal being applied. Finished connections and terminals shall comply with the requirements of Military Specification MIL-T-7928.

All stranded conductors smaller than No. 14 AWG shall be terminated in crimp style terminal lugs.

- d. Splicing. Unless specified otherwise or permitted by the Engineer, splices will be permitted only in the following types of circuits at the following locations:

1. Branch signal light neutrals in pull boxes.
2. Pedestrian push button circuits in pull boxes.
3. Multiple lighting conductors in bases of standards or in pull boxes.
4. In pull boxes in series lighting circuits where runs are more than 400 feet between units.
5. In modified traffic signal systems where shown on the Plans.

In lieu of the 600 volt or the 5,000 volt splice and splice insulation shown on the Plans, the Contractor may elect to use:

A pin and receptacle, locking type connector, with waterproof housing, capable of being disconnected without damage. The pin shall be of medium hard copper material with the portion to be crimped onto the conductor fully annealed. The receptacle shall be of copper material fully annealed. The pin and receptacle shall be of a size to provide not less than 90 percent amperage of the conductor being spliced. The pin and receptacle shall be applied to the conductor using a tool as recommended by the connector manufacturer and soldering will not be required. Both the pin and receptacle shall have centrally located, recessed locking areas, which shall match complementary areas of the housing.

The receptacle shall establish contact pressure with the pin through the use of a copper beryllium sleeve spring and the receptacle and pin shall lock together so that the connection will be maintained when a minimum force of 20 pounds tension pull is applied to the attached conductors.

Separate housings shall be provided for the pin and the receptacle. Each housing shall be made of water resisting synthetic rubber suitable for direct burial in the ground or installation in direct sunlight. Each housing shall have an interior arrangement, complementary to the pin and receptacle, suitable to receive and securely retain the pin and receptacle, also a section to form a water-seal between the housings at the point of disconnection. A small slot or vent shall be provided along the housings to permit the exclusion of air. Sufficient silicon type insulating compound to fill all the voids in the assembly shall be placed in the housings before installing the pin and receptacle.

In lieu of the 600 volt splice and splice insulation shown on the Plans, the Contractor may elect to use an epoxy insulated spring connector applied as follows:

The ends of the wires shall be joined together with an insulated spring type connector without soldering.

A two component, self-curing, epoxy resin shall be furnished in a double compartment, plastic envelope. The splice insulation shall be made by thoroughly mixing the two components in the envelope and, after cutting open one end of the envelope, inserting the wire-connection into the epoxy resin and then taping shut the open end of the envelope.

Other methods may be used to mix and apply epoxy resin.

Sufficient epoxy resin shall be provided to completely cover the connector and exposed bare wires at connector. The container shall be transparent to allow inspection.

Conductors in controller cabinets, signal cable and interconnect cable shall not be spliced.

- e. Splice Insulation. Splice insulation shall conform to the details shown on the Plans.

Low-voltage tape shall be UL approved and shall be either of the following types at the option of the Contractor.

1. Self-fusing, oil and flame-resistant, synthetic rubber.
2. Pressure-sensitive, adhesive, polyvinyl chloride, 0.007 inch minimum thickness.

Tape for insulating splices in low-voltage circuits (600 volts, maximum) by "method A" as shown on the Plans shall be either of the low-voltage types. Splices made by "Method B" shown on the Plans shall be insulated with both types of low-voltage tape.

Where polyvinyl chloride tape is used for a final layer, an electrical insulating coating shall be used which shall be fast drying, resistant to oil, acids, alkalis, and corrosive atmospheric conditions and be compatible with the tape.

Where more than one conductor enters a ballast sleeve, the insulation and taping shall be applied between the conductors in such a manner as to provide a watertight joint. The splice shall be capable of satisfactory operation under continuous submersion in water.

On 600 volt and 5,000 volt conductor splices, the Contractor, at his option, may use a cast insulation of self-curing epoxy resin which is compatible with wire insulation to form a moisture resistant joint. The resin shall be resistant to weather and aromatic and straight chain solvents and, in addition, shall not sustain combustion. The resin shall be poured into molds of dimensions suitable for the splice.

On 600 volt maximum circuits, the Contractor, at his option may elect to use either of the following splice insulation methods.

- a. A minimum of two thicknesses of electrical insulating pad, composed of a laminate of 0.085 inch thickness of electrical grade polyvinyl chloride and a 0.125 inch thickness of butyl splicing compound with removable liner. Pads shall be applied to the splice in accordance with the manufacturer's recommendations.

The ends of the applied pad shall be wrapped with polyvinyl chloride tape half lapped over the conductor insulation.

- b. Heat-shrinkable, insulating tubing shall be applied after completing the splicing procedure shown on the Plans. Insulation over the connector shall consist of a heat shrinkable, mastic lined, heavy wall polyolefin cable sleeve or cover, to which heat shall be applied at a temperature greater than 120 degrees Centigrade until the sleeve, or cover, shrinks and covers the connector and the mastic material has flowed completely around the cable to form a waterproof insulation.

On 5,000 volt conductors, the Contractor, at his option may elect to waterproof splices as follows:

In lieu of the final application of two layers of polyvinyl chloride tape, waterproofing of 5,000 volt splices after being insulated as shown on the Plans shall consist of heat shrinkable, mastic

lined, heavy wall polyolefin cable sleeve, or cover, to which heat shall be applied at a temperature greater than 120 degrees Centigrade until flowed sleeve, or cover, shrinks and covers the connector and the mastic material has flowed completely around the cable to form a waterproof insulation.

- f. Fused Splice Connectors. In each pull box adjacent to an electrolier or in base of pole, a fused disconnect splice connector shall be installed in each ungrounded conductor between the line and the ballast. The connector shall be readily accessible in the pull box or in the base of the pole.

For 240 volt and 480 volt circuits, each connector shall be designed so that both ungrounded conductors are disconnected simultaneously. The connector shall have no exposed metal parts.

The splice connector shall completely enclose the fuse and shall protect the fuse against damage from water and weather. The contact between the fuse and fuse holder shall be by spring pressure. Springs shall not be a part of the current carrying circuit. The terminals of the splice connector shall be rigidly crimped, using a tool of the type recommended by the manufacturer of the fused splice connector, on to the line conductors and the conductors to the ballasts and shall be insulated and made waterproof in accordance with the splice connector manufacturer's recommendations. Fused splice connectors shall not be used in series circuits.

Fuses shall be standard midget, ferrule type.

325.02.10 Bonding and Grounding. Metallic cable sheaths, metal pull box covers, metal conduit, nonmetallic conduit grounding wire, ballast and transformer cases, service equipment, sign switches, anchor bolts, and metal poles and pedestals shall be made mechanically and electrically secure to form a continuous system, and shall be effectively grounded. Bonding and grounding jumpers shall be copper wire or copper braid of the same cross sectional area as No. 6 AWG for series lighting systems and No. 8 AWG or larger for all other systems.

Bonding of standards and pedestals shall be by means of a bonding wire or braid attached to the anchor bolts or a 3/16 inch , or larger, brass or bronze bolt installed in the lower portion of the shaft.

Where slip base standards or slip base insets are installed, the grounding jumper shall not intrude into the slip plane. Bonding shall be accomplished by a bonding strap to the anchor bolts or a 3/16 inch or larger brass bolt installed in the bottom slip base plate.

One side of the secondary circuit of series-multiple and step down transformers shall be grounded.

Grounding of metal conduit, service equipment, and neutral conductor at service point shall be accomplished as required by the Code and the serving utility, except that grounding conductors shall be No. 6 AWG or equal.

For bonding purposes in all nonmetallic type conduit, a bare No. 6 AWG copper wire shall be run continuously in circuits used for series lighting, and a bare No. 8 AWG copper wire shall be run continuously in all other circuits. In lieu of the continuous copper ground wire, a ground rod, when approved by the Engineer, may be installed at each pole or standard.

Where nonmetallic conduit is to be installed for future conductors, the above mentioned copper wire may be omitted.

At each multiple service point, unless otherwise shown on the Plans, a ground electrode shall be furnished and installed. Ground electrodes of steel or iron shall be one piece lengths of galvanized rod or pipe at least 3/4 inch in diameter. Electrodes of nonferrous materials, or their approved equivalent, shall be not less than 1/2 inch in diameter. Ground electrodes shall be installed in accordance with the Provisions of the Code. The service equipment shall be bonded to the ground electrode by use of a ground clamp and No. 6 AWG copper wire, enclosed in a 1/2 inch diameter conduit.

When a ground connection is required in a series lighting system, a plug cutout, as shown on the Plans, shall be connected into the circuit and installed in a pull box. The plug shall be grounded to a water pipe or ground electrode.

Where a metal conduit system parallels, or crosses, a permanent water system in accessible areas, grounding jumpers shall be installed at intervals not exceeding 500 feet.

Ground clamps for service grounding and for grounding of equipment on wood poles shall be a 1/2 inch galvanized, malleable iron conduit hub with swivel feature.

On wood poles, all equipment mounted less than 8 feet above ground surface shall be grounded.

Bonding of metallic conduit in concrete pull boxes shall be by means of galvanized grounding bushings and bonding jumpers.

Bonding of metallic conduit in steel pull boxes shall be by means of locknuts, one inside and one outside of the box.

325.02.11 Service. Electrical service installation and materials shall conform to the requirements of the serving utility.

Service equipment shall be installed as soon as possible to enable the utility to schedule work well in advance of the completion of the project.

Where the service point is a utility-owned pole, the Contractor shall furnish conduit, conductors, and all other necessary material to complete the installation of the service riser. If the Contractor is required by the Plans or Special Provisions to install the service riser and equipment on a utility-owned pole, the position of the riser and equipment will be determined by the utility.

It shall be the Contractor's responsibility to arrange with the serving utility to complete service connections for both temporary and permanent installations and the Contractor shall pay all required costs and fees therefor.

Full compensation for furnishing and installing service poles, service equipment, conduit, and conductors, placed on utility owned poles, and the additional conductor where the serving utility requires three wire, 120/240 volt service into the meter socket for a 120 volt load, and for service connection fees, shall be considered as included in the Contract item of electrical work involved and no additional compensation will be allowed therefor.

- (a) Service Conduit and Riser. Service conduit for multiple lighting or traffic signals shall be not less than 2 inches in size. Service conduit for series lighting shall be not less than one and 1 1/2 inches in size.

Service riser conduit shall terminate with a service head or shall be sealed to prevent the entrance of water, as approved by the serving utility.

- (b) Service Equipment. Service equipment for multiple lighting systems or traffic signals, or both, shall be a three wire, solid-neutral, fused switch. The switch shall be enclosed in a NEMA Type 3R rain-tight enclosure which shall be provided with a top hinged cover, hasp for sealing cover, and Provisions for locking the handle in the "On" and "Off" positions. The padlock will be furnished by others. Service switch cabinet cover shall not be interlocked with operating handle.

When specified in the Special Provisions or shown on the Plans a circuit breaker may be used in lieu of the service switch specified above. Ratings shall be as shown on the Plans. Circuit breakers shall be

approved and listed by the UL. The operating mechanism shall be enclosed and shall be trip-free from operating handle on overload, shall be trip-indicating, and shall have trip and frame size plainly marked. Multiple-pole circuit breakers shall have a common trip. All circuit breakers shall be quick-make, quick-break on either automatic or manual operation. Contacts shall be silver alloy enclosed in an arc quenching chamber. Overload tripping of breakers shall not be influenced by an ambient temperature range of from zero degrees Fahrenheit to plus 160 degrees Fahrenheit. Enclosure for circuit breakers shall be provided with a top hinged cover, dead front panel, and a hasp for a padlock.

Where a kilowatt-hour meter is required, a meter socket, as approved by the serving utility, complete with sealings rings, shall be furnished and installed. Service equipment for traffic signals, lighting systems, or flashing beacons shall, in addition, be provided with a manual circuit closing device or space for a test block as required by the serving utility.

Each service for a series lighting circuit shall be provided with a series circuit switch of (5,000 volt rating). The switch shall be enclosed in a NEMA 3R, 18 inches by 24 inches by 6 inches cutout box. The cutout box shall be fitted with a cover permanently inscribed "Danger—High Voltage." The cover shall be attached to the box to form a rain-tight plate and shall require tools for removal. The cutout box shall be installed not less than eight (8) feet above the ground.

Service equipment enclosures, except cast aluminum meter sockets, shall be hot-dip galvanized or, at the option of the Contractor, said enclosures may be provided with a factory applied rust resistant prime coat and baked enamel finish coat in lieu of galvanizing.

325.02.12 Wood Poles. Wood poles for service or temporary installation shall be ASA Class 5, or larger, Douglas Fir or Southern Yellow Pine.

Poles shall not have more than 180 degrees twist in grain over the full length. Sweep shall be no more than 4 inches. Top of poles shall be beveled. Poles shall be placed in the ground to a depth of at least 6 feet. The lengths of poles shall be 25 feet for service poles and 35 feet for other poles, unless otherwise specified.

After each wood pole is set in the ground, the space around the pole shall be backfilled with selected earth or sand, free of rocks and other deleterious material, placed in layers approximately 0.33 foot thick. Each layer shall be moistened and thoroughly compacted.

Mast arms and tie rods for wood pole installations shall conform to the Provisions in Subsection 325.02.04 – "Standards, Steel Pedestals, and Posts" – and to the details shown on the Plans. Each mast arm shall be provided with an insulated wire inlet and wood pile mounting brackets for mast arm and tie rod crossarm.

Mast arms for luminaires shall be mounted to provide a mounting height of 30 feet. Mast arms for traffic signals, flashing beacons, and overhead detectors shall provide a minimum vertical clearance of 17 feet from bottom of equipment to the pavement.

Wood poles, not to be painted, shall be pressure treated after fabrication as provided in Section 208 – "Timber and Preservation Treatment."

325.02.13 Field Tests. Prior to completion of the work, the Contractor shall cause the following tests to be made on all traffic signal, sign illumination, and lighting circuits, in the presence of the Engineer.

- (a) Continuity. Each circuit shall be tested for continuity.
- (b) Ground. Each circuit shall be tested for grounds.

- (c) Megger. A megger test at 500 volts DC shall be made on each circuit between the circuit and a ground. The insulation resistance shall not be less than 10 megohms on all circuits, except for inductive loop detector circuits which shall have an insulation resistance value of not less than 100 megohms.
- (d) Functional. A functional test shall be made in which it is demonstrated that each and every part of the system functions as specified.

The functional test for each new or modified traffic signal, flashing beacon, and ramp metering system shall consist of not less than five days of continuous satisfactory operation. If unsatisfactory performance of the system develops, the condition shall be corrected and the test shall be repeated until the five days of continuous satisfactory operation is obtained.

The initial turn-on shall be made between 9:00 a.m. and 2:00 p.m. unless specified otherwise in the Special Provisions. Prior to turn-on, all equipment as shown on the Plans shall be installed and operable. This includes "WALK — DON'T WALK" pedestrian signals, pedestrian push buttons, vehicle detectors, and highway lighting. All louvers, hoods, and signal heads shall be directed to provide maximum visibility.

Turn-on of new or modified traffic signal systems shall be made only after all traffic signal circuits have been thoroughly tested as specified above and a signal timing program acceptable to the maintenance agency has been implemented.

On all projects with new traffic signal controllers, there shall be a qualified manufacturers representative present at turn-on to oversee the initial signal system operation.

The functional test for each lighting system and sign illumination system shall consist of an operational test for two consecutive days according to the regular lighting schedule.

During the test period, State or local forces will maintain the system or systems. The cost of any maintenance necessary, except electrical energy and maintenance due to damage by public traffic, shall be at the Contractor's expense and will be deducted from any moneys due, or to become due, the Contractor.

Functional tests shall start on any working day except Friday, or the day preceding a legal holiday.

Shutdown caused by damage by public traffic or a power interruption shall not constitute discontinuity of the functional test.

325.02.14 Galvanizing. Galvanizing shall be in accordance with the Provisions in Section 213 – "Galvanizing" – except that cabinets may be constructed of material galvanized prior to fabrication in conformance with the Specifications of ASTM Designation A525, Coating Designation G90.

Iron or steel pipe standards and pipe mast arms shall be hot-dip galvanized after fabrication in conformance with the Specifications of ASTM Designation A120.

Tie-rods, nuts, washers, clamps, and other miscellaneous ferrous parts shall be hot-dip galvanized after fabrication in accordance with the Provisions in Section 213 – "Galvanizing."

Not less than 10 inches of the upper end of the anchor bolts, anchor bars, or studs, and all nuts and washers shall be galvanized in accordance with the Provisions in Section 213 – "Galvanizing Components."

After galvanizing, the bolt threads shall accept galvanized standard nuts without requiring tools or causing removal of protective coatings.

Galvanizing of existing materials in an electrical installation will not be required.

325.02.15 Painting. Painting of electrical equipment and materials shall conform to the Provisions in Section 214 – “Paint” – and Section 324 – “Painting, Pavement Striping and Marking” – with the following additions and modifications.

Paint materials for electrical installation, unless otherwise specified, shall conform to the Provisions in Section 214 – “Paint.”

Factory or shop cleaning methods for metals will be acceptable if equal to the methods specified herein.

In lieu of the temperature and seasonal restrictions for painting as provided in Section 324 – “Painting, Pavement Striping, and Marking” – paint may be applied to equipment and material for electrical installations at any time approved by the Engineer.

All ferrous surfaces to be painted shall be cleaned as provided in said Section 324 – “Painting, Pavement Striping, and Marking” – prior to applying the vinyl wash primer or prime coat. Blast cleaning of galvanized metal surfaces in good condition, as determined by the Engineer, will not be permitted.

Existing equipment to be painted in the field, including Agency-furnished equipment, shall be washed with a stiff bristle brush using a solution of water containing two tablespoonfuls of heavy duty detergent powder per gallon. After rinsing, all surfaces shall be wire brushed with a coarse, cup shaped, power driven brush to remove all poorly bonded paint, rust, scale, corrosion, grease, or dirt. Any dust or residue remaining after wire brushing shall also be removed prior to priming.

Galvanized metal poles and metal guard posts will not require painting.

Two finishing coats of Aluminum Paint, Finish Coat, Section 214 – “Paint” – shall be applied to the following nongalvanized equipment: controller cabinets, reused lighting and signal standards, and reused luminaires; and to exterior surfaces and ungalvanized steel edges of rain-tight enclosures (switches, service, control equipment, transformers, etc.).

Interior of signal hoods, louvers, and front faces of back plates shall be finished with two coats of Enamel; Traffic Signal, Lusterless, Black, as provided in Section 214 – “Paints” – except that factory enamel finish in good condition will be acceptable.

Painting of outside of signal heads and other signal equipment which have been factory enameled in dark olive green and are in good condition, may be omitted.

Factory finish on new equipment will be acceptable if of proper color and if equal in quality to the specified finish.

Conduit and conduit fittings above ground shall be prepared and finished in the same manner as the adjacent standard or post.

Signal heads, signal head mounting, brackets and fittings, outside of hoods, pedestrian push button housings, pedestrian signal head housings and hoods, and back faces of back plates shall be finished with two coats of Enamel; Traffic Signal, Dark Olive Green, as provided in Section 214 – “Paint.”

Rusted equipment previously finished as specified in subsection 325.02.14 – “Galvanizing” – shall be given a spot finishing coat on newly primed areas, followed by one finishing coat over the entire surface.

Reused galvanized equipment with extensively rusted areas shall be cleaned and painted as provided for nongalvanized equipment.

Small rusted or repaired areas of reused galvanized equipment shall be cleaned and painted as provided in Section 213 – “Galvanizing” – for repairing damaged galvanized surfaces.

New galvanized equipment shall not be painted.

All paint coats may be applied either by hand brushing or by approved spraying machines in the hands of skilled operators. The work shall be done in a neat and workmanlike manner. The Engineer reserves the right to require the use of brushes for the application of paint, should the work done by the paint spraying machine prove unsatisfactory or objectionable, as determined by the Engineer.

325.03 CONTROLLERS

325.03.01 Controllers. A controller shall consist of a complete electrical mechanism for controlling the operations of traffic control signals, including the timing mechanism and all necessary auxiliary equipment, mounted in a cabinet.

All equipment inputs, outputs, and terminals shall be identified by the phase designations shown on the Plans.

325.03.02 Interval Sequence. The color sequence of signal indicators shall be green, yellow, red. During any interval there shall be no visual flicker of signal indications.

325.03.03 Flashing Operations. All controller cabinets shall be equipped for flashing operation of signal lights. Flashing operations, when required by railroad pre-emption, flashing control, or other causes, shall be set for flashing yellow lights on the main street or highway and for flashing red on the cross street or streets or left turn lanes, unless otherwise specified in the Contract Documents or directed by the Engineer.

325.03.04 Railroad Pre-emptor. The railroad pre-emptor shall pre-empt normal controller unit operation, or flashing operation as provided in Subsection 325.02.25 (10i) – “Switches Behind Police Auxiliary Door” – when actuated by the normally closed trace circuit or by a test switch. The pre-emptor shall cause the signals to display the sequence of indications shown on the Plans. Once clearance sequence is begun it shall continue to the end regardless of the condition of the track circuit or test switch. After the track clearance interval the signals shall flash while the pre-emption circuit is actuated. When the track circuit or test switch is returned to its normal condition flashing operation shall terminate through the signal sequence shown on the Plans. The controller shall go through the phase sequence shown on the Plans as if calls had been received on all phases. Pedestrian “WALK” indications shall appear with the first corresponding green indication.

325.03.05 Railroad Pre-emption Equipment. The pre-emptor shall consist of solid-state components and circuits. Solid-state circuitry shall conform to the material requirements specified in Subsection 325.03.10 – “Traffic Pre-empting Devices.”

The pre-emptor shall be a module which plugs into the controller unit, or a separate unit built on a shelf mounted chassis, which is connected into the controller through an “MS” connector.

The controller shall operate only in the flashing mode when the pre-emptor is removed.

The pre-emptor shall be provided with timing controls for the intervals shown on the Plans. Pilot lights shall indicate which interval the pre-emptor is in. Means shall be provided to turn the pilot lights on and off.

A momentary contact, normally closed switch shall be installed in series with the track circuit to provide a means to test the pre-emptor.

Relays and flashers shall be as specified for controllers. During pre-emption of normal signal operation, the signal lights may be switched by the normal load switching devices.

325.03.06 Operating Voltage. All traffic signal equipment, except pedestrian push buttons, shall be designed to operate from a 120 volt, 60 Hz, AC supply. Operation shall be satisfactory at voltages from 105 to 130.

The voltage for pedestrian push buttons shall not exceed 18 volts.

325.03.07 Radio Interference Suppressors. Each traffic controller unit, flasher, and other current interrupting device shall be equipped with a suitable radio interference suppresser installed at the input power point. Interference suppresser shall be of a design which will minimize interference in both broadcast and aircraft frequencies, and shall provide a minimum attenuation of 50 decibels over a frequency range of 200 kilocycles to 75 megacycles when used in connection with normal installations. The interference suppresser shall be hermetically sealed in a substantial metal case filled with a suitable insulating compound. Terminals shall be nickel-plated, 10 to 24 brass studs of sufficient external length to provide space for connecting two No. 8 AWG conductors, and shall be so mounted that the terminals cannot be turned in the case. Ungrounded terminals shall be properly insulated from each other, and shall maintain a surface leakage distance of not less than 1/4 inch between any exposed current conductor and any other metallic part, with an insulation factor of 100 to 200 megohms dependent on external circuit conditions. Suppressors shall be designed for 125 percent of the total connected load and in no event less than 25 amperes, 120 volts, 60 Hz, single-wire circuits, and shall meet standards of the UL and the EIA.

325.03.08 Traffic Actuated Controllers.

(a) General Requirements

1. The controller supplied under these specification may be modular or nonmodular in construction with all phases or function timing sections identified to the phase(s) it controls.
2. The controller supplied shall meet requirements of the NEMA Standards Publication, T-S1, current edition.
3. Modular controllers shall be microprocessors, supplied in main frame construction as follows:
 - a. **Two Phases Active.** Two or four phase main frame with all phase modules supplied.
 - b. **Three or Four Phases Active.** Four phase main frame with all four phase modules supplied.
 - c. **Five to Eight Phases Active.** Eight phase main frame with all eight phase modules supplied.
4. Nonmodular controllers shall be microprocessors, supplied in two, four, or eight phase configurations, using pushbutton keyboard entry system for selectable and settable timing periods.
5. All timing and addressing functions of the controller shall be performed using digital techniques in accordance with the NEMA Standards.

6. All circuits shall consist entirely of solid-state electric circuitry. No vacuum or gaseous tubes may be used in any timing circuits. No electro-mechanical devices, such as camshafts, rotary, stepping, or line switches may be used for switching functions.
7. Circuits shall be designed using MOS or CMOS components. All components used shall have at least two sources of supply. Memory chips that are programmed by the manufacturer may be single source.
8. The timing circuits shall be designed so that the length of any interval, portion, or period of extension shall correspond to the accuracy of the 60 Hz source without variance.
9. The controller and all associated equipment shall be designed for use on 120 VAC, 60 Hz source.

(b) Visual Monitoring Indications:

1. All indicator lights required in Section T-S1-14.3.6 of the NEMA Standards shall be provided for controller function observation. The "Call" lights shall be located with their respective phase on modular units and shall be provided for all phase intervals on nonmodular units. "Call" lights and interval indications shall be displayed without the necessity of calling up stored information.
2. Keyboard address instructions shall be provided on nonmodular controllers to verify phase and settable timing period readouts without the necessity of halting the controller timing.

(c) Phase Module Description:

1. The following phase modules shall have the timing period indicated. The timing ranges shall encompass those specified by the NEMA Standards.
 - a. Type 11 Phase Modules. Type 11 phase modules shall be nonvolume density without pedestrian feature. Type II modules shall provide the following functions:

Minimum green, passage time, maximum green, vehicle clearance, and all red clearance.
 - b. Type 12 Phase Modules. Type 12 phase modules shall be nonvolume density with pedestrian features. Type 12 phase modules shall provide the following functions:

Minimum green, passage time, walk, pedestrian clearance, maximum green, vehicle clearance, and all red clearance
 - c. Type 22 Phase Modules. Type 22 phase modules shall be volume density with pedestrian features. Type 22 phase modules shall provide the following functions:

Minimum green, passage time, walk, pedestrian clearance, time to reduce to minimum gap, minimum gap, actuations before added initial, seconds per actuation, maximum green, vehicle clearance, all red clearance.
 - d. Nonmodular keyboard address instruction shall provide type 22 phase timing periods on all phases.

- e. All controllers shall have button or switch selection of the following options, located on the front panel; vehicle recall, pedestrian recall, nonlocking detector memory, and recall to maximum timing. These features shall be for all phases.

(d) Controller Construction:

1. All active devices used for logic, timing, or control functions shall be solid-state in design and be sufficiently derated to ensure no material shortening of life under conditions of maximum power dissipation at maximum ambient temperatures.
2. Individual components shall be grouped and soldered to epoxy glass printed circuit boards with 2 ounce or better copper track, forming modular plug-in assemblies, internal to the controller, on nonmodular units, and in main frame slots on modular units. These assemblies, when collectively grouped, shall have a mean-time-to-failure of not less than three years. The design life of individual components, under 24 hours per day operation in the circuit application, shall not be less than five years.
3. Power failures between 500 and 1,000 milliseconds shall have no material effect on the controller, and it shall continue to operate in a normal manner. If the power is disrupted in excess of 500 milliseconds, when restored, the controller shall resume timing in its programmed start-on interval.
4. Temperature. All solid-state equipment shall be designed to operate satisfactorily over the range of minus 30 to plus 165 degrees F.
5. Humidity. All solid-state equipment shall be designed to operate satisfactory in up to 95 percent relative humidity.
6. Dust Resistance. All solid-state equipment shall be designed to prevent dust or dirt from entering the enclosed solid-state components.
7. Microprocessor. The controller's timing, decision making, and control elements shall utilize a stored program microcomputer. The microcomputer system shall encompass, but not be limited to, a microprocessor unit (MPU), a programmable read-only memory (PROM), and a read-alter memory (RAM), which together store the computer programs and data necessary to operate the MPU, a clock generator that provides MPU timing, a real-time clock that provides controller interval timing, flexible input/output circuitry that provides interface to traffic sensors and traffic lights, and special function commands.
8. Inputs/Outputs. Inputs and outputs related to external devices in the cabinet shall be related to the pin assignments prescribed by NEMA and shall not require cabinet modification for interchangeability with NEMA controllers. Any special functions required for controller operation shall utilize spare pins in the input/output connectors as specified by NEMA.
9. Controller Sequence Reversal. Dual ring controllers shall be capable of phase sequence reversal by applying a ground-true signal to connector B pins W and X on the controller. Applying ground-true signal to pin W shall cause the controller to reverse sequence phases 1 and 2 (lead-lag). Applying ground-true signal to pin X shall cause the controller to reverse sequence phases 5 and 6 (lead-lag). Applying a ground-true signal to both pins W and X simultaneously shall cause the controller to sequence to phases 2 and 6 before phases 1 and 5 (lagging left turns).
10. System Control. A controller phase type 12 or 22, operating in a call to nonactuated mode 1 or 2, with the phase hold active, and the walk rest modifier input active, shall rest in a walk dwell condition until a yield (release of the phase hold input). Upon a yield, the controller shall be capable of timing the pedestrian clearance interval followed by the vehicle clearance interval, and all red interval

without the need of other input control such as a force-off. The controller shall be capable of responding to yield durations of 500 milliseconds and perform the said function.

325.03.09 Traffic Actuated Controller Cabinet. Each traffic actuated controller unit and auxiliary equipment shall be housed in a weatherproof aluminum, steel, or other approved metal cabinet or cabinets, as shown on the Plans and as described herein.

- (a) General Requirements. All cabinets shall be provided as a complete unit to include all shelves, foundations, anchor bolts with template, locks, door stops, etc., and to be completely painted as specified on each cabinet standard drawing.
1. All cabinets shall be weatherproof, properly ventilated, and have a vent fan as specified. All cabinets shall have each and every door mounted with hinges welded to door and jamb.
 2. The type of cabinet to be furnished shall be as specified in the Contract Documents.
 3. Each cabinet must fit the anchor bolt locations and foundations as specified on the standard drawings without modification to the cabinet or foundation.
 4. All cabinet wiring shall be neat and firm and all harnesses and cabinet wiring shall be laced or bound together with TY-WRAP or equivalent.
 5. All terminals shall be numbered and identified in accordance with the cabinet wiring diagram.
 6. Wiring diagram prints shall be furnished for each cabinet, reproduced from a reproducible drawing provided by the manufacture, pursuant to Subsection 325.01.03. The cabinet shall be equipped with a plastic envelope to house one or more cabinet wiring diagrams.
 7. The cabinet wiring diagram shall show and identify the connectors for all equipment and switches, relays, flashers, and signal control bases.
 8. The cabinet wiring diagram shall also have an intersection sketch with heads, detectors, and pushbuttons identified and a Signal Sequence Chart identified and related to the intersection sketch.
 9. All mechanical relays shall have clear covers.
 10. The following terminals, wiring, and switches shall be furnished for all cabinets:
 - a. A single pole circuit breaker, plug-in type, for control of all power to the controller and its auxiliary equipment. There shall be a terminal, unfused, for neutral side of the power supply line.
 - b. Terminal blocks for connection of traffic and pedestrian signal light field wires not specified for flashing operation.
 - c. Terminal blocks for connection of traffic and pedestrian signal light field wires specified for flashing operation.
 - d. Terminal blocks for connection of detector amplifiers, detectors, and pedestrian pushbutton field wires.

- e. Copper ground strip, mounted and grounded to cabinet wall, for connection of all common conductors.
 - f. Terminal blocks for connecting cable tie points and intercabinet terminations. Also a terminal block or terminal blocks (depending on intersection requirements) for terminating the traffic computer system interconnect cable. This block or blocks shall be telephone type Reliable Electric #R66B4-25 or equivalent.
 - g. A two circuit, solid-state, jack-mounted flasher, having a minimum flashing rate of 50 to 60 flashes per minute. The flasher circuits shall be wired in the cabinet in accordance with the standard auxiliary cabinet equipment wiring drawing.
 - h. Convenience Outlet and Voice Communication Phone Jacks:
 - (1) A duplex "u" ground type of convenience outlet shall be furnished for test equipment, tools, and lighting. It shall have an integral ground fault protection device.
 - (2) One phone jack, unless otherwise indicated on the Plans, shall be wired to the interconnect terminal block.
 - i. Switches Behind Police Auxiliary Door. "Auto-flash" switch identified "auto-flash" wired to de-energize signal light power and place signals on "flash", but to keep controller power energized during the flash period. When the "auto-flash" switch is placed in the "flash" position, the stop-time device required within paragraph (c) "Conflict Monitor" shall be activated to store and display the indication that the "auto-flash" switch was triggered.
 - j. Interior Cabinet Switches:
 - (1) "Main switch" identified "on-off" wired to de-energize both controller and signal light power when switched to "off" position.
 - (2) "Test switch" three position switch (or equivalent) identified "auto-off-flash" wired to de-energize controller power during "off" and "flash" positions.
 - (3) The test switch, main switch, voice communication phone jacks, and convenience outlet may be combined on a signal panel, and preferably, mounted on the cabinet door behind the police auxiliary panel.
 - k. Radio line filter or filters for filtering AC + lights and control power for solid-state light control and controller operation.
 - l. Thyrector or gas filled surge protector for filtering lightning or high voltage surges to ground for protection of solid-state components.
- (b) Additional Cabinet Equipment.
- 1. Cabinet types M-1 and R shall have a top mounted fan as specified.

2. Each type D and type G cabinet shall be ventilated if a fan is not a requirement.
3. Type M-1 and type R cabinets shall have a fluorescent fixture and light mounted in the cabinet interior, preferably over the door, at a location least likely to be damaged. The length shall be determined by the cabinet width. The fixture shall have an on-off switch operated automatically with light on when door is opened and off when the door is closed.
4. Each cabinet shall have a vehicle and pedestrian detector test panel located on the inside of the cabinet door, equipped with toggle switches and pushbuttons, wired for permitting the introduction of manual calls into each controller vehicle or pedestrian detector input. The toggle switch, in one position, shall permit calls into the controller for vehicle and pedestrian detectors. The toggle switch, in one position, shall disconnect the vehicle and pedestrian detectors and permit calls into the controller via manual push button actuation. Each vehicle and pedestrian detector circuit shall have a separate toggle switch and manual push button. Toggle switches and push buttons shall be provided for all future phases and wired to the terminal blocks.
5. Type M-1 cabinets shall have a hook type door stop. The hook end shall be at least 1 1/2 inches long.

Type R cabinets shall have a door stop device located at the top or bottom of the door that will allow securely fastening the door opened to 90 or 180 degrees.
6. A conflict monitor as hereinafter described shall be installed in each traffic signal cabinet.
7. Load switches as hereinafter described shall be installed in each traffic signal cabinet.
8. All necessary cabinet wiring, connecting cables, and support bases shall be provided for all future vehicle and pedestrian phasing possible for each specific controller. Phase overlaps shall be provided when specified on the traffic signal drawings.
 - a. A loadswitch shall be provided with each support base for future operation.
 - b. The cabinet wiring diagram shall include clear instructions for expansion to the additional phases and all wiring to be changed or removed shall be tabulated. It shall not be necessary to add wiring to expand phases.
9. Terminal blocks shall be provided for connection of a minimum of 16 loop amplifier connecting cables (160 terminals) in each "Type R" cabinet. Other cabinet sizes shall require 20 spare terminal block terminals for future loop amplifiers. Additional terminal blocks shall be provided for loop amplifier connecting cables required for local traffic computer systems and counter detectors.

(c) Conflict Monitor.

1. The conflict monitor shall be a self-contained, solid-state device capable of detecting conflicting signal displays and/or improper power-supply voltage from the controller.
2. The unit shall monitor for conflicting indications during the green, amber, and walk of each phase and be programmable to designate the conflicting phases. The unit shall also monitor all red signal sections on each approach of each phase; a conflict shall be indicated if all red signal lamps on any signal approach are dark. All monitoring shall be done on the field side of the cabinet wiring terminals.

3. When the monitor is triggered, as a result of sensing conflicting indications, or the "auto-flash" switch is switched to "flash", the monitor shall place the intersection into emergency flash, stop time the controller, and store and display the conflicting indications experienced at the moment of the conflict on the front of the unit. The monitor shall retain this operation until reset by a front panel pushbutton.
4. When the monitor is triggered as a result of sensing a supply voltage error, it shall place the intersection into emergency flash and retain this operation until reset by the front-panel pushbutton or restoration of proper power.
5. The sensitivity of the threshold level shall be 25 plus or minus 5 volts AC. Voltage levels above 30 VAC shall be sensed while voltages below 20 VAC shall not be sensed. The monitor shall not trigger until the conflict has been sensed for more than 100 milliseconds.
6. All 5 to 8 phase cabinets shall have a conflict monitor wired for all 8 vehicle and 4 pedestrian phases.
7. The conflict monitor shall be capable of outputting a ground-true signal when in a conflicted condition. This output shall be wired to the communication interface panel terminal.
8. The conflict monitor shall meet the requirements of current NEMA Standards Publication No. TS1, Part 6.

(d) Load Switches.

1. The interface between the controller and the vehicle and pedestrian signals shall be accomplished through solid-state load packs. Each load pack shall have three solid-state switches in a modular assembly for opening and closing the connection between applied power and the traffic signals.
2. The load switch(es) shall conform in its entirety to the current NEMA Standards Publication No. TS1, Part 5.

325.03.10 Traffic Pre-empting Devices.

(a) Pre-empt System Designation.

1. The pre-empt system is intended to identify the presence of designated priority vehicles, and shall enable such vehicle to remotely cause the traffic signal controller to advance to and/or hold a desired traffic signal display by using existing controller functions. The control shall be effective for a distance of up to 1,800 feet along an unobstructed "line of sight" path. When the optical emitters are equipped with a visible light filter, the control is effective for a distance of up to 1,000 feet.
2. The pre-empt system shall utilize optical pulses transmitted at the rate of 14.035 Hz plus or minus 0.25 Hz.
3. No distinction is made between the various vehicles that are equipped with optical emitters. One timing strategy is used to yield the same level of priority for all classes of optical emitter equipped vehicles unless otherwise provided in the Plans or the Special Provisions.

(b) Functional Elements. The re-empt system shall be comprised of three basic functional elements.

1. Optical Emitter Assembly. An emitter and a control for transmitting a predetermined signal indicating the approach of the priority vehicle.
 2. Optical Detector. An optical detector capable of directionally detecting the predetermined transmitted signal.
 3. Phase Selection.
 - a. Equipment for remotely controlling a traffic signal control system which controls a set of traffic signal lights.
 - b. The equipment shall be operatively coupled to the optical detector and to the traffic signal controller.
 - c. The equipment shall include sensing circuits for operative coupling to the traffic light thereby sensing the phase of the traffic light.
 - d. The equipment shall respond to both the detected direction of the predetermined signal and the sensed phase of the traffic light and cause the traffic signal controller to operate in a selected phase.
- (c) Pre-empt System Operation.
1. The system shall, in response to an optically transmitted predetermined signal of 14.035 Hz or upon the actuation of a test switch, cause the traffic signal controller to select and either hold a preselected green indication or advance to and hold that green indication.
 2. The system shall not be interposed between the traffic signal control unit and the traffic signal light displays.
 3. The system shall cause the traffic signal control unit to select one of its available green phases by activation of a combination of its normally available inputs such as stop time, manual, force off, manual control enable, interval advance, phase omit, and vehicle detector.
 4. The system, when activated, shall provide a ground-true signal to the communications interface panel. Where dual pre-emption exists, the system will provide a ground true to the communication interface panel for each pre-emption activation. These outputs shall be wired to pre-empt one.
 5. The system shall not compromise the existing fail-safe or conflict monitoring provisions of the controller.
 6. The equipment manufacturer shall not modify the existing traffic control equipment to alter its capabilities beyond adding the remote control feature.
 7. The pre-empt system shall not cause the traffic control assembly to display any signal for less than is acceptable to the Engineer.
 - a. Minimum green times shall be provided on phases that are to be terminated in response to a priority demand.

- b. Green displays that appear to be not timed or changes from red to yellow to red with no apparent omission of a minimum green display are not allowed.
 - c. Transitions from green to red without an appropriate yellow change interval are not allowed.
 - d. Minimum acceptable displays of pedestrian walk and flashing don't walk shall be maintained on phases that are to be terminated.
8. The system shall cause the controller to advance to and/or hold the desired traffic signal display even if the optical energy signals cease before the desired display is obtained unless the demand is overridden by a higher priority demand.
9. The system shall begin the process to allow the traffic signal controller to resume normal operation within 10 seconds after optical energy signals cease or the optical energy signals cease after the desired traffic signal display is obtained.
10. The presence of a priority demand shall be held in the system as long as the conditions of a valid signal remain present on the called channel.
11. The system shall be designed so that it can only act upon a priority demand for a traffic signal phase or nonconflicting phase pair at any one time.

(d) Pre-empt System Component Specifications.

1. Emitter Assembly (shall be furnished by others).
- a. Shall be pulsed optical energy source with a controlled repetition rate producing pulses of relatively fast rise time.
 - b. Shall be capable of producing high priority pulses of 14.035 Hz plus or minus 0.25 Hz as determined by the frequency setting of the emitter control.
 - c. Shall be controlled by a single on-off switch which requires no other setting or adjustments by the operator. The on/off condition shall be indicated by a light located adjacent to the on/off switch on the emitter control assembly.
 - d. Shall operate on 10 to 15 volts DC input voltage, but shall not be damaged by sustained input voltages up to 25 volts DC.
 - e. Shall not weigh more than 4.5 pounds.
 - f. Shall not exceed the following physical dimensions:
Length 5 1/4 inches, Height 6 5/8 inches, Width 7 inches.
 - g. Shall operate over an ambient temperature range of minus 30 to plus 140 degrees F. without the use of an internal or external heater.

- h. Shall operate in zero to 95 percent humidity.
 - i. Shall not exceed current consumption of 5 amps.
 - j. Shall not emit visible light exceeding an average of 0.0003 candles per flash when the emitter is equipped with a visible light filter in the wavelength range of 380 to 750 nanometers.
2. Optical Detector.
- a. Shall be solid-state construction.
 - b. Shall have internal circuitry encapsulated in a semi-flexible compound to insure moisture resistance.
 - c. Shall be capable of receiving optical energy signals from either one or both of two axially opposed directions.
 - d. Shall contain internal circuitry to prevent electrical outputs due to steady state ambient light.
3. Phase Selection Equipment.
- a. Shall use primary solid-state electrical components, but in no case use more than four electromechanical relays.
 - b. Shall have two channel operation with the capability of interfacing with an additional phase selector for expansion of channels of operation.
 - c. Shall be compatible with currently manufactured high priority detection equipment to allow expansion to dual priority operation at a future date.
 - d. Shall have a maximum of three standard "MS" type connectors, one for the main wiring harness to the controller, and one for each channel optical detector connection.
 - e. Shall have a control for adjusting the pulse width of the advance of "manual" pulses.
 - f. Shall be capable of providing signals such as stop time and advance or "manual" pulses to manipulate the controller to advance to and/or hold the desired traffic signal display.
 - g. Shall have RC digital timing controls for each channel which adjusts the time between advance pulses during yellow displays from at least 1 to 10 seconds in 1 second steps.
 - h. Shall have RC digital timing controls for each channel which adjust the time between advance pulses during non-yellow displays from at least 1 to 10 seconds in 1 second steps.
 - i. Shall have a control that is capable of multiplying the time setting by two.
 - j. Shall have solid-state indicator light to indicate power on, signal being received, channel called, and advance circuit operation.

- k. Shall be capable of automatically placing a call on a predetermined channel after servicing a call on another channel (recall).
 - l. Shall have switches to control system power, activate "recall", test the phase selector advance operation, and to multiply timing control settings by two.
4. Pre-empt System Interface.
- a. When additional interfacing beyond two external relays is required, it shall be housed in a pre-empt system interface unit.
 - b. The pre-empt system interface unit shall:
 - (1) Have the capability to allow mounting 60 dual terminals rated at 300 volts to allow making connection between internal logic and external sources.
 - (2) Have provision for mounting up to eight card edge sockets for mounting and wiring to the various logic elements of the system interface unit.
 - (3) Have one connector to provide input/output connections for interfacing with the controller assembly.
 - (4) When more than one interface unit is used in a particular installation, the units shall be individually keyed to preclude connection to the wrong harness assembly.
 - (5) The system interface unit dimensions shall not exceed those of the phase selector.
- (e) Reliability.
- 1. All controller cabinet equipment supplied as part of the remote control system must meet the NEMA environmental specifications spelled out in current NEMA Standard Publication No. TS1, Part 2:
 - TS1-2.1.2 Voltage
 - TS1-2.1.3 Frequency Range
 - TS1-2.1.4 Power Interruption
 - TS1-2.1.5 Temperature and Humidity
 - TS1-2.1.6 Transients Power Service
 - TS1-2.1.7 Transients Input/Output Terminals
 - TS1-2.1.8 Nondestruct Transient Immunity.

2. All equipment mounted externally to the intersection control equipment cabinets or the priority vehicle must operate properly under any combination of the following environmental conditions without the use of internal or external heating devices.

Temperature -30 to +140 degrees F.

Relative Humidity 0 to 95 percent

(f) Installation.

1. The pre-empt system equipment manufacturer shall be responsible for "Pre-empt System Design and Documentation." Pre-empt system design and documentation includes the following:
 - (a) Design controller interface logic to generate an interface diagram that indicates the recommended interface technique.
 - (b) Provide the installing agency and using agency with interface diagram.
2. The installer shall install the equipment consistent with the equipment manufacturer's recommended installation procedures and interface diagrams in a neat and workmanlike manner.
3. The equipment manufacturer shall be responsible for "Pre-empt System Checkout" prior to final acceptance and approval by the purchasing and/or using agency (agencies). Pre-empt system checkout includes the following:
 - a. Verifying that the system is properly installed per the manufacturer's recommendations and the interface diagrams as provided by the equipment manufacturer.
 - b. Verifying that the priority system timing and range are properly set.
 - c. Pre-empt system warranties are put into effect.
 - d. Instructing the emergency vehicle drivers or their representative(s) in the operation of the system.
 - e. Instructing maintenance personnel in routine maintenance of the system.

(g) General.

1. Manufacturer shall replace or repair, without charge any component parts that prove to be defective within 1 year after installation. Manufacturer shall certify upon request that all materials furnished will conform to this specification.
2. The traffic pre-empting devices shall be installed at the locations shown on the Plans.

325.03.11 Time Base Coordination Unit. The unit shall provide for coordination of signalized intersections without the use of the interconnect cable. The unit shall use the latest technology solid-state circuitry as specified in the Special Provisions.

325.03.12 Pre-Timed Controller Units. Pre-timed controller units shall be the expansible type designed to permit the installation of plug-connected dial units without additional wiring or modification of the controller unit. Controller units shall be 1-dial, 2-dial, or 3-dial. The types of pre-timed controller units, number of dials, cabinets, and auxiliary equipment shall be as shown on the Plans or specified in the Special Provisions. Solid-state pre-timed controllers will be acceptable.

- (a) Controller Units. Pre-timed controller units shall be of the following types:
1. Type XXV Controller Units. Type XXV controller units shall be the future interconnected type and shall be capable of being operated as future units in an interconnected, master controlled flexible progressive system by the addition of easily installed auxiliary attachments.
 2. Type XXVI Controller Units. Type XXVI controller units shall be the interconnected type; shall be capable of being operated as units in an interconnected, master controlled flexible progressive system; and shall have three (3) offsets per dial, unless otherwise specified in the Special Provisions.
 3. Type XXVII Controller Units. Type XXVII controller units shall be the combined master and intersection interconnected type and shall be similar to Type XXVI controller units, except that the Type XXVII shall be equipped with master offset supervision, dial change, offset selection, and flashing operation of the intersection controllers.
- (b) Operations. All pre-timed controller units shall be capable of being operated by manual control; as a pre-timed controller of the independent, isolated type; and as a synchronous-motor-driven coordinated type, for progressive timing without interconnecting circuits.
- (c) Mechanism for Pre-Timed Controller Units. Mechanism for pre-timed controller units shall be constructed as a complete, self-contained, readily interchangeable unit arranged to swing out for inspection while in operation. All parts shall be readily accessible.

All circuits of each unit shall be terminated in a multiple-contact connector. Connection between the connector and the panel or field terminal board shall be by means of a flexible cable. Panel or field terminal board end of the conductors shall be fitted with proper terminals. Each field terminal shall be identified.

- (d) Motor and Dial. Controller unit motor shall be of the self-starting, synchronous type, and shall have ample torque for the requirements of the controller operation. All intervals in each phase shall be readily adjustable by a suitable dial on the face of the controller unit. Intervals shall be adjusted in steps not to exceed 1 percent of the total cycle by means of self-retained timing keys.

Each dial unit shall consist of motor, dial with slots for timing keys, contact block, motor switch, and connector for plug-in mounting of the entire dial unit assembly. Design of the dial unit shall allow gear changing without tools or with simple tools. The cycle length of the gear used shall be indicated on the face of the dial unit when the gear mesh is correct. Gears shall be brass.

A suitable dust cover shall be provided for the timing mechanism. Dial key settings shall be visible without the necessity of removing the cover.

Color code of dial keys shall be as follows:

Drum Release	Green
Drum Advance	Unpainted
Offset 1	Red
Offset 2	Yellow
Offset 3	White

- (e) Signal Contact Mechanism. All parts of the contact mechanism for signal lights, including contacts and contact supports, shall operate one million times without mechanical wear that impairs normal operation.

All signal light contact points shall be of fine silver, silver alloy, or superior alternative material not less than 5/16 inch in diameter; shall be of not less than 10 ampere capacity, capable of operating 1,000,000 times without excessive burning or pitting; and shall be easily removed and replaced.

Cam or drum assembly shall provide not less than 12 intervals, all necessary contacts, and Provisions for not less than a total of 14 signal light contacts. Wiring shall be complete from terminal strip to each contact position.

- (f) Auxiliary Equipment. Each pre-timed controller unit shall be equipped with a complete set of brass gears for each dial 50 to 120 seconds, inclusive, in 10 second steps.

1. Controls. Switches shall provide local control of the following functions:

- a. Transfer from automatic to manual operation and vice versa.
- b. Transfer from normal operation to flashing and vice versa.
- c. Transfer from one dial to another.
- d. Turn-off signal lights only without shutting down controller unit mechanism.
- e. Shutdown timer mechanism.

Combined master and intersection controller units shall have additional switches properly marked for functions (b) and (c) above and for offset selection for the interconnected system. Switch for local control of function (c) is not required at the master.

Combined master and intersection controller units shall also have Provisions for time switch or program device control of functions (b) and (c) above and for offset selection for the interconnected system.

Interconnected controller units shall have relays and wiring for remote control of functions (b) and (c) above for offset selection.

Future interconnected controller units shall have Provisions for local time switch control of functions (b) and (c) above and for offset selection.

- 2. Offset Interrupter. Each Type XXVI controller unit shall be provided with an offset interrupter which, during reset of time cycle to the master synchronization pulse, shall limit the length of the dwell in any one cycle. Interrupter shall have 5 second, minimum, increments, and shall have a range of 40 seconds, minimum.

Timing adjustments shall be made without the use of tools and shall have an accuracy of plus or minus 10 percent of the setting over the full range. Timer shall be plug-in mounted.

A switch shall be provided to bypass the interruption feature.

Removal of the interrupter shall not affect the operation of the Type XXVI controller unit.

3. Flashers. Each pre-timed controller unit shall be wired and furnished with a plug-in-mounted flasher and provisions for jack-mounted relays conforming to the Provisions in Subsection 325.02.24 (a) 10g.

Plug-in-mounted flasher and jack-mounted relays for flasher shall be independent of the controller unit and shall remain in operation upon the shut down of the controller or removal of the controller unit from the cabinet.

4. Manual Control. Each pre-timed controller unit shall be provided with labeled terminals for a hand switch.
5. Mounting Panel. A readily accessible mounting panel shall be furnished in each pre-timed controller cabinet, with adequate Provisions for terminating all field circuits and for mounting fuses and relays. Each power and direct wire interconnect circuit, except neutrals, shall be fused.

- (g) Special Auxiliary Equipment. The following special equipment shall be furnished and installed when required to perform specified functions, when specified in the Special Provisions or when shown on the Plans.

1. Time Switches. Time switches to control system or local flash, dial change, or other specified functions shall be synchronous motor driven; shall be equipped with 10 hour spring wound reserve carryover; shall be equipped with an omitting device; and shall provide for at least three openings and three closings per 24 hour period. Mechanical and electrical characteristics shall be equal to those specified in Subsection 325.03.12 – “Mechanism for Pre-Timed Controller Units.”
2. Railroad Pre-emption. Railroad pre-emption relays, when required, shall perform the operations provided in Subsection 325.03.04 – “Railroad Pre-emption.”
3. Telephone Relays. Telephone relays shall conform to the Provisions in Subsection 325.03.09 (a) 10H
4. Toggle Switches. Toggle switches shall conform to the Provisions in Subsection 325.03.09 (a) 10K.
5. Circuit Breakers. Circuit breakers shall be as specified for service switches under Subsection 325.02.11 – “Service.”
6. Interconnect Isolation Relay Units. Interconnect isolation relay units shall conform to the Provisions under Subsection 325.03.09 (12) – “Interconnect Isolation Relay Unit.”

- (h) Pedestrian Signal Sequence. The controller unit shall provide the following sequence of operations for pedestrian signals:

Steady "WALK" interval

Flashing "DON'T WALK" clearance interval

Steady "DON'T WALK" interval

On pedestrian signal installations where pre-timed controller units are used, flashing "DON'T WALK" indication shall occur during the pedestrian clearance interval and shall continue until the beginning of the vehicle yellow interval.

Flashing "DON'T WALK" indication shall be accomplished by the light cam assembly and a separate flasher. The flasher shall conform to the Provisions in subsection 325.03.09 (a) 10g.

- (i) Pre-Timed Controller Cabinet. Each pre-timed controller unit and auxiliary equipment shall be enclosed in a weatherproof metal cabinet.

The cabinet shall be fitted with a master-keyed, police lock and shall be mounted on a pedestal, as shown on the Plans. Two keys with shanks at least 1 and 1-3/4 inches long shall be furnished for each cabinet.

The cabinet shall be fitted with a slip-fitter attachment to permit post-top mounting as shown on the Plans.

One screened, rain-tight vent, 1 1/2 inches in diameter, or larger, shall be installed in the top of the controller cabinet; eight screened, rain-tight vent holes 1/2 inch in diameter, or larger, shall be provided in the lower backside or bottom of the controller cabinet.

Each controller cabinet door which is 22 inches, or larger, in width or 6 square feet, or larger, in area shall be provided with a stop to limit door opening to 90 and 180 degrees plus or minus 10 degrees. The stop shall be provided with a catch which can be operated when the door reaches the extreme open position and will hold the door open securely until released.

325.04 TRAFFIC SIGNALS AND APPURTENANCES

325.04.01 Signal Faces. Each signal face shall be of the adjustable, colored light, vertical type with the number and type of sections as specified herein or as shown on the Plans; shall provide an indication in one direction only; shall be adjustable through 360 degrees about a vertical axis; and shall be mounted at the location and in the manner shown on the Plans.

Unless otherwise shown on the Plans, all vehicle signal faces shall contain three sections arranged; red-top, yellow-center, green-bottom.

Pedestrian signals shall be the "WALK-DON'T WALK" type as specified in Subsection 325.04.07 – "Pedestrian Signals."

All new vehicular signal faces installed at any one intersection shall be of the same make and type.

All new pedestrian signal faces installed at any one intersection shall be of the same make and type.

Vehicle and pedestrian signal mountings shall be oriented so as to provide maximum horizontal clearance to the adjacent roadway.

- (a) Optical Units. Each optical unit shall consist of a lens, a reflector, a lampholder, and a clear traffic signal lamp, visible to the traffic to be controlled.

Lenses shall be made of either glass or ultra-violet stabilized polycarbonate plastic conforming to the requirements of ASTM Designation D 2473. Plastic lenses shall not distort due to heat from the highest wattage lamp required. Lamps shall be in conformance with the Institute of Transportation Engineers Standards of Traffic Signal Lamps.

Candlepower distribution shall conform to ANSI Standard D-10.1.

All mast arm mounted signal faces shall be provided with 12 inch sections.

A 12 inch section with crosshatched lens shall be provided for all green arrow signal indications. Configuration of the arrows shall conform to the dimensions shown on the Plans.

Reflectors shall be made of silvered glass or of specular aluminum with an anodic coating. All reflectors shall conform to ANSI Standard D-10.1.

Lampholders shall conform to the Provisions in ANSI Standard D-10.1.

Each reflector, lens, and hood shall be designed in such a manner as to reduce sun-phantom to a minimum.

Lamps for the 8 inch units shall be 69 watt maximum, 550 minimum initial lumens, clear, 8,000 hour life, 2-7/16 inch Light Center Length (L.C.L.), 120 volt traffic signal lamps.

Lamps for the 12 inch units shall be 150 watt maximum, 1650 minimum initial lumens, clear, 8,000 hour life, 3 inch Light Center Length (L.C.L.), 120 volt traffic signal lamps.

The lamp shall be positioned in the lamp holder to provide lamp filament orientation with the open portion of the filament facing upward or as recommended by the manufacturer of the lamps.

- (b) Housing. The signal face housing, or case, shall consist of an assembly of separate interchangeable sections, expansible type for vertical mounting without tie rods, substantially secured together in a watertight manner to form a unit. Each section shall house an individual optical unit.

Each section shall be complete with a one piece, hinged door mounting for the lens and other parts of the optical system, water-tight gaskets, and a simple door-locking device. The optical system shall be so mounted that the various parts may be swung open for ready access or removal. The sections shall be interchangeable and so constructed that sections can be removed or added. There shall be a round opening in the top and bottom of each head to receive 1/2 inch supporting pipe frame. All parts of the housing, including the doors and end plates, shall be of die cast aluminum conforming to the Specifications of ASTM Designation B 85, and all parts shall be clean, smooth and free from flaws, cracks, blow holes, or other imperfections.

All exposed bolts, screws, hinge pins, and door-locking devices shall be stainless steel. All interior screws and fittings shall be stainless steel or approved nonferrous, corrosion-resistant material.

All gaskets, including door, lens, and reflector gaskets, but not including lampholder gaskets, shall be of neoprene. Lampholder gaskets shall be of material not affected by heat. The lampholder gasket will not be required when lampholder is not in direct contact with the glass reflector.

All lampholders shall be so wired that a white wire will be connected to shell of the lampholder and a black or colored wire to the bottom or end terminal of the lampholder. These wires shall, in turn, be connected to the terminal block mounted inside at the back of the housing. The terminal block shall have sufficient screw type terminals so as to terminate all field wires and lamp wires independently, with separate screws. The terminals to which field wires are attached shall be permanently identified or wiring shall be color coded to facilitate field work.

Lampholder wires shall be No. 18 AWG, or larger, 600 volt, appliance wiring material (AWM), with 2/64 inch thermoplastic insulation rated 105 degrees Centigrade or with insulation that conforms to Military Specification MIL W-16878 D, Type B, with vinyl nylon jacket rated 115 degrees Centigrade.

The manufacturer's name or trademark, wire size, insulation type-letter designation and temperature rating shall be marked on the insulation or a Certificate of Compliance. "Certificates of Compliance" shall be submitted by the manufacturer with each shipment of traffic signal head units.

Each lens shall be provided with a removable hood, 0.05 inch thick, of sheet aluminum of the full circle type completely closed, except at the ends. Hoods for 8 inch section shall be 7 inches minimum length and for 12 inch section shall be 9 1/2 inches minimum length unless otherwise shown on the Plans. Hoods shall have a minimum downward tilt of 3 1/2 degrees.

Each signal section shall be constructed in such a manner that structural failure of the housing will not occur with a wind load pressure of 25 pounds per square foot on the projected area of the complete signal face housing, including back plate and hoods.

325.04.02 Directional Louvers. Where shown on the Plans, louvers shall be furnished and installed in signal hoods. Directional louvers shall be so constructed as to have a snug fit in the signal hoods. The outside cylinder shall be constructed of No. 22 U.S. gauge sheet steel and the vanes shall be constructed of No. 27 U.S. gauge sheet steel or the cylinder and vanes shall be constructed of 3003 H14 aluminum alloy of similar construction. Thickness dimensions and arrangements of vanes shall be as shown on the Plans.

325.04.03 Back Plates. Back plates shall be constructed of 3003 H14 aluminum alloy sheet 0.051 inch minimum thickness, and of the dimensions shown on the Plans.

Where a back plate consists of two or more sections, the sections shall be fastened with rivets or with aluminum bolts, peened after assembly to prevent loosening.

All mast arm mounted, bracket mounted and post top signal heads and all programmed visibility signal heads shall be provided with back plates.

325.04.04 Signal Head Mounting. Bracket mounted signal heads, as shown on the Plans, shall be supported by mounting brackets consisting of watertight assemblies of 1 1/2 inch standard steel pipe and malleable iron, ductile iron, or brass pipe fittings. All members shall be either plumb or level, symmetrically arranged, and securely assembled. Construction shall be such that all conductors are concealed within the assembly.

The dimensions of mounting brackets between the axis through the center of the terminal compartment, or slip-fitter, shall not exceed 11 inches, except where required to provide proper signal head alignment or directed by the Engineer.

At each signal location, unless otherwise shown on the Plans, a terminal compartment shall be constructed into the mounting brackets. Each compartment shall be fitted with a terminal block containing 12 poles, each with two screw type terminals. Each terminal shall accommodate at least five No. 14 AWG conductors. A rain-tight cover shall be provided, giving ready access to the terminal block. The terminal compartment shall be of sufficient strength to remain intact in the event the pole is knocked down.

Slip-fitters, where used without integral terminal compartment, shall be of cast-iron or bronze.

For post-top mounting of bracket mounted signals, the terminal compartment shall be cast with an integral slip-fitter. For post-top mounting of a one way signal head, a slip-fitter without a terminal compartment may be used. Slip-fitter shall fit over a four 4 inch standard pipe or 4 1/2 inch outside diameter end of tapered standard. Each slip-fitter shall be provided with two rows of steel set screws, with three screws in each row to secure the assembly in plumb position. Set screws shall be cadmium plated.

Where signal heads are side mounted on poles, the terminal compartment shall be designed to bolt securely to the pole.

Signal heads shall be equipped with positive brass lock rings and fittings designed to prevent heads from turning due to external forces. Lock ring and connecting fittings shall have serrated contacts as shown on the Plans.

Signal head assembly for suspension from mast arm shall be equipped with a slip-fitter as shown on the Plans.

Signal heads shall not be installed at any intersection until all other signal equipment, including the controller, is in place and ready for operation at that intersection, except that the signal heads may be mounted if the faces are not directed toward traffic or if the faces are covered.

325.04.05 Vehicle Detectors. All vehicle detectors shall be the "inductive loop" type.

- a. General. The term "inductive loop detector" applies to a complete installation consisting of a conductor loop or group of loops installed in the roadway, as shown on the Plans, lead-in cable and a sensor unit with power supply installed in a traffic signal controller or traffic count station cabinet.

The sensor (amplifier) unit shall be an electronic device capable of providing closure of an output circuit when a vehicle stands or passes over a loop or one of several loops connected to the input circuitry of the sensor unit.

- b. Performance Characteristics. Sensor units shall provide an output closure for each vehicle passing through the response area of the loop at speeds up to 75 miles per hour and shall also provide an output closure of at least 3 minutes duration when a vehicle is occupying the response area of the loop.
- c. Sensor Unit Construction. Each sensor unit shall be housed in a metal case. Sensor units may be furnished with either an integral power supply or a separate power supply common to more than one sensor unit.

Sensor units to be installed in a common cabinet shall have a frequency difference and shall not interfere with the operation of other sensor units installed in the same cabinet.

In multiple loop installations, all loop conductors to be connected to the same sensor unit shall be wound in the same direction. No more than four loops shall be connected to a single sensor unit.

All input and output circuits for each unit with an integral power supply shall enter via a single connector, type and circuitry for which shall be as shown in the following table. Each connector for modular-type units shall be provided with either threaded shell or spring-loaded latch locking.

Connector Circuitry For Inductive Loop Detector Sensor Units

<u>MS Connector Circuit</u>	<u>Inductive Loop Type 18-1 Pin</u>
120-volt (AC Line)	C
120-volt (AC Neutral)	A
Chassis Ground	H
Loop	D
Loop	E
Relay Contact common	B
Relay Contact	F

Connector Circuitry For Inductive Loop Detector Sensor Units

<u>MS Connector Circuit</u>	<u>Inductive Loop Type 18-1 Pin</u>
Relay Contact	G
Spare	I, J

All pilot lights and meters shall be mounted on the front panel of the sensor or the sensor power source assembly. Input power shall be fused.

Capacitors or inductors necessary for loop tuning shall not be mounted external to the loop detector sensor unit.

The unit shall not be affected by transient voltage or voltage variations of plus or minus 10 percent.

Each sensor unit shall have a fail safe feature that provides a continuous call when the loop is either open or shorted out.

After a power interruption the units shall return to normal operation within 5 minutes.

A separate sensor unit, control unit, or amplifier shall be provided for each direction of travel and for each left turn lane.

Each unit shall be provided with a light or meter to indicate when the detector is ready to detect vehicles.

Each detector shall operate over the voltage range specified in Subsection 325.03.06 – “Operating Voltage.”

Circuitry shall be solid-state except for output relays.

Output relays, if used, shall be normally closed.

Units shall be designed to provide ease of maintenance with easily accessible electronic components.

Each detector shall provide positive vehicle detection without readjustment from zero degrees Fahrenheit to 160 degrees Fahrenheit.

Units shall use printed circuit board designed to facilitate identification of components. This shall be done by either part identification markings or by providing a pictorial diagram showing physical location and identification of each component. Each printed circuit board shall have the following minimum quality requirements: NEMA Grade G-10 glass cloth base epoxy resin board, 1/16 inch minimum thickness, organic solder masking and gold plated contacts. Intercomponent wiring shall be copper track with a minimum of two ounces weight per square foot. Printed circuit design shall be such that components may be removed and replaced without permanent damage to boards or tracks.

Sensor unit amplifiers shall conform to the following:

1. Type I Loop Amplifier.

- a. The sensor unit shall be designed with one sensor in one frame to control one loop system.
- b. The unit shall have switch frequency separation when used on identical loops.
- c. The unit shall have a tuning switch or knob. The switch shall provide for resetting the unit and have an operation position.
- d. The unit shall have a sensitivity switch which may be used to minimize calls for adjacent lane vehicles.
- e. The sensor unit shall be digital in its timing modes.

2. Type II Loop Amplifier.

- a. The sensor unit shall be two channel, shelf mounted.
- b. Two channel units shall have two MS connectors, one for each channel, wired in accordance with Subsection 325.03.09 (b) 10.
- c. The unit shall have internal circuitry to prevent cross talk or spurious signals induced between the loops it controls.
- d. The unit shall have switches for frequency selection between units.

3. Type III Loop Amplifier.

- a. The unit shall have circuitry and controls for individual selection of delay or extension timing on each channel. Delay timing shall be adjustable from zero to 31 seconds in 1 second increments. Extension timing shall be adjustable from zero (0) to 7.5 seconds in 0.5 second increments. All controls shall be on the outside of the unit.
- b. Pins "I" and "J" on the MS connectors shall be used to provide control of delay and extension timing by external devices.
- c. All advance detectors shall be provided with Type III loop amplifiers.
- d. The Contractor may supply single unit loop amplifiers in lieu of multichannel amplifiers if all other function of this subsection are met.
- e. The sensor unit shall operate with both channels connected to one loop in the extension timing mode.

4. Type IV Loop Amplifiers.

- a. The sensor unit shall be a four channel device, shelf mounted.
- b. The unit shall have internal circuitry to prevent cross talk or spurious signals induced between all loops it controls.
- c. The unit shall have switches for frequency selection between units.

(d) Construction Materials.

1. The conductor for each inductive detector loop shall be continuous, unspliced, Type XHHW-USE, No. 12 AWG neoprene jacketed, 7 strand, copper wire.

All lengths of loop wires that are not imbedded in the pavement shall be twisted with at least two turns per foot between roadway and pull box. Splicing between loop wire and detector cable in the pull box shall be done in a manner satisfactory to the Engineer.

Where detector lead-in cables are spliced or are spliced to loop conductors or magnetometer detector leads, the splices shall be soldered by the hot iron, pouring, or dipping method. Open flame soldering will not be permitted. Conductors shall be joined by the use of UL listed pressure connectors or other methods permitted by the Engineer. Splices shall be insulated by one or the following methods:

- a. Thermosetting Epoxy Compound. A two part liquid thermosetting self-curing epoxy resin, where the two parts are mixed just prior to use, shall be poured into molds of dimensions suitable for the splice.
- b. Thermosetting Polyurethane Compound. A two part liquid thermosetting self-curing polyurethane resin, where the two parts are mixed just prior to use, shall be poured into molds of dimensions suitable for the splice.
- c. Handcrafted Insulation. Handcrafted insulation shall consist of the following steps.

- (1) Completely cover the splice with an electrical insulating coating and allow to dry.
- (2) Apply one layer of high voltage tape half-lapped. High voltage tape shall be self-fusing, designed for use on rubber, synthetic, or plastic insulation and shall have a minimum thickness of 26 mils.
- (3) Apply electrical insulating coating and allow to dry.
- (4) Apply one layer of PVC tape, half-lapped.
- (5) Apply electrical insulating coating and allow to dry.
- (6) Loop detector lead-in cable, from the pull box adjacent to the loop to the field terminals in the cabinet, shall consist of two No. 12 AWG solid copper conductors with each conductor insulated with 0.03- inch minimum, high molecular weight, head-stabilized, colored polyethylene, conforming to the requirements of ASTM Designation D 1248, Type I, Class B, Grade 4. The conductors shall be twisted together with approximately two turns per foot. Nonhygroscopic fillers shall be used to form a firm compact cylindrical core. A nonhygroscopic core tape shall be applied spirally over the core. The cable shall be provided with an outer jacket consisting of extruded, black polyvinyl chloride conforming to ASTM Designation D 1047. The cable shall conform to the International Municipal Signal Association's Specification 19-2.
- (7) The loop detector lead-in, from the field terminals in the cabinet to the sensor unit, shall conform to one of the following:
 - (a) A twisted pair of No. 22 AWG, or larger, conductors conforming to the requirements for cabinet wiring.
 - (b) A cable containing two No. 22 AWG, or larger, copper conductors with each conductor insulated with 0.014 inch minimum polyethylene or polypropylene. The conductors shall be twisted and the twisted-pair shall be protected with a shield of tinned copper-brass or aluminum-polyester. The shield shall be grounded at one end of the cable. The cable shall be provided with a chrome vinyl outer jacket with a minimum thickness of 0.027 inch.

Splices in the cable may be made in pull boxes only. All splices in the lead-in cable shall be soldered.

- (8) Epoxy Sealant for Inductive Loops.

Classification:

This specification covers a high viscosity liquid epoxy formulated primarily for use in sealing inductive wire loops and leads imbedded in asphalt concrete and Portland Cement Concrete for traffic signal controls and vehicle counters. This epoxy is to be used for repair work on existing spalls, cracks, and other deformations in and around saw cuts housing inductor loops and leads. The rapid cure allows minimum traffic delay. This sealant is suitable for use in freeze-thaw areas and can be used on grades up to 15 percent without excessive flow of material.

<u>Composition</u>	<u>Component A</u>	<u>Parts by Weight</u>
Epoxy Resin ¹		85.00
Orthocresol Glycidyl Ether ²		15.00
Titanium Dioxide, ASTM Designation D 476, Type III or IV		2.00
Colloidal Silica ³		1.50
Glycerine, ASTM Designation D 1257		0.50
Silicone Anti-Foam, Type Q		0.01

<u>Composition B</u>	<u>Component B</u>	<u>Parts by Weight</u>
High Functionality Polymercaptan hardener ⁴		40.00
N-Aminoethyl Piperazine ⁵		10.00
2, 4, 6-Tri (Dimethylaminomethyl) Phenol ⁶		4.00
Polysulfide Polymer ⁷		48.94
Colloidal Silica 3 1.00		1.00
Glycerine, ASTM Designation D 1257		0.50
Carbon Black ⁸		0.10
Silicone Anti-Foam, Type Q		0.01

Tests:

All tests shall be performed in accordance with Test Method No. Nev. T501.

Characteristics of Components:

¹ Di glycidyl ether of disphenol A. viscosity, 100-600 poise at 25° Centigrade, epoxide equivalent 180-200, Color, Gardner 1933, 3 max.

² Viscosity at 25° Centigrade, 510 centipoise, weight per gallon 9.00-9.10 pounds. Epoxide equivalent 180-200.

³ SiO₂ (moisture-free basis), 99 percent minimum; refractive index, 1.46; surface area 175-225 square meters per gram; particle size 0.015 microns; pH (4 percent aqueous dispersion), 3.5-4.2; pour density, 2.3 lbs./cu. ft. maximum; free moisture at 105° Centigrade, 1.0 percent maximum.

⁴ Liquid polymercaptan resin, viscosity 100-130 poise at 25° Centigrade; specific gravity 1.14-1.16; mercaptan value, 3.6 meq./gram. Color, Gardner 1933, I, Infrared curve shall match the curve on file in the Department of Transportation.

⁵ Color (APHA) 50 maximum; amine value 1250-1350 based on titration which reacts with the three nitrogens in the molecule; appearance clear and substantially free of suspended matter.

⁶ Formula weight 265; specific gravity at 25°/25° Centigrade, 0.973; refractive index 1.514 at 25° Centigrade; distillation range 96 percent at 130° Centigrade to 160° Centigrade (0.5-1.5m); flash point, Tag. open cup, 300° Fahrenheit minimum; water content 0.06 percent maximum.

⁷ Specific gravity, 1.24-1.30 at 20°/20° Centigrade; viscosity, 700-1200 centipoise. Brookfield at 25° C.; pH water extract. 6.08.0; moisture content, 0.1 percent maximum; pour point, - 15°F.; average molecular weight, 1000; flash point, Fahrenheit, Cleveland Open cup, 390 minimum; sulfur content, percent, 36-40; color, Hellige, 9-12. The product shall be a difunctional mercaptan made from 98 mole percent of bis (2-chloroethyl) formal and 2 mole percent of trichloropropane.

⁸ Surface area, square meters/gram, 80-150; particle diameter, millimicrons, 18-30; pH, 7.0-8.5; fixed carbon (moisture free), percent, 96-98; volatile matter, percent, 1-4; oil absorption, stiff paste endpoint, CCS/gram; 0.75-0.90.

Component A

Viscosity, poise, Brookfield	100-250
Shear Ratio	2.0 min.

Component B

Viscosity, poise, Brookfield	100-250
Shear Ratio	1.8 min.

Infrared curves of the vehicle components shall match those on file in the Department of Transportation.

Characteristics of Combined Components:

Gel Time	13-18 minutes on 1/8" cast sheet, cured 18 hours at 77° Fahrenheit + 5 hours at 158°Fahrenheit -
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Characteristics of Combined Components:

Tensile Strength, p.s.i.	400 min.
Elongation, percent	90 min.
Shore D Hardness	45 min.

Color to range from Color No. 26081 to Color No. 26173 of Federal Standards No. 595.

Directions for Use:

Saw cuts shall be blown clean and dry with compressed air to remove all excess moisture and debris. For repairing damaged saw cuts, all loose spalled material shall be cleaned away from saw cut, chipping back to sound asphalt concrete or Portland Cement Concrete and all loose material cleaned from loop wire.

The mixing ratio is one part by volume of Component A to one part by volume of Component B. No more material shall be mixed that can be used within 10 minutes from the time mixing operations are started.

- (e) Installation Details. Installation and tests shall conform to the details and notes shown on the Plans.

Unless shown otherwise each loop shall consist of three turns of conductor as specified in Subsection 325.04.05(d) – "Construction Materials."

Slots cut in the pavement shall be blown out and dried before installing inductive loop detectors. All sharp edges and 90 degree corners should be chipped off. In addition to the required tests, the Contractor shall check each detector loop prior to filling slot with epoxy or sealant as follows:

1. Each loop shall be tested for continuity.
2. Insulation test for each loop to ground shall not read less than 10 megohms to infinity, using a megger.

The slots shall be filled with epoxy sealant to within 1/8 inch of the pavement surface. The sealant shall be at least 1/2 inch thick above the top conductor in the saw cut. Before setting, surplus sealant shall be removed from the adjacent road surfaces without the use of solvent. The epoxy sealant shall conform to the requirements of Subsection 325.04.05(d) 1 (8) – “Epoxy Sealant for Inductive Loops.”

Conductors of all loops to be operated by each sensor unit shall be run continuous to the nearest pull box. The loops shall be joined in the pull box in combination of series and parallel so that optimum sensitivity is obtained at the sensor unit. Final splices between loops and lead-in cable shall not be made until the operation of the loops under actual traffic conditions is approved by the Engineer.

All loop conductors for each direction of travel for the same phase of a traffic signal system in the same pull box, shall be spliced to a cable which shall be run from the pull box adjacent to the loop detector to a sensor unit mounted in the controller cabinet.

All loop conductors for traffic counters shall terminate in a pull box or on a terminal strip in the traffic count station cabinet when such a cabinet is installed.

Conductors for inductive loop traffic signal and traffic counting installations shall be identified and banded, in pairs, by lane, in the pull box adjacent to the loops and near the termination of the conductors in the controller or traffic count station cabinet. Bands shall conform to the Provisions in Subsection 325.02.09 – “Wiring.”

The loop detector conductors shall be installed prior to placing the final surface course on new paving projects. The conductors shall be installed, as shown on the Plans, in the compacted layer of asphalt concrete immediately below the uppermost layer.

Sensor units shall not be provided for inductive loop traffic counting installations.

- (f) Raising or Relocating Existing Pressure-Sensitive Detectors. Raising existing pressure-sensitive detectors to grade shall be accomplished by removing the existing concrete from the detector frame and filling with Class A concrete around the frame at the new grade, unless otherwise specified.

When detectors are to be relocated, either the existing detector contact unit shall be installed in a new frame and foundation, or the existing frame, if in good condition as determined by the Engineer, may be set in a new foundation. The hole left by removing the detector frame and foundation shall be filled with Class C concrete, except the roadway surface shall be reconstructed with material to match existing surfacing.

325.04.06 Pedestrian Push Buttons. Where shown on the Plans, pedestrian push buttons of substantial tamper-proof construction shall be furnished and installed.

The assembly shall be weatherproof and so constructed that it will be impossible to receive any electrical shock under any weather conditions.

The pedestrian push button switch shall be a phenolic enclosed precision snap-acting type, switching unit, single-pole, double-throw, with screw type terminals, rated 15 amperes at 125 volts, AC, and shall have the following characteristics:

Switching unit shall have a stainless steel plunger actuator and shall be provided with U-frame to permit recessed mounting in push button housing.

Switch shall have an operating force of 9 to 13 ounces and a minimum release force of 4 ounces.

Pre-travel shall be 1/64 inch maximum.

Over-travel shall be 7/32 inch minimum.

Differential travel shall be 0.0004 to 0.002 inch.

Where a pedestrian push button is attached to a pole, the housing shall be shaped to fit the curvature of the pole and secured to provide a rigid installation. Saddles shall be provided to make a neat fit when required.

Where a pedestrian push button is to be mounted on top of a 2 1/2 inch diameter post, the housing shall be provided with a slip-fitter fitting and screws for securing rigidly to the post.

Push button and sign shall be installed on the crosswalk side of the pole.

Arrows on push button signs shall point in the same direction as the corresponding crosswalk.

325.04.07 Pedestrian Signals. Pedestrian signals shall conform to the following:

- (a) Messages. Messages shall be lunar white "WALK" and Portland orange "DON'T WALK" or "hand/man" symbols as defined in the Manual on Uniform Traffic Control Devices (MUTCD).
- (b) Types. Pedestrian signal ("WALK, DON'T WALK" or "hand/man" symbols) shall be a one piece jack mounted push-in plastic module in which the formed neon words and grid neon tubing are integrally molded and positively positioned with relation to the internally screened message plate. The molded polycarbonate module shall plug in for operation without requiring tools or additional wiring. The letter height shall be 5 1/2 inches. The letters shall have a stroke width of 5/8 inch.

Each signal shall be provided with an "egg crate type" visor designed to eliminate sun phantom.

- (c) Housing. The housing shall be made of cast aluminum or 3003 H14 sheet aluminum alloy with finish on both sides, and shall be 1/8 inch thick minimum at the points of support.

The housing for pedestrian signals shall be dustproof, weatherproof, and corrosion resistant and shall provide easy access to, and replacement of, all components.

The housing shall be suitable for either post-top or bracket mounting.

- (d) Hoods. The hood shall be of material similar to the housing. The top of the hood shall extend a minimum length of 6 inches at the top and 5 inches at the bottom when measured from the surface of the lens. The front shall be normal to the top.

A full divider strip shall be provided between the "DON'T" and the "WALK" indications.

- (e) Transformers. Transformers shall be of the proper size for the length of tubing and shall carry the label of UL or Electrical Testing Laboratories.

A separate transformer shall be provided for each of the "DON'T WALK" and the "WALK" indications.

The orange words "DON'T" and "WALK" shall operate from a single transformer.

Transformers shall have a power-factor of 90 percent and shall provide 27 milliamperes minimum current.

Solid-state neon types with "hand/man" symbols may be furnished in lieu of transformer types unless otherwise indicated on the Plans or in the Special Provisions.

- (f) Conductors. High-voltage wiring between the gas tubes and the secondary side of the transformer shall be made with Gas Tube Sign and Oil Burner Ignition Cable, Type GTO-15 labeled by UL.

Other conductors shall be No. 14 AWG, or larger, with 2/64 inch minimum Type TW insulation.

- (g) Switch. A fused switch consisting of two cartridge fuses and a lever for disconnecting the fuses for pedestrian signals shall be mounted within the signal housing and shall be connected to de-energize the transformer primary circuit.

- (h) Relays. All relays for operation of the "WALK-DON'T WALK" signals shall be placed in the controller cabinet.

- (i) Fasteners. All the machine screws, studs, and washers shall be either plated brass, stainless steel, or other corrosion resistant material.

- (j) Gaskets. Gaskets shall be provided as required to make the unit rain-tight and dust-tight.

- (k) Finish. The outside of the housing and hood shall be painted in accordance with the provisions in Section 324 – "Painting, Pavement Striping and Marking."

- (l) Terminal Block. A terminal block as specified in Subsection 325.02.28 (b) – "Housing" shall be mounted in the unit for field wiring.

325.04.08 Programmed Visibility Traffic Signal Heads. Programmed visibility traffic signal heads and the installation thereof shall conform to the provision in Subsections 325.04.01 – "Signal Faces" – and 325.04.04 – "Signal Head Mounting" – except the Provisions in Subsection 325.04.01(a) – "Optical Units" – and the eighth paragraph in Subsection 325.04.01(b) – "Housing" – shall not apply.

The visibility of the signal indication shall be adjustable within the signal head to fit the lane or lanes in which traffic is to be controlled.

External illumination shall not cause a signal indication nor shall a signal indication in one signal head cause a signal indication in another signal head.

Each section of a signal face shall provide a 12 inch diameter, round indication.

Each section shall be provided with a sun visor.

The indication of each signal head, when unprogrammed, shall be visible from anywhere within 15 degrees of the optical axis. The signal head shall be capable of being pre-set at angles between 9 degrees above and 9 degrees below the horizontal and shall be pre-set at 5 degrees below the horizontal, unless otherwise specified.

The signal head with the yellow indication, prior to programming, shall provide a minimum candlepower of 2,500 in the direction of the axis and a maximum candlepower of 100 at 15 degrees horizontally in each direction from the axis. Said signal head with yellow indication shall be capable of being programmed so that a minimum candlepower of 2,500 can be directed along the optical axis and a candlepower of less than 100 directed at 1/2 degree horizontal from the axis and no measurable light is directed from 1 degree to 15 degrees horizontal from the axis. Under the same conditions, the candlepower of the red indication shall be at least 19 percent of the yellow indication and the candlepower of the green indication shall be at least 38 percent of the yellow indication.

Lamps for the signal units shall be 150 watt, 120 volt, incandescent lamps with a minimum average rated life of 6,000 hours.

During daylight, the signal indications shall be visible only in those areas or lanes designated. During dusk and darkness, a faint glow visible to the side will be permissible.

Dimming devices shall be provided to gradually reduce the candlepower of each signal head for nighttime operation to approximately 15 percent of that for daytime operation.

The Contractor shall program the head as provided by the manufacturer and as directed by the Engineer.

325.04.09 The R10-5a(s) sign for mast arm as shown on the Plans (left turn on green arrow only) shall be furnished and installed as indicated on the Plans and as directed by the Engineer.

325.04.10 The protective/permissive left turn signal heads (cluster type) for mast arms and accompanied five-section, bracket-mounted heads shall be furnished and installed as indicated on the Plans and as directed by the Engineer.

The R10-5d(s) "Left Turn Yield on Green (Solid Ball Symbol)" sign shall be furnished and installed unless otherwise indicated on the Plans

325.05 HIGH INTENSITY-DISCHARGE LUMINAIRES. High-intensity-discharge luminaires shall be of the enclosed type with horizontal burning lamp and slip-fitted for horizontal mounting on 2 inch pipe. Luminaires shall be either a semicutoff or a cutoff type and shall be provided with a high pressure lamp. Semicutoff luminaires shall be provided with a refractor and cutoff luminaires with a flat lens. Check plans for type required and if not indicated, semicutoff types shall be furnished.

Prior to energizing a luminaire, the lamp socket shall be set in the proper location for the required light distribution in accordance with the manufacturer's instructions, and the luminaire shall be leveled.

Each luminaire shall consist of a housing, reflector, terminal strip, refractor or a lens, a lamp socket and lamp, and an integral ballast. Glare shields shall not be required unless indicated on the Plans.

All parts of the luminaire shall be fabricated from corrosion-resistant materials.

Each housing shall be fabricated from aluminum by either diecasting or forming. Housings that are painted shall withstand a 1,000 hour salt spray test as specified in ASTM Designation B 117. Glare shields when required shall be fabricated from the same materials as the luminaire.

The reflector may be a separate unit or may be integral with the housing. The reflector surface shall be specular and shall be protected by an electro-chemically applied anodized finish. The reflector configuration shall reflect a minimum of light through the arch tube of the lamp.

Each refractor or flat lens shall be mounted in a frame that is hinged to the housing and secured with a spring loaded automatic latch. The joint between the frame or reflector and the housing shall be gasketed. Each refractor shall be made of heat-resisting glass or polycarbonate material as indicated on the Plans. Each flat lens shall be made of heat and impact resistant glass.

Each lamp socket shall be a porcelain enclosed mogul-multiple type. The shell shall contain integral lamp grips to assure electrical contact under conditions of normal vibration. The socket shall be mounted in the luminaire in a manner to permit pre-setting a variety of specific light distribution patterns. The socket leads shall be welded to the screw shell and spring-loaded center contact. Socket shall be rated for 1,000 watts and shall withstand a 6 kilovolt high potential test.

The optical system (reflector, refractor or flat lens lamp socket and lamp) shall be a sealed chamber with provision for filtered breathing. Breathing shall permit intake and exit of air into or from the chamber as a result of expansion or contraction of air in the chamber due to lamp heat. Filtering shall be accomplished by either a separate filter or a filtering gasket.

Field wires connected to the luminaire shall terminate on a barrier type terminal block secured to the housing. The terminal screws shall be captive and equipped with wire grips for wire up to No. 6. All components shall be prewired to a single strip assuring that field connections are made to clearly identified line terminals.

Each integral ballast shall be as specified in Subsection 325.03.10 of these Special Provisions. Where the components are mounted on a down-opening door, the door shall be hinged and secured separately from the refractor or flat lens frame. The door shall be easily removable and replaceable. It shall be secured to the housing in a manner to prevent accidental opening.

In-line fuse holders shall be provided for all luminaires either in base of pole or in signal controller cabinets.

325.05.01 Mercury Vapor Luminaires. Mercury vapor luminaires shall be horizontal burning type. Unless otherwise specified, light distribution shall be IES Type III.

Luminaires shall be provided for slip-fitter end mounting on 2 inch mast arms.

Glassware shall be the refractor type with inner or outer prisms.

The refractor shall be mounted in a door frame assembly which shall be hinged to the luminaire at the house side and fastened at the street side by means of an automatic type latch.

The refractor and door frame assembly shall be forced upward at the street side by spring-pressure, against the gasket seat, when in the closed and latched position.

All gaskets shall be composed of a material capable of withstanding the temperature involved and they shall be securely held in place.

All parts of the luminaire shall be manufactured from corrosion-resistant materials.

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TRAFFIC SIGNALS AND STREET LIGHTING

Unless otherwise specified in the Special Provisions or shown on the Plans lamps shall be hard glass type, 400 watt, mercury vapor, ANSI Type H33-1CD, on 30 foot mounting height.

Mercury vapor lamps shall have a minimum average rated life of 24,000 hours.

When specified, luminaires shall have an integral ballast as provided in Subsection 325.05.12 – “Multiple Circuit Ballasts.”

Unless otherwise specified in the Special Provisions or shown on the Plans, all mercury vapor luminaires mounted on standards shall be equipped with glare shields as provided in Subsection 325.05.03 – “Mercury Vapor Luminaires with Glare Shields.”

325.05.02A High Pressure Sodium Luminaires. Each high pressure sodium luminaire shall be furnished with a 100 watt, 250 watt, 400 watt or other wattage high pressure sodium lamp as indicated on the Plans.

The light distribution for luminaires shall correspond to the IES type shown on the Plans.

The lamp shall be operated at the wattage necessary to produce 9,500 lumens with the 100 watt lamp, 25,500 lumens with the 250 watt lamp and 50,000 lumens with the 400 watt lamp.

325.05.03 Mercury Vapor Luminaires with Glare Shields. In addition to the Provisions in Subsection 325.05.01 – “Mercury Vapor Luminaires,” – mercury vapor luminaires with glare shields shall conform to the following requirements:

The minimum light distribution for luminaires shall correspond to the isolux charts, or IES Type distribution shown on the Plans.

Maximum luminaire brightness reading for luminaires with 400-watt lamps shall not exceed 100 foot-lamberts when measured with a photo-electric brightness meter, under the following test conditions:

Using a 1 1/2 degree photoelectric brightness meter on the 90 degree and 270 degree lateral angle line, the maximum luminaire brightness shall not exceed 100 foot-lamberts when the meter is located at a horizontal distance of 120 feet and a vertical distance of 7.5 feet between the luminaire and the meter, or at an angle of 3 degrees 35 minutes from the horizontal to the line between the luminaire and the meter.

Measurements shall be made from both the 90 degree line and the 270 degree line and averaged.

The lamp shall be operated at the wattage necessary to produce 20,000 lumens with 400-watt lamps.

All equipment shall be new and clean and the test conducted under conditions of good visibility.

325.05.04 Incandescent Luminaries. Type and style of incandescent luminaires, lamp equipment and transformers shall be as specified in the Special Provisions.

All side and end mounted luminaires shall be equipped with a 2 inch slip-fitter.

All side mounted incandescent luminaires shall be equipped with a porcelain heat barrier busing, except that for multiple type luminaires, glass sleeving may be used.

325.05.05 Soffit and Wall Luminaires and Lamps. Soffit and wall luminaires shall be of the type or types specified.

Soffit and wall luminaires shall be weatherproof and corrosion resistant. Installation details and minimum light distribution shall be as shown on the Plans.

Each flush-mounted soffit luminaire shall consist of a cast metal body, a prismatic refractor mounted in a door frame, a prismatic glass reflector and a socket. The body shall have a continuous anchor ring and shall be provided with four 2 inch conduit hubs. The door frame assembly shall be hinged, gasketed and secured to the body by at least three machine screws

The refractor shall be clearly identified as to "street side" and shall be keyed so as to fit into the frame in only one way.

Unless otherwise specified, each flush mounted soffit luminaire shall be furnished with an integral ballast mounted on a bracket so constructed that the light center of the mercury vapor lamp is within 1/2 inch of the light center location for which the luminaire is designed.

Where an existing flush mounted incandescent soffit luminaire is to be modified, the mounting bracket for the lamp socket or for the integral ballast shall be so designed that the existing tapped holes and machine screws can be utilized for the attachment of the bracket to the fixture body.

Each pendant soffit luminaire shall be enclosed and gasketed, and shall be furnished with aluminum finish, 3/4 inch top-tapped head, stepped or fluted reflector, and refractor attached to reflector. The reflector shall have a specular anodized aluminum finish. The refractor shall be made of heat-resistant acrylic plastic or glass. The optical assembly shall be hinged and latched for lamp access and shall be provided with a safety chain.

Each pendant soffit luminaire shall be furnished with an 11 gauge minimum thickness, metal box (maximum dimensions of 8 inches by 9 inches by 11 inches) and such box shall house the ballast for the luminaire. The box shall be provided with a gasketed cover with two captive screws and two chains to prevent dropping. Box shall be hot-dip galvanized.

Each wall-mounted luminaire shall consist of a cast metal body of the dimensions shown on the Plans. The lens frame shall be gasketed and shall allow servicing without detachment from the body.

Cast metal bodies made of aluminum, which are to be flush mounted in concrete, shall be given a heavy coat of alkali-resistant bituminous paint on all surfaces to be in contact with concrete. The paint shall conform to Military Specification MIL-P-6883.

Unless otherwise specified, each soffit luminaire and each wall luminaire shall be furnished with a hard glass type, 100 watt, high pressure sodium vapor lamp, with a minimum average rated life of 24,000 hours.

325.05.06 Sign Lighting Fixtures — Fluorescent. Each fluorescent sign lighting fixture shall be designed for mounting at the bottom of the sign on a overhead sign structure as shown on the Plans. The fixture shall be a fully enclosed type, rain-tight, dust-tight, corrosion-resistant, with hinged plastic cover.

Painting of fixtures will not be required.

- (a) Housing. The shell of the fixture shall be fabricated of 0.064 inch minimum thickness, 3003 H14 aluminum alloy sheet with Type 7072 alloy cladding or fabricated of other material which will provide equivalent strength and corrosion resistance.

The maximum dimensions of the fixture housing with cover shall be 74 inches long (for 72 inch nominal lamps), 15 1/2 inches wide and 5 1/2 inches high.

All external machine screw parts, lock washers, hinge pins, etc., shall be made of Type 316 stainless steel.

- (b) Reflector. The reflector shall be fabricated of 0.02 inch minimum thickness, 3003 H14 aluminum alloy sheet with Type 1175 alloy cladding on the reflective side.

The reflector surface shall be mechanically polished prior to anodizing. The finish process shall be performed before or after fabrication of the reflector and shall include the electrochemical brightening procedure using an acid process. The minimum weight of the protective oxide coating shall be five milligrams p.s.i. The coating shall be sealed.

The reflector shall have a specular reflectance of not less than 68 percent when measured at 45 degrees specular angle in accordance with Test Method No. Nev. T-541.

Reflectors shall be protected during forming and assembling with secure coverings which shall be removed after the assembly has been completed.

Reflectors shall have hemmed edges for safe handling.

- (c) Cover. Cover shall be of acrylic material.

Each plastic cover shall latch easily and securely in place without the use of tools and shall be completely free from any tendency to loosen under high winds and vibration. The cover shall be fitted with non-stretching safety cords, chain safety devices, or equivalent, which shall also serve as stops when the cover is hinged open.

- (d) Gaskets. Gaskets between the cover and the fixture housing shall be uniform and even-textured, and shall be square-section polyvinyl chloride formed tube with a pressure-sensitive adhesive on one side.

Gaskets shall be neatly applied to thoroughly degreased, clean surfaces with a suitable heat resistant adhesive, which will not allow the gaskets to slip at a temperature of 160 degrees Fahrenheit (continuous).

- (e) Lampholders. Lampholders shall be listed by UL for outdoor use, shall be provided with silver coated contacts and waterproofed lead entrance for use with a 1,500 milliamperere, rapid-start, fluorescent lamp. One lampholder for each lamp shall be of the spring-loaded type. Each lampholder shall be provided with a head-resistant, circular cross section, partially recessed neoprene ring to seal against the lamp ends and protect electrical contacts from moisture and dirt or other injurious elements.

The distance between the face of the lampholders for each lamp shall be designed to provide a compression of at least 0.1 inch on the spring-type lampholder when the lamp is in place. The lamp shall have positive mechanical and electrical contact when the lamp is in place. The socket on the spring-type lampholder shall have sufficient travel to permit installation of the lamp.

Springs for lampholders shall not be a part of the current carrying circuit.

Lampholders shall match lamp requirements and shall not increase cathode filament circuit resistance by more than 0.01 ohm.

- (f) Terminal Blocks. Each field wiring terminal block shall be of the heavy-duty pressure connector type with minimum rating of 35 amperes, 600 volts, (RMS 60 Hz), and shall have a phenolic base, marking strip and corrosion resistant metal parts. Terminal screws shall be no smaller than size 10-32. Marking strips shall have permanent symbols indicating wire color as shown on the Plans.

All wiring connections in the fixtures and in the ballast boxes shall be terminated on molded, phenolic, barrier type, terminal blocks rated at 15 amperes, 600 volts, and shall have integral type, white waterproof, marking strips. All current carrying parts of the terminal blocks shall be insulated from the fixture or ballast box with integral plugs or strips to provide an insulating value in excess of the line-to-ground flashover voltage. If the Contractor elects to use sectionalized terminal blocks, each section shall be provided with an integral barrier on each side and shall be capable of rigid mounting and alignment.

- (g) Conductors. All conductors within the fixture shall be UL approved appliance wiring material (AWM), stranded copper wire with 2/64 inch thermoplastic insulation. Conductors for ballasts shall be No. 16 AWG. Ballast conductors shall be secured with easily removable spring cross straps (not clamped, cabled, or served) on the underside of the chassis.

Conductors between sign switch and fixture terminal blocks shall be No. 14 AWG minimum.

Stranded copper conductors shall be tinned before insertion into pressure connector type terminals. conductors connected to screw type terminals shall terminate in crimp type ring connectors.

1. Sign Lighting Fixtures (120 Volt/240 Volt) Integral Ballast Type. In addition to the requirements in Subsection 325.05.06 – “Sign Lighting Fixtures — Fluorescent,” – the following requirements shall also apply:

- a. Lamps. Each fixture shall be provided with one F72T12, extra high output, cool white fluorescent lamp with recessed double contact base, designed for use at 1,500 milliamperes and which shall meet the requirements of ANSI Standard C78.
- b. Fuses. Fuses shall be of the miniature, slow blowing type, with appropriate current and voltage rating.

Fuseholder shall be a panel mounting type with threaded or bayonet type knob which grips fuse tightly for extraction.

- c. Ballasts. Ballasts shall be the high power factor type with weatherproof leads for operation of one 72 inch rapid start lamp. Ballasts shall be listed by UL for outdoor operation on 110 to 125 or 220 to 250 volts, 60 Hz circuits (input voltage shown on the Plans). Ballasts shall be rated at 1,500 milliamperes for high-beam and 800 milliamperes for low-beam operation. Multiple to multiple transformers shall not be used.

325.05.07 Sign Switches. Each sign illumination installation shall be provided with a disconnect switch mounted on the sign standard or structure, as shown on the Plans.

Enclosure for the sign switch shall be NEMA Type 3R, shall be galvanized or, at the option of the Contractor, shall be provided with a factory applied rust resistant prime coat and baked enamel finish coat, in lieu of galvanizing, and shall be provided with top hinged cover, hasp for sealing cover, and Provisions for locking the handle in the “On” and “Off” positions. Padlocks shall be furnished for all sign switch enclosures.

When specified in the Special Provisions, a circuit breaker shall be provided in lieu of the above fused switch. Circuit breakers shall conform to the requirements under Subsection 325.02.11 – “Service,” – and the amperage of the circuit breaker shall conform to the requirements of the Code.

In the event the sign structure is to be painted, the sign switch or circuit breaker enclosure shall be painted the same color as the sign structure on which it is installed.

325.05.08 Flashing Beacons. Where shown on the Plans, flashing beacons shall be installed. Each beacon shall consist of a single section traffic signal head, conforming to the Provisions in Subsection 325.04.01 – “Signal Faces,” – with yellow or red lens as shown on the Plans. Mounting of beacons, including span-wire mounting is required, shall be as shown on the Plans.

Each flashing beacon control unit shall consist of a switch, 10 ampere plug fuse, flasher, and terminal block housed in a single enclosure.

The enclosure shall be NEMA Type 3R, and shall be provided with top hinged cover, dead front panel, and a hasp for sealing cover. Padlocks shall be furnished for all enclosures.

The enclosure shall be provided with factory applied, rust-resistant prime coat and baked enamel finish coat. Two coats of aluminum paint shall be applied as specified in Subsection 325.02.15. At the option of the Contractor the enclosure may be hot-dip galvanized in lieu of painting.

Switches shall be ten ampere, toggle type, single-pole, two wire, 120 volt, AC, and shall be mounted at the top and center of the dead front panel.

When shown on the Plans or specified in the Special Provisions, a 15-ampere circuit breaker, conforming to the Provisions in Subsection 325.02.11 – “Service” – shall be installed in lieu of the control switch and 10-ampere plug fuse specified above.

The flasher shall be solid-state device of adequate capacity and shall have no contact points or moving parts.

Flashers shall provide 50 to 60 flashes per minute with a 40 to 60 percent duty cycle.

Flashers shall provide for two circuit, alternate operation of beacons and shall be furnished with plug-in mounting.

Terminal blocks shall be rated at 15 amperes, 600 volts, shall be molded from phenolic material and shall be the barrier type with plated brass screw type terminals and integral type marking strips.

Workmanship and material shall be equal to that of first class electrical instruments.

When flashing beacons are installed adjacent to or in conjunction with a traffic signal system, the flasher control shall be installed in the controller cabinet unless otherwise shown on the Plans.

The sign panel to be installed on cantilever flashing beacon shall be mounted using galvanized commercial quality 5/16 inch diameter hexagonal-head bolts and nuts, galvanized flat washers, and lock washers with a fiber washer contacting face of the sign panel.

325.05.09 Photoelectric Controls. Photoelectric controls, as specified in the Special Provisions or as shown on the Plans, shall be capable of switching multiple lighting systems directly or of switching series lighting systems through a high voltage controller.

(a) Types. The types of photoelectric controls shall be as follows:

Type I photoelectric control shall consist of a photoelectric unit and a contactor in a single weatherproof housing.

Type II photoelectric control shall consist of a photoelectric unit in a weatherproof housing and a separate Contactor located in a traffic signal controller cabinet.

Type III photoelectric control shall consist of a photoelectric unit and a separate contactor, each in a separate weatherproof housing.

Type IV photoelectric control shall consist of a photoelectric unit in a weatherproof housing which plugs into an EEI-NEMA twist lock receptacle integral with the luminaire.

A switch to permit manual operation of the lighting circuit shall be provided for each Type I, Type II, and Type III photoelectric control. Switches shall be of the single-hole mounting toggle type, single-pole, single-throw, rated at 12 amperes, 125 volts. Switches shall be furnished with an indicating nameplate reading "Auto-Test" and shall be connected in parallel with the load contacts of the photoelectric unit.

(b) Equipment Details. Equipment details shall conform to the following:

1. Photoelectric Unit. The photoelectric unit shall provide an output in response to changing light levels. The response level shall remain stable throughout the life of the control unit. Components of the unit shall not require periodic replacement.

Units for highway lighting shall have a "turn-on" between 1 and 5 foot candles and a "turn-off" at between 1 1/2 and 5 times "turn-on."

Units for illuminated signs shall have a "turn-on" level of between 20 and 30 foot candles. (Turn-on level specified above corresponds to a switching level of approximately 40 to 60 foot-candles measured in the horizontal plane.) "turn-off" level shall not exceed three times "turn-on" level.

Measurements shall be by the procedures set forth in EEI-NEMA Standards for Physical and Electrical Interchangeability of Light-Sensitive Control Devices Used in the Control of Roadway Lighting.

Photoelectric controls, except Type IV, shall be furnished with a 4 inch minimum inside diameter slip-fitter containing a terminal block and with cable supports or clamps to support pole wires.

The photoelectric unit receptacle shall be the EEI-NEMA type. Mounting brackets shall be used where pole-top mounting is not possible. Photoelectric controls shall be installed at the locations shown on the Plans and oriented as directed by the Engineer.

For switching 480 volts, 60 Hz circuits, a 100 volt-ampere, minimum, 480 to 120 volt transformer shall be installed in the contactor enclosure to provide 120 volts for the photoelectric control unit. Where more than one photoelectric unit is to be installed at the same location, a single transformer, with a volt-ampere rating capable of handling the total controlled load, may be used.

Photoelectric units shall be screened to prevent artificial light from causing cycling.

The photoelectric unit shall also conform to the following:

The supply voltage rating shall be 60 Hz, 105 to 130, 210 to 240, or 105 to 240 volts, as required.

The load rating shall be 800 watts minimum, incandescent, mercury vapor or fluorescent.

The operating temperature range shall be from minus twenty (20) degrees Fahrenheit to plus 150 degrees Fahrenheit.

The power consumption shall be less than 10 watts.

The base of the unit shall be provided with a three (prong, EEI-NEMA standard, twist-lock plug mounting).

2. Contactor. The contactor shall have contacts rated to switch the specified lighting load and shall be normally open, unless otherwise specified.

The contactor shall be the mechanical armature type consisting of an operating coil, a laminated core, a laminated armature, contacts, and terminals. Contacts shall be fine silver, silver alloy, or superior alternative material.

3. Contactor and Test Switch Housing. For Type I control, the enclosure shall house the test switch only. For Type III control, the contactor and test switch shall be housed in a suitable NEMA Type 3R enclosure. The enclosure shall be provided with a factory applied rust-resistant prime coat and baked enamel finish coat. Two coats of aluminum paint shall be applied as specified in Section 214 – "Paint." At the Contractor's option the enclosure may be hot-dip galvanized in lieu of painting. A minimum of 2 1/2 inches shall be provided between contactor terminals and end of enclosure for wiring connections. The enclosure shall be mounted on the same standard as the photoelectric unit at a height of approximately 6 feet above the base.

For Type II control, the test switch shall be housed in the traffic signal controller cabinet with the contactor.

4. Wiring. Conductors between the photoelectric unit and an external contactor shall be No. 12 AWG and shall be run inside the lighting standard, or in conduit, unless otherwise shown on the Plans.

325.05.10 Transformers. Multiple to multiple and series to multiple transformers shall be of the single-phase, dry type designed for operation of a 60 Hz supply.

- (a) Electrical Requirements. Transformer ratings shall be 120 to 480 volt, 240 to 480 volt, or 480 to 120 volt for multiple to multiple units and 6.6 ampere to 480 volt for series to multiple units or other ratings as shown on the Plans.

Secondary 480 volt windings shall be center tapped and the center tap shall be grounded.

Special taps for high or low voltages will not be required.

Volt-ampere ratings shall be as shown on the Plans.

Transformer efficiency shall exceed 95 percent for multiple to multiple units and 80 percent for series to multiple units.

Average temperature rise of windings, at full load, shall conform to NEMA requirements for Class A insulation.

Secondary voltage regulation and tolerance shall be plus or minus 3 percent from half load to full load for multiple to multiple units and plus 10 percent (maximum) at no load to plus or minus 3 percent at full load for series to multiple units.

External leads for multiple to multiple and series to multiple secondary connections shall be Type RHW-USE, No. 10 AWG, rated 600 volts, AC, Primary conductors for series to multiple transformers shall be rated for use on 5,000 volt, AC circuits.

Transformer insulation shall be NEMA Class F or better.
Potting compound shall conform to the temperature requirements of NEMA Class A insulation.

Series to multiple transformers shall withstand the application of 12,000 volts (RMS, 60 Hz) from core to primary coil and from coil to coil for a 1 minute period.

Series to multiple transformer secondaries and multiple to multiple transformers shall withstand the application of 2,200 volts (RMS, 60 Hz) from core to coils, and, for multiple units only, from coil to coil for a 1 minute period.

The above tests shall be made immediately after operation of the transformer at full load for 24 hours.

- (b) Physical Requirements. Submersible type transformers shall be securely encased in a rugged, corrosion resistant, watertight case and shall withstand a 5 day test submerged in 2 feet of salt water (2 percent salt by weight) with 12 hour on and off periods. The operating periods shall be at full load.

Submersible units shall be capable of withstanding a shock test as specified in Military Specification MIL-STD-202; Test Method 205; Test Condition C. Mounting for shock test may be by any convenient means.

Proof of performance after the above tests shall be as follows:

1. Continuity in all windings.
2. Insulation test at 90 percent of initial test voltage.
3. There shall be no evidence of physical damage such as cracks.

Each transformer to be installed in a pull box shall be the submersible type and shall be provided with a handle and a hanger as shown on the Plans for ballast installation in pull box.

Nonsubmersible transformer units shall be provided with metal half-shell coil protection, shall have moisture resistant, synthetic varnish impregnated windings and shall be suitable for outdoor operation in a rain-tight enclosure.

Transformer leads shall extend a minimum of 12 inches from the case. Leads of submersible units shall be brought out through one sealed hub and shall be secured in a manner which will withstand a 100 pound static pull without loosening or leaking.

325.05.11 Multiple Circuit Ballasts. Each ballast for a high-intensity-discharge lamp shall be designed for the type, characteristics, and wattage of the lamp it is to operate and it shall provide the proper starting and operating waveforms, voltage, and current. Ballasts shall provide reliable lamp starting and operation at ambient temperature down to minus 30 degrees C. for the rated life of the lamp.

Ballasts shall be designed for continuous operation at ambient temperature from minus 30 degrees C. To 65 degrees C., and shall have an average design life not less than 100,000 hours. Ballasts shall be designed to operate continuously for 6 months without reduction in life, over the specified temperature range, with the lamp operating normally or with the lamp circuit in an open or short-circuited condition.

Integral ballasts shall be tested within the luminaire and shall be rated at the temperature normally found within the luminaire.

Starting aids for ballasts of a given lamp wattage shall be interchangeable between ballasts of the same wattage and manufacturer without adjustment.

A Certificate of Compliance shall be submitted by the manufacturer with each lot of integral ballast luminaires and with each lot of ballasts designed for use outside of luminaires. The certificate shall state that the lot of ballasts meets, in every respect, the above requirements and the lamp-ballast specifications of the lamp manufacturer.

The input voltage for ballasts shall be as shown on the Plans or as specified in the Special Provisions.

Each integral ballast shall consist of separate components, each of which shall be capable of being easily replaced. A starting aid which is encapsulated will be considered as a single component. Each component shall be provided with screw terminals, NEMA tab connectors, or a single multi-circuit connector. All conductor terminals shall be identified as to the component terminal to which they connect.

Heat-generating components shall be mounted so as to use the portion of the luminaire upon which they are mounted as a heat sink. Capacitors shall be located as far as practicable from heat-generating components or shall be thermally shielded to limit the case temperature to 75 degrees C.

Transformers and inductors shall be resin-impregnated for protection against moisture. Capacitors, except those in starting aids, shall be metal cased and hermetically sealed.

Ballasts for luminaires mounted on mast arms, rackets, or lowering assemblies shall be the magnetic regulator or auto-regulator (CWA) type with the primary and secondary windings electrically isolated and shall be located within the luminaire housing. The ballast for each horizontally mounted luminaire shall consist of individual components mounted on the luminaire housing, an assembly of components mounted on a metal plate secured to the housing, or individual components mounted on a down opening door conforming to the requirements in Subsection 325.05 – “High-Intensity-Discharge Luminaires.”

Ballasts for wall-mounted luminaires shall be the high power factor reactor type and shall be located within the luminaire housing.

Ballasts for soffit luminaires shall be the high power factor reactor type and shall be located within the luminaire housing or, when shown on the Plans, in a pull box adjacent to the luminaire.

Ballasts for mercury sign lighting fixtures shall be the high power factor type and shall be located within the sign lighting fixture, unless otherwise shown on the Plans or specified in these Specifications.

- (a) Regulator Type Ballasts. Each regulator type ballast shall, when operated with the appropriate lamp, have the following characteristics and shall maintain the following lamp operation:
1. The power factor shall be not less than 90 percent throughout the life of the lamp at nominal line voltage.
 2. Lamp wattage at any lamp voltage from nominal through life shall not vary by more than 18 percent for plus or minus 10 percent input voltage variation.
 3. For nominal input voltage and lamp voltage, the ballast design center shall not vary more than 7 1/2 percent from rated lamp watts.
 4. The ballast shall be designed so that a capacitance variance of plus or minus 6 percent will not cause more than a plus or minus 8 percent variation in lamp wattage regulation throughout rated lamp life for nominal input voltage.
 5. The lamp current crest factor shall not exceed 1.8 for input voltage variation of plus or minus 10 percent at any lamp voltage from initial through life.
- (b) High Power Factor Reactor Type Ballasts. Each high power factor reactor type ballast shall, when operated with the appropriate lamp, have the following characteristics and shall maintain the following lamp operation:
1. The power factor shall be not less than 85 percent throughout the life of the lamp at nominal line voltage.
 2. Lamp wattage at any lamp voltage from nominal through life shall not vary by more than 25 percent for plus or minus 5 percent input voltage variation.
 3. For nominal input voltage and lamp voltage, the ballast design center shall not vary more than 7 1/2 percent from rated lamp watts.

325.05.12 Falsework Lighting. When required by the Special Provisions, falsework lighting shall be installed where vehicular traffic with or without pedestrian traffic crosses through or under structure falsework.

Illumination shall be provided during the hours from dusk to dawn.

The Contractor shall submit a plan of the proposed lighting installations and shall not commence falsework construction until such plans have been reviewed by the Engineer. A subsequent review shall be made by the Engineer after falsework lights have been placed in operation.

Fixtures for illumination of roadway pavement between entrances and exit portals shall be provided with an RLM standard dome reflector. The reflector shall have a white porcelain enamel finish on the inside and shall be provided with a steel wire guard.

Fixtures shall be equipped with high-temperature glazed porcelain medium base sockets and 6 foot conductors for splicing, approved by UL, for outdoor use.

Fixtures shall be fully adjustable with bracket and locking screws on a mounting-plate and shall provide mounting directly to a standard metal junction box.

Fixtures for pedestrian passageways shall be porcelain box receptacles mounted on standard metal junction boxes and equipped with wire lamp guards. Porcelain box receptacles shall be rated at 660 watts, 250 volts. Wire lamp guards shall be made of No. 10 AWG wire and shall be suitable for general construction work.

Lamps shall be an approved type.

Portal faces of falsework shall be illuminated on the side facing traffic with 150 watt minimum PAR reflector flood lamps mounted on the structure directly over each vertical support adjacent to the traveled way and over the center of each lane. Each lamp shall be supported approximately 16 feet above the pavement and approximately 6 feet in front of the portal face, the exact position to be as directed by the Engineer. In addition to the overhead lighting, each side of each vehicular passageway between portals shall be illuminated by a string of yellow, 25 watt lamps spaced at 12 foot intervals and mounted between 8 and 8 1/2 feet above the pavement.

Each flood light shall be aimed in such a manner as to preclude glare to oncoming motorists.

The overhead clearance sign mounted on the falsework shall also be illuminated. For illumination of roadway pavement between entrance and exit portals, a continuous row of fixtures shall be installed over the center of each lane beneath the falsework structure at intervals of not more than 15 feet, with the end fixtures not further than 7 feet inside the portal faces. Mounting height of fixtures over the pavement shall be as directed by the Engineer.

Pedestrian openings, through or under falsework, shall be illuminated with fixtures centered over the passageway at intervals of not more than 15 feet, with the end fixtures not more than 7 feet inside the portal faces. The fixtures shall be mounted between 9.5 feet and 10.5 feet above the walkway surface.

For roadway pavement and portal face illumination, No. 10 AWG conductors with Type S insulation shall be used. For pedestrian passageways, conductors shall be No. 10 AWG and enclosed in a 1/2 inch unpainted zinc-coated metallic conduit.

No less than two branch circuits shall be provided. Pedestrian passageway lights and roadway pavement lights shall be on a minimum of one circuit and portal flood lights shall be on a minimum of one separate circuit. Each branch circuit shall be fused, not to exceed 20 amperes.

The above specified portal lighting shall be installed on the day that horizontal members are erected and before traffic is permitted to pass under the falsework during the hours from dusk to dawn. The other falsework lights shall be installed as soon as the members on which they are to be supported are in place.

Energy costs for falsework lighting shall be paid by the Contractor.

On each side of each portal entrance, and no farther apart than the least horizontal clearance within the portal, clearance guides consisting of a panel of boards or a plywood sheet, 4 feet wide by 8 feet long, shall be fastened vertically facing traffic with the bottom of the panel 3 feet to 4 feet above the roadway. Said clearance guides shall be fastened in place before darkness on the day that vertical supports are erected and shall be maintained clean and white by the Contractor.

Upon completion of the project or when directed by the Engineer, falsework lighting equipment shall become the property of the Contractor and shall be removed from the site of the work.

325.06 SALVAGING AND REINSTALLING OR STOCKPILING ELECTRICAL EQUIPMENT

325.06.01 Salvaging Electrical Equipment. Where shown on the Plans or ordered by the Engineer, existing electrical equipment to be removed, including controller units, cabinets, signal heads, luminaires, standards, mast arms, ballasts, transformers, service equipment, pull boxes, and detector contact units shall be salvaged for reuse by the maintaining agency.

Care shall be exercised in removing and salvaging electrical equipment so that it will remain in its original form and existing condition whenever possible. Attention is directed to the Provisions in Subsection 133.00 – “Protection of Person and Property.” The Contractor will be required to replace, at his expense, any of the above-mentioned electrical equipment, which, as determined by the Engineer, has been damaged or destroyed by reason of his operations.

Unless otherwise specified, underground conduit, conductors, foundations, and detector frames not reused shall become the property of the Contractor and shall be removed from the highway right of way, except if not interfering with other construction, said materials, except foundations, may, with the written approval of the Engineer, be abandoned in place. Certain other materials, when shown on the Plans, shall also become the property of the Contractor.

Attention is directed to the Provisions in Subsection 325.02.02 – “Foundations,” – regarding foundations to be abandoned.

Holes formed by removing pull boxes and foundations shall be filled with material equivalent to the surrounding material.

325.06.02 Reinstalling Salvaged Electrical Equipment. When salvaged electrical equipment is to be reinstalled, the Contractor shall furnish and install all necessary materials and equipment, including signal mounting brackets, anchor bolts, nuts, washers, and concrete as required to complete the installation.

All traffic signal, flashing beacon, and lighting fixtures to be reinstalled shall be cleaned and relamped.

325.06.03 Stockpiling Salvaged Electrical Equipment. Existing equipment removed and not reused shall be salvaged and shall be stockpiled at the site of the work.

325.07 METHOD OF MEASUREMENT. When a Traffic Signal System, a Highway Lighting System, or a Traffic Signal and Highway Lighting System is bid on a lump sum basis, measurement will be made as a complete system.

When a Traffic Signal System or Highway Lighting System is bid on individual items, measurement will be made by the linear foot, square foot, lump sum, or by the unit furnished and installed in accordance with the Contract Documents, and making all required tests, as directed by the Engineer and the following methods:

Linear Foot Measurement. Conduit installed complete in place. Conductors, lead-in cable for loop detectors, signal cable, and interconnect cable installed complete in conduit.

Square Foot Measurement. Traffic signal signs installed complete in place.

Each Unit Measurement. Pull boxes, steel poles, luminaires, street name signs, signal heads, pedestrian signal heads, pedestrian push buttons with signs, loop detectors, controllers, electrical service, underpass luminaires, sign lighting fixtures, modify controllers, detector amplifier channels, remove and reset light pole, remove and reset signal pole, remove and reset street name sign, remove and reset signal head, remove and reset luminaire, remove existing signal head and junction boxes installed complete in place.

Lump Sum Measurement. Removal of existing traffic signal systems and removal of existing lighting systems for the work complete as set forth on the Plans and these Specifications.

325.08 BASIS OF PAYMENT. The lump sum price or prices paid for traffic signals, highway lighting systems, sign illumination systems, or combinations thereof measured as set forth in Subsection 325.07 – “Method of Measurement,” – shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in furnishing and installing, modifying, or removing the systems or combinations thereof as shown on the Plans as specified herein and as directed by the Engineer, including any necessary pull boxes, excavation and backfill, concrete foundations, restoring sidewalk, pavement, and appurtenances damaged or destroyed during construction, salvaging existing materials, and making all required tests.

Conduit. The unit price bid per linear foot shall include all excavations, backfill, all cutting, bending, fitting, capping, furnishing and placing pull lines and tags, expansion fittings, hardware, and incidental fittings as required.

Modify Controller. The unit price bid per each shall include all material and labor costs to complete modifications as described on the Plans.

Loop Detector Amplifier Channels (existing cabinet). The unit price bid per each shall include the cost of furnishing and installing sensor units in existing cabinets wired to function with local controller as shown on the Plans.

Loop Detector Amplifier Channels (new cabinet). The unit price bid each shall include the cost of furnishing and installing sensor units in cabinets wired to function with local controller and traffic control system as shown on plans.

Remove and Reset Signal Head. The Contract unit price bid per each shall include removal and relocation of signal head, mounting, incidental fittings, and new lenses when required as noted on plans.

Remove and Reset Luminaire. The Contract unit price bid per each shall include removal and relocation of luminaire, wired in and functional as described on the Plans.

Remove and Reset Light Pole. The unit price bid shall include removing existing light poles and resetting the poles on a new foundation. The cost of material, labor, and equipment, including the cost of the foundation shall be included in the Contract unit price bid per each for “Remove and Reset Light Pole.”

Remove and Reset Signal Pole. The unit price bid shall include removing existing signal poles and resetting the poles on a new foundation. The cost of material, labor, and equipment including the cost of the foundation shall be included in the Contract unit price bid per each for “Remove and Reset Signal Pole.”

Steel Poles. The unit price bid each for the type of pole specified in the Contract Documents shall include the furnishing of arms and all fittings, safety bases when required, and the necessary anchor bolts, concrete foundation, and reinforcing steel, as well as all structure excavation and backfill required to complete the work.

Electrical Service. The unit price bid each shall include all rigid conduit, enclosures, circuit-breakers, wiring, hardware, panels, meter pedestals or sockets, riser pole, overhead conductors, drops, etc., furnished and installed as shown on the Plans.

Controller. The unit price bid each shall include the controller, cabinet, concrete foundation, and incidental items required.

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Signal Heads. The unit price bid each shall include the signal head, internal wiring, mounting fittings, hoods, lamps, and incidental fittings as required.

Removing Existing Lighting and/or Signal Systems. The unit lump sum price bid shall include the excavation, concrete, and backfill materials required or specified by the Engineer.

Restoring sidewalks, pavement, and appurtenances damaged or destroyed during construction, salvaging existing material, and marking.

326.01 DESCRIPTION. This work shall consist of furnishing, fabricating, casting, machining, preparing, transporting, erecting, or placing any or all reinforcing steel, structural steel, rivet and eye bar steel, steel forging, casting, and any other metal of the type, shape, dimensions, and quality required by the Plans or these Specifications.

326.02 REINFORCING STEEL

326.02.01 Material Grades. Materials shall conform to Section 206 – “Reinforcing” – and 207- “Structural Steel” – of these Specifications.

All bar steel reinforcement may be either Grade 40 or Grade 60 unless otherwise specified on the Plans.

Spiral reinforcement may be either Bar Steel Reinforcement or Steel Wire of the equivalent size of the bar steel.

One extra bar of each diameter shall be furnished per contract for each 100 tons or fraction(s) thereof. This bar shall be from the longest bar of each size so that it can be used to replace any bar of that diameter which is selected to be used as a field sample. The field sample must be of sufficient length to provide for two, 2 foot samples of each diameter. The extra bars shall be indicated on the fabricator’s details.

326.02.02 Materials List. Before placing reinforcing steel, two copies of a list of all reinforcing steel shall be furnished to the Engineer at the site of his use in administering the Contract. Furnishing such lists to the Engineer shall not be construed to mean that the lists will be reviewed for accuracy. The Contractor shall be wholly and completely responsible for the accuracy of the lists and for furnishing and placing all bar reinforcing steel in accordance with the details shown on the Plans and as specified.

326.02.03 Protection of Material. Reinforcing steel shall be protected at all times from damage. When placed in the work, the reinforcing steel shall be free from dirt, detrimental scale, paint, oil, or other foreign substance. However, when steel has on its surface loose mill scale or dust which is easily removable, it may be cleaned by a satisfactory method, if approved by the Engineer.

326.02.04 Bending Requirements. Bent bar reinforcement shall be cold bent to the shape shown on the Plans and unless otherwise provided on the Plans or by authorization. Bends shall be made in accordance with the ACI Manual of Standard Practice for Detailing Reinforced Concrete Structures.

326.02.05 Placement and Support. All bar reinforcement shall be accurately placed in the positions shown on the Plans, and firmly held during the placing and setting of concrete. When the spacing of bars exceeds one foot in either direction, all intersections shall be ties. When the spacing of bars is 1 foot or less in both directions, alternate intersections shall be tied.

Distances from the vertical and horizontal forms shall be maintained by means of stays, blocks, ties, hangers, or other approved supports. Blocks used for holding reinforcing bars from contact with the forms or between layers of bars shall be precast mortar blocks of approved shape and dimensions and shall have a compressive strength of not less than 3000 p.s.i.. Metal chairs which are in contact with the exterior surface of the concrete shall be fabricated of either galvanized steel, or have the steel tips plastic coated to at least 3/4 inch into the concrete, or be of stainless steel conforming to the requirements of ASTM A 493 Type 430. The use of pebbles, pieces of broken stone or brick, metal pipe, and wooden blocks will not be permitted. Reinforcement in any member shall be placed, and then inspected and approved by the Engineer, before the placing of concrete begins. Concrete placed in violation of this provision may be rejected and its removal required.

If mesh reinforcement is shipped in rolls, it shall be straightened into flat sheets before being placed.

326.02.06 Splices. All reinforcement bars shall be furnished in the full lengths indicated on the Plans. Splicing of bars, except where shown on the Plans, will not be permitted without the written approval of the Engineer. Splices shall be staggered as far as possible. All splices shall be in accordance with the latest edition of ACI Standard 318,

unless modified by the Plans, Specifications, or Engineer. In lapped splices, the bars shall be placed in contact and wired together. Welding of reinforcing steel shall be done only if detailed on the Plans or authorized by the Engineer in writing. Welding shall conform to the Specifications of the American Welding Society.

Lapped splices in reinforcement shall not be used for sizes larger than number 11.

Splices in spiral steel shall be made by welding or by a lap of 1 1/2 turns.

Sheets of mesh reinforcement shall overlap each other sufficiently to maintain a uniform strength and shall be securely fastened at the ends and edges. The edge lap shall not be less than 1 1/2 mesh width.

326.02.07 Substitution. Substitution of different size bars will be permitted only with specified authorization by the Engineer. The bars substituted shall have an area equivalent to the design area or larger.

326.03 STRUCTURAL STEEL

326.03.01 Materials. Materials shall conform to Section 207 – “Structural Steel” – of these Specifications.

Turned bolts shall meet the material specifications set forth for Structural Rivet Steel. Anchor bolts, nuts, and washers shall be of structural steel, galvanized in accordance with ASTM Designation A 153. Bolts for fastening tubes to the rail post sockets shall be stainless steel.

Bridge or pedestrian rails and posts made of aluminum shall not be painted.

326.03.02 Shop Drawings. Shop drawings shall consist of shop detail erection and other working plans showing dimensions, sizes of material, details, and other information necessary for the complete fabrication and erection of the metal work. The drawings shall be prepared on sheets 22 inches wide by 36 inches. The original drawings may be made either on paper or on cloth, but the details must be drawn so that the prints will be clear and legible.

Unless otherwise requested, the Contractor shall submit to the Engineer for approval two sets of checked drawings. The Engineer reserves the right to refuse prints of shop drawings which are not clear and legible. Upon approval, the Contractor shall furnish the Engineer with the number of sets of shop drawings requested and the original tracings or reproducible negatives thereof. All shop plans shall be submitted for approval at least 15 working days before fabrication is started and no material shall be fabricated until the Plans have been finally approved by the Engineer. The shop drawing as approved by the Engineer shall become a part of the Contract provided, however, that any substitution of sections contemplated by the shop drawing different from sections shown on the Plans shall be made only when approved by the Engineer and, in such case, additional costs resulting from such substitution shall be borne by the Contractor.

In the event the Contractor elects to furnish bridge rail constructed of aluminum as provided herein and the plan sheets show only steel bridge rail, the Contractor shall submit the fabricator's design calculations to the Engineer in order that it may be verified that the railing and hardware conform to Section 1.1.9 – “Railings” – of the AASHTO Standard Specifications for Highway Bridges, current edition.

After approval there shall be no deviation from the shop drawings or changes made thereon without the prior written approval of the Engineer.

Approval of shop drawings shall be understood to be an acceptance of the character and sufficiency of the details and not a check of any dimensions. Checking shop drawings is intended as a means of facilitating the work and avoiding errors so far as possible, but it is expressly understood that it will not relieve the Contractor from total responsibility in regard to errors or omissions on said shop drawings.

The contract price shall include the cost of furnishing all shop drawings and the Contractor will be allowed no extra compensation for such drawings.

326.03.03 Notice of Fabrication. The Contractor shall give the Engineer 15 working days written notice of manufacturing of material at the mill so that inspection may be provided. No material shall be manufactured or fabrication begun without authorization by the Engineer. The Engineer may inspect the material, as provided for in ASTM Designation A 6, at his option. Material not inspected at the manufacturer shall be subject to inspection as provided for in Section 324.03.04 – “Inspection and Testing of Materials.” “Mill” means any rolling mill or foundry where material for the work is to be manufactured. Prior to the fabricator placing his order with the mill, he shall inquire with the Engineer if additional material will be required for testing. The additional material required for testing shall be at no additional cost to the Department. Prior to the beginning of fabrication, a 15 day written notice shall be provided by the Contractor to the Engineer. Any purchase of material prior to inspection at the mill or fabrication of any work without authorization from the Engineer shall be at the Contractor’s risk.

326.03.04 Inspection and Testing of Materials. The Engineer will examine, and test as necessary, all material before fabrication. Adequate facilities and free access to the necessary work areas will be provided to the Engineer by the manufacturer and fabricator. Required test samples will be furnished free of charge. Material not inspected at the place of manufacture shall be subject to all chemical, physical, and workmanship requirements established for the material supplied. Materials or workmanship not in conformity with the specified product may be rejected. The Engineer may inspect and test all material by any visual, destructive, or non-destructive method to evaluate the material for its specified properties. Mill orders and certificates showing test values obtained must be furnished in triplicate to the Engineer. All certified test values must include physical and chemical results and steel making process used. Acceptance of any material at the mill or fabrication shop prior to incorporation into the work shall not prevent the rejection of the material or finished member if defects are discovered.

Inspection in the fabrication shop is intended as a means of facilitating the work and avoiding errors so far as possible. It is expressly understood that shop inspection does not relieve the Contractor from responsibility for material or fabrication defects or errors and the necessity for replacement or correction of rejected materials and workmanship.

Shop inspection of rail pipe and tubes will in most cases be waived and the Contractor permitted to ship subject to inspection at the project site. The field inspection will cover the general appearance, size, thickness, etc., of the pipe and tubing. Conformance of chemical and mechanical properties to requirements of the Specifications will also be considered before the material is approved. Shop inspection of rail posts will be made on the first few rail post castings furnished for each project in order to establish a satisfactory class of finish and workmanship. When shop inspection is waived on a portion of the handrail posts for a project, a careful inspection will be made in the field to determine the acceptability of these post on the basis of the finish and workmanship as compared to that of the other posts previously inspected and approved.

Fabrication of aluminum alloy material shall, in general, conform to or be equivalent to fabrication methods and practices recommended in the handbooks of the major producers of aluminum materials and specifically the following requirements:

- (a) Material shall be sawed, routed, or milled.
- (b) Flame cutting is not permissible.
- (c) Tubing may be heated to a temperature not exceeding 400 degrees Fahrenheit for a period not exceeding 15 minutes to facilitate bending.
- (d) Holes in pipe and tubing shall be drilled. Holes in castings shall be cored and reamed, or drilled from the solid. Seats for pipe shall be finished smooth.

The fabrication and handling of aluminum materials in the shop and field shall be performed in a manner to prevent scoring or marring of the surfaces. An objectionable appearance resulting from such

scoring or marring shall be cause for rejection of the material. Sleeves and rails shall be fabricated in lengths indicated on the Plans.

The finishing of rail posts shall be performed after fabrication is completed. All fins, pipes, and other casting irregularities and all drilling, reaming, and other fabrication marks shall be removed.

326.03.05 Handling and Transporting. The loading, transporting, unloading, storing, and handling of structural steel shall be conducted so that the metal will be kept clean and free from grease and other foreign material. When unloaded, the material shall be placed on skids, platforms, or other supports above the ground. In addition, the material shall be properly drained and protected from corrosion. All material for the project shall be stored separate for "in stock" materials. Girders and beams shall be placed upright above ground and stored. Other members, such as columns, chords, cross frames, wind bracing, etc., shall be supported above ground on skids placed near enough together to prevent injury from deflections. Different grades or classifications of material shall be color coded as provided for in ASTM Designation A 6. This color code must be transferred throughout fabrication. If the Contract covering the erection of the steel does not include the fabrication, the Contractor shall check the material received by him and report promptly in writing to the Engineer any shortage or injury discovered.

326.03.06 Straightening. Rolled material before being laid out or worked shall be straight. Methods of straightening shall be in accordance with ASTM Designation A 6.

Subassemblies and completed members shall be straight before being incorporated into the work. If straightening is necessary, it shall be done by methods acceptable to the Engineer and in accordance with AWS D1.1-80 and revisions thereto as modified by AASHTO Standard Specifications for Welding of Structural Steel Highway Bridges, Third Edition.

Details of methods proposed for straightening of rolled material, subassemblies, or completed members shall be submitted in writing to the Engineer prior to their use. In addition, a detailed procedure for correcting camber shall be submitted to the Engineer for approval. After straightening or correcting camber, evidence of fracture or other damage will be cause for rejection of the material.

If required, beams and girders shall be curved by either: (1) precutting curved flanges or (2) heat curving the members after fabrication. The heat curving shall be in accordance with Division II, Article 10.5 of AASHTO Standard Specifications for Highway Bridges, Thirteenth Edition. The procedure used shall be submitted to the Engineer for review and approval.

326.03.07 Punching, Subpunching, Drilling, and Reaming. Unless otherwise specified, connections and splices (shop and field) of main truss or arch members, continuous beams, plate girders, rigid frames, and web splices shall either be subpunched (or subdrilled) and reamed while shop assembled or drilled to full size from the solid while assembled at the shop. Full size punching of holes will be allowed on intermediate stiffeners, bearing stiffeners, cross bracing, wind bracing, and diaphragms.

Punching and subpunching of structural steel conforming to ASTM A 36 shall not be permitted on material thicker than 7/8 inch or thicker than 3/4 inch for high strength structural steel. Holes subpunched for reaming shall be subpunched 1/4 inch less in diameter than the finished hole.

Reamed or drilled holes shall be cylindrical and perpendicular to the member. Oversize or slotted holes shall not be permitted unless specified on the Plans, except as noted in Subsection 324.03.08 – "High Strength Bolts." Reamers shall be directed by mechanical means where practicable. Burrs on the outside surfaces shall be removed. Poor matching of holes shall be cause for rejection. Reaming and drilling shall be done by twist drills.

Unless otherwise specified, each individual (full length) truss, arch, continuous beam, or plate girder shall be assembled at the shop before reaming or drilling is commenced. During shop assembly, all members shall be supported at such intervals and in such manner as is necessary to avoid undesirable deflections.

326.03.08 Bolts and Bolted Connections

- (a) General. Bolts shall be of such length that they will extend entirely through the nut but not more than 3/8 inch beyond. The Contractor shall furnish sufficient bolts of each type for each size and length to bolt such connections as called for with an ample surplus to replace those lost or rejected.

The holes, except holes in end diaphragms, shall be truly cylindrical. Holes shall be at right angles to the surface of the metal so that both head and nut will bear squarely against the metal. Bolts shall be driven accurately into the holes without damaging the thread.

Bolt holes in end diaphragms shall be slotted 1/2 inch in addition to the dimensions shown on the Plans, in the direction to facilitate erection. At all locations where such slotted bolt holes are required, circular washers shall be placed on each side of the bolted connection and the necessary bolt length adjusted accordingly.

Bolts in end diaphragm to girder connections shall not be tightened until the deck pour has been completed.

All bolted connections shall be fastened with high-tensile strength bolts.

(b) High-Tensile Strength Bolts

1. General. This article covers the assembly of structural joints using ASTM A 325 or ASTM A 490 high strength bolts, or equivalent fasteners, tightened to a high tension.
2. Bolts, Nuts, and Washers. Bolts, nuts, and washers shall conform to the requirements of subsection ASTM A 325 – “High-Strength Bolts,” – except the use of lock-pin and collar fasteners shall not be permitted.
3. Bolted Parts. The slope of surfaces of bolted parts in contact with the bolt head and nut shall not exceed 1 to 20 with respect to a plane normal to the bolt axis. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material.

When assembled, all joint surfaces including those adjacent to the bolt head, nuts, or washers, shall be free of scale, except tight mill scale, and shall also be free of burrs, dirt, and other foreign material that would prevent solid seating of the parts. Paint is permitted unconditionally in bearing-type connections.

In friction-type conditions the class, as defined below, indicating the condition of the contact surfaces shall be specified on the Plans. Where no class is specified all joint surfaces shall be free of scale, except tight mill scale, and shall not have vinyl wash.

Class A, B, and C (uncoated). Contact surfaces shall be free of oil, paint, lacquer, or other coatings.

Class D (hot dip galvanized and roughened). Contact surfaces shall be lightly scored by wire brushing or blasting after galvanizing and prior to assembly. The wire brushing treatment shall be a light application of manual or power brushing that marks or scores the surface but removes relatively little of the zinc coating. The blasting treatment shall be a light “brush-off” treatment which will produce a dull gray appearance. However, neither treatment should be severe enough to produce any break or discontinuity in the zinc surface.

Class E and F (blast-cleaned, zinc rich paint). Contact surfaces shall be coated with organic or inorganic zinc rich paint as defined in the Steel Structures Painting Council System SSPC 12.00.

Class G and H (blast-cleaned, metallized zinc or aluminum). Contact surfaces shall be coated in accordance with AWS C-2.2, Recommended Practice for Metallizing with Aluminum and Zinc for Protection of Iron and Steel, except that subsequent sealing treatments described in Section IV therein shall not be used.

Class I (vinyl-wash). Contact surfaces shall be coated in accordance with the provisions of the Steel Structures Painting Council Pretreatment Specifications SSPC PT3.

High-tensile strength bolts shall not be galvanized unless shown on the plans. ASTM A 325 and ASTM A 490 bolts shall not be galvanized nor shall they be used to connect galvanized material.

4. Installation

- a. Bolt Tension. When all fasteners in the joint are tight, each fastener shall be tightened to provide at least the minimum bolt tension shown in Table 1 for the size of fastener used.

If required because of bolt entering and wrench operation clearances, tightening may be done by turning the bolt while the nut is prevented from rotating. Impact wrenches, if used, shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately 10 seconds.

ASTM A 490 and galvanized ASTM A 325 bolts shall not be reused. Other ASTM A 325 bolts may be reused, but not more than once, if approved by the Engineer. Retightening previously tightened bolts which may have been loosened by the tightening of adjacent bolts shall not be considered as a reuse.

- b. Washers. All fasteners shall have a hardened washer under the element (nut or bolt head) turned in tightening. Hardened washers shall be used under both the head and nut regardless of the element turned in the case of ASTM A 490 bolts if the material against which it bears has a specified yield strength of less than 40 p.s.i.

Where an outer face of the bolted parts has a slope of more than 1 to 20 with respect to a plane normal to the bolt axis, a smooth beveled washer shall be used to compensate for the lack of perpendicularity.

- c. Tightening by Use of a Load Indicating Fastener System. Tightening will be by a load indicating fastener system. Unless otherwise indicated, the authorized load indicating fastener shall be a specifically hardened washer with protrusions on one face. Tightening shall be by the manufacturer's methods and procedures and shall have the approval of the Engineer. Certification shall be supplied by the manufacturer that the fastener used is available to indicate that the bolt has been tightened to obtain the bolt tension in accordance with Table I.

TABLE I
BOLT TENSION
MINIMUM BOLT TENSION IN POUNDS¹

<u>Bolt Size, in Inches</u>	<u>ASTM A 325 Bolts, p.s.i</u>	<u>ASTM A 490 Bolts, p.s.i</u>
1/2	12,050	14,900
5/8	19,200	23,700
3/4	28,400	35,100
7/8	39,250	48,500
1	51,500	623,600
1 1/8	56,450	80,100
1 1/4	71,700	101,800
1 3/8	85,450	121,300
1 1/2	104,000	147,500

¹ Equal to 70 percent of specified minimum tensile strength of bolts.

5. Inspection. The Engineer shall determine that the requirements of Subsection 506.03.10(b) a through 4 of this subsection are met in the work.

The Engineer shall observe the installation and tightening of bolts to determine that the approved procedure is properly used and shall determine that the correct indication of tension has been achieved.

326.03.09 Shop Assembly. Shop assembly of trusses, arches, continuous beams, plate girders, and rigid frames shall be according to Subsection 326.03.07 – “Punching, Subpunching, Drilling, and Reaming.” All members shall be match marked before being disassembled.

The several component parts of a built up member shall be straight and close fitting.

Surfaces of metal in contact shall be cleaned before assembling. The parts of a member shall be assembled, well pinned, and firmly drawn together with bolts before drilling and reaming. Assembled pieces shall be taken apart, if necessary, for the removal of burrs and shavings produced by the operation. The member shall be free from twists, bends, and other deformations.

The drilling done during assembling shall be only such as to bring the parts into position and not sufficient to enlarge the holes or distort the metal.

Connecting parts in the shop for the purpose of reaming holes in field connections shall be match marked, and a diagram showing such marks shall be furnished to the Engineer.

A camber diagram shall be furnished to the Engineer showing the camber at each panel point in the cases of trusses, and at field splices and 1/10 points of span for beams, girders, and rigid frames. The final camber shall be checked on the fully assembled girders in the “no load” position for rolled beams and I-plate girders, and in the “dead load” position for box plate girders. The bolts in the field splice need not have the final tension applied. Only enough tension need be applied to adequately keep the assembled section together for the camber measurements.

Prior to fabrication, a handling procedure for box plate girders shall be submitted to the Engineer for approval. The procedure shall be such that no undue stresses are applied to the flange to web welds.

326.03.10 Edge Planing. Sheared edges of plates more than 5/8 inch in thickness and carrying calculated stress shall be planed to a depth of 1/4 inch. Re-entrant cuts shall be filleted to a radius of 3/4 inch.

326.03.11 Milled Surfaces. The surface finish of bearing and base plates and other bearing surfaces that are to come in contact with each other or with concrete shall meet the American Standards Association surface roughness requirements as defined in ANSI B-46.1, Surface Roughness, Waviness, and Lay, Part I.

Steel slaps	ANSI 2,000
Heavy plates in contact in shoes to be welded	ANSI 1,000
Milled ends of compression members, stiffeners, and fillers	ANSI 500
Bridge rollers and rockers	ANSI 250
Pins and pin holes	ANSI 125
Sliding bearings	ANSI 125

Surfaces of bronze bearing plates intended for sliding contact shall be planed parallel to the movement of the spans and polished.

326.03.12 Abutting Members. Abutting joints in compression members of trusses and in columns shall be milled.

Openings and abutting joints in tension members shall not exceed 1/4 inch.

Abutting joints of rolled beams, plate girders, and box plate girders shall not exceed 1/4 inch.

326.03.13 Flame Cutting. This work shall be in accordance with provisions of AWS D1.1-80 and revisions as modified by the AASHTO Standard Specifications for Welding of Structural Steel Highway Bridges, Third Edition.

326.03.14 Length Tolerances. Floorbeams, stringers, and girders having end connection angles shall be built to the exact length shown on the Plans measured between the heels of the connection angles, with a permissible tolerance of plus zero inch to 1/16 inch. Where continuity is to be required, end connections shall be faced. The thickness of the connection angles shall not be less than 3/8 inch, nor less than that shown on the Plans.

326.03.15 Lacing Bars. The ends of lacing bars shall be neatly rounded unless another form is required.

326.03.16 Girder Top Flanges. In girders having no cover plates and not to be encased in concrete, the top edge of the web plate shall not extend above backs of the flange angles and shall not be more than 1/8 inch below at any point.

Splices in webs of girders without cover plates shall be sealed on the top by welding.

At web splices, the clearance between the ends of the web plates shall not exceed 3/8 inch. The clearance at the top and bottom ends of web splice plates shall not exceed 1/4 inch.

326.03.17 Shear Stud Connectors. Stud shear connectors shall be of a design suitable for end welding and shall be end welded to steel beams, girders, or plates with automatically timed stud welding equipment. The type, size or diameter, and length of the stud shall be as specified in the Contract Documents. A maximum variation of 1 inch from the location shown will be accepted, provided the adjacent studs are not closer than 2 1/2 inches center to center. The clear distance between the edge of a girder flange and the edge of the shear connectors shall be not less than 1 inch. Fillet welds varying in size from 3/16 inch to 5/16 inch are satisfactory, provided the studs pass all other tests required. Adequate provision shall be made in the fabrication of structural members to compensate for loss of camber due to welding of the shear connectors.

Studs shall be painted or galvanized. The studs shall be free from rust, scale, rust pits, and oil at the time of welding and immediately before the concrete is placed. The beam surface to which the studs are welded shall be free from excessive mill scale, rust, dirt, paint, grease, or any other material which might impair the quality of the weld. When necessary to obtain satisfactory welds, the areas on the beam, girder, or plate to which the studs are to be welded shall be wire-brushed, peened, prickpunched, or ground free of scale or rust.

The Contractor shall submit to the Engineer for approval before installation information on the studs to be furnished as follows:

1. The name of the manufacturer.
2. A detailed description of the stud and shield.
3. A certification from the manufacturer that the stud is qualified as specified in AWS D 1.1. The certification must also indicate the heat from which the studs were manufactured.

Welding specifications and procedure requirements shall conform to AWS D1.1.

326.03.18 Welding

- (a) General. All welding shall be performed in the fabrication shop, except as otherwise noted on the Plans or permitted by the Engineer.

Automatic welding shall be used for all flange to web welds.

Shop splices of flanges or webs of main members shall be limited to locations where section changes occur, where shown on the Plans, or as approved by the Engineer.

The weldments in butt splices of both webs and flanges shall be inspected and found satisfactory prior to performing web to flange connections.

Field splices shall be limited to the actual locations shown on the Plans.

The use of additional field or shop splices, if required, shall be reviewed and approved in writing by the Engineer prior to fabrication.

Welding shall conform to the provisions of AWS D1.1-80 and revisions thereto, as modified by AASHTO Standard Specifications for Welding of Structural Steel Highway Bridges, Third Edition, except the use of electroslag weldments will not be allowed.

All groove welds on primary members shall be finished smooth and flush with the base metal on all surfaces by grinding in the direction of applied stress, leaving the surface free from depressions.

Extension bars of runoff tabs shall be used at the end of a joint in a manner that will ensure sound welds.

Fillet welds on stiffeners or gusset plates shall be terminated 1/4 inch from the end of the plate or cope.

The minimum length of all welds shall be 2 inches.

All welding on structural steel shall be only at locations shown on the shop drawings, including tack welds. The welding of lifting lugs or attachments will not be allowed.

The fabricator shall submit to the Engineer for his review all welding procedures for prequalified welds at no additional cost to the Owner. In addition, the Engineer reserves the right to test any prequalified weld at no additional cost to the Owner.

Shear stud connectors shall not be placed on shop splices, but may be moved up to 3 inches either side of the splice if a conflict occurs.

Where weldments in both the web and flange fall at the same location, they shall be offset a minimum of 6 inches. When a stiffener falls at a location of a flange or web weldment, the stiffener shall be offset a minimum of 3 inches from the weldment.

Upon approval of the Engineer, shop splices may be located at points that are consistent with lengths of plate available from the mill and in areas of reduced tensile stress. To eliminate shop splices, the length of a thicker plate may extend to the end of a thinner plate or the end of a member. These changes, if approved by the Engineer, shall be shown on the shop drawings. Extra material and workmanship required by these changes shall be at no additional cost to the Owner.

- (b) Inspection-Testing. All shop and field welds shall be inspected to the provisions of AWS D1.1-80 and revisions thereto as modified by AASHTO Standard Specifications for Welding of Structural Steel Highway Bridges, Third Edition, Nevada Test Methods NHD 900, 901, 903, and these Specifications.

Paragraph 6.1.3.1 of the AASHTO Welding Specifications is hereby deleted in its entirety and any reference to said paragraph in AWS or AASHTO is also deleted.

The Contractor shall visually inspect all welds and test welds in accordance with the requirements of this subsection of these Specifications. The Engineer will make the final evaluation of the acceptability of all welds.

- (c) Quality Control. Prior to any fabrication, the Contractor shall submit in writing a quality control program to the Engineer. The program shall outline the quality control tasks to be performed by the Contractor to insure that the work conforms to the Plans and these Specifications. The quality control program shall also identify the Contractor's personnel who will be responsible for performing the quality control tasks.
- (d) Supervision. Adequate supervision and inspection of all welds shall be provided by the Contractor to ensure satisfactory, consistent, and uniform workmanship. Repeated and chronic weld defects shall be considered as evidence that proper quality control and supervision procedures are not being provided.
- (e) Time of Inspection. Visual inspection shall be continuous. Nondestructive testing of welds shall begin immediately after welding operations are completed, except for ASTM A 514 and A 517 steels. Final

nondestructive testing of welds for ASTM A 514 and A 517 steels shall not be performed until at least 96 hours have elapsed after completing welding operations.

- (f) Heat Numbers. Prior to nondestructive testing, the Contractor shall furnish to the Engineer heat numbers of all structural steel parts welded together to form a main member. Heat numbers of all plates separated into flange and web sections shall be transferred through steel stamping by the Contractor at his expense.
- (g) Visual Inspection of Welds. Visual inspection of welds will be performed by the Engineer at no expense to the Contractor, except as provided in the Contractor's quality control program. Inspection requirements and standards for visual acceptance shall be as stated in AWS D-1.1 and revisions thereto as modified by AASHTO Standard Specifications for Welding of Structural Steel Highway Bridges, Third Edition, and Nevada Test Methods NHD 900, 901, and 903. All welds shall be inspected and accepted visually, and any required repairs made prior to performing any nondestructive testing for acceptance.
- (h) Testing Precedence. When both radiographic inspection and ultrasonic inspection are to be performed on a weld, radiographic inspection shall be performed prior to ultrasonic inspection except in flanges where acceptance is based on ultrasonic method.
- (i) Radiographic Inspection. All radiographic testing and inspection will be performed by the Contractor at his expense.
 - 1. Licensing Requirements. The agency performing the radiographic testing shall be currently licensed for the operation involving radioactive materials under the proper jurisdiction where such inspections are performed.
 - 2. Testing Procedures Submittal. Before beginning fabrication of structural steel components, the Contractor shall submit in writing to the Engineer for approval a copy of his proposed radiographic test procedures.
 - 3. Resume. The Contractor shall furnish to the Engineer a resume listing the specific radiographic equipment and outlining the particular radiographic procedures proposed for use on the work. The Contractor shall furnish a statement to the Engineer detailing the radiographic training and experience for each person to be employed in radiographic testing and certifying that each of these persons is a competent radiographer or radiographer's assistant.
 - 4. Scheduling. The Contractor shall schedule radiographic testing and notify the Engineer not less than 12 hours in advance of the scheduled time and place for this testing. The items to be radiographed and the radiographic agency to be utilized, unless otherwise authorized by the Engineer. Radiographic testing shall be scheduled during daylight hours only unless requested in writing by the Contractor and approved by the Engineer. Blanket approval for an extended period may be given at the discretion of the Engineer.

Butt welds in girder flanges and webs shall not be radiographically inspected until the rider flange or web section is cut to its finished width.

5. Extent of Inspection

a. Groove Welds. The Contractor shall furnish to the Engineer for his use in evaluating the acceptability of groove welds, radiographs, and radiographic reports for the following welds:

TABLE II

Radiographic Weld Inspection Schedule

<u>Girder Material</u>	<u>Member</u>	<u>Tension/ Compression</u>	<u>Weld Orientation</u>	<u>Percent Inspection</u>
All	Flange	Tension	Transverse	10
All	Flange	Compression	Transverse	5

Percent inspection on flange welds indicated the percentage of the total number of welds in the structure. Each weld designated for radiographic testing shall be tested for the entire length of the weld. The inspector will designate which welds to be tested.

<u>Girder Material</u>	<u>Member</u>	<u>Tension/ Compression</u>	<u>Weld Orientation</u>	<u>Percent Inspection</u>
All	Web	Tension	Transverse	100
All	Web	Compression	Transverse	100
All	Web	Tension	Longitudinal	10
All	Web	Compression	Longitudinal	10

Percent inspection on web indicated the percentage of the length to be tested on each individual web weld; however, a minimum of one radiograph 17 inches in length at each end of all web welds is required. In addition, if the original radiographs show rejectable discontinuities, the area on each side of the defect for a minimum length of 17 inches shall be tested.

- b. Additional Radiographic Inspection. The Engineer may perform radiographic inspection in addition to such inspection performed by the Contractor. The Contractor shall make available, at no cost to the State, the facilities used in his operations for use by the Engineer in performing such additional inspection. In the event such additional radiographic inspection discloses defective welds, repairing of the defective welds and reradiographic inspection shall be performed by the Contractor at his expense.

6. Radiographic Procedure

- a. Requirement. The radiographic procedure used shall conform to the requirements in ASTM Designation E-94, and the requirements of these Specifications.
- b. Film. Radiographs made on material whose thickness is 0.9 inch or less shall be done on Type 1 industrial radiographic film.

Radiographs made on material whose thickness is 0.901 inch to 3.5 inches shall be done on Type II industrial radiographic film. All radiographic film shall conform to the requirements of ASTM Designation E-94. The film shall be wide enough to fully span the width of the weld with sufficient excess to allow the specified location markers and other identification to show on the film outside of the weld area, but in no case shall the film be less than 4 1/2 inches in width. The testing agency conducting the radiograph shall submit for approval all data concerning the film, including brand name and type, prior to any radiograph being performed on the project.

- c. Process and Detail. Radiographs shall be made by either X-ray or gamma ray. All radiographs shall determine quantitatively the size of defects having thickness equal to or greater than 2 percent of the thickness of the thinner of the part joined by the weld under examination. They

shall be clean, free of film processing defects, shall have densities of not less than 1.5, and no more than three in the area of interest. Any gamma ray source used to radiograph welded material up to 3 inches in thickness shall not exceed 0.16 inch across its greatest diagonal dimension.

Radiographs shall show the following:

- (1) The 2T hole in each penetrometer.
 - (2) The penetrometer identification number.
 - (3) The radiograph identification and location marks below under "identification and Location Marks."
- d. Film Development. Radiographic film shall be developed within the time and temperature range recommended by the film manufacturer. Sight development will not be permitted. The film shall be manually hot air dried to the satisfaction of the Engineer. The use of automatic dryers will not be permitted.
- e. Dual Film Technique. In the event that the greatest and least thickness of a weld joining parts of different thickness cannot both be rendered with a single exposure on a single film having densities within the limits specified under "Process and Detail", a dual film or dual exposure technique shall be used. These techniques shall be calibrated to obtain the required density for both the greatest and the least thickness of the weld. When these techniques are employed, two extra penetrometers shall be used in addition to the two specified under "Penetrometers." The four penetrometers shall be positioned so that at least one penetrometer image appears at each end of each film on the plate thickness for which that film has been exposed.
- f. Penetrometers. Two or more penetrometers shall be used for each radiograph on a film 10 inches or more in length. Only one penetrometer need be used for radiographs on film less than 10 inches in length. Penetrometers shall be placed on the side of the work nearest the source of radiation located as shown in the current edition of AWS. Penetrometers shall conform to the requirements in Table III of this subsection of these Specifications. The thickness of each penetrometer shall be equal to or less than 2 percent of the thickness of the thinner of the parts joined by the weld under examination, but need not be less than 0.005 inch thick.

In each penetrometer there shall be three holes, one of which shall be of diameter equal to twice the nominal penetrometer thickness (2T), but not less than 1/16 inch for X- ray and 3/32 inch for gamma ray. The diameter of the two remaining holes shall be selected by the manufacturer. They will ordinarily be equal to three or four times the penetrometer thickness, but not be smaller than 1/16 inch. Smaller holes are permitted. These holes shall be true and normal to the surface and not chamfered. For weld thickness less than 1/2 inch, the penetrometer shall also contain a slit 1/4 inch long by 0.01 inch wide.

TABLE III

Standard Penetrometer Sizes

<u>Weld Thickness Range</u>	<u>Thickness of Penetrometer on Source Side (inch)</u>	<u>Example of Penetrometer Identification</u>
Up to 1/4 inclusive	0.005	5
Over 3/8 thru 1/2	0.0075	7
Over 3/8 thru 1/2	0.010	10
Over 1/2 thru 5/8	0.0125	12
Over 3/4 thru 7/8	0.015	15
Over 3/4 thru 7/8	0.0175	17
Over 7/8 thru 1	0.020	20
Over 1 thru 1-1/4	0.025	25
Over 1 1/4 thru 1 1/2	0.030	30
Over 1 1/2 thru 2	0.035	35
Over 2 thru 2 1/2	0.040	40
Over 2 1/2 thru 3	0.045	45
Over 3 thru 4	0.050	50
Over 4 thru 6	0.060	60
Over 6 thru 8	0.080	80

- g. Radiographic Exposure. Radiographs shall be made with a single source of radiation approximately centered with respect to the length of the weld being examined. The perpendicular distance from the radioactive source to the film shall be not less than seven times the maximum thickness of the weld under examination and the rays shall not penetrate the weld at an angle greater than 26 1/2 degrees from a line perpendicular to the weld surface. During exposure the film shall be placed at the opposite side to the source of radiation and as close to the surface of the weld as possible.

7. Identification and Location Marks

- a. Fabrication. Radiographic identification for inspection of welds shall consist of the following:

(1) Contract number.

(2) Weld Identification Number. The weld identification number shall consist of a sequence of digits conforming to the following:

- (a) The fabrication number of the girder in which the radiographed weld occurs, followed by a dash (-).

- (b) Letter combination designating the section in which the radiographed section occurred. The section shall be designated by the letters TF (Top Flange), BF (Bottom Flange), or the word Web.
 - (c) The joint designation consisting of the letter W preceded by a space and followed by a number. The number shall designate the joint in which the radiographed weld occurs and shall correspond to the number of welded joints between the reference or work end of the section and the radiographed weld.
 - (d) All weld identification numbers will be steel stamped.
- (3) Identification of the company performing the radiograph.
 - (4) Radiographer's initials.
 - (5) Six numeric digits indicating "Month" – "Day" – "Year."
- b. Erection. Radiograph identification for radiographs of welds performed after erection shall be designated by the Engineer.
 - c. Repairs. The weld identification number on radiographs of repaired welds shall be suffixed with the letter R and a number showing how many times the weld has been repaired.
 - d. Radiograph Location Marks. When complete radiographic coverage of a weld is specified, location or other supplementary match marks shall be placed to appear on the film in accordance with the provisions in Section 14 of ASTM Designation E94. Radiograph location marks will not be required for radiographs made at field construction sites. The location of radiographs made at field construction sites shall be indicated by a number added to the end of the weld identification number. Such a number, separated from the joint or splice number by a space, shall signify the location of radiographs on plate girder joints or splices when viewed ahead on line, as follows:
 - 1. Right side bottom flange
 - 2. Left side bottom flange
 - 3. Left side top flange
 - 4. Right side top flange
 - 5. Web adjacent to top flangeIn the event additional radiographs of a given web weld are required, these will be identified as consecutive location numbers starting with 7. The exact location of such radiographs shall be approved by the Engineer and noted in the radiographic reports.
 - e. Radiographic Identification (Miscellaneous). The radiograph identification and marking system for welds on other than plate girder structures shall be established by agreement between the Contractor and the Engineer before radiographic inspection begins.

8. Examination, Reports, and Disposition of Radiographs

- a. Viewer. The Contractor shall provide a suitable high-intensity radiograph viewer at the place where radiographic inspection is performed.
- b. Acceptance. Prior to acceptance by the Engineer of a weld subject to radiographic inspection by the Contractor, all radiographs including any that show unacceptable quality prior to repair, and a report interpreting them, shall be submitted to the Engineer.
- c. Reports. The Contractor shall submit to the Engineer three or more copies of the radiographic report showing the results of radiographic tests performed during each shift. This radiographic report shall include the following information:
 - (1) Date.
 - (2) Name and address of the radiographic inspection agency.
 - (3) Description of structure being inspected.
 - (4) Location of structure or fabrication site.
 - (5) Contract number.
 - (6) The specification being used to accept or reject welds radiographically inspected.
 - (7) Name and address of the fabricator.
 - (8) The radioactive source, type, and size (either current or dated strength), or X-ray unit type and size.
 - (9) Type of film used.
 - (10) The names of technicians performing the radiograph
 - (11) The NDT numbers for the reported radiographs.
 6. The weld identification number for each radiograph.
 - (13) The item radiographed (flanged, web, etc.) for each radiograph.
 - (14) The thickness of the item radiographed for each radiograph.
 - (15) The distance from the radioactive source or focal spot to the film for each radiograph.

(16) An interpretation of each radiograph providing an analysis of:

- (a) Cracks.
- (b) Porosity or gas holes.
- (c) Slag or inclusion.
- (d) Lack of fusion.
- (e) Incomplete penetration.

(17) Acceptability of both weld and radiograph for each radiograph.

(18) Remarks (if any) concerning any unusual observation or condition in the weld or radiograph.

(19) Radiographer's signature.

d. Packaging. Radiographs and reports shall be packaged in suitable envelopes and shall be clearly marked on the outside with the following identification:

- (1) The Contract number.
- (2) The fabricator.
- (3) The NDT report numbers for the radiographs in the package.

e. Disposition of Reports. After review and approval of radiographic reports, the Engineer will retain the original and two copies of the reports together with the radiographs. All additional copies of the reports will be returned to the Contractor.

(j) Ultrasonic Inspection of Welds

1. General. Ultrasonic inspection will be performed by the Engineer at no expense to the Contractor except for joint preparation. Inspection method shall be as provided for in AWS D1.1-80 and revisions thereto as modified by AASHTO Standard Specifications for Welding of Structural Steel Highway Bridges, Third Edition.
2. Extent of Ultrasonic Inspection. Ultrasonic inspection will be performed on 100 percent of the total weld length of groove welds in all flange welds.
3. Location. The locations for ultrasonic inspection will overlap locations selected for radiographic inspection. Flange welds shall be accepted by ultrasonic method. Radiographs taken in areas of previously accepted welds shall be for documentation only.
4. Scheduling of Inspection. The Engineer will schedule ultrasonic inspection and evaluation at the request of the Contractor subject to the following conditions:

- a. If the Contractor only provided time and space for ultrasonic inspection intermittently, each time he requires such inspection he shall submit his request to the Engineer not less than 24 hours in advance. This request shall identify the welds that are ready to be inspected so that the Engineer can verify the accessibility and preparation of these welds before he schedules the requested ultrasonic inspection.
 - b. If the Contractor schedules fabrication and erection at such a rate that he can support continuous ultrasonic inspection and evaluation, and if he provides time and space for this inspection to proceed in an uninterrupted manner, he shall maintain and provide the Engineer or the Engineer's agent with a 6 hour notice of the identity and location for each of the welds that are ready for inspection. This will allow time for the Engineer or his agent to optimize his ultrasonic inspection schedule.
5. Weld preparation. Ultrasonic inspection and evaluation will not be scheduled until welds have been prepared by the Contractor as follows:
- a. Web-to-flange fillet welds within 6 inches of either side of the butt weld to be inspected shall be withheld until after ultrasonic inspection has been completed and the butt weld has been accepted.
 - b. All shear studs, stiffeners, brackets, bolt holes, and other projections or obstructions within the ultrasonic scanning zone shall be removed or left off until after ultrasonic inspection has been completed and the butt weld has been accepted.
 - c. Backup plates and run-off tabs, if any, shall be removed.
 - d. Welds shall be found flush and smooth with a maximum roughness not to exceed 250 micro-inches rms.
 - e. All loose mill scale, rust, dirt, grease, weld spatter, etc., shall be removed from the scanning zone and the flange or plate surface within the zone shall be finished flush.
 - f. Pint shall be removed.
6. Inspection Procedure. Ultrasonic inspection and evaluation by the Engineer will be performed in conformance with the following:
- a. Ultrasonic inspection and evaluation will be performed only during daylight hours unless otherwise allowed by the Engineer.
 - b. Ultrasonic inspection and evaluation will not be performed at unsafe locations or locations not readily accessible.
 - c. Ultrasonic inspection will not be performed in the presence of rain, snow, or blowing sand, or when the wind velocity exceed 10 mph, except under shelter approved by the Engineer.
 - d. Ultrasonic inspection and evaluation will be performed only when the temperature of the steel is above 40 degrees F. but not above 120 degrees F.
 - e. Prior to the initiation of ultrasonic inspection joints shall be visually inspected for surface defects and conformance to joint preparation requirements.

- (k) Dye Penetrant Inspection of Welds. The use of dye penetrant inspection shall be at the discretion of the Engineer.

When dye penetrant inspection is required by the Engineer, the procedure ASTM E-165, and the standards set forth in AWS D1.1-80 and revisions thereto as modified by AASHTO Standard Specifications for Welding of Structural Steel Bridges, Third Edition, and Nevada Test Methods NHD 900, 901, and 903 shall control the work.

- (l) Magnetic Particle Inspection of Welds. The use of magnetic particle inspection shall be at the discretion of the Engineer.

When magnetic particle inspection is required by the Engineer the procedure ASTM E709 and standards set forth in AWS D1.1-80 and revisions thereto as modified by AASHTO Standard Specifications for Welding of Structural Steel Bridges, Third Edition, and Nevada Test Methods NHD 900, 901, and 903 shall control the work.

- (m) Marking of Welds for Repair. Defective welds will be clearly marked by the Engineer in the presence of the Contractor on the surface and side repairs will be made from. Markings will clearly indicate the length and depth of the defect. Defect length will be noted by a line on the surface directly over the defect, running the entire length of the defect. Depth from the noted surface will be marked (out of the weld area) with a suitable line or arrow referencing the applicable defect.

- (n) Allowable Number of Repairs. When any weld has been repaired three times and rejected four times, hardness tests shall be performed to the Engineer or his authorized representative. Acceptable values shall be determined by the Engineer for weld metal and the heat affected zone depending on the type of base metal. If the hardness values exceed the permissible range then the weld and heat affected material.

326.03.19 Fit of Stiffeners. The fit of stiffeners shall be as specified in AWS D1.1-80 and revisions thereto as modified by AASHTO Standard Specifications for Welding of Structural Steel Bridges, Third Edition.

326.03.20 Annealing and Stress Relieving. Annealing and stress relieving shall be as specified in Division II, Article 10.26 of the AASHTO Standard Specifications for Highway Bridges.

326.03.21 Pins and Rollers. Rollers shall be of structural carbon steel, and pins shall be of carbon steel forging meeting the requirements of Section 207. Pins and rollers shall be accurately turned to the dimensions shown on the Plans and shall be straight, smooth, and free from flaws. Final surface shall be produced by a finishing cut.

In pins larger than 9 inches in diameter, a hole not less than 2 inches in diameter shall be bored full length along the axis after the forging has been cooled to a temperature below the critical range under suitable conditions to prevent injury by too rapid cooling, and before being annealed.

Pin holes shall be bored true to the specified diameter, smooth and straight, at right angles with the axis of the member and parallel with each other unless otherwise specified.

The distance outside to outside of holes in tension members and inside to inside of holes in compression members shall not vary from that specified more than one 1/32 inch. Boring of holes in built up members shall be done after the bolting is completed.

The diameter of the pin hole shall not exceed that of the pin by more than 1/50 inch for pins 5 inches or less in diameter, or more than 1/32 inch for larger pins.

Screw threads for all bolts and pins for structural steel construction shall conform to the American National Coarse Thread Series, Class 2m free fit, except that pin ends having a diameter of 1 3/8 inches or more shall be threaded six threads to the inch.

Pilot and driving nuts shall be used in driving pins. They shall be furnished by the Contractor without charge. Two pilot nuts and two driving nuts for each size of pin shall be furnished, unless otherwise specified. Pins shall be so driven that the members will take full bearing on them. Pin nuts shall be screwed up tight and the threads burred at the face of the nut with a pointed tool.

326.03.22 Shop Painting. Unless otherwise provided the application of shop paints shall conform to the requirements of Section 322 -"Painting, Pavement Striping, and Marking." Surfaces to be in contact after shop bolting is completed shall be cleaned but not painted.

326.03.23 Identification. Each member shall have an erection mark permanently stamped to the metal for identification and an erection diagram shall be furnished with erection marks shown thereon. Painted erection marks will not be permitted. Members weighing more than 3 tons shall have the weight marked thereon. Structural members shall be loaded on trucks or cars in such a manner that they may be transported and unloaded at their destination without being excessively stressed, deformed, or otherwise damaged. All girders must be shipped in a standing position, which position shall be maintained in subsequent operations.

326.03.24 Erection Methods. 15 days prior to the start of erection the Contractor shall inform the Engineer in writing as to the method of erection he proposes to follow, and as to the amount and character of the equipment he proposes to use, the adequacy of which shall be subject to the approval of the Engineer. Storage and handling of the beams or girders on the erection site shall conform to Subsections 324.03.05 – "Handling and Transporting" – and 326.03.09 – "Shop Assembly." The approval of the Engineer shall not be considered as relieving the Contractor of the responsibility for the safety and adequacy of his methods or equipment or from carrying out the work in full accordance with the Plans and Specifications.

Spot welding for the purpose of eliminating field erection bolts or for holding steel parts together while bolting will not be permitted.

All work of erection shall be subject to inspection and the Contractor shall furnish facilities for such inspection of material and workmanship. Material and workmanship not previously inspected shall be inspected after its delivery to the site of the work.

The Contractor shall provide the falsework and all tools, machinery, and appliances, including drift pins and fitting up bolts necessary for the expeditious handling of the work.

Anchor bolts for rail posts shall be galvanized high-strength bolts set with suitable templates in exact position and securely fixed to prevent displacement during the concreting operations. The areas of concrete upon which posts are to be set shall be dressed by grinding and rubbing to a true plane for the proper seating of the posts. All surfaces of aluminum alloy posts and adjustment shims to be in contact with concrete or with the steel anchor bolts, nuts, and washers shall be coated with aluminum insulating compound.

Rail posts shall be erected in sections. Erection of sections of rails and posts shall continue successfully until all or an approved portion of the required rail is erected. The rail shall then be aligned and the nuts on the anchor bolts tightened. In final adjustment no posts shall deviate more than 1/8 inch from true alignment and there shall be no abrupt break in alignment at any location. Aluminum shims may be slotted for ease in placing if approved by the Engineer.

326.03.25 Falsework. The falsework shall be properly designed and substantially constructed and maintained for the loads which come upon it. The Contractor shall prepare and submit to the Engineer for approval plans for falsework or for changes in an existing structure necessary for maintaining traffic. Approval of the Contractor's plans shall not be considered as relieving the Contractor of any responsibility.

Holes for falsework and forms shall be shown on the shop drawings. Holes shall be located such that distortion of the web shall not occur. Temporary ties and struts shall be required when necessary to resist lateral loads and control relative deflections.

Welding of falsework supports shall be limited to compression flanges only, as approved by the Engineer.

Upon completion of the erection and before final acceptance, the Contractor shall remove all falsework, excavated or useless materials, rubbish, and temporary buildings, replace or renew any fences damaged, restore in an acceptable manner all property, both public and private, which may have been damaged during the prosecution of the work, and leave the structure site and adjacent highway in a neat and presentable condition satisfactory to the Engineer.

All excavated material or falsework placed in the stream channel before construction shall be removed by the Contractor before final acceptance.

At a time to be determined by the Engineer and when applicable, the Contractor shall remove and dispose of temporary cross frames between the box plate girders.

326.03.26 Bearing and Anchorage. Bridge bearing shall set in exact position as shown on the Plans and shall have full and even bearing on the masonry. Bridge bearing shall not be placed on masonry bearing areas which are irregular or improperly formed.

Cast iron, steel, or rolled steel bearings shall be bedded on the masonry with alternate layers of red lead and canvas, a single thickness of sheet lead, or preformed elastomeric bearing pads as shown on the Plans.

Surfaces designed for sliding movement, one upon the other, shall be given a field coat of graphite grease when placed in the structure.

The Contractor shall drill the holes and set and anchor bolts, except where the holes are formed or the bolts are built into the masonry. The bolts shall be set accurately and fixed with Portland Cement grout, completely filling the holes. The location of the anchor bolts in relation to the slotted holes in the expansion shoes shall correspond with the temperature at the time of erection. The nuts on anchor bolts at the expansion ends of spans shall be adjusted to permit free movement of the span.

326.03.27 Field Assembly. If the contract covering the erection of the steel does not include the fabrication, the Contractor shall check the material received by him and report promptly in writing to the Engineer any shortage or injury discovered. The parts shall be accurately assembled as shown on the Plans and match-marks shall be followed. The material shall be carefully handled so that no part will be bent, broken, or otherwise damaged. Hammering which will injure or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled.

Unless erected by the cantilever method, truss spans shall be erected on blocking so placed as to give the trusses proper camber.

326.03.28 Minor Erection Misfits. The correction of minor misfits involving no harmful amounts of reaming, cutting, and chipping shall be considered a legitimate part of the erection. However, any error in the shop fabrication, or deformation resulting from handling and transportation, which prevents the proper assembling and fitting up of the parts by the moderate use of drift pins or by a moderate amount of reaming and slight chipping or cutting, shall be reported immediately to the Engineer and his approval of the method of correction obtained. The corrections shall be made in his presence. The Contractor shall be responsible for all misfits, errors, and injuries and shall make the necessary corrections and replacements.

326.03.29 Painting. Structural steel, unless otherwise specified, shall be painted as specified in Section 322 – "Painting, Pavement Striping, and Marking."

326.04 MEASUREMENT OF QUANTITIES AND BASIS OF PAYMENT

326.04.01 Reinforcing Steel. Unless otherwise specified, no direct measurement or payment shall be made for reinforcing steel. Compensation for reinforcing steel shall be included in the unit price bid for the structure involved.

326.04.02 Structural Steel. Structural steel shall be measured and compensated for by the units bid and the unit prices established for structural steel in the Contract Documents. Units shall be measured by the pound, by the lineal foot, or by lump sum, unless otherwise directed by the Engineer.

327.01 DESCRIPTION. This work shall consist of furnishing and erecting new barbed wire (Type BW), woven wire mesh (Type WM), or chain link (Type CL) fence, including gates and related appurtenances; or reconstructing temporarily removed fences, all in conformity with these Specifications and the Plans. It is the intent of these Specifications, and the Standard Details, that fences built in compliance meet the Nevada Statute definitions of a legal fence for the specific application.

327.01.01 Barbed wire fence (Type BW) shall consist of galvanized barbed and/or barbless wire, fastened to wood or metal posts or to a combination of the two kinds of posts as shown on the Plans, including related appurtenances. The numbers of strands and types of wire and positioning are shown on the Plans and further detailed in the Standard Details.

327.01.02 Woven wire mesh fence (Type WM) shall consist of a combination of wire mesh fence fabric with galvanized barbed and/or barbless wire fastened to wood or metal posts or to a combination of the two kinds of posts as shown on the Plans, including related appurtenances. The mesh fabric height and numbers and separations of barbed and/or barbless strands are indicated on the Plans and further detailed in the Standard Details.

327.01.03 Chain link fence (Type CL) shall consist of chain link fabric attached to metal posts and fastened to a specified top tensioning cable or top rail, and a bottom tensioning wire, including related appurtenances. The height of chain link fences shall be designated on the Plans. Barbed wire strands fastened to vertical and/or angled security arm extensions, if required, are indicated on the Plans and further detailed in the Standard Details. Selvage types and orientation, and special fabric types such as vinyl coating and/or slating, shall be as required in the Plans.

327.02 MATERIALS. Materials shall conform to the requirements specified in Section 209 – “Fence Materials” for the required type of fencing and appurtenances. Materials shall also comply with the Standard Details.

327.03 CONSTRUCTION REQUIREMENTS

327.03.01 Location of Fencing. Fencing and appurtenances shall be constructed in exact locations shown on the Plans. Where field evidence of property lines or rights-of-way appear to conflict with the Plans, the Contractor shall notify the Engineer in advance of clearing and construction in these locations.

327.03.02 Project Access and Protection of Existing Improvements. The Contractor shall be responsible for familiarizing himself, his representatives, and his subcontractors, with Plans and Contract Documents regarding access and environmental limitations, and existing above and below ground improvements, and to insure compliance. The Contractor shall notify USA Underground Service Alert (1-800-227-2600) 2-working days prior to attempting excavation or post driving in any area where underground utilities are known or suspected to be at risk. It shall be the Contractor's responsibility to take any such conditions or limitations into account and make allowances in prices bid. No direct payment will be made for such conditions.

327.03.03 Clearing and Grubbing. All trees, brush, and other obstructions which interfere with proper construction of fences shall be removed and disposed of in accordance with the requirements of Section 300 – “Clearing and Grubbing” of these specifications, except that no direct payment will be made for such work. Clearance may be limited in conformance with applicable project environmental constraints.

327.03.04 Fence Line Ground Surface Preparation. In addition to clearing and grubbing, the Contractor shall perform grading necessary to permit placement of the fence, fence fabric, gates, and other appurtenances, in compliance with the Plans, the Standard Details, and these Specifications. The prepared surface shall be adequately compacted, as necessary, to result in a stable surface for placement of fencing.

Grading and surface preparation shall not block or impede the existing surface drainage. Special grading and surface preparation limitations ranging from prohibition to limitations for width and depth are shown on the Plans. Where no specific requirements are provided, the Contractor shall, in advance of construction, secure the Engineer's approval of his site preparation plan and procedure. Unless otherwise directed, the Contractor shall distribute excess site preparation soil evenly along the fence including removal of berms, etc.

Fence line site grading for fence Type WM and CL is critical. The clearance between the bottom wire/fabric element and the ground on Type WM and CL should not exceed 4 inches in any case with an average or nominal clearance of 2 inches. Clearance should be evaluated prior to setting of any posts.

When noted in the project plans, surface grading may be scheduled for performance by others. Where this applies, fence construction shall not proceed until grading has been accepted and authority to proceed with fence construction has been issued in writing.

Surface preparation shall be considered a subsidiary obligation of the Contractor and no direct payment will be made for such work.

327.03.05 Placement of Posts

327.03.05.01 Alignment. Fence posts shall be located in the horizontal alignment shown on the Plans. Fence posts shall be plumb.

Steel "T" and "H" posts shall be oriented to permit wire fastening on the side directed.

327.03.05.02 Intervals. Fence posts shall be positioned at nominal intervals shown in the Standard Details for the fence required in the project Plans, except for spans adjacent to gates and other required interruptions in the normal pattern. The tolerance of fence post intervals shall be such that all top rails, diagonals, truss rods, braces, gates, and similar features are fully secured, seated, and functional.

327.03.05.03 Depths. Fence posts shall be placed at the depths shown on the Plans for the respective post types and uses. At a minimum, steel "T" posts shall be driven to a depth totally burying the attached spade anchor plate.

327.03.05.04 Excavations. Excavation for fence posts may be by any method selected by the Contractor unless otherwise required on the Plans, except that explosives may only be used with the advance written approval of the Engineer.

327.03.05.05 Backfill of Excavated Post Holes. Backfill material shall be clean backfill soil free of rocks over 3 inches in largest dimension, or one-third the annular opening, whichever is smaller. The backfill shall be tamped in place in layers not to exceed 4 inches and in such a manner as to firmly set the post. Sand backfill is acceptable only when use results in secure and stable post placement.

327.03.05.06 Concrete Post Anchorage. Concrete shall be placed in equal or greater depth and diameter as shown for the application in the plans. Concrete mix, placement, and cure procedures shall conform with Section 209, except as otherwise described herein. Posts may be anchored with either a PCC mix or an Engineer-approved commercial rapid set grout. Unusually dry post holes shall be saturated prior to placement of concrete. The concrete shall be adequately braced to prevent movement during the cure period. The concrete or grout shall be crowned and smoothly contoured around the posts to enhance drainage. The concrete and grout shall not shrink or crack. Posts shall not be loaded or stressed prior to curing the anchorage. Concrete and grout anchorage is not permitted for wood posts without written approval of the Engineer.

327.03.05.07 Drilling and Grouting Post Placement. Drilling and grouting is limited to steel posts in competent rock. The spade anchors may be removed from steel "T" type line posts prior to placement in drilled and grouted holes. For the Contractor-prepared grouting, the hole shall be not less than 2 inches in diameter larger than the post. For commercial premix rapid set grout, unless otherwise recommended by the manufacturer, the drilled hole shall be 1 inch in diameter, larger than the outside diameter of the post.

327.03.05.08 Grouting. Posts placed in holes drilled in competent rock shall be securely grouted with Contractor-prepared or approved commercial premix grout to full depth with rodding to insure all voids are filled.

Grout mix and cure procedures shall be in accordance with the manufacturer's instructions and Section 202. The grout shall not crack or shrink. The grout shall be crowned around the post to enhance drainage. During the cure period, the post shall be adequately braced to prevent movement. Grouted posts shall not be loaded or stressed prior to curing.

327.03.05.09 Driving Fence Posts

- a. Steel "T" type and "H" type posts shall normally be driven in place, except when soil resistance is such that driving damages the posts, whether at base, top, or by bending. Where soil resistance is inadequate to result in average in-place post stability, the posts shall be set in concrete.
- b. Wooden posts may be driven only when machine pointed at the post production plant and where soil resistance is adequate to result in placement of undamaged posts at full depth and with stable placement.

327.03.05.10 Fence Gates. Fence gates shall be constructed of the type, material, size, and at locations shown on the Plans. Unless specifically prohibited on the Plans, the maximum interval between vehicular gates shall not exceed 1 fence mile. Such minimum interval gate locations shall be selected to provide usable cross country access for emergency vehicles. Unless specifically prohibited on the Plans, vehicular gates shall also be constructed adjacent to all cattle guards to permit passage of livestock and tracked vehicles. Gates in fence shall be the same type material as the fence unless otherwise required in the Plans.

327.03.05.11 Grounding. When fence construction utilizes wood line posts, the fence fabric and fence wires shall be grounded. The grounding device shall consist of a metal fence post which shall be substituted for a regular fence post at intervals not to exceed 500 feet with not less than one metal post any length of fence over 200 feet between openings. Each line of barbed wire and alternate longitudinal wires of the fence fabric shall be tightly fastened to the metal post with 11 gauge, or heavier, galvanized steel wire. At each location where an electric transmission, distribution, or secondary line crossed fences with wood posts, the fence shall be grounded with a ground rod installed directly below the point of crossing. The rod shall be driven vertically until the top is 2 inches above the ground surface. A grounding conductor shall be used to connect each fence element to the ground rod. The connections shall be either brazed or fastened with approved noncorrosive clamps. When a power line runs parallel or nearly parallel to and within 100 feet of the wood post fence, the fence shall be grounded with a ground rod at each end post or at intervals not to exceed 1,500 feet. When the specified vertical penetration of the ground rod cannot be obtained, an equivalent horizontal grounding system approved by the Engineer shall be installed.

327.03.06 Fence wire and fabric shall be fastened on the side of the posts opposite the highway centerline unless otherwise directed by the Engineer.

327.03.07 Gate Reflectors. Each vehicular gate shall have three gate reflectors, situated as shown in the Standard Details, on the side of gates opposite the highway/road. Reflectors shall be firmly secured including resistance to wind deflection.

327.03.08 Connection. Existing cross fences shall be connected to the new fence. At bridges, cattle passes, culverts, and similar improvements fences shall be connected to the structure in such a manner as to control the passage of persons, livestock, and/or wildlife, as applies.

327.03.09 Site Conditions. The Contractor shall notify the Engineer in advance of attempting fence construction in any work area not identified on the Plans and characterized by inundation, swamp, deep mud, and similar conditions where routine post placement procedures will not result in average post withdrawal resistance, wind resistance, or lack of penetration resistance. Similar notice is also required when flood or other damage has changed site conditions substantially from those shown on the Plans and/or described in the contract documents.

327.03.10 Damage. The Contractor shall replace all damaged fence material and remove debris from the site. The Contractor shall repair any damage to existing improvement. No payment will be made for repair and replacement of damaged material.

327.03.11 Disposal of scrap fencing material, wire spools, banding, tags, and related debris shall be removed from the project and disposed of at an authorized location.

327.03.12 Reconstructed Fence. Reconstructed fences shall be erected using Engineer-approved salvaged materials and shall be constructed in accordance with the respective elements of the Specifications, the Standard Details, and the Plans. Any new materials necessary to rebuild the fence shall be furnished by the Contractor, and shall be in conformance with the applicable requirements for new construction.

327.03.13 Site Rehabilitation. Refer to project Plans for applicable site rehabilitation requirements, if any. Such requirements shall be considered Contractor's subsidiary obligations and no direct payment will be made.

327.04 WIRE FENCE TYPES BW AND WM

327.04.01 See Section 327.03 – "CONSTRUCTION REQUIREMENTS" – of this Specification Section.

327.04.02 Wire fence Structural Panels, General. Wood post braces in stress panels, end panels, and corner panels shall be either mortised and nailed, or drilled for equal depth placement of pairs of steel dowels as shown on the Standard Details.

When braces are mortised and nailed in placed, nail lengths shall be adequate to provide 1 1/2 to 2 1/2 inch anchorage into the second member. Dependent on brace post and mortise sizes, this will require nails between 40d and 60d in size. Mortise depths shall be approximately 30 percent of post diameter at the mortise but not less than 1 inch. Pre-drilling is required in the first member when undrilled installation tends to split the post or brace.

Diagonal tensioning wires for the various wood post stress, end, and corner panels shall be made using either barbed or unbarbed fence wire or 9 gauge smooth wire. Each diagonal shall be comprised of two strands of wire, each double-wrapped around posts, and secured with four turns around the same wire with stapling both sides of posts. The wire loops shall be attached 4 inches from the top of one post to 4 inches above the ground on the second post. The diagonal tension wire shall then be tensioned by twisting at midway on the diagonal until the assembly is rigid.

327.04.03 Wire Fence End Panels. Wire fence end panels shall be of the type and material shown on the Plans and are required at all of the following locations.

327.04.03.01 At all fence line origins and terminations, except at junctions or connections with existing wire fence, an additional in-line-end section shall be centered and constructed in the existing fence resulting in one common post.

327.04.03.02 On both sides of all fence openings including gates, except that a stress panel may be substituted where the tangent tensioned fence segment is less than 165 feet (10 rods).

327.04.03.03 Adjacent to each side of all flood way break-away fence segments.

327.04.04 Wire Fence Stress Panels. Except where a stronger assembly is otherwise required, such as end section or corner assembly, wire fence stress panels are required as follows:

327.04.04.01 Intervals Not To Exceed. Type BW, 1320 feet (40 rods); Type WM, 660 feet (20 rods); or the nominal manufacturer's wire roll length, whichever is shorter.

327.04.04.02 At all vertical alignment abrupt grade breaks in excess of 10 degrees (22 percent). These include ridge crests, dips, bases of steep slopes, etc. Stress panels shall not be constructed in obvious high flood damage risk locations; therefore, minor field location adjustment may be required.

327.04.04.03 At all locations from or to which wire tensioning is applied prior to securing.

327.04.05 Fence Corners, Wire Fence. Corners shall be of the type and material shown on the Plans. This may include either or both wooden post and metal post corners. Unless otherwise shown on the Plans, the following criteria apply:

<u>Horizontal Alignment Deflection</u>	<u>Corner Type</u>
Below 10°	none required
10° to 30°	3-post corner
Over 30°	*5-post corner

*Except that where the tensioned fence tangent is 165 feet (10 rods) or less, that wing of the 5-post corner may be reduced to a stress panel equivalent or an unequal four post corner.

327.04.06 Wire Fence Flood Way Breakaway Sections. Except where otherwise provided for or specifically prohibited, active seasonal or store event flood channels with apparent flood debris shall have independent breakaway wire fence segments otherwise identical with the required fence. The terminal ends of each breakaway segment shall be stress panels which are not connected to adjacent end panels in the primary fence. No end panels or stress panels may be constructed in obviously high flood damage risk segments of the channel.

327.04.07 Special Drainage Crossing Treatment. Special details will be provided in the Plans which are customized to address site specific problems not provided for in these Specifications or the Standard Details. The Contractor shall notify the Engineer in advance of construction of all locations where the provisions in the Plans appear inappropriate for field conditions, especially in regard to drainage crossings.

327.04.08 Fence Wire Installation. Wire material and construction configuration shall be that shown in the Standard Details, as selected in the Plans, and conforming with Specification 207.

327.04.08.01 Vertical Wire Separation. Fence Types BW and WM shall have wire strands separated as shown on the Standard Details for the fence type selected on the Plans. These are nominal separations. The spacing intervals shall begin with the ground level as measured at each post. The lower strand shall not be permitted to contact the ground between posts. When the terrain irregularities are such that the distance between the lowest wire and the ground exceeds 20 inches, an additional strand shall be added at or near ground level at the spanning posts. For greater distances, a minimum 50 pound rock dead man shall be suspended and secured to each longitudinal wire. See Standard Details.

327.04.08.02 Wire Tensioning. Each strand of barbed or barbless wire and Type WM wire mesh shall be tensioned until taunt and springy prior to fastening to the posts.

327.04.08.03 Wire Fastening.

- a. Each strand of wire in Type BW fence and each individual strand above the fabric in a Type WM fence shall be terminated and secured to the opposite end post in each stress panel, end panel, and corner panel. The wire shall be wrapped twice around the post followed with four tight turns around the same strand. Excess wire shall be trimmed.

- b. Each fence wire in Type BW fence and each individual strand in Type WM fence shall be secured to each wood post using a wire staple driven to full depth, except that staples in line posts shall not be overdriven resulting in crimping the wire or totally stopping lateral movement of the wire. Staples shall be oriented at a 45 degree diagonal, resulting in each staple leg in a different wood grain pattern.
- c. Each fence wire in Type BW fence and individual strands on Type WM fence shall be attached to each steel "T" post with a wire clip. Each fence wire shall be attached to each steel "H" post and tubular pipe steel post with a full wrap, then at least one full twist around the wire on each side of the post using tie wire.
- d. Wire mesh fabric shall be fastened to each wood and metal post in the same manner as described for Type BW fence for each post type, except that the top wire and the bottom wire are always fastened and other alternate longitudinal wires are fastened with not less than five fasteners per post.

327.04.08.04 Wire Splicing. Wire splicing shall be made by looping strands together with not less than four tight turns wrapped back on each loop. Acceptable splices should nearly match the original wire tensile strength. Between structural panels, splices are limited to not more than one single strand splice. Stress panels should be added where these limitations cannot be met or a new wire roll utilized.

327.04.08.05 Wire Stays. Wire stays are to be provided as shown on the Standard Details. Wire stays shall be twisted in place vertically beginning on the top strand. Individual strand separation requirements shall be maintained as the stay is attached. Stays shall be twisted until the stay does not extend above the top strand. Stays shall be trimmed at or above ground level.

327.04.09 Gates in Wire Fences. Wire gates and metal gates shall be constructed in conformance with the Standard Details except when modified in the Plans.

327.04.09.01 The wire gate hinge loops and latch loops shall permit full and free operation. The mechanical closer/latch shall be installed according to the manufacturer's instructions and shall, at a minimum, be firmly secured and conveniently operable. Reflectors shall be attached to the gate as shown in the Standard Details. Reflector fasteners shall be hog rings or equivalent. Wire stays shall be clipped at 4 inches above the ground.

327.04.09.02 Metal gate hinges and latches shall be secured and operate freely, unless otherwise required on the Plans. The gate swing path shall be unobstructed for at least a 100 degree angle in at least one direction. Vehicular gates shall be equipped with a gate stop and hold-open latch which shall be positioned and adequately secured to permit free operation. The gates and/or gate leaves shall be squared and free of warp or sag.

327.05 CHAIN LINK FENCE, TYPE CL

327.05.01 Refer to GENERAL FENCE CONSTRUCTION portion of this Specification Section.

327.05.02 All chain link fence accessories and components shall be fully compatible for both function and fit. Vinyl coated and slat material shall be specially protected from damage in the transport and installation process.

327.05.03 All posts shall be fitted with tips designed so as to fit securely over the posts and carry the top tension cable, except that the top of the H-section posts may be open-slotted in such a manner as to securely hold the top tension cable in position without vertical movement. Such slotting shall allow removal and replacement of a post without disturbing the top tension cable. Tubular posts shall be fitted with watertight tops. All posts shall be anchored in concrete or grout in accordance with these Specifications and the Standard Details for each application. The nominal post interval is 10 feet, except for slatted fence, which shall be at 8 foot intervals.

327.05.04 Horizontal fence line deflections of 20 degrees or more shall be considered corners and corner posts shall be provided.

327.05.05 End, corner, and gate posts shall be braced with galvanized braces used as compression members and galvanized truss rods with truss tighteners used as tension members. Line posts, at intervals of 500 feet, shall be braced and trussed in both directions as shown on the Plans. Braces are not required on fences 4 feet or less in height when top rails are provided on all panels.

327.05.06 The fabric gauge, height, and salvage shall be in accordance with the Standard Details and as shown on the Plans.

327.05.07 The fabric shall be stretched taut and securely fastened to the posts, and between posts the top edge of the fabric shall be fastened to the top tension cable or top rail, and the lower edge fastened to the bottom tension wire. Tension cable and wire shall be stretched tight with truss tightener as shown on the Plans. The bottom tension wire shall be installed on a straight grade between posts by excavating the high points of the ground and in no case will filling of depressions be permitted. Slating shall be protected from damage. Any broken or distorted slats shall be replaced.

327.05.08 The fabric shall be fastened to the end, corner, and gate posts with steel stretcher bars and stretcher bar bands placed at 1 foot intervals, and to line posts tension cable, top rail, and tension wires with tie wires or metal bands. Tie wires or metal bands shall be spaced on line posts at intervals of approximately 14 inches and on tension cables and tension wires at intervals of approximately 18 inches.

327.05.09 Gates. The width of all gates shall be as shown on the Plans and as detailed in the Standard Details. The filler shall be chain-link fence fabric for chain-link fencing.

327.05.09.01 The gates shall be hung by hinges installed securely, permitting the gate to swing smoothly throughout a full 180-degree swing in both directions unless otherwise specified.

327.05.09.02 Gate Latches. All chain link gates shall have closing latches installed for smooth function and padlocking accessible from both sides. All vehicular gates shall have gate stops and hold-open latches on both sides installed to be easily fastened and released.

327.06 MEASUREMENT. Quantities of fence to be paid for will be determined for each type of fence by the linear foot from actual measurements. Measurements will be made parallel to the ground slope along the line of the completed fence, deducting the widths of openings and gates. No other separate measurement or direct payment will be made for clearing and grubbing, deadman, stress, end, or corner panels, or breakaway sections or any other related fence work, except gates.

Quantities of each gate type will be determined from actual count. A double leaf gate is a single gate. A gate unit complete in place shall include one gate with all necessary fittings, hardware, and gate and latch posts with braces.

327.07 BASIS OF PAYMENT. Accepted items of work, measured as specified, will be paid for at the Contract price per linear foot for each fence type constructed. Gates will be paid for at the contract unit price for each gate type.

The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in constructing fences with related appurtenances, and gates, complete in place, as shown on the Plans and as specified in these Specifications, the Plans, and the Standard Details.

328.01 DESCRIPTION. This work shall consist of the furnishing and installing of culvert markers and guide posts of the design and at locations shown on the Plans or established by the Engineer.

328.02 MATERIALS. Materials shall conform to the requirements specified in Section 211 – “Culvert Markers and Guide Posts.”

328.03 CONSTRUCTION. Target members and reflectors appropriate to the color involved shall be assembled, fastened, set, and aligned in accordance with the details and dimensions shown on the Plans. All fastenings shall be tight.

Markers shall be assembled, fastened, set and aligned in accordance with the details and dimensions shown on the Plans. Reflectors shall be installed when required as indicated. The exact locations will be determined by the Engineer.

328.04 RESET MARKERS AND GUIDE POSTS. Reset markers and guide posts shall be carefully erected using salvaged materials and shall be similar in type to the original construction. Any new materials necessary to rebuild the markers shall be furnished by the Contractor, shall be the same kind as those in the original, if available, and the cost thereof shall be included in the Contract price for the work.

328.05 MEASUREMENT OF QUANTITIES AND BASIS OF PAYMENT. The quantity of new or reset markers and/or guide posts measured for payment shall be the number and type indicated in the Contract Documents, on the Plans, or as ordered by the Engineer.

Quantities shall be compensated for at the unit price established in the Contract Documents for the type of marker or guide post specified.

329.01 DESCRIPTION. This work shall consist of furnishing and driving bearing piles of the kind, shape, and size called for in the Contract Documents. It includes timber piles, precast or cast-in-place concrete piles, sheet piling, and steel piles as described herein and is also applicable to other types of bearing piles if called for in the Contract Documents.

329.02 MATERIALS. Materials shall conform to the requirements of the following sections and subsections:

Steel Shell for Piles	Section 207
Steel Piles (“H” piles, sheet piling)	Section 207
Reinforcement	Section 206
Timber Piles	Section 208

Materials for concrete shall conform to the requirements of Section 202 – “Portland Cement Concrete.”

The Contractor shall furnish the Engineer with copies of mill test reports on the steel shells and steel piles.

329.03 CONSTRUCTION

329.03.01 Determination of Length. Bearing piles of any material shall be of such length as is required to develop the specified bearing value, to obtain the specified penetration, and to extend into the cap or footing block as indicated on the Plans, after cutoff of any damaged portion.

The Contractor shall be responsible for furnishing piling of sufficient length to obtain the penetration and bearing value required. For the purpose of determining the lengths of the piles required, the Contractor, at his expense, may drive test piles, make borings, or make such other investigations as may be necessary.

329.03.02 Test Piles. Test piles furnished and driven by the Contractor for his use in determining the lengths of piles to be furnished may be so located that they may be cut off and become a part of the completed structure, provided that such test piles conform to the requirements for piling as specified in these Specifications.

Test piles which are designated in the Contract Documents shall conform to the requirements for piling as specified in these Specifications and shall be so located that they may be cut off and become a part of the completed structure.

Test piles that are to become a part of the completed structure shall be driven with the same type of equipment that is to be used for driving foundation piles.

Test piles which are not to be incorporated in the completed structure shall be removed to at least 2 feet below the surface of the ground and the remaining hole shall be backfilled with earth or other suitable material.

When piles are shown on the Plans or specified in the Special Provisions to be load tested, such piles shall be load tested in accordance with the provisions in Subsection 329.03.07 – “Load Testing.”

329.03.03 Equipment. The driving equipment shall be in good operating condition.

The size of hammer shall be selected to suit the conditions that will be encountered. It shall neither be so small that its energy will be largely dissipated in lost energy during driving nor so great that it will cause too rapid penetration and damage to the pile. If the size of the hammer used is found to be unsatisfactory, it shall be replaced

with a larger or smaller hammer or other corrective measures shall be used as required to produce satisfactory results.

All piles shall be driven with either single or double acting steam, air, or diesel hammers.

Precast concrete piles shall be driven with a steam, air, or diesel hammer which shall develop an energy per blow at each full stroke of the piston of not less than 1 foot pound for each pound of weight driven.

For cast-in-place concrete piles where a mandrel is used in driving the shell, the total weight of the mandrel and the shell shall be considered as the weight of the pile and the hammer shall meet the same requirements as for precast concrete piles.

Hammers for driving H-bearing steel piles and steel shells for cast-in-place concrete piles, which are driven without mandrel, shall be steam, air, or diesel hammers of sufficient capacity to drive the pile or shell to the required penetration and bearing value without appreciable distortion or distress to the pile or shell.

Steam or air hammers shall be furnished with boiler or air capacity at least equal to that specified by the manufacturers of the hammers to be used. The boiler or compressor shall be equipped with an accurate pressure gauge at all times. The valve mechanism and other parts of the steam or air hammer shall be maintained in first-class condition so that the length of stroke and number of blows per minute for which the hammer is designed will be obtained. Inefficient steam or air hammers shall be removed from the work. When necessary to obtain the required penetration, the Contractor shall supply, and operate at his own expense, single or double water jets and pumps or furnish the necessary drilling apparatus and drill holes not greater than the diameter of the pile to the proper depth and drive the piles therein. If a pile is set in a drilled hole, it shall be driven sufficiently to fix the point firmly and secure full bearing. Except as described in Subsection 508.03.04 – "Driving of Piles," – jets or drills may be used only when so specified or ordered in writing by the Engineer.

Diesel-powered hammers may be used provided the required energy per blow, as specified for steam hammers, is delivered for the type of piling to be driven.

Driving leads shall be used and shall be constructed in such a manner as to afford freedom of movement of the hammer, and they shall be held in position by guys or stiff braces to insure support to the piles during driving. Except where piles are driven through water, the leads shall be of sufficient length so that the use of a follower will not be necessary.

329.03.04 Driving of Piles. Unless otherwise permitted by the Engineer, piles shall not be driven until after the excavation is completed. Any material forced up between the piles shall be removed to the correct elevation before masonry for the foundation is placed.

Care shall be exercised to prevent damage to the piles due to overdriving.

Piles shall be driven battered (sloped) if called for on the Plans.

Piles, other than sheet piles, shall not be driven until the approach fills are compacted and in place to an elevation of 1 1/2 feet above the bottom of the concrete abutment, as indicated on the Plans. When piles are to be driven through embankment and the depth of the embankment at the pile location is in excess of 5 feet, the pile (other than sheet pile) shall be driven in a hole drilled through the embankment. The hole shall have a diameter large enough to allow a minimum of 2 inches clearance around the pile. After driving the pile, the space around the pile shall be filled to ground surface with dry sand or pea gravel.

When an abutment area is to be surcharged, piles shall not be driven therein until the surcharge has been in place the required period of time.

All piles raised during the process of driving adjacent piles shall be driven down again.

Unless otherwise ordered, inclined leads shall be used in driving battered piles.

An adequate cushion cap shall be used in driving precast concrete piles. When driving timber piles, a cushion cap shall be used and not less than two separate steel straps shall be placed within 2 feet of the butt of each pile. Steel strapping shall conform to the requirements of AWPI specifications, except that the straps shall encircle the pile only once per strap. The top of the pile and the cap shall be so shaped that the blow of the hammer will be uniformly distributed to the entire top surface of the pile.

When load tests are required, piling shall not be driven until after test loading has been completed, except in case of service piles driven to serve as anchor piles for the test loading.

If the top of a pile becomes broomed, split, or crushed during the driving, the driving shall be stopped until the pile has been repaired or replaced by a new one.

The driving heads shall closely fit the top of the steel pile or shall extend down over the sides of the pile at least 4 inches.

Piles shall be driven to the position and line indicated on the Plans. Piles out of position and line more than the diameter of the pile shall be pulled and replaced unless otherwise approved by the Engineer. When the tops of foundation piles are incorporated in a concrete footing, the distance from the side of any pile to the nearest edge of the footing shall not be less than 9 inches. Any additional materials required because of out-of-line piles that are allowed to remain in place will be at the expense of the Contractor.

329.03.05 Bearing Value and Penetration

- (a) All pile driving equipment used by the Contractor shall be approved by the Engineer. Prerequisite to approval, the Contractor shall submit the following:
 - 1. A completed pile and driving equipment data form (copy included in the Special Provisions) for each pile driving hammer proposed for the project.
 - 2. A wave equation analysis performed by a professional Engineer for each hammer at twice the design load (ultimate load) value shown on the Plans.
- (b) Notification of acceptance or rejection of the hammer by the Engineer shall be made to the Contractor within 7 days of receipt of data form and wave equation analysis. Acceptance of the hammer will be based on the following criteria determined from wave equation analysis:
 - 1. At the proposed pile design tip length, the penetration rate to obtain ultimate load under-the-hammer bearing value is not less than 0.1 foot for ten blows.
 - 2. The driving stress in the pile at ultimate load does not exceed the value shown on the Plans.
- (c) The Engineer shall conduct an independent wave equation analysis to:
 - 1. Verify the Contractor's submission.
 - 2. Develop driving criteria that relates an under-the-hammer bearing value to penetration rate. If the hammer is approved, the criteria will be used only for the accepted driving equipment. Any change in hammer make, model, or associated equipment in the driving system will require a resubmission for approval.

- (d) Piles must penetrate below the minimum pile tip elevation shown on the Plans. Drilling may be required to obtain minimum pile tip elevation and, if this is required, drilling shall be done in accordance with Subsection 508.03.03 – “Equipment.”
- (e) Below minimum tip, using Engineer-developed pile driving criteria, piles shall be driven to an under-the-hammer bearing value equal to the ultimate load.
- (f) If the ultimate load value is not reached at the design tip elevation shown on the Plans, then the pile shall be left undisturbed for at least 24 hours prior to further driving. The under-the-hammer bearing value will then be determined by the first ten blows of the redrive.

329.03.06 Cut Off and Extensions. Timber piles which are to be capped shall be accurately cut off so that true bearing is obtained on every pile without use of shims. Other timber piles shall be cut off on the square at the elevation designated. Piles inaccurately cut off shall be replaced. Splicing of timber piles will not be permitted, except upon the written permission of the Engineer. Concrete piles shall be cut off at such elevation that they will extend into the cap or footing as indicated on the Plans. Concrete piles may be cast the full length of the reinforcing bars, providing that the concrete is cut off to expose the steel as shown on the Plans after the piles have been driven. When it is necessary, after driving, to increase the length of precast concrete piles, concrete shall be removed to expose sufficient reinforcing steel to permit a lap of at least 40 diameters. The added length shall be sufficient to reach the elevation of the bottom of the cap and shall be of the same section and the same reinforcement as the pile itself.

When the cut off elevation for precast concrete pile is below the elevation of the bottom of the cap, the pile shall be built up from the butt of the pile to the elevation of the bottom of the cap by means of a reinforced concrete extension constructed as shown on the Plans.

The work of cutting off precast concrete piles shall be performed in such a manner as to avoid spalling or damaging the pile below the cut off. In case of such damage, the pile shall be replaced or repaired as required by the Engineer.

All cut off lengths of piling shall remain the property of the Contractor and shall be disposed of outside the project limits.

329.03.07 Load Testing. The number and location of the load tests shall be as noted on the Plans or as designated by the Engineer.

The Contractor shall furnish and assemble a suitable reaction system for each load test capable of sustaining a 200 ton test load without excessive deflection. This reaction system may utilize production piles and/or additional anchor piles or may be constructed as a total dead load reaction system. Additional piling required to match beam lengths, or cribbing and dead load material, shall be at the Contractor's option.

In addition to the above requirements, the reaction system shall meet the following minimum requirements:

- (a) It shall be supported in such a manner that it is stable without support from the loading equipment.
- (b) It shall be constructed in such a manner as to ensure that all structural elements in the system carry their intended proportion of the load, and any slack in the system is taken up before a 50 ton test load is reached.
- (c) It shall be so positioned that the test load can be applied axially on the test pile without any eccentricity.

Further, the Contractor shall submit detailed plans and design calculations for his proposed reaction system to the Engineer for approval.

If during the performance of any test any member or connection of the reaction system fails or is stressed beyond its yield point, or there is insufficient reaction to maintain the required load, the test shall be discontinued, and the Contractor shall correct any deficiencies in the system at his own expense before the test is restarted.

It shall also be the Contractor's responsibility to provide a smooth cut off surface on the test pile which is both planar and perpendicular to the longitudinal axis of the test pile. The Contractor shall also assist the Engineer in the placement of and the removal of the hydraulic jack to the test pile.

All other work of making and recording the test load will be performed by the Department. The "Quick Load Test" – will be run in accordance with Test Method No. Nev. T-600A, and the average time required to accomplish this test is expected to be about 3 hours.

At any structure site where a load test is required and driven piles are specified, the penetration of all production piling for that structure shall be based upon the results of the load test(s), providing these pilings are driven with the same equipment and the resistance to driving (penetration per blow) is comparable. The Engineer shall make this determination and may require the Contractor to redrive any pile when necessary to assist him in this decision.

329.03.08 Timber Piles. The specie of timber used for timber piles shall be either Douglas Fir, Southern Yellow Pine, Larch, or Cedar as shown in the Contract Documents.

When treated piles are required, they shall be given a preservative treatment of creosote by pressure processes to retain at least 10 pounds of creosote per cubic foot.

Timber piles shall conform to the requirements of Section 210 – "Pilings," – and shall be inspected as therein provided.

Commercially treated piles from stock may be used for test piles when required. Where commercially treated piles are permitted, stamping the piles by the inspector before treatment will not be required.

Treated timber piles shall be carefully handled during and after unloading from cars. They shall not be dragged across the ground at any time and shall be handled only with rope slings or with wooden equipment. Sharp tools shall be permitted only when used for necessary field cutting and trimming. All places where the surface of creosoted piling is broken by cutting, boring, or otherwise shall be thoroughly coated with at least three applications of hot creosote oil. Each application shall be allowed to become reasonably dry before the succeeding one is applied.

The piles in any one bent shall be carefully selected as to size to avoid undue bending or distortion of the sway bracing. However, care shall be exercised in the distribution of piles of varying sizes to secure uniform strength and rigidity in the bents of any given structure.

Heads of piles, when the nature of the driving is such as to unduly injure them, shall be protected by caps of approved design.

When timber caps are specified, a coat of hot creosote oil shall be first applied to the head of the pile and a protective cap shall be built up by applying alternate layers of loosely woven fabric in a hot asphalt or tar using three layers of asphalt or tar and two layers of fabric. The fabric shall measure at least 6 inches more in each direction than the diameter of the pile and shall be turned over the pile and the edges secured by binding with two turns of No. 10 galvanized wire. The fabric shall be wired in advance of the application of the final coat of asphalt or tar which shall extend down over the wiring.

In lieu of the above method of treatment, the sawed surface may be covered with three applications of a hot mixture of 60 percent creosote oil and 40 percent roofing pitch, or thoroughly brush-coated with three applications of hot creosote oil and covered with hot roofing pitch.

A covering of galvanized sheet iron shall be placed over the pitch coating and bent down over the sides of the pile to shed water.

The method to be used shall be at the option of the Contractor unless otherwise provided on the Plans or in the Special Provisions.

329.03.09 Precast Concrete Piles. Precast concrete piles shall be constructed of Class A or AA Portland Cement Concrete proportioned and mixed in accordance with the requirements of Section 202 – “Portland Cement Concrete” – and placed in accordance with Section 311 – “Concrete Structures” – of these Specifications. Reinforcing steel shall conform to the requirements of Section 206 – “Reinforcing Steel” – of these Specifications.

Concrete for precast concrete piles shall be poured in smooth watertight forms, so supported as to prevent appreciable deformation or settlement during pouring or curing. When removed from the form, the piles shall present true, smooth, even surfaces free from honeycombs and voids and shall be such that a line stretched from butt to tip on any face will not be more than 1 inch from the face of the pile at any point.

Concrete piles shall be kept continuously wet for at least 10 days after pouring and shall be allowed to harden for at least 30 days before being lifted or driven, except that this 30 day requirement may be decreased if the specimen of concrete from which the piles were poured develops a strength of 3,000 pounds or more per square inch of compression.

When raising or transporting precast concrete piles, the Contractor shall provide slings or other equipment to avoid any appreciable bending of the pile or cracking of the concrete. Piles materially damaged in handling or driving shall be replaced. Concrete piles shall be handled at all times as to avoid breaking or chipping of the edges.

329.03.10 Cast-in-Place Concrete Piles. Concrete filling for cast-in-place concrete piles shall be Class A or AA Portland Cement Concrete conforming to the requirements of Section 501 – “Portland Cement Concrete” – of these Specifications. Reinforcement shall conform with the details shown on the Plans and the requirements of Section 505 – “Reinforcing Steel.” Cast-in-place concrete piles shall consist of one of the following: steel shells driven permanently to the required bearing value and filled with concrete or drilled holes filled with concrete.

- (a) Steel Shells. Steel shells shall be of sufficient strength and rigidity to permit their driving and to prevent distortion caused by soil pressures or the driving of adjacent piles until filled with concrete. The shells shall also be sufficiently watertight to exclude water during the placing of concrete.

The shells may be cylindrical or tapered, step tapered, or a combination of either with cylindrical sections. The tip diameter shall not be less than 8 inches and the butt diameter shall not be less than shown on the Plans.

Shells to be driven without a mandrel shall be equipped with heavy steel driving ends and all joints in the shell shall be welded or adequately lock seamed.

After being driven and prior to placing concrete and reinforcing steel therein, the steel shells or casings shall be examined for collapse or reduced diameter at any point. Any shell or casing that is improperly driven or broken or shows partial collapse to such an extent as to materially decrease its bearing value will not be accepted and shall be replaced by the Contractor at his own expense. Driven shells or casings shall be clean and free from water before concrete and reinforcing steel are placed. The Contractor shall have available at all times a suitable light for the inspection of the shells, throughout the entire length, before they are filled with concrete and reinforcing steel.

Concrete shall be placed in steel shells so that it is dense and homogeneous. The upper portion of the shell shall be vibrated to a depth of not less than 1/3 the length of the pile or 10 feet, whichever is the greater.

The length of steel shell to be ordered shall be determined by the Contractor. Should the Contractor elect to order piling in short lengths, all splices necessary to build up these shorter lengths to the length required, other than those splices specified for payment in Subsection 327.04.01 of these Specifications, shall be at the Contractor's expense.

- (b) Drilled Holes. This work shall govern the construction of "cast-in-drilled hole" concrete piles. Piles shall be of a concrete section, cast-in-place against in-situ-soil and shall be reinforced as shown on the Plans.
- (c) Ground and Surface Water. The water table elevations indicated on the test boring logs are those existing on the dates and at the boring locations as noted on the Plans.
- (d) Drilled Shaft Inspection Report. The Contractor shall provide any assistance that may be required for the Engineer to prepare and submit daily reports for the complete drilled shaft construction program. The reports will include: logging all excavated soils, concrete quantities, recording actual elevations at top and bottom of each drilled shaft, elevation of rock (if any), plumbness of casing left in place, any unusual conditions, and any other pertinent information deemed necessary.
- (e) Pile Locations, Alignment, and Tolerance. The drilled shafts shall be constructed such that the axis of the shaft at the top is no more than 2 inches from its plan location. Drilled shafts shall be within 1 1/2 percent of the plumb deviation for the total length of the pile and shall not exceed 12 1/2 percent of the shaft diameter or 15 inches, whichever is less. The plumbness of the drilled shaft shall be measured by an accurate probing procedure, inclinometer in the Kelly bar, or other techniques that may be approved by the Engineer.

When temporary starter casing or a vibrated casing is extracted, a short collar form shall be placed at the top of the drilled portion of the shaft such that diameter tolerances can be achieved.

- (f) Excavation. Straight, drilled shafts shall be advanced with flight or bucket augers or with other approved drilling tools capable of drilling soil, cobbles, boulders, rock, or whatever materials encountered, to the dimensions and elevations shown on the Plans. The Plans indicate the expected depths and elevation where satisfactory bearing material will be encountered. If satisfactory material is not encountered at plan elevation, the bottom of the shaft may be lowered only as approved by the Engineer.

Caving of the drilled holes shall be prevented at all times during pile construction by use of steel casing or other procedures as approved by the Engineer. Drilling equipment shall be constructed and operated so that free passage of fluids is provided around the drilling head during its insertion and removal from the hole to the extent that scouring or caving will not occur.

If steel casing is utilized to prevent sloughing, said casing shall be smooth metal and of ample strength to withstand handling stresses, the pressure of concrete, surrounding earth, or backfill materials and shall be watertight. The outside diameter of the casing shall be less than the specified size of the shafts.

If a casing is used, its removal shall not be started until the level of concrete within the casing is at least 5 feet above the bottom of the casing. Movement of the casing for short pulls of a few inches, exerting downward pressure, hammering, and vibrating the casing will be permitted to facilitate extraction and to avoid separation of the concrete. When casing is used, its extraction must be done so that the concrete cast against the surrounding soil will develop the designed skin friction. No casing extraction will be allowed after 2 hours from the concrete batch time unless a retarding agent is used. When a retarder is used, this 2 hour period may be extended provided that no concrete achieves an initial set. Casing not extracted within the allotted time shall remain in the excavation.

Drilling without the use of casing may be allowed as follows: (1) above the water table and (2) below the water table, only if the foundation Contractor can conclusively prove with a full-depth, design diameter test shaft that such procedures are applicable at this site, and that all of the tolerances and design criteria detailed in the Plans and within these Specifications for drilled pile foundations can be adhered to. This test shaft shall not be incorporated into the foundation and shall be filled to ground line with pea gravel.

No payment will be made for the test shaft or any other items incidental to the dry hole or uncased drilling.

Regardless of construction method used, the bottom of the excavation shall be cleaned of loose material, by using a bucket auger or any other technique approved the Engineer. After cleaning, a probe shall be lowered to the base of the drilled shaft to insure that cleaning has been satisfactorily completed. An accumulation of loose soils, muck, etc., at the bottom of the excavation shall not be allowed.

After completion of shaft excavation and prior to placement of reinforcing steel and concrete, the proper condition of the excavated shaft will be verified by the Engineer. The Contractor shall measure the shaft dimensions, determine the plumb deviation of the shaft, and produce such information for the "Shaft Inspection Report."

- (g) Reinforcing Steel. Reinforcing steel shall conform to the requirements of Section 206 – "Reinforcing Steel" – and the Plans. The cage of reinforcing steel, consisting of longitudinal bars, spiral, and any temporary bar braces, shall be completely assembled and placed in the drilled shaft at a unit upon completion of drilling and immediately prior to concrete placement. If concrete placement does not follow immediately after cage placement, the steel must be removed from the shaft and the integrity of the excavation recertified prior to reinstallation of the cage.

The rebar cage shall be supported from the top by a ground surface frame, crane, or other positive means during complete concrete placement in order to insure cage plumbness and to minimize downward slumping. The support system shall be concentric with the cage to prevent racking and distortion of the steel. Every effort shall be made to keep the cage plumb during casing extraction.

To insure adequate concrete cover and achieve concentric spacing of the entire length of the cage within the shaft, 3 inch (minimum) thick concrete spacer blocks shall be securely tied at 5th points around the cage perimeter. The blocks shall span two adjacent-vertical bars or horizontal ties such that rotation will not occur. Block locations shall start at the bottom of the cage and continue up along its length at spacing no greater than 10 feet. Additional peripheral blocks and closer intervals may be required as determined by conditions in the field.

- (h) Placement of Concrete. Concrete shall be placed as soon as possible after all excavation is complete and immediately after the reinforcing steel is placed. Prior to placing concrete, the bottom of the excavation shall be cleaned and free of all loose material, as specified above. Concrete shall be placed only by pumping through a tremie pipe. No free fall of the concrete will be allowed. The tremie pipe shall be of a rigid watertight pipe for the full length of the shaft and shall not be less than 5 inches inside diameter. Jointless solid pipe is recommended. The pipe shall be equipped with a bottom valve, or other approved device, which would prevent mixing of slurry or other contaminants with the concrete inside the pipe.

The Contractor shall be required to have on site, or make provisions for, a second (backup) pump to be available during the concreting operations. Reinforcing steel shall be in place and the tremie pipe inserted to the bottom of the drilled shaft before concrete placement is started. The pump shall be properly primed and the concrete shall be placed in a continuous operation in such a manner that the concrete always flows upward within the hole. The delivery pipe shall be slowly withdrawn as the elevation of the concrete in the hole rises, but the discharge end of the pipe shall, at all times, be maintained at least 5 feet and not more than 10 feet below the surface of the concrete. This 5 to 10 foot range may be assured by the use of a fixed tremie pipe float device. During concrete placement the Contractor shall provide and maintain markings on the tremie pipe, a sounding device, or other adequate methods in which to determine the relative elevation of the concrete surface and the end of the tremie pipe. Raising of the tremie pipe shall be done only when the pipe contains a sufficient head of concrete to prevent the formation of a void at the tip and as approved by the Engineer. A predetermined plan shall be formulated between the Contractor's job foreman and the pump operator concerning how and when an order will be given to lift the tremie pipe.

Concrete delivery into the shaft shall continue until the discharge at the top of the pile is free of water, soil, and debris, and uncontaminated concrete extends to the cut-off elevation. Should a delay occur because of concrete delivery or other factors, the rate of placement for concrete shall be reduced so as to

maintain some movement of the concrete. The procedures employed shall be such that the concrete within the shaft consists of a monolithic homogeneous structure. In uncased piles, concrete shall not be vibrated during placement, except from the bottom of the reinforcing cage to the top of the pile. If casing is utilized, vibration shall take place during withdrawal of the last 15 feet of the casing and shall stay below the bottom of the casing as it is removed. Where steel liners or casings have been used to support the excavation walls, the liners shall be withdrawn as the concrete is being placed within the limits previously specified elsewhere in these Specifications. The steel liner shall be removed in a manner so that the lower edge of the steel liner shall always remain a minimum of 5 feet below the surface of the concrete as placed to prevent water or soil from entering the shaft excavation from below the bottom of the casing. The Contractor shall submit to the Engineer for approval appropriate procedures and methods of withdrawal of steel liners to ensure that the concrete is not being lifted as the steel liner is being withdrawn.

The elevation of the top of the steel cage and the surface of the concrete shall be carefully checked before and after casing extraction. Any upward or downward movement of the steel exceeding 2 inches or any downward movement of the concrete may be cause for rejection.

The top surface of the pile shall be cured as prescribed in Section 311 of these Specifications.

- (l) Scheduling and Restrictions. After the first pile has been successfully constructed, no significant change shall be made in construction methods, equipment, or materials to be used in the construction of such piles unless approved by the Engineer. The first pile must be approved prior to proceeding with additional piles. Drilling may commence on a subsequent pile at an approved location provided that the concrete operation on the previously drilled shaft is in progress and the manpower is adequate to cover all required operations.

Drilling and concrete placement should be scheduled so that each pile is placed immediately after drilling is completed and reinforcing steel accurately placed and approved.

For a period of at least 24 hours after pile concrete has been placed, no adjacent pile shall be drilled, no excessive wheel loads shall be allowed, and no vibration shall be allowed to occur or be felt at any point within 5 feet from the periphery of the pile.

In the event that the Contractor fails to satisfactorily perform the procedures described within, the Engineer may shut down the construction operation and/or reject the pile. If the integrity of the pile is in question, core drilling, sonic, or other approved methods shall be employed by the Contractor at his expense under the direction of the Engineer. Core-drilled holes will be backfilled with grout or mortar. Any remedial measures will be directed and approved by the Engineer. No compensation will be due the Contractor for losses or damages due to remedial work or any testing required on piles found defective or not in accordance with the requirements of the Plans and these Specifications.

The footings of pier columns shall not be cast on the drilled piles until at least 7 days have elapsed, or 50 percent of the compressive strength is obtained.

- (j) Inspection, Supervision, and Records. The Contractor will be required to provide full construction supervision and maintain accurate records during all phases of the drilled shaft operation.

329.03.11 Steel Piles. Steel piles shall be H-bearing of the section shown on the Plans.

The length of steel pile may be built up in sections either before or during the driving operations. The sections, unless otherwise shown on the Plans, shall be identical in cross section. The connections shall be made by welding the entire cross section in conformance with the requirements of Subsection 326.03.18 – "Welding." Care shall be taken to properly align the sections connected so that the axis of the pile will be straight. The number of welded connections in the length of the pile shall be as few as practicable. If a welded splice is made during the driving operation, it shall be done when the top of the lower portion is at least 3 feet above the ground to permit observation of the welded connection during several feet of driving.

Piling built up from structural steel plates welded together may be substituted for the rolled steel piling shown on the Plans provided that the depth, width, average mean thickness, and moments of inertia of the built-up sections are at least equal to those of the rolled section, the flanges are welded to the web with continuous fillet welds on each side of the web, and the welding conforms to Section 326 – “Reinforcing and Structural Steel.”

Commercially prefabricated pile splices may be used when approved by the Engineer.

329.04 MEASUREMENT. The quantity of “Furnish (type) Piles” – to be measured for payment will be the number of linear feet of (type) pile complete and in place measured from the tip of the pile to the plane of pile cutoff.

The quantity of “Driving (type) Piles” to be measured for payment will be the number of piles driven complete in place.

“Redrive Piles” shall be measured for payment on a force account basis.

If the Contractor casts concrete piles full length of the reinforcement bars to facilitate driving, no measurement will be made for the portion where concrete must be removed in order that bars may project as shown on the Plans.

Load tests will be measured for each and the number used in the work will be the number paid for.

The quantity of splices to be measured for payment will be limited to the number required to splice the pile if it becomes necessary to drive beyond “Design Pile Tip Penetration.” Length of extensions will be determined by the Engineer. All splices necessary to drive to “Design Pile Tip Penetration” and for extensions made of shorter lengths than ordered by the Engineer will be at the Contractor’s expense.

Metal pile shells driven with a removable core or mandrel shall be spliced according to the manufacturer’s specifications. No splices will be measured and paid for when thin shell piles are used that do not require complete circumferential welding performed in the field.

329.05 BASIS OF PAYMENT. The accepted quantity of “Furnish (type) Piles” measured as provided in Subsection 329.04 – “Measurement,” – will be paid for at the contract unit price bid per linear foot, which price shall be full compensation for furnishing all materials including Portland Cement Concrete, steel shells and reinforcing steel, placing filling materials, and disposing of all unused material.

The accepted quantity of “Driving (type) Piles” measured as provided in Subsection 329.04 – “Measurement” – will be paid for at the contract unit price bid per each, which price shall be full compensation for doing all the work involved in driving, drilling holes, cutting off piles, excavation and backfill, and for filling the space around the pile with sand or pea gravel, all to the required bearing and penetration as shown on the Plans or ordered by the Engineer.

Payment for “Redrive Piles” measured as provided in Subsection 329.04.01 – “Measurement” – will be paid for by force account, except the force account method of payment for labor and equipment required to redrive piles shall be restricted to the labor and equipment on the job site. Force account will not be paid to import labor and equipment from areas outside the project limits.

The cost of furnishing, moving (except moving required to redrive piles), and removing equipment for driving piles on the job shall be considered as included in the lump sum price bid for “Mobilization” and no further compensation will be allowed therefor.

When brackets or plates are required on the plans for pile tip reinforcement for steel piles or special driving shoes for timber piles, the Contractor shall furnish and place such devices and all costs involved shall be considered included in the Contract unit price bid per linear foot for “Furnish (type) Piles.”

Test piles that become a part of the completed structure will be paid for at the Contract prices for the type of piling used.

No payment will be made for piles driven out of place, for imperfect piles, or for piles which are damaged in handling or driving.

When, in addition to the requirements of the Plans and Specifications, brackets or plates are required on steel piles, or special driving shoes are required on timber piles, the Contractor shall furnish and place such devices and the cost thereof will be paid for as extra work.

The accepted quantity of load tests measured as provided in Subsection 329.04 – “Measurement” – will be paid for at the Contract unit price bid per each for “Quick Load Test,” which price shall be full compensation for all material, equipment, tools, and labor involved in furnishing, placing, and moving the reaction system from place to place as well as conditioning the test pile ready for the test and removing the reaction system at the completion of the test, all as required by the Engineer.

The accepted quantity of splices measured as provided in Subsection 329.04 – “Measurement” – will be paid for at the Contract unit price bid per each for the splice, which price shall be full compensation for all material, equipment, tools, and labor incidental to make the splice.

Where piling built up from structural steel plates is substituted for the piling specified on the Plans, the Contractor shall be entitled to no extra compensation for any excess thickness of steel furnished or for any extra work, materials, equipment, handling, or treatment required to construct such piling.

The accepted quantity of “Furnish Cast in Drilled Hole Concrete Piles” measured as provided in Subsection 329.04.01 – “Measurement” – will be paid for at the Contract unit price bid per linear foot, which price shall be full compensation for drilling holes for piling and disposing of material resulting therefrom, and for furnishing and placing all materials including Portland Cement Concrete and reinforcing steel and for doing all the work necessary to install the piling complete and in place as shown on the Plans and as directed by the Engineer.

The Contract unit price bid per linear foot for “Furnishing Cast in Drilled Hole Concrete Piles” shall also include all casing, bracing, concrete overages, test shaft, and any other items or incidentals necessary to install the piles complete in place.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
Furnish (type) Piles	Linear Foot
Drive (type) Piles	Linear Foot
Redrive Piles	Force Account
Quick Load Test	Each
Splices	Each

330.01 DESCRIPTION. This work shall consist of furnishing, framing, and installing timber of the kind, sizes, and dimensions and in accordance with the lines, grades, and sections shown on the Plans or specified in the Contract Documents.

330.02 MATERIALS. Materials shall meet the requirements of the following sections:

Structural Steel	Section 207
Paint	Section 214
Miscellaneous Metals	Section 207
Timber	Section 208
Timber Preservative	Section 208

If material lists or order lists are sent by the Contractor to the Engineer for checking or approval, such checking or approval by the Engineer shall in no way relieve the Contractor of responsibility for the correctness of such lists. Any expense incident to the revision of materials furnished in accordance with such lists to make them comply with the Plans shall be borne by the Contractor.

Structural glued/laminated timber shall conform to the National Bureau of Standards, Voluntary Product Standard PS 56-73, for Structural Glued/Laminated Timber.

All framing lumber and structural timber, unless otherwise specified or shown on the Plans, shall be Douglas Fir or West Coast Hemlock or Larch.

Structural lumber and timber, solid sawn or glued/laminated, shall not be used in exposed permanent structures without a pressure preservative treatment, unless otherwise noted on the Plans or in the Special Provisions.

Timber connectors for treated timber structures, except those of malleable iron, shall be galvanized.

Split ring connectors of 2 1/2 inch inside diameter and 4 inch outside diameter shall be manufactured from hot rolled, low-carbon steel. Each ring shall form a closed true circle with the principal axis of the cross section of the ring metal parallel to the geometric axis of the ring. The metal section shall be beveled from the central portion toward the edges to a thickness less than the midsection. It shall be cut through in one place in its circumference to form a tongue and slot.

Shear-plate connectors of the pressed steel type, 2 5/8 inches in diameter, shall be manufactured from mild steel. Each plate shall be a true circle with a flange around the edge, extending at right angles to the face of the plate and extending from one face only, the plate portion having a central bolt hole and two small perforations on opposite sides of the hole and midway from the center and circumference.

Shear-plate connectors of the malleable iron type, 4 inches in diameter, shall be manufactured according to ASTM A 47, Grade 35018, for malleable iron castings. Each casting shall consist of a perforated round plate with a flange around the edge extending at right angles to the face of the plate and projecting from one face only, the plate portion having a central bolt hole reamed to size with an integral hub concentric to the bolt hole and extending from the same face as the flange.

Spike-grid timber connectors shall be manufactured according to ASTM A 47, Grade 35018, for malleable iron castings. They shall consist of four rows of opposing spikes forming a 4 1/8 inch square grid with 16 teeth that are held in place by fillets. Fillets for the flat grid in a cross section shall be diamond shaped. Fillets for the single curve grids shall be increased in depth to allow for curvature and shall maintain a thickness between the sloping faces of the fillets equal to the width of the fillet.

Circular grids of 3 1/4 inch diameter shall consist of eight opposing spikes equally spaced around the outer circumference and held in place by connecting fillets around the outer diameter and radial fillets projecting to a central circular fillet which forms a bolt hole opening of 1 1/4 inch. Fillets in a cross section shall be diamond shaped, except that the inner circular fillet may be flattened on one side to provide for manufacturer identification.

330.03 STORAGE OF MATERIALS. Lumber and timber on the site of the work shall be stored in piles.

Untreated material shall be open-stacked at least 12 inches above the ground surface and piled to shed water and prevent warping. When required by the Engineer, it shall be protected from the weather by moisture-resistant material.

Clear polyethylene films should not be used because wood members are subject to bleaching from sunlight. Individual wrappings should be slit or punctured on the lower side to permit drainage of water that may have accumulated.

Water-resistant wrapping used for the in-transit protection of glued/laminated members should be left intact until the members are enclosed within the building. If wrapping has to be removed at certain connection points during the erection, it should be replaced after the connection is made. If it is impractical to replace the wrapping, all of it should be removed to avoid the non-uniform appearance caused by sun and weather exposure.

Treated timber and piling shall be close-stacked and piled to prevent warping.

The ground underneath and in the vicinity of all material piles shall be cleared of all weeds and rubbish.

330.04 WORKMANSHIP. The erection of structural timber framing requires experienced erection crews and proper lifting equipment. Workmanship shall be first class throughout. None but competent carpenters shall be employed, and all framing shall be true and exact. Unless otherwise specified, nails and spikes shall be driven with just sufficient force to set the heads flush with the surface of the wood. Deep hammer marks in wood surfaces shall be considered evidence of poor workmanship and sufficient cause for removal of the workman causing them.

The unloading and storage of structural timber framing before erection also demands care and good judgment. The following general precautions shall be adhered to:

1. Lift members or roll them on dollies or rollers out of railroad cars; do not drag or drop them. Unload trucks by lifting from the truck; do not dump or drop members.
2. If unloading with lifting equipment, use wide fabric or plastic belts or other slings that will not mar wood. If chains or cables are used, provide protective blocking or padding to sharp edges or sharp corners.
3. Guard against soiling, dirt, footprints, or abrasions. If members are wrapped, avoid tearing or damaging the protective material.

330.05 TREATED TIMBER. Treated timber and piling shall be carefully handled without sudden dropping, breaking of the outer fibers, bruising, or penetrating the surface with tools. It shall be handled with rope sling. Cant hooks, peaveys, pikes, or hooks shall not be used.

All cutting, framing, and boring of treated timber shall be done before treatment, insofar as is practicable.

All cuts in treated piles or timbers and all abrasions, after being carefully trimmed, shall be covered with two applications of a mixture of 60 percent creosote oil and 40 percent roofing pitch, or brush coated with a least two applications of hot creosote oil and covered with hot roofing pitch.

All bolt holes bored after treatment shall be treated with creosote oil by means of an approved pressure bolt hole treater.

Unfilled holes, after being treated with creosote oil, shall be plugged with creosoted plugs.

Whenever, with the approval of the Engineer, forms or temporary braces are attached to treated timber with nails or spikes, the hole shall be filled by driving galvanized nails or spikes flush with the surface or plugging holes as required for bolt holes.

330.06 UNTREATED TIMBER. In structures of untreated timber, the following surfaces shall be thoroughly coated with two coats of hot creosote oil before assembling: ends, tops, and all contact surfaces of sills, caps, floors, and stringers, and all end joints and all contact surfaces of bracing and truss members. The back faces of bulkheads and all other timber which is to be in contact with earth, metal, or other timber shall be similarly treated.

Unless untreated timber is to be used in the construction within 3 days after date of delivery, it shall be painted on each end with a prime coat at the time of delivery.

330.07 HOLES FOR BOLTS, DOWELS, RODS, AND LAG SCREWS. Holes for round drift-holes and dowels shall be bored with a bit 1/16 inch less in diameter than the bolt or dowel to be used. The diameter of holes for square drift-bolts or dowels shall be equal to the least dimension of the bolt or dowel.

Holes for machine bolts shall be bored with a bit of the same diameter as the bolt.

Holes for rods shall be bored with a bit 1/16 inch greater in diameter than the rod.

Holes for lag screws shall be bored with a bit not larger than the body of the screw at the base of the thread.

330.08 BOLTS AND WASHERS. A washer of the size and type specified shall be used under all bolt heads and nuts which would otherwise come in contact with wood.

The nuts of all bolts shall be effectively locked after they have been finally tightened.

Countersinking shall be done whenever smooth faces are required.

Horizontal recesses formed for countersinking shall be painted with hot creosote oil, and, after the bolts are screwed in place, shall be filled with hot pitch.

330.09 FRAMING AND FASTENING. All lumber and timber shall be accurately cut and framed to a close fit in such manner that the joints will have even bearing over the entire contact surfaces. Mortises shall be true to size for their full depth and tenons shall fit snugly. No shimming will be permitted in making joints, nor will open joints be accepted. All framing must be true and plumb. Final tightening of alignment bolts should not be completed until the structure has been properly aligned.

Mud shall have true and even bearing on mud sills, piles, or pedestals. They shall be drift-bolted to mud sills or piles with bolts of not less than 3/4 inch diameter and extending into the mud sills or piles at least 6 inches. When possible, all earth shall be removed from contact with sills so that there will be free air circulation around them.

Posts shall be fastened to pedestals with dowels of not less than 3/4 inch diameter, extending at least 6 inches into the posts.

Posts shall be fastened to sills by one of the following methods, as indicated on the Plans:

- a. By dowels of not less than 3/4 inch diameter, extending at least 6 inches into posts and sills.
- b. By drift-holes of not less than 3/4 inch diameter driven diagonally through the base of the post and extending at least 9 inches into the sill.

330.10 CAPS. Timber caps shall be placed to secure an even and uniform bearing over the tops of the supporting posts or piles and to secure an even alignment of their ends. All caps shall be secured by drift-bolts, as indicated on the Plans, extending at least 9 inches into the posts or piles. Drift-bolts shall be approximately in the center of the post or pile.

330.11 BRACING. The ends of bracing shall be bolted through the pile, post, or cap with a bolt of not less than 5/8 inch diameter. Intermediate intersections shall be bolted and spiked with wire or bolt spikes as indicated on the Plans. In all cases, spikes shall be used in addition to the bolts.

330.12 STRINGERS. Stringers shall be sized at bearings and shall be placed in position so that knots near edges will be in the top portions of the stringers.

Outside stringers may have butt joints with the ends cut on a taper, but interior stringers shall be lapped to take bearing over the full width of the floor beam or cap at each end. The lapped ends of untreated stringers shall be separated at least 1/2 inch for the circulation of air and shall be securely fastened by drift-bolts where specified. When stringers are two panels in length, the joints shall be staggered.

Cross-bridging between stringers shall be neatly and accurately framed and securely toenailed with at least two nails at each end. All cross-bridging members shall have full bearing at each end against the sides of stringers. Unless otherwise specified on the Plans, cross-bridging shall be placed at the center of each span.

330.13 PLANK FLOORS. Unless otherwise specified, flooring plank shall be surfaced on one side and on one edge. Single plank floors shall consist of a single thickness of plank supported by stringers or joists. The plank shall be laid heart side down with 1/4 inch openings between them for locally seasoned material and with tight joints for unseasoned material.

Each plank shall be securely spiked to each joist. The plank shall be carefully graded as to thickness and so laid that no two adjacent planks will vary in thickness more than 1/16 inch.

Two-ply timber plank floors shall consist of two layers of flooring supported on stringers or joists. The lower course shall be pressure-treated with a creosote oil. The top course may be laid either diagonal or parallel to the centerline of the roadway, as specified, and each floor piece shall be securely fastened to the lower course. Joints shall be staggered at least 3 feet. If the top flooring is placed parallel to the centerline of the roadway, special care shall be taken to securely fasten the ends of the flooring. These members shall be beveled at each end of the bridge.

330.14 LAMINATED FLOORS. Laminated floors shall be composed of 3 by 6 inch or 2 by 6 inch timbers, as indicated on the Plans and laid on edge at right angles to the centerline of the roadbed, unless otherwise shown on the Plans.

The flooring may be of random length and multiples of the stringer spacing with no single piece less than 6 feet long. All splices shall be made on the centerline of a stringer and shall not occur oftener than once in 6 inches on any one stringer.

Laminations shall be laid with a finished edge down. Before laying, the tops of stringers shall be checked with a straightedge and adjacent stringers which vary more than 1/8 inch from a true plane, except treated stringers, shall be surfaced to meet this requirement. Treated stringers which do not meet the requirements may be rejected, but shall not be framed or added after treatment. Each piece of flooring shall be fastened to the preceding strip at each end and at approximately 18 inch intervals with spikes, or nails shall be of sufficient length to pass through two strips and at least halfway through the third strip. If timber supports are used, each piece shall be toe-nailed to every other support with 20d or 30d nails. Care shall be taken to have each strip vertical and tight against the preceding one and bearing evenly on all supports.

330.15 TRUSSES. Trusses which are shipped partially or completely disassembled shall be assembled on the ground at the site before erection. Arches may be assembled on the ground or connections may be made after the half arches are in position. When trusses and arches are assembled on the ground at the site, they should be assembled on level blocking to permit connections to be fitted properly and tightened securely without damage. The end compression joints should be brought into full bearing and compression plates installed where specified.

Trusses, when completed, shall show no irregularities of line. Chords shall be straight and true from end to end in horizontal projection, and in vertical projection shall show a smooth curve through panel points conforming to the correct camber. All bearing surfaces shall fit accurately. Uneven or rough cuts at the points of bearing shall be cause for rejection of the piece containing the defect.

Before erection, the assembly shall be checked for prescribed overall dimensions, prescribed camber, and accuracy of anchorage connections. Erection should be planned and executed in such a way that the close fit and neat appearance of joints and the structure as a whole will not be impaired.

Anchor bolts should be checked prior to start of erection.

Before erection begins, all supports and anchors should be complete, accessible, and free of obstructions. The weights and balance points of the structural timber framing should be determined before lifting begins so that proper equipment and lifting methods may be employed.

Unless otherwise directed by the Engineer, housings and railings shall be built after the removal of the falsework and the adjustment of the trusses to correct alignment and camber.

330.16 PAINTING. Outside stringers, wheel guards, rails, rail posts, and exposed surfaces of scupper blocks, filler blocks, and flooring of untreated timber or timber treated with preservative salts, shall be painted as specified in Section 324 – “Painting, Pavement Striping, and Marking.”

Ends of all pieces of untreated timber not otherwise painted shall be painted with one prime coat.

Metal parts shall be painted as specified in Section 324 – “Painting, Pavement Striping, and Marking.”

330.17 TIMBER CONNECTORS. Timber connectors shall be one of the following types, as specified on the Plans: the split ring, the shear plate, or the spike grid. The split ring and the shear plate shall be installed in precut grooves of dimensions as given herein or as recommended by the manufacturer. The spike grid shall be forced into the contact surfaces of the timbers and joined by means of pressure equipment. All connectors of this type at a joint shall be embedded simultaneously and uniformly.

Fabrication of all structures using connectors shall be done prior to treatment. When prefabricated from templates or shop details, bolt holes shall not be more than 1/16 inch from required placement. Bolt holes shall be 1/16 inch larger than bolt diameter. Bolt holes shall be bored perpendicular to the face of the timber.

330.00-6

TIMBER CONSTRUCTION

Connector grooves in timber shall be cut concentric with the bolt hole, shall conform to the cross-sectional shape of the rings, and shall provide a snug fit. Inside groove diameter shall be larger than the nominal ring diameter in order that the ring will expand slightly during installation.

Timber, after fabrication, shall be stored in a manner that will prevent changes in the dimensions of the members before assembly.

Dimensions of material and details not otherwise specified shall meet with the approval of the Engineer.

330.18 MEASUREMENT OF QUANTITIES AND BASIS OF PAYMENT. Lumber and timber shall be measured in accordance with the Contract Documents.

Lumber and timber shall be compensated for at the lump sum or unit prices established in the Contract Documents or as directed by the Engineer. All prices shall be full compensation for furnishing all materials, including hardware, treating, erecting, and for all incidentals necessary for doing all the work involved, as shown on the Plans or established by the Engineer.

331.01 DESCRIPTION. This work shall consist of furnishing and erecting new guardrail, end anchor assemblies, guardrail expansion joints, breakaway cable terminals, and additional guardrail beam elements required for constructing double beam rail, or reconstructing guardrail previously removed, in conformity with these Specifications and of the types and at the points shown on the Plans or ordered by the Engineer. This item shall also consist of furnishing and installing reflector plates as shown on the Plans.

331.02 MATERIALS. All material shall conform to the requirements specified in the following sections:

Timber	Section 208
Timber Preservatives	Section 208
Guardrail Materials	Section 212
Galvanizing	Section 213

Guardrail posts and blocks shall be rough construction grade and shall comply with the grading requirements of Section 208 – “Timber and Preservative Treatment.”

Cable end anchor assemblies for metal beam guard railing shall be constructed as shown on the Plans.

Each wood post and block, after fabrication, shall be given a preservative treatment by pressure processes in accordance with the provisions of Section 208 – “Timber and Preservative Treatment.”

The minimum retention of preservative in pounds per cubic foot of wood shall be as follows:

- a. Creosote — 8 pounds
- b. Creosote — Petroleum — 8 pounds
- c. Pentachlorophenol — 0.5 pound

Guardrail quantities shown on the Plans are approximate. As construction progresses, the Engineer will review the need for guardrail and will, at the completion of this review, provide the Contractor with the revised amount of guardrail required. Should the Contractor elect to order guardrail materials prior to receiving this revised list from the Engineer, he shall be completely responsible for furnishing the amount of guardrail and appurtenances required by said list. Should additional quantities be required to meet the requirements of the list, there shall be no additional compensation allowed above the unit price bid, and no compensation shall be allowed for surplus materials in excess of the requirements of the list.

331.03 REFLECTORS. Reflector plates for guardrail shall be fabricated from 16 gauge steel sheet or 0.080 inch thick aluminum sheet alloy 6061-T6. Nails for fastening reflector plates to the guardrail post shall be either galvanized metal or aluminum. Steel reflector plates shall be galvanized. Reflectorized material for reflector plates shall conform to the requirements of Subsection 211.03.03 – “Reflectors.”

Reflector plates shall be constructed and erected on guardrails in accordance with the requirements of the Agency.

331.04 CONSTRUCTION. Unless otherwise specified, guardrails shall be constructed with either treated Douglas Fir, West Coast Hemlock, or Western Larch posts with beam-type plates and fittings as shown on the Plans or indicated in the Special Provisions. Post spacing shall be as shown and guardrails shall be constructed in accordance with the design shown on the Plans. The use of more than one type of guardrail on a single project will not be approved unless so provided in the Special Provisions or Contract Documents.

Posts shall be set plumb, except on super-elevated curves, where they shall be set perpendicular to the roadbed. Front faces of posts shall form a straight line, except on curves, where they shall be a uniform distance from the centerline of the roadway. Post holes shall be backfilled in layers with approved material thoroughly rammed with an iron tamping tool in such a manner as not to displace the bottom of posts from correct alignment.

Guardrail beam elements may be furnished in 12 1/2 or 25 foot lengths, at the option of the Contractor.

Cable end anchor assemblies for metal beam guard railing shall be constructed as shown on the Plans and as specified herein.

Cable clips and a cable thimble shall be used to attach cable to the anchor rod.

After installation and before backfilling, the portion of the anchor rod to be buried in earth shall be coated with a minimum 20-mil thickness of coal tar enamel conforming to AWWA Standard C203.

Metal components of the anchor assembly shall be fabricated in conformance with good shop practice and shall be hot-dip galvanized in accordance with the ASTM A 123.

Anchor blocks shall be constructed of concrete containing five sacks of Type II cement per cubic yard of concrete, 1 1/2 inch maximum aggregate size, and shall obtain a compressive strength of 2,000 pounds per square inch in 28 days.

Concrete shall be placed against undisturbed material of the excavated holes for anchor blocks. The top 12 inches of holes shall be formed, if required, by the Engineer.

Surplus excavated material remaining after the guard railing has been constructed shall be disposed of in a manner satisfactory to the Engineer.

The overall length of each anchor cable assembly shall be a minimum of 10 feet.

Workmanship shall be first class in all respects, and framing shall be done and fittings attached in such a manner that the rail, after erection, shall be true to line and grade and shall have the proper tension in the rail plates. Care shall be taken to prevent the disturbance of posts during the erection of the rail and, when necessary, temporary braces shall be installed to insure against post displacement.

331.05 PAINTED GUARDRAIL. After erection, all metal parts and fittings free from coatings of any kind, including dirt, rust, and oil and grease, shall be given three coats of paint as specified in Section 214 – “Paint.” Parts shop prime-coated by the manufacturer shall conform to Section 214 – “Paint.”

Posts shall not be painted.

All beams shall be cleaned prior to priming by wiping down the surface with solvents such as naphtha, white (lead-free) gasoline, or detergent. Detergents may be of the type commonly used in washing machines; however, if detergent is used, it shall be thoroughly rinsed from the rail with clear water.

All loose white deposit shall be removed with a stiff brush (not steel), steel wool, or sandpaper. Care shall be exercised so as not to remove zinc coating.

Intermediate and finish coats shall be as specified in Section 324 – “Painting, Pavement Striping, and Marking.” Surfaces to be painted shall be dry and the temperature during priming, painting, and for 6 hours thereafter shall not be below 50 degrees Fahrenheit.

After the posts are set, the exposed portions shall be wrapped or otherwise protected to the satisfaction of the Engineer so that they shall remain free from paint, road oil, and other objectionable materials. After all other work is completed and prior to the semi-final inspection, the wrapping or protection shall be removed. All posts that have paint, road oil, or other objectionable materials on the exposed surface or that do not otherwise meet the required Specifications shall be cleaned or removed, as the case may require, at the Contractor's expense.

All exposed surfaces of the metal guardrail that has become soiled or marred shall be cleaned or repainted at the expense of the Contractor as required by the Engineer.

After the rail has been painted as specified, nuts fastening rail plate to springs shall be backed off slightly so that the connection is firm but not tight and will permit the slight movement necessary to absorb expansion and contraction of the rail.

New guardrail beam elements shall be galvanized on both sides and cleaned, primed, and painted on the side facing traffic.

331.06 PRIMING. Priming shall be as specified in Section 324 – "Painting, Pavement Striping, and Marking."

Prime coat may be added in the field.

331.07 PAINTING. Intermediate and finish coats shall be as specified in Section 324 – "Painting, Pavement Striping, and Marking."

Prepainted guardrail beam elements shall be galvanized, cleaned, primed, and prepainted on the side facing public traffic by the manufacturer prior to delivery to the jobsite as hereinafter specified:

331.07.01 Galvanizing. Guardrail beam elements shall be post-galvanized on both sides in accordance with the requirements of AASHTO Design M180, Type 2.

331.07.02 Cleaning. All beam elements shall be alkaline cleaned, mechanically brushed, rinsed, given a zinc phosphate coating with a nominal coating weight of 200 milligrams per square foot, rinsed, and neutralized metal preparation to comply with Military Specification MIL-T-12879, Type 1, Class 1.

331.07.03 Priming and Painting.

- a. Alternate 1. Prime coat shall be vinyl type, containing corrosion inhibiting pigment, applied at a nominal dry film thickness of 0.50 milligrams.

Finish coat shall be a high gloss white thermosetting acrylic, baked enamel, applied at one mil. nominal. The white pigment used shall be a non-chalking type.

- b. Alternate 2. Prime coat shall be epoxy type, containing corrosion inhibiting pigment, applied at a nominal dry film thickness of 0.50 mil.

Finish coat shall be a high gloss white thermosetting polyester, baked enamel, applied at one mil. nominal. The white pigment used shall be a non-chalking type.

All exposed surfaces of the metal guardrail that have become soiled or marred shall be cleaned or repainted at the expense of the Contractor as required by the Engineer.

331.08 GALVANIZED GUARDRAIL. The guardrail beam elements and end sections shall be galvanized. Galvanizing shall be performed after fabrication. Fabrication shall include all operations such as shearing, cutting, punching, forming, drilling, milling, and bending.

Galvanized surfaces that are abraded or damaged at any time after the application of the zinc coating shall be repaired by thoroughly wire brushing the damaged areas and removing all loose and cracked coating, after which the cleaned areas shall be painted with two coats of Federal Specification MIL-P-21035.

All exposed surface of the metal guardrail that has become soiled shall be cleaned at the expense of the Contractor as required by the Engineer.

331.09 RECONSTRUCTED GUARDRAIL. Reconstructed guardrail shall be carefully erected using salvaged materials and shall be similar in type to the original construction. Any new materials necessary to rebuild the guardrail shall be furnished by the Contractor, shall be of the same kind as those in the original, if available, and the cost thereof shall be included in the Contract price for the work.

Reconstructed guardrail shall be painted with one coat of paint after first touching up all spots on which the original paint has been removed or destroyed.

331.10 MEASUREMENT OF QUANTITIES. The quantity of new or reconstructed guardrail measured for payment will be the number of lineal feet measured along the front face of the rail between centers of end posts or between the center of the end post and the bridge connection as the case may be, complete and in place. In the case of new guardrail, an allowance of 2 feet at each end post shall be added to the length measured between the centers of end posts when terminal sections are specified. The length of expansion joints, cable end anchors, guardrail expansion joints, additional guardrail beam elements used to construct double beam rail, and breakaway cable terminals shall be included in the measurement per lineal foot.

331.11 BASIS OF PAYMENT. The accepted quantity of new and reconstructed guardrail will be paid for at the Contract unit price bid per lineal foot.

The above prices shall be full compensation for furnishing hardware, reflectors, erecting, painting, galvanizing, cable end anchors, guardrail expansion joints, beam elements, and breakaway cable terminal, and all incidentals necessary to complete the work.

332.01 DESCRIPTION. This work shall consist of furnishing, erecting, and installing all signs, sign supports, and all other related appurtenances required for permanent and temporary signs.

332.02 MATERIALS. Sign materials shall be in accordance with Section 215 – “Signs” – of these Specifications.

332.02.01 Reflectorization. The types of reflective materials to be used for signing shall be as follows:

- (a) Type III reflective sheeting for sign background, letters, numerals, symbols, borders, and accessories shall be used on all overhead guide signs.
- (b) Type I reflective sheeting for sign background and Type III reflective sheeting for letters, numerals, symbols, borders, and accessories shall be used on all other guide signs, unless noted on the Plans.
- (c) All letters, numerals, symbols, borders, and accessories shall be directly applied to the sign background on all guide signs, unless otherwise noted on the Plans.
- (d) Type III reflective sheeting shall be used on the following warning and regulatory signs:
 - 1. Railroad Crossing W10-1
 - 2. Narrow Bridge W5-2 or W5-2a
 - 3. Two Way Traffic W6-3
 - 4. Do Not Enter R5-1
 - 5. Wrong Way R5-1a
 - 6. Stop R1-1.
- (e) Type I reflective sheeting shall be used on all other warning and regulatory signs, unless otherwise noted on the Plans.

332.02.02 Overhead Guide Signs. All overhead guide signs shall be reflecting aluminum.

332.03 PERMANENT SIGNS

332.03.01 Description. This work shall consist of furnishing, erecting, and installing all signs, sign supports, and other materials required for highway signs in accordance with the MUTCD Manual, Standard Highway Sign Book (current edition, including the Nevada Supplement), these Specifications, as shown on the Plans, and as directed by the Engineer.

The work shall generally consist of:

- a. Overhead signs, including concrete foundations, steel sign posts and frames, and steel sign panels with porcelain enamel finish.
- b. Ground mounted signs consisting of concrete foundations, steel sign posts, reflecting aluminum sign panels, and appurtenances.

This item does not include sign illumination systems.

332.03.02 Panel Fastenings. The panel sections shall be provided with suitable fastenings, as shown on the Plans, to permit easy attachment to the supporting frames.

The fastenings shall be so designed as to carry the full design load with a factor of safety of not less than 1.5. Panel sections shall be provided with closure strips at the joints.

Panel fastenings for use on sign panels covered with Type II reflective sheeting shall utilize nylon washers for contact between the reflective sheeting and the metal washer.

Panel fastenings for use on sign panels covered with Type III reflective sheeting shall utilize nylon washers for contact between the reflective sheeting and the metal washer.

332.03.03 Closure Strips. Closure strips shall be anchored by aluminum rivets as shown on the Plans. Rivets shall be the same color as the sign face. Closure strips are required only on aluminum sign panels.

332.03.04 Installation. Sign locations indicated on the Plans are approximate only. Final determination of sign locations will be made in the field by the Engineer.

Sign and sign islands shall be constructed to the lines and grades given by the Engineer and locations shown on the Plans.

All signs shall be erected as specified before, during, or immediately after the completion of bituminous plantmix surface operations.

The date of installation, consisting of month and year, shall be permanently stamped on the back of each sign with metal dies and shall be placed on the lower right hand corner when facing the rear of the sign.

Each sign face shall be thoroughly cleaned according to the reflective material manufacturer's recommendations, and all undesirable material that is visible on the face of the sign shall be removed. The use of abrasives or other cleaning material that will scratch or otherwise deface shall not be permitted.

Should the Contractor be required to cover any directional signs that are not functional, he shall not cover the front of the sign surface with adhesive.

Sign islands shall be constructed as roadway embankment in conformity with Section 303 – "Unclassified Excavation" – and Section 304 – "Unclassified Fill." Structure excavation and backfill shall conform to the requirements of Subsection 303.02.09 – "Structure Excavation" – and Subsection 304.07 – "Structure Backfill." Anchor bolts shall be set true to line and grade and posts shall be plumb. Sign illumination systems shall conform to the requirements of Section 325 – "Traffic Signals and Street Lighting."

Sign faces of all directional signs facing public traffic and directing such traffic to a portion of the project not yet open to public traffic shall have the message covered.

Care shall be exercised at all times in the handling, storing, transporting, and erecting of the signs. Signs which are damaged shall be repaired or replaced at the Contractor's expense.

Pipe sign posts may be field cut and drilled to adjust for local conditions when approved by the Engineer. Flame cutting will not be permitted. All field cuts and abraded areas on steel pipe posts shall be thoroughly cleaned and given two coats of paint having zinc dust content conforming to the requirements of Federal Specification MIL-P-21035.

Extending the lengths of sign posts to adjust for local conditions by splicing or welding will not be permitted.

332.03.05 Removal. This work shall consist of removal of existing permanent sign panels, posts, and footings as shown on the Plans and as directed by the Engineer. Existing sign panels and posts that are removed shall be stockpiled on the job site at locations determined by the Engineer and shall remain the property of the Agency. The Contractor shall remove and dispose of all concrete from sign posts prior to stockpiling as directed by the Engineer.

The Contractor shall exercise care when removing and stockpiling signs that are designated for removal. Signs which are damaged shall be repaired or replaced at the Contractor's expense.

332.03.06 Reset. This work shall consist of resetting existing sign panels on new posts and footings as shown on the Plans and as directed by the Engineer. Existing sign panels will normally be all or portions of those removed in accordance with Subsection 332.03.05 – "Removal" – unless otherwise indicated on the Plans or directed by the Engineer.

332.03.07 Tests. It shall be the Contractor's responsibility to ascertain that all required tests have been made by qualified testing laboratories as approved by the Engineer. The Contractor shall furnish the Engineer with a written certification that all required tests have been satisfactorily completed and that materials and fabrication thereof comply with all the requirements.

332.04 TEMPORARY SIGNS

332.04.01 Description. This work shall consist of furnishing and erecting signs, barricades, traffic cones, delineators, and/or warning lights, or erecting similar traffic control devices previously removed at locations shown in the Contract Documents, indicated on the Plans, or directed by the Engineer for the safety of the traveling public at temporary connections, crossovers, and/or detours.

All signs, barricades, traffic cones, delineators, and/or warning lights shall conform to the requirements of the MUTCD Manual, Standard Highway Sign Book (current edition, including the Nevada supplement), unless indicated otherwise on the Plans or in the Special Provisions.

332.04.02 ReflectORIZATION. All signs, barricades, traffic cones, and delineators shall be reflecting. The minimum reflectORIZATION shall be as follows:

- (a) Signs shall be reflecting using Type I reflective sheeting, unless otherwise specified.
- (b) Barricades and traffic cones shall be reflecting so as to be visible under normal atmospheric conditions from a maximum distance of 1,000 feet when illuminated by the low beams of standard automobile headlights.
- (c) Delineators shall be reflecting by means of a prismatic reflector with a minimum diameter of 3 inches.

332.04.03 Route Opening. Before any route is opened to traffic, all necessary signs shall be in place. Signs, barricades, traffic cones, and delineators shall conform to the details shown on the Plans.

332.04.04 Installation. Sign locations indicated on the Plans are approximate only. Final determination of sign locations will be made in the field by the Engineer.

Each sign face shall be thoroughly cleaned according to the reflective material manufacturer's recommendations, and all undesirable material that is visible on the face of the sign shall be removed. The use of abrasives or other cleaning material that will scratch or otherwise deface the sign shall not be permitted.

Sign faces of all directional signs facing public traffic and directing such traffic to a portion of the project not yet open to public traffic shall have the message covered.

Care shall be exercised at all times in handling, storing, transporting, and erecting of the signs. Signs which are damaged shall be repaired or replaced at the Contractor's expense.

332.04.05 Temporary Traffic Cones. Temporary traffic cones shall conform to the design and placement shown on the Plans. Cones shall be attached to the pavement with an epoxy designed for the purpose of attaching the flexible cone material to the type of pavement at the location shown on the Plans. The rate of application of the epoxy, the allowable temperature at time of application, and the method of application shall be as recommended by the manufacturer and as approved by the Engineer.

332.04.06 Barricade Weighting Devices. Rocks, asphalt or concrete pieces, construction materials, and other devices shall not be used as a weighting device for barricades; however, sand bags will be permitted as long as a low center of gravity is maintained as approved by the Engineer.

332.04.07 Removal of Signs and/or Barricades. Signs or barricades to be removed and re-erected will be designated on the Plans or in the Special Provisions. Care shall be taken in removing signs or barricades, and no equipment or devices shall be used which might cause damage thereto. If damage is done due to the negligence of the Contractor, the sign shall be replaced in kind at the expense of the Contractor.

Any new posts or hardware necessary to re-erect the sign or barricade shall be furnished by the Contractor, shall be of the same kind as those in the original, if available, and the cost thereof shall be included in the Contract price for the work.

332.05 CONSTRUCTION SIGNS

332.05.01 Description. This work shall consist of furnishing and erecting for rental all necessary barricades, traffic cones, delineators, Type A, Type B, and Type C, barricade warning lights and arrow boards, and standard construction signs at locations set forth in the Contract Documents, or as directed by the Engineer, for the protection of the work, workmen, and guidance and safety of the traveling public.

All rented construction signs, barricades, portable precast concrete barrier rail, drums, vertical panels, traffic cones, delineators, barricade warning lights, and arrow boards shall remain the property of the Contractor upon completion of the contract and shall be removed from the project by him.

All signs, barricades, drums, vertical panels, traffic cones, delineators, barricade warning lights, and arrow boards shall conform to the requirements of the MUTCD Manual, the Standard Highway Sign Book (current edition, including the Nevada supplement), unless indicated otherwise on the Plans or the Special Provisions.

It is expressly intended that a rather broad selection of material be granted the Contractor since construction signs are in temporary use. Sign panels may be constructed of steel, aluminum, wood, or other approved material and be of a sound, durable nature. The materials shall be of such quality to do the job for which they are intended and are subject to approval by the Engineer. Signs which have become dull, have flaking or peeling paint, are dirty, or are otherwise marred shall be repaired or replaced with acceptable signs.

332.05.02 General. Before any detour or temporary route is opened to traffic, all necessary signs shall be in place. Signs required by road conditions or restrictions shall be removed immediately when those conditions cease to exist or the restrictions are withdrawn. Guide signs directing traffic to and on temporary routes or detours shall be removed when no longer applicable.

332.05.03 ReflectORIZATION. All construction signs, barricades, and delineators shall be reflecting. Traffic cones, when used during the hours of darkness, shall be reflecting. Minimum reflectORIZATION shall be as follows:

- (a) Signs shall be reflecting using Type I reflective sheeting materials.
- (b) Barricades, drums, vertical panels, and traffic cones shall be reflecting so as to be visible under normal atmospheric conditions from a minimum distance of 1,000 feet when illuminated by the low beams of standard automobile headlights.
- (c) Delineators shall be reflecting by means of a prismatic reflector with a minimum diameter of 3 inches.
- (d) Portable precast concrete barrier rail shall be reflecting by placement of a two way reflector in the center of each barrier rail section and located on top of the rail. Color of the reflectors shall conform to the requirements of the MUTCD Manual.

332.05.04. Sign Dimensions. Sign dimensions shown are minimum standard. Increases above this minimum are permissible and desirable where investigation has shown a larger sign is needed for adequate emphasis. In the enlarging of signs, standard shapes and colors shall be used and standard proportions shall be retained, so far as practicable.

332.05.05 Sign Placement. Signs must always be placed in positions where they will convey their messages most effectively without restricting lateral clearance of sight distance. Placement must therefor be accommodated to highway design and alignment. Signs must be so placed that the driver will have sufficient time to absorb the message before having to act.

332.05.06 Sign Supports. Signs, posts, and their foundations shall be so constructed as to hold signs rigidly in a proper and permanent position, and prevent them from swaying in the wind, or from being turned or otherwise displaced by children or irresponsible persons.

A portable or removable type of mounting may be used for signs required intermittently or which are frequently moved. Such a mounting shall be heavy enough not to turn over in the wind, and its base shall not be appreciably wider than the sign.

332.05.07 Barricades. Highways closed to traffic shall be protected by Type I, Type II, Type III, or Type IIIB barricades or drums, or portable precast concrete barrier rail, as approved by the Engineer, on which shall be placed appropriate regulatory signs. The Contractor shall provide and maintain appropriate warning and detour signs at all closures, intersections, and along detour routes, directing the traffic around the closed portions of the highway so that the temporary detour route or routes shall be indicated clearly throughout its or their entire length.

Rocks, asphalt, or concrete pieces, construction materials, and other debris shall not be used as a weighting device to barricades; however, sand bags will be permitted as long as a low center of gravity is maintained, as approved by the Engineer.

332.06 MEASUREMENT OF QUANTITIES AND BASIS OF PAYMENT. Signs shall be measured and compensated for in accordance with the unit prices established in the Contract Documents.

333.01 DESCRIPTION. This work shall consist of furnishing and planting trees, shrubs, and ground cover where shown on the Plans, indicated in the Special Provisions, or established by the Landscape Architect, all in accordance with the Specifications and accepted horticultural practices. The use of the term "Landscape Architect" – in this section will be interpreted as a person licensed to practice landscape architecture in the State of Nevada, or the Owner's representative.

333.02 MATERIALS

333.02.01 Nomenclature. Nomenclature for plant names and varieties shall be in accordance with the latest edition of "Standardized Plant Names" – as prepared by the American Joint Committee on Horticultural Nomenclature.

All plant material will be classified as follows:

Plants, Group A	Denotes canned plant material
Plants, Group B	Denotes balled and burlapped plant material
Plants, Group C	Denotes ground cover
Plants, Group D	Denotes grass (turf)
Plants, Group E	Denotes grass (meadow)

333.02.02 Quality of Plant Materials. It is the intent of these Specifications that all plant material meet the standards as set forth therein throughout the life of the Contract. During inspections, as set forth hereinafter, all plant material will be judged and rejections shall be based upon these standards.

It is to be understood that when plant materials do not meet the standards and are rejected, no consideration will be given to the possibility of survival.

All plants shall be well-formed and shaped, free from disease, insects, and defects such as knots, sun-scald, windburn, injuries, abrasions, or disfigurements.

All plants shall be true to type or name as shown on the Plans and shall conform to the American Standard for Nursery Stock. No. 1 grade American Association of Nurserymen, Inc., latest edition, ASA Spec. Z 60.1, and shall be tagged in accordance with the most recent standard practice recommended by the American Association of Nurserymen and to the latest edition of Standardized Plant Names, American Joint Committee on Horticultural Nomenclature.

All plants shall comply with Federal and State laws requiring inspection for plant diseases and infestations. Inspection certificates required by law shall accompany each shipment of plants, and certificates shall be delivered to the Landscape Architect.

In determining the quality of plant material, the following elements shall be valued:

- a. Root condition
- b. Plant size (above ground)
- c. Insect and disease free condition

- d. General appearance (color, shape, prior pruning).

A deficiency in any one or more of these areas shall be sufficient reason to reject selectively or by lot.

333.02.03 Handling and Shipping. Plants shall be packed for shipment according to standard practice for the type of plant being shipped. The root system of all plants shall not be permitted to dry out at any time. Plants shall be protected at all times against heat and freezing temperature, sun, wind, climatic, or seasonal conditions during transit. All plants balled and burlapped (B&B) shall at all times be handled by the ball of earth and not the plant. Broken or "make" balls will not be accepted. Container grown plants shall be well developed with sufficient root development to hold the earth intact after removal from the container without being root bound.

All Group A-1, A-5, and A-15 plants are to be hardened material. This is to be accomplished by storing all plants in the immediate area of planting for a period of not less than 3 weeks prior to planting. Plants shall be stored in a licensed commercial nursery, or the Contractor may provide equivalent storage and care with written approval of the Engineer.

Prior to moving plants from nursery or storage area to job site, they shall be thoroughly sprayed with a solution of anti-desiccant/anti-transparent which will meet the requirements set forth in the Special Provisions or as directed by the Landscape Architect.

Packaged seed material shall be delivered in original containers showing analysis of mixture, percentage of pure seed, year of production, net weight, date of packaging, and location of packaging. Damaged packages are not acceptable.

333.02.04 Inspection of Plant Materials. The Contractor shall inform the Landscape Architect, as soon as practical, of the source of plant material for the project. At the Landscape Architect's option, an inspection of all plant materials at the source may be required prior to shipping of plants from the nursery. This inspection shall coordinate the judgment areas regarding size and quality of plant material between the Owner, the Contractor, and the Nursery. However, there will be no acceptance of any plant material during this inspection.

All plant material will be inspected by the Landscape Architect on arrival at the storage area. This inspection shall determine the acceptance or rejection of the plant material, is for quality of plant material only, and does not constitute final acceptance. Plants which are rejected shall be immediately removed from the holding area and replaced by the Contractor at his expense.

All plant material will be periodically inspected by the Landscape Architect from the time of arrival at the holding area, during planting, and through the plant establishment period. Plants may be individually rejected during this time based on mechanical damage, quality, or physical change of the plant which is not normal to the plant or to the season of the year. Plants which are rejected shall be immediately removed from either the holding area or the project and replaced by the Contractor at his expense.

333.02.05 Substitution of Plants. No substitution of plant material will be permitted unless evidence is submitted in writing to the Landscape Architect that a specified plant cannot be obtained along with proposal for equivalent material for substitution. If substitution is permitted, it can be made only with written approval by the Engineer.

333.02.06 Temporary Storage. Plant material delivered and accepted shall be planted immediately. Plants that cannot be planted within 1 day after arrival shall be "heeled-in" in accordance with accepted horticultural practice, and as follows:

- a. Balled and burlapped plants shall have the root ball protected by moist earth, sawdust, or other acceptable material.
- b. Canned plants shall be placed in and under shelter and kept moist.

Plants stored under temporary conditions shall be protected at all times from extreme weather conditions, and shall be kept moist.

333.02.07 Lumber. Lumber for header boards and plant boxes shall conform to the requirements of Section 208 – “Lumber and Preservative Treatment.”

333.02.08 Wrapping Materials. Tree wrap shall consist of two thicknesses of crepe paper 8 inches to 10 inches wide, cemented together with bituminous material. Twine for securing tree wrap shall be lightly tarred medium or coarse sisal yarn or duct tape.

333.02.09 Guying and Staking Material. Stakes for tree support shall be construction-grade redwood or shall conform to the requirements of Section 208 – “Lumber and Preservative Treatment.” Minimum nominal size shall be 2 feet by 2 feet or 2 1/2 inches in diameter by 9 feet long and pointed at one end. Guying wire shall be annealed, galvanized iron or 12 gauge steel. Hose shall be 22 ply 3/4 inch reinforced rubber or plastic.

333.03 SITE PREPARATION. This work shall consist of all work necessary, as set forth in the Contract Documents, to prepare the area for the actual landscaping work. Verify that all subgrade elevations have been established; beginning landscape work shall mean acceptance of existing conditions.

333.04 LAYOUT OF PLANTING. The Contractor will designate, by means of stakes or other approved markings, the ground location of each random placed plant. Area of massed or uniform solid plantings shall be marked at their outer extreme only. The Landscape Architect's approval of plant stakeout will be required prior to the commencement of the preparation of planting areas.

In mixed planting areas, trees shall be planted first, followed by the larger shrubs, low shrubs, and the final planting of ground covers.

333.05 PREPARATION OF PLANTING AREAS. During the preparation of planting areas, all clods, rocks, or other debris over 1 inch in largest dimensions shall be removed from both cultivated areas and backfill material, and disposed of as directed by the Landscape Architect. In addition thereto, the following requirements will apply:

333.05.01 Planter Boxes. Backfill material shall consist of one part humus to three parts approved top soil by volume. This material shall be thoroughly and uniformly mixed before placing in the planter boxes. After placing in the planter box, the material shall be watered until it is completely saturated. Sufficient backfill mixture shall be added and adequately wet so that, after settlement has taken place, the material is no more than 2 inches below the top of the box.

333.05.02 Planting Beds. The soil preparation shall not be initiated until after all grading has been completed and the irrigation system has been installed, tested, adjusted by the Contractor, and accepted by the Landscape Architect. The ground surface within the area shall then be loosened and thoroughly cultivated to a depth of 6 inches. Repeat cultivation in areas where equipment has compacted subgrade.

When required, humus, commercial fertilizer, and other soil additives shall be incorporated at the rate specified in the Contract Documents, and shall be thoroughly and uniformly tilled into the soil to a depth of 6 inches. The area shall then be brought to a plane in conformance to the elevations shown on the Plans.

333.05.03 Seed Beds. The soil preparation shall be the same as specified for planting beds.

333.05.04 Planting Holes. Prior to digging holes, the proposed location of the irrigation lines shall be designated by means of stakes or other approved markings. In the event of conflict between individual plant holes and irrigation lines, the planting holes in question shall be dug prior to installing the irrigation lines.

Plant holes shall have vertical walls and flat bottoms. Tree planting holes shall be sized as necessary to accommodate tree ball and a 6 inch minimum of compacted top soil below the ball. Tree planting holes shall be three times greater than the width of the ball in diameter.

Shrub planting holes shall be a minimum of 16 inches in depth and increased as necessary to accommodate root balls and with at least 6 inch minimum of top soil below the ball. Shrub planting holes shall be 1 foot greater than the width of the ball in diameter.

When required, humus, commercial fertilizer, and other additives shall be incorporated at the rates specified in the Contract Documents and shall be thoroughly and uniformly mixed with the native material removed from the holes prior to backfilling. After backfilling the holes, the material shall be saturated with water to the full depth of the holes and until ponding appears in the basin. Sufficient backfill material shall be placed so that, after planting and settlement has taken place, the basin will conform to the section as shown in the Plans.

333.05.05 Planting Trenches. Trenches shall be excavated to the dimensions as specified in 333.05.04 – “Planting Holes” – and shall be centered on the planting line as staked or otherwise marked.

When required, humus, commercial fertilizer, and other additives shall be incorporated at the rates specified in the Contract Documents and shall be thoroughly and uniformly mixed with the native material removed from the trenches prior to the backfilling. After backfilling the trenches, the material shall be saturated with water to the full depth of the trench. Cross checks may be performed as necessary to permit ponding of water during the saturation period, but must be removed prior to planting. Sufficient backfill material shall be placed so that after planting and settlement has taken place, the basin will conform to the section as shown in the Plans.

333.06 PLANTING. No more plants shall be distributed within the project on any 1 day than can be planted and watered on that day.

Any planting done in soil that is too wet or dry or not properly conditioned as provided herein will not be accepted. No payment will be made for such planting, and any further planting work will be suspended until the Contractor has complied in every way with the Specifications.

(a) General.

1. Center plant for pit or trench.
2. Face for best effect.
3. Set plant plumb and hold rigidly in position until soil has been tamped firmly around ball or roots.
4. Use only planting soil for backfill.
5. Place sufficient planting soil under plant to bring top of root ball level to finish grade of surrounding soil.
6. Backfill pit with planting soil until 2/3 full and water each layer thoroughly to settle soil.
7. After soil settles, fill pit with planting soil mix, water, and leave pit surface even with finish grade of surrounding ground.
8. Watering basin.

- a. Construct a topsoil berm 4 inches above finish grade, forming a watering basin with a level bottom around each plant.
- b. Size: 2 feet (600mm) greater than diameter of ball or spread of roots if barerooted.

333.06.01 Plants (Group A). Nursery stakes supporting plants in containers shall be removed and the plants properly pruned as specified herein.

Containers shall be cut, at least twice, from top to bottom and plants shall be removed from the containers in such a manner that the ball of earth surrounding the roots is not broken, and they shall be planted and watered as hereinafter specified immediately after removal from the containers. Containers shall not be cut prior to delivery of the plants to the planting areas.

333.06.02 Plants (Group B). Balled and burlapped material shall have all strings or cords cut, and the burlap shall be laid back from the top half of the ball. This shall be done only after the plant is placed in its final position and before completion of the backfill.

333.06.03 Plant (Group C). As soon as each plant is removed from its container, it shall be planted in the prepared planting bed, in a hole previously prepared with a broad, blunt end trowel. The plant shall be carefully lifted with the trowel, inserted in the hole, and the earth shall be gently firmed around it to eliminate air pockets.

Plants brought to the job site in plastic or clay pots shall be tapped loose from their containers in such a manner that the ball of earth surrounding the roots is not broken, and then immediately planted. Plants which are brought to the job site in peat pots may be planted in the pots, provided the peat fiber is thoroughly wet. Plants which are brought to the job site in other cellulose fiber pots shall have the pots carefully removed by tapping or peeling before planting. No plants brought to the job site in flats, pony packs, or bare root will be accepted.

Plants shall be watered as hereinafter specified immediately after planting.

Roots of plants not in containers shall be kept moist and covered at all times and shall not be exposed to the air, except while actually being placed in the ground.

Plants shall be planted in such a manner that the roots will not be restricted or distorted. Soil shall not be compacted around the roots or ball of the plant during or after planting operations. Any plants which have settled deeper than specified above shall be raised back to the required level, or replaced, at the option of the Contractor.

333.06.04 Plants (Group D). The seed bed shall be in a moist, friable condition when seeding is begun. Seeding shall be done as soon as soil conditions allow after the initial watering of the amended soil. Seeding done in soil that is too wet or too dry, or in a condition not generally accepted as satisfactory for lawn seeding, will not be accepted. No payment will be made for seeding when the soil condition is considered unsatisfactory, and any further seeding work will be suspended until the Contractor has complied in every way with these provisions.

Lawn seed may be sown from standard mechanical grass seeding equipment and fertilized or applied together with mulch and fertilizer in a hydromulch solution.

After sowing, the seed shall be covered by light raking or dragging and seeded areas shall be compacted by rolling. The Contractor shall exercise care to avoid leaving any footprints or other depressions in the compacted seed bed.

Humus mulch shall be evenly applied immediately after the seed bed has been compacted, with manure spreaders, mulch blowers, or other approved equipment. Humus shall be spread at the rate of 1 cubic yard per 1,000 square feet. As soon as mulch is in place, the surface of the seed bed is to be dampened with a fine spray from a nozzle until the mulch is thoroughly moist.

333.06.05 Plants (Group E). The seed ball shall be in a moist, friable condition when seeding is begun. Seeding shall be done as soon as soil conditions allow after the initial watering of the amended soil. Seeding done in soil that is too wet or dry, or in a condition not generally accepted as satisfactory for seeding, will not be accepted. No payment will be made for seeding when soil condition is considered unsatisfactory, and any further seeding work will be suspended until the Contractor has complied in every way with these provisions.

Seed may be sown from standard mechanical grass seeding equipment and fertilized or applied together with mulch and fertilizer in a hydromulch solution. After sowing, the seed shall be covered by rolling. The Contractor shall exercise care to avoid leaving any footprints or other depressions in the compacted seed bed.

333.07 MULCHING. Mulch planting holes, trenches, planting beds, and areas within 2 days after planting. Cover watering basin or bed evenly with 4 inches of shredded bark mulch material. Water thoroughly immediately after mulching.

333.08 STAKING AND GUYING. All staking and guying shall be done concurrently with the planting operation.

333.08.01 Staking. Plants which are to be staked will be specified in the Special Provisions or indicated on the Plans.

The size, number of stakes, and the depth to be driven shall be as specified in the Special Provisions, indicated on the Plans, or as approved by the Landscape Architect.

The stakes shall be placed adjacent to plant pits in undisturbed soil in the case of Plants (Groups A and B).

333.08.02 Tree Ties. The method of attaching the ties to stakes and trees shall provide a firm connection, as shown in the Plans or as approved by the Landscape Architect.

333.08.03 Guying. All guying shall be done as specified in the Special Provisions, indicated on the Plans, or as approved by the Landscape Architect.

333.09 PRUNING. Prune the minimum necessary to remove injured twigs and branches, deadwood, and sucker growth.

Prune evergreen coniferous plants only at the direction of the Landscape Architect.

333.10 WRAPPING. Spirally wrap trees from the bottom of the trunk to the top (height of the second branch); overlap wrapping approximately 2 inches.

333.11 WATERING. If water is available from a new or existing irrigation system within the limits of the project, it may be obtained from such system free of charge. Where water is not available from such facilities, the Contractor shall make his own arrangements for furnishing and applying water and he shall pay all costs involved.

Valves at meters shall be kept closed at all times, except while the irrigation system is actually in use.

Precautions shall be taken during times when the irrigation system is on to prevent water from wetting vehicles, pedestrians, and pavement. Any erosion, slippage, or settlement of the soil caused by watering shall be repaired by the Contractor at his expense.

Compliance with the provisions in this Section shall not relieve the Contractor of his responsibility for his replacement of plants as provided hereinafter.

333.11.01 Plants (Groups A and B). All plants shall be watered immediately after planting. Water shall be applied in a moderate stream until the backfill soil around and below the roots or ball, or earth around each plant, is thoroughly saturated. Where watering is done with a hose, a metal or plastic pressure reducing device approved by the Landscape Architect shall be used. Under no circumstances shall the full force of the water from the open end of a hose be allowed to fall within the basin around any plant.

After the first watering, water shall be applied to all plants as often and in sufficient amounts as conditions may require to keep the soil set above, around, and below the root systems of the plant during the life of the Contract. After the installed irrigation system has been accepted, it may be used to water the planted area.

Any additional watering measures required to initially saturate the backfill, water the plants immediately after planting, or to maintain the plants in a satisfactory growing condition shall be anticipated and furnished by the Contractor at his expense.

333.11.02 Plants (Group C). As soon as all the perennials in a given area have been planted, water shall be applied to that area in a fine mist from an atomizing nozzle until the entire planting bed is saturated. This initial watering shall not be done with the installed irrigation system.

After the first watering, water shall be applied to the areas as often and in sufficient amount as conditions may require to keep the soil wet above, around, and below the root systems of the plants during the life of the Contract.

333.11.03 Plants (Groups D and E). The seed beds shall be kept in a moist, but not soggy, condition until after germination. After germination, water shall be applied to the areas as often and in sufficient amount as conditions may require during the life of the Contract.

The installed turf irrigation system may be used to water those areas as long as care is taken to prevent erosion or other damage to the area. However, should the irrigation system prove to be unsatisfactory, other means of watering, as approved by the Landscape Architect, shall be used until germination is complete and all grass has attained a height of 1 inch. After the uniform stand of grass which has attained a height of 1 inch has been achieved over the entire turf area, the installed turf irrigation system may be used to keep the area moist.

333.12 REPLACEMENTS

333.12.01 Plants (Groups A, B, and C). During the planting and plant establishment period of the project, all plants that show signs of failure to grow normally or which are so injured or damaged as to render them unsuitable for the purpose intended, as determined by the Landscape Architect, shall be removed and replaced in kind. The Landscape Architect will inspect the work on the first or second working day of each week during the planting and plant establishment periods, and will mark or otherwise indicate all plants to be replaced. The Contractor shall complete replacement of such plants as soon as possible, but in no case shall the Contractor take more than 2 weeks to complete the replacement.

Plants required to replace plants shall be furnished and planted by the Contractor at his expense.

333.12.02 Plants (Groups D and E). Seed areas shall be in a thriving condition, having been properly seeded, and having produced an acceptable rate of germination. The seed area will be considered to have produced an acceptable rate of germination if, during inspection, the Landscape Architect can select a 12 square foot area of the work and find no portion of that area to have more than 10 percent soil visible.

The Landscape Architect will inspect the turf at the time of the second cutting and the meadow area when the grass has reached a height of approximately 2 inches and will designate any areas which require reseeding. Seed used for reseeding shall be the same types and amounts as specified for the initial planting and shall be planted in

accordance with the Special Provisions as directed by the Landscape Architect. The cost of the seed and actual reseeded shall be borne by the Contractor.

333.13 FERTILIZERS AND ADDITIVES. When fertilizers or additives are called for, they shall be applied at the rates as specified in the Special Provisions or as approved by the Landscape Architect.

333.14 PROTECTION OF EXISTING FACILITIES. Any existing buildings, equipment, piping, pipe covering, sprinkling systems, sewers, sidewalks, landscaping, utilities, roadways, or any other improvements of facilities damaged due to the Contractor's operations shall be repaired or replaced by the Contractor at his expense as directed by the Landscape Architect.

333.15 PLANT ESTABLISHMENT WORK. This work shall consist of watering and caring for all of the plants and planting areas, the replacement of plants, the weeding, and general maintenance as specified in the Contract Documents.

The plant establishment period shall begin at such time as all planting has been accomplished and all other work has been completed and the project is in a neat and clean condition.

The length of the plant establishment period shall be as specified in the Special Provisions.

The Landscape Architect will notify the Contractor in writing of the start of the plant establishment period, and will furnish statements regarding days credited to the plant establishment period after said notification.

The time required for plant establishment work shall be considered as included in the total time limit specified for the Contract. Any day upon which no work is required, as determined by the Landscape Architect, will be credited as one of the plant establishment days, regardless of whether or not the Contractor performs plant establishment work.

Any day when the Contractor fails to adequately water plants, replace unsuitable or damaged plants, perform weed control, adjust or replace bracing and ties, or other work as determined necessary by the Landscape Architect, will not be credited as one of the plant establishment days. No extension of Contract time will be granted beyond the final completion day by reason of failing to perform plant establishment work on days when such work is necessary.

All plants shall be kept watered, as indicated in Section 333.11 – "Watering" – of these Specifications.

Surplus earth, papers, trash, and debris which accumulates in the planted areas shall be removed and disposed of by the Contractor, and the planted areas shall be so cared for as to present a neat and clean condition at all times.

During the plant establishment period, trees and shrubs shall be pruned or headed back by the Contractor at his expense, when and as directed by the Landscape Architect.

In order to carry out the plant establishment work, the Contractor shall furnish sufficient men and adequate equipment to perform the work during the plant establishment period.

333.16 GUARANTEE. The Contractor shall guarantee all plant material through one full growing season after all plants are installed and Notice of Completion is filed. The Contractor shall inspect the site monthly to generally determine conditions of all plantings. If any changes in the overall maintenance program are required to improve the condition to an acceptable standard, the Contractor must notify the Owner in writing; otherwise, the Contractor accepts full responsibility for the condition of the plantings and must honor his guarantee for the 1 year period.

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Replacement plants under this guarantee shall be granted one full growing season from date of installation. Repair damage to other plants during plant replacement shall be at no cost to the Owner.

333.17 MEASUREMENT OF QUANTITIES. The quantity of material and work shall be measured in accordance with the Contract Documents, and shall be either lump sum for the landscaped area complete in place, or by unit prices established for the individual components of the landscaped area.

333.18 BASIS OF PAYMENT. The accepted quantities shall be compensated for at the lump sum or unit price established in the Contract Documents.

334.01 DESCRIPTION. This work shall consist of the installation of cast-in-place survey monuments at the locations shown on the Plans, in the Special Provisions, or as directed by the Engineer.

Monuments shall conform to the dimensions and details shown on the Plans.

334.02 MATERIALS. Materials used in the construction of survey monuments shall be in accordance with Section 216 – “Monuments” – of these Specifications.

Concrete used in the construction of survey monuments shall contain six sacks of Type II cement per cubic yard of concrete, 1 inch maximum aggregate size, and shall obtain a compressive strength of at least 3,000 p.s.i. in 28 days.

334.03 CONSTRUCTION. Survey monuments shall be cast-in-place in neat holes without the use of forms. The exposed surface of the finished monuments shall be uniform, of even texture, and free of holes, cracks, and chipped edges.

Bronze survey markers with deformed stems shall be placed in survey monuments before the concrete has acquired its initial set and shall be firmly embedded in the concrete. The concrete shall be so located that, when the marker is inserted, the reference point shall fall within a 1 inch circle in the center of the plate.

Monuments shall be set firmly and vertically in the ground to a minimum depth of 2 feet measured from the top of the monument cover. The concrete into which the bronze survey marker has been embedded shall extend up into the cast iron well, or “pot”, but will be shaped so that the bottom of the “pot” does not come in contact with the monument. A separation of a minimum of 1 inch shall be allowed between the “pot” and the monument. This separation shall be filled with a free-draining rock that extends to the bottom of the monument concrete, and the top of the monument concrete shall be shaped to drain from the center outward. The bronze survey marker shall be approximately 6 inches from the top of the cover.

334.04 PUNCHING/SCRIBING. Bronze survey markers shall have a point punched or a cross scribed at the location of the monument as indicated on the Plans. The point or cross shall be punched or scribed sufficiently deep to prevent the easy removal or defacing of the marks. The P.L.S. (Professional Land Surveyor) number shall be punched legibly on the survey marker.

The punching/scribing of the bronze survey marker can be done before the marker is inserted into the concrete. If the punching/scribing takes place after the marker has been inserted into the concrete, the points shall not be punched/scribed within 24 hours after placement into the concrete in order to allow the concrete to set.

334.05 MEASUREMENT OF QUANTITIES AND BASIS OF PAYMENT. Measurement of quantities shall be done in accordance with the Contract Documents, and the unit price paid for survey monuments shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all work involved in constructing the survey monuments complete, in place, including necessary excavation and backfill as shown on the Plans or as directed by the Engineer.

335.01 DESCRIPTION. This work shall include the cleanup of construction areas.

After all of the work indicated on the Plans and in the Specifications is completed and before final acceptance of the project, the entire construction area, including the roadbed, parking, sidewalk areas, shoulders, driveways, alleys, and side street approaches, slopes, ditches, sewer trenches, and construction areas, shall be neatly finished to the lines, grades, and cross-sections shown on the Plans as hereinafter specified.

335.02 DRESSING. Slopes, sidewalk areas, parking areas, and roadways shall be smooth and finished to the required cross-section and grade by means of a grading machine, so far as it is possible to do so without damaging the existing improvements, trees, and shrubs. Machine dressing shall be supplemented by hand work meeting the requirements as outlined herein.

At the completion of cleaning and dressing, the project shall appear uniform in all respects. All graded areas shall be true to line and grade shown on typical sections and as required by the Engineer.

All rocks in excess of 2 inches in diameter, or as directed by the Engineer, shall be removed from the entire construction area by loading into trucks and disposing in the same manner as required for the waste material. In no instance shall the rocks be thrown onto private property. Overhang on slopes shall be removed and slopes dressed neatly so as to present a uniform, well-sloped surface.

All windrows of earth at the outer lateral limits of the project shall be removed entirely. Trash of any kind resulting from clearing and grubbing or grading operations shall be removed and disposed of at the Contractor's expense. Where machine operations have broken down the brush and trees beyond the lateral limits of the project, the Contractor shall remove and dispose of same at his expense.

All catch basins and manholes shall be cleaned, as well as open ditches and pipes which have been partially clogged by the Contractor's activities. The Contractor will not be required to perform any work beyond that described in these Specifications. The Contractor shall remove and dispose of all construction stakes.

335.03 PAVEMENT SURFACES. All pavement surfaces, whether new or old, shall be thoroughly cleaned and sidewalks shall be hand swept. The Contractor shall flush the street at the conclusion of the work.

335.04 SEWER PROJECTS IN UNDEVELOPED AREAS. On sewer projects where all or portions of construction are in undeveloped areas, the entire area which has been disturbed by the construction shall be shaped by blading with a dozer or motor-patrol grader so that, at completion, the area will present a uniform appearance blending to the contour of the adjacent properties.

335.05 MEASUREMENT OF QUANTITIES AND BASIS FOR PAYMENT. Unless specified otherwise, no direct compensation shall be paid for cleanup work. The Contractor shall include cleanup work as a part of the several segments of work involved.

336.01 DESCRIPTION. All materials furnished by the *Contractor* shall be subject to the inspection, testing, and approval by the Engineer. All sampling and acceptance testing for public works construction shall be performed by an approved independent testing laboratory accredited by AASHTO or other ASTM recognized accrediting organization in the applicable test methods and paid for as stipulated in the Special Provisions. Accreditation requirements became effective March 1, 2008, for all public works construction, whether administered directly by local government agency or by developer. Individuals who perform acceptance or field testing and sampling for public works construction shall have the appropriate qualification from the Nevada Alliance for Quality Transportation Construction (NAQTC). ACI Grade I Technician certification is recognized by the NAQTC for concrete testing. NAQTC qualification requirements became effective January 1, 2002, for all public works construction, whether administered directly by local government agency or by developer. For specific information regarding training, examination, and qualification, contact:

University of Nevada, Reno
1664 North Virginia Street/MS257
Reno, Nevada 89557
(775) 784-1433

Random sampling and testing shall be conducted after the *Contractor* has delivered materials to the site to verify that they meet the Specifications. Materials that do not meet the Specifications and are rejected shall be immediately removed from the site. The *Contractor* shall furnish, at no additional expense, any labor that may be required to enable the Engineer to make a thorough inspection of the materials. The neglect or failure on the part of the Engineer to condemn or reject materials or work shall not be construed to imply an acceptance of the materials or work.

336.02 SAMPLING AND TESTING. Sampling and testing of materials and methods shall be in accordance with the latest revision of the following methods:

SOILS

<u>Test</u>	<u>Test Methods</u>
California Bearing Ratio (CBR) of Laboratory-Compacted Soils	ASTM D 1883
Density of Soil In-Place by Nuclear Method	ASTM D 2922
Density of Soil In-Place by Rubber Balloon Method	ASTM D 2167
Density of Soil In-Place by Sand Cone Method	ASTM D 1556
Liquid Limit, Plastic Limit, Plasticity Index of Soils	ASTM D 4318
Material in Soils Finer than No. 200 Sieve	ASTM D 1140
Moisture Content of Soil Microwave Oven Method	ASTM D 4643
Moisture Content of Soil Nuclear Method	ASTM D 3017
Moisture Content of Soil Oven Dry Method	ASTM D 2216
Moisture Density Relation of Soil using 10 lb. Rammer and 18-inch Drop	ASTM D 1557
pH	ASTM E 70
Particle Size Analysis of Soils	ASTM D 422
Resistance (R) Value	ASTM D 2844
Sand Equivalent of Soils and Fine Aggregate	ASTM D 2419
Shrinkage Factors of Soils	ASTM D 427
Specific Gravity of Soil Solids by Water Pycnometer	ASTM D 854

AGGREGATES

<u>Test</u>	<u>Test Methods</u>
Absorption and Bulk Specific Gravity of Dimension Stone	ASTM C 97
Aggregate Durability Index	ASTM D 3744
Clay Lumps and Friable Particles in Aggregates	ASTM C 142
Cleanness of Coarse Aggregate	NEV T228
Effect of Organic Impurities in Fine Aggregates on Strength of Mortar	ASTM C 87
Fractured Particles in Coarse Aggregate	ASTM D 5821
Lightweight Particles in Aggregate	ASTM C 123
Liquid Limit, Plastic Limit, Plasticity Index of Soils	ASTM D 4318
Material Finer than No. 200 Sieve	ASTM C 117
Organic Impurities in Fine Aggregates for Concrete	ASTM C 40
Petrographic Examination of Aggregates for Concrete	ASTM C 295
Potential Alkali Reactivity of Cement Aggregate Combinations	ASTM C 33
Resistance to Degradation of Small Size Coarse Aggregate by Abrasion	ASTM C 131
Resistance to Degradation of Large Size Coarse Aggregate by Abrasion	ASTM C 535
Resistance (R) Value	ASTM D 2844
Sampling Aggregates	ASTM D 75
Sand Equivalent of Soils and Fine Aggregate	ASTM D 2419
Sieve Analysis of Fine and Coarse Aggregate	ASTM C 136
Soundness of Aggregates by Sodium Sulfate or Magnesium Sulfate	ASTM C 88
Specific Gravity & Absorption of Coarse Aggregate	ASTM C 127
Specific Gravity & Absorption of Fine Aggregate	ASTM C 128
Unit Weight and Voids in Aggregate	ASTM C 29

CEMENT TREATED AGGREGATE BASE

Making and Curing of Soil-Cement Compression and Flexure Test Specimens In the Laboratory	ASTM D 1632
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SLURRY BACKFILL

Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders	ASTM D 4832
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PORTLAND CEMENT CONCRETE

<u>Test</u>	<u>Test Methods</u>
Air Content of Fresh Concrete (Pressure Method)	ASTM C 231
Air Content of Fresh Concrete (Volumetric Method)	ASTM C 173
Bleeding of Concrete	ASTM C 232
Compressive Strength of Molded Concrete Cylinders	ASTM C 39
Flexural Strength of Concrete	ASTM C 78
Standard Specification for Lightweight Aggregates for Structural Concrete	ASTM C 330
Making & Curing Concrete Compression & Flexure Test Specimen in the Field	ASTM C 31
Making & Curing Concrete Compression & Flexure Test Specimen in the Laboratory	ASTM C 192
Measuring Length of Drilled Concrete Cores	ASTM C 174
Obtaining & Testing of Drilled Cores & Sawed Beams of Concrete	ASTM C 42
Resistance of Concrete to Rapid Freezing & Thawing	ASTM C 666
Sampling Fresh Concrete	ASTM C 172
Slump of Portland Cement Concrete	ASTM C 143
Splitting Tensile Strength of Molded Concrete Cylinders	ASTM C 496
Unit Weight and Yield	ASTM C 138
Unit Weight of Structural Lightweight Concrete	ASTM C 567

BITUMINOUS MIXTURES

<u>Test</u>	<u>Test Method</u>
Air Voids in Compacted Dense and Open Bituminous Paving Mixtures	ASTM D 3203
Asphalt Binder Content of Hot Mix Asphalt (HMA) by Ignition Method	AASHTO T 308
Asphalt Content of Hot Mix Asphalt (HMA) by Ignition Method	ASTM D 6307
Asphalt Mixture by Means of the Marshall Apparatus	AASHTO R 68
Bituminous Specimens Using Marshal Apparatus	ASTM D 6926
Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures	ASTM D 2726
Marshall Stability and Flow of Bituminous Mixtures	ASTM D 6927
Mechanical Size Analysis of Extracted Aggregate	ASTM D 5444
Performance-Graded Asphalt Binder	AASHTO M 320
Quantitative Extraction of Bitumen from Bituminous Paving Mixtures	ASTM D 2172
Recovery of Asphalt from Solution by Abson Method	ASTM D 1856

BITUMINOUS MIXTURES, CONTINUED

Recovery of Asphalt from Solution using the Rotary Evaporator	ASTM D 5404
Sampling Bituminous Materials	ASTM D 140
Sampling Bituminous Paving Mixtures	ASTM D 979
Superpave Volumetric Mix Design	AASHTO M 323
Theoretical Maximum Specific Gravity of Bituminous Paving Mixtures	ASTM D 2041
Thickness or Height of Compacted Bituminous Paving Mixture Specimens	ASTM D 3549

336.03 TESTING REQUIREMENTS

336.03.01 FILL MATERIAL. All backfill material and base material placed in roadway sections and designated fills shall be controlled for compaction by performing at least the minimum testing as specified below. The density tests shall be compared to the maximum dry density as determined by ASTM D 1557.

Fill Material Minimum Density Testing Requirements are as follows:

- A. Mass Grading. One test for each 500 cubic yards or fraction thereof placed daily.
- B. Roadway, Curb & Gutter, and Sidewalk Subgrade and Base. One test for every 250 linear feet of roadway.
- C. Trench Bedding. One test between manholes or valves, or every 500 feet, including laterals, whichever is more restrictive.
- D. Trench Backfill. One test per 1 Foot of thickness between manholes or valves, or every 500 Feet, including laterals, whichever is more restrictive.

Testing of trench backfill shall be distributed along the pipe alignment and not clustered at a single location. If test pits are required for testing, no more than two tests may be performed in a single test pit.

All material shall be tested for gradation and plasticity index, if required by the Plans and Specifications, within 1 month of the date the material is delivered. Additional testing may be required at the discretion of the testing agency.

336.03.02 GENERAL STRUCTURAL USE PORTLAND CEMENT CONCRETE. Four 6 x 12 Inch or five 4 x 8 Inch test cylinders shall be prepared and tested for each day's pour of concrete per mix, or every 50 cubic yards per mix, whichever is more restrictive. It is recommended, that the diameter of cylindrically molded specimens be at least equal to four times the nominal maximum size of the aggregate. Additional cylinders may be taken at the *Contractor's* request and expense. Slump, air content, and temperature tests shall also be performed at the time of sampling.

During field curing, cylinders shall be protected from the elements in a container equipped with a thermometer capable of recording the high and low temperature experienced during the storage period. Records of thermometer readings shall be documented on the test forms.

One cylinder from each set shall be tested at 7 days, one at 14 days, and the remaining cylinders at 28 days, unless the first 28 day test indicates that the specified compressive strength has not been attained. In the event the specified strength has not been attained in 28 days, the remaining cylinder(s) shall be tested at 56 days.

When the final compressive strength test indicates that the specified compressive strength has not been attained, cores may be obtained from adjacent areas at the *Contractor's* expense. Three cores shall be taken for each location that the compressive strength test result is challenged. Cores shall be obtained and moisture conditioned in accordance with ASTM C 42. It is recommended, that the diameter of cored specimens or the width of sawed specimens be at least equal to four times the nominal maximum size of the aggregate.

Concrete in the area represented by the cores shall be considered structurally adequate and in compliance with specification documents if the average of the three cores is equal to at least 85 percent of the required minimum design strength, and no single core is less than 75 percent of the design strength. To check testing accuracy, locations represented by erratic core strengths may be retested. Should the cores document that the concrete is structurally adequate, the *Contractor* may request compensation for the expenses associated with the cores. Should the additional cores prove deficient, the work shall be subject to rejection.

336.03.03 SPECIFIC USE PORTLAND CEMENT CONCRETE.

336.03.03.01 Portland Cement Concrete for Roadway Paving. This Subsection intentionally left blank.

336.03.03.02 Air Placed Concrete. The strength of air placed concrete shall be determined from cores cut from the completed work and/or cores cut from test panels as directed by the Engineer. At least one set of test specimens shall be obtained for each day's work from each nozzleman employed.

Panels prepared for core tests shall be constructed by the *Contractor* of material that is representative of that used in the structure. The size of the test panel shall be as directed by the Engineer. Four Inch diameter (minimum) core specimens shall be obtained from the completed work or test panels and tested in accordance with ASTM C 42 at the *Contractor's* expense. Core holes in the completed work shall be repaired with mortar. If the test specimens are cored, one shall be tested at 14 days. The remaining two specimens shall be tested at 28 days.

When the final compressive strength test indicates that the specified compressive strength has not been attained, additional cores may be obtained from adjacent areas at the *Contractor's* expense. Cores shall be obtained and moisture conditioned in accordance with ASTM C 42. Should the additional cores prove deficient, the work shall be subject to rejection.

336.03.04 BITUMINOUS MIXTURES/HMA.

336.03.04.01 BITUMINOUS MIXTURES/HMA. Bituminous mixtures, with the exception of chip seal, slurry seal and micro-surfacing, shall be tested for density on a "lot" basis. A "lot" for density determination will consist of 500 tons of bituminous mixture or portion thereof exceeding 250 tons for each day's placement, with each day's placement consisting of at least one "lot".

At the discretion of the Engineer, mineral aggregate may be sampled from bins of the asphalt paving plant for every 2000 tons of materials used in bituminous mixture, and shall be tested to determine conformance with gradation, liquid limit, and plasticity index specifications.

336.03.04.02 BITUMINOUS MIXTURES/HMA.

HMA SAMPLING AND TESTING. Sampling and testing shall conform to Table 336.03.04.02-I.

Table 336.03.04.02-1

Test	Test Method	Frequency
Sampling Bituminous Paving Mixtures	ASTM D979 ⁽¹⁾	1 per lot
Air Voids in Compacted Dense and Open Bituminous Paving Mixtures	ASTM D3203	
Asphalt Content of Hot-Mix Asphalt by Ignition Method	ASTM D6307 ⁽²⁾	1 per lot
Quantitative Extraction of Bitumen from Bituminous Paving Mixtures	ASTM D2172 ⁽²⁾	
Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures	ASTM D2726 Compacted Pavement	1 set per lot
	ASTM D2726 Lab molded	1 per 2,000 tons, or 1 per day whichever is more
Marshall Stability and Flow of Bituminous Mixtures	ASTM D6927	1 per 2,000 tons, or 1 per day whichever is more
Mechanical Size Analysis of Extracted Aggregate	ASTM D5444	1 per lot
Theoretical Maximum Specific Gravity of Bituminous Paving Mixtures	ASTM D2041 ⁽³⁾⁽⁴⁾	1 per lot
Thickness or Height of Compacted Bituminous Paving Mixture Specimens	ASTM D3549 ⁽⁵⁾ Compacted Pavement	1 set per lot
	ASTM D3549 ⁽⁶⁾ Lab Molded	1 per 2,000 tons, or 1 per day whichever is more
Sampling Bituminous Materials	ASTM D140	As directed

1. A minimum of three locations shall be sampled within a 20-Foot traverse of the paver. However, no samples will be taken within 1 Foot of either edge of paver width. The sample shall be taken such that the material sampled will represent a single lot. When samples are obtained by more than one testing laboratory, the samples shall be split from a single sample or taken at the same time and at locations immediately adjacent to each other.
2. Unless shown on the *Plans* or specified in the *Special Provisions* and/or *Special Technical Specifications*, method shall be selected by the *Engineer*.
3. Test duration shall be 15 minutes unless stripping is noted in which case the test will be discontinued when stripping is first observed (note: an automatic timer is recommended).
4. The supplemental "dry back" procedure shall not be used.
5. Thickness shall be determined using Method A to the nearest 0.05 Inch for individual samples with the average for the lot rounded to the nearest 0.1 Inch. Averages ending in 0.05 shall be rounded up. For laboratory compacted specimens for air voids analysis, the thickness shall be reported to the 0.01 inch.
6. Thickness shall be determined and reported using Method A to the nearest 0.01 Inch

Shipping. Samples shall be transported in containers constructed to preclude heat loss or eliminate contamination of any part of the sample, or damage to the contents from mishandling during shipment.

Required Information. Samples shall have individual identification attached giving the following information at a minimum:

- A. Project name, highway or street name, and other pertinent geographical information;
- B. *Contractor* placing the *HMA*;
- C. *HMA* plant location and mix Identification;
- D. Point at which sampled, for samples taken from roadway, both by station and location transversely in pavement; lift and specified thickness, sample location;
- E. Quantity represented and lot number;
- F. Date sampled;
- G. Personnel name(s);

- H. Other parties obtaining sample(s) representative of the lot and if split or individual samples(s); and
- I. Temperature of the *HMA* upon sampling.

The temperature of the *HMA* as received in the laboratory shall be recorded and reported.

An approximate sample size of 50 pounds or more shall be obtained such that a 25 pound sample is available for retesting at a later date. All samples shall be retained until the entire project is accepted.

Laboratory Testing of *HMA*. The testing agency shall make every effort to provide test results in a timely manner. Mix properties and Marshall test results should be provided within 24 hours of *HMA* placement. *Rice Relative Compaction* results should be provided within 48 hours of obtaining cut samples.

Preparing Field Sample. The *HMA* sample received by the laboratory shall be split or quartered, such that enough material is available to perform required tests with a minimum excess of 2,000 grams of *HMA*.

Theoretical Maximum (Rice) Specific Gravity. At least one *Theoretical Maximum (Rice) Specific Gravity* determination shall be made for each lot to be tested.

Mix Properties. Bituminous Mixtures shall be tested in accordance with the frequencies shown in Table 336.03.04.02.02-I. As directed or approved by the *Engineer* the frequency may be adjusted.

Ignition Oven Correction Factors. Laboratories testing *HMA* shall request and obtain representative samples of all materials used in the production of the *HMA*, including, but not limited to, aggregates (virgin and recycled), binder and additives, for determination of equipment specific ignition oven correction factors in accordance with *AASHTO T 308* for each type of aggregate used.

Marshall Compaction. The field sample shall be reheated to the associated mix design compaction temperature for Marshall testing in a covered container in an oven. Duration of reheating of the sample and the oven temperature shall be noted on the test report.

The mold assembly, hammers and pedestal shall conform to *ASTM D6926*. Molds and hammers shall be heated to a temperature between 200-300°F. A filter paper should be placed in the bottom of the mold and the amount of *HMA* to achieve a 2-1/2 Inch compacted sample shall be placed in the mold. It may be necessary to adjust the mass of *HMA* placed in the mold by splitting or quartering to ensure a 2-1/2 inch specimen is achieved. Specimens outside the range of 2.450-2.550 inches in measured thickness shall be considered invalid for laboratory air voids determination.

Spade the mixture vigorously with a heated spatula 15 times around the perimeter and ten times over the interior. Smooth the surface of the mix with a heated spatula to a slightly rounded shape. Temperatures of the *HMA* immediately prior to compaction shall be within 5°F of the compaction temperature used in the preparation of the mix design.

Compact the specimens with a properly correlated single mechanical compactor with a fixed base or by a manually held, hand-operated Marshall compaction hammer. If a dispute arises a manually operated, hand-held Marshall compaction hammer shall be the referee method.

In addition to the procedures outlined in *ASTM D6926*, Section 1.3, the number of compaction blows to be applied by a mechanical Marshall hammer shall be adjusted to produce Marshall unit weights within 2% of a manually held hand-operated Marshall compaction hammer on a similar mix. At a minimum, this correlation shall be performed annually for each mechanical hammer at 50 and 75 blows on each aggregate source. Correlation records shall be made available upon request.

A minimum of three specimens shall be compacted for each *HMA* sample taken. The compacted samples may be extruded from the molds once the molds have reached approximately 120°F.

Specimens shall be corrected for stability based on Table 1 of *ASTM D6927*. The height of the specimens shall be determined by Method A of *ASTM D3549* using properly calibrated calipers.

Marshall Density. The range of specific gravity test results of the three Marshall specimens shall not exceed 0.020. One specimen may be eliminated from the set of Marshall specimens when averaging the specific gravity values and analyzing the validity of the set of specimens.

Note: The eliminated specimen must be obviously different than the other two; otherwise the entire set shall be rerun.

An additional set of Marshall specimens shall be prepared in accordance with the above procedures if specimens do not conform to thickness range requirements.

Record and report the specimen set average dry mass in grams to the nearest 0.1 gram, and measured thickness to the nearest 0.01 inch on the test result summary.

Relative Compaction. Relative compaction of the compacted layer shall be determined by dividing the specific gravity of a cut sample by the *Theoretical Maximum (Rice) Specific Gravity* representative of lot from which the sample was obtained expressed as a percentage to the nearest 0.1 percent. At least three cut samples shall be obtained at random representative locations within the lot. Cut samples which are vertically comprised of more than one lot placed shall be divided at the interface(s) of the lot(s) and each lot shall be individually tested.

The average *Rice Relative Compaction* of each lot will be based on the average of the relative compaction determinations, rounded to the nearest 1 percent. *Rice Relative Compaction* which averages exactly 0.5 percent and greater shall be rounded up to the nearest 1 percent; *Rice Relative Compaction* which averages less than 0.5 percent shall be rounded down to the nearest 1 percent. At the *Engineer's* option, *Rice Relative Compaction* may be reported to the nearest 0.1 percent for informational purposes; however, evaluation for acceptance and mitigation shall be based on the *Rice Relative Compaction* of the lot rounded to the nearest 1 percent.

In the event that *Rice Relative Compaction* of the lot based on the initial cut samples obtained does not conform to Subsection 320.04.02 – “Relative Compaction”, supplemental cut samples may be obtained. The *Engineer* and *Contractor* shall agree on the method of payment prior to obtaining the cut samples. The *Engineer* and *Contractor* shall agree if the supplemental results will be used in determining the *Rice Relative Compaction* of the lot or to isolate areas of low relative compaction and select the sample locations.

Results of all tests performed by qualified personnel in an *Accredited Laboratory* shall be accepted for determination of the *Rice Relative Compaction* of the lot. All supplemental results will be used in addition to, not in lieu of, the relative compaction obtained on the initial cut samples.

Thickness. Compacted *HMA* layer thickness of the lot shall be determined from the average of the thicknesses of the random cut samples obtained for relative compaction determination.

Individual cut samples shall be measured to the nearest 0.05”. Individual cut samples shall be recorded and reported to the nearest 0.05” in accordance with the Table 336.03.04.02-II.

Table 336.03.04.02-II

Recorded Individual Measurements		Reported Thickness ⁽¹⁾
Using Apparatus Capable of 2 Decimal Places	Using Apparatus Capable of 1/16 Inch	
2.23” to 2.27”	2-4/16” = 2.250”	2.25”
2.28: to 2.32”	2-5/16” = 2.313”	2.30”
2.33” to 2.37”	---	2.35”
2.38” to 2.42”	2-6/16” = 2.375”	2.40”
2.43” to 2.47”	2-7/16” = 2.438”	2.45”
2.48” to 2.52”	2-8/16” = 2.500”	2.50”

1. Rounded.

For purpose of acceptance and mitigation, the average of the rounded thickness measurements of the 3 cut samples for each lot shall be reported to the nearest 0.1". A number ending in 0.05" shall be rounded up. For example, both 2.35" and 2.40" are rounded to 2.4".

In the event that average thickness of the lot based on the initial cut samples obtained does not conform to Subsection 320.03.10 – "Thickness", supplemental cut samples may be obtained. The *Engineer* and *Contractor* shall agree on the method of payment prior to obtaining the cut samples. The *Engineer* and *Contractor* shall agree if the supplemental results will be used in determining the average thickness of the lot or to isolate areas of insufficient thickness and select the sample locations.

All supplemental results will be used in addition to, not in lieu of, the thicknesses of the initial cut samples.

Thickness Greater Than ½ Inch Less Than Specified Minimum Thickness. In the event that a cut sample is greater than ½ inch less than the specified minimum thickness, three supplemental cut samples shall be obtained within a 15' radius of the sample that is deficient. The *Engineer* and *Contractor* shall agree if the supplemental results will be used in determining the thickness of the lot or to isolate areas of deficient thickness and select the sample locations. When used for lot thickness determination, the initial cut sample thickness shall be averaged with the thicknesses of the three supplemental cut samples and the resultant value shall be averaged with the thicknesses of the remaining initial cut samples.

RAP Used in HMA. In addition to conformance to Subsections 336.03.04.02 – "Preparing Field Sampling" and "Laboratory Testing of HMA", process control testing shall be performed on the stockpiled RAP used in HMA.

General. Regardless of the percentage of RAP incorporated in the HMA, each finished RAP stockpile shall be tested to verify production of a uniform material. One representative sample shall be obtained for every 1000 tons of RAP in a stockpile, with a minimum number of 3 samples per stockpile. The following tests shall be performed on each sample:

Standard Practice for Sampling Aggregates	ASTM D75
Bitumen Ratio	ASTM D6307
Or¹	
Quantitative Extraction of Bitumen from Bituminous Mixtures	ASTM D2172
Extracted Aggregate Gradation	ASTM D5444

The individual values as determined during stockpile testing should not vary more than 2 percent between the high and low values for bitumen ratio.

Note 1: Perform both ASTM D6307 and ASTM D2172 on at least 3 split samples per stockpile for the establishment of the ignition oven correction factor.

In addition, one composite sample shall be obtained by combining a fraction from each individual 1000 ton sample, representing no more than 5000 tons of RAP produced. The following tests shall be performed on the composite sample:

Bulk Specific Gravity of Coarse Aggregate	ASTM C127
Bulk Specific Gravity of Fine Aggregate	ASTM C128
Theoretical Maximum Specific Gravity of Bituminous Paving Mixtures	ASTM D2041
Quantitative Extraction of Bitumen Mixtures	ASTM D2172
Extracted Aggregate Gradation	ASTM D5444

RAP aggregate shall have a minimum combined aggregate bulk specific gravity of 2.470.

Any subsequent or additional testing of RAP required for mix design purposes shall be conducted on representative samples taken from the RAP stockpile.

HMA Containing Greater Than 15 Percent RAP By Dry Weight of Aggregate. For *RAP* to be incorporated in a recycled bituminous plantmix in an amount greater than 15 percent by dry weight of aggregate, 1 representative sample shall be obtained for every 5000 tons of *RAP* in a stockpile, with a minimum of 1 sample per stockpile. The testing program shall include the performance of one of the following test sets:

Quantitative Extraction of Bitumen from Bituminous Mixtures	ASTM D2172
Recovery of Asphalt from Solvent by the Abson Method	ASTM D1856
Performance Graded Asphalt Binder	AASHTO M 320
Appendix of Superpave Volumetric Mix Design (Blending Charts)	AASHTO M 323
Or	
Quantitative Extraction of Bitumen from Bituminous Mixtures	ASTM D2172
Practice for Recovery of Asphalt from Solution using the Rotary Evaporator	ASTM D5404
Performance Graded Asphalt Binder	AASHTO M 320
Appendix of Superpave Volumetric Mix Design (Blending Charts)	AASHTO M 323

The blend of *RAP* binder and virgin asphalt binder shall meet the original binder grade as specified by the *Engineer*.

Unless otherwise directed or approved by the *Engineer*, combined aggregate blend, including *RAP*, shall be sampled at the plant daily, and shall be tested to determine conformance with gradation, liquid limit, and plasticity index specifications.

336.03.05 STEEL. Mill Certificates for structural and reinforcing steel shall be submitted by the *Contractor*.

336.03.06 PIPE. This Subsection intentionally left blank.

336.03.07 GRAVITY LINES - PRESSURE TESTS

336.03.07.01 Description. This work shall consist of the testing of all sewers and appurtenances, such as manholes, tees, risers, and services for the purposes of determining whether or not the facility has been installed in such a manner as to meet hydrostatic requirements set forth herein. Testing of storm drains may be required at the request of the *Engineer* or *Agency*.

336.03.07.02 Responsibility of Contractor. It shall be the responsibility of the *Contractor* to construct all sewers and appurtenances consistent with testing requirements contained herein. Any section tested, including manholes, which does not meet these requirements shall be repaired and retested until the conditions set forth herein are met. Any cost incurred by the *Contractor* in repair or reconstructing lines will be the sole responsibility of the *Contractor*.

The *Contractor* shall furnish all labor, equipment, and materials necessary to perform pressure tests.

Hydrostatic or Air Pressure tests may be used as approved by the *Engineer* or *Agency*.

336.03.07.03 Hydrostatic Tests. Water to be used in these tests will be furnished to the *Contractor* free of charge at hydrants. The *Contractor* shall meet the requirements of Section 143 - "Utility Services" of these Specifications and respect the use of Agency-owned hydrants. Where hydrants are not accessible, the *Contractor* shall provide necessary equipment for hauling water.

The hydrostatic tests shall be conducted in the presence of the *Engineer* or his authorized representative.

336.03.07.03.01 Test Requirements

- A. General. The *Contractor* shall be required to test each section of gravity sanitary sewer for leakage by means of a hydraulic test. Gravity sanitary sewers shall be tested by water exfiltration or infiltration method. The *Engineer* may allow substitution of an air pressure test for the water exfiltration test.

- B. Exfiltration. Each section of sewer shall be tested between successive manholes by closing the lower end of the pipe to be tested and the inlet of the upper manhole with plugs. The test shall be made after the pipe has been bedded and backfilled to a minimum of 1 Foot above the crown of the pipe, unless otherwise allowed by the *Agency* or *Engineer*. Prior to the start of the test, the sewer may be filled with water to a height of 5 feet over the crown of the pipe or existing groundwater and allowed to stand for a period not to exceed 72 hours.

Hydrostatic head for test purposes shall be equivalent to a maximum head of 5 feet above the (a) crown of the pipe at the upper manhole, or (b) groundwater level at the time of the test, whichever is greater. Where the gradient of the sewer would allow the hydrostatic head to exceed 7 feet above the crown at the lower manhole, the allowable leakage will be increased in accordance with these Specifications.

Hydrostatic test head shall be maintained for a period of at least 1 hour, or for such a length of time as may be necessary to satisfy the *Agency* or *Engineer*. Test shall be acceptable if the maximum allowable exfiltration from the sewer line does not exceed 500 gallons per inch of pipe diameter per mile per 24 hours. For head in excess of 7 feet above the crown at the lower manhole, the allowable leakage will be increased at a rate of 80 gallons per inch of pipe diameter per mile per 24 hours.

When leakage or infiltration exceeds the amount allowed by the Specifications, the *Contractor* at his own expense shall locate the leaks and make necessary repairs or replacements to reduce the leakage or infiltration to the specified limits. Any individually detectable leaks shall be repaired, regardless of the results of the tests.

- C. Infiltration. Where the sewer is laid in groundwater, the *Agency* or *Engineer* shall require infiltration tests.

In areas where the groundwater is at least 2 feet above the crown of the pipe, the *Contractor* shall backfill to a depth to prevent floating of pipe and, in no case, less than 1 Foot above the groundwater or 4 feet above the crown on the pipe, whichever is greater. After the initial backfilling has been completed, the *Engineer* will measure the amount of infiltration at the lower manhole of each section being tested.

The final decision as to the method of testing by means of infiltration shall be made by the *Agency* or *Engineer*.

The allowable leakage in the sewer lines shall be equal to the amount allowed when testing by means of the exfiltration test. Infiltration shall not exceed 200 gallons per mile per day per inch of diameter of pipe at 5-Foot head.

336.03.07.04 Air Pressure Tests. The *Contractor* shall furnish all materials, equipment, and labor for making an air test. Air test equipment shall be approved by the *Agency* or *Engineer*, unless otherwise provided on the Plans or in the Special Provisions.

The air test may be dangerous if the line tested is not prepared properly or proper procedures are not followed. It is extremely important that plugs be installed and braced in such a way as to prevent blowouts. No one shall be allowed in or near manholes during pressurization, testing, or depressurization.

The *Contractor* shall submit to the governing *Agency* for approval a plan of safety in writing for any air test on pipe sizes above 24 Inches in diameter.

The *Contractor* may conduct an initial air test of the sewer main line after densification of the backfill, but prior to installation of the house connection sewers. Such test will be considered for the *Contractor's* convenience and need not be performed in the presence of the *Agency* or *Engineer*.

336.03.07.04.01 Test Requirements. Each section of sewer shall be tested between successive manholes by plugging and bracing all openings in the main line and the upper ends of all house connections for sanitary sewers. Prior to any air pressure testing, all pipe plugs shall be checked with a soap solution to detect any air leakage. If any leaks are found, the air pressure shall be released, the leaks eliminated, and the test procedure started over again.

The final leakage test of the main line and branching house connection sewers shall be conducted in the presence of the *Engineer* in the following manner:

Air shall be introduced into the pipeline until 3.0 p.s.i. (20.68kPa) gauge pressure has been reached, at which time the flow of air shall be reduced and the internal air pressure shall be maintained between 2.5 and 3.5 p.s.i. (17.24 and 24.13kPa) (gauge) for at least 2 minutes to allow the air temperature to come to equilibrium with the temperature of the pipe walls. Pressure in the pipeline shall be constantly monitored by a gate and hose arrangement separate from hose used to introduce air into the line. Pressure in the pipeline shall not be allowed to exceed 5 p.s.i. (34.47kPa) (gauge).

After the temperature has stabilized and no air leaks at the plugs have been found, the air pressure shall be permitted to drop and, when the internal pressure has reached 2.5 p.s.i. (17.24kPa) (gauge), the line shall be disconnected from the air source and a stop watch or sweep-second-hand watch shall be used to determine the time lapse required for the air pressure to drop to 1.5 p.s.i. (10.34kPa) (gauge).

If the time lapse (in seconds) required for the air pressure to decrease from 2.5 to 1.5 p.s.i. (17.24 to 10.34kPa) (gauge) exceeds that shown in the following table, the pipe shall be presumed to be within acceptable limits for leakage.

If the time lapse is less than that shown in the table, the *Contractor* shall make the necessary corrections to reduce the leakage to acceptance limits.

T = time in seconds for pressure to drop from 2.5 to 1.5 p.s.i. (17.24 to 10.34kPa) (gauge).

D = diameter (inside) of pipe in inches.

336.03.08 PRESSURE LINE - PRESSURE AND LEAKAGE TESTS.

336.03.08.01 Description. Test pressure shall not be less than 1 1/4 times the working pressure at the highest point along the test section.

Test pressure shall not exceed pipe or thrust-restraint design pressures.

The hydrostatic test shall have a minimum duration of 2 hours.

Test pressure shall not vary by more than ± 5 p.s.i. for the duration of the test.

Valves shall not be operated in either direction at differential pressure exceeding the rated valve working pressure. For tests at these pressures, the test setup shall include provision independent of the valve to reduce the line pressure to the rated valve pressure on completion of the test. The valve can then be opened enough to equalize the trapped pressure with the line pressure, or fully opened if desired.

TABLE 336.03.08-I
LOW PRESSURE AIR TEST FOR SEWERS

Time (T) in Seconds

<u>Main Line</u>		<u>4 Inch House Connection</u>					<u>Main Line</u>		<u>6 Inch House Connection</u>				
<u>Dia. Length</u>		<u>House Connection Length</u>					<u>Dia. Length</u>		<u>House Connection Length</u>				
<u>In.</u>	<u>Ft.</u>	<u>0 ft.</u>	<u>100 ft.</u>	<u>200 ft.</u>	<u>300 ft.</u>	<u>400 ft.</u>	<u>In.</u>	<u>Ft.</u>	<u>0 ft.</u>	<u>100 ft.</u>	<u>200 ft.</u>	<u>300 ft.</u>	<u>400ft.</u>
<u>8</u>	0	0	20	40	50	70	<u>8</u>	0	0	40	80	100	100
	50	40	50	70	90	80		50	40	70	110	110	110
	100	70	90	100	100	90		100	70	110	120	110	110
	150	110	120	110	100	100		150	110	120	120	120	110
	200	140	120	110	110	100		200	140	130	120	120	120
	300	140	130	120	110	110		300	140	130	120	120	120
	400	140	130	120	120	110		400	140	130	130	120	120
<u>10</u>	50	50	70	90	100	90	<u>10</u>	50	50	90	120	120	110
	100	110	130	120	110	110		100	110	140	130	130	120
	200	170	150	140	130	120		200	170	150	140	140	130
	300	170	160	150	140	130		300	170	160	150	140	140
	400	170	160	150	150	140		400	170	160	150	150	140
<u>12</u>	50	80	100	110	110	110	<u>12</u>	50	80	120	140	130	120
	100	160	170	150	140	130		100	160	170	150	140	140
	200	200	180	170	160	150		200	200	180	170	160	150
	300	200	190	180	170	160		300	200	190	180	170	160
	400	200	190	180	180	170		400	200	190	180	180	170
<u>15</u>	50	120	140	160	140	130	<u>15</u>	50	120	160	160	150	140
	100	250	220	190	170	160		100	250	210	190	170	160
	200	260	230	220	200	190		200	260	230	210	200	190
	300	260	240	230	220	210		300	260	240	220	210	200
	400	260	240	230	220	220		400	260	240	230	220	210

TALE 336.03.08 CONTINUED

Time (T) in Seconds

<u>Main Line</u>		<u>4 Inch House Connection</u>					<u>Main Line</u>		<u>6 Inch House Connection</u>				
<u>Dia. Length</u>		<u>House Connection Length</u>					<u>Dia. Length</u>		<u>House Connection Length</u>				
<u>In.</u>	<u>Ft.</u>	<u>0 ft.</u>	<u>100 ft.</u>	<u>200 ft.</u>	<u>300 ft.</u>	<u>400 ft.</u>	<u>In.</u>	<u>Ft.</u>	<u>0 ft.</u>	<u>100 ft.</u>	<u>200 ft.</u>	<u>300 ft.</u>	<u>400ft.</u>
<u>18</u>	50	180	200	190	170	150	<u>18</u>	50	180	220	190	170	160
	100	310	260	230	210	190		100	310	260	220	200	190
	200	310	280	260	250	230		200	310	280	260	240	220
	300	310	290	280	260	250		300	310	290	270	260	240
	400	310	290	280	270	260		400	310	290	280	270	260
<u>21</u>	50	240	260	230	200	180	<u>21</u>	50	240	260	220	200	180
	100	360	310	280	250	230		100	360	300	260	240	220
	200	360	330	310	290	280		200	360	330	300	280	260
	300	360	340	320	310	300		300	360	330	320	300	290
	400	360	340	330	320	310		400	360	340	330	310	300
<u>24</u>	50	320	320	270	240	210	<u>24</u>	50	320	310	260	220	200
	100	410	360	320	290	270		100	410	350	310	280	260
	200	410	380	360	340	320		200	410	370	350	320	310
	300	410	390	370	360	350		300	410	380	360	350	330
	400	410	390	380	370	360		400	410	390	370	360	350

Test pressure shall not exceed the rated pressure of the valves when the pressure boundary of the test section includes closed, resilient-seated gate valves or butterfly valves.

336.03.08.02 Pressurization. After the pipe has been laid, all newly laid pipe or any valved section thereof shall be subjected to a hydrostatic pressure of at least 1 1/2 times the working pressure at the point of testing. Each valved section of pipe shall be slowly filled with water, and the specified test pressure, based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe in a manner satisfactory to the *Agency* or *Engineer*. Valves shall not be operated in either the opening or closing direction at differential pressures above the rated pressure. It is good practice to allow the system to stabilize at the test pressure before conducting the leakage test.

336.03.08.03 Air Removal. Before applying the specified test pressure, air shall be expelled completely from the pipe, valves, and hydrants. If permanent air vents are not located at all high points, the *Contractor* shall install corporation cocks at such points so that the air can be expelled as the line is filled with water. After all the air has been expelled, the corporation cocks shall be closed and the test pressure applied. At the conclusion of the pressure test, the corporation cocks shall be removed and plugged or left in place at the discretion of the *Agency* or *Engineer*.

336.03.08.04 Examination. Any exposed pipe, fittings, valves, hydrants, and joints shall be examined carefully during the test. Any damaged or defective pipe, fittings, valves, hydrants, or joints that are discovered following the pressure test shall be repaired or replaced with sound material, and the test shall be repeated until it is satisfactory to the *Agency* or *Engineer*.

336.03.08.05 Leakage Defined. Leakage shall be defined as the quantity of water that must be supplied within 5 p.s.i. of the specified test pressure after the pipe has been filled with water and the air has been expelled. Leakage shall not be measured by a drop in pressure in a test section over a period of time.

336.03.08.06 Allowable Leakage. No pipe installation will be accepted if the leakage is greater than that determined by the following formula:

$$L = \frac{CSD\sqrt{P}}{133,200}$$

Where:

- L = allowable leakage, in gallons per hour
- S = length of pipe tested, in feet
- D = nominal diameter of the pipe, in inches
- P = average test pressure during the leakage test, in pounds per square inch (gauge)
- C = 1.0 for ductile iron pipe; 0.90 for C900 PVC pipe

These formulas are based on an allowable leakage of 11.65 gpd/mi/in. of nominal diameter at a pressure of 150 p.s.i.

Allowable leakage at various pressure per 1,000 feet of Pipeline shall conform to Table 336.03.08.06-l.

**TABLE 336.03.08.06
ALLOWABLE LEAKAGE (GPH/1000 Ft)**

Average Test Pressure	Nominal Pipe Diameter – Inches															
	3	4	6	8	10	12	14	1.6	1.8	20	24	30	36	42	48	54
450	0.48	0.64	0.95	1.27	1.59	1.91	2.23	2.55	2.87	3.18	3.82	4.78	5.73	6.69	7.64	8.60
400	0.45	0.60	0.90	1.20	1.50	1.80	2.10	2.40	2.70	3.00	3.60	4.50	5.41	6.31	7.21	8.11
350	0.42	0.56	0.84	1.12	1.40	1.69	1.97	2.25	2.53	2.81	3.37	4.21	5.06	5.90	6.74	7.58
300	0.39	0.52	0.78	1.04	1.30	1.56	1.82	2.08	2.34	2.60	3.12	3.90	4.68	5.46	6.24	7.02
275	0.37	0.50	0.75	1.00	1.24	1.49	1.74	1.99	2.24	2.49	2.99	3.73	4.48	5.23	5.98	6.72
250	0.36	0.47	0.71	0.95	1.19	1.42	1.66	1.90	2.14	2.37	2.85	3.56	4.27	4.99	5.70	6.41
225	0.34	0.45	0.68	0.90	1.13	1.35	1.58	1.80	2.03	2.25	2.70	3.38	4.05	4.73	5.41	6.03
200	0.32	0.43	0.64	0.85	1.06	1.28	1.48	1.70	1.91	2.12	2.55	3.19	3.82	4.46	5.09	5.73
175	0.30	0.40	0.59	0.80	0.99	1.19	1.39	1.59	1.79	1.98	2.38	2.98	3.58	4.17	4.77	5.36
150	0.28	0.37	0.55	0.74	0.92	1.10	1.29	1.47	1.66	1.84	2.21	2.76	3.31	3.86	4.41	4.97
125	0.25	0.34	0.50	0.67	0.84	1.01	1.18	1.34	1.51	1.68	2.01	2.52	3.02	3.53	4.03	4.53
100	0.13	0.30	0.45	0.60	0.75	0.90	1.05	1.20	1.35	1.50	1.80	2.25	2.70	3.15	3.60	4.05

- Note 1: For C900 and C905 PVC pipe, multiply the values in the table by 0.90.
- Note 2: If the pipeline under test contains sections of various diameters, the allowable leakage will be the sum of the computed leakage for each size.

- A. When testing against closed metal-seated valves, an additional leakage per closed valve of 0.0078 gpd/in. of nominal valve size shall be allowed.
- B. When hydrants are in the test section, the test shall be made against closed hydrant valves.
- C. Acceptance of Installation. Acceptance shall be determined on the basis of allowable leakage. If any test of laid pipe discloses leakage greater than that specified in this section, the *Contractor* shall, at his own expense, locate and make approved repairs as necessary until the leakage is within the specified allowance.
- D. All visible leaks are to be repaired, regardless of the amount of leakage.

336.03.09 PLASTIC PIPE DEFLECTION TEST.

336.03.09.01 Deflection Test for Plastic Pipe and Fittings. Installed pipe shall be tested to insure that vertical deflections for plastic pipe do not exceed the maximum allowable deflection. Maximum allowable deflections shall be governed by the mandrel requirements stated herein and shall nominally be:

1. Three percent of the maximum average ID for ABS or PVC Composite Pipe.
2. For all plastic pipe other than ABS or PVC Composite Pipe, the percentage listed of the maximum average ID.

<u>Nominal Pipe Size</u>	<u>Percentage</u>
Up to and including 12 Inch	5.0
Over 12 Inch to and including 30 Inch	4.0
Over 30 Inch	3.0

The maximum base inside diameter shall be equal to the average OD minus 2 times the minimum wall thickness in accordance with ASTM Standards and other manufacturing tolerances for determining maximum allowable deflections. See Appendix XI and table XI.1 of ASTM D 3034 and Appendix X2 and table X2.1 of ASTM F 679.

Deflection tests shall be performed not sooner than 30 days after completion of placement and densification of backfill. The pipe shall be cleaned and inspected for offsets and obstructions prior to testing. For all pipes less than 24 Inch ID, a mandrel shall be pulled through the pipe by hand to ensure that maximum allowable deflections have not been exceeded. If the mandrel fails to pass, the pipe will be deemed to be over-deflected. Prior to use, the mandrel shall be approved by the *Agency* or *Engineer* or by another entity approved by the *Agency*. Use of an uncertified mandrel or a mandrel altered or modified after certification will invalidate the test.

Any over-deflected pipe shall be uncovered and, if not damaged, reinstalled.

Damaged pipe shall not be reinstalled, but shall be removed from the work site. Any pipe subjected to any method or process other than removal, which attempts, even successfully, to reduce or cure any over-deflection, shall be uncovered, removed from the work site, and replaced with new pipe.

The mandrel shall:

1. Have an odd number of legs (9 legs minimum) and be a rigid, nonadjustable mandrel having an effective length not less than its nominal diameter.
2. Be fabricated of steel; be fitted with pulling rings at each end; be stamped or engraved on some segment, other than a runner, indicating the pipe material specification, nominal size, and mandrel OD (e.g., PVC D 3034-8" - 7.524", ABS Composite D 2680-10" - 9.584"); and be furnished in a suitable carrying case labeled with the same data as stamped or engraved on the mandrel. For the pipe IDs nominally 24 Inch and larger, deflections shall be determined by a method submitted to and approved by the Engineer. If a mandrel is selected, the minimum diameter, length, and other requirements shall conform to the dimensions and requirements as stated above.

All costs incurred by the *Contractor* attributable to mandrel and deflection testing, including any delays, shall be borne by the *Contractor* at no additional cost.

337.01 GENERAL.

337.01.01 MIX DESIGN. The *Contractor* shall submit, in writing, for approval by the *Engineer*, a mix design for the composition of each mixture to be supplied. Unless otherwise specified, the *Contractor* shall submit the mix design at least 30 *Calendar Days* prior to providing the material or product for acceptance by the *Engineer*. Written comments regarding the submittal shall be provided to the *Contractor* within 7 *Calendar Days* of the submittal. The *Contractor* shall ensure that the mix design has been reviewed and accepted by the *Engineer* prior to transport.

Unless otherwise specified, the mix design trial batch shall be prepared no more than 365 *Calendar Days* prior to the date of the submittal. Mix designs, with the exception of slurry seal and micro-surfacing, shall be performed in an *Accredited Laboratory* and stamped and signed by a *Professional Engineer*. Individuals who perform sampling and testing required for developing the mix design shall have the appropriate *NAQTC* qualification. *ACI* Grade I Technician certification is recognized by the *NAQTC* for *PCC* testing. Mix designs for slurry seal and micro-surfacing shall be performed in a qualified laboratory approved by the *ISSA*.

337.01.02 NEW MIX DESIGN BASED ON CHANGE IN SOURCE OR SUPPLIER OR CHANGES IN MIX PROPORTIONS. Unless waived by the *Agency* or *Engineer*, any change in source or *Supplier* of any of the component materials will require the preparation of a new mix design.

337.01.03 NEW MIX DESIGN BASED ON UNSATISFACTORY FIELD RESULTS. The *Agency* or *Engineer* may require a new mix design based on unsatisfactory test results.

337.01.04 TEST PROCEDURES. Unless otherwise noted or approved by the *Agency* or *Engineer*, all tests shall be performed in accordance with the current version of the referenced standard with no modifications.

337.02 CEMENT TREATED CRUSHED AGGREGATE BASE.

337.02.01 COMPOSITION OF MIXTURES. Cement treated crushed aggregate base shall consist of a mixture of aggregate, cementitious materials, and water.

The mix design for cement treated crushed aggregate base shall be determined utilizing samples compacted in accordance with ASTM D-1633-07, Method A, at the optimum moisture content for the mixture determined in accordance with ASTM D558. When specifications require a specific cement content, a one point design will be acceptable, provided the required strength is attained and all other parameters are satisfied. If no cement content is specified, at least three mixtures with varying cement contents shall be batched and the resulting strength versus age of specimen shall be graphically plotted for each mixture. The mix design shall conform to the requirements of Table 337.02.01-I.

TABLE 337.02.01-I

Test	Test Method	Requirements
Curing of Specimens	ASTM D 1632-07	-
Water Content	ASTM D 2216	Determine at time of compressive strength test
Compressive Strength at 7 days ⁽¹⁾⁽²⁾ (psi)	ASTM C 1633-07, Method A	As specified by <i>Agency</i> or <i>Engineer</i>

1. Unless otherwise specified by the *Agency* or *Engineer*.
2. Average of three specimens.

337.02.02 REPORT OF MIX DESIGN. The mix design report shall include the following:

- A. Mix *Supplier* and mix designation used by *Supplier*;
- B. Aggregate designation and source;
- C. Aggregate qualification test results and a gradation summary;
- D. Dry density of test specimens;
- E. Optimum moisture content and maximum dry density for each mixture batched determined in accordance with *ASTM D1557*;
- F. Specimen identification number(s);
- G. Cross-sectional area of specimen(s);
- H. Curing and conditioning periods;
- I. Age of specimen(s);

- J. Maximum load applied to specimen(s);
- K. Compressive strength test result(s);
- L. Recommended cementitious content;
- M. *Certificates of Compliance* for cementitious materials;
- N. Date of mix design preparation;
- O. *Accredited Laboratory* name and website address of accreditation program;
- P. Personnel name(s) and website address of qualification program;
- Q. Signature of mix design preparer; and
- R. Stamp and Signature of the *Professional Engineer* responsible for review of the mix design.

337.02.03 AGGREGATES. Aggregates shall conform to the requirements of Subsection 200.01.05 – “Aggregate for Cement Treated Crushed Aggregate Base”.

337.02.04 CEMENT AND RELATED MATERIALS. Cement and related materials, including mineral and liquid admixtures, shall conform to the requirements of Section 202 – “Cement and Related Materials”.

337.02.05 WATER. Water shall conform to the requirements of Section 205 – “Water”.

337.03 CEMENT TREATED RECYCLED AGGREGATE BASE.

337.03.01 COMPOSITION OF MIXTURES. Cement treated recycled aggregate base shall consist of a mixture of recycled aggregates, cementitious materials, and water.

The mix design for cement treated recycled aggregate base shall be determined utilizing samples compacted in accordance with ASTM D1633-07, Method A, at the optimum moisture content for the mixture determined in accordance with ASTM D 1557, with the exception that the maximum drying temperature shall be 140° F. When specifications require a specific cement content, a one point design will be acceptable, provided the required strength is attained and all other parameters are satisfied. If no cement content is specified, at least three mixtures with varying cement contents shall be batched and the resulting strength versus age of specimen shall be graphically plotted for each mixture. The mix design shall conform to the requirements of Table 337.03.01-I.

TABLE 337.03.01-I

Test	Test Method	Requirements
Curing of Specimens	ASTM D 1632-07	-
Water Content	ASTM D 2216	Determine at time of compressive strength test
Compressive Strength 7 days ⁽¹⁾⁽²⁾ (psi)	ASTM D 1633-07, Method A	As specified by <i>Agency</i> or <i>Engineer</i>

1. Unless otherwise specified by the *Agency* or *Engineer*.
2. Average of three specimens.

337.03.02 REPORT OF MIX DESIGN. The mix design report shall include the following:

- A. Mix *Supplier* and mix designation used by *Supplier*;
- B. Aggregate designation and source;
- C. Aggregate qualification test results and a gradation summary;
- D. Dry density of test specimens;
- E. Optimum moisture content and maximum dry density for each mixture batched determined in accordance with ASTM D1557;
- F. Specimen identification number(s);
- G. Cross-sectional area of specimen(s);
- H. Curing and conditioning periods;
- I. Age of specimen(s);
- J. Maximum load applied to specimen(s);
- K. Compressive strength test result(s);
- L. Recommended cementitious content;
- M. *Certificates of Compliance* for cementitious materials;
- N. Date of mix design preparation;
- O. *Accredited Laboratory* name and website address of accreditation program;
- P. Personnel name(s) and website address of qualification program;
- Q. Signature of mix design preparer; and
- R. Stamp and Signature of the *Professional Engineer* responsible for review of the mix design.

337.03.03 AGGREGATES. Aggregates shall conform to the requirements of Subsection 200.01.06 “Aggregate for Cement Treated Recycled Aggregate Base”.

337.03.04 CEMENT AND RELATED MATERIALS. Cement and related materials, including mineral and liquid admixtures, shall conform to the requirements of Section 202 – “Cement and Related Materials”.

337.03.05 WATER. Water shall conform to the requirements of Section 205 – “Water”.

337.04 BITUMINOUS PLANTMIX/HMA.

337.04.01 COMPOSITION OF MIXTURES. *Bituminous Plantmix/HMA* shall consist of a mixture of aggregate, including 15 percent or less of *RAP* by dry weight of the mix, asphalt cement, and additives, if required.

The aggregate gradation shall be well graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or inversely.

The mix design for *Bituminous Plantmix/HMA* shall be performed in accordance with the Asphalt Institute MS-2 (Asphalt Mix Design Methods), utilizing the Marshall method. *RAP* shall be produced, stockpiled and tested prior to the performance of a mix design. For purposes of the mix design, the weight of any *RAP* shall be considered to contribute solely to the total weight of the aggregate.

The specimens shall be compacted with a properly correlated single mechanical or a manually-operated Marshall compaction hammer.

The mix design shall demonstrate that the *Bituminous Plantmix/HMA* can attain a minimum dry tensile strength of at least 65 *PSI* and a tensile strength ratio of at least 70 percent determined in accordance with *AASHTO* T 283. The *Engineer* may elect to accept the addition of hydrated lime at a rate of at least 1-1/2 percent by dry weight of aggregate in lieu of test results.

The optimum asphalt cement content shall be determined to 0.1 percent, by total weight of mix and by dry weight of aggregate. The mix design for *HMA* shall conform to the applicable requirements of Table 337.04.01-I.

TABLE 337.04.01-I

Test	Test Method	Requirements			
		50 Blows per Side		75 Blows per Side	
Air Voids, Total Mix (%) ⁽¹⁾	ASTM D3203	3	4	3 ⁽²⁾	4
Voids in Mineral Aggregate (%) ⁽³⁾	MS-2	Per Table 7.3 of MS-2			
Voids Filled with Asphalt (%) ⁽³⁾	MS-2	-	65 - 78	-	65 - 75
Marshall Stability (pounds)	ASTM D6927	1800 Minimum			
Marshall Flow (0.01 inch)	ASTM D6927	8 – 20 ⁽⁴⁾			

1. Target value.
2. Unless directed by the *Engineer*, mix designs with the target air void value of 3% shall not be used for the surface course or within the zone affected by rutting when the Design *ESAL* > 10⁴.
3. At target air void percentage.
4. Marshall Flow requirements do not apply when polymer modified binders are used.

337.04.02 REPORT OF MIX DESIGN. The mix design report shall include the following:

- A. Mix *Supplier* and mix designation used by the *Supplier*;
- B. Aggregate designation and source;
- C. Aggregate qualification test results for the combined grading;
- D. Gradation summary, including percentage passing each specified sieve size for the individual materials and combined grading target values, demonstrating compliance with the gradation requirements set forth in section 200.02.03-I;
- E. Bin percentages, with each bin clearly identified;
- F. The job control grading band determined in accordance with Subsection 320.03.06.01.02.05 – “Job Control Grading Band” used during production;
- G. Asphalt cement grade and source;
- H. Specific Gravity of asphalt cement;

- I. Source and percentage by dry weight of aggregate of any mineral additive;
- J. Source and percentage based on percentage of binder of any chemical additive;
- K. Number of compaction blows per side as designated and correlated blow count if using mechanical hammer;
- L. Compaction and mixing temperatures used in producing the mix design;
- M. Summary of volumetric and mechanical mix properties for each asphalt cement content and related plots;
- N. Optimum percentage of virgin asphalt cement, contribution of the asphalt cement from the *RAP* and the optimum percentage of total asphalt cement, all to the nearest 0.1 percent based on total weight of mix and by dry weight of aggregate;
- O. Unit weight, percent air voids, stability, flow, percent voids in mineral aggregate and voids filled with asphalt at the optimum asphalt cement content;
- P. *Certificates of Compliance* for asphalt cement, including temperature/viscosity curves, and for any additives;
- Q. Date of mix design preparation
- R. *Accredited Laboratory* name and website address of accreditation program;
- S. Personnel name(s) and website address of qualification program;
- T. Signature of mix design preparer; and
- U. Stamp and Signature of the *Professional Engineer* responsible for review of the mix design.

337.04.02.01 Mix Design Review.

337.04.02.01.01 Compaction Hammer Correlation Records. Compaction hammer correlation records shall be made available upon request.

337.04.02.01.02 Ignition Oven Calibration. Quality control and quality assurance laboratories testing bituminous plantmix shall calibrate ignition ovens in accordance with NEV T761. At the time of the mix design review, the reviewing laboratory shall request and obtain, and the *Contractor* make available, representative samples of any materials used in the development of the mix design, including, but not limited to, aggregates, binder and anti-strip agent, for determination of equipment specific ignition oven correction factors.

337.04.03 AGGREGATES. Aggregates shall conform to the requirements of Subsection 200.02 – “Aggregates for Bituminous Courses”. The combined grading of the aggregate shall include the hydrated lime and/or mineral filler.

337.04.04 ASPHALT CEMENT. Asphalt cement shall conform to the requirements of Subsection 201.02 – “Asphalt Cements”.

337.04.05 HYDRATED LIME. Hydrated lime shall conform to the requirements of Subsection 202.02.01.02.02.07 – “Hydrated Lime for Use in Bituminous Mixtures”.

337.04.06 MINERAL FILLER. Mineral filler shall conform to the requirements of Subsection 202.02.01.02.03 – “Mineral Filler for Bituminous Paving Mixtures”.

337.05 BITUMINOUS PLANTMIX/HMA WITH GREATER THAN 15 PERCENT RAP.

337.05.01 COMPOSITION OF MIXTURES. *Bituminous Plantmix/HMA* shall consist of a mixture of greater than 15 percent *RAP*, additional virgin aggregate, additive, if required, and/or additional virgin asphalt cement.

The mix design shall conform to the requirements of Subsection 337.04 – “Bituminous Plantmix/HMA” except as modified herein.

337.05.02 REPORT OF MIX DESIGN. The mix design report shall include the following:

- A. Mix *Supplier* and mix designation used by the *Supplier*;
- B. Aggregate designation and source;
- C. Aggregate qualification test results for the combined grading;
- D. Gradation summary, including percentage passing each specified sieve size for the individual materials and combined grading target values, demonstrating compliance with the gradation requirements set forth in section 200.02.03-1;
- E. Bin percentages, with each bin clearly identified;
- F. The job control grading band determined;
- G. Virgin asphalt cement grade and source;
- H. When required, recycling agent type and source;

- I. When required, test results on the blend of RAP binder and virgin asphalt meeting the original binder grade specified (blending charts);
- J. Specific gravity of virgin asphalt cement and, when required, reclaimed asphalt cement;
- K. Source and percentage by dry weight of aggregate of any mineral additive;
- L. Source and percentage based on percentage of binder of any chemical additive;
- M. Number of compaction blows per side as designated and correlated blow count if using mechanical hammer;
- N. Compaction and mixing temperatures used on producing the mix design;
- O. Summary of volumetric and mechanical mix properties for each asphalt cement content and related plots;
- P. Optimum percentage of virgin asphalt cement, contribution of the asphalt cement from the recycled asphalt product and the optimum percentage of total asphalt cement, all to the nearest 0.1 percent based on total weight of mix and by dry weight of aggregate;
- Q. When required, optimum percentage of recycling agent, based on the percent mass of the total asphalt cement;
- R. Unit weight, percent air voids, stability, flow, percent voids in mineral aggregate and voids filled with asphalt at the optimum asphalt cement content;
- S. *Certificates of Compliance* for asphalt cement and any additives, including recycling agent;
- T. Date of mix design preparation;
- U. *Accredited Laboratory* name and website address of accreditation program;
- V. Personnel name(s) and website address of qualification program;
- W. Signature of mix design preparer; and
- X. Stamp and Signature of the *Professional Engineer* responsible for review of the mix design.

337.04.02.01 Mix Design Review.

337.04.02.01.01 Compaction Hammer Correlation Records. Compaction hammer correlation records shall be made available upon request.

337.04.02.01.02 Ignition Oven Calibration. Quality control and quality assurance laboratories testing bituminous plantmix shall calibrate ignition ovens in accordance with NEV T761. At the time of the mix design review, the reviewing laboratory shall request and obtain, and the *Contractor* make available, representative samples of any materials used in the development of the mix design, including, but not limited to, virgin aggregates, RAP, binder and anti-strip agent, for determination of equipment specific ignition oven correction factors.

337.05.03 AGGREGATES. Virgin aggregates shall conform to the requirements of Subsection 200.02 – “Aggregates for Bituminous Courses”. The combined grading of the virgin aggregate and RAP shall include the hydrated lime and/or mineral filler and conform to the requirements of Subsection 200.02.03.

337.05.03.01 Reclaimed Asphalt Pavement. The aggregate shall be the product of crushed, milled, or planed bituminous pavement.

337.05.04 ASPHALT CEMENT. Asphalt cement shall conform to the requirements of Subsection 201.02 – “Asphalt Cements”.

337.05.05 RECYCLING AGENT. The recycling agent shall conform to the requirements of Subsection 201.06 – “Recycling Agents”.

337.05.06 HYDRATED LIME. Hydrated lime shall conform to the requirements Subsection 202.02.01.02.02.07 – “Hydrated Lime for Use in Bituminous Mixtures”.

337.05.07 MINERAL FILLER. Mineral filler shall conform to the requirements Subsection 202.02.01.02.03 - “Mineral Filler for Bituminous Paving Mixtures”.

337.06 CHIP SEAL.

337.06.01 COMPOSITION OF MIXTURES. Chip seal shall consist of a mixture of aggregate and asphalt cement or emulsified asphalt as specified by the *Agency or Engineer* or noted in the Plans or Special Technical Specifications.

337.06.02 REPORT OF MIX DESIGN. The mix design report shall include the following:

- A. Mix *Supplier* and mix designation used by the *Supplier*;
- B. Aggregate designation and source;
- C. Aggregate qualification test results, including a gradation summary;
- D. Binder type and source;
- E. *Certificate of Compliance* for binder; and
- F. Signature of mix design preparer.

337.06.03 AGGREGATES. Aggregates shall conform to the requirements of Subsection 200.02.05 – “Chip Seal Aggregate”.

337.06.04 BINDER. The binder shall be specified by the *Agency* or *Engineer* or noted in the Plans or Special Technical Specifications.

337.07 SLURRY SEAL AND MICRO-SURFACING.

337.07.01 COMPOSITION OF MIXTURES. Slurry seal and micro-surfacing shall consist of a mixture of aggregate and emulsified asphalt.

The mix design for slurry seal shall be performed in accordance with the guidelines contained in *ISSA* Publication A105. The mix design for micro-surfacing shall be performed in accordance with the guidelines contained in *ISSA* Publication A143.

337.07.02 REPORT OF MIX DESIGN. The mix design report shall include the following:

- A. Mix *Supplier* and mix designation used by *Supplier*;
- B. Aggregate designation and source;
- C. Aggregate qualification test results;
- D. Gradation summary, including percentage passing each specified sieve size for the individual materials used and combined grading, with the job control grading band for each specified sieve size. The report must clearly show the proportions of aggregate, mineral filler (minimum and maximum), additive(s), usage, and asphalt emulsion based on dry weight of aggregate;
- E. Emulsified asphalt type and source;
- F. Recommended mix design showing mix proportions, including additives;
- G. Results of wet cohesion, excess asphalt, wet stripping, set-track abrasion loss, lateral displacement, classification compatibility and mix time tests, as applicable;
- H. A report of the quantitative effects of the moisture on the unit weight of the aggregate (bulking effect);
- I. *Certificate of Compliance* for emulsified asphalt;
- J. Date of mix design preparation;
- K. Laboratory name; and
- L. Signature of mix design preparer;

337.07.03 AGGREGATES. Aggregates shall conform to the requirements of Subsection 200.02.06 – “Slurry Seal and Microsurfacing Aggregate”.

337.07.04 EMULSIFIED ASPHALT. Emulsified asphalt shall conform to the requirements of Section 201.04 – “Emulsified Asphalts” for SS1H, utilizing a minimum of 3 percent latex rubber based on weight of bitumen.

337.07.05 WATER. Water shall conform to the requirements of Section 205 – “Water”.

337.08 SLURRY BACKFILL.

337.08.01 COMPOSITION OF MIXTURES. Slurry backfill shall consist of a fluid, workable mixture of aggregate, cementitious materials, mineral and liquid admixtures, and water.

The mix design for slurry backfill shall conform to the applicable requirements of Table 337.08.01-I.

TABLE 337.08.01-I

Test	Test Method	Requirements	
		Type A (Excavatable)	Type B (Non-Excavatable)
Compressive Strength at 28 days (psi)	ASTM D 4832 ⁽¹⁾	50 – 200	200 – 1000
Slump (inches)	ASTM C 143	6 – 10	6 – 10
Air Content (percent)	ASTM C 173 or ASTM C 231	5 Minimum	5 Minimum
Subsidence (percent)	ASTM C 940 ⁽²⁾	1 Maximum ⁽³⁾	1 Maximum ⁽³⁰⁾

1. Cylinders or other test specimens shall not be rodded or tapped.
2. A 6 inch by 12 inch cylinder shall be used for measurement purposes.
3. Mixtures that require placement by use of a concrete or grout pump will be allowed a maximum subsidence of 2 percent.

337.08.02 REPORT OF MIX DESIGN. The mix design report shall include the following:

- A. Mix supplier and mix designation;
- B. Aggregate designation and source;
- C. Aggregate test results and a gradation summary;
- D. Recommended mix design showing all components with their associated one cubic yard batch weights and absolute volumes;
- E. Recommended design slump and air content, including the test method used;
- F. Theoretical unit weight of design mix;
- G. One cubic yard trial weights of trial batch points;
- H. Trial batch compressive strength test results;
- I. Trial batch slump test and subsidence results;
- J. Trial batch air content test results and the test method used;
- K. Trial batch unit weights;
- L. Certificates of compliance for cementitious materials and admixtures;
- M. Date of mix design preparation;
- N. Laboratory name and verification of accreditation;
- O. Signature of mix design preparer; and
- P. Stamp and Signature of the registered *Professional Engineer* responsible for review of the mix design.

337.08.03 AGGREGATES. Aggregates shall conform to the requirements of Subsection 200.03.07 – Slurry Backfill Aggregates”.

337.08.04 CEMENT AND RELATED MATERIALS. Cement and related materials, including mineral and liquid admixtures, shall conform to the requirements of Section 202 – “cement and Related Materials”.

337.08.05 WATER. Water shall conform to the requirements of Section 205 – “Water”.

337.09 MASONRY.

337.09.01 MORTAR.

337.09.01.01 Composition of Materials. Mortar used in unit masonry construction shall consist of a workable mixture of aggregate, cementitious materials, mineral and liquid admixtures, and water.

The mix design for mortar used in unit masonry construction shall be performed in accordance with ASTM C 270 and conform to the requirements of Tables 337.09.01.01-I or 337.09.01.01-II for cement-lime or masonry cement mixtures, respectively.

TABLE 337.09.01.01-I

Component	Proportion By Volume (Cementitious Material)			
	Type M	Type S	Type N	Type O
Portland Cement or Blended Cement	1	1	1	1
Hydrated Lime or Lime Putty ⁽¹⁾	1/4	1/4 - 1/2	1/2 – 1 1/4	1 1/4 - 2 1/2
Aggregate ⁽²⁾	Not less than 2 1/4 and not more than 3 times the sum of the separate volumes of cementitious material			

1. When plastic cement is used in lieu of Portland cement, hydrated lime or putty may be added, but not in excess of 1/10 of the volume of cement.
2. Measured in a damp, loose condition.

TABLE 337.09.01.01-II

Component	Proportion By Volume (Cementitious Material)			
	Type M	Type S	Type N	Type O
Portland Cement or Blended Cement	1	1/2		
Masonry Cement				
Type M	1			
Type S		1		
Type N	1	1	1	1
Aggregate ⁽¹⁾	Not less than 2 1/4 and not more than 3 times the sum of the separate volumes of cementitious material			

1. Measured in a damp, loose condition.

337.09.01.01.01 Quantity of Water. The quantity of water to be used in the preparation of mortar shall be the minimum required to produce a mixture that is sufficiently workable for the intended use.

337.09.01.01.02 Deleterious Substances. Chloride salts or other deleterious substances shall not be used in mortar.

337.09.01.01.03 Additives and Admixtures. Air entraining substances shall not be used in mortar unless tests are conducted to determine compliance with *Agency* or *Engineer* requirements. Other additives and admixtures shall not be used in mortar unless approved in writing by the *Agency* or *Engineer*.

337.09.01.02 Report of Mix Design. The mix design report shall include the following:

- A. Mix *Supplier* and mix designation used by *Supplier*;
- B. Aggregate designation and source;
- C. Aggregate qualification test results, including a gradation summary ;
- D. Bulk specific gravity (SSD basis), absorption values and loose unit weight;
- E. Recommended mix design showing mix proportions;
- F. Trial batch compressive strength test results;
- G. Trial batch water retention test results;
- H. Trial batch air content test results;
- I. *Certificates of Compliance* for cementitious materials and admixtures;
- J. Date of mix design preparation;
- K. *Accredited Laboratory* name and website address of accreditation program;
- L. Personnel name(s) and website address of qualification program;
- M. Signature of mix design preparer; and
- N. Stamp and Signature of the *Professional Engineer* responsible for review of the mix design.

337.09.01.03 Aggregates. Aggregates shall conform to the requirements of Subsection 200.04 – “Aggregate for Mortar and Grout”.

337.09.01.04 Cement and Related Materials. Cement and related materials, including mineral and liquid admixtures, shall conform to the requirements of Section 202 – “Cement and Related Materials”.

337.09.01.05 Water. Water shall conform to the requirements of Section 205 – “Water”.

337.09.02 GROUT.

337.09.02.01 Composition of Materials. Grout used in unit masonry construction shall consist of a fluid mixture of aggregate, cementitious materials, mineral and liquid admixtures, and water.

The mix design for grout used in unit masonry construction shall be determined in accordance with Subsection 337.09.02.01.01 or Subsection 337.09.02.01.02.

337.09.02.01.01 Proportions by Volume. When proportions are established by volume, grout used in masonry unit construction shall conform to the applicable requirements of Tables 337.09.02.01.01-I and 337.09.02.01.01-II.

TABLE 337.09.02.01.01-I

Component	Proportion by Volume (Cementitious Material)	
	Fine	Coarse
Portland Cement or Blended Cement	1	
Hydrated Lime or Lime Putty	0 – 1/10	
Aggregate ⁽¹⁾		
Fine	2 1/4 to 3 times the sum of the volumes of the cementitious materials	2 1/4 to 3 times the sum of the volumes of the cementitious materials
Coarse		1 to 2 times the sum of the volumes of the cementitious materials

1. Measured in a damp, loose condition.

TABLE 337.09.02.01.01-II

Test	Test Method	Requirements
Slump (inches)	ASTM C 143	8 - 11

337.09.02.01.02 Proportions by Compressive Strength. When proportions are established by compressive strength, grout used in masonry unit construction shall conform to the requirements of Table 337.09.02.01.02-I.

TABLE 337.09.02.01.02-I

Test	Test Method	Requirements
Test Specimens ⁽¹⁾	ASTM C 1019	-
Compressive Strength at 28 days (psi)	ASTM C 1019	As specified by the <i>Agency or Engineer</i>
Slump (inches)	ASTM C 143	8 - 11

1. Locally available masonry test block may be used as specimen mold.

337.09.02.02 Report of Mix Design. The mix design report shall include the following:

- A. Mix *Supplier* and mix designation used by the *Supplier*;
- B. Aggregate designation and source;
- C. Aggregate qualification test results, including a gradation summary ;
- D. Bulk specific gravity (SSD basis), absorption values and loose unit weight;
- E. Recommended mix design showing mix proportions;
- F. Trial batch compressive strength test results for mixes proportioned by compressive strength;
- G. Trial batch slump test results;
- H. Trial batch air content test results;
- I. *Certificates of Compliance* for cementitious materials and admixtures;
- J. Date of mix design preparation;
- K. *Accredited Laboratory* name and website address of accreditation program;
- L. Personnel name(s) and website address of qualification program;
- M. Signature of mix design preparer; and
- N. Stamp and Signature of the *Professional Engineer* responsible for review of the mix design.

337.09.02.03 Aggregates. Aggregates shall conform to the requirements of Subsection 200.04 – “Aggregate for Mortar and Grout”.

337.09.02.04 Cement and Related Materials. Cement and related materials, including mineral and liquid admixtures, shall conform to the requirements of Section 202 – “Cement and Related Materials”.

337.09.02.05 Water. Water shall conform to the requirements of Section 205 – “Water”.

337.10 GENERAL STRUCTURAL USE PORTLAND CEMENT CONCRETE.

337.10.01 COMPOSITION OF MIXTURES. General structural use Portland cement concrete shall consist of a workable mixture of aggregate, cementitious materials, admixtures, and water.

The mix design for general structural use Portland cement concrete shall be performed in accordance with ACI 301, utilizing the ACI 211.1 trial batch method. Results shall be plotted on a curve showing compressive or flexural strength versus age of specimen for each water to cementitious ratio batched. When specifications require a maximum water to cementitious ratio, a one point design will be acceptable, provided the required strength is attained and all other parameters are satisfied. If no maximum water to cementitious ratio is specified, at least three mixtures with varying water to cementitious ratios shall be batched and the resulting strength versus age of specimen shall be graphically plotted for each mixture.

The cementitious content shall be met by a combination of portland cement and *SCM*, including fly ash, ground blast furnace slag, and pozzolan.

337.10.01.01 SCM. *SCM* content shall not be less than 20 percent by weight of the cement.

337.10.01.02 Ground Blast Furnance Slag. Ground blast furnace slag may constitute up to 55 percent of the total cementitious material by weight.

337.10.01.02.01 Slipforming. If the *PCC* is to be used for slipforming and the ambient air temperature is expected to be lower than 55 °F, the percent of slag shall not exceed 30 percent by weight.

The compressive strength of the *PCC* referred to in this Subsection will be based on the average results of tests performed on three 6 x 12 Inch or five 4 x 8 Inch cylinders.

337.10.01.03 PCC Exposed to Freeze-Thaw Cycles. All *PCC* exposed to freeze-thaw cycles shall be air entrained. Unless otherwise directed by the *Engineer*, all *PCC* exposed to freeze-thaw cycles shall conform to Table 337.10.01.01-I or Table 337.10.01.01-II as shown on the *Plans* or specified in the *Special Provisions* and/or *Special Technical Specifications*.

TABLE 337.10.01.03-I

Test	Test Method	Requirements
Test Specimens	ASTM C 192	-
Water to Cementitious Ratio	-	0.45 Maximum
Compressive Strength at 28 days (psi)	ASTM C 39	4000 Minimum
Slump (inches)	ASTM C 143	
Initial		4 Maximum
After Addition of HRWR ⁽¹⁾		8 Maximum
Air Content (percent) ⁽²⁾	ASTM C 173 or ASTM C 231	
No. 67/No. 57 Aggregate		6.0
No. 467 Aggregate		5.5

1. High Range Water Reducers.

2. Target Value. The variation for the produced material shall be within plus or minus 1.5 percent of the target value.

TABLE 337.10.01.03-II

	Severity of Potential Exposure			
	Negligible	Moderate	Severe	Very Severe
Water-Soluble Soluble Sulfate (SO ₄) ⁽¹⁾⁽²⁾ (percent)	0.00 to 0.10	>0.10 and <0.20	>0.20 and <2.00	>2.00
Sulfate (SO ₄) ⁽¹⁾ in Water (ppm)	0 to 150	>150 and <1500	>1500 and <10,000	>10,000
Type of Cement	No special requirements	II II & Fly Ash/Slag 1-P (MS) V V & Fly Ash/Slag	II & Fly Ash/Slag 1-P (MS) V V & Fly Ash/Slag	V & Fly Ash ⁽³⁾ /Slag ⁽⁴⁾
Water to Cementitious Ratio	No special requirements	0.50 Maximum	0.45 Maximum	0.40 Maximum

1. Determined in accordance with ASTM C 1580.
2. Sulfate expressed as SO₄ is related to sulfate expressed as SO₃, as given in reports of chemical analysis of Portland cements as follows: SO₃ % x 1.2 = SO₄ %.
3. Fly Ash proportion should be between 25 and 35 % by mass of the total cementitious material.
4. Slag proportion should be between 40 and 70 % by mass of the total cementitious material.
5. Natural pozzolans, fly ash, slag and blended cements may be qualified in accordance with ACI 201.2R and ASTM C 1012.

337.10.02 REPORT OF MIX DESIGN. The mix design report shall include the following:

- A. Mix *Supplier* and mix designation used by *Supplier*;
- B. Aggregate designation and source;
- C. Fine aggregate qualification test results, including a gradation summary ;
- D. Fine aggregate bulk specific gravity (*SSD* basis) and absorption values;
- E. Coarse aggregate qualification test results, including a gradation summary;
- F. Coarse aggregate bulk specific gravity (*SSD* basis) and absorption values;
- G. Coarse aggregate dry rodded unit weight;
- H. Recommended mix design showing all components with their associated one cubic yard batch weights and absolute volumes, including water to cementitious ratio;
- I. Recommended design slump and air content, including the test method used;
- J. Theoretical unit weight of design mix;
- K. One cubic yard trial weights of trial batch points;
- L. Trial batch compressive and flexural strength test results;
- M. Trial batch slump test results;
- N. Trial batch air content test results and the test method used;
- O. Trial batch unit weights;
- P. *Certificates of Compliance* for cementitious materials and admixtures;
- Q. Date of mix design preparation;
- R. *Accredited Laboratory* name and website address of accreditation program;
- S. Personnel name(s) and website address of qualification program;
- T. Signature of mix design preparer; and
- U. Stamp and Signature of the *Professional Engineer* responsible for review of the mix design.

337.10.03 AGGREGATES. Aggregates shall conform to the requirements of Subsection 200.05 – “Aggregates for General Structural Use Portland Cement Concrete”.

337.10.04 CEMENT AND RELATED MATERIALS. Cement and related materials, including mineral and liquid admixtures, shall conform to the requirements of Section 202 – “Cement and Related Materials”.

337.10.05 WATER. Water shall conform to the requirements of Section 205 – Water”.

337.11 SPECIFIC USE PORTLAND CEMENT CONCRETE.**337.11.01 PORTLAND CEMENT CONCRETE FOR ROADWAY PAVING.**

337.11.01.01 Composition Of Mixtures. Portland cement concrete for roadway paving shall consist of a workable mixture of aggregate, cementitious materials, admixtures, and water.

The mix design for Portland cement concrete for roadway paving shall be performed in accordance with ACI 301, utilizing the ACI 211.1 trial batch method. Results shall be plotted on a curve showing compressive or flexural strength versus age of specimen for each water to cementitious ratio batched. When specifications require a maximum water to cementitious ratio, a one point design will be acceptable, provided the required strength is attained and all other parameters are satisfied. If no maximum water to cementitious ratio is specified, at least three mixtures with varying water to cementitious ratios shall be batched and the resulting strength versus age of specimen shall be graphically plotted for each mixture.

The cementitious content shall be met by a combination of portland cement and *SCM*, including fly ash, ground blast furnace slag, and pozzolan.

337.11.01.01 SCM. *SCM* content shall not be less than 20 percent by weight of the cement.

337.11.01.02 Ground Blast Furnace Slag. Ground blast furnace slag may constitute up to 55 percent of the total cementitious material by weight.

The compressive strength of the *PCC* referred to in this Subsection will be based on the average results of tests performed on three 6 x 12 Inch cylinders. The flexural strength of the *PCC* referred to in this Subsection will be based on the average results of tests performed on three flexural beams. The mix design shall establish the relationship between flexural and compressive strength.

Unless otherwise directed by the *Engineer*, all *PCC* used for *PCCP* shall conform to Table 337.11.01.03-I.

TABLE 337.11.01.03-I

Test	Test Method	Requirements
Test Specimens	ASTM C192	-
Water to Cementitious Ratio	-	0.45 Maximum
Compressive Strength at 28 Days (PSI)	ASTM C39	-
Flexural Strength at 28 Days (PSI)	ASTM C78	650 Minimum
Slump (inches)	ASTM C143	
Initial		2 Maximum ⁽¹⁾
After Addition of HRWR		4 Maximum
Air Content (%) ⁽²⁾	ASTM C173 or ASTM C231	
No. 467 Aggregate		5.5

1. Sideform Paving, for Slipform Paving, a 1" maximum slump is recommended for constructability.

2. Target Value. The variation for the produced material shall be within plus or minus 1.5 percent of the target value.

337.11.01.01 PCC Exposed to Soils Containing Water-Soluble Sulfates. Unless otherwise directed by the *Engineer*, all *PCC* exposed to soils containing soluble sulfates shall conform to the applicable requirements of Table 337.10.01.03-I, based on the percentage of the soluble sulfate contained in the soil.

337.11.01.02 Report Of Mix Design. The mix design report shall include the following:

- A. Mix *Supplier* and mix designation used by *Supplier*;
- B. Aggregate designation and source;
- C. Fine aggregate qualification test results, including a gradation summary ;
- D. Fine aggregate bulk specific gravity (*SSD* basis) and absorption values;
- E. Coarse aggregate qualification test results, including a gradation summary;

- F. Coarse aggregate bulk specific gravity (SSD basis) and absorption values;
- G. Coarse aggregate dry rodded unit weight;
- H. Recommended mix design showing all components with their associated one cubic yard batch weights and absolute volumes, including water to cementitious ratio;
- I. Recommended design slump and air content, including the test method used;
- J. Theoretical unit weight of design mix;
- K. One cubic yard trial weights of trial batch points;
- L. Trial batch compressive and flexural strength test results;
- M. Trial batch slump test results;
- N. Trial batch air content test results and the test method used;
- O. Trial batch unit weights;
- P. Type, brand, and source of cementitious materials and admixtures;
- Q. *Certificates of Compliance* for cementitious materials and admixtures;
- R. Date of mix design preparation;
- S. *Accredited Laboratory* name and website address of accreditation program;
- T. Personnel name(s) and website address of qualification program;
- U. Signature of mix design preparer; and
- V. Stamp and Signature of the *Professional Engineer* responsible for review of the mix design.

337.11.01.03 Aggregates. Aggregates shall conform to the applicable requirements of Subsection 200.06.01 – “Aggregates for PCCP”.

Unless otherwise directed by the *Agency* or *Engineer*, all Portland cement concrete used for roadway paving shall conform to the requirements of Table 337.11.01.01-I.

TABLE 337.11.01.01-I

Test	Test Method	Requirements
Test Specimens	ASTM C 192	-
Water to Cementitious Ratio	-	0.45 Maximum
Flexural Strength at 28 days (psi)	ASTM C 78	650 Minimum
Slump (inches)	ASTM C 143	
Initial		2 Maximum ⁽¹⁾
After Addition of HRWR ⁽²⁾		4 Maximum
Air Content (percent) ⁽³⁾	ASTM C 173 or ASTM C 231	
No. 57 or No. 67 Aggregate		6.0
No. 467 Aggregate		5.5

1. Sideform Paving, for Slipform Paving, a 1" maximum slump is recommended for constructability.
2. High Range Water Reducers.
3. Target Value. The variation for the produced material shall be within plus or minus 1.5 percent of the target value.

337.11.01.01.01 Portland Cement Concrete Exposed to Soils Containing Water-Soluble Sulfates.

Unless otherwise directed by the *Agency* or *Engineer*, all Portland cement concrete exposed to soils containing soluble sulfates shall conform to the requirements of Table 337.10.01.02-I, based on the percentage of the soluble sulfate contained in the soil.

337.11.01.02 Report Of Mix Design. The mix design report shall include the following:

- A. Mix supplier and mix designation;
- B. Aggregate designation and source;
- C. Fine aggregate qualification test results, including a gradation summary ;
- D. Fine aggregate bulk specific gravity (SSD) basis and absorption values;
- E. Coarse aggregate qualification test results, including a gradation summary;
- F. Coarse aggregate bulk specific gravity (SSD) basis and absorption values;
Coarse aggregate dry rodded unit weight;
- G. Recommended mix design showing all components with their associated one cubic yard batch weights and absolute volumes, including water to cementitious ratio;
- H. Recommended design slump and air content, including the test method used;
- I. Theoretical unit weight of design mix;
- J. One cubic yard trial weights of trial batch points;
- K. Trial batch compressive and flexural strength test results;
- L. Trial batch slump test results;

- M. Trial batch air content test results and the test method used;
- N. Trial batch unit weights;
- O. Certificates of compliance for cementitious materials and admixtures;
- P. Date of mix design preparation;
- Q. Laboratory name and verification of accreditation;
- R. Signature of mix design preparer; and
- S. Stamp and Signature of the registered *Professional Engineer* responsible for review of the mix design.

337.11.01.03 Aggregates. Aggregates shall conform to the requirements of Subsection 200.06.01 – “Aggregates for Portland Cement Concrete Roadway Paving”.

337.11.01.04 Cement And Related Materials. Cement and related materials, including mineral and liquid admixtures, shall conform to the requirements of Section 202 – “Cement and Related Materials”.

337.11.01.05 Water. Water shall conform to the requirements of Section 205 – “Water”.

337.11.02 AIR PLACED CONCRETE.

337.11.02.01 Gunite.

337.11.02.01.01 Composition of Materials. Gunite shall consist of a mixture of aggregate, cementitious materials, and water, which is mixed at the nozzle immediately prior to placement.

Unless otherwise directed by the *Agency* or *Engineer*, the mix design for gunite shall be proportioned in accordance with Table 337.11.02.01.01-I.

TABLE 337.11.02.01.01-I

Component	Proportion by Dry, Loose Volume
Portland Cement or Blended Cement	1
Aggregate ⁽¹⁾	4 1/2

1. The aggregate shall contain not less than 3 percent nor more than 6 percent moisture by dry weight when determined in accordance with ASTM 70.

337.11.02.01.02 Quantity of Water. The quantity of water to be used in the preparation of gunite shall be the minimum required to for proper hydration of the mix.

337.11.02.01.03 Report of Mix Design. The mix design report shall include the following:

- A. Mix *Supplier* and mix designation used by *Supplier*;
- B. Aggregate designation and source;
- C. Aggregate qualification test results, including a gradation summary ;
- D. Bulk specific gravity (SSD basis), absorption values and loose unit weight;
- E. Recommended mix design showing mix proportions;
- F. *Certificates of Compliance* for cementitious materials;
- G. Date of mix design preparation;
- H. *Accredited Laboratory* name and website address of accreditation program;
- I. Personnel name(s) and website address of qualification program;
- J. Signature of mix design preparer; and
- K. Stamp and Signature of the *Professional Engineer* responsible for review of the mix design.

337.11.02.01.04 Aggregates. Aggregates shall conform to the requirements of Subsection 200.06.02 – “Aggregates for Gunite”.

337.11.02.01.05 Cement and Related Materials. Cement and related materials, including mineral and liquid admixtures, shall conform to the requirements of Section 202 – “Cement and Related Materials”.

337.11.02.01.06 Water. Water shall conform to the requirements of Section 205 – “Water”.

337.11.02.02 Shotcrete.

337.11.02.02.01 Composition of Materials. Shotcrete shall consist of a mechanically mixed fluid mixture of aggregate, cementitious materials, and water.

The compressive strength of the shotcrete referred to in this Subsection will be based specimens prepared and obtained in accordance with the procedures outlined in ACI 506, Chapter 6, Section 6.4. The specimens shall be obtained one day prior to compressive strength testing.

Unless otherwise directed by the *Agency* or *Engineer*, the mix design for shotcrete shall conform to the requirements of Table 337.11.02.02.01-I.

TABLE 337.11.02.02.01-I

Test	Test Method	Requirements
Maximum Aggregate Size	ASTM C 136	As specified by <i>Agency</i> or <i>Engineer</i>
Water to Cementitious Ratio	-	
Compressive Strength at 28 days (psi) ⁽¹⁾	ASTM C 42	
Slump (inches)	ASTM C 143	
Air Content (percent)	ASTM C 138 or ASTM C 231	

1. Tested in the as received condition after curing in accordance with ASTM C 42.

337.11.02.02.02 Report of Mix Design. The mix design report shall include the following:

- A. Mix *Supplier* and mix designation used by *Supplier*;
- B. Aggregate designation and source;
- C. Aggregate qualification test results, including a gradation summary ;
- D. Bulk specific gravity (SSD basis), absorption values and loose unit weight;
- E. Cement type;
- F. Recommended mix design showing mix proportions, including water to cementitious ratio;
- G. Compressive strength test results;
- H. Slump test results
- I. Air content test results;
- J. *Certificates of Compliance* for cementitious materials;
- K. Date of mix design preparation;
- L. *Accredited Laboratory* name and website address of accreditation program;
- M. Personnel name(s) and website address of qualification program;
- N. Signature of mix design preparer; and
- O. Stamp and Signature of the *Professional Engineer* responsible for review of the mix design.

337.11.02.02.03 Aggregates. Aggregates shall conform to the requirements of Subsection 200.06.03 – “Aggregates for Shotcrete”.

337.11.02.02.04 Cement and Related Materials. Cement and related materials, including mineral and liquid admixtures, shall conform to the requirements of Section 202 – “Cement and Related Materials”.

337.11.02.02.05 Water. Water shall conform to the requirements of Section 205 – “Water”.

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