



STANDARD CONSTRUCTION SPECIFICATIONS

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SECTION 01100

DEFINITION OF TERMS

PART 1 GENERAL

1.1 GENERAL

- A. Unless the context otherwise requires, wherever in the specifications and other contract documents, the following terms and abbreviations, or pronouns in place of them, are used, the intent and meaning shall be interpreted as provided in this section.

1.2 DEFINITION OF TERMS

- A. **Railroad/Company:** shall mean The BNSF Railway Company and/or its respective affiliates and/or subsidiary companies and/or corporation.
- B. **Contract:** The written agreement and any written supplements or amendments thereto, covering the performance of the work and the furnishing of all superintendence, labor, tools, equipment, materials, supplies and all other things required to properly complete the work.
- C. **Contractor:** The person or persons, firm, partnership, corporation, or combination thereof, who have entered into the contract with the Company.
- D. **Drawings:** The official project plans, profiles, typical cross sections, general cross sections, working drawings and supplemental drawings, or reproductions thereof, approved by the engineer, which show the location character, dimensions and details of the work to be performed.
- E. **Subcontractor:** Wherever the word Subcontractor, or a pronoun in place of it, is used in the Contract Documents, it shall mean a party who has a direct contract with the Contractor for the performance of a designated portion of the work, or the supply of material or equipment in connection therewith.
- F. **Plans:** The official project plans, profiles, typical cross sections, general cross sections, working drawings and supplemental drawings, or reproductions thereof, approved by the engineer, which show the location character, dimensions and details of the work to be performed.
- G. **Special Provisions:** Additions and revisions to the standard and supplemental specifications covering conditions peculiar to an individual project.
- H. **Specifications:** The general term comprising all the directions, provisions, and requirements necessary for the proper performance of the contract.
- I. **Supplemental Specifications:** Specifications adopted subsequent to the publication of the standard specifications. They generally involve new construction items or substantial changes in the approved specifications.
- J. **Engineer:** The Vice President-Chief Engineer, of the Company or his authorized representative.
- K. **Right-of-way:** Land which the Company owns or owns an interest in, sufficient to permit performance of the work.
- L. **Project:** The total construction, of which the work performed under the contract documents may be the whole or a part, and which may include construction by the Company or by separate contractors.
- M. **Change Order:** A change order is any change in the original contract line items or amounts, which shall result in either the altering of contract line item quantities or the performance of "force account"

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work. The performance of force account work shall be as described in the Standard Contract. Change orders are limited by the amounts stated in the contract.

1.3 ABBREVIATIONS

AAN	American Association of Nurserymen
AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
AREA	American Railway Engineering Association
AREMA	American Railway Engineering and Maintenance of Way Association
ASTM	American Society for Testing and Materials
AWG	American Wire Gage
AWPA	American Wood-Preservers' Association
AWS	American Welding Society
BWC	Bridge Welding Code
EPA	United States Environmental Protection Agency
FHWA	Federal Highway Administration
FRA	Federal Railway Administration
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NPDES	National Pollutant Discharge Elimination System
UL	Underwriters' Laboratories Inc.

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SECTION 01690

ENVIRONMENTAL PROTECTION

PART 1 GENERAL

1.1 GENERAL REQUIREMENTS

- A. **Governing Philosophy:** The Contractor shall perform the work minimizing environmental pollution and damage as the result of construction operations. Environmental pollution and damage is the generation of chemical, physical, or biological elements or agents which adversely affect human health or welfare or unfavorably alter ecological balances of plant and animal species; or degrade the aesthetic, cultural and/or historical resources. The control of environmental pollution and damage requires consideration of land, water, and air, as well as management of visual aesthetics, noise and odors. The environmental resources within the project boundaries and those affected outside the limits of permanent work shall be protected during the entire duration of this contract.
- B. **Subcontractors:** The Contractor shall be responsible for ensuring compliance with this section by all subcontractors.
- C. **Environmental Protection Plan:** The Contractor shall submit an environmental protection plan within 15 days after receipt of the notice to proceed. Approval of the Contractor's plan will not relieve the Contractor of responsibility for adequate and continuing control of pollutants and other environmental protection measures. The environmental protection plan shall include, but shall not be limited to, the following:
 - 1. A list of Federal, State, and local laws, regulations, and permits concerning environmental protection, pollution control and abatement that are applicable to the Contractor's proposed operations and the requirements imposed by those laws, regulations, and permits.
 - 2. Methods for protection of features to be preserved within authorized work areas like trees, shrubs, vines, grasses and ground cover, landscape features, air and water quality, fish and wildlife, soil, historical, archaeological, and cultural resources.
 - 3. Procedures to be implemented to provide the required environmental protection, to comply with the applicable laws and regulations, and to correct pollution due to accident, natural causes, or failure to follow the procedures of the environmental protection plan.
 - 4. Location of the solid waste disposal area.
 - 5. Drawings showing locations of any proposed temporary excavations or embankments for haul roads, stream crossings, material storage areas, structures, sanitary facilities, and stockpiles of excess or spoil materials.
 - 6. Environmental monitoring plans for the job site, including land, water, air, and noise monitoring.
 - 7. Traffic control plan including measures to reduce erosion of temporary roadbeds by construction traffic, especially during wet weather, and the amount of mud transported onto paved public roads by vehicles or runoff.
 - 8. Methods of protecting surface and ground water during construction activities.
 - 9. Plan showing the proposed activity in each portion of the work area and identifying the areas of limited use or nonuse. Plan should include measures for marking the limits of use areas.
 - 10. Drawing of borrow area location. Protection measures required at the work site shall apply to the borrow areas including final restoration for subsequent beneficial use of the land.

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11. A recycling and waste prevention plan with a list of measures to reduce consumption of energy and natural resources; for example: the possibility to shred fallen trees and use them as mulch shall be considered as an alternative to burning or burial.
 12. A settling pond removal plan to be submitted for approval by the BNSF prior to removal work. The plan shall include the method of removing and testing of the collected sediment. Pond removal cannot be initiated prior to receipt of approval.
 13. Training for Contractor's personnel during the construction period.
- D. **Permits:** The Contractor shall investigate the need for permits and licenses for this project. The Contractor will be expected to obtain all permits that do not place a statutory obligation for their filing on the Owner. If an individual State department of natural resources so allows, the Contractor must file the appropriate national pollutant discharge elimination system (NPDES) permits, including but not limited to general permits, a notice of intent, and a notice of termination. The Contractor shall be responsible for implementing the terms and requirements of the appropriate permits as needed and for payment of all fees.
- E. **Meetings:** The Contractor shall meet with representatives of the Engineer to alter the environmental protection plan as needed for compliance with the environmental pollution control program.
- F. **Notification:** The Engineer will notify the Contractor of any observed noncompliance with the previously mentioned Federal, State or local laws or regulations, permits, and other elements of the environmental protection plan. The Contractor shall, within 24 hours of receipt of such notice, provide the Engineer with a proposed corrective action plan, and take such action when approved. If the Contractor fails to comply within 48 hours of approval, the Engineer may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No time extensions shall be granted or costs or damages allowed to the Contractor for any such suspensions.
- G. **Litigation:** If work is suspended, delayed, or interrupted due to a court order of competent jurisdiction, the Engineer will determine whether the order is due in any part to the acts or omissions of the Contractor, or subcontractors at any tier, not required by the terms of the contract. If it is determined that the order is not due to Contractor's failing, such suspension, delay, or interruption shall be considered as ordered by the Engineer in the administration of the contract.
- H. **Previously Used Equipment:** The Contractor shall thoroughly clean all construction equipment previously used at other sites before it is brought into the work areas, ensuring that soil residuals are removed and no noxious weeds or pests brought onto the project.
- I. **Payment:** Unless directed elsewhere in the plans or construction documents, no separate payment will be made for work covered under this section. All costs associated with this section shall be included in the contract unit and/or lump sum prices in the Bidding Schedule.

1.2 LAND RESOURCES

- A. **General Strategy:** The Contractor shall confine all activities to areas defined by the drawings and specifications. Prior to the beginning of any construction, the BNSF or its duly authorized representative shall identify the land resources to be preserved within the work area. Except in areas indicated on the drawings or specified to be cleared, the Contractor shall not remove, cut, deface, injure, or destroy land resources including trees, shrubs, vines, grasses, topsoil, and land forms without permission. No ropes, cables, or guys shall be fastened to or attached to any trees for anchorage unless specifically authorized. Where such emergency use is permitted, the Contractor shall provide effective protection for land and vegetation resources at all times as defined in the following subparagraphs. Stone, earth or other material displaced into uncleared areas shall be removed.

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- B. **Work Area Limits:** Prior to any construction, the BNSF or its duly authorized representative shall mark the areas that need not be disturbed under this contract. Isolated areas within the general work area which are to be saved and protected shall also be marked or fenced. Monuments and markers shall be protected before construction operations commence. Where construction operations are to be conducted during darkness, the markers shall be visible. The Contractor's personnel shall be knowledgeable of the purpose for marking and/or protecting particular objects.
- C. **Landscape:** Trees, shrubs, vines, grasses, land forms and other landscape features indicated and defined on the drawings to be preserved shall be clearly identified by marking, fencing, or wrapping with boards, or any other approved techniques.
- D. **Unprotected Erodible Soils:** Earthwork brought to final grade shall be finished as indicated. Disturbed areas shall be protected as soon as practicable upon completion of rough grading. All earthwork shall be planned and conducted to minimize the duration of exposure of unprotected soils. Except in cases where the constructed feature obscures borrow areas, quarries, and waste material areas, these areas shall not initially be totally cleared. Clearing of such areas shall progress in reasonably sized increments as needed. Prior to the start of construction, the size of these increments shall be reviewed and agreed upon by the contractor and project engineer.
- E. **Disturbed Areas:** The Contractor shall effectively prevent erosion and control sedimentation through approved methods including, but not limited to, the following:
1. Runoff from the construction site or from storms shall be controlled, and diverted to protected drainage courses by means of diversion ditches, benches, berms, and by any measures required by area wide plans under the Clean Water Act.
 2. The Contractor shall construct or install temporary and permanent erosion and sedimentation control features as indicated on the drawings. Berms, dikes, drains, sedimentation basins, grassing, and mulching shall be maintained until permanent drainage and erosion control facilities are completed and operative.
 3. Sediment from construction areas shall be trapped in temporary or permanent sediment basins in accordance with the drawings. After each significant storm event, the basins shall be pumped dry and accumulated sediment shall be removed as needed to maintain basin effectiveness. Overflow shall be controlled by paved weirs or by vertical overflow pipes. The collected topsoil sediment, if suitable, shall be reused for fill on the construction site, and/or stockpiled for use at another site. The Contractor shall institute effluent quality monitoring programs as required by State and local environmental agencies.
- F. **Contractor Facilities and Work Areas:** The Contractor's field offices, staging areas, stockpile storage, and temporary buildings shall be placed in areas designated on the drawings or as directed by the Engineer. Temporary movement or relocation of Contractor facilities shall be made only when approved. Borrow areas shall be managed to minimize erosion and to prevent sediment from entering nearby waters. Spoil areas shall be managed and controlled to limit spoil intrusion into areas designated on the drawings and to prevent erosion of soil or sediment from entering nearby waters. Spoil areas shall be developed in accordance with the grading plan indicated on the drawings. Temporary excavation and embankments for plant and/or work areas shall be controlled to protect adjacent areas.

1.3 WATER RESOURCES

- A. **General Strategy:** The Contractor shall keep construction activities under surveillance, management, and control to avoid pollution of surface and ground waters. Toxic or hazardous chemicals shall not be applied to soil or vegetation when such application may cause contamination of the fresh water reserve. Monitoring of water areas affected by construction shall be the Contractor's responsibility.

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- B. **Washing and Curing Water:** Waste waters directly derived from the Contractor's washing and curing construction activities shall not be allowed to enter water areas. Waste waters shall be collected and placed in retention ponds where suspended material can be settled out or the water evaporates to separate pollutants from the water. Analysis shall be performed and results reviewed and approved before water in retention ponds is discharged. All construction of, and all water discharged from the Contractor's retention ponds shall meet all applicable local, State and Federal rules and regulations.
- C. **Cofferdam and Diversion Operations:** Construction operations for dewatering, removal of cofferdams, tailrace excavation, and tunnel closure shall be controlled at all times to limit the impact of water turbidity on the habitat for wildlife and on water quality for downstream use.
- D. **Stream Crossings:** shall allow movement of materials or equipment without violating water pollution control standards of the Federal, State or local Company.
- E. **Fish and Wildlife:** The Contractor shall minimize interference with, disturbance to, and damage of fish and wildlife. Species that require specific attention along with measures for their protection shall be listed by the Contractor prior to beginning of construction operations. Such lists shall be developed with the aid of the appropriate local agencies responsible for the development and enforcement of such regulatory measures.

1.4 AIR RESOURCES

- A. **General Strategy:** Equipment operation and activities or processes performed by the Contractor in accomplishing the specified construction shall be in accordance with all local and state rules and all Federal emission and performance laws and standards. Ambient Air Quality Standards set by the Environmental Protection Agency shall be maintained. Monitoring of air quality shall be the Contractor's responsibility. Monitoring results will be periodically reviewed by the BNSF or its duly authorized representative to ensure compliance.
- B. **Particulates:** Dust particles; aerosols and gaseous by-products from construction activities; and processing and preparation of materials, such as from asphaltic batch plants; shall be controlled at all times, including weekends, holidays and hours when work is not in progress. The Contractor shall maintain excavations, stockpiles, haul roads, permanent and temporary access roads, plant sites, spoil areas, borrow areas, and other work areas within or outside the project boundaries free from particulates which would cause the air pollution standards to be exceeded or which would cause a hazard or a nuisance. Sprinkling, chemical treatment of an approved type, light bituminous treatment, baghouse, scrubbers, electrostatic precipitators or other methods may be required to control particulates in the work area. Sprinkling, to be effective must be repeated as often as needed to keep the disturbed area damp at all times. The Contractor must have sufficient, competent equipment available to accomplish these tasks. Particulate control shall be performed as the work proceeds and whenever a particulate nuisance or hazard occurs. Nuisance or hazard shall be determined by the project engineer or manager.
- C. **Hydrocarbons and Carbon Monoxide:** emissions from equipment shall be controlled to Federal and State allowable limits at all times.
- D. **Odors:** shall be controlled with the best available technology for the activity producing the odor.
- E. **Noise Levels:** The Contractor shall keep construction activities under surveillance and control to minimize noise to the greatest extent technically feasible. The Contractor shall comply with the provisions and rules of the local, state, and federal agencies having jurisdiction.

1.5 WASTE DISPOSAL

- A. **Solid Wastes:** (excluding clearing debris) shall be placed in containers which are emptied on a regular schedule. Handling and disposal shall be conducted to prevent contamination. Segregation

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measures shall be employed so that no hazardous or toxic waste will become co-mingled with solid waste. The Contractor shall transport solid waste off Company property and dispose of it in compliance with Federal, State, and local requirements for solid waste disposal.

- B. **Chemical Wastes:** Chemicals shall be dispensed ensuring no spillage to ground or water. Periodic inspections of dispensing areas to identify leakage and initiate corrective action shall be performed and documented. This documentation will be periodically reviewed by the Company. Chemical waste shall be collected in corrosion resistant, compatible containers. Collection drums shall be monitored and stored in double lined staging or storage areas. Storage containers shall be removed from the company property when contents are within 6 inches of the top. Wastes shall be disposed of in accordance with Federal and local laws and regulations.
- C. **Hazardous Wastes:** The Contractor shall take sufficient measures to prevent spillage of hazardous and toxic materials during dispensing and shall collect waste in suitable containers observing compatibility. The Contractor shall transport hazardous waste off Company property and dispose of it in compliance with Federal and local laws and regulations. Spills of hazardous or toxic materials shall be immediately reported to the Engineer. Cleanup and cleanup costs due to spills shall be the Contractor's responsibility.
- D. **Burning:** Will be allowed only if permitted in other sections of the specifications or authorized in writing by the Engineer. The specific time, location, and manner of burning shall be subject to regulation and approval by the company and local fire ordinances. Fires shall be confined to a controlled area, guarded at all times, and shall be under constant surveillance until they have burned out or have been extinguished. Burning shall be thorough, reducing the materials to ashes.

1.6 HISTORICAL, ARCHAEOLOGICAL, AND CULTURAL RESOURCES

- A. Existing historical, archaeological, and cultural resources within the Contractor's work area will be so designated by the Engineer if any has been identified. The Contractor shall take precautions to preserve all such resources as they existed at the time they were first pointed out. The Contractor shall provide and install protection for these resources and be responsible for their preservation during the life of the contract. If during excavation or other construction activities any previously unidentified or unanticipated cultural or historic resources are discovered or found, all activities that may damage or alter such resources shall be temporarily suspended. Resources covered by this paragraph include but are not limited to: any human skeletal remains or burials; artifacts; shell, midden, bone, charcoal, or other deposits; rocks or coral alignments, pavings, wall, or other constructed features; and any indication of agricultural or other human activities. Upon such discovery or find, the Contractor shall immediately notify the Engineer. It is understood that discovery of finds after beginning of construction may be reason for extending the project deadline.

1.7 POST CONSTRUCTION CLEANUP

- A. The Contractor shall clean up all areas used for construction, staging, or stockpiles to the owner satisfaction.

1.8 RESTORATION OF LANDSCAPE DAMAGE

- A. The Contractor shall restore landscape features damaged or destroyed during construction operations outside the limits of the approved work areas, to the owner's satisfaction, at no charge to the owner.

1.9 MAINTENANCE OF POLLUTION FACILITIES

- A. The Contractor shall maintain permanent and temporary pollution control facilities and devices for the duration of the contract or for that length of time construction activities create the particular

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pollutant, or until the filing of a Notice of Termination, whichever is necessary to protect the owner from regulatory enforcement actions.

1.10 TRAINING OF CONTRACTOR PERSONNEL

- A. The Contractor's personnel shall be trained as required by local, state and federal rules and regulations governing environmental protection. The training shall include methods of detecting and avoiding pollution, familiarization with pollution standards, both statutory and contractual, and installation and care of devices, vegetative covers, and instruments required for monitoring purposes to ensure adequate and continuous environmental pollution control.

END OF SECTION

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SECTION 01700

CONTRACTOR GENERAL SAFETY REQUIREMENTS

PART 1 GENERAL

1.1 GENERAL SAFETY REQUIREMENTS

- A. Safety is of prime importance in performing any of the service under the Company's contract. The Company does not in any manner assume the control or responsibility of the Contractor to provide safe working conditions for the Contractor's employees or subcontractors in requiring the Contractor to follow the Company's general safety requirements. The Contractor is responsible for compliance with Federal and State laws and any government regulations, including those related to Track Work Protection when work is conducted around tracks. Additionally, the Contractor is responsible for ensuring all State and Federal Safety Regulations are followed for all construction operations. These governing agencies will include, but are not limited to, the FRA (Federal Railroad Administration) and OSHA.
- B. Work in the proximity of a railroad track is potentially dangerous. The Contractor and its employees, subcontractors and invitees are governed by the following Safety Rules and General Safety Requirements while on Company property. The Contractor is responsible for enforcement of these rules and requirements. The Company has the right to bar the Contractor, its employees, subcontractors and invitees from working on Company property if the Company deems such persons are acting in an unsafe manner.
- C. Safety rules cannot be all-inclusive. Workers must refrain from unsafe and improper practices, including both the violation of written rules and regulations, and rules of common sense.
- D. IN ALL CASES OF DOUBT OR UNCERTAINTY, THE SAFEST COURSE MUST BE TAKEN.
- E. The use of alcoholic beverages, intoxicants, narcotics, marijuana or other controlled substances by employees subject to duty or in their possession or use while on duty or on Company property is prohibited. Workers must not report for duty under the influence of any alcoholic beverage, intoxicant, narcotic, marijuana or other controlled substance, or medication, including those prescribed by a doctor, that may in any way adversely affect their alertness, coordination, reaction, response or safety.
- F. Good housekeeping is of the utmost importance in the prevention of accidents, injuries and fires. Clean-up will be conducted on a daily basis.
- G. Throwing waste, garbage, bottles, refuse, or other such materials on Company property or disposing of such at other than designated locations is prohibited. Each Contractor will provide refuse containers at the work site and empty them on a daily basis.
- H. Objects which constitute a slipping or tripping hazard must not be left in walking areas.
- I. Open fires or fires in barrels are not allowed on Company property unless appropriate permits are acquired.
- J. In all cases, established route of travel in and about the property must be used.
- K. When it is necessary to create a hazardous condition in performing work on or in the vicinity of a track, proper protection must be afforded in accordance with a safety plan submitted to and approved by the Engineer or his representative prior to creating the hazardous condition, as well as taking any other precautions that may be necessary to protect the condition.
- L. All work over water will meet State and Federal regulations.

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- M. When Contractor employees are required to work on the Company property after normal working hours or on weekends, the Company representative in charge of the project must be notified. No one will be allowed to work alone during the times specified above. When it is necessary to work during these times, a minimum of two employees are required to be present. This could be a Company employee with a Contractor employee or two Contractor employees.
- N. Contractor General Safety Requirement: IMPORTANT: Disregard of any of these safety requirements may result in a shutdown of the Contractor for a minimum of 48 hours while the infraction is investigated. If the investigation determines gross negligence on behalf of the Contractor, the Contract may be canceled and the Contractor removed from the Company's list of approved contractors, until such time as proof of satisfactory remedial action has been provided.

1.2 EMERGENCIES

- A. Each person in charge of a work party must be familiar with the Mile Post location of the area in which work is being performed so that in cases of emergencies the exact location may be given to Company personnel.
- B. In cases of emergency, it may be necessary for the Contractor's employees or agents to flag and stop approaching trains. Flagging equipment should consist of red fusees and/or red flags.
- C. When emergency flagging is necessary, Workers should protect against trains moving in both directions.
- D. If required to perform emergency flagging, Workers must understand that a great distance is required in which to stop a moving train. The railroad flagger must be at least 1.5 miles from the point being protected in order to provide minimum distance for the locomotive engineer to stop the train. A stop signal is given by swinging the lighted fusee or red flag at right angle to the track, but the engineer will recognize the stop signal if given violently in any manner from a point near the track. Workers, when giving a stop signal, must not stand on or within fouling distance of the track, as normally the engineer will not have the required stopping distance to stop short of the point where the signal is being given.
- E. When an emergency exists or if any hazard is noticed on passing trains, the Engineer or his representative on site must be notified immediately.

1.3 WORK NEAR RAILROAD

- A. Tools or work materials must not be left in close proximity to tracks.
- B. Railroad vehicles have an unquestioned right-of-way in all circumstances relating to work on or about the track area.
- C. All workers will become familiar with and be capable of recognizing railroad equipment adjacent to the tracks.
- D. Walking, stepping or standing on rails or ties, or sitting on any part of track structure except in performance of duty is prohibited. NOTE: The term "track structure" means the space between the rails and within eight feet outside the rails, unless otherwise specified.
- E. Workers are prohibited from tampering with switches or any other railroad equipment unless it is necessary for work operation and only in the presence of an authorized railroad worker.
- F. Workers must not go underneath rail cars. They must not occupy rail cars except in performance of their duty.
- G. Workers must not cross tracks by crossing over or between cars that are coupled together.

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- H. Workers must not attempt to catch onto or ride any moving railroad equipment, even though it may be moving slowly.
- I. Workers must not take refuge from rain, heat, etc., under or in cars or other rail equipment.
- J. Workers are warned that trains, locomotives or cars may be expected at any time, on any track, in either direction, and that they must watch for and keep clear of such movements. Workers must take extra precaution to be on the lookout for approaching trains, especially when working in multiple track territory, when field of vision is limited, or when noisy equipment is in use. A portable air horn may be used by a designated person to warn workers of approaching trains or equipment. Under certain conditions, trains and equipment can approach without being heard. Proper attention and protection are essential to personal safety when working near railroad tracks.
- K. Workers shall not work on the track, between tracks in multiple track territory, or nearer than 25 feet to the track without proper flag protection provided by the Company, unless the track is protected by track bulletin and work has been authorized by the Company.
- L. Any work within 25 feet of the rail, without consideration to height, must be stopped in the clear to acknowledge approaching and passing trains.
- M. Work in tunnels, on bridges and overpasses must be done in accordance with a safety plan agreed upon by the Engineer or his representative prior to beginning work in these areas. When work is being done in tunnels, specific requirements must be met and work done under the Company's supervision.
- N. Do not wave arms or objects violently except in an emergency; this is a STOP signal.
- O. Workers must not make any movement toward an approaching train or operate machinery in a manner that would cause the engineer to believe that the track is going to be fouled.
- P. Crossing tracks immediately in front of moving equipment is prohibited.
- Q. When necessary to cross any track, look both ways and keep at least 25 feet from the nearest end of stationary rail cars.
- R. Machines may be operated across tracks only at established grade crossings. If it is necessary to do so at any other location, it may be done only with permission of and under the supervision of the Engineer or his representative on site.
- S. Some rails are conductors of electrical current and are integral parts of the railroad's operating system. Devices that could shunt this electrical current must not be laid across rails. No hand or portable tools will be left on the rails at any time. Use a wooden lath to provide separation when making measurements adjacent to the tracks.
- T. Machines or vehicles must not be left unattended with the engine running. If a machine is left unattended, it must be in gear with brakes set. If it is equipped with blade, pan or bucket, that must be lowered to the ground.
- U. All machinery and equipment left unattended on the right-of-way must be left inoperable and secured against movement.

1.4 PERSONNEL

- A. Scuffling, horseplay, practical jokes and all conduct of a similar nature is prohibited.
- B. All persons are prohibited from having firearms or other deadly weapons, including knives with a blade in excess of three inches, in their possession while on duty or on Company property, except those authorized to have them in the performance of their duties or those given special permission.

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- C. Workers must not wear or use anything which impairs vision or hearing. Listening to personal radios or tape players is prohibited while on duty.
- D. All contractor employees working on the Company's property will be required to wear OSHA approved safety glasses with permanently attached side shields, hard hats and above-the-ankle, lace-up, hard toed safety boots with a defined heel, and high visibility retro-reflective orange vests. During inclement weather, proper clothing to protect against frostbite, etc., will be worn. Particular attention to footing and the use of proper footwear is essential. Hearing protection, fall protection and respirators will be worn as required by State and Federal regulations. Office employees restricted to office work will not be required to comply.
- E. When leaving work site areas at night and over weekends, the areas must be left in a condition that will ensure that railroad employees who might be working in the area are protected from all hazards. Any open pits or holes shall be covered securely and a physical barrier such as a fence placed around the opening.
- F. Machinery or equipment shall not be stored or left temporarily near a highway grade crossing in such a manner as to interfere with the sight distances of persons approaching that crossing. Prior to beginning work, the Contractor, with concurrence of the Engineer or his representative on site, will establish a storage area.
- G. Cutting or knocking down trees or moving rocks and other materials that might fall on the track structure or on communications or power lines is prohibited, unless done with the approval and supervision of the Engineer or his representative.
- H. Workers must not create and leave any condition at the work site that would interfere with water drainage.
- I. Safeguards and safety signs must be kept in place and in good condition. It is the responsibility of the Contractor to provide same.

1.5 VEHICLES AND EQUIPMENT

- A. All vehicle accidents resulting in damage to Company property will be reported immediately to the Engineer.
- B. High frequency radios (not CB's) shall be used by all crews for emergency communications between crews.
- C. Radio transmitters must not be operated when located less than 250 feet from blasting operations.
- D. Equipment and vehicles must operate at a safe speed, being aware of operating conditions as well as other equipment and persons working in close proximity. Extreme caution must be exercised at all grade crossings.

1.6 EXCAVATIONS AND UTILITIES

- A. Before excavating, it must be ascertained by the Contractor if there are underground electric wires, cables, or pipe lines in the vicinity. Excavating on the right of way could result in damage to buried cables resulting in delay to railroad traffic. Before any excavation commences, contact the BNSF signal and track representative in charge of the area. All underground and overhead wires are to be considered HIGH VOLTAGE and dangerous until verified with the company having ownership of the line. It is the Contractor's responsibility to notify any other companies that have underground utilities in the area before excavating.
- B. If obstructions are encountered that do not appear on drawings, the Engineer must be notified immediately before continuing excavation in the area. If the obstruction is a utility, and the owner of the utility can be identified, then the owner should also be notified immediately. If there is any

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doubt about the location of underground cables or lines of any kind, no work will be performed until the exact location has been determined. There will be no exceptions to these instructions.

- C. All excavations regardless of depth will be shored where there is any danger to track structure or personnel.
- D. No excavation will be left uncovered or unprotected overnight.
- E. Holes or trenches in the vicinity of the track must be covered, guarded and protected when not being worked on.
- F. Excavations, trenches or pits on or adjacent to public roads will be physically protected and denoted by highway barriers with flashing lights when not in use.
- G. All excavations will be backfilled as soon as possible.
- H. All power line wires must be considered dangerous and of high voltage unless informed to the contrary by proper authority. For lines rated 50KV or below, minimum clearance between the lines and any part of the equipment or load shall be 10 feet. For lines rated over 50KV, minimum clearance between the line and any part of equipment or load shall be 10 feet plus 0.4 inches for each 1KV over 50KV. If the capacity of the line is not known, minimum clearance of 20 feet must be maintained. A person shall be designated to observe clearance of the equipment and give a timely warning for all operations where it is difficult for an operator to maintain the desired clearance by visual means.

END OF SECTION

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SECTION 01800

PERSONAL INJURY REPORTING

PART 1 GENERAL

1.1 GENERAL

- A. The Railroad is required to report certain injuries as a part of compliance with Federal reporting requirements.
- B. Any personal injury sustained by a Contractor employee while on the Company's property must be reported immediately (by phone mail if unable to contact a person) to the Company's representative in charge of the project. The injury report form provided by the Company at the end of this section is to be completed per the attached instructions and sent by Fax to the address indicated by the engineer, no later than the close of shift on the date of the injury.

END OF SECTION

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SECTION 02000 SITEWORK

SECTION 02100 AGGREGATE BASE COURSE AND SURFACE COURSE

SECTION 02200 ASPHALTIC CONCRETE PAVING

SECTION 02300 PORTLAND CEMENT CONCRETE PAVING

SECTION 02400 FENCING

SECTION 02500 STEEL GUARD RAIL

SECTION 02600 LANDSCAPE GRADING

SECTION 02700 SEEDING

SECTION 02800 PIPELINE PROTECTION AND ENCASEMENT

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SECTION 02100

AGGREGATE BASE COURSE AND SURFACE COURSE

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Aggregate base course.
- B. Aggregate surface course.
- C. Aggregate shoulders.

1.2 REFERENCES

AASHTO T 27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 89	Determining the Liquid Limit of Soils
AASHTO T 90	Determining the Plastic Limit and Plasticity Index of Soils
AASHTO T 96	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
AASHTO T 99	Moisture–Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop
AASHTO T 104	Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate
AASHTO T 180	Moisture–Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
AASHTO T 191	Density of Soil In-Place by the Sand Cone Method
AASHTO T 310	In-Place Density and Moisture Content of Soil and Soil–Aggregate by Nuclear Methods (Shallow Depth)
ASTM D1241	Standard Specification for Materials for Soil-Aggregate Subbase, Base, and Surface Courses
ASTM D2419	Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
ASTM D2844	Standard Test Method for Resistance R-Value and Expansion Pressure of Compacted Soils
ASTM D3744	Standard Test Method for Aggregate Durability Index
ASTM D4546	Standard Test Methods for One-Dimensional Swell or Collapse of Soils
ASTM D4718	Standard Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles

1.3 QUALITY ASSURANCE

- A. The density of the compacted aggregate base course and aggregate surface course will be determined by the Engineer at regular intervals in accordance with AASHTO T 191 or AASHTO T 310, or by other methods approved by the Engineer.

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1.4 SUBMITTALS

- A. Submit to the Engineer, in air-tight containers, samples of the aggregate base course and aggregate surface course. The amount and number of samples will be directed by the Engineer; minimum weight of sample is 50 pounds. Label samples to identify source and intended usage of material.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Coarse Aggregate - The coarse aggregate for the aggregate base course, aggregate surface course, and aggregate shoulders shall be pit run gravel (base course only), gravel, crushed gravel, crushed stone, crushed concrete, or crushed bituminous concrete paving. Aggregates shall be free from lumps and balls of clay, organic matter, objectionable coatings and other foreign materials. The aggregates shall be as defined below.
1. Gravel shall be the coarse granular material resulting from the reduction of rock by the natural action of the elements and having subangular to rounded surfaces. It may be partially crushed.
 2. Crushed gravel shall be the product resulting from crushing by mechanical means, and shall consist entirely of particles obtained by crushing gravel, all of which before crushing will be retained on a screen with openings equal to or larger than the maximum nominal size of the resulting crushed material. If approved by the Engineer, final product gradations may be obtained by screening or blending various sizes of crushed gravel material.
 3. Pit or Bank Run Gravel (Base Course Only) shall be a mixture of sand, gravel, silt and clay occurring naturally in a deposit, which is of such quality that it may be used with only minor processing.
 4. Crushed stone shall be the angular fragments resulting from crushing by mechanical means the following types of rocks quarried from undisturbed, consolidated deposits: granite and similar phanerocrystalline igneous rocks; limestone; dolomite; sandstone; massive metamorphic quartzite, or similar rocks.
 5. Crushed recycled concrete shall consist of previously hardened Portland cement concrete or other concrete containing pozzolanic binder material. The recycled material shall be free of all reinforcing steel, bituminous concrete surfacing, and any other foreign material and shall be crushed and processed to meet the required gradations for coarse aggregate.
 6. Reclaimed Asphalt Pavement (RAP) shall consist of previously hardened asphalt concrete. RAP shall be processed by mechanically milling or recrushing clean pavement. The reclaimed material shall not be manufactured from asphalt utilizing slag material as an aggregate component. The reclaimed material shall be free from all foreign material and shall be crushed and processed to meet the required gradations for coarse aggregate.
- B. Gradation
1. Aggregate Base Course
 - (a) Gradation A or B, Type 1 as defined by ASTM D1241. However, the maximum percentage by weight passing the No. 200 Sieve for Gradation B shall be limited to 10%. or
 - (b) The gradation specified in the current Department of Transportation Standard Specifications of the State in which the work is being performed. However, the maximum percentage by weight passing the No. 200 Sieve shall be limited to 10%. or
 2. Aggregate Surface Course and Aggregate Shoulders

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- (a) Gradation C or D, Type 1 as defined by ASTM D1241. However, the minimum percentage by weight passing the No. 200 Sieve shall be 8%.
- (b) The gradation specified in the current Department of Transportation Standard Specifications of the State in which the work is being performed. However, the minimum percentage by weight passing No. 200 Sieve shall be limited to 8%.

C. Quality and Material Characteristics

Na2SO4 Soundness (5 Cycles)	25 (Base Course)
AASHTO T 104, Max. % Loss	30 (Surface Course & Shoulders)
Los Angeles Abrasion	45 %
AASHTO T 96, Max. % Loss	
Plasticity Index, Max	5%
AASHTO T 90	
Liquid Limit, Max.	25 %
AASHTO T 89	
Dust Ratio = $\frac{\% \text{ Passing \#200 Sieve}}{\% \text{ Passing \#40 Sieve}}$	2/3 Max.
Sand Equivalent, Min.	25 % (Base Course)
ASTM D2419	40 % (Surface Course & Shoulders)
Durability Index	35 Min.
ASTM D3744	
Resistance R-Value	72 Min.
ASTM D2844	
Swell Pressure	0.3 psi Max.
ASTM D4546	

PART 3 EXECUTION**3.1 EXAMINATION**

- A. Verify substrate has been inspected and approved by the Engineer, has correct gradients and elevations, and has appropriate moisture content.
- B. Obtain all necessary permits for hauling on public rights of way.

3.2 PREPARATION

- A. Prepare subgrade in accordance with Section 03200.

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- B. Correct irregularities in substrate gradient and elevation by scarifying, reshaping, and re-compacting.
- C. Do not place materials in snow or on soft, muddy, or frozen subgrade.
- D. Before the aggregate is deposited on the subgrade, it shall contain the amount of moisture required for compaction. The amount of moisture required shall be that determined by the Engineer for the material and compaction methods being used. The water and aggregate shall be mixed at a central mixing plant.

3.3 AGGREGATE PLACEMENT

- A. Spread and compact aggregate over the prepared substrate to the thickness shown on the plans. When placed, it shall be free from segregation and shall require minimum blading or manipulation.
- B. Construct aggregate base course, aggregate surface course, and aggregate shoulders in layers not more than 6 inches thick when compacted. When a compacted layer 6 inches or less is required, the material shall be placed in a single layer. When a compacted layer in excess of 6 inches is required, the material shall be placed in equal layers.
- C. Add water to assist compaction. If excess water is present, remove aggregate and aerate to reduce moisture content.
- D. Compact granular material for aggregate base course, aggregate surface course, and aggregate shoulders to not less than 95 percent of the maximum laboratory density, in accordance with AASHTO T 180, The Modified Proctor Moisture-Density Relations of Soils (Method A or C). A coarse particle correction in accordance with ASTM D4718 will be used with Method A and may be used with Method C.
- E. Proof rolling shall be in addition to the compaction specified and shall consist of the application of a heavy-pneumatic tired roller having four or more tires, each loaded to a minimum of 30,000 pounds and inflated to a minimum of 150 psi. Any material or underlying material that provides unsatisfactory results by proofrolling shall be removed and replaced with satisfactory materials, recompacted and proof rolled to meet these specifications.
- F. Hauling surface course over the base course in the process of construction will not be permitted when, in the opinion of the Engineer, the effect will be detrimental to the base course.
- G. When using as a haul route, keep aggregate and shoulder surfaces smooth by dragging or blading and recompacting as many times each day as the Engineer may direct. Fill holes, waves and undulations which develop and which are not filled by blading. Apply water for dust control as directed by the Engineer.
- H. Construct and maintain an aggregate surface course for temporary roads, approaches and entrances in accordance with the plans and as directed by the Engineer.
- I. Where plans specify temporary aggregate surface, constructed as specified, maintain to the satisfaction of the Engineer, remove and reuse (if acceptable to the Engineer) or dispose of removed material offsite, at no additional cost to the Company.

PART 4 MEASUREMENT AND PAYMENT

4.1 AGGREGATE BASE COURSE AND SURFACE COURSE

- A. Aggregate Base Course or Surface Course, of the various types specified by the plans and contract documents, will be measured by the cubic yard, unless specified elsewhere in the plans or contract documents. The measured quantities for payment will be the volumes of specified materials described by the limits of the lines, slopes and grades of the plans and contract documents. No

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allowance for shrinkage or compaction will be make. No additional measurement will be allowed for materials placed beyond the plan limits unless directed otherwise by the Engineer.

- B. If disagreement exists between the Contractor and the Engineer as to the accuracy of the plan quantities, either party shall, before any work is started which would affect the measurement, have the right to so request in writing, and thereby cause the quantities to be measured. If measured quantities requested by the Contractor do not materially differ from the plan quantities, then the Contractor shall pay the Company's costs to verify measurements of quantities.
- C. Aggregate Base Course and Surface Course shall be paid for at the contract unit price per cubic yard of Aggregate Base Course and Surface Course of proper types within the limits of lines and slopes described in the typical sections and cross sections as defined in the plans and contract documents. This price shall be full compensation for furnishing all labor, materials, supervision, water for compaction, tools, equipment, and incidentals necessary for excavating, loading, transporting, and depositing base course and surface course material either from off site or from stockpile when required; loading, transporting, and distributing water; spreading, aerating if necessary, and compacting the various course materials to the designated lines and slopes.

END OF SECTION

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SECTION 03000 EARTHWORK

SECTION 03100 CLEARING AND GRUBBING

SECTION 03200 EXCAVATION AND EMBANKMENTS

SECTION 03220 ROCK SLOPE SUPPORT AND STABILIZATION

SECTION 03300 SUBBALLAST

SECTION 03400 GEOSYNTHETICS

SECTION 03500 LIME OR FLY ASH STABILIZED SUBGRADE

SECTION 03600 CEMENT STABILIZED SUBGRADE

SECTION 03700 HOT-MIX ASPHALT ROADBED

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SECTION 03100 CLEARING AND GRUBBING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Clearing and Grubbing. See General Provisions for utility and permitting requirements and sections that apply.

1.2 DESCRIPTION

- A. This work shall consist of clearing and grubbing of all trees, stumps, undergrowth, brush, trash, grass, weeds, roots larger than 3 inches in diameter, debris, or other objectionable materials within the limits of the excavation, embankment, borrow, and other areas as shown on the plans and Contract Documents.

PART 2 EXECUTION

2.1 EXCAVATIONS

- A. Areas that are to be excavated and hauled into embankments shall be cleared and grubbed of all objectionable material to the full depth and width of the completed excavation. Areas that are to be excavated and wasted shall not be cleared unless specifically requested by the Engineer. Roots or other vegetation more than 3 inches in diameter existing below the finished surface of excavated sections shall be removed to a depth of 6 inches below the finished surface. There will be no allowance for any grubbing required below such finished surface. All such grubbing below the finished surface shall be considered incidental to clearing and grubbing and shall be included in the bid item cost for clearing and grubbing.

2.2 BORROW PITS

- A. Borrow pits shall be free of all objectionable material to the full depth of the borrow pit.

2.3 EMBANKMENTS

- A. All areas that will be beneath embankments shall be free from all vegetation and roots to a depth of 6 inches below the ground surface. For embankments 3 feet and less, roots that are over 3 inches in diameter shall be removed to a depth of 6 inches below ground surface.
- B. All rubbish shall be removed in embankment areas.

2.4 OTHER DESIGNATED AREAS

- A. Designated portions of the right-of-way other than excavations, borrow areas, and embankments shall be cleared off level with ground surface by cutting and removal of all trees (standing or fallen), stumps, undergrowth, brush, vines, roots, and other vegetation, trash, or objectionable materials so that no obstruction will interfere with close machine or hand mowing of cleared areas. Cleared areas shall be left smooth and free of obstructions that will impound water.

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2.5 SCHEDULING

- A. When required by the Engineer, the Contractor shall complete clearing and grubbing work far enough in advance of other operations to permit the placement of construction stakes.

2.6 LIMITS OF WORK

- A. Trees or other growth outside the limits for clearing and grubbing shall be preserved and protected from damage during construction operations. If rare or endangered plants or artifacts are encountered during construction, work shall stop in the vicinity of the find, and the Contractor shall notify the Engineer of said find.

2.7 DISPOSAL

- A. Cleared or grubbed material shall be piled and disposed of in a legal manner as directed by the Engineer. Stripped material composed of a mixture of vegetation and earth shall be deposited in specified waste areas, along berms outside of fill slopes, or in other locations designated by the Engineer. No material will be disposed of in the footprint of the excavation /embankment.
- B. Unless otherwise stated in the special provisions, all merchantable timber will be the property of the Contractor.
- C. In National Forest areas, the clearing and grubbing, and piling of brush, and burning shall conform to the rules and regulations of the National Forest Service. Contractor is responsible for all permitting, licensing or any other associated administrative duties or costs that may be required by the Forest Service or any other regulating agency.

PART 3 MEASUREMENT AND PAYMENT

3.1 CLEARING AND GRUBBING

- A. Clearing and grubbing will be measured as the quantities shown on the plans and contract documents. If disagreement exists between the Contractor and the Engineer as to the accuracy of the plan quantities, either party shall, before any work is started which would affect the measurement, have the right to request in writing and thereby cause the quantities to be measured. If the measured quantities requested by the Contractor do not differ from plan quantities, then the Contractor shall pay the Engineer's costs for verifying measurements and calculations of quantities.
- B. Clearing and grubbing shall be paid for at the contract unit price per acre cleared and grubbed within the designated areas. This price shall be full compensation for furnishing all labor, materials, tools, equipment, supplies, supervision, and incidentals necessary for clearing, grubbing, and disposal of the resulting materials.

END OF SECTION

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SECTION 03200 EXCAVATION AND EMBANKMENTS

PART 1 GENERAL

1.1 SECTION INCLUDES¹

- A. Roadway Excavation
- B. Borrow
- C. Ditch Excavation
- D. Embankment Fill
- E. Select Material
- F. Granular Embankment Fill

1.2 DESCRIPTION

- A. These specifications shall govern the construction and completion of cuts, embankments, slopes, ditches, channel changes, and incidental work all in reasonably close conformity with the alignment, grade, and cross-sections shown on the plans or as established by the Engineer. The work shall be conducted so that the terrain outside the limits of slopes will not be disturbed except where approved by the Engineer.
- B. For rock excavation, to reduce the chances of causing property damage (both private and railroad) blasting operations shall be designed and executed to loosen rock as an aid to mechanical excavation, rather than to break and move masses of bedrock. Blasting shall be permitted only during daylight hours.
- C. The Blaster-in-Charge shall have at least 5 years of verifiable experience in designing and executing blasts, especially with the techniques of controlled blasting. The resume of the Blaster-in-Charge shall be included with the Blast Plan Submittal.

1.3 SUBMITTALS

- A. For rock excavation, a detailed Blast Plan Submittal and Mechanical Excavation Submittal shall be presented for review to the Engineer at least two weeks prior, unless otherwise directed by the Engineer, to commencing blasting and mechanical excavation operations at the site.

PART 2 MATERIALS

2.1 EXCAVATION

- A. Classification:
 - 1. When bids for excavation are taken on an "Unclassified" basis, no recognition will be made of classification of any kind.
 - 2. When bids are taken on a "Classified" basis, it is the intent of these specifications that all excavated material will be classified as "Rock" or "Common" by the Engineer while the work is in progress. In special cases, other classifications may be specified in the invitation to bid, such as: peat, topsoil, etc.

¹ See General Provisions for utility and permitting requirements and sections that apply

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- B. Common Excavation is considered to be material that can be excavated with a dozer blade or any size backhoe, ripping with a D-7 or smaller dozer, impact breaker less than 6,000 ft.-lb. or directly by a wheel loader. Unless other classifications are specified in the invitation to bid, "Common Excavation" shall include all materials that cannot be classified as "Rock" by the definition in Paragraph C.1.
- C. Rock Excavation
1. Rock excavation is considered to be material requiring blasting or the use of heavy mechanical breakage (D-8 or larger dozer ripping with a single shank ripper blade and/or 6,000 ft.-lb. or greater impact breaker). Rock excavation shall include all rock in ledges, and bedded deposits, cemented and conglomerate deposits exhibiting the physical characteristics and difficulty of rock removal which cannot be removed without systematic drilling and blasting or as determined by the Engineer. The fact that blasting may be resorted to by the Contractor shall not, of itself, entitle the material to be classified as "Rock." If during excavation the Contractor encounters material that may be classified as rock excavation, such material shall be uncovered, and the Engineer notified so that the Engineer can classify the material. Rock excavation and blasting shall be governed by the requirements set forth in Section 3.4 and 3.5 of this specification section.
 2. Materials from rock excavation which are to be used in embankments shall be processed so as to produce a well-graded fill material which will permit the placing of layers not to exceed 24 inches in thickness as per Paragraph 3.8C, or as otherwise approved by the Engineer.

2.2 EMBANKMENT FILL

- A. It is the intent of these specifications that all suitable materials from roadway, cut ditch, channel, or other excavation, other than surface ditch, be used so far as practicable in forming embankments, dikes, or similar facilities.
- B. When the areas staked for excavations are insufficient or unsuitable to form the embankments, the deficiency shall be obtained by widening cuts or borrowing at points as directed by the Engineer. Such cut widening beyond the limits of the designated and staked excavation section and other borrow excavation shall be considered as incidental to embankment and the cost of the work shall be included in the unit price for embankment.
- C. Stakes set beyond the limits of standard or designated excavation sections for the purpose of assisting Contractor in establishing limits of cut widening or borrow shall not constitute a standard, designated, or staked section for pay purposes.

2.3 SELECT MATERIAL

- A. Select material shall be limited to non-expansive, non-swelling soils meeting the following criteria:

Liquid Limit ASTM D4318	Maximum Allowable Percent Passing #200 Sieve ASTM D1140
> 50	30%
50 < 30	40%
< 30	50%

- B. The plasticity index of select material as determined in accordance with ASTM D4318 shall not exceed 15%.

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2.4 GRANULAR EMBANKMENT FILL

- A. Granular embankment fill shall consist of crushed stone or gravel meeting the following quality requirements:

Sodium Sulfate Soundness, 5 cycle ASTM C88	25% Maximum Loss
Los Angeles Abrasion ASTM C131	45% Maximum Loss
Deleterious Substances (shale, clay lumps, coal, soft and unsound fragments)	10% Maximum

- B. Granular embankment fill shall be uniformly graded from coarse to fine and shall meet the following gradation requirements:

Sieve Size	Percent Passing
3"	100
#4	45-85
#16	25-65
#50	10-30
#200	0-15

PART 3 EXECUTION

3.1 ROADWAY EXCAVATION

- A. Disposal of Excess Material

- Excavation in excess of that needed to make the embankments according to the plans and specifications shall be used to widen embankments, flatten slopes, or be deposited in spoil banks, at locations and in height and form as directed by the Engineer. Payment for such excess material placed outside of the limits of the staked embankment section shall be in excavation only.
- Stakes set beyond the limits of standard or designated embankment sections for the purpose of assisting Contractor in establishing limits of disposal areas shall not constitute a standard, designated, or staked section for pay purposes.

- B. Waste

- At the discretion of the Engineer and with his written consent, the Contractor may waste excavated materials in a manner and location approved by the Engineer.
- If the Contractor should desire to waste off of the right-of-way, he may do so only with the written approval of the Engineer. Before entering on the property, the Contractor must obtain easement, license, permission or other means to release use of the property from landowner or his authorized agent. Such agreement shall be submitted to the Engineer in writing. Such agreement shall be at the Contractor's expense.
- The Contractor's activities shall be conducted in a manner which will not impact Railroad property, including fences, ditches, underground and overhead utilities, etc.

- C. Haul

- Transporting excavated material shall be considered as merely incidental to the grading work. It is the Contractor's responsibility to thoroughly inspect the project site, plans, and contract

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- documents. Submittal of a bid by the Contractor shall be taken as an indication of the Contractor's understanding of the relationship of excavation, embankment, borrow and haul distances for the grading work required for this project. No direct payment will be made for so-called overhaul.
2. Vehicles used for hauling shall be satisfactory to the Engineer and shall be sufficient in number and capacity to meet the project schedule for the work involved. Whenever feasible the Contractor shall route his hauling equipment over the grade in such a manner as to maintain uniform compaction across the roadway and minimize damage to completed work.
- D. **Overbreak and Slides**
1. Properly licensed and approved Contractors are required for all blasting operations. Excessive blasting or "overshooting" will not be permitted. The Engineer shall have authority to require the Contractor to discontinue any method of blasting which leads to overshooting, is dangerous to the public, destructive to property or to natural features, or in the opinion of the Engineer, causes excessive rock damage to the finished excavation slope. Preshear or cushion techniques shall be used when called for on the plans, in the special provisions, or when directed by the Engineer.
 2. Any material outside the specified cross section which is shattered or loosened by blasting shall be removed at the Contractor's expense.
 3. Material outside the design slopes which is deemed unstable by the Engineer because of its natural formation shall be removed and paid for as excavation of the proper classification.
 4. Slides, which in the judgment of the Engineer are unavoidable, shall be measured and paid for as excavation according to the classification in which the material is found after the slide occurs.
- E. **Finishing Excavated Slopes:** All excavated slopes, including roadway, channel, road, and borrow pit adjacent to embankment, shall be trimmed accurately to authorized cross sections. In rock or other material, when in the judgment of the Engineer a true slope cannot be made, an irregular slope approximating the design slope will be permitted. No loose material shall be left on the sides or in the bottom of any excavation. This work shall be considered as incidental to excavation and direct payment for this work will not be made.

3.2 BORROW

- A. No borrowing will be permitted except as shown on the plans or as instructed by the Engineer in writing. No borrowing will be permitted except in materials approved by the Engineer. Borrow pits shall be left in neat and regular shape and shall be excavated so that they will drain as directed by the Engineer. Necessary clearing, grubbing and satisfactory drainage of borrow pits and the disposal of debris thereon shall be considered related operations to the borrow excavation and not paid for separately.
- B. If the Contractor should desire to borrow off of the right-of-way, he may do so only with the written approval of the Engineer. Before entering on the property, the Contractor must obtain easement, license, permission or other means to release use of the property from landowner or his authorized agent. The Contractor is also responsible for all federal, state and local environmental permitting and requirements all agreements and authorizations shall be submitted to the Engineer in writing.
- C. The necessary borrow materials will be obtained from a source selected by the Contractor. The Contractor will advise the Company in writing at the time of submission of his proposal along with all data regarding the suitability of such material to be used in the construction of the proposed embankments and approved by the Engineer. Further, the Contractor shall furnish the Company copies of all agreements from such an independent source, and shall be responsible for the construction of all necessary haul roads, opening up the borrow areas, payment to the landowner for all materials, restoration of the borrow areas, and removal of all haul roads.

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- D. The Contractor shall be responsible for all survey work at each borrow area to determine the quantity of material removed. Survey work shall include all cross sections and limits of material removed. All such survey work and method of measurement of borrow materials removed shall be done in a manner acceptable to the property owner. Payment for borrow materials shall be made directly to respective property owner.
- E. The Contractor's activities shall be conducted in a manner which will not impact Railroad property including fences, ditches, underground and overhead utilities, etc.

3.3 DITCH EXCAVATION

- A. When ordered by the Engineer, intercepting surface ditches shall be made at the top of excavations and at the foot of embankments, or at other locations where conditions make them desirable. The cross section and location of such ditches shall be as directed by the Engineer; ditch outlets shall diverge sufficiently from adjoining works to prevent erosion damage. Material excavated shall be placed without compaction on the downhill side of the excavation in one operation such as may be accomplished by a motor grader or dozer. Payment for such ditches shall be in excavation only.

3.4 ROCK EXCAVATION

- A. Blasting
 - 1. A track window will be required for all blasting. The track window should be requested as part of the Shot Plan (see Paragraph 1.3A) to be submitted for each individual blast. The track window must be received prior to commencement of blasting operations. The blast shall occur within the first 30 minutes of the window unless otherwise approved in writing.
 - 2. Slopes that require blasting either because of the hardness of the bedrock or inaccessibility of mechanical equipment shall be excavated in such a manner that the resulting slope is left in a safe and stable condition, and minimal damage to the slope face due to the effects of the blasting and material removal. The Contractor shall scale and dress the slope after each lift, removing all loose fragments not firmly attached to the slope face, and any overhangs the Engineer considers as a potential hazard to rail maintenance activities and operations.
 - 3. All slopes higher than 10 feet shall be excavated using the methods of controlled blasting. For the purpose of these specifications, controlled blasting refers to the techniques known as presplitting and cushion blasting. Controlled blasting consists of the controlled use of explosives in carefully spaced and aligned drill holes to provide a planar surface in the rock at the specified backslope.
 - 4. Production blasting away from the specified backslope shall be designed and executed to eliminate the possibility of placing excavated material on the mainline track. Exceptions to placing material on the mainline track will be discussed in paragraph 3.5A.
 - 5. The Contractor shall submit to the Engineer for review the Shot Plan for each individual blast containing the full details of the drilling and blasting operations, including the following minimum information:
 - (a) Station limits of proposed shot.
 - (b) Plan and section views of proposed drill pattern including hole spacing, diameter, depth, drill hole angles, burden, and subdrill depth. Dust control measures, if required, shall be described for the drilling equipment.
 - (c) Loading diagram showing type and amount of explosive, primers, initiators, and location and depth of stemming and decking. If dust is considered an environmental problem with the blasting, the use of water bag stemming may be required, and at no additional cost to the Owner.
 - (d) Initiation sequence of blast holes including delay system and timing.

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- (e) Name of Blaster-in-Charge
 - (f) Date of plan, date of proposed shot, length of window requested.
 - (g) Review of the blast plan by the Engineer shall not relieve the Contractor of the responsibility for the accuracy, adequacy and safety of the plan when implemented in the field.
6. The Contractor shall obtain all required federal, state and local permits related to the blasting operations, including the transportation, handling, and storage of explosives.
7. The following general guidelines are to be followed in the blasting operations. Localized site conditions, geologic or other, may require changes in some of the following guidelines, however, the Contractor's equipment and operations shall be capable of adhering to the requirements and results expected of the controlled blasting operations:
- (a) The Contractor shall remove all overburden soil and loose rock along the top of the excavation for a distance of at least 10 feet beyond the limits of the controlled blasting area.
 - (b) The controlled blasting and production holes shall be not less than 2-1/2 inches nor more than 3 inches in diameter, unless the Contractor demonstrates that larger diameter holes produce adequate results, in the opinion of the Engineer.
 - (c) The Contractor shall control drilling operations by the use of the proper equipment and workmanship to ensure that no hole shall deviate from the plane of the planned slope by more than 9 inches either parallel or normal to the slope. Drill holes exceeding these limits shall not be paid unless satisfactory slopes, as described by these specifications, are obtained.
 - (d) The length of controlled blast holes shall not exceed 20 feet unless, in the opinion of the Engineer, the Contractor can demonstrate the accuracy of his drilling and the results of the blasting produces a uniform slope free of undue irregularities or overbreak.
 - (e) Before placing charges, the Contractor shall determine that the hole is free of obstructions for its entire length.
 - (f) The maximum diameter of explosives used in presplit or cushion blast holes shall not be greater than 1/2 the diameter of the drill hole, and the resultant charge density shall be less than 1/4 pound per foot of drill hole, except that greater charge may be used in the bottom 1 to 3 feet of the hole. Higher charge densities shall be permitted only after field tests performed by the Contractor demonstrate adequate results, in the opinion of the Engineer. Use only explosives manufactured specifically for use in presplit and cushion blast holes. Cartridges shall be spaced 12 to 24 inches down the hole, or columnar charges used. ANFO shall not be used in the presplit or cushion holes.
 - (g) The spacing of the presplit/cushion holes shall be 30 inches, unless with written approval based on trial blasts in the actual slopes show that greater or lesser spacing give adequate results.
 - (h) The stemming above the explosive column for presplit/cushion holes shall be a minimum of 3 feet, and the hole directly above the explosive column shall be blocked to prevent the stemming from filling in around the explosive. Stemming shall be 3/8 minus sand or similar material.
 - (i) The spacing of cushion blasting holes shot as part of the production blasting shall be less than or equal to the final burden resulting from the production blasting.
 - (j) If presplitting is used, these holes shall be fired before the production holes, while if cushion blasting is used, the holes shall be fired after the production holes.
 - (k) Production blast holes shall not be drilled closer than 3 feet to the controlled blast line, without the written approval of the Engineer. Production holes shall not exceed 3 inches in diameter. Delay patterns, charge densities, and hole spacing for the production holes shall be designed to break the rock without heaving it onto the mainline track or into the river. A

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minimum delay of 10 millisecond (MS) per foot of burden shall be used between production rows.

- (l) The spacing-to-burden ratio for production holes drilled on a rectangular pattern shall be 6-to-5 unless field trials performed by the Contractor demonstrate to the satisfaction of the Engineer that other spacing-to-burden ratios produce adequate results. Maximum hole spacing shall be 8 feet.
- (m) Adjacent holes in any direction shall not be detonated on the same delay.
- (n) The maximum charge-per-delay shall be 15 pounds, and the maximum charge-per blast shall be 200 lbs, unless otherwise specified by the Engineer or Special Provisions.
- (o) Ground vibrations from the blasting shall not exceed 2 inches per second, as measured at the track structure.
- (p) Blast mats approved by the Engineer shall be required over any blast capable of producing fly rock or other debris that can reach any track.

B. Mechanical Excavation

- 1. Occasionally slopes contain rock that can be excavated with mechanical equipment such as large dozer rippers and impact breakers. The requirements for final slope face, including scaling and dressing, are the same as for slopes formed by blasting, as are the requirements for dust control, equipment/personnel blockage of the mainline or other tracks.

C. Slope Scaling and Clearing

- 1. Prior to commencing excavation operations, the perimeter of the slopes shall be scaled of loose rock and cleared of trees to a distance of 25 feet in back of the cut slope line. Rock scaling is incidental to the cost of Rock excavation and will not be paid separately, while clearing is payable under the pay item of Clearing and Grubbing.
- 2. Contractor is also responsible for scaling and dressing the slope after each lift, removing all loose fragments not firmly attached to the slope face, and any overhangs the Engineer considers as a potential hazard. This scaling and dressing is incidental to the rock excavation and will not be paid separately.

3.5 SPECIAL BLASTING SITUATIONS

- A. Very steep slopes located near the track will require special efforts to protect the track and ample time to remove the excavated material which will foul the track. The Contractor shall submit a detailed plan for excavating these areas, including the method of protecting track, a site/location specific blasting plan to avoid damage to the track structure, and maximum time required for the track window. NOTE: Coordination for the track window will need to take place a minimum of 7 days prior.

3.6 ROCK EXCAVATION BELOW SUBGRADE

- A. When directed by the Engineer, rock or other similarly hard material shall be removed to specified depth below subgrade and backfilled with compacted materials approved for roadbed.
- B. Unless otherwise specified, rock shall be removed to a depth of 1 foot below subgrade and backfilled by the method as shown on the plans or in the special provisions.
- C. If developed in well-graded sizes with a maximum dimension of no greater than 6 inches, the fines from the rock excavation may be used for backfill. Backfill placement procedures shall be as specified in Paragraph B.
- D. If rock excavation does not yield sufficient fines acceptable to the Engineer, select material shall be used for backfilling.
- E. Select material will be used to level off the bottom of the excavation so track can be laid without damage to ties. If select material for backfilling or material qualifying as sub-ballast is not available

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within the length of the longest haul of excavation to embankment on the project, the Company may elect to train haul same, at its expense, or have Contractor truck haul material to the site. If truck hauling by the contractor is required, payment shall be in accordance with the contract unit rates for subballast.

- F. The select material excavated from the designated undercut section and fines from rock excavation used to backfill the designated undercut section will be paid for at the same unit prices that apply to roadway grading.
- G. Additional select material as may be required beneath the designated undercut section due to the roughness of rock excavation shall be considered as incidental to rock excavation and direct payment for this material will not be made.

3.7 SUBGRADE AND EMBANKMENT FOUNDATION PREPARATION

- A. **Embankment Foundation Preparation:** The Contractor shall proof roll the ground surface of all areas to receive embankment prior to commencement of fill operations. Proofrolling shall consist of the Engineer's observation of soil deflection beneath the tires of the Contractor's heaviest rubber tired equipment, e.g. loaded water trucks, loaded scrapers, or loaded dump trucks. Proof rolling shall consist of a minimum of two passes. Any soft zones detected in this manner which cannot be effectively compacted with repeated passes of a roller shall be treated in accordance with Paragraph C. When shown on the plans, in the special provisions, or when directed by the Engineer, the Contractor shall plow, scarify, and break up the full width of the embankment foundation, and then shall condition the material, as may be required, and compact to the density specified for earth fill embankment for the particular material to a depth of at least 6 and up to 18 inches (if necessary to reach the specified density) below the ground surface. This work shall be considered as incidental to embankment and direct payment for such work will not be made.
- B. **Excavation Base Preparation:** When shown on the plans, in the special provisions, or when directed by the Engineer, the Contractor shall plow, scarify, and break up the base of the excavations for the entire crown width of the subgrade, and then shall condition and compact the material to the density specified for earth fill embankment for the particular material to a depth of at least 6 and up to 18 inches (if necessary to reach the specified density) below finished surface of the excavated section. This work shall be considered as incidental to excavation and direct payment for such work will not be made.
- C. Where soils encountered at subgrade elevation in excavations or in foundations for embankments less than 3 feet high are naturally soft, loose, or contain excessive moisture, the Engineer may require that one or more of the following improvement techniques be used in order to establish a firm, stable subgrade or foundation.
 - 1. **Removal and Replacement:** When directed by the Engineer, the soils shall be removed to a depth determined by the Engineer. The area of overexcavation shall be backfilled with material suitable for embankment and compacted to a density of not less than that specified for earth fill embankments. Payment for excavating the soils will be made in accordance with the contract unit price for excavation. Payment for backfilling and compacting with suitable soils will be made at the contract unit price for embankment.
 - 2. **Use of geosynthetics:** When directed by the Engineer, geotextiles and/or geogrids shall be placed over the soft or wet soils in order to provide reinforcement and stability of soft soils. The type and weight of geosynthetic shall be as specified by the Engineer. Placement requirements and payment provisions shall be as specified in SECTION 03400.
 - 3. **Soil Treatment/Modification:** In special situations as shown on the plans, in the special provisions, or as directed by the Engineer, treatment of the soils using lime, flyash, or other additive to stabilize or condition wet soils may be used. Use of fly ash or other additive shall be in accordance with all applicable federal, state, and local environmental regulations. The additives may be applied directly to the ground and blended using the most effective method

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available, or the additives and soil may be blended on stable ground and worked into the soft or wet soils. Use of additives for soil treatment/modification shall not be interpreted as a lime or cement stabilized subgrade. Payment for soil treatment/modification shall be at contract unit prices.

- D. **Embankments on Swampy Ground:** Embankments which are to be constructed across low or swampy ground which will not support the weight of trucks or other hauling equipment will receive special consideration for construction. The considerations may be, but are not limited to: (a) removal and replacement of unstable material; (b) displacement of unstable material by surcharging with rock or granular material to provide a stable base; (c) placing a woven geotextile fabric or geogrid and the placement (dumping) of material, preferably rock, in a uniformly distributed layer of thickness not greater than that necessary to support the equipment while placing subsequent layers. The Engineer will approve the method to be used and will specify the type and thickness of geosynthetic material if it is to be used. Compaction requirements are specified in Section 3.6. Compaction requirements. Placement requirements and payment provisions shall be as specified in SECTION 03400.

3.8 ROADWAY EMBANKMENT

A. General

1. Roadway embankment shall be constructed as shown on the plans, in these specifications, in the special provisions, or as instructed by the Engineer. Embankment material and depths of different embankment material shall be as shown on the plans, in the special provisions, or as instructed by the Engineer.
2. In general, it is desirable that the upper portion of all embankments be constructed of predominantly coarse grained soils (i.e., select or granular embankment materials). Soils with high plasticity (Unified Soils Classifications of CH, MH, or OH) should not be used in the upper portions of embankments unless stabilized using lime or cement stabilization. Other soils containing significant percentages of fine grained soils (USCS classifications CL, ML, SC, SM, GC, and GM) are potentially susceptible to pumping or frost heaving and exhibit poor drainage characteristics. The use of these soils in the upper portions of embankments should be avoided unless stabilized or used in conjunction with a hot-mix asphalt roadbed or granular embankment. The most desirable materials to be used in the upper portions of embankments are well-graded sands and gravels (SW and GW classifications). These soils are well drained, have good compaction characteristics, and are not susceptible to frost heave or pumping.
3. Wherever an embankment is to be placed on or against an existing slope steeper than four horizontal to one vertical, such slope shall be cut into steps as the construction of new embankment progresses. Such steps shall have a horizontal dimension of not more than 6 feet and a vertical rise of 2 feet. The Contractor shall modify slope cuts as requested by the Engineer to maintain slope and track structure integrity. Steps cut into the slope shall not be allowed to remain unsupported overnight.

B. Earth Fill

1. Embankments built of soil material or material consisting of gravel or small pieces of rock 6 inches or less in maximum dimension shall be placed, using conditioned material when necessary, and compacted until the required degree of compaction is obtained thoroughly and uniformly throughout the layer. No stones larger than 3 inches in diameter will be permitted within the top 12 inches of roadway embankment.
2. Embankments shall be constructed in layers containing only that amount of material which will ensure sufficient and uniform compaction, but in no case shall any layer or lift exceed 8 inches after compaction. Each successive lift or layer shall be carefully leveled and completely and uniformly compacted over the full width of the embankment before a succeeding layer is placed.

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3. Compaction requirements for earth embankments are as follows. All embankments shall be compacted to a density of not less than 95% of the maximum standard laboratory density, and not more than +4 percentage points above the optimum moisture content, unless otherwise specified on the drawings. The standard laboratory density and optimum moisture content shall be the maximum density and optimum moisture as determined in accordance with ASTM Designation: D 698 (Standard Proctor Test). Compaction shall be accomplished by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.
4. Embankment material which does not contain sufficient moisture to permit the required compaction shall have water added in sufficient quantity to obtain the specified compaction. Material containing an excess of moisture shall be aerated until the material is near optimum moisture content before being compacted. When it is necessary to add water, it shall be thoroughly and uniformly mixed with the material before it is compacted using equipment and methods approved by the Engineer. When it is necessary for the Contractor to furnish water, he shall provide means for adequate and proper distribution. The quantity of water used shall not exceed the maximum amount that will permit the equipment to obtain the required densities, and at no time shall free water be allowed to stand on the surface of a fill.
5. At the option of the Contractor, excavation areas and borrow sources may be watered prior to excavating the material. Moisture content of pre-watered excavation shall be brought to near optimum before compaction in the embankment.
6. Earth fills shall be uniformly compacted to the required densities using methods and equipment best suited for the material encountered.
7. With the approval of the Engineer, the Contractor may construct embankment during freezing weather. For this purpose, the Contractor shall provide the necessary amount of earth moving and compacting equipment to provide a continuous operation during freezing weather on both excavation and embankment areas. The Contractor shall control his operations to ensure that no frozen material is placed in the fills, and that the material placed is completely compacted before freezing. If materials freeze before the required compaction is obtained, the placing of fills shall stop and the frozen material shall be removed at the Contractor's expense before filling resumes.
8. Select material may be required, when shown on the plans, in the special provisions, or directed by the Engineer, for the upper portion of the embankment and to backfill excavations to the top of subgrade. The top of the select material shall be placed on a slope in accordance with plans.
 - (a) If, in the opinion of the Engineer, suitable materials for select material are available within the limits of excavation, the Engineer shall select the materials to be used and payment for placement of the select material will be at contract prices for embankment.
 - (b) When, in the opinion of the Engineer, select materials are not available within the above described haul limits, select material may be imported from locations shown on the plans, in the special provisions, or as directed by the Engineer. Payment will be at contract prices, if established, or by special provision.
 - (c) Select material shall, when practicable, be hauled directly from excavation to its final position in the subgrade prism. When shown on the plans, in the special provisions, or when in the opinion of the Engineer it is not possible to haul select material directly from the excavation to its final location, select material shall be excavated and placed in stockpiles for use at designated locations. Such work will be considered incidental to excavation and no separate payment will be made for such stockpiling and subsequent placement in embankment.
9. When shown on the plans, in the special provisions, or directed by the Engineer, either parts or all of the embankment shall be constructed of granular embankment fill. The materials

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required for granular embankment fill are provided in Section 2.4. Placement and compaction of granular embankment fill shall be in accordance with the requirements for earth fill.

C. Rock Fill

1. Embankments built of materials comprised predominantly of rock larger than 6 inches in maximum dimension shall be constructed by placing the material in layers not exceeding the maximum size of the rock present, but in no case shall the thickness of layers exceed 24 inches, unless approved by the engineer. The maximum size of any individual rock shall not exceed 16 inches in any one dimension, or as approved by the Engineer. The material shall be dumped from the hauling equipment on top of the layer being constructed and then pushed ahead over the face of the layer by the spreading equipment. Dumping of rockfill material directly onto uncompacted areas will not be permitted.
2. Layers shall extend the full width of the roadbed and a dense, solid embankment shall be obtained for the full width by distributing the larger stones over the area and filling between them with fine material sufficient to fill the interstices. Each layer shall be compacted by routing the spreading equipment and the loaded hauling equipment over the entire width of the fill until compaction is obtained, or with vibratory compactors.

3.9 FINISHING AND TRIMMING

- A. All cuts, embankments and ditches shall be left in a neatly trimmed condition to the specified width, elevations, and slopes. Waste and stockpile areas shall be left in a neat trimmed condition to the satisfaction of the engineer.
- B. The finished roadway surface shall be compacted and finished to a true surface with no depressions which will hold water or prevent proper drainage. The finished top of subgrade shall conform to the grades shown on the plans with a tolerance of plus or minus 0.05 feet from the profile grade and cross section, shall be uniform, and free from sharp breaks in the surface.
- C. When requested by the Engineer, the contractor shall be responsible for "track packing" of the final slopes that are 2:1 or flatter. Track packing or "walking" of the slopes using tracked equipment is required prior to seeding and mulching. The slopes shall be "walked" perpendicular to the contours. For slopes steeper than 2:1, the contractor must submit a detailed plan, for approval, showing how to compact and provide the tracked sections as noted for seeding. "Tracking" of the final slopes will be considered incidental to the cost of excavation or embankment.

3.10 SUBGRADE AND EMBANKMENT PROTECTION

- A. During construction, embankments and excavations shall be kept shaped and drained. Ditches and drains along subgrade shall be maintained to drain effectively at all times. The finished subgrade shall not be disturbed by traffic or other operations and shall be protected and maintained by the Contractor in a satisfactory condition until ballast, subbase, base, or pavement is placed. The storage or stockpiling of materials on the finished subgrade will not be permitted. No subbase, base course, subballast, ballast, or pavement shall be laid until the subgrade has been checked and approved, and in no case shall subbase, base, surfacing, pavement, subballast, or ballast be placed on a muddy, spongy, or frozen subgrade.

3.11 CLEANLINESS, SWEEPING, AND DUST CONTROL

- A. The contractor shall maintain the construction site to minimize dust conditions that would adversely affect construction or railroad operations, including equipment operation and worker safety.
- B. Dust or dirt from the construction site, which accumulates on adjacent public or private streets, highways, or roads, shall be swept or washed off the roadway surface. Special care shall be taken during sweeping or washing of the roadway surface to adequately expose traffic markings and striping.

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- C. The contractor shall control dust conditions through the use of water spray applied by hoses, sprinklers, or trucks at an appropriate rate and interval to settle the dust without creating muddy or sloppy conditions. Water and any dust control additives shall be environmentally safe.
- D. Cleanliness, sweeping, and dust control measures will not be measured or paid for separately, but will be considered incidental to excavation and embankments.

PART 4 MEASUREMENT AND PAYMENT

4.1 EXCAVATION

- A. Excavation will be measured by the cubic yards acceptably excavated within the limits of lines and slope described in typical sections and cross sections in the plans and contract documents. Materials excavated outside of the designated sections or from borrow pits will not be measured. When the project is constructed essentially to the dimensions shown on the plans no further measurement will be required, and payment will be made for the quantities shown in the contract for the various bid items involved. If disagreement exists between the Contractor and the Engineer as to the accuracy of the plan quantities, either party shall, before any work is started which would affect the measurement, have the right to request in writing and thereby cause the quantities involved to be measured. If measured quantities do not reveal a discrepancy when compared to plan quantities, the Contractor shall pay for the cost of the Engineer to perform measurements and calculations of quantities.
- B. Excavations with More Than One Classified Material
 - 1. When "Rock" and "Common", or other classifications, specified in the invitation to bid are removed they will be paid per the limits of lines and slopes described in the typical sections and cross sections as defined in the plans and contract documents, by type of material, as shown on the plans and specifications.
 - 2. When, in the judgment of the Engineer, it is impracticable, because of mixture of materials, to measure the actual cubic yard content of each kind of material the Contractor and the Engineer shall agree upon payment provisions prior to proceeding with work. The Engineer shall, from time to time, make such measurements as will best aid him in arriving at a just and equitable conclusion as to the proper percentage of the materials of the different classifications in the entire excavation, and he shall so separate and classify the different materials.
- C. Excavation shall be paid for at the contract unit price per cubic yard of excavation of proper classification within the limits of lines and slopes described in the typical sections and cross sections as defined in the plans and contract documents. This price shall be full compensation for furnishing all labor, materials, tools, equipment, supplies, supervision, and incidentals necessary for excavating, loading, transporting, and depositing materials in embankment, spoil bank, stockpile, or other designated location by whatever method is adopted, including all permission/permitting for haul operations.

4.2 EMBANKMENT

- A. Measurement of Embankment of the various types, as specified, will be measured by the cubic yard in the space occupied within the limits of lines and slopes described in the typical sections and cross sections as defined in the plans and contract documents. No payment will be made for the volume of material bladed off the top of roadway embankments outside of the roadbed limits. No allowance for shrinkage or compaction will be made. If disagreement exists between the Contractor and the Engineer as to the accuracy of the plan quantities, either party shall, before any work is started which would affect the measurement have the right to request in writing and thereby cause the quantities to be measured. If measured quantities requested by the Contractor do not differ from plan quantities, then the Contractor shall pay the Engineer's costs to verify measurements of quantities.

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- B. Payment of Embankments shall be paid for at the contract unit price per cubic yard of embankment of proper type within the limits of lines and slopes described in the typical sections and cross sections as defined in the plans and contract documents. This price shall be full compensation for furnishing all labor, materials, tools, equipment, supplies, water for compaction, supervision, and incidentals necessary for excavating, loading, transporting, and depositing borrow material when required; loading, transporting, and depositing select material from stockpile when required; loading, transporting, and distributing water; spreading, aerating if necessary, and compacting the embankment material; and finishing the embankment sections to the designated line and grades.

END OF SECTION

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SECTION 03220

ROCK SLOPE SUPPORT AND STABILIZATION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Rock Bolt Slope Support
- B. Wire Mesh Slope Protection

1.2 DESCRIPTION

- A. This item consists of the furnishing of all labor, materials, equipment, power, and incidentals required to place untensioned cement-grouted (CGRB) or resin-grouted (RGRB) rock bolts (dowels) for slope support, along with wire mesh for slope rock fall containment, where indicated on the plans or required by the Engineer.
- B. The rock bolts shall be grouted full-length in rock with attached steel bearing plates, hex nuts, and washers as shown in the Drawings or as directed by the Engineer.
- C. Ground support of any kind shall not interfere with the required clearance.
- D. The slopes shall be supported at all times as required for the protection of workers and construction traffic. All equipment for installing support shall be of such design and type to permit installation to be accomplished in all areas in an approved, safe, and timely manner.

1.3 SUBMITTALS

- A. A detailed Rock bolt and Slope Wire Mesh Submittal shall be submitted to the Engineer for review at least two weeks prior to commencing the rock slope excavation operations. This submittal shall include material certifications for the rock bolts and related hardware, cement grout, resin anchorage material, wire mesh and related hardware, and description of the drilling equipment to be used in the placement of the rock bolts and wire mesh slope support.

PART 2 MATERIALS

2.1 ROCK BOLTS

- A. Rock bolt assemblies shall be a standard product of a company regularly engaged in their manufacture. The rock bolts shall be furnished complete with all accessories, including resin cartridges or cement grout, steel bearing plates, beveled washers or domed anchor nuts, and flat-hardened washers, necessary for their installation.
- B. Rock bolts shall be 1-3/8-inch diameter (#11) conforming to ASTM A615 Grade 60. The rock bolt shall be of continuous thread type (Dywidag threadbar or equivalent). The bolts shall be supplied in lengths of 10 and 15 feet.
- C. The resin grouted rock bolts shall be supplied with spin adapters to facilitate installation using standard construction tools and equipment or specialized bolt spinning equipment.

2.2 BEARING PLATES

- A. Steel bearing plates shall conform to ASTM A36 and shall meet load and deflection criteria of ASTM F432. The bearing plates shall be 3/8-inch flat steel or equal, providing 36-square-inch area for

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each bolt and with a hole drilled, beveled and sized to allow at least a 15 degree skew of the bolt in all directions from normal to the plate.

2.3 HEX NUTS

- A. Domed anchor nuts or hex nuts for use on threaded portions of rock bolts shall be hexagonal head of the heavy duty type. Nuts shall develop an ultimate strength of not less than 125% of the minimum yield strength of the rock bolt.

2.4 WASHERS

- A. Washers for use with thread bolts shall ensure that there is continuous load transfer between the tightened hex nut and the bearing plate. Beveled washers shall be steel or malleable iron. Flat steel washers shall conform to the requirements of ASTM A3125. Two beveled washers and one flat washer shall be provided with each rock bolt.

2.5 RESIN

- A. The resin shall be supplied in cartridge form, 12-inch or longer, of medium viscosity, and with a gel time of between 15 and 30 minutes, or sufficient gel time to assure a suitable installation. Gel and cure time of cartridges shall be as specified by the manufacturer and approved by the Engineer. The material should be thixotropic and of such viscosity that the anchor bar can adequately mix the material. A quick setting (0001) cartridge may be required at the back of any holes angled upwards to hold the bolt in place while the slower setting resin sets up.
- B. Compressive strength of the mixed and cured resin shall be a minimum of 14,000 psi when tested in accordance with ASTM C39. The resin anchor system shall be equal in performance and similar to resin anchor systems manufactured by Celtite, Inc.
- C. Cartridges shall have a minimum shelf life of 6 months and cartridges that are older than the stated shelf life shall not be used. Cartridges shall be stored so as to ensure maximum protection until their use. The Contractor shall provide facilities to prevent prolonged exposure to sunlight or elevated temperatures (above 90 degrees F) during storage.
- D. All cartridges shall be inspected prior to insertion to assure that the polyester resin compounds have not hardened, and meet the above requirements.

2.6 CEMENT GROUT

- A. The non-shrink cement grout used in the CGRB shall conform to ASTM C1107 Grade B Dry-Package Hydraulic Cement Grout. The required compressive strength of the grout is 6000 psi at 28 days. Handling, storage, and the general requirements for placing the grout shall be as delineated in SECTION 04400.

2.7 WIRE MESH

- A. The wire mesh shall be 11 gauge gabion twisted galvanized wire mesh fabric conforming to ASTM A641 with a nominal diameter of 0.120 inch, Class 1 coating, and a minimum ensile strength of 60,000 psi. Maximum mesh size shall be approximately 4-3/4 inches with triple twist and hexagonal shape.
- B. Rock bolts for securing the mesh at the top of the slope shall be #8 Grade 60 threadbar at least 5 feet in length, embedded a minimum of 18 inches in bedrock with resin anchorage material that complies with the requirements of Section 2.5. Plates, washers, and hex nuts shall comply with the requirements of Section 2.2 through 2.4.
- C. Hog rings for securing adjacent sections of wire mesh shall be as submitted by the Contractor and approved by the Engineer.

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PART 3 EXECUTION

3.1 DRILLING ROCK BOLT HOLES

- A. Just prior to drilling holes for rock bolts, the area to be supported shall be inspected and scaled as required to assure safety and to provide adequate faces to seat the bearing plates. Holes for installation of rock bolts shall be drilled into the rock at the locations and to depths and inclinations as shown on the Drawings or as directed by the Engineer.
- B. Diameter of the holes shall be in accordance with the recommendations of the resin anchor system manufacturer for 1-3/8 inch bolts.
- C. Rotary percussion-type drilling equipment shall be used to perform the drilling. Rock bolt holes shall be drilled to the depths and diameters necessary to give the optimum anchorage for the bolt and at inclinations indicated on the plans, except where otherwise directed by the Engineer.
- D. Drilled holes shall be blown clear with compressed air or water introduced at the back of the hole to remove all drill cuttings, sludge, and debris immediately before installation of the resin grout cartridges, steel dowel or cement grout. Dust suppression measures shall be as specified in SECTION 01690.

3.2 INSTALLATION OF ROCK BOLTS

- A. Rock bolts shall be installed in accordance with the recommendations of the manufacturer. Bolt stickout shall be sufficient for installing the anchorage assembly but shall not infringe on required clearances.
- B. The steel dowels shall be free from rust, burrs, foreign matters, and coatings.
- C. Rock Bolts shall stick out 4 inches from the slope in order to allow for the placement of the bearing plate, hex nut, and wire mesh and a second plate/nut where applicable.
- D. Hex nuts shall be tightened to 100 foot-pounds with calibrated torque wrench.

3.3 RESIN ANCHORAGE

- A. The resin cartridges shall be inserted to the bottom (or back) of the hole, taking care not to rupture the skin. Sufficient resin shall be used to completely fill the hole. The first cartridge shall be inserted to the back of the hole prior to feeding in the rest of the cartridges in order to assure that the bolt has adequate end-anchorage.
- B. Installation equipment shall be capable of rotating the bolt as per the manufacturer's recommendations as the bar is being installed in the hole, i/e., spun, not pushed along the entire length of the hole, in a manner that adequately mixes the polyester resin and accelerator, unless the resin manufacturer recommends other methods.

3.4 GROUT ANCHORAGE

- A. The rock bolt shall include a tremie tube and vent tube for placing grout along the entire length of the bolt. Return of grout through the vent tube shall be verification that the entire bolt is grouted.
- B. Where holes are oriented 5 degrees or greater downward, the hole may be filled with grout prior to inserting the bolt and the tremie tube omitted. Grouting of the upper few feet of the bolt shall be completed by introducing grout through the vent tube.

3.5 CORROSION PROTECTION

- A. The exposed ends of the rock bolts and the entire surface area of the anchor plates, hex nuts, and washers shall be coated with an approved corrosion protection paint.

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3.6 TESTING

- A. Provision shall be made by the Contractor for conducting anchorage tests (150) on bolt installations throughout the job selected by the Engineer and under the observation of the Engineer. The pullout test shall be performed as follows:
 - 1. Apply axial load to bolt through a coupling attached to the threaded end, using a hydraulic jack designed specifically for tensioning and/or testing rock bolt installations.
 - 2. Test bolts to 50,000 lbs. For #11 bolts.
 - 3. A bolt shall be considered to have failed if more than 1/8-inch of outward movement of the bolt anchorage occurs at or below the design load.

3.7 COLLAPSED OR OBSTRUCTED HOLES

- A. Holes that, through no fault of the Contractor, cannot be used for bolt installation, in the opinion of the Engineer, will be paid at one-third the cost of installed bolts, provided that those holes were drilled during the same shift that the bolt installation was attempted.

3.8 WIRE MESH

- A. Wire mesh shall be placed over portions of the slopes indicated on the plans or where directed by the Engineer.
- B. Wire mesh shall be anchored at the top of the slope to #11 CGRB with at least 18 inches of the rock bolt anchored in in-place rock, and at intermediate portions of the slopes to #11 bolts (CGRB or RGRB) or to 18-inch-long #8 RGRB, as indicated on the Plans.
- C. Adjacent strips of wire mesh shall be joined by hog rings attached at 20 feet or less spacing. No overlap of the wire mesh in either direction is required.

PART 4 MEASUREMENT AND PAYMENT

4.1 ROCK BOLTS

- A. The quantity of #11 resin grouted rock bolts (RGRB) or cement grouted rock bolts (CGRB) 10 and 15 feet long installed as slope support, and variable-length #8 bolts used to anchor wire mesh at the top of slopes, shall be measured as the linear feet of #11 or #8 threadbar bolts installed.
- B. Rock Bolts shall be paid for at the contract unit price per linear feet. This price shall be full compensation for furnished all materials including resin or cement grout, face plates, hex nuts, and washers, corrosion protection, drilled holes into rock, localized slope scaling for safety, equipment, tools, labor, and all other items of expense required to install and test the rock bolts as shown on the Plans.

4.2 WIRE MESH

- A. The quantity of wire mesh will be measured as the square feet of wire mesh placed on the slope as rockfall protection.
- B. Wire Mesh shall be paid for at the contract unit price per square foot. This price shall be full compensation for furnishing all materials including 11 gauge gabion twisted wire mesh, minimum 5-foot-long RGRB anchors with face plates and hex nuts, hog rings, equipment, tools, labor, and all other items of expense required to install wire mesh as shown on the plans.

END OF SECTION

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SECTION 03300

SUBBALLAST

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Subballast

1.2 DESCRIPTION

- A. When shown on the plans or in the special provisions, subballast shall be placed directly onto the finished subgrade in order to provide a roadbed finish such that preservative impregnated fibers on the underside of ties will not be penetrated or crushed during track construction. Two types of subballast are defined. Type 1 subballast is a coarse-grained pervious aggregate base material, while Type 2 subballast is a fine-grained impervious aggregate base material.

1.3 SUBMITTALS

- A. Submit the following items to the Engineer:
 - 1. The source of the subballast to be used on the project.
 - 2. Material Test results of the subballast proposed for use on the project. Test results must outline the material gradation and percentage of material with two fractured faces.

PART 2 MATERIALS

2.1 SUBBALLAST

- A. Subballast shall be crushed gravel or crushed stone with a minimum 75% of the material having two fractured faces. Subballast must meet the quality requirements of ASTM D1241 and be approved by the Engineer.
 - 1. Crushed Gravel shall be the product resulting from crushing by mechanical means and shall consist entirely of particles obtained by crushing gravel, all of which before crushing will be retained on a screen with openings equal to or larger than the maximum nominal size of the resulting crushed material. If approved by the Engineer, final product gradations may be obtained by screening or blending various sizes of crushed gravel material.
 - 2. Crushed Stone shall be the angular fragments resulting from crushing by mechanical means the following types of rocks quarried from undisturbed, consolidated deposits: granite and similar phanerocrystalline igneous rocks; limestone; dolomite; sandstone; massive metamorphic quartzite, or similar rocks.
 - 3. Quality and Material Characteristics:
 - (a) Coarse Aggregate Portion (Fraction retained on a No. 10 sieve):

Na ₂ SO ₄ Soundness (5 cycles)	25%
AASHTO T 104, Max. % Loss	

Los Angeles Abrasion	45%
AASHTO T 96, Max. %Loss	

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(b) Fine Aggregate Portion (Fraction passing a No. 40 sieve)

Plasticity Index, Max. AASHTO T 90	10%
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Liquid Limit, Max. AASHTO T 89	35%
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B. Subballast shall be uniformly graded and shall meet the following gradation requirements:

Type 1 (Pervious)		Type 2 (impervious)	
Sieve Size	Percent Passing	Sieve Size	Percent Passing
2"	100	¾"	100
1"	90-100	3/8"	90-100
¾"	50-84	#4	65-90
#10	26-50	#16	20-50
#40	12-30	#100	10-20
#200	0-10	#200	7-15

C. If acceptable to the Engineer, the subballast may conform to the gradation specified for aggregate base by the State Department of Transportation for the state in which the work is to be performed which most nearly matches the gradation of Type 1 or Type 2 Subballast, as specified.

PART 3 EXECUTION**3.1 GENERAL**

- A. Subballast shall be placed only when weather conditions do not detrimentally affect the quality of the finished subballast. Hauling and placing of subballast will not be permitted when doing so will rut or deform the finished subgrade.
- B. Subballast shall be placed in uniform lifts of not more than 6 inches loose for the full width of the cross section. Each lift of subballast shall be compacted to a density of not less than 95% of the maximum dry density determined by ASTM D698 (Standard Proctor).
- C. The subballast shall be trimmed to the lines and grades shown on the plans and shall be maintained in a condition or manner acceptable to the Engineer until the final acceptance and completion of all work under this Contract. Any irregularities that develop in the subballast section during construction operations and prior to laying track, shall be filled and compacted to a smooth and even surface true to the subgrade elevations without any additional cost to the Company.

PART 4 MEASUREMENT AND PAYMENT**4.1 SUBBALLAST**

- A. Subballast will be measured in cubic yards of each type of subballast acceptably placed within the limits of lines and slopes described in the typical sections and cross sections as defined in the plans and contract documents. No allowance for shrinkage or compaction will be allowed. If disagreement exists between the Contractor and the Engineer as to the accuracy of the plan quantities, either party shall, before any work is started which would affect the measurement have the right to request in writing and thereby cause the quantities to be measured. If measured quantities requested by

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the Contractor do not differ from plan quantities, then the Contractor shall pay the Engineer's costs to verify measurements of quantities.

- B. Payment for subballast will be made at the contract unit price per cubic yard of the type of subballast furnished and placed. This price shall be full compensation for furnishing all labor, materials, tools, equipment, supplies, supervision, crushing, loading, hauling, placing, compacting, wetting, drying, trimming, and all other items required to complete the work in accordance with the plans and specifications.

END OF SECTION

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SECTION 03400 GEOSYNTHETICS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Geotextiles
- B. Geogrids

1.2 DESCRIPTION

- A. Geotextiles are typically used to provide a separation/stabilization layer between natural subgrade materials and subballast materials. Geotextiles may also be used for protection of existing Railroad ballast in existing track where designated by the Engineer. Geotextiles are manufactured fabrics composed of woven or nonwoven filaments of polypropylene, polyester, or polyethylene.
- B. Geogrids are used to provide reinforcement for embankments over weak foundation soils. The purpose of the geogrid reinforcement is to reduce lateral spreading and differential settlement and improve the stability of embankments constructed over such soils. Geogrids are manufactured materials consisting of two sets of straight ribs intersecting at right angles and forming an open structure. Geogrids are composed of polyethylene or polypropylene polymers, or high tenacity polyester fibers or yarns.

1.3 SUBMITTALS

- A. Submit the following items to the engineer:
 - 1. Manufacturer and designation of geosynthetics to be used.
 - 2. Test values and certificates of compliance of physical properties described in PART 2.
 - 3. Manufacturer's quality control manual including instructions for geotextile storage, handling, installation, seaming and repair.

PART 2 MATERIALS

2.1 GEOTEXTILES

- A. The geotextile fabric shall be resistant to ultraviolet radiation. Nonwoven fabric may be needle punched, heat-bonded, resin-bonded, or combination thereof.

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- B. Unless otherwise indicated on the plans or special provisions, the geotextile fabrics shall comply with the following physical characteristics:

Physical Property	Test Method	Minimum Value
Grab Tensile Strength	ASTM D4632	200 pounds ¹
Grab Elongation at Break	ASTM 4632	12%
Mullen Burst Strength	ASTM 3786	450 psi ²
Trapezoidal Tear Strength	ASTM 4533	75 pounds
Weight	ASTM 3776	20.0 oz/yd ²

2.2 GEOGRIDS

- A. Geogrids shall be manufactured either by drawing a perforated polymer sheet in one or two perpendicular directions to form an open structure, or by joining perpendicular polymer strands through bonding, weaving, knitting or other process.
- B. Unless otherwise indicated on the plans or special provisions, geogrids shall comply with the following physical characteristics:

Physical Property ³	Test Method	Minimum Value
Tensile Strength (5% Strain)	ASTM D4595	1,500 lb/ft
Tensile Strength (Ultimate)	ASTM D4595	2,600 lb/ft
Weight	ASTM D5261	9.0 oz/yd ²
Modulus at 2% Strain	ASTM D4595	15,000 lb/ft

PART 3 EXECUTION

3.1 GEOTEXTILES

- A. Geotextiles shall be placed between the finished subgrade and subballast in the manner and locations shown on the plans or as directed by the Engineer. Immediately in advance of the placing of the geotextile, the entire subgrade shall be graded to remove ruts, depressions, or extrusions in order to provide a firm, uniform surface true to the lines, grades, and cross sections shown on the plans.
- B. The fabric shall be unrolled directly over the area shown on the plans. Fabric may be installed either by hand or mechanical methods provided the surface is not rutted. The fabric shall be laid loosely and free of tension, stress, folds, wrinkles, or creases.
- C. The fabric shall be placed with the long dimension parallel to the centerline of the tracks unless otherwise directed by the Engineer. Fabric of insufficient width or length to fully cover the specified area shall be lapped a minimum of 24 inches. Upslope rolls shall lap over the top of downslope rolls.

¹ For woven fabric, test results shall be referenced to orientation with warp or weave, whichever the case may be. Both woven and nonwoven fabric shall be tested wet.

² Test results may be obtained by manufacturer's certification.

³ Test results may be obtained by manufacturer's certification.

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- D. Placement of subballast or other granular material on the fabric shall be accomplished in such a manner to prevent tearing or shoving of the cloth.
- E. Fabric which is damaged during installation or subsequent placement of granular material, due to failure of the Contractor to comply with these provisions, shall be repaired or replaced at the Contractor's expense, including the costs of removal and replacement of the granular material.
- F. Torn fabric may be patched in place by cutting and placing a piece of the same fabric over the tear. The dimensions of the patch shall be at least 24 inches larger than the tear in each direction and shall be weighted or otherwise secured to prevent the granular material from causing lap separation.
- G. For protection of existing ballast in existing track structure, the fabric shall be placed parallel to the track structure and cut to fit. The geotextile will cover inside the two rails and the ballast outside of the rails to the toe of the existing ballast slope, unless otherwise directed by the engineer. This geotextile shall be removed upon completion of blasting or hauling operations on the designated section of track.

3.2 GEOGRIDS

- A. A geotextile separator layer shall be placed between the finished subgrade and the geogrid in the manner and locations shown on the plans or as directed by the Engineer. The geotextile shall be placed in accordance with the procedures described in Section 3.1.
- B. The geogrid shall be unrolled directly over the area shown on the plans with its stronger direction perpendicular to the embankment centerline.
- C. Joints in the longitudinal direction of the embankment centerline shall be connected or overlapped as shown on the plans or as directed by the Engineer. The joint strength shall equal or exceed the strength of the geogrid material. The minimum overlap of geogrids perpendicular to the embankment centerline shall be not less than 12 inches.
- D. The geogrids shall be pre-tensioned prior to backfilling in such a manner that the geogrid material is free from any wrinkles.
- E. The backfill material placed over the geogrids shall be as shown on the plans or shall be material meeting the requirements of **Error! Reference source not found..**
- F. Placement of subballast or other granular material on the fabric shall be accomplished in such a manner to prevent tearing or wrinkling of the geogrid material.
- G. Geogrid material which is damaged during installation or subsequent placement of granular material, due to failure of Contractor to comply with these provisions, shall be repaired or replaced at the Contractor's expense, including the cost of removal and replacement of the granular material.

PART 4 MEASUREMENT AND PAYMENT

4.1 GEOTEXTILE

- A. Geotextile will be measured by the square yard of geotextile fabric placed in accordance with these specifications.
- B. Geotextile will be paid for at the contract unit price per square yard for geotextile. This price shall be full compensation for furnishing all materials, equipment, and labor, and performing all required operations for the installation of the geotextile fabric.

4.2 GEOGRID

- A. Geogrid will be measured by the square yard of geogrid placed in accordance with these specifications.

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- B. Geogrid will be paid for at the contract unit price per square yard for geogrid. This price shall be full compensation for furnishing all materials, equipment, and labor, and performing all required operations for the installation of the geogrid material.

END OF SECTION

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SECTION 03500

LIME OR FLY ASH STABILIZED SUBGRADE

PART 1 GENERAL

1.1 GENERAL

- A. These specifications cover the construction of one or more courses of a mixture of soil, hydrated lime, fly ash, and water in reasonably close conformity with the lines, grades, thicknesses, and cross sections shown on the plans or established by the Engineer.

1.2 SUBMITTALS

- A. Provide the mix design to the Engineer at least 14 days prior to use.

PART 2 MATERIALS

2.1 HYDRATED LIME

- A. Hydrated lime shall consist of a dry powder consisting essentially of calcium hydroxide ($\text{Ca}(\text{OH})_2$), or a mixture of calcium hydroxide, magnesium oxide (MgO), and magnesium hydroxide ($\text{Mg}(\text{OH})_2$), which are the active constituents of lime. The use of quicklime (CaO) will not be allowed.
- B. Lime Concentration
 - 1. For high calcium or dolomitic hydrated lime, the minimum total oxide content ($\text{CaO} + \text{MgO}$) shall be 90 percent, on a non-volatile basis. The hydrate shall not contain more than 5 percent carbon dioxide, if sampled at the lime plant, or 7 percent carbon dioxide, if sampled at the destination. Determination of total oxide and carbon dioxide contents shall conform to ASTM C25.
 - 2. For high calcium hydrated lime, the minimum available lime (CaO) content shall be 90 percent, on a non-volatile basis, as determined by the "Rapid Sugar" test, ASTM C25.
- C. The gradation of hydrated lime shall be such that a minimum of 75 percent will pass a #200 sieve when tested under the provisions for wet sieving in ASTM C110.

2.2 FLY ASH

- A. Fly ash stabilization of the subgrade may be used when the fly ash material and the method of placement of the fly ash material are approved by the Engineer. The use of flyash shall be in accordance with all applicable federal, state, and local environmental regulations.

2.3 WATER

- A. Water shall be clean and free from deleterious quantities of oil, acid, sugar, vegetable matter, organic matter, and salt.

2.4 SOIL

- A. The soil shall be a reactive soil. Reactive soils are defined as those soils which when mixed thoroughly with at least 3 percent lime, compacted and cured for 48 hours at 120 degree F will exhibit a strength gain of at least 50 psi greater than that obtained from similarly prepared untreated control specimens.

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- B. In general, lime reacts readily with most plastic soils containing clay, either the fine-grained clay or clay-gravel types. Such soils range in Plasticity Index (P.I.) from 10 to greater than 50. Soils with a P.I. lower than 10 do not generally react as readily with lime. Soils with low P.I. should contain at least 15 percent material finer than the #200 sieve in order to be treated with lime.
- C. For non-plastic and low P.I. soils that are unresponsive to lime, a pozzolan (second additive) is needed to produce the necessary lime-silica reaction. Fly ash is the most commonly used pozzolan for this purpose.

PART 3 EXECUTION

3.1 GENERAL

- A. Lime or fly ash stabilization shall not commence at any time that the ground or air temperature is below 40 degree F.
- B. If fly ash stabilization is used, the Contractor shall be governed by the plans, special provisions, or the Engineer as to methods of placement, mixing, finishing, and curing.
- C. It is required to secure a completed course of treated material containing a uniform lime mixture free from loose or segregated areas, of uniform density and moisture content, and a smooth surface. The Contractor shall regulate the sequence of his work, use the proper amount of lime, maintain the work, and rework the courses as necessary to meet the above requirements.

3.2 EQUIPMENT

- A. Equipment necessary for the proper construction of the work shall be on the project site and in good working condition before construction operations will be permitted to begin. The Contractor shall at all times provide sufficient equipment to enable continuous execution of the work. The Engineer shall have the right to reject equipment which is not capable of producing the required results, or which cannot be properly calibrated or controlled.

3.3 PREPARATION OF SUBGRADE

- A. Prior to beginning any lime stabilization, the subgrade shall be compacted and shaped to reasonably close conformity with the lines, grades, and cross sections shown on the plans or established by the Engineer.

3.4 PREPARATION OF MATERIALS

- A. The prepared subgrade shall be scarified to the depth and width required for the stabilized section. The material thus obtained shall be partially pulverized. The depth of scarification shall be carefully controlled and blading operations conducted in a manner so that the surface below the scarified material shall remain undisturbed and shall conform to the established cross section.
- B. The Contractor may elect to use a cutting and pulverizing machine that, at the same time, will loosen and remove the material within the section to be stabilized. This method will be permitted only where a machine is provided that will insure the material is cut uniformly to the proper depth and which has cutters that will plane the bottom of the section to a smooth surface over the entire width of the cut.
- C. Any unsuitable material and/or stones larger than 3-inch diameter shall be removed prior to the application of lime.

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3.5 APPLICATION OF LIME

- A. The rate of application of lime shall be as shown on the plans, in the special provisions, or as directed by the Engineer, and shall be based on tests of the soil to be stabilized.
- B. Spreading equipment shall uniformly distribute the lime without excessive loss. No equipment except water trucks and equipment used for spreading and mixing shall be permitted to pass over the spread lime until it is mixed. Any procedure which results in excessive loss or displacement of lime shall be discontinued immediately. Lime shall be applied only on that area where the first mixing operations can be completed during the same working day. During the interval of time between application and mixing, lime that has been exposed to the open air for a period of 6 hours or more, or to excessive loss due to watering or blowing, will not be accepted for payment.
- C. Lime may be applied dry or as a slurry. Dry lime shall not be applied when wind conditions are such that blowing lime becomes objectionable. A motor grader shall not be used to spread the dry lime. Lime that is mixed in a slurry shall be applied the same day it is mixed. The slurry shall consist of a minimum mixture of one ton of lime to each 500 gallons of water so that the dry solids content of the slurry will be between 31 percent and 40 percent. Use of compressed air for mixing or agitation of the slurry will not be permitted.

3.6 PRELIMINARY MIXING AND CURING

- A. The soil, lime and water shall be mixed until a uniform mixture is obtained in which all non-slaking clods and lumps are reduced to a maximum of 2 inches. During this operation sufficient water shall be added to raise the moisture content of the soil-lime mixture to at least 5 percent above optimum moisture content. The mixed material shall then be shaped to the approximate designated section, compacted lightly to seal the surface, and allowed to cure for a minimum period of 48 hours, or for a longer period when so directed by the Engineer. The material shall be maintained in a moist condition.

3.7 FINAL MIXING

- A. Following the required period of preliminary curing and mixing, pulverization shall continue until all of the non-slaking clods are broken down to pass a 1-inch screen and at least 60 percent pass a #4 sieve. During the operation, the mixture shall be maintained between optimum moisture content and 5 percent above optimum moisture content.
- B. At the option of the Contractor, subject to approval by the Engineer, preliminary mixing, curing, and final mixing may be performed at the excavation site.

3.8 COMPACTION

- A. The same day the final mixing is completed, the mixture shall be placed and compacted to a density of at least 95 percent of the maximum standard density. The maximum standard density shall be as determined by ASTM D698 (Standard Proctor). Light sprinkling may be required during laying operations to maintain the specified moisture content. Compaction shall be accompanied with sufficient blading to eliminate all irregularities.
- B. Layers up to and including 8 inches compacted thickness may be mixed and compacted in one course. Layers of over 8 inches compacted thickness shall be mixed and compacted in two or more separate courses of approximately equal thickness. Specified density shall be obtained on the lower course prior to beginning compaction on any subsequent course.

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3.9 FINISHING

- A. After the final course of material has been compacted, it shall be brought within reasonably close conformity with the required lines, grades, and cross sections shown on the plans. The completed section shall then be rolled with a pneumatic roller sufficiently light to prevent hairline cracking.

3.10 CURING AND PROTECTION

- A. The mixture shall be cured by lightly sprinkling the surface with water at frequent intervals to prevent drying for a period of 7 days. No vehicles or equipment other than sprinkling equipment shall be permitted on the roadbed during the curing period.

PART 4 MEASUREMENT AND PAYMENT

4.1 LIME OR FLY ASH STABILIZED SUBGRADE

- A. Lime or fly ash stabilized subgrade of the designated cross section and thickness shown on the plans will be measured by the square yard to neat lines stabilized in accordance with these specifications. Water will not be measured for payment.
- B. Lime or fly ash stabilized subgrade shall be paid for at the contract price per square yard of lime or fly ash stabilized subgrade. These prices shall be full compensation for furnishing all labor, materials, tools, equipment, supplies, water for compaction, supervision, and incidentals necessary to complete the work in accordance with these specifications. When the project is constructed essentially to the dimensions shown on the plans no further measurement will be required, and payment will be made for the quantities shown in the contract for the various bid items involved. If disagreement exists between the Contractor and the Engineer as to the accuracy of the plan quantities, either party shall, before any work is started which would affect the measurement, have the right to request in writing and thereby cause the quantities involved to be measured. If measured quantities do not reveal a discrepancy when compared to plan quantities, the Contractor shall pay for the cost of the Engineer to perform measurements and calculations of quantities.

END OF SECTION

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SECTION 03600

CEMENT STABILIZED SUBGRADE

PART 1 GENERAL

1.1 GENERAL

- A. Cement stabilized subgrade shall consist of soil, water, and portland cement uniformly mixed, compacted, finished, and cured in accordance with these specifications, and it shall conform to the lines, grades, thickness, and typical cross section(s) as shown on the plans or special provisions.

1.2 SUBMITTALS

- A. Submit the proposed design mix to the Engineer 14 days prior to beginning of stabilization work.

PART 2 MATERIALS

2.1 CEMENT

- A. Portland cement shall conform to the requirements of ASTM C150.

2.2 WATER

- A. Water shall be clean and free from injurious amounts of oil, acid, salt, alkali, organic matter, and any deleterious substances.

2.3 SOIL

- A. Type of soil to be cement stabilized shall be determined by soil classification. Soil may be the soil encountered in the existing subgrade, or soil secured from approved sources. Existing subgrade soil shall contain no more than 5 percent of gravel and stone retained on a 3-inch sieve. Any additional soil from approved sources shall pass a 2-inch sieve.

PART 3 EXECUTION

3.1 GENERAL

- A. It is required to secure a completed course of treated material containing a uniform cement mixture free from loose or segregated areas, of uniform density and moisture content, and a smooth surface. The Contractor shall regulate the sequence of his work, use the proper amount of cement, maintain the work, and rework the courses as necessary to meet the above requirements.

3.2 PREPARATION OF SUBGRADE

- A. The embankment and/or excavation section(s) shall be brought to grade and shaped as shown on the plans, and as required herein.
- B. The subgrade shall be graded and shaped as required to construct the soil cement section in conformance with the lines, grades, and thickness as shown on the plans. Soft or yielding subgrade shall be compacted and made stable before construction shall proceed.

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3.3 EQUIPMENT

- A. Equipment necessary for the proper construction of the work shall be on the project site and in good working condition before construction operations will be permitted to begin. The Contractor shall at all items provide sufficient equipment to enable continuous execution of the work. The Engineer shall have the right to reject equipment which is not capable of producing the required results, or which cannot be properly calibrated or controlled.

3.4 PULVERIZATION

- A. The soil shall be pulverized so that at the completion of moist-mixing, 100 percent by dry weight passes a 1-inch sieve, and a minimum of 80 percent passes a No. 4 sieve, exclusive of gravel or stone retained on these sieves.

3.5 CEMENT APPLICATION

- A. Cement shall not be spread or mixed when the air temperature is below 40 degree F and falling; but may be spread or mixed when the air temperature is above 35 degree F and rising. The temperature shall be taken in the shade away from artificial heat. Cement shall be spread or mixed only when weather conditions, in the opinion of the Engineer, are suitable. No cement or soil cement mixture shall be spread when the soil or subgrade is frozen.
- B. Portland cement shall be spread uniformly on the soil at the rate specified by the Engineer. If a bulk cement spreader is used, it shall be positioned by string lines during spreading to insure a uniform distribution of cement.
- C. Cement shall be applied only to an area such that the spreading, mixing, compaction, and finishing of the soil and cement can be continuous and completed within 6 hours of the cement application.
- D. The percentage of moisture content in the soil, at the time of cement application, shall not exceed the quantity that will permit uniform and intimate mixing of soil and cement during dry mixing operations, and it shall not exceed the specified optimum moisture content for the soil cement mixture.
- E. No equipment, except that used in spreading and mixing, will be allowed to pass over the freshly spread cement until it is mixed with the soil.

3.6 MIXING

- A. After the cement has been applied it shall be dry-mixed with the soil. Mixing shall continue until the cement has been sufficiently blended with the soil to prevent the formation of cement balls when water is applied. Any mixture of soil and cement that has not been compacted and finished shall not remain undisturbed for more than 30 minutes.
- B. Immediately after the dry mixing of soil and cement is complete, water as necessary shall be uniformly applied and incorporated into the mixture. A water supply system with pressure distributing equipment shall be provided that will assure the continuous application, within 3 hours, of all mixing water required on the section being processed. Care shall be exercised to insure proper moisture distribution at all times. After all mixing water has been applied, mixing shall continue until a uniform and intimate mixture of soil, cement, and water has been obtained.

3.7 COMPACTION AND FINISHING

- A. At the start of compaction, the percentage of moisture in the mixture and in unpulverized soil lumps, based on oven-dry weights, shall not be below or more than 2 percentage points above the specified optimum moisture content, and shall be less than that quantity which will cause the soil cement mixture to become unstable during compaction and finishing. When the uncompacted soil cement mixture is wetted by rain so that the average moisture content exceeds the tolerance given

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above at the time of final compaction, the entire section shall be reconstructed in accordance with this specification.

- B. The specified optimum moisture content and density shall be determined in the field by compacting representative samples of soil cement mixture in a 4-inch diameter mold using a 5.5 pound hammer (ASTM D698). After final compaction, the soil cement subgrade shall have a uniform density of not less than 95 percent of the maximum density as determined by the test specified above.
- C. Prior to the beginning of compaction, the mixture shall be in a loose condition for its full depth. The loose mixture shall then be uniformly compacted to the specified density within 2 hours.
- D. After the soil and cement mixture is compacted, water shall be uniformly applied as needed and thoroughly mixed in with a spike tooth harrow or equal. The surface shall then be reshaped to the required lines, grades, and cross section and then lightly scarified to loosen any imprint left by the compacting or shaping equipment.
- E. The resulting surface shall be thoroughly rolled with a pneumatic tire roller and then "clipped," "skinned," or "tight bladed" by a power grader to a depth of approximately 1/4 inch removing all loose soil cement from the section. The surface shall then be thoroughly compacted with the pneumatic roller, adding small increments of moisture as needed during rolling. If Plus No. 4 aggregate is present in the mixture, one complete coverage of the section with the steel wheel roller shall be made immediately after the "Clipping" operation. When directed by the Engineer, surface finishing methods may be varied from this procedure provided a dense uniform surface, free of surface compaction planes, is produced. The surface material must be maintained at its specified optimum moisture content during all finishing operations. Surface compaction and finishing shall be done in such a manner so as to produce within two hours a smooth, closely knit surface, free of cracks, ridges, or loose material and conforming to the crown, grade, and line shown on the plans.

3.8 CONSTRUCTION JOINTS

- A. At the end of each day's construction a straight transverse construction joint shall be formed by cutting back into the completed work to form a true vertical face free of loose or shattered material. Soil cement sections for large, wide areas shall be built in a series of parallel lanes of convenient length and width meeting the approval of the Engineer.

3.9 CURING

- A. After the soil cement has been finished as specified herein, it shall be protected against drying by one of the following curing methods for a period of not less than 7 days. If more than one lift is required, each lift shall cure 24 hours before placing the next lift. Curing material shall be applied as soon as possible, but not later than 24 hours after the completion of finishing operations of the final lift. The finished soil cement shall be kept continuously moist until one of the following curing methods is employed:
 - 1. **Sprinkling Method:** Maintain cement stabilized subgrade in a thorough and continuously moist condition by sprinkling.
 - 2. **Moist Earth Method:** Apply a 2-inch layer of earth on the completed cement stabilized subgrade and maintain in a moist condition.
 - 3. **Asphalt Membrane Method:** Apply an asphalt membrane to the cement stabilized subgrade, immediately after same is completed. The asphalt membrane material shall consist of an emulsified or liquid asphalt. When the asphalt membrane is applied, the stabilized surface shall be smooth, dense, and free of all loose and extraneous material. The asphalt shall be uniformly applied to the surface of the completed soil cement at the rate of approximately 0.2 gallons per square yard with proven heating and distributing equipment to provide a complete surface seal without runoff. If the Contractor uses this method, it shall be his responsibility to protect the

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- asphalt membrane from being picked up by traffic. The asphalt membrane may remain in place when the proposed surface or other base courses are placed.
- B. The curing material or method shall be maintained by the Contractor during the seven-day protection period so that all of the soil cement will be covered effectively during this period.
 - C. Finished portions of soil cement that are traveled on by equipment used in constructing an adjoining section shall be protected in such a manner as to prevent equipment from marring or damaging completed work.
 - D. The soil cement shall be protected from freezing for 7 days after its construction and until it has cured.

3.10 OPENING TO TRAFFIC

- A. Completed portions of soil cement subgrade may be opened to construction equipment and to all traffic after the seven-day curing period, provided the soil cement has cured sufficiently to prevent marring or distorting of the surface by equipment or traffic.

3.11 MAINTENANCE

- A. The Contractor will be required to maintain the soil cement subgrade in good condition until all work has been completed and accepted. Maintenance will include immediate repair to any defects that may occur. Maintenance shall be done by the Contractor at his own expense. Faulty work shall be replaced for the full depth and length as specified by the Engineer.

PART 4 MEASUREMENT AND PAYMENT

4.1 CEMENT STABILIZED SUBGRADE

- A. Soil cement stabilized subgrade of the designated cross section and thickness shown on the plans will be measured by the square yard to neat lines of Type I cement applied and accepted in accordance with this specification. Water will not be measured for payment. When the project is constructed essentially to the dimensions shown on the plans no further measurement will be required, and payment will be made for the quantities shown in the contract for the various bid items involved. If disagreement exists between the Contractor and the Engineer as to the accuracy of the plan quantities, either party shall, before any work is started which would affect the measurement, have the right to request in writing and thereby cause the quantities involved to be measured. If measured quantities do not reveal a discrepancy when compared to plan quantities, the Contractor shall pay for the cost of the Engineer to perform measurements and calculations of quantities.
- B. Soil cement stabilized subgrade will be paid for at the contract price per square yard of soil cement stabilized subgrade.

END OF SECTION

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SECTION 03700

HOT-MIX ASPHALT ROADBED

PART 1 GENERAL

1.1 GENERAL

- A. These specifications cover construction of a hot-mix asphalt (HMA) layer placed directly on top of the subgrade. When specified, the HMA layer takes the place of granular subballast and geotextile fabric, or other stabilization technique. The primary benefits of the HMA layer include improving the load distribution to the subgrade, waterproofing the subgrade and creating more uniform subgrade support, and confining the ballast and providing separation from the subgrade.

1.2 SUBMITTALS

- A. Submit design mix to Engineer 14 days prior to placement of HMA.

PART 2 MATERIALS

2.1 ASPHALT

- A. Unless otherwise shown on the plans, the asphalt shall be AC-10 or AC-20 viscosity graded asphalt cement and shall meet the applicable requirements of ASTM D3515.

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2.2 AGGREGATE

- A. The aggregates shall meet the applicable sections of ASTM D3515 with a gradation as follows.

Sieve Size	Percent Passing
1-1/2"	100
1"	90-100
1/2"	70-90
#4	40-65
#8	28-48
#50	7-20
#200	3-8

2.3 ASPHALT MIXTURE

- A. The Marshall mix properties for the asphalt mixture shall be as follows.

Property	Range
Compaction (blows)	50
Stability, N (min)	3375
Flow, mm	3.8-6.4
Percent Air Voids	1-3
Percent Voids Filled	80-90

- B. The asphalt content shall be in the range of 4% to 10%.
- C. The asphalt production facility shall be capable of producing a mix meeting the specified mix properties and have sufficient capacity to produce the anticipated volume of asphalt mix.

PART 3 EXECUTION

3.1 GENERAL

- A. Asphalt shall not be applied to the soil when the air temperature in the shade is less than 40 degree F and rising unless otherwise permitted by the engineer. Work shall be suspended during rain or when the mix is wet.

3.2 PREPARATION OF SUBGRADE

- A. Prior to beginning any asphalt stabilization, the subgrade shall be compacted and shaped in conformance with the lines, grades, and cross sections shown on the plans or established by the Engineer. The subgrade shall be free of ruts, depressions, or loose material.

3.3 EQUIPMENT

- A. Equipment necessary for the proper construction of the work shall be on the project site and in good working condition before construction operations will be permitted to begin. The Contractor shall at all times provide sufficient equipment to enable continuous execution of the work. The

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Engineer shall have the right to reject equipment which is not capable of producing the required results, or which cannot be properly calibrated or controlled.

3.4 PLACEMENT AND COMPACTION

- A. The asphalt mix shall be hauled by truck from the mix plant. The temperature of the mix when leaving the plant shall not be less than 290 degree F and the trucks shall be covered to minimize temperature loss. The mix shall be placed using either a standard highway asphalt paver or backdumped from trucks and spread with a dozer blade. Procedures for spreading and compacting the mix shall minimize temperature loss. The temperature of the mix shall not be allowed to fall below 200 degree F prior to obtaining the required compaction.
- B. The asphalt mix shall be placed in lifts not exceeding 4 inches in compacted thickness. The layer shall be compacted using pneumatic roller or steel drum vibratory compactors meeting the requirements for compacting equipment specified in SECTION 03200. The layer shall be compacted to a minimum of 95% of the theoretical maximum density determined in accordance with ASTM D2041.
- C. The top surface of the compacted layer shall be finished to a true surface with no depressions which will hold water or prevent proper drainage. The finished top of subgrade shall conform to the grades shown on the plans with a tolerance of plus or minus 1/2 inch, except that for full depth designs, where the ties are placed directly on top of the HMA layer, the tolerance of the finished surface shall be plus or minus 1/4 inch.

PART 4 MEASUREMENT AND PAYMENT

4.1 HOT-MIX ASPHALT ROADBED

- A. HMA roadbed will be measured by the square yard of HMA mixture placed in accordance with these specifications within the neat lines shown on the plans.
- B. When the project is constructed essentially to the dimensions shown on the plans no further measurement will be required, and payment will be made for the quantities shown in the contract for the various bid items involved. If disagreement exists between the Contractor and the Engineer as to the accuracy of the plan quantities, either party shall, before any work is started which would affect the measurement, have the right to request in writing and thereby cause the quantities involved to be measured. If measured quantities do not reveal a discrepancy when compared to plan quantities, the Contractor shall pay for the cost of the Engineer to perform measurements and calculations of quantities.
- C. Payment for HMA roadbed will be made at the contract unit price per square yard of HMA roadbed of the specified type and thickness furnished and placed. This price shall be full compensation for furnishing all labor, materials, tools, equipment, supplies, supervision, loading, hauling, placing, compacting, and incidentals necessary to complete the work in accordance with these specifications.

END OF SECTION

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SECTION 04000 STRUCTURES

SECTION 04100 STRUCTURE EXCAVATION AND BACKFILL

SECTION 04200 PILES

SECTION 04210 DRILLED AND GROUTED MICROPILE

SECTION 04300 DRILLED SHAFT FOUNDATIONS

SECTION 04310 SONIC TESTING OF DRILLED SHAFT FOUNDATIONS

SECTION 04400 CONCRETE CONSTRUCTION

SECTION 04410 MASS CONCRETE PLACEMENT

SECTION 04500 PRECAST CONCRETE CONSTRUCTION

SECTION 04600 STEEL CONSTRUCTION

SECTION 04610 RAIL JOINTS

SECTION 04620 PROTECTIVE COATINGS FOR STEEL SURFACES

SECTION 04700 STRUCTURE MONITORING

SECTION 04800 WATERPROOFING

SECTION 04810 DECK WATERPROOFING SYSTEM

SECTION 04900 ELASTOMERIC BEARING PADS

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SECTION 04100 STRUCTURE EXCAVATION AND BACKFILL

PART 1 GENERAL

1.1 SECTION INCLUDES¹

- A. Protective Shoring
- B. Cofferdams
- C. Structure Excavation
- D. Structure Backfill
- E. Structure Drain Pipe
- F. Pervious Backfill Material

1.2 SAFETY

- A. Contractor is responsible for performing all Structure excavation and backfill in compliance with the applicable state, federal, local and OSHA regulations.

1.3 DESCRIPTION

- A. Protective Shoring
 - 1. Protective shoring shall consist of providing protection to railroad track or other areas designated on the plans due to an adjacent excavation. See FIGURE 04100 - 1: Zone of Influence for limit lines where protective shoring is required.

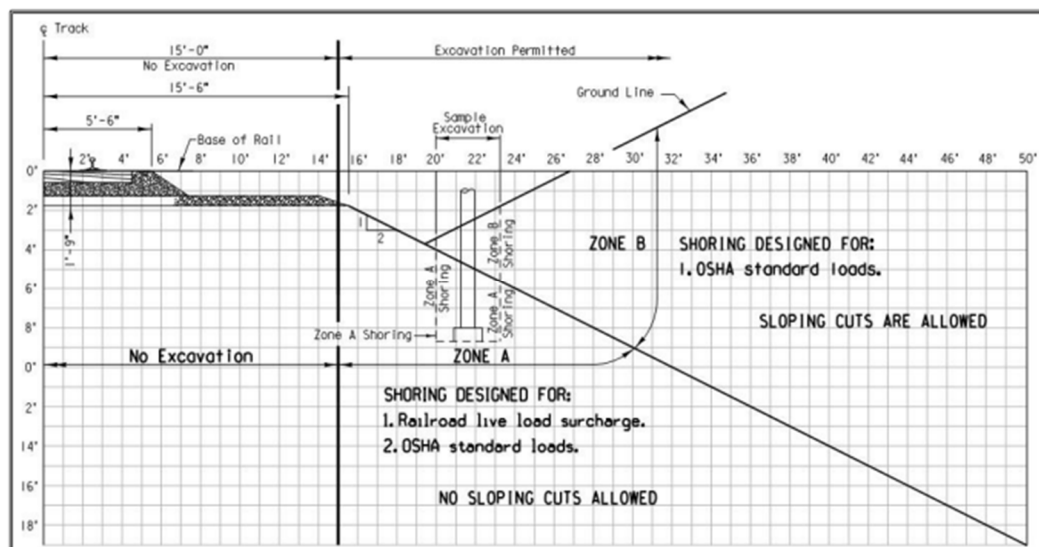


FIGURE 04100 - 1: Zone of Influence

¹ See General Provisions for utility and permitting requirements and sections that apply

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2. Protective shoring shall be designed and constructed, in accordance with the Engineer's approval. Removal of protective shoring shall be in accordance with the project plans and the Engineer's approval.
3. Protective shoring shall be constructed of engineered structural components consisting of timber, standard steel sheet pile sections, structural steel sections, cylindrical metal shells or combination of the above.
4. The Contractor shall submit drawings and design calculations showing the proposed design, method of construction, removal, as well as other details left open to choice and not fully detailed on the plans. These drawings and design computations, stamped by a licensed professional or structural engineer in the state where the work is to be done, shall be submitted to the Engineer and approved prior to the start of construction. This approval shall not relieve the Contractor of responsibility for the protective shoring.
5. Design of protective shoring shall consider Cooper E80 live load surcharge for excavations adjacent to railroad tracks. Refer to the AREMA Manual for Railway Engineering, Chapter 8, Part 20 for methods to determine lateral pressure values for railroad surcharge loading.
6. A safety factor of one and one half (1.5) shall be used in the design of temporary protective shoring. A safety factor of two (2.0) shall be used in the design of permanent protective shoring.

B. Cofferdams

1. A cofferdam is defined as any temporary or removable structure constructed to hold the surrounding earth, water, or both, out of the excavation, whether the structure is formed of timber, steel, concrete, or a combination thereof.
2. Cofferdams for placing concrete or other required construction shall consist of watertight enclosures surrounding excavations that cannot be kept free of water by pumping and/or diverting water by the use of sheeting or dikes.
3. When cofferdams are not specified in the contract documents and conditions are encountered where the excavation for the structure cannot be kept free of water for concrete placement by pumping and/or diverting water by the use of sheeting or dikes, the Contractor, with the written permission of the Engineer, will be permitted to construct a cofferdam.
4. When specified in the contract, the cofferdams shall be designed, constructed, and removed in accordance with the Engineer's approval. When not specified in the contract and site conditions warrant, as determined by the Engineer, cofferdams may be added to the contract upon written approval of the Engineer.
5. Cofferdams shall be constructed of engineered structural components consisting of timber, standard steel sheet pile sections, structural steel sections, cylindrical metal shells or combination of the above. Earthen embankments or dikes will not be classified as cofferdams.
6. The Contractor shall submit drawings and design calculations showing the proposed design, method of construction, removal, as well as other details left open to choice and not fully detailed on the plans. These drawings and design computations, stamped by a licensed professional or structural engineer in the state where the work is to be done, shall be submitted to the Engineer and approved prior to the start of construction. This approval shall not relieve the Contractor of responsibility for the cofferdam.

C. Structure Excavation

1. Structure excavation shall consist of excavation for the construction of foundations for all structures other than drilled shaft foundations or pipe culverts.
2. This work includes: All required pumping, bailing or sloping for drainage; the construction and removal of all sheeting, shoring, and bracing required to support and dewater the excavations; removal and disposal of all material removed from the excavation including old structures or the portions thereof; and clearing and grubbing as required for construction of the structure.

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- D. **Structure Backfill:** shall consist of furnishing, placing and compacting backfill material around structures to the lines designated on the plans or specified or directed by the Engineer.
- E. **Structure Drain Pipe:** shall consist of furnishing and placing underdrain pipe, granular fill and geotextile fabric behind bridge abutments, wingwalls, and retaining walls in accordance with the details shown on the plans and this section.
- F. **Pervious Backfill Material:** shall consist of furnishing and placing pervious backfill material behind bridge abutments, wingwalls, and retaining walls in accordance with details shown on the plans and this section.

PART 2 MATERIALS

2.1 PROTECTIVE SHORING

- A. Protective shoring materials shall be in accordance with the Contractor's drawings approved by the Engineer.

2.2 COFFERDAMS

- A. Cofferdam materials shall be in accordance with the Contractor's drawings approved by the Engineer.

2.3 STRUCTURE BACKFILL

- A. Structural backfill shall be made using materials indicated on the plans, in the special provisions, or as approved by the Engineer, and may be obtained from excavation or other sources. Backfill material shall be free from stones or lumps of such size as to interfere with compaction, frozen lumps, wood, or other extraneous material.

2.4 STRUCTURE DRAIN PIPE

- A. Asphalt-coated perforated galvanized steel underdrain pipe shall be in accordance with details shown in the plans and SECTION 05100.
- B. Granular fill material around structure drain pipe shall be as specified in Paragraph 2.5A.
- C. Geotextile fabric for structure drain pipe shall be woven or nonwoven fabric. The filaments for woven or nonwoven fabric shall be polypropylene, polyester, or polyethylene. The filaments must be dimensionally stable (i.e., filaments must maintain their relative position with respect to each other) and resistant to delamination. The filaments must be free from any chemical treatment or coating that might significantly reduce porosity and permeability. Nonwoven fabric may be needle-punched, heat-bonded, resin-bonded, or combinations thereof.
- D. The physical properties for woven or nonwoven fabric shall conform to the following:

Property ²	Test Method ³	Requirement
Minimum Weight (oz/yd ²)	ASTM D3776	3.5
Minimum Wet Grab Tensile Strength (lbs)	ASTM 4632	100
Minimum Grab Elongation at Break	ASTM 4632	20%

² For woven fabric, test results shall be referenced to orientation with warp or fill, whichever the case may be.

³ Manufacturer's certification to meet test requirements.

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Minimum Equivalent Opening Size (EOS #)	USACE CW02215	Nonwoven: 305 Woven: 505
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2.5 PERVIOUS BACKFILL MATERIAL

- A. Pervious backfill material shall consist of crushed rock or crushed gravel, or combinations thereof. Pervious backfill material shall conform to the following grading requirements:

Sieve Size	Percentage Passing
1-1/2"	100
1"	90-100
3/4"	40-85
1/2"	10-40
3/8"	0-15
#4	0-5

PART 3 EXECUTION

3.1 PROTECTIVE SHORING

- A. The Contractor is responsible for designing, providing, installing, maintaining, and removing the protective shoring when specified on the plans or by the Engineer. Installation or excavation shall not begin without the prior approval of the Engineer.
- B. The limits of the excavation shall not extend beyond the approved limits without permission from the Engineer.
- C. The Engineer shall be notified of any conditions not in agreement with the plans including any weak or soft soils, or other conditions causing additional excavation.

3.2 COFFERDAMS

- A. Cofferdams for foundation construction shall, in general, be carried below the bottom of footings to a depth as shown in the plans; except in solid rock, where cofferdams shall be seated into rock, sealed, and excavation continued to bottom of footing elevation. The inside dimensions of the cofferdam shall in no case be less than the plan footing dimensions.
- B. When conditions, in the judgment of the Engineer, render it impractical to dewater a cofferdam, the Engineer may require the Contractor to place a concrete seal at the base of the excavation to such dimensions as will permit pumping and dewatering of the excavation.
- C. No component of the cofferdam shall extend into the substructure concrete without written permission of the Engineer.

3.3 STRUCTURE EXCAVATION

- A. General
- Excavation shall conform to the lines and grades shown on the plans, or as directed by the Engineer. Excavation shall include removal of all materials encountered, regardless of their nature.

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2. Prior to excavation, the area to be excavated shall be cleared and grubbed in accordance with the procedures described in SECTION 03100.
 3. Excavated material will be classified as "Structure Excavation Common" or "Structure Excavation Rock." "Structure Excavation Rock" shall include excavation of all rock in ledges, and bedded, cemented, and conglomerate deposits exhibiting the physical characteristics and difficulty of rock removal as determined by the Engineer. "Structure Excavation Rock" shall also include removal of the portions of existing structures which cannot be loosened by the use of a pick. All other excavated material will be classified as "Structure Excavation Common."
 4. Excavated material not suitable for backfill, or excess excavated material shall be legally disposed of by the Contractor at a location and in a manner directed or approved by the Engineer.
 5. Over-excavation shall not be allowed without specific instructions from the engineer.
- B. Protection of Excavations
1. The Contractor is responsible for designing, providing, installing, and removing protective sheeting, shoring, cofferdams, or other elements required in order to provide stable and dry excavations for all structures. Protection and shoring of excavations shall, as a minimum, be as required by applicable standards and regulations, including 29CFR Part 1926, Subpart P - Excavations, Trenching, and Shoring of OSHA's Standards and Interpretations. The Contractor shall submit detailed plans for protection and support of excavations to the Engineer prior to construction. Installation or construction of excavation protection or support elements, including cofferdams, shall not begin without the prior approval of the Engineer.
 2. The Contractor shall, by means of dikes, sheeting, cofferdams, pumps, or other measures, keep the excavations free of water at all times. Placing of concrete in or under water will not be permitted, except when specifically directed by the Engineer.
 3. Excavations for Spread Footing Foundations:
 4. Immediately prior to placing concrete for spread footing foundations founded in common material, the bottom of the excavations shall be trimmed to the required level. All loose, spongy, or frozen material existing at the base of foundations shall be removed and replaced with clean gravel or other suitable material as directed by the Engineer. The amount of time during which the excavation for spread footings is allowed to remain open prior to placing concrete shall be minimized. Water shall not be allowed to stand on the base of excavations for spread footings.
 5. Spread footing foundations founded in rock shall be excavated to the required lines and grades, and the bottom of the excavations shall be finished to a rough surface. All soil, water, and loose and unsound rock shall be removed prior to placing the concrete foundation.
 6. After each excavation is completed, the Contractor shall notify the Engineer. No concrete shall be placed until the Engineer has approved the excavation and the character and condition of the foundation material.
- C. Excavations for Pile-supported Foundations
1. Excavations shall be approximately completed to the bottom of structure elevation prior to driving any piles. No piles for any foundation shall be driven until the Engineer has approved the excavation. All excess or loose material remaining in the excavation after pile driving is completed shall be removed to the elevation of the bottom of the structure.
 2. After all piles are driven, the Contractor shall notify the Engineer. No concrete shall be placed until the Engineer has approved the excavation and the character and condition of the foundation material.
- D. Excavations Within Channels
1. When excavation encroaches upon a live streambed or channel, unless otherwise permitted, no excavation shall be made outside of caissons, cribs, cofferdams, steel piling, or sheeting, and the natural streambed adjacent to the structure shall not be disturbed without permission

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from the Engineer. If any excavation or dredging is made at the site of the structure before caissons, cribs, or cofferdams are sunk or are in place, the Contractor shall, without extra charge, after the foundation base is in place, backfill all such excavation to the original ground surface or riverbed with material satisfactory to the Engineer. Material temporarily deposited within the flow area of streams from foundation or other excavation shall be removed and the stream flow area freed from obstruction thereby.

3.4 STRUCTURE BACKFILL

- A. Backfilling shall consist of placing and compacting the necessary fill within the limits specified in Paragraph 4.3A. Fill required above the ground surface as it existed prior to any excavation is considered as embankment. The backfill shall be constructed up to the ground surface as it existed prior to any excavation, unless the original ground surface is higher than the proposed finish elevation of roadway surface, stream banks, or channels.
- B. All bracing, forms, and rubbish shall be removed prior to placing the backfill. Unless sheeting and shoring is to remain in place, it shall be removed in such a manner to prevent loosening unexcavated material.
- C. Backfill shall not be placed until the structure has been approved for backfilling by the Engineer. Backfill shall not be placed against concrete walls or piers until the concrete has cured for a minimum of 14 days, or until test cylinders show the strength to be approximately equal to the design strength, whichever is the lesser time.
- D. Backfill material shall be placed in uniform horizontal layers not exceeding 8 inches in thickness before compaction. The backfill shall be brought up uniformly on all sides of the structure. The backfill shall be compacted to the density shown on the plans, in the special provisions, as specified for the adjacent ground, or to a minimum of 95% of the maximum dry density determined in accordance with the Standard Proctor compaction test (ASTM D698) if not otherwise specified.
- E. Backfill material shall not have rocks larger than 3 inches placed within 18 inches of the concrete columns, piers, wing walls, retaining walls or abutments.

3.5 STRUCTURE DRAIN PIPE

- A. Structure drain pipe shall be enclosed by uncompacted granular fill surrounded by geotextile fabric. The installation of the structure drain pipe shall be in accordance with details shown on the plans and SECTION 05100.

3.6 PERVIOUS BACKFILL MATERIAL

- A. Pervious backfill material shall be placed behind bridge abutments, wingwalls and retaining walls to the lines, grades and elevations shown on the plans or as directed by the Engineer. Pervious backfill material shall be placed in layers along with and by the same methods specified for structure backfill. Pervious backfill material at any one location shall be approximately the same grading, and at locations where the material would otherwise be exposed to erosion shall be covered with at least a 12 inch layer of earthy material approved by the Engineer.

PART 4 MEASUREMENT AND PAYMENT

4.1 PROTECTIVE SHORING

- A. Protective Shoring, when specified on the plans or as directed by the Engineer, will be measured as individual units complete in place.
- B. Protective Shoring: shall be paid for at the contract price per unit as designated on the plans. This price shall include full compensation for protective shoring design and plans and for furnishing all

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labor, materials, tools and equipment necessary for the construction of the protective shoring and its subsequent removal, when required.

4.2 COFFERDAMS

- A. Cofferdams, when specified on the plans or as directed by the Engineer, will be measured as individual units complete in place.
- B. Cofferdams shall be paid for at the contract price per unit as designated on the plans. This price shall include full compensation for cofferdam design and plans and for furnishing all labor, materials, tools and equipment necessary for the construction of the cofferdam and its subsequent removal. No extra compensation will be allowed for a cofferdam of excessive size.

4.3 STRUCTURE EXCAVATION

- A. Structure Excavation will be measured by the cubic yard. The limits for measurement of structure excavation will be in accordance with the following provisions: The upper limit shall be the original ground surface as it existed prior to the start of the construction operations, except, where structure excavation is performed within channel excavation area or roadway excavation area, said roadway or channel excavation shall be assumed to have been completed, the upper limit shall be the planes of the bottom and side slopes of said areas excavated as shown on the plans or as directed by the Engineer. Channel and roadway sections which are required beyond the limits of the structure will be considered to be continuous through the structure. The bottom and side slopes of this extension of the channel shall form the upper limit of the structure excavation. The lower limit shall be the bottom of the structure as shown on the plans or as specified by the Engineer. The lateral limits shall be vertical planes 2 feet outside of the foundation lines. Excavation outside of the above defined limits will not be included in structure excavation quantities, unless such excavations are required to comply with Federal/State/local regulations.
- B. Structure excavation shall be paid for at the contract unit price per cubic yard for structure excavation of the proper classification. This price shall include full compensation for furnishing all labor, materials, tools and equipment, and doing all the work involved in making the excavation and disposing of the resulting excavated material as specified, including the furnishing and installation or construction of all sheeting, shoring and other facilities necessary to the excavation operations, and their subsequent removal if required.
- C. As directed by the Engineer, unsuitable materials found below the elevation of bottom of structure as shown on the plans will be removed and paid for as structure excavation. If, in the opinion of the Engineer, the unsatisfactory materials below the bottom of the structure are the result of negligence on the part of the Contractor, due to allowing water to stand on earth foundations, overshooting rock excavations, or from other causes, the unsatisfactory material shall be removed and replaced in a manner specified by the Engineer, and no compensation will be allowed for the work.
- D. No compensation will be made for the removal and disposal of swell material resulting from the driving of piles in an excavation.

4.4 STRUCTURE BACKFILL

- A. Structure Backfill will be measured by the ton. The limits for measurement of structure backfill will be that volume of structure excavation and roadway excavation or channel excavation, as shown on the plans or specified by the Engineer, which is below the finish elevation of roadway surface or stream banks and channel flow line or below the elevation of ground surface as it existed before any excavation was made, and is not occupied by the structure. Backfill required beyond the limits of measured structure excavation, roadway excavation, and channel excavation will not be included in structure backfill quantities.

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- B. Structure Backfill shall be paid for at the contract unit price per ton. This price shall include full compensation for furnishing all labor, materials, tools and equipment, water for compaction if required, and doing all work involved in furnishing, placing, and compacting the material in place as specified, and applying water necessary for compaction. No payment will be made for any so-called overhaul.
- C. Compacted backfill or crushed rock, if specified by the Engineer, required to replace unsuitable materials excavated below the elevation of bottom of structure as shown on the plans when unsuitable materials are not the result of Contractor's negligence, will be paid for as structure backfill.
- D. No payment will be made for backfilling foundations up to the bottom of plan structures when the Contractor has excavated below plan elevation due to his negligence.

4.5 STRUCTURE DRAIN PIPE

- A. Structure Drain Pipe will be measured by the lineal foot of acceptable pipe of the various diameters in place.
- B. Structure Drain Pipe shall be paid for at the contract unit price per lineal foot of pipe of the various diameters in place. This price shall be full compensation for furnishing all materials, and for all equipment, tools, labor and incidentals necessary to install the pipe, granular fill and geotextile fabric and complete the work.

4.6 PERVIOUS BACKFILL MATERIAL

- A. Pervious Backfill Material will be measured by the ton in place within the designated sections shown on the plans.
- B. Pervious Backfill Material shall be paid for at the contract unit price per ton of material in place. This price shall be full compensation for constructing or excavating the roadbed embankment behind bridge abutments, wingwalls, and retaining walls to the designated section shown on the plans, any special compaction required, furnishing the material, and placing the material to the designated sections shown on the plans.

END OF SECTION

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SECTION 04200 PILES

PART 1 GENERAL

1.1 SECTION INCLUDES¹

- A. Piles
- B. Test Piles

1.2 SAFETY

- A. Contractor is responsible for performing all pile operations in compliance with the current state, federal, local, FRA and OSHA regulations, specifically with respect to fall protection.

1.3 DESCRIPTION

- A. These specifications shall govern the furnishing, driving, building up and cutting off of timber, steel bearing, steel sheet, steel pipe, and concrete (precast and prestressed) piles in accordance with the lines, grades, and locations shown on the plans or as directed by the Engineer.
- B. Test Piles
 - 1. When shown on the plans or when directed by the Engineer, test piles shall be driven to determine the necessary lengths of piles to be ordered for the work.
 - 2. The number and location of test piles to be driven shall be as shown on the plans or as established by the Engineer; in general, at least two test piles shall be driven at each structure.
- C. Unless otherwise directed by the Engineer, the embankment at bridge ends shall be constructed to grade and thoroughly compacted to the full amount required by SECTION 03200, prior to the driving of piling in the embankment area.
- D. Foundation piling shall not be driven until the excavation is complete.

1.4 SUBMITTALS

- A. The Contractor shall provide to the Engineer a description of all pile driving equipment to be employed in the work, prior to commencement of pile installation. This shall include details including weights of pile hammer, power plant, leads, pile cushion, cap block and helmet.
- B. The Contractor shall provide to the Engineer drawings demonstrating compliance of driving equipment and steel casing with Contract Documents. Drawings shall include shop and erection details, casing details, and enclosures, splices, driving helmets, and reinforcement.
- C. The Contractor shall submit to the Engineer a complete report on the load test, within seven days of completion of load test, including, but not limited to, a description of the pile driving equipment, driving records for both test piles and reaction piles, complete test data, analysis of test data, and recommended allowable design loads based on the load test results. The report shall be prepared by or under the direct supervision of a registered professional or structural engineer experienced in pile load testing and load test analysis. In Addition, a "Test Pile Record Form" in accordance with FIGURE 04200 - 1 shall be submitted to the Engineer.

¹ See General Provisions for utility and permitting requirements and sections that apply

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FIGURE 04200 - 1

TEST PILE RECORD FORM

LS:	BR:	TRACK:	PLAN NO:	AFE:	PILE TYPE:
BENT/PIER/ABUT NO.:	ROW NO.:	PILE NO.:	DATE/TIME START:		
R/L ABOVE OR BELOW T/T (FT):			DATE/TIME END:		
DIST. T/T TO G/L (FT):		HAMMER MODEL:	RAM WEIGHT:		
TOTAL PIL LENGTH UNDER HAMMER (INCLUDE FOLLOWER) (FT):			CUSION MATERIAL(S) – TYPES & THICKNESS:		
DISTANCE T/T TO P/T AT END OF DRIVING (FT):			HAMMER:		
DISTANCE T/T TO SPLICE AT END OF DRIVING (FT):			CONCRETE PILE:		
COMMENTS:	R/L = REFERENCE LINE – POINT FROM WHICH PENETRATION IS RECORDED, USUALLY T/T OR G/L				
	G/L = GROUNDLINE	T/T = TOP OF TIE	P/T = PILE TIP	BPM = BLOWS PER MINUTE	

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FOREMAN/INSPECTOR:

- D. The Contractor shall submit to the Engineer a complete and accurate record of each driven pile, within 3 days of completion of driving. The record shall indicate the pile location, driven length, embedded length, final elevations of tip and top, pile weight, butt and tip diameter, quantity and strength of concrete used in each pile, number of splices and locations, blows required for each foot of penetration throughout the entire length of the pile and for the final 6 inches of penetration, and the total driving time. The record shall also include the type and size of the hammer used, the rate of operation, and the type and dimensions of driving helmet, pile cushion, and cap block used. Any unusual conditions encountered during pile installation shall be recorded and immediately reported to the Engineer. In Addition, a "pile Driving Summary Form" in accordance with Figure 04200-2 shall be submitted to the Engineer.

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FIGURE 04200 - 2

PILE DRIVE SUMMARY FORM

LS: BR: TRACK: PLAN NO: AFE: PILE TYPE:

HAMMER MODEL:

RAM WEIGHT:

COMMENTS:

R/L = REFERENCE LINE – POINT FROM WHICH PENETRATION IS RECORDED, USUALLY T/T OR G/L

G/L = GROUNDLINE T/T = TOP OF TIE R_u = ULTIMATE RESISTANCE BPM = BLOWS PER MINUTE

[illegible]

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PART 2 MATERIALS

2.1 TIMBER PILES

- A. Timber piles shall be in accordance with Chapter 7, Part 1, Article 1.9 of the AREMA Manual for Railway Engineering for first-class piles with a minimum tip circumference of 25 inches.
- B. If preservative treatment is specified in the special provisions or on the plans, it shall be in accordance with Chapter 3, Part 6 of the AREMA Manual for Railway Engineering.
- C. The method of storing and handling timber piles shall be such as to avoid damage to the piles. Piles shall be handled with hemp or synthetic fiber slings or wire rope encased in rubber hose whenever possible, taking care to avoid dropping, bruising, breaking or penetrating the outer fibers.

2.2 STEEL PILES

- A. **Steel Bearing Piles:** shall be of the section shown on the plans and shall be structural steel, ASTM A572, Grade 50. Piles shall not be painted before driving.
- B. **Steel Sheet Piles:** shall be of the section and length shown on the plans and shall conform to ASTM A328 unless otherwise shown on the plans.
- C. **Steel Pipe Piles:** shall be of the outside diameter and wall thickness shown on the plans and shall conform to ASTM A252, Grade 2 unless other material is specified on the plans. Piles shall have a 3/4 inch thick steel (ASTM A36) closure plate of the same outside diameter as the pile groove welded to the pile on the tip end. Piles shall not be painted before driving.
 - 1. All concrete materials and reinforcing steel and their preparation and placement, used in filling steel pipe piles, shall be in accordance with SECTION 04400. All concrete shall have a minimum compressive strength equal to that shown on the plans.
- D. **Reinforced Pile Tips:** If shown on the plans or directed by the Engineer, steel bearing piles shall be equipped with a cast steel reinforced driving tip in accordance with details shown on the plans. The tips shall be installed in accordance with the manufacturer's recommendations.
- E. **Storing and Handling:** Piles to be stored shall be placed on skids above ground and a sufficient number used to prevent visible deflection in the stored piles. Piles shall be kept clean and fully drained at all times. The method of handling shall be such that no damage will result to the piles.

2.3 CONCRETE PILES

- A. **Precast concrete piles:** shall be of the type, size and length shown on the plans.
 - 1. All concrete materials and steel reinforcing and their preparation and placement shall be in accordance with SECTION 04500. All concrete shall have a minimum compressive strength equal to that shown on the plans.
- B. **Prestressed concrete piles:** shall meet the requirements, and shall be of the type, size, and length shown on the plans, manufactured in accordance with SECTION 04500.
- C. **Defects and Breakage:** Piles cracked in the process of curing, handling or driving, which in the opinion of the Engineer can be satisfactorily repaired, shall be repaired at the Contractor's expense and under the direction of the Engineer. If repair is not possible in the opinion of the Engineer, the piles shall be replaced at the Contractor's expense.
- D. **Storing and Handling:** The method of storing and handling piles shall be such as to minimize the danger of fracture by impact or undue bending stresses. Unless otherwise provided, piles shall be handled by means of a suitable bridle or sling attached to the pile at the pick-up points marked on the pile. Use of rubberized cables is also acceptable. The use of chain slings will not be permitted.
 - 1. Piles shall be stored above ground on adequate blocking located within 1 foot of the pick-up points marked on the pile that will prevent undue stresses in the piles. When piles are only

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partially supported during hauling, the overhang shall not exceed the lengths permitted for pick-up. If piles are stacked for storage, blocking for all layers shall be in the same vertical plane.

PART 3 EXECUTION

3.1 DRIVING PILES

A. Driving Equipment

1. Piles shall be driven with steam, air, or diesel-powered hammers approved by the Engineer prior to use. The use of drop hammers will not be permitted. The weight of the ram of the hammer shall not exceed 7000 lb. unless approved in writing by the engineer. The hammer to be used shall have the approval of the Engineer. Steel sheet piles and steel H piles may be driven with vibratory hammers under conditions approved by the Engineer.
2. The minimum acceptable hammer energy for use with various pile types is as follows:

Pile Type	Minimum Energy (ft-lbs)
Timber, <60 ft	8,000
Timber, >60 ft	13,000
Steel Bearing and Steel Pipe	30,000
Concrete	15,000 (but not less than 1.5 ft-lb per lb of pile)
Steel Sheet	As necessary to drive the piles to the required depth without damage to the piles

3. The hammer shall be operated at all times at pressures and speeds recommended by the manufacturer. If steam or air hammers are used, boiler or air compressor capacity shall be adequate to maintain full rated pressure throughout the driving period of any pile. The boiler or air compressor shall be equipped with an accurate pressure gage at all times.
4. Pile drivers shall be equipped with leads which are constructed in such a manner as to afford freedom of movement of the hammer and to provide adequate support of the pile during driving. The longitudinal axis of the leads and hammer shall coincide with the longitudinal axis of the pile. Except where piles are driven through water, the leads shall be long enough so that a follower will not be necessary. Where a follower is required for driving piles underwater, one pile in each group of ten shall be long enough to permit driving without a follower. This pile shall be used as a test pile for proper correlation of the follower-driven piles bearing capacity. This pile shall be paid for as a permanent pile and not as a "test pile."

B. Driving Tolerances

1. Piles for bent construction shall be driven with a degree of accuracy that will permit framing into bents with a minimum of pulling or jacking. Under ordinary conditions, timber piles, after driving and before framing, shall not vary from the vertical or from the required batter by more than 1/4 inch per foot of pile above finished ground. Other types of piles, after driving and before framing, shall not vary from the vertical or from the required batter by more than 1/8 inch per foot of pile above finished ground, except that under ordinary conditions, the maximum deviation of the top of the pile from the plan location shall be 2 inches in the direction of the structure centerline and 4 inches in the direction along the centerline of the bent.
2. Foundation piles shall be driven to the vertical or batter line shown on the plans and the top of the completed pile shall not be more than 4 inches in any direction from the position shown on the plans. The center of gravity of the completed pile group shall not vary by more than 3 inches from the center of gravity determined from plan location.

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3. If necessary to meet the required tolerances, pilot holes or guide templates may be used. Generally, the diameter of pilot hole shall be as specified in Paragraph F.1.
- C. Protection of Pile Heads
1. A steel driving head suitable for the type and size of piles being driven shall be used. Steel bearing piles and steel sheet piles shall be driven with a driving head compatible with the specific pile shape driven.
 2. For concrete piles, a cushion block shall be provided between the driving head and the top of the pile. Wood cushion blocks, wire rope mat, belting, or other suitable material shall be used, subject to the approval of the Engineer, to prevent damage to the pile. Cushion blocks shall be changed as necessary to maintain an effective cushion.
- D. Pile Damage and Misalignment: Care shall be exercised to avoid damage to piles from overdriving. Any pile that is damaged to the extent that, in the opinion of the Engineer, it will not perform its design function; any pile that is driven off location or alignment beyond the allowable tolerances; or any timber pile that is driven below cut-off elevation shall be pulled, if possible, or cut off below ground line and another pile driven as close as possible to the proper location. Splicing of timber piles will not be permitted. If the defective pile condition is due to Contractor's negligence, the cost of replacement and re-driving shall be borne by the Contractor.
- E. Pile Penetration
1. All piles shall be driven to a penetration satisfactory to the Engineer. The length of the piles shown on the plans is the length which is estimated to give the minimum required penetration and bearing and is for estimating purposes only.
 2. When test piles are required by the contract, the pile lengths and penetration required will be established by the Engineer on the basis of the test pile data. These lengths and elevation of pile tips shall supersede requirements shown on the plans.
 3. Unless otherwise shown on the plans or directed in writing by the Engineer for cases where piles penetrate into competent rock, foundation piles shall be driven to a penetration of a minimum 10 feet below bottom of footing, and other piles to a penetration of at least 15 feet below natural or finished ground line, whichever is lower. Piles in streambeds or on the banks of streams, where marked erosion is expected, shall be driven to such penetration as the Engineer deems necessary for protection against scour.
 4. When the specified penetration cannot be obtained without overdriving the piles, the Contractor shall provide either pilot holes or jetting equipment or a combination of both, as directed by the Engineer.
- F. Pilot Holes
1. If piles cannot be driven to the required penetration and the material is not suitable for jetting, the Engineer may permit pilot holes to be drilled to facilitate driving. The Engineer will designate the diameter and depth of the drilled hole. Ordinarily, a drill diameter of 12 inches will be satisfactory for timber piles and typically a drill diameter 4 inches less than the diagonal of square piles, 2 inches less than the diagonal of octagonal piles, and 1 inch less than the diameter of round piles will be satisfactory for steel pipe and concrete piles.
 2. Where pilot holes are required in granular material which cannot be sealed off by ordinary "mudding" drilling methods, a casing pipe of sufficient diameter shall be placed around the boring device. The casing shall be of sufficient length to extend through the loose materials and shall be held in position until the pilot hole is completed, and the pile placed ready for driving.
 3. If the hard material extends below the desired penetration, the drilling shall be stopped 1 foot above that level and the pile driven the remaining distance if it is possible to do so without damaging the pile. If the pile does not completely fill the pilot hole, the space between the pile

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and the wall of the hole shall be filled with dry granular material prior to driving as directed by the Engineer.

- Pilot holes shall be considered as incidental to piles and no direct payment will be made for this work.

G. Jetting

- For jetting operations sufficient power shall be provided, in addition to that used for operating the hammer, to supply water volume and pressure sufficient to freely erode the material adjacent to the pile.
- Jetting shall be stopped a minimum of 2 feet above the desired tip elevation and the final penetration obtained by driving without jetting. In silty soils it is possible that jetting may loosen the soil around piles already driven. If such a condition is considered possible, piles shall be re-driven after all jetting within 25 feet has been completed.
- Jetting shall be considered as incidental to piles, and no direct payment will be made for this work.

H. Shooting Pilot Holes: The use of explosives for drilling of pilot holes will not be permitted.

I. Bearing Capacity

- All piles shall be driven to the ultimate bearing capacity specified on the plans, in the special provisions, or by the Engineer. The bearing values shall be determined using the wave equation method or the following formula as directed by the Engineer:

$$Ru = \frac{12eE}{s + c} \times \frac{W + n^2P}{W + P}$$

Ru	=	Ultimate dynamic pile resistance (pounds)
----	---	---

e	=	Hammer efficiency = 0.9
---	---	-------------------------

E	=	Hammer energy per blow = Wh for single acting steam or air hammer or open cylinder Diesel hammer.
---	---	---

s	=	Penetration of pile per hammer blow (inches)
---	---	--

c	=	Average temporary compression (inches). The value of c shall be determined from test pile rebound graphs or as specified by the Engineer.
---	---	--

W	=	Weight of striking parts of hammer (pounds)
---	---	---

h	=	Hammer ram stroke (feet) average during 1 inch of pile penetration
---	---	--

n	=	Coefficient of restitution = 0.7
---	---	----------------------------------

P	=	Weight being driven (pounds) includes pile and pile follower, anvil, drive cap and adapter as applicable
---	---	--

- When measuring penetration per blow to determine if adequate bearing capacity has been obtained, the hammer shall be running freely and at the speed specified by the manufacturer for full rated energy output.
- If, for some unavoidable reason, driving must be interrupted before final penetration is reached, the penetration per blow to determine bearing capacity shall not be measured until 12 inches of penetration or refusal has been obtained after driving has been resumed.

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3.2 PILE DRIVING NEAR FRESH CONCRETE

- A. Piles shall not be driven within 150 feet of concrete that was placed within the previous 24 hours. If piling are driven within 150 feet of concrete that has not attained its specified 28-day strength, the following distances, based on the concrete strength and pile hammer rated energy, shall be maintained between the concrete and the nearest pile. The minimum distance to concrete should be as follows:

Percent of 28 Day Strength	Energy less than 40,000 ft-lb	Energy 40,000 ft-lb to 60,000 ft-lb	Energy 60,000 ft-lb or greater
20	60 ft	70 ft	85 ft
40	35 ft	45 ft	50 ft
60	25 ft	25 ft	30 ft
80	10 ft	15 ft	15 ft

3.3 TEST PILES

- A. The furnished length of test piles shall be a minimum of 10 feet longer than the estimated length of the permanent piles shown on the plans or as directed by the Engineer.
- B. Wherever possible, test piles shall be driven in a location such that they can become part of the permanent structure. If not so used, test piles shall be cut off or extracted as directed by the Engineer. Extraction of test piles shall be considered incidental to the test pile item, and no separate compensation will be made for this work.
- C. Ground elevations shall be brought to finished grade wherever possible prior to driving test piles, so that the test pile will be comparable to the piles used in the permanent structure.
- D. Equipment used for driving test piles shall be adequate for handling the lengths provided without splicing. The hammer used shall be the same make and model as that to be used in driving the permanent piles.
- E. Driving of a test pile shall continue until a penetration and bearing capacity is obtained which is satisfactory to the Engineer. Typically, test piles shall be driven to not less than 125% of the ultimate pile capacity required for permanent piles in the bridge structure.

3.4 TIMBER PILES

- A. Pile Preparation
1. When the furnished length is much longer than the required length, the Engineer may permit shortening the tip end before driving so as to have the desired diameter at the cut-off.
 2. Pile tips shall be cut perpendicular to the axis of the pile.
 3. The piles for bents shall be matched as much as possible in diameter to facilitate framing and bracing.
- B. Cut-offs
1. Piles which are to be encased in concrete shall be cut-off square with a saw to the elevation shown on the plan or established by the Engineer. The pile heads shall then be swabbed with preservative as specified on the plans.
 2. Piles which are to support steel or timber caps shall be brought into final position and held while cut-off is made. Any chains or jacks used in positioning the piles shall be arranged so that the surface of the pile below cut-off will not be damaged. Cut-off shall be made with a saw to a true plane and to the exact elevation shown on the plans or established by the Engineer so that the

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cap will bear on the entire cross section of each pile in the bent. No shims will be permitted between the pile and the cap. Piles must show a solid head at the plane of cutting, and after cut-off, the pile caps shall be protected with preservative, fabric, and plastic cement as specified on the plans.

3. Cut-off portions of piles furnished by the Company remain the property of the Company and shall be hauled to and loaded into rail cars by the Contractor. In the event rail cars are not available, the cut-offs will be stockpiled at a location designated by the Engineer. Stubs under 5 feet in length shall be disposed of by the Contractor in accordance with all applicable environmental laws and regulations. No extra payment will be allowed for this work.
- C. **Treatment of Damaged Surfaces:** Any pile surface below cut-off that has been scuffed, torn or otherwise damaged shall be treated in accordance with the requirements of the applicable plans.

3.5 STEEL BEARING PILES AND STEEL SHEET PILES

- A. **Splices and Build-ups:** The length of steel bearing piles and steel sheet piles shown on the plans or ordered by the Engineer may be built up in sections either before or during driving operations. The sections, unless otherwise shown on the plans, shall be of identical cross-section. Pile splices shall be made by full penetration butt welding the entire cross-section or as otherwise shown on the plans. All welding shall be in accordance with ANSI/AASHTO/AWS D1.5 Bridge Welding Code. Care shall be taken to properly align the sections connected so that the axis of the pile will be straight. Pile splices above a point 15 feet below finished ground line shall be reinforced as shown on the plans, unless otherwise directed by the Engineer. Field splices shall be avoided for lengths under 60 feet.
- B. **Cut-Offs:** Piles shall be cut off, with a cutting torch, or by other acceptable methods, to the elevation shown on the plans or established by the Engineer. Where caps are required, piles shall be brought into final position and held while cut off is made and the end surface of the piles shall be made as smooth as practicable with maximum gap of 1/8 inch between pile and pile cap.

3.6 STEEL PIPE PILES

- A. **Splices and Build-ups**
1. The length of a steel pipe pile may be built up in sections either before or during the driving operation. The minimum length of a section measured between welded splices shall be 5 feet, and between drive splices shall be 30 feet. Only one welded splice and no drive splices will be permitted in that portion of the pile exposed above ground line or normal water line. Drive splices shall be 15 feet below the ground line, unless directed by the engineer.
 2. Care shall be taken to properly align the sections to be spliced to insure a straight axis. The sections shall be spliced together in accordance with details shown on the plans. All welding shall be in accordance with the ANSI/AASHTO/AWS D1.5 Bridge Welding Code.
- B. **Cut-Offs:** Piles shall be cut off, with a cutting torch, or by other acceptable methods, to the elevation shown on the plans or established by the Engineer. Where caps are required, piles shall be brought into final position and held while cut off is made and the end surface of the piles shall be made as smooth as practicable with maximum gap of 1/8 inch between pile and pile cap.
- C. **Placement of Concrete**
1. After all driving, splicing, and positioning of pile is completed, the pile shall be free from buckles, splits, distortions, water or other foreign matter. The Contractor shall provide equipment, lighting, and facilities necessary for the proper inspection of the piles. Any damaged, improperly driven, or otherwise defective pile shall be removed and replaced at the Contractor's expense.
 2. The tops of piles shall be kept covered after driving until the concrete is placed. No concrete shall be placed in the piles in any unit until the driving of all piles in that unit has been completed. No concrete shall be placed until the Engineer has inspected the completed pile and reinforcing

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steel, when required, and given his approval to proceed. Unit is defined as a pier, bent or abutment.

3. Concrete shall be placed in a continuous operation taking care to prevent segregation. Special placing devices shall be used if necessary.

3.7 PRECAST AND PRESTRESSED CONCRETE PILES

A. Build-ups

1. Build-ups shall be made in accordance with the details shown on the plans or provided by the Engineer. The concrete used for the build-up shall be of the same quality as that used originally in the pile. Just prior to placing the concrete, the top of the pile shall be coated with an epoxy bonding compound approved by the Engineer.
2. When additional driving of precast non-prestressed piles is required, the built-up portion shall obtain a compressive strength equal to the design compressive strength of the original pile prior to redriving.

- B. **Cut-Offs:** Concrete at the end of a pile terminating in cast-in-place concrete shall be cut back the required amount leaving the reinforcing steel or prestressing steel exposed. The final cut of the concrete shall be normal to the axis of the pile. Any damage to the pile below the plan cut-off elevation shall be remedied by further cut-back and built-up.

PART 4 MEASUREMENT AND PAYMENT

4.1 PILES

A. Measurement

1. Piles delivered of the various kinds, sizes, types, and weights will be measured by the lineal foot, except steel sheet piles will be measured by the square foot, of acceptable pile delivered at the site of work and furnished in accordance with the lengths specified on the plans.
2. Piles driven of the various kinds, sizes, types, and weights will be measured to the nearest 1/10 lineal foot of net length of pile in place, except steel sheet piles will be measured by the square foot of acceptable pile in place, after all cut-offs and build-ups have been made.
3. That portion of piles driven below the elevation required by the plans or as directed by the Engineer and piles driven below the elevation at which the minimum penetration and bearing requirements were first obtained will not be measured for payment.
4. Timber Piles
 - (a) Piles supplied by the Company which fail during driving, due to an inherent weakness in the pile and not due to negligence on the part of the Contractor, and which are extracted or cut-off at the direction of the Engineer, will be measured for payment by the lineal foot of pile in the leads. Piles supplied by the Company and broken during driving due to Contractor's negligence will not be measured for payment. Piles supplied by the Contractor and broken during driving will not be measured for payment.
 - (b) Cut-off portions of piles will not be measured for payment.
5. Steel Piles: Cut-off portions of piles will not be measured for payment.
6. Concrete Piles, Precast and Prestressed
 - (a) Two feet will be added to the length of piles, measured for payment in accordance with Paragraph 1, for each authorized build-up made, other than those made necessary by improper casting, handling or driving of piles.
 - (b) Cut-off portions of piles, when piles are supplied by the Contractor in the lengths shown on the plans or ordered by the Engineer, will be measured by the lineal foot of cut-off above

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design elevation. Cutbacks made below design elevation for the purpose of making build-ups will be considered incidental to the work and will not be measured.

- (c) When piles of extra length are furnished to eliminate protrusion of reinforcing steel required for splicing, such extra length will not be measured for payment as either piles or cut-off portion of piles.
- B. **Piles Delivered:** shall be paid for at the contract unit price per lineal foot or square foot, of the various kinds, sizes, types, and weights. This price shall include full compensation for all work and costs involved for furnishing the piles, unless otherwise specified; unloading, storing, and transporting the piles. This price shall not include compensation for concrete or reinforcing steel in steel pipe piles which will be paid for under SECTION 04400.
- C. **Piles Driven:** shall be paid for at the contract unit price per lineal foot or square foot, of the various kinds, sizes, types, and weights. This price shall include full compensation for furnishing all labor, materials, tools, equipment, jetting, pilot holes, and incidentals necessary to drive and cut-off the piles and complete the work. The Contractor shall accept the contingencies of driving greater or lesser length of piles or other changes of features in construction which this may involve, all without modification of the unit price fixed by the contract.
- D. **Timber Piles:** The contract price per lineal foot of acceptable timber pile shall also include full compensation for preparing the piles, disposing of the pile heads, treating the pile tops as specified in Paragraph 3.3B and the treating of damaged surfaces, splits, and checks as specified in Paragraph 3.3C.
- E. **Steel Bearing Piles and Steel Pipe Piles:** Payment for the work and materials, exclusive of additional length of pile, required in making each pile splice shall be made at a unit price per splice equal to two times the unit price bid for "Steel Bearing Piles Driven" or "Steel Pipe Piles Driven," as applies, of the size and weight on which the splice is made except that no payment will be made for any splice on any pile whose actual length left in place, after all cut-offs, splices, or build-ups have been made, is not greater than the length shown on the plans or specified by the Engineer, nor will payment be made for more than one splice on any one pile less than 120 feet long.
- F. **Steel Sheet Piles:** No direct payment will be made for cut-off portions of piles.
- G. **Concrete Piles, Precast and Prestressed:** Cut-off portions of piles, will be paid for at one half the unit price bid per lineal foot for concrete piles.

4.2 TEST PILES

- A. Test piles of the various kinds, sizes, types and weights, when the piles do not become a part of the permanent structure, will be measured by the lineal foot of pile in the leads and driven in accordance with these specifications and in the location specified on the plans or by the Engineer. When test piles become a part of the permanent structure, they will be measured by the lineal foot of acceptable pile in place after all cut-offs and build-ups have been made in accordance with the provisions of Paragraph 4.1 covering the various kinds of piles.
- B. Test piles shall be paid for at the contract unit price per lineal foot of test pile of the various kinds, sizes, types, and weights. This price shall include full compensation for furnishing the piles, unless otherwise specified; unloading, storing, and transporting the piles; and for furnishing all labor, materials, tools, equipment, jetting, pilot holes, and incidentals necessary to drive the piles and complete the work. Payment will be made for splices authorized by the Engineer at the rate specified in Section 4.2.

4.3 REINFORCED PILE TIPS

- A. Reinforced pile tips will be measured by the number of reinforced tips installed on steel bearing piles and driven in place.

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- B. Payment for reinforced pile tips on steel bearing piles, if required, shall be made at the contract unit price per each which shall be full compensation for furnishing all material, labor and equipment required to install the tips. Payment will be made only for reinforced tips required as shown on the plans or as requested by the Engineer.

END OF SECTION

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SECTION 04210

DRILLED AND GROUTED MICROPILE

PART 1 GENERAL

1.1 GENERAL

- A. For purposes of this Specification a micropile shall be defined as a pile 12 inches or less in diameter, incorporating steel pipe casing and/or steel reinforcement, grouted into a predrilled hole with a minimum working load of 25 tons, in which most of the applied load is resisted by the steel reinforcement. A micropile will accept loads directly to provide structural support. Micropiles shall develop their load carrying capacity through a bond zone in soil, bedrock or a combination of soil and bedrock. Micropiles used for slope stabilization, ground improvement or support of excavations are not addressed in this Specification.

1.2 SCOPE OF WORK

- A. The work consists of furnishing all necessary engineering and design services, supervision, labor, materials and equipment to perform all work necessary to install and test the micropiles at the locations shown on the plans per this Specification and as shown on the design drawings. The Contractor shall install a micropile system that will develop the load capacities indicated on the design drawings. The micropile load capacities shall be verified by testing as specified herein.

1.3 QUALIFICATIONS OF THE CONTRACTOR

- A. The micropile Contractor shall be fully experienced in all aspects of micropile design and construction. The Contractor will have successfully completed at least five projects in the previous five years of similar scope and size.

1.4 DESIGN CRITERIA

- A. The micropiles shall be designed to meet the loading and movement conditions as shown on the plans. The calculations and drawings required from the Contractor shall be submitted to the Engineer for review and approval in accordance with Section 3.1 "Submittals".
- B. Structural design shall be in accordance with the recommendations of the current American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering (Manual), except as modified hereinafter.
- C. The allowable working load of the micropile in compression shall be based on the following allowable stresses:

Allowable compression of grout	$0.33*f_c$
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Allowable compression of reinforcing steel	$0.40*f_y$
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Allowable compression of steel casing	$0.40*f_y$
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f_c = 28 day unconfined compressive strength of grout	
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f_y = yield strength of steel, not to exceed 80 ksi	
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- D. The ultimate structural capacity of the micropile in compression shall be based on the following material stresses:

Strength of grout	$0.85*f_c$
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Strength of steel	1.0*fy
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- E. Lateral load and bending: Bending moments from lateral loads shall be determined using an accepted method of analysis. The structural design for combined bending and axial loads shall not exceed the allowable stresses in the AREMA Manual.
- F. The micropile top attachment shall distribute the design loads to the footing such that the stresses do not exceed the allowable stresses in the AREMA Manual.
- G. The geotechnical capacity of the micropile shall be designed based on an ultimate grout-to-soil bond strength that is consistent with the site soil characteristics and the method of construction. A minimum factor of safety of 2.5 shall be used to establish allowable grout-to-soil bond stresses.

PART 2 MATERIAL

2.1 WATER

- A. Water for mixing grout shall be potable, clean and free from substances which may be deleterious to grout or steel.

2.2 CEMENT

- A. All cement shall be Portland cement conforming to ASTM C150 Type I, Type II, or Type III, and shall be the product of one manufacturer.

2.3 ADMIXTURES

- A. Admixtures shall conform to the requirements of ASTM C494. Admixtures which control bleed, improve flowability, reduce water content and retard set may be used in the grout subject to the review and acceptance of the Engineer. Expansive admixtures shall only be added to the grout used for filling sealed encapsulations. Admixtures shall be compatible with the grout and mixed in accordance with the manufacturer's recommendations. Admixtures containing chlorides shall not be used.

2.4 FILLERS

- A. Inert fillers such as sand may be used in the grout in special situations, such as presence of large voids in the ground, when approved by the Engineer.

2.5 BAR REINFORCING STEEL

- A. Reinforcing steel shall be deformed bars in accordance with ASTM A615, Grade 60 or Grade 75; ASTM A722 Grade 150; or as shown on the plans.

2.6 STEEL CASING/PIPE

- A. Permanent casing/pipe relied upon to carry structural loads or reduce deflection shall conform to the requirements of ASTM A252, Grade 3; API 5 CT Grade N80 "Structural Grade" (also known as "Mill Secondary") without mill certification and free from structural defects; or as shown on the plans.
- B. Temporary casings shall be of sufficient strength to withstand handling stresses, grout pressure, and surrounding earth and/or fluid pressures.

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2.7 STEEL PLATES AND SHAPES

- A. Structural steel plates and shapes for pile top attachments shall conform to ASTM A36; ASTM A572 Gr. 50; ASTM A992; or as shown on the plans.

2.8 CENTRALIZERS

- A. Devices for centering the reinforcing bars shall be fabricated from plastic, steel, or other material that is non-detrimental to the reinforcing steel and grout. Wood centralizers shall not be used.

PART 3 EXECUTION

3.1 SUBMITTALS

- A. The Contractor shall prepare and submit to the Engineer, for review and approval, Working Drawings, a detailed description of the construction procedure and relevant structural design calculations for the micropile system intended for use at least 21 calendar days prior to the planned start of construction. All design submittals shall be sealed by a Registered Professional Engineer currently licensed in the state in which the work will take place.
- B. The Working Drawings shall include micropile installation details indicating:
 - 1. micropile number, location and pattern
 - 2. micropile design load
 - 3. type and size of reinforcing steel
 - 4. minimum total bond length
 - 5. total micropile length
 - 6. grouting volumes and maximum pressures
 - 7. micropile top attachments
 - 8. micropile cut-off elevations
 - 9. other details to appropriately describe the installation
- C. The Contractor shall prepare and submit shop drawings for all structural steel, including the micropile components, pile top attachment, corrosion protection system and bond length details to the Engineer for review and approval.
- D. The Contractor shall submit certified mill test reports, properly identified, for the reinforcing steel as the materials are delivered, to the Engineer for record purposes. For steel pipe used as permanent casing or steel core, the Contractor shall submit to the Engineer for record purposes a minimum of two representative coupon tests or mill certifications on each load delivered to the project.
- E. The Contractor shall submit the grout mix designs including details of all materials to be incorporated and the procedure for mixing and placing the grout, to the Engineer for approval. This submittal shall include certified test results verifying the acceptability of the proposed mix designs.
- F. The Contractor shall submit detailed plans for the proposed method for testing the micropiles, to the Engineer for review and acceptance prior to beginning the load tests. This shall include drawings and details to clearly describe the equipment and test procedure. This submittal shall also include calibration reports for each test jack, pressure gauge and master pressure gauge to be used. The calibration tests shall have been performed by an independent testing laboratory within one year of the date submitted.
- G. Work shall not begin until the appropriate submittals have been received, reviewed and approved in writing by the Engineer. The Contractor shall allow the Engineer up to two weeks to review, comment upon and return the Working Drawing submittal package after a complete set has been received. Note that any additional time required due to incomplete or unacceptable submittals shall

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not be cause for delay or impact claims. All costs associated with incomplete or unacceptable submittals shall be the responsibility of the Contractor.

3.2 GROUND CONDITIONS

- A. A Geotechnical Report will be provided by BNSF. The test boring logs as described in the Geotechnical Report are believed to be representative of the conditions likely to be encountered on the site, and are to be used as the basis for micropile design in conjunction with the appropriate levels of engineering experience and judgment.
- B. If, during the installation of a pile, an obstruction is encountered that prevents the practical advancement of the hole, the Contractor shall immediately notify the Engineer. Upon approval of the Engineer, the hole shall be abandoned and filled with grout. A new hole shall be drilled at a location as determined by the Engineer.
- C. If during drilling, obstructions are encountered at a frequency, composition and location that were not inferable at the time of preparation of the bid, the additional costs utilized in trying to overcome such obstructions shall be paid for as "Force Account" work as described in the Contract for Construction.

3.3 CONSTRUCTION TOLERANCES

- A. The centerline of micropiles shall not be more than 3 inches from indicated design plan location.
- B. Pile hole alignment of micropiles shall be within 2% of design alignment.
- C. Top elevation of the micropiles shall be within +1 inch to -1 inch of the design vertical elevation.
- D. Centerline of core reinforcement shall not be more than 3/4 inches from the design centerline.
- E. The micropile shaft diameter shall be at least as specified on the design plan, or as approved by the Engineer.

3.4 DISPOSAL OF EXCAVATED SOILS

- A. Excavated soils from the drilling operation shall be transported from the site by the Contractor to BNSF property as designated by the Engineer. The soils shall be spread uniformly over an area designated by the Engineer and graded to drain. There will be no specific compaction requirement beyond that which will occur as a result of machine compaction while performing the uniform grading operations.

3.5 INSTALLATION

- A. The micropile installation technique shall be such that it is consistent with the geotechnical, logistical, environmental and load carrying conditions of the project. The Contractor shall select the drilling method and the grouting procedures used for the installation of the micropiles, subject to the approval of the Engineer.
- B. The drilling equipment and methods shall be suitable for drilling through the conditions encountered, with minimal disturbance to these conditions, adjacent structures and railroad operations. The borehole must be open to the defined nominal diameter, full length, prior to placing grout and reinforcement. If borehole wall support is required for all or part of the pile length, the wall support method shall be selected by the Contractor subject to the approval of the Engineer. Such support methods may include temporary steel casing, hollow stem augers or the use of a hole-stabilizing drilling fluid (provided the drilling fluid does not have a deleterious effect on geotechnical bond development).
- C. All installation techniques shall be determined and scheduled such that there will be no interconnection or damage to micropiles in which grout has not achieved final set.

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- D. Centralizers shall be provided at 10-foot maximum vertical spacing on central reinforcement. The uppermost centralizer shall be located a maximum of 5 feet from the top of the micropile. Centralizers shall permit free flow of the grout without misalignment of the reinforcement.
- E. The central reinforcement steel with centralizers shall be lowered into the stabilized drill hole to the desired depth without difficulty. Partially inserted reinforcing bars shall not be driven or forced into the hole such that there will be no damage to piles in which the grout has not achieved final set.
- F. The grout shall be injected as per Section 3.6.
- G. The Contractor shall check micropile top elevations and adjust all installed micropiles to the planned elevations.

3.6 GROUTING

- A. The Contractor shall provide systems and equipment to measure the grout quality, quantity and pumping pressure during the grouting operations.
- B. After drilling, the hole shall be flushed with water and/or air to remove drill cuttings and loose debris.
- C. The Contractor shall provide a stable, homogenous, neat cement grout (or a sand-cement grout when approved by the Engineer) with a minimum 28-day unconfined compressive strength of 4000 psi. The grout shall not contain lumps or any other evidence of poor or incomplete mixing. Admixtures, if used, shall be mixed in accordance with the manufacturer's recommendations. The pump shall be equipped with a pressure gauge to monitor grouting pressures. The pressure gauge shall be capable of measuring pressures of at least 150 psi or twice the actual grout pressures used by the Contractor, whichever is greater. The grout shall be pumped in one continuous operation. The grout shall be kept in constant agitation prior to pumping. The grout shall be injected from the lowest point of the drill hole by tremie methods until clean, pure grout flows from the top of the micropile. The tremie grout may be pumped through grout tubes, hollow stem augers or drill rods. Subsequent to tremie grouting, all grouting operations associated with extraction of the drill casing and pressure grouting must ensure complete continuity of the grout column. The use of compressed air to directly pressurize the fluid grout is not permissible. The grout pressures and grout shall be controlled to prevent excessive heave in cohesive soils and fracturing of soil or rock formations. The entire pile shall be grouted to the design cut-off elevation.
- D. Grout within the micropiles shall obtain the minimum design strength prior to being loaded.
- E. If the Contractor uses a post-grouting system, all relevant details including grouting pressures, volume, location and mix design, shall be submitted as part of Section 3.1.
- F. During production, the Contractor shall test the compressive strength of the micropile grout in accordance with ASTM C109, at a frequency of no less than one set of three 2-inch grout cubes from each grout plant each week of operation or per every ten production micropiles, whichever occurs more frequently. The compressive strength shall be taken as the average of the three cubes tested. Grout samples shall be taken directly from the grout plant. The Contractor shall provide the compressive strength test records as part of Section 3.10, Installation Records.

3.7 SPLICES

- A. Splices of casing pipe and reinforcing steel shall be constructed to develop the required design strength of the section.
- B. Lengths of casing and reinforcing steel to be spliced shall be secured in proper alignment and in such a manner that no eccentricity between the axes of the two lengths spliced or angle between them results.

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3.8 PRE-PRODUCTION LOAD TESTS

- A. If required by the plans or special provisions, the Contractor shall perform micropile load tests to verify the adequacy of the design of the system and the proposed construction procedures prior to installation of the production micropiles. The construction and testing of the sacrificial test micropiles shall take place immediately prior to the commencement of the installation of the production micropiles. The number of sacrificial test micropiles shall be as specified in the plans or special provisions.
- B. The location of the pre-production load tests will be as directed by the Engineer.
- C. The Contractor shall submit a full description of the proposed micropile load testing program to the Engineer for review and acceptance. The testing program shall be provided at least two weeks prior to the starting of the load tests. This micropile load testing program shall be in general conformance with ASTM D1143 and/or D3689.
- D. The drilling and grouting methods, casing and other reinforcement details, and depth of embedment of the test micropiles shall be identical to the production piles, except as approved by the Engineer.
- E. The pre-production tested micropiles shall be loaded to 200% of the compression design load (DL). The jack shall be positioned at the beginning of the test such that the unloading and repositioning of the jack during the test will not be required. An alignment load (AL) may be applied to the micropile prior to setting the movement recording devices in order to keep the testing equipment properly positioned. The alignment load shall be no more than 10% of the design load. Dial gauges shall be zeroed at the first setting of the alignment load.
- F. Axial pile pre-production load tests shall be made by loading the micropile and recording pile head movement in the following load increments (AL = Alignment Load, DL = Design Load):

Load	Hold Time (min)	Load	Hold Time (min)	Load	Hold Time (min)
AL		AL	1.0	AL	1.0
0.15DL	2.5	0.15DL	1.0	0.15DL	1.0
0.30DL	2.5	1.00DL	1.0	1.45DL	1.0
0.45DL	2.5	1.15DL	2.5	1.60DL	1.0
AL	1.0	1.30	10.0 ¹	1.75DL	2.5
0.15DL	1.0	1.45	2.5	1.90DL	2.5
0.45DL	1.0			2.00DL	10.0
0.60DL	2.5			1.50DL	5.0
0.75DL	2.5			1.00DL	5.0
0.90DL	2.5			0.50DL	5.0
1.00DL	2.5			AL	5.0

- G. The acceptance criteria for pre-production load tests are:
 1. The micropile shall sustain the compression design load (1.0 DL) with no more than 1/2 inch of total vertical movement at the top of the pile as measured relative to the pile prior to the start of proof testing.

¹ Hold until the creep criteria 2 of the next paragraph is met

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2. Test micropiles shall have a creep rate at the end of the 130% DL increment which is not greater than 0.040 inches/log cycle time from 1 to 10 minutes or 0.080 inches/log cycle time from 6 to 60 minutes. The creep rate shall be linear or decreasing.
 3. Failure shall not occur at the 2.0 DL load increment. Failure is defined as the slope of the load versus deflection curve (at end of increment) exceeding 0.025 inches/kip.
- H. When a tested pre-production micropile fails to meet the acceptance criteria, the cause(s) shall be established and the Contractor shall modify the design, construction procedure or both. The modifications may include, but are not limited to, installing replacement micropiles, regrouting via pre-placed regrout tubes, modifying the installation methods, increasing the bond length or changing the micropile type. The modified system shall be retested. Any modification which requires changes to the structure shall have prior review and acceptance of the Engineer. All costs associated with additional preproduction testing required due to a failed test and all cost associated with modifications to remedy a failed test shall be the responsibility of the Contractor.
- I. The Contractor shall provide the Engineer with a written report confirming micropile geometry and construction details with 7 working days after the completion of the preproduction tests. This written confirmation will either confirm the bond lengths as shown in the Contractor's Working Drawings or proposed modifications based on the results of the pre-production tests.

3.9 PRODUCTION MICROPILE PROOF TESTS

- A. The Contractor shall proof test at least one production micropile, but not less than the quantity specified in the plans or special provisions. The micropiles to be tested will be selected by the Engineer.
- B. The proof-tested micropile shall be loaded to 130% of the compression design load (DL). The jack shall be positioned at the beginning of the test such that the unloading and repositioning of the jack during the test will not be required. An alignment load (AL) may be applied to the micropile prior to setting the movement recording devices in order to keep the testing equipment properly positioned. The alignment load shall be no more than 10% of the design load. Dial gauges shall be zeroed at the first setting of the alignment load.
- C. Axial pile load proof tests shall be made by loading the micropile and recording pile head movement in the following load increments (AL = Alignment Load, DL = Design Load):

Load	Hold Time (min)	Load	Hold Time (min)
AL		1.15DL	2.5
0.15DL	2.5	1.30DL	10 ²
0.30DL	2.5	1.00DL	4.0
0.45DL	2.5	0.75DL	4.0
0.60DL	2.5	0.50DL	4.0
0.75DL	2.5	0.25DL	4.0
0.90DL	2.5	AL	4.0
1.00DL	2.5		

- D. Acceptance criteria for micropile proof load tests are:

² Hold until the creep criteria 2 of the next paragraph is met

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1. The micropile shall sustain the compression design load (1.0 DL) with no more than 1/2 inch of total vertical movement at the top of the pile as measured relative to the pile prior to the start of proof testing.
 2. Test micropiles shall have a creep rate at the end of the 130% DL increment which is not greater than 0.040 inches/log cycle time from 1 to 10 minutes or 0.080 inches/log cycle time from 6 to 60 minutes. The creep rate shall be linear or decreasing.
 3. Failure shall not occur at the maximum load increment. Failure is defined as the slope of the load versus deflection curve (at end of increment) exceeding 0.025 inches/kip.
- E. If a micropile that is proof tested fails to meet the acceptance criteria, the Contractor shall proof test another micropile in the vicinity. For failed micropiles and further construction of other micropiles, the Contractor shall modify the design, construction procedure or both. The modifications may include, but are not limited to, installing replacement micropiles, incorporating additional micropiles of reduced load capacities, modifying the installation methods, increasing the bond length or changing the micropile type. Any modification which requires changes to the structure shall have prior review and acceptance of the Engineer. All costs associated with additional proof testing required due to a failed proof test and all cost associated with modifications to remedy a failed proof test shall be the responsibility of the Contractor.

3.10 INSTALLATION RECORDS

- A. Micropile installation records shall be prepared by the Contractor and submitted to the Engineer within 24 hours after each pile installation is completed. The records shall include the following minimum information:
1. Drilling duration and observations
 2. Information on soil and rock encountered, including soil description, water, etc.
 3. Approximate final tip elevations
 4. Cut-off elevations
 5. Design loads
 6. Description of unusual behavior or conditions
 7. Deviations from intended parameters
 8. Grout pressures obtained
 9. Grout quantities pumped
 10. Pile material and dimensions
 11. Micropile test records, analyses and details

PART 4 MEASUREMENT AND PAYMENT

4.1 DRILLED AND GROUTED MICROPILES

- A. Drilled and grouted micropiles will be measured per each acceptable micropile completed in place as shown on the plans or designated by the Engineer.
- B. Drilled and grouted micropiles will be paid for at the contract unit price per each acceptable micropile in place. This price shall include full compensation for all design and submittals; excavation, boring and drilling; furnishing, placing, and removing any required casings; furnishing and placing all reinforcing steel, permanent casings and grout; removing excess material; and for furnishing all tools, labor, equipment, and incidentals necessary to complete the work. No extra payment will be made for filling oversize excavations or for casings left in place.

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4.2 PRE-PRODUCTION MICROPILE LOAD TESTS

- A. A pre-production load testing program will be measured as a lump sum unit.
- B. A pre-production load testing program will be paid for at the contract lump sum unit price. This price shall include full compensation for all reaction piles, ground anchors and dead weight and other testing structures; subsequent testing as required due to a failed test; and for furnishing all tools, instruments, labor, equipment, and incidentals necessary to complete the work.

4.3 PRODUCTION MICROPILE PROOF TESTS

- A. Proof testing of production micropiles will be measured per each acceptable proof test completed.
- B. Production micropile proof tests will be paid for at the contract unit price per each acceptable proof test completed. This price shall include full compensation for all reaction piles, ground anchors and dead weight and other testing structures; subsequent testing as required due to a failed test; and for furnishing all tools, instruments, labor, equipment, and incidentals necessary to complete the work.

END OF SECTION

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SECTION 04300

DRILLED SHAFT FOUNDATIONS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Drilled Shaft Foundations⁷

1.2 DESCRIPTION

- A. This work consists of furnishing all materials, labor, tools, equipment, services and incidentals necessary to construct the drilled shafts in accordance with the contract documents and these specifications.
- B. Throughout these specifications, the terms “drilled shaft” and “shaft” are used interchangeably and shall include the upper cased portion of the shaft and the socket, which shall be defined as that portion of the drilled shaft below the upper elevation of which sound rock occurs across the entire width of the shaft.

PART 2 MATERIAL

2.1 CONCRETE

- A. Concrete for drilled shafts shall be Class 40 with 28-day strength of 4,000 psi.
- B. Concrete slump range shall be 7-9 inches
- C. To achieve the required slump range Type D or Type G admixture shall be used. This will increase the slump range without adding water.

2.2 REINFORCING STEEL

- A. Reinforcing steel shall be ASTM A615 or ASTM A706, Grade 60.

2.3 CASING

- A. Casing shall conform to ASTM A252, Grade 2 or 3, unless otherwise noted, and be of sufficient thickness to carry working stress and loads imposed on the casing during construction. The minimum casing thickness shall be 1/2 inch.

PART 3 EXECUTION

3.1 DRILLED SHAFT INSTALLATION PLAN

- A. Two weeks prior to the pre-construction conference unless required as part of bid, the Contractor shall submit a list containing at least three projects completed in the last five years on which the Contractor has installed drilled shafts of a similar size (diameter and length) and difficulty to those shown on the plans, and with similar subsurface conditions. The list of projects shall contain names and phone numbers of owner's representatives who can verify the Contractor's participation on those projects.

⁷ See General Provisions for utility and permitting requirements and sections that apply

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- B. The Contractor shall also submit a signed statement that the Contractor has inspected the project site and all the subsurface information made available in the contract documents.
- C. No later than one month prior to constructing the drilled shafts, the Contractor shall submit a Drilled Shaft Installation Plan for review by the Engineer. This plan shall provide information on the following:
 - 1. Name and experience record of the drilled shaft superintendent in charge of drilled shaft operations for this project. The drilled shaft superintendent shall have a minimum of five years of experience in drilled shaft construction.
 - 2. List of proposed equipment to be used including drill rig, drill tools and other associated equipment, final cleaning equipment, de-sanding equipment, tremies or concrete pumps, casing, slurry equipment, airlift pumps, etc.
 - 3. Details of overall construction operation sequence and the sequence of shaft construction in groups.
 - 4. Details of shaft excavation methods in soils and rock.
 - 5. When the use of slurry is anticipated, details of the slurry properties relevant to the subsurface conditions at the construction site, mixing and storage methods, maintenance methods and disposal procedures.
 - 6. Details of methods to clean and inspect the shaft excavation.
 - 7. Details of reinforcement placement, including support and centralization methods.
 - 8. Details of concrete placement, including proposed operational procedures for tremie or pumping methods.
 - 9. Details for permanent casing including installation methods, diameter and casing thickness.
 - 10. Details for temporary casing (if required) including installation and extraction methods, diameter and casing thickness, if temporary casings are used in addition to permanent casings.
- D. The Engineer will evaluate the Drilled Shaft Installation Plan for conformance with the contract documents. Within 14 days after receipt of the plan, the Engineer will notify the Contractor of any additional information required and/or changes necessary to meet the contract requirements. All procedural approvals given by the Engineer shall be subject to trial in the field and shall not relieve the Contractor of the responsibility to satisfactorily complete the work as detailed in the contract documents.

3.2 PROTECTION OF EXISTING STRUCTURES

- A. The Contractor shall control his operations to prevent damage to existing structures and utilities. Preventive measures shall include, but are not limited to, selecting construction methods and procedures that will prevent caving of the drilled shaft during excavation and construction including monitoring and controlling the vibrations and settlement from construction activities such as the driving of casing, sheeting, or excavation of the drilled shaft.

3.3 GENERAL METHODS AND EQUIPMENT

- A. FHWA Publication No. FHWA-NHI 18-024 Drilled Shafts: Construction Procedures and Design Methods (2018) shall be used as a guide for the construction of drilled shafts.
- B. The Contractor shall perform the excavations required for the drilled shafts in a continuous operation (unless otherwise authorized in writing by the Engineer), through whatever materials are encountered, to the dimensions and elevations shown in the plans or otherwise required by the specifications and special provisions. The Contractor's methods and equipment shall be suitable for the intended purpose and materials encountered. The permanent casing method shall be used for all drilled shaft locations unless shown otherwise in the plans.
 - 1. Drilling Equipment

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- (a) The excavation and drilling equipment shall have adequate capacity, including power, torque and down thrust to excavate a drilled shaft of both the maximum diameter and to a depth of 25 percent beyond the depths shown on the plans.
- (b) The excavation tools shall be of adequate design, size and strength to perform the work shown in the plans or described herein. When the material encountered cannot be drilled using conventional earth augers with soil teeth, drill buckets, grooving tools, and/or underreaming tools, the Contractor shall provide special drilling equipment, including but not limited to: rock augers, core barrels, rock tools, air tools, and other equipment as necessary to excavate the drilled shaft to the size and depth required.

2. Excavation

- (a) Drilled shaft excavations shall be made at the locations, top and bottom of drilled shaft elevations, minimum (rock) socket lengths and dimensions shown in the contract documents. All drilled shafts shall be advanced to the minimum (rock) socket lengths and to the bottom of drilled shaft elevation, whichever is deeper as determined by the Engineer. The integrity of the drilled shaft excavation shall be maintained throughout the placement of the reinforcing and concrete material following completion of the drilled shaft excavation. Placement of concrete shall proceed in a continuous manner after completion of the rock socket excavation and rebar cage placement without delay unless prior approval by the Engineer has been given. (No two adjacent shafts shall be excavated at the same time, but may be allowed if approved during the review of the drilled shaft installation plan. (i.e. Permanent casing, type of rock, ctr.-to-ctr. spacing of the drilled shafts, etc.) If the casing is to be advanced in conjunction with shaft excavation, the Contractor shall determine minimum distance between the bottom of the excavation and bottom of casing that must be maintained at any point during placement of the drilled shaft.

3. Obstructions

- (a) The Contractor shall remove surface and subsurface obstructions at drilled shaft locations. Such obstructions may include man-made materials such as old concrete foundations, timber pile as well as natural materials such as ironstone layers and boulders. Special procedures and/or drilling tools shall be employed by the Contractor after the hole cannot be advanced using conventional augers, drilling buckets and/or underreaming tools. Such special procedures/tools may include but are not limited to: chisels, boulder breakers, core barrels, rock augers, air tools, temporary casing, and increasing the shaft diameter.

4. Lost Tools

- (a) Drilling tools that are lost in the excavation shall not be considered obstructions and shall be promptly removed by the Contractor without compensation. All costs due to lost tool removal shall be borne by the Contractor including, but not limited to, costs associated with the repair of hole degradation due to removal operations or an excessive time that the hole remains open.

3.4 SHAFT CONSTRUCTION

- A. The drilled shafts shall be constructed by the permanent casing method, unless otherwise authorized in writing by the Engineer, to produce a sound, durable drilled shaft foundation free of defects or anomalies. The casing shall be continuous between top and bottom elevations shown on the plans.
- B. A drilled shaft may be constructed using dry construction methods if the following conditions are met. If water seepage collects at a rate less than 6 inch per hour when no pumping is permitted and the side or bottom surfaces of the excavation remain stable without detrimental caving, sloughing or swelling.
- C. The Contractor shall maintain a drilling log during drilled shaft excavation. The log shall contain information such as the description and approximate top and bottom depth of each soil or rock

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material encountered; drilling time in each stratum; description of the tools and drill rigs used and any equipment changes necessitated by changing ground conditions; seepage or ground water encountered and remarks. Two copies of the log, signed by the Contractor and the Engineer's representative, shall be furnished to the Engineer within one week after completion of the excavation.

- D. The Contractor shall clean the base of each shaft so that a minimum of 50% of the base shall have less than 0.5 inch of sediment at the time of concrete placement. The maximum depth of sediment or debris at the base of the shaft shall not exceed 1.5 inches. Shaft cleanliness will be verified by the Engineer prior to placing concrete.
- E. Disposal of excavated material as well as any slurry and/or water removed from the drilled shaft excavation by the Contractor shall be in accordance with applicable special provisions and specifications for disposal of excavated materials and in compliance with federal and state laws.
- F. No foundation piling shall be driven by pile hammer or drilled shaft excavation performed, within a radius of 50 feet of concrete that has taken its initial set until the concrete has attained a compressive strength of 1,500 psi.

1. Casings

- (a) Casings shall be steel, smooth, clean, and watertight and of ample strength and thickness to withstand both handling and driving stresses and the pressure of both concrete and the surrounding earth materials. The outside diameter of the casing shall not be less than the specified diameter of the drilled shaft and the outside diameter of any excavation made below the casing shall not be less than the specified diameter of the rock socket. No extra compensation will be allowed for concrete required to fill an oversized casing.
- (b) Furnish full-penetration welds, as needed, meeting the requirements of "Structural Welding Code Steel" (ANSI/AWS D1.1) of the American Welding Society requirements for joints in non-corrugated permanent steel casings. Welders shall be AWS certified.
- (c) Deliver casing to site in undamaged condition. Handle and protect casing to maintain diameter within 2 percent.
- (d) The use of an oversized excavation to install the permanent casing is not permitted. The casing shall maintain direct contact with the surrounding soils at all times to minimize disturbance, formation of voids and loss of ground.
- (e) The casing shall have cutting teeth in its leading edge to permit it to seat into the rock. The casing shall be seated to limit the possibility of groundwater seepage under artesian conditions. It is the Contractor's responsibility to adequately seat the casing.

2. Allowable Tolerances

- (a) The shafts shall be installed as shown on the applicable design drawing and in accordance with this specification.
 - 1. The bottom of shaft elevations have been estimated from the boring data. The location and log of each boring is shown on the plan.
 - 2. No shaft shall be off center from its design location more than 3 inches at the top of the shaft.
 - 3. No vertical shaft shall be out of plumb more than 1 percent of its length.
 - 4. The reinforcement steel cage shall be set at no less than 6 inches above the bottom of the excavated shaft prior to placement of concrete.
 - 5. The top elevation of the shaft shall have a tolerance of + 1 inch or -3 inches from plan top-of-shaft elevation.
 - 6. Excavation equipment and methods shall be designed so that the completed excavation will have a flat bottom. The cutting edges of excavation tooling shall be

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normal to the vertical axis of the equipment within a tolerance of 3/8 inch/foot of diameter.

7. After the concrete is placed, the top of the reinforcing steel cage shall be no more than 6 inch above and no more than 3 inch below plan position.
8. Drilled shaft excavations and completed drilled shafts not constructed within the required tolerances are unacceptable. The Contractor shall be responsible for correcting all unacceptable shaft excavations and completed drilled shafts to the satisfaction of the Engineer. Materials and work necessary, including engineering analysis and redesign, to complete corrections for out of tolerance drilled shaft excavations shall be furnished without cost to the Railroad.

3.5 SLURRY

- A. For rock sockets excavated in geomaterial that may erode by drilling fluid or water, such as shale, a polymer slurry will be required prior to beginning rock socket excavation through the completion of concreting the rock socket.
- B. Polymer slurries shall be employed when slurry is used in the drilling process unless other drilling fluids are approved in writing by the Engineer. The slurry manufacturer's representative shall be on site during slurry use to provide technical assistance unless approved in writing by the Engineer. Slurry mixed with shaft excavation cuttings shall not be permitted. The slurry shall be pre-mixed and ready for placement prior to start of excavation.
- C. The Contractor shall take all steps necessary to maintain uniform properties of the slurry fluid throughout the height of the slurry column such as but are not limited to: agitation, circulation and/or adjusting the properties of the slurry. Disposal of slurry removed from the drilled shaft excavation by the Contractor shall be in accordance with applicable special provisions and specifications for disposal of excavated materials and in compliance with federal and state laws.
- D. If polymer slurry is proposed, the Contractor's slurry management plan shall include detailed provisions for controlling the properties of the slurry, including tests to be performed, the frequency of those tests, the test methods, and the maximum and/or minimum property requirements that must be met to ensure that the slurry meets its intended functions within the subsurface conditions present and with the construction methods that are to be used. The slurry management plan shall include a set of the slurry manufacturer's written recommendations and shall include at a minimum, the following tests: Density test (API (American Petroleum Institute) 13B-I, Section 1), viscosity test (Marsh funnel and cup, API 13B-I, Section 2.2, or approved viscometer), pH test (pH meter, pH paper), and sand content test (API sand content kit, API 13B-I, Section 5). However, whatever product is used, the sand content at the base of the drilled shaft excavation shall not exceed 1 percent.
- E. The Contractor shall insure that a heavily contaminated slurry suspension, which may impact the free flow of concrete, has not accumulated in the bottom of the shaft. Prior to placing concrete in any shaft excavation, the Contractor shall take slurry samples using a sampling tool approved by the Engineer. Slurry samples shall be extracted from the base of the shaft and at intervals not exceeding 10 feet up the slurry column in the shaft, until two consecutive samples produce acceptable values for density, viscosity, and pH.
- F. When any slurry samples are found to be unacceptable, the Contractor shall take whatever action is necessary to bring the slurry within specification requirements. Concrete shall not be poured until the slurry in the hole is re-sampled and test results produce acceptable values.
- G. During construction, the level of polymer slurry shall be maintained at a level not less than 6 feet above the highest expected piezometric pressure head along the shaft. If at any time the slurry construction method fails, in the opinion of the Engineer, to produce the desired final results, then the Contractor shall both discontinue the current method being utilized and propose an alternate method for approval by the Engineer.

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3.6 EXCAVATION INSPECTION

- A. At all times, the Contractor shall maintain at the job site, all equipment necessary for use in the shaft inspection.
- B. Final drilled shaft depth shall be measured using an approved method following final cleaning using a method approved by the Engineer. Cleaning of the bearing elevation of the drilled shaft or sidewalls shall occur by a method approved by the Engineer as necessary to remove the depth of softened bearing material or to remove excessive sidewall buildup.
- C. The primary means of verifying cleanliness of the bottom of the rock socket shall be by television camera lowered into the shaft. The Contractor shall furnish all equipment necessary to conduct the camera inspection. The Contractor shall operate the camera and supporting equipment under the direction of the Engineer in such a manner as to obtain optimum results from the equipment. The television camera and lighting equipment shall be capable of operating in dry or submerged conditions encountered during the inspection. The excavated shaft shall have the Engineer's approval prior to proceeding with construction.
- D. Methods and equipment for controlling the camera will be subject to approval from the Engineer and achievement of a satisfactory video record.
- E. Inspection of a drilled shaft by television camera shall be performed as directed by the Engineer. The excavated shaft shall be thoroughly cleaned of all loose fragments, sediment and turbidity prior to inspection. The camera shall be operated such that optimum clarity of detail can be obtained and surface area of the rock socket's base, can be observed. All scanning of the rock socket shall be recorded on videotape or electronically. All tapes shall be stored in proper containers with dust-tight closures and shall be properly labeled as to shaft number along with project and Contractor identification. Tapes shall be furnished to and shall become the property of the Engineer upon completion of the work.
- F. NX size cores will be required for rock sockets. The Contractor may be directed to extend the rock socket to a lower elevation, resulting from the Engineer's evaluation of the foundation inspection cores.
- G. The Contractor shall drill one NX size core for each rock socket to a depth of two(2) times the plan diameter of the rock socket below the plan elevation of the drilled shaft, or as directed by the Engineer. These rock cores, also referred to as Foundation Inspection Holes, will be used to determine the quality of the bearing material directly below the bottom of the rock socket. The Engineer will determine final bearing elevation of the rock socket based on suitability of the bearing stratum indicated by the rock cores. Foundation inspection holes shall be drilled a minimum of two weeks prior to shaft excavation.
- H. The Contractor shall maintain a log of excavated material for each foundation inspection hole, and such logs shall be delivered to the Engineer within 24 hours of completion of the boring. The log shall include the following:
 - 1. The amount of NX cored per run and the amount recovered. All core loss shall be noted and explained. Clay layers shall be noted and located on the log by depth.
 - 2. The Rock Quality Designation (RQD) for the NX core. The bedding thickness and degree of weathering shall also be noted.
- I. Rock cores shall be stored in structurally sound core boxes and shall be protected from the elements. The core boxes shall be properly labeled to indicate location, depth, beginning elevation, Contractor and date, and shall be delivered to the Engineer.

3.7 REINFORCING STEEL CAGE CONSTRUCTION AND PLACEMENT

- A. The reinforcing steel cage, consisting of longitudinal bars, ties, cage stiffener bars, spacers, centralizers, pipes for CSL, and other necessary appurtenances, shall be completely assembled and placed as a unit immediately after the shaft excavation is inspected and accepted, and prior to

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concrete placement. Internal stiffeners shall be removed as the cage is placed in the drilled shaft excavation so as not to interfere with the placement of concrete. Splices of longitudinal reinforcing shall be located as shown on the plans. In the event that the shaft has been extended below the anticipated tip elevation, the reinforcing cage shall be extended by lap splice or mechanical splice.

- B. The reinforcing steel in the shaft shall be tied and supported so that the reinforcing steel will remain within allowable tolerances. Concrete spacers or other approved non-corrosive spacing devices shall be used at sufficient intervals beginning one (1) foot from the bottom of the reinforcing steel cage and spaced at intervals not exceeding 10 vertical feet, center-to-center, for the entire length of the reinforcing steel cage, including a set of spacers to be placed within two (2) feet from the top of the reinforcing steel cage to ensure concentric spacing for the entire cage length. Spacers should be located at no more than 30 inch spacing around the circumference of the reinforcing cage with a minimum of three spacers. Spacers shall be constructed of approved material equal in quality and durability to the concrete specified for the shaft. The spacers shall be of adequate dimension to insure a minimum 3 inch annular space between the outside of the reinforcing cage and the side of the excavated hole. Approved bottom supports (boots) shall be provided to insure that the bottom elevation of the cage is maintained the proper distance above the bearing elevation of the drilled shaft.

3.8 CONCRETE PLACEMENT

- A. Concrete placement shall be performed in accordance with the SECTION 04400.
- B. Concrete shall be placed as soon as possible following reinforcing steel placement. Concrete placement shall be continuous from the bottom to the top of the shaft. Concrete placement shall continue after the shaft excavation is filled until good quality concrete is evident at the top of shaft. Immediately after concrete placement has been completed, all contaminated concrete and deleterious material accumulated above the top of shaft shall be removed to within one foot of plan top of shaft. Any concrete remaining above the top of shaft shall be carefully removed to the plan construction joint after casing removal. Concrete shall be placed either by free fall or through a tremie or concrete pump. The free fall placement shall only be permitted in dry holes. Concrete placed by free fall shall fall directly to the base without contacting either the rebar cage or shaft sidewall. Drop chutes may be used to direct concrete to the base during free fall placement.
- C. Admixtures such as water reducers, plasticizers, and retarders shall not be used in the concrete mix unless permitted in the contract documents. All admixtures, when approved for use, shall be adjusted for the conditions encountered on the job so the concrete remains in a workable plastic state.
- D. Tremies
1. Tremies may be used for concrete placement in either wet or dry holes. Tremies used to place concrete shall consist of a tube of sufficient length, weight, and diameter to discharge concrete at the bottom of the excavated drilled shaft. The tremie shall not contain aluminum parts that will have contact with the concrete. The tremie inside diameter shall be at least 6 times the maximum size of aggregate used in the concrete mix but shall not be less than 10 inches. The inside and outside surfaces of the tremie shall be clean and smooth to permit both flow of concrete and unimpeded withdrawal during concreting. The wall thickness of the tremie shall be adequate to prevent crimping or sharp bends, which restrict concrete placement.
 2. The tremie used for concrete placement under water shall be watertight. Underwater or under slurry placement shall not begin until the tremie is placed on the bottom of the excavated shaft, and the concrete shall be kept completely separated from the water or slurry prior to the time it is discharged. A valve, bottom plate, plug or tremie "pig" may be used for this purpose only if concrete discharge can begin within one tremie diameter of the base of the drilled shaft. Plugs shall either be removed from the excavation or be of a material, approved by the Engineer, which will not cause a defect in the shaft if not removed. The discharge end of the tremie shall

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- be constructed to permit the free radial flow of concrete during placement operations. The tremie discharge end shall be immersed at least 10 feet in concrete at all times after starting the placement of concrete. The flow of the concrete shall be continuous. The level of the concrete in the tremie shall be maintained above the level of slurry or water in the excavation at all times to prevent water or slurry intrusion into the shaft concrete.
3. If at any time during the concrete placement, the bottom of the tremie is removed from the fluid concrete column and discharges concrete above the rising concrete level, the shaft will be considered defective. In such case, the Contractor shall remove the reinforcing cage and concrete, complete any necessary sidewall removal directed by the Engineer and repour the shaft. All costs of replacement of defective shafts shall be the responsibility of the Contractor.
- E. Pumped Concrete
1. Concrete pumps and lines may be used for concrete placement in either wet or dry excavations. All pump lines shall have a minimum 4 inch diameter and be constructed with watertight joints. Concrete placement shall not begin until the pump pipe discharge orifice is at the bottom of the excavated drilled shaft.
 2. For wet excavations, a plug, "pig" or similar device shall be used to separate the concrete from the fluid in the hole until pumping begins. The plug shall either be removed from the excavation or be of a material, approved by the Engineer, that will not cause a defect in the shaft if not removed.
 3. The discharge orifice shall remain at least 5 feet below the surface of the fluid concrete. When lifting the pump line during concreting, the Contractor shall temporarily reduce the line pressure until the orifice has been repositioned at a higher level in the excavation.
 4. If at any time during the concrete pour the pump line orifice is removed from the fluid concrete column and discharges concrete above the rising concrete level, the shaft shall be considered defective. In such case, the Contractor shall remove the reinforcing cage and concrete, complete any necessary sidewall removal directed by the Engineer, and repour the shaft. All costs of replacement of defective shafts shall be the responsibility of the Contractor.
- F. Drop Chutes
1. Drop chutes may be used to direct placement of free-fall concrete in excavations where the maximum depth of water does not exceed 3 inches. Free fall placement is not permitted in wet excavations. Drop chutes shall consist of a smooth tube of either one-piece construction or sections that can be added and removed. A drop chute can also be a hopper with a short tube to direct the flow of concrete. Concrete may be placed through either the hopper at the top of the tube or side openings as the drop chute is retrieved during concrete placement. If concrete placement causes the shaft excavation to cave or slough, or if the concrete strikes the rebar cage or sidewall, the Contractor shall reduce the height of free fall and/or reduce the rate of concrete flow into the excavation. If caving or sloughing of the borehole walls occurs during free-fall placement of concrete, the shaft shall be considered defective. In such case, the Contractor shall remove the reinforcing cage and concrete, complete any necessary sidewall removal directed by the Engineer and repour the shaft. All costs of replacement of defective shafts shall be the responsibility of the Contractor. If concrete placement cannot be satisfactorily accomplished by free fall in the opinion of the Engineer, the Contractor shall use either tremie or pumping techniques to accomplish the pour.

3.9 CROSSHOLE SONIC LOG (CSL) TESTING

- A. The Contractor shall perform non-destructive integrity testing on completed drilled shafts and rock sockets using the crosshole sonic logging (CSL) method for concrete drilled shafts as detailed in SECTION 04310.

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PART 4 MEASUREMENT AND PAYMENT

4.1 DRILLED SHAFT FOUNDATIONS

- A. Drilled shafts shall be measured by the lineal foot for each diameter of completed concrete drilled shaft listed. Rock Sockets shall be measured by the lineal foot for each diameter of completed concrete socket at each pier location listed. The length for the Drilled Shafts shall be determined as the difference between the plan top of shaft elevation and the top of the Rock Socket. The length of the Rock Socket shall be determined as the difference between the top of the Rock Socket and the bottom of Rock Socket. The top of the Rock Socket will be defined as the upper elevation of which sound rock occurs across the entire width of the shaft as shown in the plans.
- B. This work will be paid for at the contract unit price per linear foot for the items “DRILLED SHAFT (X.XX’, DIAMETER)” and “ROCK SOCKET (X.XX’, DIAMETER)” and shall include all costs for drilling, excavation, inspection, furnishing and placing concrete and reinforcing steel, furnishing and placing permanent casings, furnishing and placing pipes for sonic logging testing along with all incidental work and materials necessary to construct the shafts according to the plans and this specification.

4.2 ROCK SOCKETS

- A. For ROCK SOCKETS that extend past plan lengths payment will be paid at contract unit price.
- B. If the test results indicate that the ROCK SOCKET length can be shortened then payment will be based on length of ROCK SOCKET installed and the contract unit price.
- C. No payment will be made for drilled shafts rejected due to installation tolerances. No payment will be made for clearing of all obstructions encountered during excavation. No payment shall be made for the length of drilled shaft remaining above the finished elevation except where specifically authorized.

END OF SECTION

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SECTION 04310

SONIC TESTING OF DRILLED SHAFT FOUNDATIONS

PART 1 DESCRIPTION

- A. The Contractor shall provide sonic non-destructive integrity testing of completed drilled shafts as shown on the plans and as directed by the Engineer. The sonic testing shall consist of cross-hole sonic logging measurements. Sonic logging measurements shall be performed by an independent, experienced testing organization approved by the Engineer.
- B. The testing organization and test method to be used for sonic testing shall be approved by the Engineer. The Contractor shall submit to the Engineer the record of experience for the testing organization and person recording the field data along with a written description of the testing procedures, operation manuals for the testing equipment, and samples of previous test results indicating both sound and defective concrete. The Contractor shall inform the Engineer at least 2 days in advance of scheduled test dates.

PART 2 MATERIALS

2.1 CSL PIPES

- A. The Contractor shall furnish and install steel pipes, ASTM A53, Standard Weight, as shown on the Drawings for use in sonic testing of each drilled shaft.

PART 3 EXECUTION

3.1 INSTALLATION OF PIPES

- A. Pipe shall be installed in each drilled shaft at the locations shown on the plans or as required by the testing agency and as approved by the Engineer. The pipes shall extend as close as practical to the bottom of shaft and be protected by vertical reinforcing extending to the same depth.
- B. The pipes shall be sufficiently regular and free from defects so as to permit the free and unobstructed passage of the probes. The pipe shall be installed such that all internal joints are flush. They shall be watertight with clean internal and external faces, the latter to ensure good bond between the concrete and the pipes.
- C. The pipes shall be fitted with watertight caps at the top and bottom and shall be securely fixed to the interior of the reinforcement cage with a minimum cover of 3 inches from the shaft periphery. The Contractor shall submit his proposals for installation of the pipes to the Engineer prior to construction. The pipes shall be as near to parallel as possible. Where several sections of pipe are required to reach the full length, joints shall be made watertight.
- D. The pipes shall extend at least 2 feet above the top of the shaft. The pipes shall be filled with water and capped before shaft concrete is poured. Water levels in the tubes shall be checked and maintained above top-of-concrete on a daily basis. After initial filling, water in pipes shall not be flushed or exchanged without the written approval of the Engineer. The upper end of the pipe shall not be left open after the pour.
- E. Care shall be taken during the drilled shaft concrete pour not to damage the pipes. The tremie shall not be allowed to rest on top of the pipes during the pour.
- F. After completion of the sonic logging and final acceptance of the drilled shaft, the Contractor shall grout the pipes from the bottom upward. Grout for filling the access tubes at the completion of the

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crosshole sonic log tests shall consist of Portland cement, water, and a water reducing admixture and shall be mixed in the following proportions:

Portland Cement Type I or II	1 Sack 94 lbs.
Water	4.5 Gallons Maximum
Water Reducing Admixture	Manufacturer's Recommendation
Fly Ash (Optional)	20 lbs. Maximum

3.2 SONIC LOGGING EQUIPMENT

- A. The Sonic Logging equipment furnished by the Contractor shall consist of at least the following components:
 - 1. Analyzer unit complete with emitter and receiver modules and thermal printer or approved equal
 - 2. Ultrasonic emitter and receiver probes
 - 3. Winch and tripod
 - 4. Connecting cables
 - 5. Centralizers
- B. The Contractor shall also furnish all necessary supplies, support equipment, power, and provide reasonable access to the shaft top for performance of the sonic logging.

3.3 SONIC LOGGING TEST PROCEDURE

- A. Surveyed elevations shall be taken on top of each pipe and each pipe plumbed and the open length recorded. These details are to be provided together with the elevation of the shaft before testing commences.
- B. The drilled shaft shall be tested between 2 and 40 days after concrete placement. The following procedures shall apply:
 - 1. Pipes shall be checked to ensure the pipes are free from blockages and are filled with water.
 - 2. Levels shall be taken on top of each pipe, each pipe shall be plumbed and the length shall be recorded.
 - 3. Pipe deficiencies shall be reported to the Engineer before testing is complete.
 - 4. Testing shall be performed between each pair of adjacent pipes around the shaft perimeter and also in pairing combinations between each pipe with all other pipes in the shaft.
 - 5. All tests shall be carried out with the probes in the same horizontal plane unless the Engineer directs that defects be further evaluated with the probes on different horizontal planes.
 - 6. In the larger diameter access pipes, the probe shall be centered within the pipe using centralizers.
 - 7. The probes shall be raised simultaneously from the bottom of the pipes ensuring that all slack is taken out of the cables before the analyzer is switched on, and that the distance between transducers remains constant during the course of the test. The speed of ascent shall be less than 12 inches per second. Measurements shall be taken at 3-inch intervals or less. Anomalies indicated by longer pulse first-arrival times (FAT) and significantly lower amplitude per energy signals shall be reported. If anomalies are detected, additional tests with two or more sources per receiver vertical offsets of greater than or equal to 20 inches shall be conducted between the same tubes unless the anomaly is within 20 inches of the bottom of the shaft.

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8. The electronic circuit shall be thoroughly checked. The choice of time base will be such that the "zero signal" and first arrival are 2 - 3 divisions apart on the horizontal axis. Amplitude should be such that the signal fills 2/3 - 3/4 of the screen vertically.
9. The Contractor shall provide accurate measurements of probe depths on the logs.

3.4 RECORD OF TESTING

- A. The results shall be shown on a graphical printout with proper labeling. The profiles will be referenced to the top of shaft level and top of concrete. The vertical scale shall represent a vertical log of the shaft. The horizontal scale shall present the signal energy, first arrival time, and apparent sonic velocity data.
- B. Plots of signal energy and first arrival time along full surveyed length of shaft shall be included in the analysis report for each tube pair surveyed. Plots of apparent sonic velocity (apparent or assumed tube spacing divided by first arrival time) along the full surveyed length of shaft shall also be included for each survey combination. Plots must be clearly visible and all horizontal scales for first arrival times and energy values must be included with each plot. If signal degradation is suspected due to access pipe de-bonding, shaft or column steel interference, or other causes, plots of stacked arrival times (waterfall plots) shall also be included in the report. Manual adjustments to the recorded first arrival time shall be described in the report.
- C. The data logs shall include XY plots of FAT, amplitude and velocity versus depth. CSL data shall be processed to provide easy to understand 2D cross-sections between tubes for all tube pair combinations. These plots shall be annotated by the CSL consultant as appropriate to delineate anomalous results. If offset surveys are performed as part of 3D tomography, data plots shall include 3D volumetric images for the entire shaft, color-coded, to indicate velocity variations along the shaft. Locations and geometry of anomalies or unconsolidated zones shall be identified in 3D color images with detailed discussion. The results for CSL and 3D surveys shall be based on the percentage decrease in velocity as correlated to the following Concrete Condition Rating Criteria (CCRC). The velocity datum of good concrete shall be established by averaging the velocities in the good concrete along the drilled shaft. Deviations from the velocity datum shall be used for determining the Concrete Condition Rating.
- D. Any suspected anomalies, honeycombing, or poor concrete detected by a fainting of the signals and a sudden lengthening of the propagation time shall be immediately indicated to the Engineer on site. The Contractor and testing organization shall duly perform further tests required by the Engineer to evaluate the extent of any detected defects.

Concrete Condition Rating	Rating Symbol	Velocity Reduction	Indicative Results
Good	G	0 to 10%	Acceptable concrete
Questionable	Q	10% to 25%	Minor concrete contamination or intrusion. Questionable quality concrete.
Poor	P/D	> 25%	Defects exist, possible water slurry contamination, soil intrusion, and or poor quality concrete.
Water	W	V= 4760 to 5005 ft/sec	Water intrusion, or water filled gravel intrusion with few or no fines present.

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No Signal	NS	No signal received	Soil intrusion or other severe defect absorbed the signal, tube debonding if near top.
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- E. Preliminary results of the testing shall be provided on site prior to the CSL consultant leaving the site.
- F. Within 7 days of completion of testing, the Contractor shall provide a report signed and sealed by a licensed Engineer in the State where the majority of the structure is located providing the results and recommendations for acceptance, modification of construction procedures (if needed), or correction of defects of each shaft. Dates of completion of drilling, cleaning, steel placement and concrete pour shall also be provided. Construction above the top of shaft shall not be performed until the shaft is accepted by the Engineer.
- G. The CSL report shall include, but is not limited to, the following:
 - 1. Project Identification
 - 2. Dates of testing
 - 3. A table and schematic showing shafts tested with accurate identification of tube coordinates and collar elevation
 - 4. A summary of the physical measurements for access pipe spacing, total embedded pipe length, pipe stick-up distance, and as-constructed length for each shaft surveyed.
 - 5. Name of personnel that performed the tests and interpretation and those personnel's affiliation
 - 6. Equipment used
 - 7. Data logs
 - 8. Interpretation, analysis and results.

PART 4 MEASUREMENT AND PAYMENT

4.1 SONIC TESTING OF DRILLED SHAFT FOUNDATIONS

- A. Payment for sonic logging testing of drilled shafts will be made at the contract unit price for "SONIC TESTING-DRILLED SHAFTS" per each drilled shaft.
- B. No payment will be made for supplementary sonic logging testing to evaluate defects.
- C. Sonic testing shall include providing all equipment, conducting the actual probing measurements as specified, grouting access pipes, preparing and furnishing report, removing equipment, all tools, labor and any incidentals necessary to complete the work. The number of sonic logging inspections may vary from the estimated quantities, but the contract price bid shall prevail regardless of the variation.
- D. Payment for furnishing and installing sonic access pipes shall be included with the other bid items.

END OF SECTION

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SECTION 04400

CONCRETE CONSTRUCTION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Concrete Construction

1.2 DESCRIPTION

- A. These specifications cover the construction of concrete structures and the concrete portion of other structures.
- B. All concrete construction shall be in accordance with the design requirements and details shown on the plans or as directed by the Engineer.

1.3 SUBMITTALS

- A. Submit design mix to the Engineer for each concrete design mix to be used.
- B. Provide material certifications for aggregate, admixtures, curing compounds and reinforcing steel.

PART 2 MATERIALS

2.1 CEMENT

- A. Portland cement and air-entraining Portland cement shall conform to the requirements of ASTM C150. One or more of the following types shall be used as specified on the plans, in the special provisions or by the Engineer:
 - 1. Type I and Type IA: For general use where alkali water or soil is not prevalent and for small masses of concrete.
 - 2. Type II and Type IIA: For use when moderate sulfate resistance or when moderate heat of hydration is desired. In Nebraska, Kansas and Iowa, and other locations where the presence of alkali reactive aggregate is a possibility, low alkali Type II or Type IIA shall be used with the alkali equivalent of the cement not exceeding 0.6% as measured by the percentage of Sodium Oxide (NA₂O) plus 0.658 times the percentage of Potassium Oxide (K₂O) unless both coarse and fine aggregates are determined to be innocuous when tested in accordance with ASTM C289. The percentage of Sodium Oxide and Potassium Oxide shall be determined in accordance with ASTM C114.
 - 3. Type III and Type IIIA: For use where high early strength is required.
 - 4. Type IV: For use when low heat of hydration is desired.
 - 5. Type V: For use when high sulfate resistance is desired.
- B. Unless otherwise specified on the plans or in the special provisions or approved in writing by the Engineer, Type II or Type IIA cement shall be used.

2.2 CONCRETE ADMIXTURES

- A. Air-entraining agent conforming to the requirements of ASTM C260 shall be added to normal Portland cement at the mixer for all concrete unless otherwise directed. The air-entraining agent

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used shall be a type which will control the entrainment of air within the limits specified and shall be compatible with the cement used.

- B. Admixtures, except air-entraining agents, to be used to alter the normal properties of concrete; either for densifying, cement dispersion, retarding, accelerating, plasticizing, or coloring; shall be used only upon the written permission of the Engineer. Acceptable evidence must be presented concerning the material proposed for use, showing that the material will perform in the manner claimed and that the strength, coloring appearance and durability of the concrete will not be adversely affected. Admixtures containing chloride ions shall not be used.

2.3 FINE AGGREGATE

- A. Fine aggregate shall consist of natural sand or other approved inert materials with similar characteristics, or a combination thereof. Grains shall be free from adherent coatings. Lightweight fine aggregate shall not be used. Except as noted in Paragraphs B and C, fine aggregates shall be graded within the limits specified below:

Sieve Size	Percentage Passing
3/8"	100
#4	95-100
#8	80-100
#16	50-85
#30	25-60
#50	10-30
#100	2-10

- B. The minimum percentages shown above for material passing the No. 50 and No. 100 sieves may be reduced to 5 and 0, respectively, if the aggregate is to be used in air-entrained concrete containing more than 420 lbs. of cement per cubic yard, or in non-air-entrained concrete containing more than 520 lbs. of cement per cubic yard, or if an approved mineral admixture is used to supply the deficiency in percentages passing these sieves. Air-entrained concrete is here considered to be concrete containing air-entraining cement or an air-entraining agent and having an air content of more than 3 percent.
- C. The fine aggregate shall have not more than 45 percent retained between any two consecutive sieves of those shown in Paragraph A and its fineness modulus shall be not less than 2.3 nor more than 3.1.
- D. For continuing shipments of fine aggregate from a given source, the fineness modulus shall not vary more than 0.20 from the base fineness modulus. Fine aggregate with a fineness modulus exceeding this limit shall be rejected or, at the option of the Engineer, may be accepted provided suitable adjustments are made in concrete proportions to compensate for the difference in grading.
- E. The fineness modulus of an aggregate is the sum of the percentages of a sample retained on each of a specified series of sieves divided by 100, using the following standard sieve sizes No. 100, No. 50, No. 30, No. 16, No. 8, No. 4, 3/8 in., 3/4 in., 1-1/2 in. and larger increasing in the ratio of 2 to 1.
- F. The amount of deleterious substances in fine aggregate shall not exceed the limits specified below:

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Item	Maximum Percent by Weight
Clay lumps	0.25
Soft particles	5.0
Chert that will readily disintegrate (soundness test, five cycles)	1.0
Material finer than #200 sieve	1.0 ¹
Coal and lignite	1.0 ²

- G. Fine aggregate shall be free of injurious amounts of organic impurities. Except as herein provided, aggregates subjected to the test for organic impurities in accordance with ASTM C40 and producing a color darker than the standard shall be rejected.
1. A fine aggregate failing in the test may be used, provided that the discoloration is due principally to the presence of small quantities of coal, lignite, or similar discrete particles.
 2. A fine aggregate failing in the test may be used provided that, when tested for the effect of organic impurities on strength of mortar, the relative strength at seven and 28 days calculated in accordance with ASTM C87, are not less than 95%.
- H. Fine aggregate for use in concrete that will be subject to wetting, extended exposure to humid atmosphere, or contact with moist ground shall not contain any materials that are deleteriously reactive with the alkalis in the cement in an amount sufficient to cause excessive expansion of mortar or concrete, except that if such materials are present in injurious amounts, the fine aggregate may be used with the low alkali Type II and Type IA cement as described in Paragraph 2.1A.2.
- I. Fine aggregate shall be of such quality that when made into a mortar and subjected to the mortar strength test prescribed in ASTM C87, the mortar shall develop a compressive strength not less than that developed by a mortar prepared in the same manner with the same cement and graded standard sand having a fineness modulus of 2.40 ± 0.10 . The graded sand shall conform to the requirements of ASTM C778.
- J. Fine aggregate subjected to five cycles of the soundness test in accordance with ASTM C88 shall have a weighted average loss not greater than 10% when sodium sulfate is used or 15% when magnesium sulfate is used.
- K. Sampling and testing shall be in accordance with ASTM C33 and the following standard methods of the American Society for Testing and Materials:

Surface Moisture in Fine Aggregate	C70
Specific Gravity and Absorption of Fine Aggregate	C128
Petrographic Examination of Aggregates	C295
Standard Sand	C778
Potential Alkali Reactivity of Aggregates	C1260

¹ In the case of crushed aggregates, if the material finer than the No. 200 sieve consists of the dust of fracture, essentially free from clay or shale, this percentage may be increased to 1.5.

² This requirement does not apply to blast furnace slag coarse aggregate.

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2.4 COARSE AGGREGATE

- A. Normal weight coarse aggregate shall consist of crushed stone, crushed gravel, crushed slag or other approved inert materials with similar characteristics, or a combination thereof, having hard, strong durable pieces free from adherent coatings. Lightweight coarse aggregate shall not be used.
- B. Crushed slag shall be rough cubical fragments of air-cooled iron-blast-furnace slag, which when conforming to the grading to be used in the concrete, shall have a compact weight of not less than 70 lbs. per cu. ft. It shall be obtained only from sources approved by the Engineer.
- C. Coarse aggregate shall be graded within the limits specified below for the designated sizes.

Total Passing – Percent by Weight														
Size #	Nominal Size	4"	3 1/2"	3"	2 1/2"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#8	#16
1	3 1/2" – 1 1/2"	100	90-100		25-60		0-15		0-5					
2	2 1/2" – 1 1/2"			100	90-100	35-70	0-15		0-5					
3	2" – 1"				100	90-100	35-70	0-15		0-5				
357	2" - #4				100	95-100		35-70		10-30				
4	1 1/2" – 3/4"					100	90-100	20-55	0-15		0-5			
467	1 1/2" - #4					100	95-100		25-60		0-10	0-5		
56	1 3/8"						100	90-100		20-55	0-10	0-5		
57	1" - #4						100	95-100		25-60		0-10	0-5	
67	3/4" - #4							100	90-100		20-55	0-10	0-5	
7	1/2" - #4								100	90-100	40-70	0-15	0-5	
8	3/8" - #8									100	85-100	10-30	0-10	0-5

- D. The maximum size of aggregate shall not be larger than 1/5 of the narrowest dimension between forms of the member for which the concrete is used, nor larger than 1/2 of the minimum clear space between reinforcing bars.
- E. The amount of deleterious substances in coarse aggregate shall not exceed the limits specified in 2.3F.
- F. Coarse aggregate for use in concrete that will be subject to wetting, extended exposure to humid atmosphere, or contact with moist ground shall not contain any materials that are deleteriously reactive with the alkalis in the cement in an amount sufficient to cause excessive expansion of mortar or concrete, except that if such materials are present in injurious amounts, the coarse aggregate may be used with low alkali Type II or Type IA cement as described in Paragraph 2.1A.2.
- G. Coarse aggregate subjected to five cycles of the soundness test in accordance with ASTM Designation: C 88 shall have a weighted average loss not greater than 12% when sodium sulfate is used or 18% when magnesium sulfate is used.
- H. Coarse aggregate when subjected to the abrasion resistance test in accordance with ASTM C131 or ASTM C535 shall show a loss of weight not more than the following:
 1. For concrete subject to severe abrasion such as concrete in water, precast concrete piles, paving for sidewalks, platforms for roadways, floor wearing surfaces, and concrete cross or bridge ties, the loss of weight shall not exceed 40 percent.
 2. For concrete subject to medium abrasion such as concrete exposed to the weather, the loss of weight shall not exceed 50 percent.
 3. For concrete not subject to abrasion, the loss in weight shall not exceed 60 percent.

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- I. Sampling and testing shall be in accordance with ASTM C33 and the following standard methods of the American Society for Testing and Materials:

Specific Gravity and Absorption of Coarse Aggregate	C127
Petrographic Examination of Aggregates	C295
Potential Alkali Reactivity of Aggregates	C1260

2.5 WATER

- A. Water used in mixing and curing concrete including free water on aggregates, shall be potable and free from any pronounced taste, odor, or color that would indicate the presence of oils, acids, alkalis, salts, sugars, vegetable matter, or other substances that may be deleterious to concrete or reinforcement and shall not contain more than 1,000 parts per million of chlorides as Cl nor more than 1,000 parts per million of sulfates as SO₄.
- B. If there is any question regarding compliance with the requirements of Paragraph A, water shall be tested in accordance with ASTM D512 and ASTM D516.

2.6 REINFORCEMENT

- A. All steel bars for reinforcement shall be deformed bars and shall conform to the requirements of ASTM A615, Grade 60 or ASTM A706 unless otherwise shown or specified. Reinforcing steel to be structurally welded as indicated on the plans shall comply with ASTM A706.
- B. Spiral reinforcement shall be hot-rolled plain round rod or cold drawn wire. The plain round rod shall conform to the requirements of ASTM A615, Grade 60 and the wire shall conform to the requirements of ASTM A1064.
- C. Fabricated deformed steel bar mats shall conform to the requirements of the ASTM A184, Grade 60.
- D. Welded plain steel wire fabric shall conform to the requirements of ASTM A1064. Welded intersections shall not be spaced further apart than 12 inches in the direction of primary flexural reinforcement.
- E. Welded deformed steel wire fabric shall conform to the requirements of ASTM A1064. Welded intersections shall not be spaced further apart than 16 inches in the direction of primary flexural reinforcement.
- F. Reinforcement shall be fabricated in accordance with Chapter 7 of the C.R.S.I. Manual of Standard Practice. Standard bending tolerances are applicable unless otherwise specified on the plans. Reinforcement shall be bent cold to conform accurately to the dimensions and shapes shown on the approved working drawings. Bends shall be made accurately in a suitable bending machine. Unless otherwise specifically approved, bars shall be shop bent before shipment and shall not be bent in the field. Reinforcement shall not be straightened or re-bent in a manner that will injure the material.

2.7 MEMBRANE CURING COMPOUND

- A. Liquid membrane-forming curing compounds shall conform to the requirements of ASTM C309. The compound may be clear (may contain a fugitive dye), white pigmented, or light gray as specified by the Engineer. Compounds for use in curing bridge decks to be waterproofed shall have a resin base and shall not contain oil, wax or pigment.

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2.8 ASPHALT EXPANSION BOARD

- A. Asphalt expansion board shall be suitable for concrete construction and shall be smooth, flat, and sufficiently rigid to permit installation.

2.9 WATERSTOPS

- A. Except where otherwise indicated on the plans, waterstops may be manufactured from natural or synthetic rubber or from polyvinylchloride.
- B. Field splices in rubber waterstop shall be either vulcanized or made with a rubber splicing union of the same stock as the waterstop. Field splices in polyvinylchloride waterstops shall be in accordance with the manufacturer's recommendations.

2.10 STORAGE OF MATERIALS

- A. **Storage of Cement:** The Contractor shall provide suitable means for storing and protecting the cement against dampness. Cement, which for any reason, has hardened or become partially set or which contains lumps of caked cement will be rejected and not used in the work. Different brands or different types of cement from the same mill, or the same brand or type from different mills shall be separated and kept in such manner as to permit easy access for proper inspection and identification of each shipment. Cement shall be used in the same order as it is received.
- B. Storage of Aggregates:
 - 1. Fine and coarse aggregates shall be stored separately and in such a manner as to avoid the inclusion of dirt and other foreign material in the concrete. Aggregates shall be unloaded and piled in such manner as to maintain the uniform grading of the sizes. Stockpiles of coarse aggregates shall be built in horizontal layers by leveling end dump piles to avoid segregation.
 - 2. A hard base shall be provided to prevent contamination from underlying material, and overlap of the different sizes shall be prevented by suitable walls or ample spacing between piles. Stockpiles shall not be contaminated by swinging aggregate filled buckets or clams over the various stockpiled aggregate sizes. Crushed slag shall be wetted down when necessary to insure not less than 3 percent moisture content.
- C. **Storage of Reinforcement:** Reinforcement shall be stored upon platforms, skids or other supports in such a manner as to avoid contact with the ground. If reinforcement is to remain in storage on the site for more than one month it shall be covered to protect it from weather. If reinforcement accumulates heavy rust, dirt, mud, loose scale, paint, oil, or any other foreign substance during storage, it shall be cleaned before being used. Severe deterioration of this kind may be a basis for rejection.

2.11 FALSEWORK

- A. The Contractor shall submit detailed plans, stamped by a licensed professional structural engineer in the state where the work is to be done, for falsework for examination by the Engineer. If such plans are not satisfactory to the Engineer, the Contractor shall make such changes in them 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 for obtaining satisfactory results.
- B. In the case of very long spans where no intermediate supports are possible, the probable deflection in the forms due to the weight of the fresh concrete shall be taken into account so that the finished members shall conform accurately to the desired line and grade. If adequate foundation for shores cannot be secured, trussed supports shall be provided.
- C. For calculating the strength of falsework, a weight of 150 lbs. per cu. ft. shall be assumed for the concrete. The design of the falsework shall take into account the weight of the concrete and also

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other loads incidental to the construction operations. All falsework shall be designed and constructed to provide the necessary rigidity and to support the imposed loads without appreciable settlement or deformation. The Contractor shall make allowance for the deflection of forms and for shrinkage and settlement of falsework, in addition to the allowance for the amount of dead load deflection and camber shown on the plans. A method satisfactory to the Engineer shall be used to detect any settlement that may occur during the placing of the concrete.

- D. Falsework bents shall generally be founded upon piles driven to a capacity sufficient to support the load without appreciable settlement. If the soil is firm and well compacted, the Contractor may, as an alternate, place falsework bents upon concrete footing or mud sills of sufficient size that the pressure on the soil will not exceed the allowable bearing value determined by the Contractor and approved by the Engineer. When requested by the Engineer, the Contractor shall demonstrate by suitable load tests that the soil bearing values assumed for the design of the falsework do not exceed the supporting capacity of the soil. Or the Contractor may support falsework from the piers or abutments, provided sleeves for any tie bolts can be cast into the concrete and the method proposed meets the approval of the Engineer. Sleeves or other appurtenances cast into the concrete shall be constructed so as to permit their removal to a depth of at least 1-1/2 inches from the face without injury to the concrete. Drilling into existing piers or abutments that are to remain as a part of the final structure will not be permitted for the support of falsework. The Engineer may require the Contractor to use screw jacks or hardwood wedges to take up any settlement in the formwork, either before or during the placing of the concrete.

2.12 FORMS

- A. Forms shall conform to the shape, lines, grade and dimensions of the concrete as called for on the plans. The shape, strength, rigidity, cleanness, mortar tightness, and surface smoothness of reused forms shall be maintained at all times. Forms which in the opinion of the Engineer, are unsatisfactory in any respect shall not be reused.
- B. Lumber may be used to form unexposed surfaces if approved by the Engineer.
- C. Plywood or metal forms shall be used to form exposed surfaces.
- D. Forms shall be smooth and mortar tight. The forms shall be so constructed as to be removable in sections without marring or damaging the surface of the concrete.
- E. Metal forms shall be of such thickness that they remain true to shape. All fasteners in contact with concrete shall be countersunk.
- F. Joints in forms shall be horizontal or vertical and forms shall be sufficiently tight to prevent leakage of mortar. They shall be properly braced or tied together so as to maintain the desired position and shape during and after placing concrete.
- G. Suitable moldings or bevels shall be placed in the angles of forms to round or bevel the edges of the concrete, including both sides of expansion board, unless otherwise directed by the Engineer. Bevel only exposed concrete.
- H. The inside of forms shall be coated with form oil or other approved bond breaking material or thoroughly wetted, except in freezing weather, immediately before the concrete is placed. Where oil is used, it shall be applied to the forms before they are placed.
- I. Forms used in casting concrete bridge floors shall be removed.
- J. Permanent metal concrete deck forms may be used only when specified on the plans or in the special provisions or approved in writing by the Engineer. Metal forms shall be at least 18 gage in thickness, perforated to provide exposure of not less than 10 percent of the undersurface of the concrete for evaporation and drainage, galvanized and designed to withstand loads imposed during placement concrete.
- K. Temporary openings shall be provided at the base of column and wall forms, and at other points where necessary, to facilitate cleaning and inspection immediately before depositing concrete.

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Forms for walls or other thin sections of considerable height shall be provided with openings or other devices which will permit the concrete to be placed in a manner to avoid accumulation of hardened concrete on the forms or reinforcement.

- L. Tie rods, bolts and anchorages, within the forms shall be constructed so as to permit their removal to a depth of at least 1-1/2 inches from the face without injury to the concrete. Wire ties, when permitted by the Engineer, shall be cut back at least 1/2 inch from the face of the concrete upon removal of the forms. All fittings for metal ties shall be of such design that, upon their removal, the cavities which are left will be of the smallest practicable size. All cavities which are left shall be filled with dry pack during finishing similar to the method described in Part 3, 3.6, A, 4.
- M. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the Engineer shall order the work stopped until the defects have been corrected. If forms develop any defects, such as bulging or sagging, after the concrete has been deposited, that portion of the work shall be removed and reconstructed as directed by the Engineer without additional compensation to the Contractor.

2.13 PROPORTIONING CONCRETE

A. General:

- 1. Concrete for all purposes shall be composed of cement, aggregates, and water of the qualities herein specified and in the required proportions, these ingredients to be well mixed and brought to a proper consistency. The proportions in which these materials are to be used for different parts of the work shall be as required to produce the specified properties and approved by the Engineer from time to time during the progress of the work, and as analyses and tests are made of samples of the aggregate and the resulting concrete. In general, the proportions shall be designed to produce a concrete of maximum practicable economy.
- 2. All concrete shall be air-entrained, unless otherwise directed by the Engineer. The entrained air may be produced through the use of air-entraining cement, by the addition of an air-entraining admixture at the concrete mixer, or through a combination of both. The method used shall have the approval of the Engineer.
- 3. The minimum 28 day compressive strength of 6 inch by 12 inch cylinders made and cured in compliance with ASTM C31 and tested in accordance with ASTM C39 shall be as follows for the various classes of concrete:

Class	Minimum 28 Day Strength
20	2,000 psi
25	2,500 psi
20	3,000 psi
35	3,500 psi
40	4,000 psi
50	As specified on the plans or in the special provisions

B. Measurement of Materials:

- 1. The unit of measure for cement shall be the pound.
- 2. Material shall be measured by weighing. The apparatus provided for weighing the aggregates and cement shall be suitably designed and constructed for this purpose. The accuracy of all weighing devices shall be such that successive quantities can be measured to within one percent of the desired amount. The mixing water shall be measured by volume or by weight.

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The water-measuring device shall be susceptible to control accuracy to plus or minus one-half percent.

3. The accuracy of the material weighing and water measuring devices shall be subject to check at all times. The Contractor shall provide suitable weights approved by the Engineer for this purpose and shall assist the Engineer in making all tests.

- C. **Minimum Cement Content:** Unless otherwise authorized in writing by the Engineer, the cement content of concrete shall be not less than that shown below and specified in Paragraph 3.31.3.

Class of Concrete	Minimum Cement Content (lbs/cy of concrete)
20	420
25	470
30	515
35	560
40 & 50	610

- D. **Water-Cement Ratio:**

1. The proportioning of materials for the class of concrete specified or shown on the plans shall be based on the requirements for a plastic and workable mix. The water-cement material ratio by weight of the mix shall not exceed that specified below:

Class of Concrete	In Air	In Fresh Water	In salt water or when sulfate concentration in soil or ground water exceeds 0.2%.
20	0.69	0.65	0.65
25	0.60	0.56	0.56
30	0.53	0.48	0.48
35	0.49	0.45	0.45
40	0.44	0.40	0.40
50	To be determined by test		

2. In salt water or when sulfate concentration in soil or ground water exceeds 0.2%, Type II, IIA or V cement must be used.
3. The required concrete compressive strength shall be as shown on the plans or specified by the Engineer.
4. Concrete compressive strengths at 28 days shown in Table 5 and 6 shall be attained in 7 days when Type III cement is used.
5. Free water content of the aggregates shall be included in the total water in determining the water-cement ratio.
6. Moisture in the aggregate shall be measured by methods satisfactory to the Engineer, which will give results within one pound for each 100 lbs. of aggregate.

- E. **Air Content of Air-Entrained Concrete:**

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- The volume of entrained air in concrete shall be within the limits shown below:

Maximum Size Coarse Aggregate	Air Content (%) by volume)
1 ½", 2" or 2 ½"	4 – 6
¾" or 1"	5 – 7
3/8" or ½"	6 – 8

- The air content shall be determined by one of the following ASTM methods:

The gravimetric method	C138
The volumetric method	C173
The pressure method	C231

F. Workability:

- The mixture shall be such as to produce concrete that can be worked readily into the corners and angles of the forms and around the reinforcement without excessive vibration, or without permitting the materials to segregate or free water to collect on the surface. The workability may be controlled by adding or deducting fine or coarse aggregate or both, but in no case shall the amount of coarse aggregate be such as to produce harshness in placing or honeycombing in the structure.
- Admixtures shall not be used for the purpose of promoting workability, unless specifically authorized by the Engineer.

- G. **Slump:** Desired and maximum slump as determined by ASTM C143 shall be as listed below or as specified by the Engineer:

Type of Structure	Desired	Maximum
Massive Structures	1 ½"	2 ½"
Floors laid on ground and bridge decks	1 ½"	3"
Plain footings, caissons and substructure walls	1 ½"	3"
Heavy Reinforced walls, slabs and beams	3 ½"	4 ½"
Ordinary reinforced slabs, beams, columns and walls	3"	4"
Thin reinforced sections	3 ½"	4 ½"
Concrete placed under water	See 3.3l	

H. Testing Concrete:

- The Contractor shall assist the Engineer in making all tests.
- Unless otherwise specified by the Engineer, four 6 inch diameter by 12 inch test cylinders shall be made for each 250 cubic yards of concrete deposited, and on no job shall less than four cylinders be made, nor less than four per day, for each design of mix being placed. Test cylinders shall be made and cured in accordance with ASTM C31.
- These cylinders shall be tested in accordance with ASTM C39.

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4. The air content of freshly mixed air-entrained concrete shall be checked at least twice daily for each class of concrete. Changes in air content above or below the amount specified shall be corrected by adjustments in the mix design or quantities of air-entraining material being used.

PART 3 EXECUTION

3.1 PLACING REINFORCEMENT

- A. Reinforcement shall not be straightened or re-bent in a manner that will injure the material. Bars with kinks or bends not shown on the plans shall not be used. Heating of reinforcement will be permitted only when the entire operation is approved by the Engineer. Bars partially embedded in concrete shall not be field bent except as shown in the plans or specifically permitted.
- B. All reinforcement shall be set in the positions shown in the plans and held securely in place. Placement tolerances of reinforcement shall be in accordance with Chapter 8 of the C.R.S.I. Manual of Standard Practice. Reinforcement bars shall not be placed by sticking or floating into place during or immediately after placement of the concrete.
- C. No concrete shall be deposited until the Engineer has inspected the placing of the reinforcement and given permission to place concrete. All concrete placed in violation of this provision shall be rejected and removed.
- D. Reinforcing bar supports, their selection and placement, unless otherwise provided, shall be in accordance with Chapter 3 of the C.R.S.I. Manual of Standard Practice. Wire bar supports shall be Class 1, plastic protected bar supports. Bars in the bottom of footings and slabs shall be supported on precast concrete blocks with adequate bearing area using doweled blocks where required. Precast concrete blocks shall have a compressive strength equal to or greater than the specified compressive strength of the concrete being placed. Pebbles, stones, building bricks, and wood blocks shall not be used for bar supports.

3.2 MIXING CONCRETE

- A. General:
 1. The concrete shall be mixed only in the quantity required for immediate use. Concrete that has developed an initial set shall not be used.
 2. The first batch of concrete materials placed in the mixer shall contain a sufficient excess of cement, sand, and water to coat the inside of the drum without reducing the required mortar content of the mix. Upon the cessation of mixing for a considerable period, the mixer shall be thoroughly cleaned.
 3. Concrete may be mixed at the site of construction, at a central point, or wholly or in part in truck mixers.
 4. Retempering concrete by adding water or by other means shall not be permitted. Concrete that is not within the specified slump limits at time of placement shall not be used.
 5. The production of concrete shall meet the applicable requirements of ASTM C94.
- B. Machine Mixing:
 1. Unless otherwise authorized by the Engineer, the mixing of concrete shall be done in a batch mixer of approved type which will insure a uniform distribution of the material throughout the mass. The equipment at the mixing plant shall be so constructed that all materials (including the water) entering the drum can be accurately measured in accordance with Paragraph 2.13B. The water measuring device shall be controlled from a case which can be kept locked. The mixer shall be equipped with an attachment for automatically locking the discharge lever until the batch has been mixed the required time. After all materials are in the mixer the entire

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contents of the drum shall be discharged before recharging. The volume of the mixer materials per batch shall not exceed the manufacturer's rated capacity of the mixer.

2. At a stationary plant, mixing of each batch shall continue not less than the periods shown below during which time the drum shall rotate at a peripheral speed of about 200 feet per minute. The mixing periods shall be measured from the time when the materials (including the water) are in the drum.
 - (a) For mixers of a capacity of 1 cubic yard or less - 1-1/2 minutes.
 - (b) For mixers of capacities greater than 1 cubic yard - the time of mixing shall be increased 25 seconds for each cubic yard capacity or fraction thereof above 1 cubic yard.
3. Pick-up and throw-over blades in the drum of the mixer which are worn down 3/4 inch or more in depth shall be replaced with new blades when directed by the Engineer.

C. Truck Mixing:

1. Truck mixers shall be an approved design revolving drum type in good condition and shall be capable of thoroughly mixing the concrete materials and of discharging the materials without segregation. All solid materials for the concrete shall be accurately measured according to 2.13B and charged into the drum at the proportioning place. The truck mixer shall leave the batch plant with a full tank of water and shall have a device giving positive control of the amount of water added. No water shall be added until the mixer is at the job site unless authorized by the Engineer. If the water is added and the batch mixed in transit, the truck mixer shall have an approved revolution counter to provide a means of verifying the amount of mixing obtained. The size of the batch shall not exceed the rated capacity of the mixer.
2. When the concrete is mixed in a truck mixer loaded to its maximum capacity, the number of revolutions of the drum at mixing speed shall not be less than 70 nor more than 100. If the batch is at least one-half cubic yard less than maximum capacity, the number of revolutions at mixing speed may be reduced to not less than 50. All revolutions after 100 shall be at agitating speed.
3. Mixing shall begin within 15 minutes after the cement has been added to either the water or the aggregate and shall be completed and the concrete deposited within 1-1/2 hours after the cement has been so added. In hot weather a lesser time, in accordance with Paragraph 3.3H.5, may be specified by the Engineer.
4. Pick-up and throw-over blades in the drum of the mixer which are worn down 3/4 inch or more in depth shall be replaced with new blades when directed by the Engineer.

D. Truck Agitator:

1. Truck agitators shall be of an approved design revolving drum type or an approved design stationary trough type with blades revolving about an axis parallel to the axis of the trough. The truck agitator, when fully loaded, shall be capable of maintaining the mixed concrete in a thoroughly mixed and uniform mass, and of discharging the concrete without segregation.
2. Time allowed for depositing concrete shall be limited according to Paragraph C.3.

- E. **Time of Hauling Mixed Concrete:** Concrete transported in hoppers or other non-agitating types of containers shall be discharged at the job within 20 minutes, or as specified in Paragraph 3.3H.5, after the cement has been combined with the water. Such handling is to be used only in specific instances and will require special approval of the Engineer.

3.3 PLACING CONCRETE

- A. General: Before beginning placement of concrete, hardened concrete and foreign materials shall be removed from the inner surfaces of the mixing and conveying equipment. Before depositing any concrete, all debris shall be removed from the space to be occupied by the concrete. Forms, if constructed of wood, shall be thoroughly wetted (except in freezing weather) or oiled. Reinforcement shall be free from mud, oil or other nonmetallic coatings that decrease bond and

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secured in position and approved by the Engineer. Where concrete is to be placed on a rock foundation, all loose rock, clay, mud, etc., shall be removed from the surface of the rock. Water shall be removed from the space to be occupied by the concrete before concrete is deposited, unless otherwise directed by the Engineer. Any flow of water into an excavation shall be diverted through proper side drains to a sump or be removed by other approved methods which will avoid washing the freshly deposited concrete. If directed by the Engineer, water vent pipes and drains shall be filled by grouting or other means after the concrete has thoroughly hardened.

B. Handling and Placing Concrete:

1. Concrete shall be handled from the mixer, or in the case of ready mixed concrete from the transporting vehicle to the place of final deposit as rapidly as practicable by methods which will prevent the separation or loss of the ingredients. It shall be deposited in the forms, starting at the low end for structures on a grade, as nearly as practicable in its final position to avoid rehandling and shall not have a free fall of more than 4 feet except in drilled shaft foundations, unless otherwise permitted by the Engineer. It shall be so deposited as to maintain, until the completion of the unit, a plastic surface approximately horizontal. Forms for walls or other thin section of considerable height shall be provided with openings in a manner that will avoid accumulations of hardened concrete on the forms or metal reinforcement. Under no circumstances shall concrete that has been partially hardened be deposited in the work. In mass concrete, including bridge substructures, concrete shall be placed in horizontal layers, the thickness of which generally should not exceed 12 inches. When it is necessary by reason of an emergency to place less than a complete horizontal layer in one operation, such layer shall terminate at a vertical bulkhead.
2. Water gain is characterized by an accumulation of water at the surface. Whenever water gain appears in the concrete placed, the succeeding batches must be placed sufficiently dry to correct the over-wet condition by the reduction of the water cement ratio without changing the proportions of the other ingredients.
3. In order to allow for shrinkage or settlement, at least 2 hours shall elapse after placing concrete in walls or columns before depositing concrete in beams or slabs supported thereon, unless otherwise specified or shown on the plans. If the columns are structural steel encased in concrete, the lapse of time to allow for shrinkage or settlement need not be observed.
4. Concrete in beams and slabs shall be placed in one continuous operation for each span, unless otherwise provided. Concrete shall be deposited uniformly for the full length of the span and brought up evenly in horizontal layers.
5. No concrete shall be placed in the superstructure until the pier forms have been stripped sufficiently to determine the character of the concrete in the piers, and the load of the superstructure shall not be allowed to come upon abutments, piers and column bents until they have been in place at least 7 days and the cylinder break results of the 7-day break have been received and approved, unless otherwise permitted by the Engineer.
6. The top flange of girders shall be cleaned of all grease, oil and dirt before deck concrete is placed.
7. Pneumatic placing of concrete shall not be permitted without the specific approval of the Engineer.

- C. Chuting:** When concrete is conveyed by chuting, the plant shall be of such size and design as to insure a practically continuous flow in the chute. The chute shall be of metal or metal lined. The angle of the chute with the horizontal and the shape of the chute shall be such as to allow the concrete to flow without separation of the ingredients. The delivery end of the chute shall be as close as possible to the point of deposit. When the operation is intermittent, the chute shall discharge into a hopper. The chute shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water before and after each run; the water used for this purpose shall

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be discharged outside the forms. The chute must be properly baffled or hooded at the discharging end to prevent separation of the aggregates.

D. Pumping Concrete:

1. The pump and all appurtenances shall be so designed and arranged that the specified concrete can be transported and placed in the forms without segregation. The pump shall be capable of developing a working pressure of at least 300 psi, and the pipeline and fittings shall be designed to withstand twice the working pressure. Aluminum pipe shall not be used, and aluminum shall not be used for any part of the system that will come into contact with fresh concrete.
2. Where it is necessary to lay the pipe on a down grade, a reducer shall be placed at the discharge end of the pipe to provide a choke and thus produce a continuous flow of concrete. When the type of pump is such that it discharges the concrete in small batches, or "belching," a baffle box shall be provided into which the concrete shall be discharged. This box should preferably be of metal, about 2 foot square, with open sides so as to permit the concrete to flow into the forms at right angles to line of discharge.
3. The pipe shall be not less than 6 inches nor more than 8 inches outside diameter, and the line shall be laid with as few bends as possible. When changes in direction are necessary, they shall be made with bends of 45 degrees or less. The maximum distance of delivery of concrete by pumping shall be 1,000 feet, horizontally and 100 feet, vertically, unless otherwise specifically permitted by the Engineer.
4. When pumping is completed, if the concrete remaining in the pipeline is to be used, it shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients. If water is used, it must be discharged outside of the forms.
5. On important work, duplicate pumping equipment and additional pipe shall be provided to prevent delay due to breakdown of equipment.

E. Compacting:

1. All concrete, except concrete placed under water and concrete otherwise exempt, shall be consolidated by mechanical vibration immediately after placement.
2. The vibration shall be internal except that external form vibrators may be used for thin sections when the forms have been designed for external vibration.
3. Vibrators shall be of approved type and design and of a size appropriate for the work. They shall be capable of transmitting vibration to the concrete at frequencies of not less than 4,500 impulses per minute.
4. The Contractor shall provide a sufficient number of vibrators to properly compact each batch immediately after it is placed in the forms. The Contractor shall also have at least one spare vibrator immediately available in case of breakdown. The number and type of vibrators shall be subject to approval of the Engineer.
5. Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and embedded fixtures and into the corners and angles of the forms. Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibrators shall be inserted and withdrawn out of the concrete slowly in a vertical position. The entire depth of each lift shall be vibrated, allowing the vibrator to penetrate approximately 4 inches into the preceding lift. It shall be withdrawn completely from the concrete before being advanced to the next point of application. The vibration shall be of sufficient duration and intensity to thoroughly consolidate the concrete but shall not be continued so as to cause segregation, honeycombing, or accumulations of water or laitance at the surface. Vibration shall not be continued at any one point to the extent that localized areas of grout are formed. Application of vibrators shall be at points uniformly spaced and not farther apart than 1.5 times the radius over which the vibration is visibly effective.

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6. Vibration shall not be applied directly to, or through the reinforcement to sections or layers of concrete which have hardened to the degree that the concrete ceases to be plastic under vibration. Vibrators shall not be used to push or transport concrete in the forms laterally.
 7. Vibration shall be supplemented by such spading as is necessary to ensure smooth surfaces and dense concrete along form surfaces and in corners and locations impossible to reach with the vibrators.
 8. When approved by the Engineer, concrete for small noncritical elements may be consolidated by the use of suitable rods and spades.
- F. Continuous Deposition: Concrete shall be deposited continuously and as rapidly as safe practice permits until the unit of operation, approved by the Engineer, is completed. Construction joints in addition to those provided on the plans will not be allowed unless authorized by the Engineer, and if so authorized, they shall be made as directed by the Engineer.
- G. Placing Concrete in Cold Weather:
1. General: When the atmospheric temperature is 40 degree F or lower, or is forecast to drop below that temperature within 24 hours of the time concrete is to be placed, special methods shall be used in producing, placing, protecting, and curing concrete. These special methods shall be followed during all such cold weather work and shall be specifically approved by the Engineer for each type of construction before concreting will be permitted to start. Notwithstanding such approval by the Engineer, the Contractor shall assume all risk connected with placing concrete under cold weather conditions and shall retain full responsibility for proper results. Should concrete placed under such conditions prove unsatisfactory, it will be rejected and shall be removed and replaced with satisfactory concrete. No allowance shall be made for removing and replacing the defective concrete. Rate of placing concrete in structures with an appreciable vertical dimension shall be controlled to prevent excessive pressure on lower portions of forms.
 2. Production:
 - (a) Adequate equipment for heating the concrete materials shall be provided. No ingredient that is frozen or contains ice shall be placed in the mixer.
 - (b) Concrete ingredients shall be heated to produce concrete having temperature at time of delivery of not less than 60 degree F nor greater than 90 degree F. A temperature of 70 degree F is preferred.
 - (c) Heating shall be accomplished by heating either the aggregates or the mixing water, or both. When the water temperature is above 165 degree F, the aggregate shall be premixed with the water for at least one minute before the cement is added. Cement shall not be mixed with water or aggregates having a temperature above 100 degree F.
 3. Placing and Finishing: Concrete shall not come in contact with forms and equipment containing ice or snow. If required by the Engineer, the formed area shall be covered and an air temperature of 50 degree F maintained for 24 hours on all surfaces against which the concrete is to be placed. During placing and finishing, the temperature of concrete shall be maintained between 50 degree F and 70 degree F. Troweling shall be delayed in order to avoid bringing an excess of fines to this surface.
 4. Protection:
 - (a) When freezing temperatures are forecast, facilities meeting the approval of the Engineer shall be provided, prior to beginning concrete placement, capable of maintaining the ambient air temperature at the surface of the concrete or forms at not less than 50 degree F for 5 days or 70 degree F for three days. Protective measures shall be maintained for at least four days beyond the period specified above. During this period, the concrete temperatures shall not be allowed to drop below 40 degree F.

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- (b) Sudden cooling (in excess of 20 degree F temperature change in any 24 hour period) of ambient air temperature at the surface of the concrete of forms will not be permitted.
- (c) Insulated forms may be used when approved by the Engineer. Conditions shall be such that the internal concrete temperature will not rise above 130 degree F and sudden cooling at the end of the protection period will not be allowed.
- (d) During the entire protection period, adequate means shall be provided to prevent loss of moisture from the concrete surface.
- (e) The temperature of concrete surfaces shall be determined by thermometers placed against the surfaces of the concrete. The number of thermometers required shall be determined by the Engineer and furnished by the Contractor. The thermometer should be able to record the high and low temperatures. The high and low records should be able to be cleared (for further monitoring) as the temperatures are recorded by the Engineer.
- (f) Provision shall be made in form construction to permit the removal of small sections of forms to accommodate the placing of thermometers against concrete surfaces at locations designated by the Engineer.
- (g) After thermometers are placed, the apertures in forms shall be covered in a way to closely simulate the protection afforded by the forms.
- (h) In determining the temperatures at angles and corners of a structure, thermometers should be placed not more than 8 inches from the angles and corners.
- (i) In determining temperatures of horizontal surfaces, thermometers shall rest upon the surface under the protection covering normal to section involved.
- (j) When protection from cold is needed to insure meeting these specification requirements, all necessary materials for covering or housing must be delivered at the site of the work before concreting is started and must be effectively applied or installed, together with such added heat furnished as may be necessary without depending in any way upon the heat of hydration during the first 24 hours after concrete with Type I, IA, II or IA portland cement is placed, or the first 18 hours when Type III or IIIA is used.
- (k) When heat is supplied by steam or salamanders, covering or housing of the structure shall be so placed as to permit free circulation of air above and around the concrete within the enclosure, but to the exclusion of air currents from without, excepting that where salamanders are used sufficient ventilation shall be provided to carry off gases. Special care shall be exercised to exclude cold drafts from angles and corners and from all projecting reinforcement.
- (l) When salamanders are used, water vessels must be placed over them or other means provided to maintain a high humidity within enclosures, or all exposed surfaces of concrete kept continuously wet during the heating period.

H. Placing Concrete in Hot Weather:

1. In hot weather, suitable provisions shall be taken to reduce the temperature of the concrete coming from the mixer by cooling the mixing water or aggregates or both so that the temperature of the concrete when deposited shall not exceed 90 degree F. Temperatures above 80 degree F require approval of the Engineer.
2. Stockpiled aggregates shall be saturated, and the surface shall be kept moist by intermittent sprinkling or continuous fog spray.
3. Mixing water shall be kept cool by adequate protection of storage tanks and piping. Supply lines shall be shaded, insulated, or buried.
4. When necessary to produce and maintain concrete at an acceptable temperature, chopped or crushed ice shall be added directly into the mixer, up to the limit of 50% by weight of the total water required. Ice shall be added at a rate and in a manner that it will be completely melted

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- during the mixing period. Chilled mixing water will be acceptable in lieu of chopped or crushed ice.
5. The maximum time interval between the addition of cement to the mixing water or aggregates and the depositing of the concrete shall not exceed the following unless a longer interval is approved in writing by the Engineer:

Air or Concrete Temperature (°F – higher of either)	Maximum Time
Non Agitated Concrete	
>80°	15 minutes
80°>	20 minutes
Agitated Concrete	
>90°	30 minutes
89° > 80°	45 minutes
79° > 70°	60 minutes
69° > 40°	90 minutes

6. Wet curing shall be carried out in accordance with Paragraph 3.7B, and exposed unformed concrete shall be protected from wind and direct sun when so directed by the Engineer. Membrane curing, in accordance with Paragraph 3.7C, if approved by the Engineer, may be used after 24 hours of initial wet curing.
- I. Depositing Concrete Under Water:
1. When it is necessary to deposit concrete under water, the methods, equipment, materials, and proportions of the mixture to be used shall be submitted to and shall be approved by the Engineer before the work is started.
 2. Concrete shall not be placed in water having a temperature below 35 degree F. The temperature of the concrete, when deposited, shall not be less than 60 degree F nor more than 100 degree F.
 3. The concrete shall contain not less than 660 lbs. of cement per cubic yard and an anti-washout admixture, Master Builders Rheamac UW450, or equal, in the quantity recommended by the manufacturer.
 4. Aggregate for this work shall be of exceptionally good quality, strong and durable. The maximum size of aggregate preferably shall be 2 inches and shall not exceed 3 inches. The coarse aggregate shall be well graded in such proportions that the weight of the coarse aggregate shall be not less than 1.25 nor more than 2.0 times that of the fine aggregate.
 5. Cofferdams or forms shall be sufficiently tight to reduce the flow or current of water to 10 feet per minute through the space into which concrete is to be deposited. Cofferdams or forms in still water shall be sufficiently tight to prevent loss of mortar through the walls. Pumping water will not be permitted while concrete is being placed, nor until 24 hours thereafter.
 6. Concrete shall be deposited continuously until it is brought to the required height. While depositing, the top surface shall be kept as nearly level as possible and the formation of seams avoided.
 7. The method to be used for depositing concrete under water shall be one of the following, preferably pumping:

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- (a) **Tremie:** shall be watertight and large enough to allow a free flow of concrete. It shall be kept filled with concrete at all times while depositing. The concrete shall be discharged and spread by so moving the tremie as to maintain as nearly as practicable a uniform flow and avoid dropping the concrete through water. If the charge is lost, while depositing, the tremie shall be withdrawn and refilled. The slump of concrete shall be maintained between 5 and 7 inches.
 - (b) **Drop Bottom Bucket:** The top of the bucket shall be open. The bottom doors shall open freely downward and outward when tripped. The bucket shall be completely filled and slowly lowered to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited and when discharged shall be withdrawn slowly until well above the concrete. The slump of concrete shall be maintained between 4 and 6 inches.
 - (c) **Pumping:** Once placement has started, discharge end of hose shall be kept embedded in fresh concrete and moved laterally to maintain a nearly level surface of concrete.
 - (d) **Bags:** Bags of at least 1 cubic foot capacity, of jute or other coarse cloth, shall be filled about two-thirds full of concrete and securely tied. They shall be placed carefully in header-and-stretcher courses so that the whole mass is interlocked. Bags used for this purpose shall be free from deleterious materials. The slump of concrete shall be maintained between 3 and 5 inches.
8. To minimize the formation of laitance, great care shall be exercised so as not to disturb the concrete while it is being deposited. Upon completion of a section of concrete, all laitance shall be entirely removed before work is resumed.
- J. Concrete in Alkali Soils or Alkali Waters:
- 1. Concrete in alkali soils or waters shall be placed in such a manner as to minimize the number of horizontal or inclined seams, or work planes. Wherever possible, placing shall be continuous until completion of the section or until the concrete is at least 18 inches above ground or water level. Corrosive waters or soils shall be kept from contact with the concrete during placement and for a period of at least 72 hours thereafter.
 - 2. The depth of protection for all reinforcement in concrete exposed to alkali soils or water, including supports, ties, and stirrups, shall be a minimum of 3 inches at all plane or curved surfaces and four inches near the corners of exposed members.

3.4 BONDING

- A. Before new concrete is placed against hardened concrete, the surface of hardened concrete shall be cleaned by abrasive blast cleaning to the extent that clean aggregate is exposed and all laitance removed. Immediately before new concrete is placed, the surfaces shall be wetted and standing water removed. Bonding agents may be used if approved in writing by the Engineer.

3.5 JOINTS

- A. Instructions given on the plans as to location and construction of joints shall be strictly followed.
- B. When the structures or portions of the structures are designed to be monolithic, they shall be cast integrally.
- C. The procedure specified in Section 3.4 for bonding new concrete to old shall be followed in the formation of all joints. The reinforcement shall continue through the joint. For concrete without reinforcement, shearing strength shall be provided by means of a concrete key, dowel bars, or both, as the Engineer may direct.
- D. Exposed reinforcement bars intended for bonding with future extensions shall be effectively protected from corrosion.

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3.6 SURFACE FINISH

A. General:

1. Surface finish is a term used to denote the process or method of mixing, placing, and treating concrete to produce a desired appearance and texture of the surface. Finishing techniques vary depending on whether the surface is formed or unformed.
2. The requirements of the sections of these specifications relating to materials, forms, mixing, curing, conveying, depositing, and protection of concrete shall apply except as they may be modified by these special requirements.
3. The same brand of cement, the same kind and size of aggregates, the same proportions and type of finish shall be used where it is desired to duplicate texture and appearance on any showing surface.
4. Unless otherwise shown on the plans or in the special provisions, surface mortar shall be the basis of the surface finish. The coarse aggregate shall be worked back from the forms so as to bring a full surface of mortar against the forms without voids or aggregate pockets. As soon as the forms are removed, any fins or other projections on the surface shall be carefully removed, offsets leveled, and voids or damaged places immediately saturated with a slurry of water and cement and repaired by filling with a concrete mortar, or dry pack as directed by the Engineer. Plastering shall not be permitted. Voids on the surface of formed concrete, resulting from the accumulation of air on the forms, shall be limited to the extent possible. Air voids larger than approximately 1-1/2 inches diameter and/or 3/4 inch deep shall be filled with concrete mortar when directed by the Engineer. The repaired area shall be cured and finished as necessary to provide an appearance as close as possible to that of the adjacent concrete.

B. **Special Surface Finishes (Formed):** when called for on the plans or in the special provisions, shall be obtained by the methods noted below for the required finish:³

1. **Rubbed Finish:** The thoroughly cured concrete surface shall be completely wetted, and rubbed or ground with carborundum or other abrasive until it presents a uniform and smooth appearance. Cement mortar may be used in the rubbing, but the surface shall not be brush coated with cement or grout after rubbing.
2. **Scrubbed Finish:** The forms shall be removed before the concrete surface has fully hardened. The surface shall then be completely wetted and scrubbed with stiff fiber or wire brushes using water freely until the surface film of mortar is removed and the aggregate uniformly exposed. The surface shall then be rinsed with clean water. If portions of the surface have become too hard to scrub in equal relief, dilute hydrochloric acid (commercial acid diluted with 4 to 10 parts water) may be used to facilitate the scrubbing, the acid being removed from the finished surface with clean water.
3. **Sandblasted Finish:** The thoroughly cured concrete surface shall be sandblasted with hard, sharp sand until the aggregate is in uniform relief.
4. **Tooled Finish:** The thoroughly cured concrete surface shall be dressed with tools to a uniform texture and even face. The tools ordinarily used are electric, air or hand tools, to give various textured surfaces such as hand-tooled, rough or fine pointed, crandalled, or bush hammered, as specified or as selected from sample surfaces.
5. **Sand-Floated Finish:** The forms shall be removed before the concrete surface has fully hardened. The surface shall then be wetted and fine sand rubbed into the surface with a wood float using a uniform circular motion until the resulting finish is even and uniform.

C. Unformed Exposed Surfaces:

³ Thoroughly cured concrete shall be concrete that has cured beyond the 28-day cylinder break, unless otherwise defined by the Engineer.

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1. Unformed exposed surfaces, including bridge seats, bridge decks and walks, and box culvert inverts, shall receive a wood float finish unless otherwise shown on the plans or directed by the Engineer.
2. Walks and box culvert inverts shall then be given a broom finish transverse to the direction of the walk or culvert. The stiffness of the bristles and the time at which the surface is finished shall be such as to leave well defined brush marks. The brush shall be kept clean at all times to avoid depositing mortar picked up during previous strokes.
3. Bridge seats shall be finished level with a wood float. Final bridge seat elevation shall be within 0.01 foot of plan elevation. The finished bridge seat shall show no deviation in excess of 1/8 inch from the testing edge of a 10-foot straight edge operated in any direction on the bridge seat surface. Top surfaces shall be thoroughly worked and floated by hand with a wood float to leave a fine, clean, smooth, sandy texture. Top surface of abutments and piers which are not covered by bearings shall slope to drain away from bearings at approximately 1/8 inch per foot.
4. In finishing bridge decks, the Contractor shall use the proper combination of revibration or refloating finishing techniques, fog sprays during finishing, or other procedures to eliminate or minimize the development of surface shrinkage cracks.

3.7 CONCRETE CURING

A. General:

1. The Contractor shall inform the Engineer of the methods proposed for curing; shall provide the proper equipment and material in adequate amounts; and shall have the proposed methods, equipment and material approved prior to placing concrete.
2. Upon removal of forms, surface defects shall be repaired the same day as specified in Paragraph 3.6A.4, and exposed surfaces shall then immediately be protected with a curing treatment equal to that provided for unformed surfaces.
3. Inadequate curing and/or facilities shall be cause for the Engineer to delay all concrete placement on the job until remedial action is taken.

B. Wet Curing:

1. When not otherwise specified, all concrete surfaces, when not protected by forms, must be kept constantly wet for a period of not less than 7 days after concrete is placed when Type I, IA, II or IA Portland cement is used, or not less than 3 days when Type III or IIIA Portland cement is used.
2. The wet curing period for all concrete which will be in contact with brine drip, sea water, salt spray, alkali or sulfate-bearing soils or water, or similar destructive agents, shall be increased to 50 percent more than the periods specified for normal exposures.
3. The use of curing water, burlap, canvas or other materials which discolor the concrete or contain deleterious substances will not be permitted.
4. Inspection shall be made of all exposed surfaces at intervals by the Engineer, and job records will be kept indicating whether surfaces were wet at times of inspection.

C. Membrane Curing:

1. Membrane curing or membrane curing following preliminary wet curing may be used. Materials shall be in accordance with Paragraph 2.7A and shall not be applied during rainfall.
2. On structures in hot and dry climates, where appearance is not important, a white pigmented compound shall be used to reflect heat during the curing period.
3. The compound shall be applied at the coverage rate of 150 or 200 square feet per gallon to all exposed concrete surfaces.

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4. The compound shall be sprayed on exposed surfaces as soon as the surface water has disappeared. Spraying equipment shall be of the pressure tank type with provision for continual agitation of the contents during application. If forms are removed during curing period, the concrete shall be sprayed lightly with water and the moistening continued until the surface will not readily absorb more water. The compound shall then be sprayed or brushed on the concrete surface as soon as moisture film has disappeared.
5. Should the film become damaged from any cause within the required curing period, the damaged portions shall be immediately repaired with additional compound.
6. The continuity of the coating must be until the 14th day after the concrete has been placed when Type I, IA, II or IA Portland cement is used, or until the 7th day when Type III or IIIA portland cement is used.

D. Bridge Decks:

1. Liquid membrane-forming curing compound shall be used as an interim cure for bridge decks and shall be applied immediately after disappearance of surface water sheen following final finishing. Curing compound shall be Type 1-D liquid membrane-forming curing compound in accordance with Paragraph 2.7A.
2. The concrete shall be covered with clean mats as soon as the curing compound has dried sufficiently to prevent adhesion, and the concrete surface will support the curing mat without marring or distorting the finish. The mat shall be sufficiently wet at time of placement to prevent moisture absorption from the finished surface and be kept continuously wet for a period of 7 days in accordance with Paragraph B.
3. At the end of the required wet-curing period, mats shall be allowed to dry thoroughly before removal to provide uniform, slow drying of the bridge deck surface. Alternative methods for controlling the rate of drying following wet-curing may be used if approved by the Engineer.

3.8 REMOVAL OF FORMS AND FALSEWORK

- A. Before the removal of forms, concrete shall have attained sufficient strength to endure such removal without being damaged. Forms shall be removed carefully so that neither the forms nor the tools used in their removal will deface the concrete. Forms carrying no loads may be removed after 48 hours to facilitate finishing in weather of temperatures above 60 degree F. If the temperature is below 60 degree F, but above 42 degree F, this time shall increase to 4 days. In weather of a temperature below 42 degree F, the forms shall be left in place a longer period as determined by the Engineer, depending on the weather encountered.
- B. Falsework shall not be removed until such time as the concrete supported by it is able to sustain itself and any load that is likely to come upon it with absolute safety to the concrete. Falsework supporting cast-in-place concrete, and forms supporting concrete slabs or beams shall remain in place until test cylinders show that the concrete has attained the design strength and also until at least 14 days have elapsed from the time concrete placement is completed, exclusive of days in which the temperature falls below 42 degree F. If high-early-strength Portland cement is used, this period may be reduced as directed by the Engineer. The Contractor shall leave falsework in place for a longer period of time when required by the Engineer. No superimposed load, either dead or live, will be allowed upon the structure during the period the falsework is required to remain in place unless approved by the Engineer.
- C. Falsework shall be removed in such a manner as to permit the concrete to take uniformly and gradually the stress due to its weight.
- D. Forms shall be removed in such a manner as not to injure the concrete. In all cases the Contractor is responsible for, and must repair at his own expense, any damage arising from inadequate forms or falsework, or from the premature removal of same.

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PART 4 MEASUREMENT AND PAYMENT

4.1 CAST-IN-PLACE CONCRETE

- A. The quantities of cast-in-place concrete of the various classifications will be measured by the cubic yard in place. The dimensions used for measurement will be those shown on the plans or as authorized in writing by the Engineer.
- B. The quantity of concrete involved in fillets, scorings or chamfers 1 square inch or less in cross sectional area shall be neglected and considered incidental to the cost of cast-in-place concrete.
- C. No deductions will be made for embedded reinforcement, embedded portions of steel bearing piles, drains, or expansion joint material. Deductions will be made for the portions of concrete piles, timber piles, steel pipe piles and structural steel embedded in the concrete. The volume of timber piles will be assumed to be 1.0 cubic foot per lineal foot of pile.
- D. Cast-in-place concrete shall be paid for at the contract unit price per cubic yard of concrete in place of the proper classification. This price shall be full compensation for furnishing all materials, and for all equipment, tools, falsework, forms, bracing, labor, surface finish, curing (including cold or hot, if required) and all other items of expense required to complete the concrete work shown on the plans, with the exception of reinforcement. This price shall also include the cost and installation of apron plates, expansion joints, joint fillers, waterstop and drains, other than structure drain pipe as specified in SECTION 04100, when required.
- E. The above provisions for payment shall not be interpreted to provide payment for concrete in precast piles, drilled shafts, or precast concrete members.

4.2 REINFORCEMENT

- A. Acceptable reinforcement incorporated in the concrete will be measured in pounds based on the total computed weight for the sizes and lengths of bars or fabric as shown on the plans or as authorized in writing by the Engineer. The weight of deformed bars shall be computed from the unit weights specified in ASTM A615; the weight of plain bars shall be computed from the theoretical weights of round bars; and the weight of fabric computed from the theoretical weight of plain wire.
- B. No allowance will be made for clips, wire, separators, wire chairs, weld metal or other material used in fabricating the reinforcement or fastening it in place.
- C. When laps are made for splices, other than those shown on the plans for the convenience of the Contractor, the weight of extra steel will not be included.
- D. Reinforcement steel shall be paid for at the contract unit price per pound of reinforcement in place of the proper classification. This price shall be full compensation for furnishing all materials and for all equipment, tools, bending, fabricating, welding and for placing the reinforcement; for all clips, wire, separators, wire chairs or other material used for fastening the reinforcement in place; and for all labor and incidentals necessary to complete the work.
- E. The above provisions for payment shall not be interpreted to provide payment for reinforcement in precast concrete piles, drilled shafts, or precast concrete members.

END OF SECTION

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SECTION 04410

MASS CONCRETE PLACEMENT

PART 1 DESCRIPTION

- A. This work shall consist of constructing mass concrete caps, columns and footings.

PART 2 EXECUTION

- A. The furnishing, forming, placing and finishing of concrete shall meet the requirements of the Standard Specifications and as modified herein for mass concrete placement. Mass concrete placement shall be defined as any pour in which the concrete being cast has dimensions greater than or equal to six (6) feet in three different directions. For all mass concrete pours, the mix temperature shall not exceed 80 degrees Fahrenheit prior to the placement of the concrete into the forms. Concrete for drilled shafts shall not be subject to the mass concrete requirements.
- B. When placing mass concrete, the Contractor shall maintain a temperature differential of 35 degrees F or less between any point in the interior of the concrete greater than twelve (12) inches from the surface and the surface of the concrete during curing. Temperature monitoring devices shall be installed at exterior and interior points within the concrete as approved by the Engineer. Temperature monitoring shall begin when casting is complete and continue until the maximum temperature differential has been reached and begins dropping off. The Contractor shall maintain records of the temperature differential and shall immediately apply corrective measures when the temperature differential exceeds 35 degrees F. The maximum curing temperature shall be 150 degrees F.
- C. A minimum of 10 working days prior to placing any mass concrete on this project, the Contractor shall submit the following items for approval:
1. Analyses of the anticipated thermal developments within the mass pour placements using the proposed materials and casting methods.
 2. A plan outlining specific measures to be taken to control the temperature differential within the limits noted above.
 3. The proposed monitoring system.
 4. If the Contractor is proposing a special mix design as part of the temperature control plan, this mix design must also be submitted for review.
- D. Any proposed mix design utilizing Type II cement shall be limited to a maximum heat of hydration of 70 calories per gram at seven (7) days, as specified in AASHTO M 85. If fly ash is to be used, the Contractor shall furnish documentation that the proposed mix of fly ash and Type II cement does not exceed the specified heat of hydration of 70 calories per gram at 7 days.
- E. If temperature monitoring indicates that the proposed measures are not controlling the concrete temperature differential within the 35 degrees F specified, the Contractor shall make the necessary revisions to the plan and submit the revised plan to the Engineer for approval.
- F. The Contractor shall assume all risks connected with the placing of mass pour concrete and approval of the Contractor's plan will in no way relieve the Contractor of the responsibility for satisfactory results. Should any mass concrete placed under the guidelines of this Special Provision prove to be unsatisfactory, the Contractor shall be required to make the necessary repairs or replace the concrete at no additional cost and without any extension of contract time.



Standard Specification

04410 Mass Concrete Placement

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PART 3 MEASUREMENT AND PAYMENT

- A. All costs associated with special temperature controls for mass concrete placement will be considered completely covered by the contract unit price for "Cast-In-Place Concrete for Piers".

END OF SECTION

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SECTION 04500 PRECAST CONCRETE CONSTRUCTION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Precast Concrete Members
- B. Precast, Prestressed Concrete Members
- C. Precast Concrete Box Culverts

1.2 SAFETY

- A. Contractor is responsible for performing all precast concrete operations in compliance with the current state, federal, local, FRA and OSHA regulations, specifically those pertaining to fall protection.

1.3 DESCRIPTION

- A. These specifications shall govern the furnishing and erecting of structures or portions thereof, consisting of precast concrete or precast, prestressed concrete members in accordance with these specifications, the special provisions and the details shown on the plans.
- B. These specifications shall govern the furnishing and placing of precast reinforced concrete box culverts in accordance with these specifications, the special provisions and the details shown on the plans.
- C. The Fabricator shall furnish all labor, plant, materials, equipment and services necessary to fabricate the precast prestressed concrete units in accordance with BNSF Plans and these Specifications.

1.4 SUBMITTALS

- A. Design calculations shall be submitted prior to initiation of manufacture of members to be used for this project.
- B. Concrete mixture proportions shall be submitted for approval.
- C. Certified test reports of required material tests shall be submitted prior to the use of the materials in the Work.
- D. The results of concrete strength testing by the Contractor shall be submitted not more than 5 days after the tests are completed.

1.5 DRAWINGS

- A. The concrete products shall conform in all respects to BNSF plans and or approved shop drawings.

1.6 CASTING PLANT STANDARDS

- A. The units shall be cast in an established manufacturers casting plant that conforms in all respects to the latest requirements of the "Manual for Quality Control for Plants and Production of Structural Precast Concrete Products", Publication No. MNL-116 of the Prestressed Concrete Institute, unless otherwise approved by the Engineer. The manufacturer shall be certified by the Prestress Concrete

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Institute Plant Certification Program in Product Group and Category B4 and shall furnish proof of the certification to the Engineer prior to the start of fabrication.

PART 2 MATERIALS

2.1 PRECAST CONCRETE MEMBERS AND BOX CULVERTS

- A. All design, material and its fabrication shall be in accordance with the Company's specifications for precast and precast, prestressed concrete members and as specified in the special provisions or on the plans.
- B. Each member shall be identified by the producer by application of a waterproof paint showing product designation, date of casting, and weight or by a metal tag cast into the concrete.
- C. Design of lifting devices shall be the responsibility of the Fabricator, unless detailed on the plans.
- D. The Company reserves the right to reject any product that is not cast in accordance with the requirements of the special provisions, plans, specifications or Manual for Quality Control for Plants and Production of Structural Precast Concrete Products, publication No. MNL-116.

2.2 CEMENT

- A. Cement shall be either type IP or type III, conforming to ASTM C150. The false set penetration, when tested in accordance with ASTM C359, shall not be less than 50mm initially, 35mm at intermediate times and 40mm after remix.
- B. Cement mill certificates shall be provided weekly by each supplier to the fabricator and shall meet the requirements of the following tests on the cement used that week:
 - 1. Fineness by air permeability, ASTM C204
 - 2. False set, ASTM C359. Penetration at 3,5,8,11 minutes and after remix
 - 3. Setting time ASTM 191
 - 4. Compressive Strength ASTM C109, at 1 day, 3 days, and 7 days
 - 5. Chemical analysis, ASTM C114, with calculated alkalis as Na₂O equivalent. The fabricator shall obtain a statement signed by an officer or chemist of the cement manufacturer, certifying that the cement furnished does not exceed 0.6% alkali equivalent, as measured by the percent of sodium oxide plus 0.658 times the % of potassium oxide. A statement shall be furnished to the Engineer prior to the start of fabrication from cement that is proposed to be used. (The results of the above tests shall be kept on file at the fabricators quality control dept. and reviewed for compliance, and shall be available for the Inspector's review.)
- C. Every three months, a randomly chosen sample of cement shall be analyzed for alkali content in accordance with ASTM C114 by an outside laboratory selected jointly with BNSF and the fabricator. Copy of results of such testing shall be furnished directly to BNSF. Costs for testing shall be borne by the fabricator. Fabricator to maintain a 1 quart minimum sample of cement in an airtight container at the plant until the results are determined and analyzed. Each sample shall be clearly identified by date.
- D. Certification shall be submitted directly to the Engineer before beginning fabrication and shall be furnished from job materials every 3 months. Cost of testing shall be borne by the fabricator.
- E. Storage of Cement. The fabricator shall provide suitable means for storing and protecting the cement against dampness. Cement which for any reason, has hardened or become partially set or which contains lumps of caked cement will be rejected and not used in the work. Cement shall be used in the order that it is received.

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2.3 ADMIXTURES

- A. Only liquid admixtures may be used and all Admixtures must be from the same manufacturer.
- B. Air entraining admixtures shall conform to ASTM C260 and shall be used to produce 7% +/- 1% entrained air in the concrete after all admixtures have been incorporated.
- C. Water reducing admixtures shall be used only with the approval of the Engineer and shall conform to ASTM C494, Types A,B,D, or E.
- D. High-range water reducers (superplasticizers) and retarding admixtures, in quantities appropriate for the ambient temperatures, may be permitted, subject to approval of the Engineer.
- E. The use of calcium chloride or any admixture containing chloride ions will not be permitted.

2.4 POZZOLANS

- A. Flyash, Type C, meeting the requirements of ASTM C618 may be used as a cement replacement with the approval of the Engineer. Type F may be used to modify potentially reactive aggregates. This mix shall be subject to the requirements of ASTM C1260. Flyash may replace up to 15%, by weight, of the cement.

2.5 AGGREGATES - COARSE

- A. Aggregates shall be natural and comply with ASTM C33 Class 4S Size 57 (Maximum size of aggregate is 1") (Tests required: 1 at the beginning of the contract and 1 at each quarter). The maximum size of the coarse aggregate shall not be larger than 1/5 of the narrowest dimension between forms of the member for which the concrete is used, nor larger than 1/2 of the minimum clear space between rebar.
- B. If the coarse aggregate is supplied in more than one size, each size shall be stored separately.
- C. Washed aggregate to be drained, in stockpiles, before use. All aggregate shall be free from ice when used.
- D. Petrographic examination to ASTM C295
 - 1. Tests required: 1 at the beginning of the contract and 1 at each quarter
- E. Evaluation of potential alkali reactivity to ASTM C1260 with job cement.
 - 1. Separate tests are required for each aggregate source and each cement
 - 2. Tests required: 1 at the beginning of the contract and 1 at each quarter.
- F. Abrasion to ASTM C131 Loss of weight not to exceed 40%.
 - 1. Tests required: 1 at the beginning of the contract and 1 at each quarter.
- G. Soundness to ASTM C88
 - 1. Tests required: 1 at the beginning of the contract and 1 at each quarter.
- H. Aggregate considered potentially reactive by the Engineer shall not be used.

2.6 AGGREGATES - FINE

- A. Washed aggregate to be drained, in stockpiles, before use. All aggregate shall be free from ice when used.
- B. Petrographic examination to ASTM C295 (Tests required: 1 at the beginning of the contract and 1 at each quarter).
- C. Evaluation of potential alkali reactivity to ASTM C1260 with job cement.
 - 1. Separate tests are required for each aggregate source and each cement.
 - 2. Tests required: 1 at the beginning of the contract and 1 at each quarter.

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- D. Organic Impurities to ASTM C40 (Tests required: 1 at the beginning of the contract and 1 at each quarter.)
- E. Soundness to ASTM C88
 - 1. Tests required: 1 at the beginning of the contract and 1 at each quarter.
- F. Fineness modulus not less than 2.3, nor more than 3.1
- G. Aggregate considered potentially reactive by the Engineer shall not be used.
- H. Coarse and fine aggregates shall be stored separately and in such a manner as to avoid the inclusion of dirt and other foreign material in the concrete. Aggregates shall be unloaded and piled in such a manner as to maintain the uniform grading of the sizes. Stockpiles of coarse aggregates shall be built in horizontal layers, not by end dumping, to avoid segregation.
- I. A hard base shall be provided to prevent contamination from underlying material, and overlap of the different sizes shall be prevented by suitable walls or ample spacing between piles. Stockpiles shall not be contaminated by swinging aggregate filled buckets or clams over the various stockpiled aggregate sizes. Crush slag shall be wetted down when necessary to insure not less than 3 percent moisture content.

2.7 WATER

- A. Water used in mixing and curing concrete including free water on aggregates, shall be potable and free from any pronounced taste, odor, or color that would indicate the presence of oils, acids, alkalis, salts, sugars, vegetable matter, or other substances that may be deleterious to concrete or reinforcement and shall not contain more than 1000 parts per million of chlorides as Cl nor more than 1000 parts per million of sulfates as SO₄.
- B. Questionable water shall be tested in accordance with and shall meet the requirements of ASTM D512 and ASTM D516.

2.8 PROPORTIONING CONCRETE

- A. General
 - 1. Concrete shall be composed of cement, aggregates, and water of the qualities herein specified and in the required proportions. These ingredients to be well mixed and brought to a proper consistency.
 - 2. All concrete shall be air-entrained. The entrained air may be produced through the use of air entraining cement, by the use of an air entraining admixture at the concrete mixer, or through a combination of both.
- B. Measurement of Materials
 - 1. The unit measure for cement shall be the pound.
 - 2. Material shall be measured by weighing. The apparatus provided for weighing the aggregates and cement shall be suitably designed and constructed for this purpose. The accuracy of all weighing devices shall be such that successive quantities can be measured to within one percent of the desired amount. The mixing water shall be measured by volume or by weight. The water-measuring device shall be susceptible to control accuracy to plus or minus one-half percent.
 - 3. The accuracy of the material weighing and water measuring devices shall be subject to check at all times. The fabricator shall provide suitable weights approved by the Engineer for this purpose and shall assist the Engineer in making all tests.
- C. Cement Content
 - 1. A minimum of 600 pounds of cement and/or cementitious materials per CY.
- D. Water - Cement Ratio

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1. Maximum of .45.
2. Required concrete compressive strength shall be as shown on the plans.
3. Free water content of the aggregates shall be included in the total water in determining the total water-cement ratio.
4. Moisture in the aggregate shall be measured by methods satisfactory to the Engineer, which will give results to within one pound for each 100 pounds of aggregate.
 - (a) Moisture contents shall be run daily for each mix design. Aggregates incorporated in the mix should be surface saturated dry (SSD).
5. Mix Design
 - (a) Designs are to be submitted for approval before any concrete is used under this contract. Minimum of 60% coarse aggregate shall be used.

2.9 REINFORCEMENT

- A. All steel bars for reinforcement shall be deformed bars and shall conform to the requirements of ASTM A615 Grade 60, unless shown otherwise on the plans. Reinforcing steel to be welded shall comply with ASTM A706.
- B. Spiral reinforcement shall be hot rolled plain round rod or cold drawn wire. The plain round rod shall conform to the requirements of ASTM A 615 Grade 60; wire shall conform to ASTM A82 Mill certification required for all reinforcement.
- C. Reinforcement shall be fabricated in accordance with Chapter 7 of the CRSI Manual of Standard Practice. Standard bending tolerances are applicable unless otherwise specified on the plans. Reinforcement shall be bent cold to conform accurately to the dimensions and shapes shown on the approved drawings. Bends shall be made accurately in a suitable bending machine. Unless otherwise specifically approved, bars shall be shop bent before shipment and shall not be bent in the field.
- D. Placement
 1. Reinforcement shall not be straightened or re-bent in a manner that will injure the material. Bars with kinks or bends not shown on the plans shall not be used. Heating of reinforcement shall be permitted only with the approval of the Engineer. Bars partially imbedded cannot be field bent except as permitted by the Engineer.
 2. All reinforcement shall be set in the positions shown on the plans and held securely in place. Placement tolerances shall be in accordance with Chapter 8 of CRSI Manual of Standard Practice. Reinforcement bars shall not be placed by sticking or floating into place during or immediately after placement of the concrete.
 3. No concrete shall be deposited until the Engineer has inspected the placing of the reinforcement and given permission to place the concrete. All concrete placed in violation of this provision shall be rejected and removed.
 4. Reinforcing bar supports, chairs, their selection and placement, unless otherwise provided, shall be in accordance with Chapter 3 of CRSI Manual of Standard Practice. Wire supports shall be Class 1, plastic protected bar supports.
 5. Splices, if not shown on the plans, shall occur at the neutral moment area and should be alternated.
 6. Minimum cover is 1-1/2" (38mm) with zero minus tolerance.
 7. Reinforcement to be securely tied in place using uncoated tie wires. Double ties are required for tying rebar to prestress strand. Tie wires to be minimum 18 gauge.
 8. Reinforcement shall be stored upon platforms, skids, or other supports in such a manner as to avoid contact with the ground. If reinforcement is to remain in storage for more than a month it shall be covered to protect it from the weather. If reinforcement accumulates heavy rust, dirt,

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mud, loose scale, paint, oil, or any other foreign substance during storage, it shall be cleaned before being used. Severe deterioration is a basis for rejection.

9. Bars may be cut to length by shear or saw. Torch cutting is not permitted

2.10 EMBEDDED ITEMS OTHER THAN REINFORCING STEEL

- A. Embedded items shall be accurately located as shown on the plans.
- B. Inserts for walk brackets, bolts, washers, etc. shall be galvanized per ASTM A153, electroplated or electrogalvanized.
- C. Pipe sleeves shall be Dywidag Spiro Duct with a coating rating of no less than G 60, meeting requirements of ASTM A653.
- D. All threaded items to be free of concrete and grout deposits.

2.11 PATCHING

- A. Patching or repair of spalled or chipped members shall be done using an approved mortar, mixed and installed in accordance with manufacturer's written instructions.

2.12 EPOXY

- A. The liquid and gel type epoxy shall be a two component, epoxy-resin bonding system conforming to the requirements of ASTM C881, Type IV, Grade 2, Class B or C. The class supplied shall be governed by the range of temperatures for which the materials are to be used.

2.13 EPOXY MORTAR

- A. Epoxy mortar shall consist of equal parts by volume of gel type epoxy and dry silica sand, mixed in accordance with the manufacturer's directions.

PART 3 EXECUTION

3.1 FORMS

- A. Steel forms shall be used for casting the precast units. Casting beds and forms shall be sufficiently rigid to prevent deflection under load. Forms must be watertight. A minor amount of bleed water is allowed, but no paste may come through any joints.

3.2 QUALITY ASSURANCE AND INSPECTION

- A. The Engineer, or his authorized representative, shall have free entry at all times to all contract work. Two weeks' notice shall be given to the beginning of contract work so that an inspector may be present. The fabricator shall provide, at no cost to BNSF, private office space and record storage accommodations for one BNSF Inspector. The office space shall be a minimum of 8'x10' and be located at the fabricating facility. It shall be furnished with standard office furniture: one desk (30"x60"), desk chair, visitor chair, and a 5 drawer lockable legal file case. The office shall be furnished with two telephone lines with access capability outside of the plant. (One for Fax machine). The office shall contain independent air conditioning and heating. The office and site must be acceptable and approved by BNSF.
- B. All products shall be inspected by the fabricators Quality Control Department. Any personnel involved in the testing of fresh concrete shall be certified by the American Concrete Institute, ACI, as a "Field Testing Technician", Grade 1. The fabricator shall designate one individual as full time railroad inspector. This individual shall be certified by American Concrete Institute, ACI, as a "Concrete Construction Inspector, Level II", and American Concrete Institute, ACI, "Concrete

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Transportation Construction Inspector". Certifications must be current and the fabricator shall furnish copies of certification prior to the start of fabrication.

3.3 CONCRETE QUALITY

- A. The water soluble chloride content of the concrete shall not exceed 0.06% expressed as chloride ion by weight of cement. This shall be measured by an outside testing laboratory on hardened concrete from a release cylinder or on individual materials in the mix when mix proportions are developed and thereafter by tests at three-month intervals which include materials from all sources in use.
- B. The minimum compressive strength is 4000 psi or as otherwise noted on the plans. The average shall be determined by using a minimum of three cylinders. All cylinders must break at or above the minimum compressive strength.
- C. Cylinders may be either 6"x12" or 4"x8". They must be cast in steel molds. They shall be air-dried adjacent to the product for release and dry cured for 28 day strengths.
- D. Maximum slump after adding high-range water reducers (superplasticizers), shall be 8". Testing shall be done and recorded at point of casting.
- E. Concrete truck mixed concrete shall receive 70-100 revolutions at mixing speed of 6 to 18 rpm. After mixing, run at agitating speed, 2-6 rpm. After addition of water or admixtures mix a minimum of 3 minutes. Maximum number of revolutions is 300. Truck counter to be checked at the start. Total load to be discharged before 90 minutes has elapsed. Truck must have plate showing capacity. Premix to 80%. Central batch to 63% (shrink mix).

3.4 DURABILITY¹

- A. One product, at the start of production and thereafter every two months is to be selected jointly with the fabricator and Inspector for air void content and durability tests. These tests are to be performed by an independent testing laboratory.
- B. The air void content shall be measured in accordance with ASTM C457 on the top, center, and bottom of a 4"x8' cored cross section from a prestressed product. The measured air void content shall not be less than 6% and the air void spacing factor shall not exceed 0.008". In-place cylinders may be used rather than coring.
- C. The durability factor shall be measured in accordance with ASTM C666 on a minimum of 4 prisms of concrete taken adjacent to the samples used for tests in Section S.2. The durability factor shall not be less than 90%.
- D. The cost of durability testing shall be borne by the fabricator. Results are to be furnished directly to BNSF from the outside testing laboratory.

3.5 PRODUCTION, SCHEDULING AND MARKING

- A. The fabricator must have sufficient capacity for producing a minimum per week of:
 - 1. 24 Single Caps
 - 2. 5 Double Caps
 - 3. 16 Parapets
 - 4. 12 Backwalls

¹ It is highly recommended that a "test" product utilizing approved materials, mix design, and methods as detailed heretofore in these specifications be cast, tested and approved to the above durability requirements well in advance of beginning production.

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- B. The fabricator shall furnish a schedule, updated weekly, which shall include the fabrication of all concrete items covered by these specifications. This shall be provided to the Inspector.
- C. In addition to the designation of one full time inspector as detailed in Section P, the fabricator shall designate one individual as the Engineer's primary contact for scheduling and changes, materials acquisition, coordination of shipments, etc.
- D. Each item shall be clearly marked to show its mark no., the date of manufacture, lifting weight, bridge no. Fabricating Plant Identification including city and state. Marking shall be done with black paint stencil, using a minimum of 2" high letters on the outside face of the curb.
- E. A system of color-coding shall be used on all products consisting of spray paint dots on each end of each product. Green: Acceptable, ready for shipment, Orange: Reject, to be removed from inventory, Yellow: Needing repair, but ultimately will be accepted, Blue: Hold pending further inspection or testing.

3.6 CONCRETE TESTING

- A. All concrete testing shall comply with ASTM C172 Sampling Freshly Mixed Concrete, and shall occur and be recorded at the point of casting.
- B. Two concrete test cylinders shall be made and tested by the Fabricator for each batch of concrete. One test cylinder shall be made, cured and tested at 28 days per ASTM C31 and ASTM C39. One cylinder shall be made and tested per ASTM C31 and ASTM C39, but shall be cured along with the precast unit to closely approximate the actual strength of the unit. This cylinder shall be broken prior to removal from form.
- C. Unit weights shall be made on each batch per ASTM C138.
- D. Slump tests shall be made on each batch per ASTM C143.
- E. Ambient temperature and concrete temperature to be made for each batch.
- F. All fresh concrete tests are to be made from the same sample.
- G. The cost of all concrete testing shall be borne by the Fabricator.
 - 1. Minimum of one test per batch of concrete. A batch is defined as initial mixing of all concrete ingredients before the addition of water.

3.7 CONCRETE PLACEMENT

- A. Concrete shall not be placed in the forms until:
 - 1. All imbedded items and reinforcing steel has been completed and has been inspected and approved by the Fabricator's Quality Control representative and by the Engineer.
 - 2. All fresh concrete testing has been done and complies with minimum requirements.
- B. Concrete shall be vibrated internally and/or externally to provide thorough consolidation and compaction. Vibration shall be done with care to avoid displacement of embedded items. An extra vibrator shall be available at all times at the point of casting. Vibrator head to be sized to fit between smallest dimension between reinforcement and/or prestress strand.
- C. The temperature of the mixed concrete when placed shall not exceed 90 degrees F. The temperature of the forms and reinforcing steel and strand shall not exceed 90 degrees F. When the temperature of the forms and reinforcement exceed 90 degrees F., it shall be cooled by acceptable methods to an ambient temperature of 90 degrees F or lower. If water is used to cool forms and steel, all standing water shall be removed by compressed air or other suitable means.
- D. Fabricating plants with demonstrated facilities for protection of the concrete during cold weather may, with the approval of the Engineer, cast prestressed units when production procedures meet the following criteria:

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1. When the ambient temperature is below 32 degrees F., the forms and reinforcing steel shall be preheated to attain form and steel temperature of at least 40 degrees F.
 2. No concrete may be placed when the wind chill temperature is 0 degrees F or lower.
 3. Air temperature and wind velocity shall be measured at the plant in order to determine equivalent wind chill, by methods approved by the Engineer.
- E. Concrete placement shall be a continuous operation as far as possible from start to completion of each precast unit. Placement shall follow the guidelines as detailed in ACI 309, and in no case shall the thickness of a lift be placed to a depth greater than the length of the vibrator head. Concrete shall not be allowed to flow through the form. The concrete shall be placed as close as possible to its final location. Concrete to be deposited against concrete. Limit drops to 5 ft. Concrete shall not be moved with vibrators. Care should be taken to prevent vibrators from touching forms. Limited delay in concrete placing will be permitted to conform to construction procedure; however, concreting shall, in all cases, be continued before preceding concrete attains its initial set. Cold joints are not permitted.

3.8 DIMENSIONAL TOLERANCES

- A. Caps, parapets and wingwalls

Length	± ¼" (6mm)
Width	± ¼" (6mm)
Height	± ¼" (6mm)
Out of Square per end	± ½" (12mm)
Bearing Areas (Variation from Plane Surface)	± 1/8" (3 mm)
Lifting Device Location	± ½" (12 mm)
Lifting Device Plumbness	± 1/8" (3 mm)

3.9 LAITANCE

- A. All laitance accumulated on steel forms must be removed from forms before reuse.

3.10 CURING

- A. Slow cool down, moist cure. Curing compound shall be used on all, as cast, exposed surfaces. Compound shall comply with ASTM C309, Type 2, Class B. Coverage should be 100 Sq Ft per gallon. Compound to be resin based. Application to provide a complete membrane (should appear as white paper). Care should be taken to avoid coating protruding reinforcing bar in curbs, and if coated must be removed before the casting of curbs/walks.
- B. All concrete covered under these specifications is to be cured also by accelerated means: either steam or moist heat. In freezing weather, or when there is the likelihood of freezing temperature during the curing period, suitable means must be provided before concreting for maintaining all concrete surfaces at a temperature of not less than 50 degrees F.
- C. The temperature of concrete surfaces shall be determined by thermometers placed against the surface of the concrete.
- D. Covering or housing of the form must be so placed as to permit free circulation of air above and around the concrete within the enclosure, and to exclude air currents from the outside. Care shall be taken to maintain the specified temperature continuously and uniformly in all parts of the enclosure.

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- E. Steam curing shall be done in an enclosure capable of containing the live steam in order to minimize moisture and heat losses. The application of steam shall be delayed from 2 to 4 hours after final placement of the concrete to allow the initial set of the concrete to take place. If retarders are used the application of steam may be increased to from 4 to 6 hours. The steam shall be at 100% relative humidity to prevent loss of moisture and to provide excess moisture for proper hydration of cement. Application of steam shall not be directly on the concrete.
 - 1. During application of the steam, the ambient air temperature shall increase at a rate not to exceed 40 degrees F. per hour until a maximum of 150 degrees F. is reached.
- F. The curing shall continue for a minimum of 12 hours (see Concrete Quality). In discontinuing steam, the ambient air shall decrease at a rate not to exceed 40 degrees F. per hour until a temperature has been reached about 20 degrees F. above the temperature of the air to which the concrete is exposed. The concrete shall not be exposed to temperatures below freezing for 24 hours after discontinuation of steam.

3.11 SURFACE FINISH

- A. See Section 1.18 and 1.19 Chapter 8 AREMA Manual for Railroad Engineering.

3.12 REPAIRS:

- A. Repairs may be made for bug holes, discoloration, or around embedments. These may consist of grinding, grouting (cement and sand), chipping and stoning with the approval of the Engineer. Rock pockets, excessive cracking, poor vibration shall be cause for rejection. All open porous surfaces to be sealed. Tarp marks or other construction deformities may be repaired. Small cracks not exceeding 1/16" may be repaired by epoxy injection. Broken edges shall be cut 1-1/2" deep for repair. No feathering of broken areas is allowed.

3.13 HANDLING STORING, AND ERECTION

- A. General:
 - 1. Transportation of members shall not be undertaken until the full 28-day concrete strength has been achieved, or by order of the Engineer.
 - 2. If members are furnished by the Company, they shall be unloaded promptly by the contractor. Rail cars or trucks shall be released upon completion of unloading.
 - 3. Rail cars will normally be spotted for unloading at nearest railroad siding.
 - 4. Members shall be handled such that the points of support and directions of the reactions with respect to the unit are approximately the same during transportation and storage as when the member is in its final position. Care shall be taken during storage, hoisting, and handling of the members to prevent cracking or damage. Members damaged by improper storage or handling shall be replaced or repaired to the satisfaction of the Engineer by the Fabricator at his expense.
 - 5. Plans including all details of the proposed lifting and transportation methods including loading, blocking and securing materials shall be submitted to the Engineer for approval before shipping may commence.
 - 6. The Contractor shall be responsible for proper handling, lifting, storing, and erection of all members so that they are placed in the structure without damage or undue marring of the concrete.
 - 7. Design of lifting devices shall be the responsibility of the Fabricator, unless detailed on the plans.

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8. Bearing areas on concrete caps and beams or girders which are to receive epoxy materials shall be abrasive blast cleaned to remove all form oil and curing agents and shall be left in a dust free condition.
 9. In erecting beams and girders, care shall be taken to keep bridge seats and tops of bearing devices free of foreign materials. Any shifting of beams shall be done while they are held free of the foundation.
 10. The Contractor will be required to shift or interchange beams and girders to achieve a better fit when directed by the Engineer. As the beams and girders are placed in their final position, and prior to securing anchor bolts, rods, or diaphragms, the beams shall be brought to full and even bearing on the bearings.
 11. Precast members shall be set in the proper location using care not to damage concrete members. After beams are set, burn off lifting loops a maximum of 2 inches above concrete surface. Remaining portion of lifting loops are to be coated with paint. Patch recesses, if necessary, around lifting loops with epoxy mortar.
- B. Precast Members:
1. All precast members shall be hauled, stored, and shipped in a manner to avoid chipping, cracking, fractures, and excessive bending stresses. These members shall be supported on firm blocking with foundations suitable to prevent differential settlement or twisting of the units.
 2. The ends of precast members shall not be permitted to extend a distance exceeding the depth of the member beyond any point of bearing during hauling or stockpiling.
 3. Precast members shall be handled with a suitable hoisting device or crane provided with a spreader sling of sufficient capacity to handle the members. The spreader shall be of sufficient length to prevent horizontal forces in the member due to lifting and shall be equipped with leads and hooks at each end.
- C. Precast, Prestressed Members:
1. The members shall be maintained in upright position at all times and shall be supported only at the ends. During lifting, they shall be supported only by the lifting devices provided for that purpose.
 2. Storing of precast, prestressed members shall be done with adequate blocking so that warpage or cracking will not occur. The blocking shall be of such nature that uneven settlement due to wet ground or inadequate material underneath the blocking will not occur. Placement of the blocking from the beam or girder ends shall be at locations not greater than the depth of the beam or girder and, in no case, more than 3-1/2 feet. Members which are improperly stored and which become cracked, warped, or otherwise damaged in storage will be subject to rejection.
 3. Precast, prestressed members, when stacked, shall be separated by blocking capable of supporting the members in a level position without twisting. The blocking shall be arranged in vertical planes. Stacking of precast prestressed members shall be arranged such that lifting devices will be accessible and undamaged.
 4. Before moving a long girder, the Contractor shall check it for any tendency to buckle. Each girder that may buckle shall be braced on the sides to prevent buckling. This bracing shall be attached securely to the top flanges of the girder. The lateral bracing shall be in place during all lifting or handling necessary for transportation from the fabricating plant to the job site and erection of the girder. The Contractor is cautioned that for some delivery routes more conservative guidelines for lateral bracing may be required. Before removing the bracing to cast diaphragms, the Contractor shall fasten all girders in place by other means.
- D. A representative amount of each type of each product shall be weighed, (not less than 50 %) by a method accurate to within 250 lbs. by using a load indicating device. The Fabricator shall load,

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block and tie down the precast units on rail cars to the satisfaction of the local railroad car inspector at no additional cost to Burlington Northern Santa Fe. See Attachment "B".

- E. Plans, including all details of the proposed lifting and transportation methods including loading, blocking and securing materials shall be submitted to the Engineer before shipping may commence.
- F. The Fabricator shall provide copies of shipping notices covering all materials shipped each day by car number.

3.14 BEARINGS AND ANCHORAGE

- A. Bearings shall be set level in exact position and shall have full and even bearing upon the bridge seat areas.
- B. Anchor bolts and anchor rods shall be installed as shown on the plans and special provisions.

3.15 FABRICATION AND PLACING OF PRECAST CONCRETE BOX CULVERTS

- A. All applicable portions of Section 3.1 of this section shall apply to precast concrete box culverts.
- B. Concrete shall be placed by the wet cast method. Fabrication by the dry cast method is not acceptable.
- C. Joining ends of box units shall be accurately formed in accordance with details shown on the plans so that when units are placed together, they will make a continuous line of units with a smooth interior free of appreciable irregularities in the flow line, all compatible with specified tolerances. Precast box culvert units shall be laid with the bell end upstream. In absence of tolerances specified elsewhere, the maximum gap at adjoining ends of box units from a snug fit shall be ½ inch. Exterior top and side wall joints shall be filled with mastic prior to backfilling. Interior bottom and side wall joints shall be filled with mastic. Mastic material shall be approved by the Engineer.
- D. Box units shall be placed on fully compacted pervious backfill material meeting the requirements of SECTION 041002.5A. The material shall be at least 1 foot in thickness and shall extend at least 1 foot beyond each side of the outer limits of the box units. The side slope at the edges of the material shall be one-to-one. Railroad track and other areas shall be protected during construction by protective shoring in accordance with SECTION 04100.
- E. Following installation of box units, lifting devices shall be removed as indicated on the plans or approved shop drawings. Holes in concrete shall be filled with non-shrink grout. Recesses in concrete shall be patched with epoxy mortar.
- F. When multi-cells are used, a 1-1/2 inch minimum space shall be left between adjacent sections. After the precast cells are in place and backfill has been placed to mid-height of the precast concrete box sections on each side, the space between the cells shall be filled with concrete having a 7-day design compressive strength of 2,500 psi. The concrete shall be in accordance with SECTION 04400, except the maximum size coarse aggregate shall be 3/8 inch. If shown in the plans, multi-cells may be bolted together in accordance with the plans and special provisions.

3.16 WRITTEN REPORTS

- A. Reports of daily pour data for each product. These shall include, but not be limited to: reinforcing steel reference, set-up check list, concrete pour check list, i.e. time of day, slump, temperature (ambient and concrete), number of yards, air entrainment, unit weight, and/or other admixtures, mix design, curing time start and end, cylinder breaks at stripping and at 28 days, average and maximum temperatures, weight of piece and post pour inspection.

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PART 4 MEASUREMENT AND PAYMENT

4.1 PRECAST AND PRECAST, PRESTRESSED CONCRETE MEMBERS

- A. Precast and precast, prestressed concrete members will be measured as individual units, complete in place.
- B. Precast and precast, prestressed concrete members shall be paid for at the contract price per unit as designated on the plans. This price shall include full compensation for furnishing all material, unless otherwise specified, and for all equipment, tools, labor and incidentals necessary to fabricate, handle, store, transport and erect the unit in accordance with the plans and to complete the work. This price shall include furnishing, unless otherwise specified, and placing any necessary tie rods, bearings, anchor bolts or rods, apron and deck plates, curb plates and angles, epoxy adhesives, epoxy or non-shrink grouts, expansion boards, and other accessories to complete the work.

4.2 PRECAST CONCRETE BOX CULVERTS

- A. Precast concrete box culverts will be measured as individual units of the size and length specified on the plans, complete in place.
- B. Precast concrete box culverts shall be paid for at the contract price per unit of the size and length specified on the plans. This price shall be full compensation for furnishing all material and for all equipment, tools, labor and incidentals necessary to fabricate, handle, store, transport and place the unit in accordance with the plans and to complete the work. This price shall also be full compensation for furnishing and placing compacted pervious backfill material under the units and cast-in-place concrete between multi-call units and in collars, when shown on the plans, connecting precast concrete wingwall and apron units.
- C. Structure excavation required for the placement of pervious backfill bedding materials and the precast concrete units, together with the required structure backfill will be measured and paid for under the provisions of SECTION 04100.
- D. When cast-in-place concrete wingwalls and aprons are shown on the plans, measurement and payment for this work will be made under the provisions of SECTION 04400.

END OF SECTION

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SECTION 04600 STEEL CONSTRUCTION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Steel Construction

1.2 SAFETY

- A. Contractor is responsible for performing all steel construction operations in compliance with the current state, local, federal, FRA and OSHA regulations, paying special attention to the fall protection.

1.3 DESCRIPTION

- A. These specifications shall govern the furnishing, fabricating, and erecting of steel structures including the furnishing, erecting and removal of falsework and special erecting devices, as required, and structural steel portions of other structures in accordance with these specifications, the special provisions, and the details shown on the plans.

1.4 SUBMITTALS

- A. The Contractor shall submit drawings and design calculations showing the proposed design, method of construction and removal of falsework and special erecting devices, as required. These drawings and design computations, stamped by a licensed professional structural engineer in the state where the work is to be done, shall be submitted to the Engineer and approved prior to the start of construction. This approval shall not relieve the Contractor of responsibility for the falsework or special erecting devices.

PART 2 MATERIALS

2.1 STRUCTURAL STEEL

- A. All design, material erection and its fabrication shall be in accordance with Chapter 15, Parts 1 and 3, of the AREMA Manual for Railway Engineering and as specified in the special provisions or on the plans.
- B. Steel construction shall be cleaned and painted or galvanized, as applicable, in accordance with SECTION 04620.

2.2 STRUCTURAL BOLTING

- A. Bolts and nuts shall be furnished by the same supplier to ensure proper fit.
- B. Rotational-capacity tests shall be performed on all black or galvanized bolt, nut and washer assemblies by the manufacturer or distributor prior to shipping. Each combination of bolt production lot, nut lot and washer lot shall be tested as an assembly and a rotational-capacity lot number assigned to each combination of the lots tested. The manufacturer or distributor shall furnish, to the Engineer, a manufacturer's certified test report (MCTR) or a distributor's certified test report (DCTR) for each rotational-capacity lot furnished. The MCTR or DCTR shall include the results of all tests; location of where bolt assembly components were manufactured; the date and location of

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the tests; results of the R-C tests and a statement that the materials represented by the test report conform to the specifications.

- C. Bolts shall be of such length that they will extend entirely through their nuts and approximately 1/4 inch beyond them and the full threads shall extend no more than 3/8 inch into the grip.

2.3 FALSEWORK

- A. Falsework materials shall be in accordance with the Contractor's drawings, when applicable, and approved by the Engineer.

2.4 LIQUID TYPE EPOXY

- A. The liquid type epoxy shall be a two component, epoxy-resin bonding system conforming to the requirements of ASTM C881, Type IV, Grade 2, Class B or C. The class supplied shall be governed by the range of temperatures for which the materials is to be used.

2.5 HANDLING AND STORING MATERIALS

- A. All material shall be handled in a manner which will prevent members from being distorted or damaged. Stored material shall be piled securely, and no material shall be placed closer than 25 feet to the centerline of the nearest tracks. Material shall be placed on level platforms, skids, or other supports above the ground and shall be kept clean and properly drained. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent damage from deflection.
- B. For those members designated as Nonredundant Steel Tension Members (NSTMs); the following shall apply: extraordinary care shall be taken in the handling of NSTMs. Lifting dogs, tongs, grips, chains, cables, or other lifting devices placed in direct contact with the NSTM which may gouge, scratch, score, scrape, or otherwise damage the surface, edges or corners of NSTMs shall not be used. Procedures for handling NSTMs using lifting straps, timber cushions or other protective devices shall be developed, submitted to the Engineer, and receive written approval by the Engineer before handling any material for or members designated as NSTM.
- C. All materials shall be carefully loaded so as to avoid injury in transit. Members weighing more than 3 tons shall have the weight marked thereon. All small parts such as rivets, bolts, pins, washers, and small connection plates shall be packed in containers, of adequate strength. The contents of each unit shall be plainly marked on the top of each container.
- D. Girders shall be shipped in an upright position and adequately blocked and braced to prevent damage during shipping. The Fabricator shall submit girder loading diagrams to the Engineer for approval well in advance of the anticipated shipping date. These diagrams shall include proposed blocking, bracing and tie-down details.

PART 3 EXECUTION

3.1 ERECTION

- A. Methods and Equipment:
 - 1. Before starting work, the Contractor shall advise the Engineer fully as to the method he proposes to follow, and the amount and character of equipment he proposes to use, which shall be subject to the approval of the Engineer. The approval of the Engineer shall not be considered as relieving the Contractor of the responsibility for the safety of his method or equipment or from carrying out the work in full accordance with the plans, specifications and special provisions.

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2. No field welding or flame cutting will be allowed on the steel spans unless shown on the plans or authorized in writing by the Engineer. Tack welding, for the purpose of eliminating field erection bolts or for holding steel parts together while bolting, will not be permitted.
 3. The Contractor shall provide the falsework, special erecting devices and all tools, machinery and appliances, including drift pins and erection bolts, necessary for the expeditious handling of the work. Drift pins sufficient to fill at least 1/4 of the bolt holes for main field connections shall be provided.
 4. All steel beams or girders placed shall be securely tied and/or braced to prevent overturning immediately after erection, and until diaphragms, floor beams or cross frames are permanently in place. The methods to be used shall be submitted on the erection drawings. When railroad or roadway traffic must be maintained beneath girders or beams already placed, traffic shall be protected against falling objects during the erection of diaphragms and other structural members, during the placing of cast-in-place concrete and during the erection and dismantling of forms. The protection shall consist of nets and/or flooring with no larger than 1-inch openings.
- B. Falsework:
1. The falsework shall be constructed in accordance with the Contractor's plans, approved by the Engineer, and shall be properly maintained.
 2. Equipment for removing falsework shall not be operated upon or attached to any portion of the new structure.
- C. Assembling Steel:
1. All parts shall be accurately assembled as shown on the plans and any match marks carefully followed. The material shall be carefully handled so that no parts will be bent, broken or otherwise damaged. Hammering which will injure or distort the members will not be permitted. Drifting done during erection shall be only such as required to bring the parts into position and enlarging the holes or distorting the metal will not be permitted.
 2. Bearing surfaces shall be cleaned of all dirt, loose rust and mill scale, grease, and paint just before the members are assembled. Wire brushes, scalers, solvents or flame shall be used to clean the surfaces under the direction of the Engineer.
 3. Fitting up bolts shall be 1/16 inch less in diameter than the hole, and cylindrical erection pins shall be 1/32 inch less in diameter than the hole.
 4. Unless erected by the cantilever method, truss spans shall be erected on blocking so placed as to give the trusses proper camber until all lower chord splices are fully connected, as called for on the plans, and all other connections are made with pins and fitting up bolts. Trusses erected by the cantilever method shall have all lower chord splices fully connected before the span is swung on intermediate falsework or permanent shoes. If necessary, such as in the case of high falsework subject to settlement, jacks shall be provided under panel points to enable making necessary adjustments to facilitate fitting up without heavy drifting. Splices of butt joints in compression members shall not be fully connected until the span has been swung. Full bearing shall be secured on milled surfaces that are designed to bear.
 5. Sole plates on beams and girders shall be in full contact with bearings before diaphragm, cross frame, or floor beam connections are made. Connections shall be adjusted as necessary, under the direction of the Engineer, to obtain full contact.
 6. Bridge handrails shall be erected plumb and in line in accordance with the drawings. Maximum vertical tolerance is +/- ¼ inch from plumb line over the full vertical height. Maximum horizontal tolerance is +/- ½ inch over the full length of the bridge rail.
- D. Misfits and Straightening of Bent Material:
1. The correction of minor misfits involving harmless amounts of reaming, cutting, and chipping and the straightening of minor cases of bent bars, plates, and the outstanding legs of angles, etc., shall be considered a legitimate part of the erection and shall be done by the Contractor

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at his expense. However, any error in the shop fabrication, or deformation resulting from handling and transportation which prevents the proper assembling and fitting up of parts by the moderate use of drift pins, or by a moderate amount of reaming, slight chipping or cutting, shall be reported immediately to the Engineer who will specify the method of correction to be used by the Contractor. The correction shall be made in the Engineer's presence.

2. The straightening of bent materials, when permitted by the Engineer, shall be done by methods that will not produce fracture or other injury. Distorted members shall be straightened by mechanical means or, if approved by the Engineer, by the carefully planned and supervised application of a limited amount of localized heat. The temperature of the heated area shall not exceed 1200 degree F (a dull red which may not be visible in bright sunlight) as controlled by temperature indicating crayons, liquids or bimetal thermometers. Parts to be heat straightened shall be substantially free of stress and from external forces, except stresses resulting from mechanical means used in conjunction with the application of heat. After heating and straightening, the metal shall be cooled as slowly as possible. Following the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fracture.
3. When, in the opinion of the Engineer, excessive misfits and deformed material are not due to the Contractor's negligence, the correction of the misfits and straightening of the deformed material shall be done by the Contractor, when directed by the Engineer, and will be paid for by the Company as "Force Account Work," providing the material was furnished by the Company.

E. Bearings and Anchorage:

1. Bearings shall be set level in exact position and shall have full and even bearing upon the bridge seat areas. All bearings shall be set so as to be at the proper location at a temperature of 60 degree F under full dead load. At this temperature, rockers shall be vertical, bearings shall be centered under the structure center line of bearing, and sliding plates shall be centered on the bearing plates.
2. The area of concrete under bearings shall be bush-hammered if necessary to provide a full and even bearing at the correct elevation. When the bridge seat is more than 1/8 inch below plan elevation, the bearings shall be raised to grade on steel plate of the same size as the bearing. The plates shall be provided by the Contractor at his expense and attached to the bearings in a manner satisfactory to the Engineer.
3. Portland cement in a stiff paste form shall be spread over the bush-hammered areas just before the bearings are set. The maximum amount of cement which will be permitted will be no more than necessary to remove irregularities in the concrete with no intent of raising the bearings.
4. Finished surfaces of bearings in moving contact shall be cleaned and greased when the bearings are placed.
5. Holes for anchor bolts shall be drilled in the bridge seat in exact locations. Holes shall be approximately 1/4 inch larger in diameter than the bolt. An approved liquid type epoxy supplied by the Contractor at his expense shall be used to set the anchor bolts. Before placing the bolts, the holes shall be cleaned of all dust and loose material by flushing with water, after which holes shall be blown dry. After all steel is in place and the bearings are set, the anchor bolts shall be set accurately with sufficient epoxy placed in the bottom of the holes so that after a bolt is inserted, the hole will be completely filled. The bolts shall not be disturbed in any way for at least 24 hours, or until the epoxy is set. Mixing and use of epoxy shall be as recommended by the manufacturer of the epoxy.

F. **Pin Connections:** All packing washers, if any, must be in place when the work is assembled. While pins are being driven into place, threads shall be protected by pilot and driving nuts supplied by the Contractor. After nuts are tightened, the threads adjacent to the nut shall be burred a minimum of two threads at two locations opposite of each other.

G. High Strength Bolted Connections:

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1. Connected Material:
 - (a) Connections shall be accurately fitted up before high strength bolts are placed. A sufficient number of the holes at a connection point shall be filled with erection pins to "fair-up" all holes. Light drifting will be permitted, but drifting to match unfair holes will not be permitted. Such holes shall be reamed or drilled under the direction of the Engineer.
 - (b) All material within the grip of the bolt shall be steel. There shall be no compressible material such as gaskets or insulation within the grip.
 - (c) Unless otherwise indicated on the plans, bolts oriented vertically shall be installed with the heads on top of the connected pieces.
2. Surface Conditions:
 - (a) All joint surfaces, including those adjacent to the bolt heads, nuts or washers, shall be free of dirt, loose rust, loose scale, burrs and other matter that will prevent solid seating of the parts.
 - (b) Unless otherwise shown on the plans, faying surfaces of all nongalvanized joints, including splice plates, shall be given a blast cleaning, in accordance with the requirements of the Steel Structures Painting Council Specifications SSPC-SP7 Brush-Off Blast Cleaning, and shall be free of loose rust prior to final bolting.
 - (c) Galvanized faying surfaces shall be roughened by hand wire brushing prior to final bolting.
 - (d) When shown on the plans, faying surfaces shall be blast cleaned and coated with a paint that provides the specified mean slip coefficient as determined by the "Test Method to Determine the Slip Coefficient for Coatings Used in Bolted Joints" as adopted by the Research Council on Structural Connections. Coated joints shall not be assembled before the coating has cured for the minimum time used in the qualifying test.
3. **Handling and Storage of Fasteners:** Bolts and nuts shall be protected from dirt and moisture at the job site. Only as many fasteners as are anticipated to be installed and tightened during a work day shall be taken from protected storage. Fasteners not used shall be returned to protected storage at the end of the day. Fasteners shall not be cleaned of lubricant that is present in the as-delivered condition. Fasteners that show signs of rust or dirt shall be cleaned and relubricated prior to installation. Any additional lubrication required must be applied prior to installing bolts in the holes. ASTM A325 or ASTM A490 bolts and associated nuts and washers shall be identified by rotational-capacity lot number and stored in a manner that will retain this identification.
4. Bolt Installation:
 - (a) Bolts shall be installed with a hardened washer under the nut or bolt head, whichever is the element to be turned in the tightening. In addition, a hardened washer shall be used under the non-turned element of ASTM A490 bolts if the material against which it bears has a specified minimum yield point less than 40 ksi. Bolts must be used with nuts and washers from the same rotational-capacity lot. Unless Lock-Pin and collar Connections are utilized according to paragraph H, tightening of high strength bolts shall be accomplished by the "turn-of-nut" method according to paragraph 5. A Skidmore-Wilhelm Bolt Calibrator or equal is required on each job per paragraph 5(a).
 - (b) If the hole diameter is more than 1/16 inch greater than the nominal bolt diameter, hardened washers shall be placed under both head and nut.
 - (c) Where necessary, washers may be clipped on one side to a point not closer than seven-eighths of the bolt diameter from the center of the washer.
 - (d) Surfaces of bolted parts in contact with the bolt head, nut or flat hardened washer shall not have a slope of more than 1:20 with respect to a plane normal to the bolt axis. When an outer face of the bolted parts has a slope of more than 1:20, a smooth hardened beveled washer shall be used to compensate for the lack of parallelism.

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- (e) 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.
- (f) All bolts shall be tightened to give at least the required minimum bolt tension values shown in Table 1 on completion of the joint:

Nominal Bolt Diameter (in)	Tension (lbs)	
	A325	A490
½"	12,000	15,000
5/8"	19,000	24,000
¾"	28,000	35,000
7/8"	39,000	49,000
1"	51,000	64,000
1 1/8"	56,000	80,000
1 ¼"	71,000	102,000

5. Turn-of-Nut Tightening:

- (a) A representative sample of not less than three bolts and nuts of each diameter, length and grade to be used in the work shall be checked at the start of work in a device capable of indicating bolt tension (Skidmore-Wilhelm Bolt Calibrator or equal). The test shall demonstrate that the method of estimating the snug tight condition and controlling turns from snug tight to be used by the bolting crews develops a tension not less than 5 percent greater than the tension required by Table 1.
- (b) Bolts shall be installed in all holes of the connection and brought to a snug tight condition. Snug tight is defined as the tightness that exists when the plies of the joint are in firm contact. This may be attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Snug tightening shall progress systematically from the most rigid part of the connection to the free edges, and then the bolts of the connection shall be retightened in a similar systematic manner as necessary until all bolts are simultaneously snug tight and the connection is fully compacted.
- (c) Following this initial operation all bolts in the connection shall be tightened further by the applicable amount of rotation specified in Table 2. During the tightening operation there shall be no rotation of the part not turned by the wrench. Tightening shall progress systematically from the most rigid part of the joint to its free edges.

Bolt Length (in)	Both faces normal to bolt axis	One face normal to bolt axis and other face sloped not more than 1:20 (beveled washer not used)	Both faces sloped not more than 1:20 from normal to the bolt axis (beveled washer not used)
Up to and including 4 diameters	1/3 turn	½ turn	2/3 turn
Over 4 diameters but not exceeding 8 diameters	½ turn	2/3 turn	5/6 turn

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Over 8 diameters but not exceeding 12 diameters	2/3 turn	5/6 turn	1 turn
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- (d) Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. For bolts installed by 1/2 turn and less, the tolerance should be plus or minus 30 degrees; for bolts installed by 2/3 turn and more, the tolerance should be plus or minus 45 degrees.
6. ASTM A490 bolts and galvanized ASTM A325 bolts shall not be reused after having once been fully torqued. These same type bolts may be used for both fitting up and final bolting if tightened to no more than snug fit during fitting up. Other ASTM A325 bolts may be reused after having been torqued only once if approved by the Engineer.
- H. Lock-Pin and Collar Connections:
1. Connections shall be accurately fitted up before lock-pins are placed. A sufficient number of the holes at a connection point shall be filled with erection pins to "fair-up" all holes. Light drifting will be permitted, but drifting to match unfair holes will not be permitted. Such holes shall be reamed or drilled under the direction of the Engineer. Parts shall fit solidly together when assembled without interposition of gaskets or other compressible material.
 2. When assembled, all joint surfaces, including those adjacent to the lock-pin heads and to the collars, shall be free of dirt, loose rust and scale, burrs and other defects that would prevent solid bearing of the parts. In addition, surface requirements shall be in accordance with Paragraph G.
 3. If the hole diameter is more than 1/16 inch greater than the nominal lock-pin diameter, hardened washers shall be placed under both the lock-pin head and collar, adjusting pin length if required for grip length. Where necessary, washers may be clipped on one side to a point not closer than seven-eighths of the nominal lock-pin diameter from the center of the washer. Surfaces of connected parts in contact with lock-pin head, collar or flat hardened washer shall not have a slope of more than 1:20 with respect to a plane normal to the lock-pin axis. When an outer face of the connected parts has a slope of more than 1:20, a smooth hardened beveled washer shall be used to compensate for the lack of parallelism.
 4. Driving of lock-pin and collar fasteners shall be done by a special driving tool capable of producing the required tension in the shank of the fastener and capable of swaging the collar into the annular locking grooves, forming the collar to the proper size and shape as recommended by the manufacturer, before the pull-groove section is removed. The expendable pull-groove section shall be recovered from the driving tool as it breaks from the shank, and shall not be permitted to drop in such a manner as to create a hazard.
- I. **Welded Connections:** Workmanship and technique, qualification of welders and welding operators, and inspection for field welded connections shown on the plans or authorized by the Engineer shall be in accordance with the ANSI/AASHTO/AWS D1.5 Bridge Welding Code.
- J. Steel construction shall be cleaned and field painted in accordance with SECTION 04620.

PART 4 MEASUREMENT AND PAYMENT

4.1 STEEL CONSTRUCTION

- A. Steel Construction will be measured as a Lump Sum unit of completed work, acceptable to the Railroad and Engineer, ready for operation.
- B. Steel Construction will be paid at the contract Lump Sum price, which shall be full compensation for furnishing all labor, materials, tools, supplies, equipment and incidentals necessary to complete the work, regardless of the weight of steel required. Payment will not be made for additional metal added for erection or other purposes unless otherwise approved.

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- C. The price paid for Steel Construction shall include furnishing all material, fabrication, shop work, weld inspection, transporting, storing, erecting, cleaning, surface preparation, painting, coating, falsework and all incidentals necessary to complete the work.
- D. Unless listed to be paid for separately or specifically designated to be included in another pay item, all castings, forgings, shoes and structural bearings of whatever materials specified, walkways, anchor bolts, grating, expansion joints, apron and deck plates, handrails, sealers and fillers in contact with metal work and all accessories such as hardware, fasteners, locks, chains and hinges shall be considered as Steel Construction for payment.

END OF SECTION

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SECTION 04610

RAIL JOINTS

PART 1 GENERAL

1.1 DESCRIPTION

- A. This section covers the furnishing and installation of movable miter rail joint systems.
- B. Scope of work for Rail Joints includes rider rails, lift rails, fixed rails, rail plates and impact pads, hydraulic cylinder assemblies, hydraulic cylinder trunnion pillow block bearings, proximity sensors for bridge control, materials, labor, tools, equipment, shop drawings, operations & maintenance manuals, lubrication charts, and performing all work, including aligning, lubrication, adjusting and testing necessary to install all the movable rail joint machinery complete and functional to the satisfaction of the Engineer
- C. Provide at no extra cost any device, material, labor or incidental not shown on the plans or specified herein yet required to complete the machinery.
- D. Structural steel supports for the hydraulic cylinder trunnion bearings shall be provided as part of structural work.
- E. Hydraulic power units and hydraulic piping for the hydraulic cylinders shall be provided as part of the bid item Fluid Power Equipment.
- F. Bridge control proximity sensors are to be wired, terminated, and adjusted as part of the bid item Electrical Work. Railroad signal system proximity sensors shall be provided, wired, terminated and adjusted by the BNSF.

1.2 SPECIFICATIONS

- A. The basis for design of the Rail Joints is the American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering specifications for movable bridges.

1.3 REQUIRED DRAWINGS AND DATA

- A. Shop Drawings
 - 1. Prepare and submit to the Engineer for approval shop drawings of the Rail Joints. See specifications for each item for additional submittal requirements.
 - 2. Identify any additional long-lead items not previously identified by the Railroad and submit shop drawings as early as practical for such items.
 - 3. Proprietary parts are shown in outline on the design drawings. Complete certified dimensions and performance data to enable a determination of the adequacy of the unit must be furnished as part of the submittals.
 - 4. Provide shop bills of materials, listing all parts by part number and quantity, on the shop drawings. The materials and specifications must be given for each part. Where standard specifications are used, the designating numbers shall be given.
 - 5. Dimensions given on the plans are nominal and intended for conceptual and estimating purposes only. Any variations from nominal dimensions on the plans must be noted. It is the contractor's responsibility to verify and adjust the dimensions given on plans and to verify dimensional compatibility of all components.
 - 6. Provide assembly and erection drawings with identifying marks and essential dimensions for locating parts and assemblies. It is the contractor's responsibility to achieve satisfactory

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construction and operation of the machinery, and approval of shop drawings by the Engineer does not constitute relief from this provision.

7. Provide start-up, adjustment and testing procedures for the Rail Joints lifting machinery. Coordinate start-up, adjustment and testing procedure with the fluid power equipment fabricator and installer.

B. Maintenance & Operations Manual

1. Provide six copies of an Operations & Maintenance (O&M) Manual covering all the Rail Joints provided under this pay item RAIL JOINTS. The O&M Manual shall include the following:
 - (a) Index of contents.
 - (b) Lubrication charts.
 - (c) Parts drawings and descriptions of proprietary units. Rail joints equipment orders.
 - (d) Manufacturer's instructions for installation, lubrication, adjustment and maintenance for each component.
2. Print the O&M Manual on 8.5" x 11" paper with 11" x 17" plan sheet fold-outs as required and bind in hard covers. Identify the index page with the name of the project, project number, owner, contractor and date of issue. Submit two copies to the Engineer for preliminary approval prior to preparation of the required number of copies to the Railroad.

C. Lubrication Charts

1. Provide one full-size (22" x 34") framed and glass-covered set of lubrication charts suitable for wall mounting in the new bridge house or existing maintenance shed. The Railroad shall determine location of lubrication charts.
2. Lubrications charts shall show all rail joints locations requiring lubrication. The frequency of lubrication and type of lubricant to be used shall also be shown on the chart in a tabular format.

D. Guarantee

1. The Contractor shall obtain and assign to BNSF Railroad all manufacturer's warranties or guarantees on all equipment, material or products furnished for or installed as part of the work.
2. The Contractor shall warrant the satisfactory in-service operation of the machinery systems, individual components, materials, and all related products. This warranty shall extend for a minimum period of one-year following the date of final acceptance of the entire project.

E. Machinery Equipment Orders

1. Copies of the Contractor's actual equipment orders shall be submitted to the Railroad after approval of shop drawings is obtained. Copies of the machinery equipment orders shall be placed in the Machinery Operations & Maintenance Manual.

1.4 SUBSTITUTIONS

A. Evaluation

1. If any departures from the plans or special provisions are deemed necessary by the Contractor, details of such departures and the reasons therefore shall be submitted in writing as soon as practicable to the Engineer for review. No such departures shall be made without written approval of the Engineer.
2. The use of alternate equipment is permitted. The specification of a manufacturer's name and part number is for the purpose of defining quality, configuration, rating and arrangement of parts. It shall be the Contractor's responsibility to submit any and all required information in order to allow the Engineer to evaluate equivalency.
3. The use of alternate equipment must in no way, as determined by the Engineer, degrade the intended performance of the machinery system, reduce the design safety factors, or have negative impact on the longevity and/or maintainability of the machinery.

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B. Equivalent Products

1. Equivalent products of another manufacturer may be substituted for the specified item upon approval of the Engineer provided that any changes necessary as a result of the substitution to related machinery, structural and electrical parts is made by the contractor at no additional cost.

PART 2 MATERIALS**2.1 QUALITY & REQUIREMENTS OF METALS**

- A. All materials shall be as specified on the drawings or as indicated in the special provisions.
- B. The current issue of all material specifications and standards shall be those in effect on the date of the bid for this project.
- C. All materials furnished for machinery shall be new, clean, and free of defects.
- D. Materials supplied which are not specified by the drawings or special provisions shall be commercially available documented materials acceptable to the Engineer.

2.2 MACHINERY SUPPORTS

- A. See special provisions for requirements for structural steel. See plans for structural steel details.
- B. Structural steel shall be ASTM A709, Grade 50W.

2.3 HIGH STRENGTH BOLTS

- A. Provide high strength ASTM A325 or A490 cut thread, washer faced, hexagonal head bolts. SAE Grade 8 material is allowed for smaller diameter fasteners such as machine and set screws.

2.4 KEYS

- A. Effectively secure all keys in place, preferably by setting into closed-end milled keyways into the shaft. Keyways must not extend into any bearing. Locate keyways 120 degrees apart where two keys are used in a hub. Use AISI 4340 material heat treated to 150 ksi ultimate strength for all keys.

2.5 SHIMS

- A. Shims 1/4" or less in thickness shall be stainless steel. Drill shims for all bolts that pass through and trim to the dimensions of the assembled unit. Sufficient thickness must be provided to permit 1/32 inch variations of the shim total. Provide at least 50 percent greater total thickness of shims than the nominal shim thickness shown on the design plans or shop drawings.

PART 3 EXECUTION**3.1 WELDMENTS**

- A. Dimensions indicated on the plans are nominal and must be verified by the contractor. Revise dimensions as necessary to accommodate the certified dimensions of specified or alternate equipment.
- B. All welding must be done in the shop and be inspected and tested in accordance with the approved shop drawings, Standard Specifications and the AWS welding code prior to stress relieving. Stress relieve all welds. Perform all tests at the expense of the contractor and at the direction of the Railroad or its representative.

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- C. Submit certified test reports to the Engineer. The BNSF or its representative may send an inspector for observing the weld testing. Notify the BNSF or its representative at least two weeks prior to the scheduled testing. The inspector will have the authority to reject the welds at any time during the testing. Welded components must be given a stress relief heat treatment after welding. Submit for approval a description of the heat treatment procedure.

3.2 RAIL JOINTS

A. Lift Rails And Fixed Rails

1. The lift rails and fixed rails shall be machined from lengths of new rail. One end of each rail shall be machined to fit the rider rail segment and holes shall be drilled for web bars and track bars. Web bars shall be bolted to the rails at the rider rail end to provide additional support of the rail head.
2. All bolting shall be self-locking to prevent loosening in service.
3. The lift rail shall have a guide block to assure proper alignment at closure.
4. The gap between the lift rails and fixed rails shall be as recommended by the Rail Joints fabricator.

B. Rider Rails

1. Rider rail segments shall bridge the gaps between the lift and fixed rails. Rider rails shall be made of hardened alloy steel for longer service life.
2. Rider rails shall be slightly lower than the running rail at its ends and slightly higher than the running rail at its center to create a gentle radius to smoothly carry the train wheel over the gap between the rails.
3. Rider rails shall be bolted to the fixed rail and shall remain stationary during lift rail operation.

C. Rail Plates

1. Rail plates shall be fabricated and machined from steel plate. Rail plates shall include grooves for the rail foot and holes for bolting to the ties. The grooves shall be machined with a slant toward track center.
2. Rail plates shall be provided with shoulders adjacent to the groove for Pandrol "E" clips to fasten the rail to the rail plates.
3. Fixed rail plates shall be provided with guide shoes to guide the lift rails into position during lowering of the lift rails.

D. Impact Pads

1. An impact pad shall be provided under each rail plate for vibration damping and shock absorption.

E. Steel Ties

1. Steel ties shall be provided in conformance with the requirements for Track Work.

F. Hydraulic Cylinder Assemblies

1. A hydraulic cylinder assembly shall be provided to raise and lower each lift rail.
2. Each hydraulic cylinder assemblies shall consist of a hydraulic cylinder and return springs enclosed in a protective cover. Fluid pressure extends the cylinder to raise the rail. The return springs retract the cylinder and provide pulldown force to secure the rail in the down position.
3. Hydraulic cylinders shall be of the bore, stroke and rod diameter as shown on the plans or recommended by the rail joints fabricator. Hydraulic cylinders shall be rated for 3000 psi continuous operation and have SAE straight thread ports.

G. Pillow Block Bearings

1. Pillow block bearings shall be provided, or as recommended, by the rail joints fabricator.

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3.3 PROTECTION AND PAINT

- A. Rail Joint parts shall be completely protected from weather, dirt and foreign materials during manufacture and be stored indoors while awaiting erection. All external exposed surfaces that are not painted and are made of a corroding metal must be coated with a rust-inhibiting compound. Store all machinery indoors until installation on the bridge.
- B. Grease and wrap exposed shaft journals in oil-soaked burlap and securely timber lagged for shipment.
- C. Crate and/or skid protect assembled units, such as bearings, for protection during handling, shipment or storage.
- D. Place mounting hardware and other small parts in plastic bags containing vapor phase, rust-inhibiting crystals.
- E. Tags recording the part number must be wired to each part prior to shipment.
- F. Any equipment found to be corroded or otherwise damaged due to improper protection, storage or shipment must be repaired or replaced to the department's satisfaction at the no extra cost.
- G. Clean and paint all unfinished surfaces of rail joint machinery and equipment. Structural steel installed, altered, modified or disturbed in connection with rail joint installation and requiring painting as a result of this work must also be painted. Provide final field coat color as designated by the BNSF. Perform all cleaning and painting in accordance with the requirements of approved BNSF procedures.

3.4 INSTALLATION AND ADJUSTMENT

- A. Shim lift rail machinery equipment and supports as required for proper rail joints alignment.
- B. The operating speed of the lift rails and synchronization of each lift rail pair shall be adjusted by means of the adjustable flow control valves located at each hydraulic power unit.
- C. Coordinate adjustments of the lift rail machinery with the adjustment requirements of the fluid power system equipment.

3.5 TESTS AND PRELIMINARY OPERATION

- A. Initial start-up and preliminary operational testing of the lift rail machinery shall be as recommended by the fluid power system fabricator.

3.6 FINAL ACCEPTANCE TESTS

- A. Perform Final Acceptance Testing of the completed Rail Joints in the presence of the Engineer to test normal operation through at least ten lift rail raise/lower cycles using the specified hydraulic power units.
- B. Properly lubricate all machinery components prior to and, if necessary, during Final Acceptance Testing with the approved lubricants. Observe all components during testing to detect incorrect adjustment, misalignment, overheating or other malfunctions. Correct any defects and repeat Final Acceptance Testing.

3.7 SPARE PARTS

- A. The following spare parts shall be provided:
 - 1. Hydraulic cylinder assembly
 - 2. One pillow block bearing for hydraulic cylinder trunnion shaft
 - 3. One clevis weldment for attachment of hydraulic cylinder to lift rail

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PART 4 MEASUREMENT AND PAYMENT

4.1 RAIL JOINTS

- A. Rail Joints will be measured as a Lump Sum unit of completed work, acceptable to the Railroad and Engineer, ready for operation.
- B. Rail Joints shall be paid for at contract lump sum price under the bid item Rail Joints.
- C. Payment is full compensation for furnishing all material and labor required to fabricate and install in working order the Rail Joints work as shown on the plans and as described herein; and for furnishing all tools, equipment and incidentals necessary to complete all work required under this bid item.

END OF SECTION

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SECTION 04620

PROTECTIVE COATINGS FOR STEEL SURFACES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Cleaning and Painting
- B. Hot Dip Galvanizing
- C. Petrolatum Application

1.2 DESCRIPTION

- A. These specifications shall govern the surface preparation, surface pretreatment, and application of protective coatings to steel structures and the steel portions of other structures, all in accordance with the plans, specifications and special provisions.
- B. Weathering Steel:
 - 1. ASTM A588 or ASTM A709, Grade 50W and ASTM A852 or ASTM A709, Grade 70W weathering steel, in order to provide a sound uniform surface for the formation of the protective oxide, shall be blast cleaned in the fabricating shop in accordance with the requirements of the Steel Structures Painting Council Specification SSPC-SP6 "Commercial Blast Cleaning."
 - 2. Contamination of blast cleaned surfaces shall be avoided through the completion of work and all contaminants such as oil, grease and dirt shall be promptly removed.
 - 3. Unless otherwise shown on the plans or in the special provisions, weathering steel shall not be shop or field painted.

1.3 PROTECTION AGAINST DAMAGE

- A. The Contractor shall provide protective devices such as tarps, screens or covers as necessary to prevent damage to the work and to other property or persons from all cleaning and painting operations.
- B. Paint or paint stains that result in an unsightly appearance on surfaces not designated to be painted shall be removed or obliterated by the Contractor at the Contractor's expense and to the satisfaction of the Engineer.
- C. All painted and galvanized surfaces that are marred or damaged as a result of operations of the Contractor shall be repaired by the Contractor, at the Contractor's expense, with materials and to a condition equal to that of the coating specified.
- D. Upon completion of all painting operations and of any other work that would cause dust, grease, or other foreign materials to be deposited upon the painted surfaces, the painted surfaces shall be thoroughly cleaned.

1.4 HANDLING, STORAGE AND SHIPPING

- A. All blocks, chains, slings, braces, clamps, etc., used in the handling, moving, storing and shipping of painted and galvanized members shall be padded in such a manner that the coating will not be damaged.
- B. Articles shall be loaded and stored to prevent the formation of wet storage stains.
 - 1. The material shall be loaded in such a manner that continuous drainage could occur.

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2. In storage, the articles shall be raised from the ground and, if necessary, separated with strip spacers to provide free access of air to most parts of the surface. They shall also be inclined in a manner which will give continuous drainage. Under no circumstances shall the steel be allowed to rest on cinders nor shall it be stored on wet soil or decaying vegetation.

1.5 WEATHER CONDITIONS

- A. Protective coatings shall be applied only on thoroughly dry surfaces and during periods of favorable weather.
- B. Painting will not be permitted when the atmospheric temperature, paint, or the surface to be painted is at or below 40 degree or above 100 degree F, or when metal surfaces are less than 5 degree F above the dew point, or, unless approved in writing by the Engineer, when the humidity exceeds 80 percent at the site of the work.
- C. Application of paint will not be permitted when freshly painted surfaces may become damaged by rain, snow, fog, or condensation, or when it can be anticipated that the atmospheric temperature or relative humidity will not remain within the specified application conditions during the drying period, except as provided in Paragraph E for enclosures.
- D. Painting shall not be done when the steel is hot enough to cause the paint to blister or produce a porous paint film.
- E. Subject to approval by the Engineer in writing, the Contractor may provide suitable enclosures to permit painting during inclement weather. Provisions shall be made to control atmospheric conditions artificially inside the enclosures within limits suitable for painting throughout the painting operation and drying period. Full compensation for providing and maintaining the enclosures shall be considered as included in the prices paid for the various contract items of work requiring paint and no additional compensation will be allowed therefor.
- F. If fresh paint is damaged by the elements, it shall be replaced or repaired by the Contractor at the Contractor's expense.
- G. If, in the opinion of the Engineer, there is an objectionable amount of dust in the atmosphere, the contractor shall, at his own expense, take necessary precautions to prevent dust and dirt from coming in contact with freshly painted surfaces or with surfaces before the paint is applied.

1.6 SURFACES IN CONTACT WITH CONCRETE

- A. Tops of beams and girders that are to have concrete cast in contact with them shall not be painted. Steel that is to be completely embedded in concrete shall not be painted.
- B. Pile plate surfaces, including shear stud connectors, in contact with and embedded in concrete shall not be painted. The exposed portion of pile plates shall be field cleaned and painted as specified in Section 3.5.
- C. Care shall be taken when painting steel that is in contact with concrete to insure full paint coverage on the steel. Concrete surfaces shall be masked or covered as necessary to prevent surface contamination. Paint on concrete surfaces shall be removed, at the Contractor's expense, in a manner approved by the Engineer.

1.7 CONTACT AND INACCESSIBLE SURFACES

- A. Surfaces in contact to be welded or bolted in the shop shall not be painted unless specified, but shall be cleaned of loose rust, scale and foreign material to meet the approval of the Engineer. Field contact surfaces shall not be painted. Surfaces not in contact, but which will be inaccessible after assembly or erection, shall be painted in the shop with the shop and field coats of the paint system required for the completed structure.

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- B. The bottom surfaces of masonry plates and surfaces of structural steel to be in contact with elastomeric bearing pads or preformed fabric pads shall be cleaned and painted with the full number of paint coats prior to erection.

1.8 MACHINE FINISHED SURFACES

- A. Machine finished surfaces of pins, pin holes, rollers or other finished surfaces that will be subject to friction, shall be coated as soon as practicable after being approved, with lacquer or an anti-rust compound. When anti-rust compound is used, it shall be removed at the time of erection.
- B. While still in the shop, machine finished surfaces and inaccessible surfaces of rocker or pin-type bearings shall receive the full paint system.

1.9 ERECTION MARKS

- A. Erection marks and match marks shall be painted upon areas not visible to view after erection or upon areas that have received the shop paint.

1.10 SIGNS AND EMBLEMS

- A. When designated, signs and/or company emblems as shown on the plans shall be painted on specified structures by qualified sign painters. This work shall not be started until the underlying finish coat is completely dry and the exact locations have been specified by the Engineer.

PART 2 MATERIALS

2.1 PAINT

- A. Paint systems and materials shall be as specified on the plans or in the special provisions.

2.2 ZINC FOR GALVANIZING

- A. Zinc for galvanizing shall conform to ASTM B6 and the requirements stated in ASTM A123 and ASTM A153 as applicable.
- B. Galvanized repair paint, Zinc Dust-Zinc Oxide Type I linseed oil paint, shall meet the Federal Specification, TT-P-641.

2.3 PETROLATUM

- A. Petrolatum is a rust inhibiting grease coating applied over surfaces free of loose rust, scale, and paint and shall be subject to the approval of the Engineer.

PART 3 EXECUTION

3.1 CLEANING AND PREPARATION OF ALL SURFACES TO BE PAINTED

- A. Unless otherwise prohibited by the special provisions, solvents shall be used to remove oil, grease, and other soluble contaminants in accordance with the requirements of the Steel Structures Painting Council Specification, SSPC-SP1, "Solvent Cleaning." Solvent cleaning shall be performed prior to blast cleaning. If contamination remains after blasting, the area shall be recleaned with solvent.
- B. After solvent cleaning, if permitted, all surfaces to be painted shall be blast cleaned in accordance with the requirements of the Steel Structures Painting Council Specification, SSPC-SP6,

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"Commercial Blast Cleaning." Special attention shall be given to the cleaning of corners and re-entrant angles. All cleaned surfaces shall have an anchor profile of 1 to 2.5 mils.

- C. Abrasives used for blast cleaning shall be either clean dry sand, mineral grit, steel shot, or steel grit, at the option of the Contractor, and shall have a suitable grading to produce satisfactory results. The use of other abrasives will not be permitted unless approved in writing by the Engineer. Unwashed beach sand containing salt or excessive amounts of silt will not be allowed.
- D. Before painting, all blast products shall be removed from the surfaces, and the cleaning shall be approved by the Engineer. The blast cleaned surfaces shall be given a coat of paint within 24 hours after cleaning, unless otherwise authorized by the Engineer. The surface must be painted before rust forms.
- E. In repainting existing steel structures, the method of cleaning will be specified in the special provisions. Any damage to sound paint, on areas not designated for treatment, resulting from the Contractor's operations shall be repaired by the Contractor at the Contractor's expense to the satisfaction of the Engineer.

3.2 PAINT APPLICATION

- A. Surfaces shall be painted as soon as practicable after they have been properly cleaned and approved for painting by the Company's inspector. Blast cleaning and painting operations shall be coordinated so that at all times the blast cleaning work will be carried on a sufficient distance from freshly painted surfaces to preclude any adhesion of grit in the fresh paint.
- B. All painting shall be done in accordance with the requirements of the Steel Structures Painting Council Specification, SSPC-PA1, "Shop, Field and Maintenance Painting."
- C. Unless otherwise specified three coats of paint shall be applied to all new structural steel (except "Weathering Steel"). The prime and intermediate coats shall be applied in the fabricating shop. The finish coat shall be applied in the field after erection. The dry film thickness of each coat shall be as specified on the plans or in the special provisions. Each coat shall differ enough in color from its preceding coat to make it easy to see voids in the fresh paint. Colors shall be as stated on the plans or special provisions as the Engineer directs. The final coat on any surface exposed to view shall be made with paint from a common batch. The Contractor shall provide the Engineer with a written method for verifying and certifying that the final coat is, in fact, from a common batch.

3.3 SHOP PAINTING

- A. Shop painting shall include the furnishing of all shop applied paint, the preparation and cleaning of surfaces, the application, drying and protection of the shop applied paint; and the supplying of all materials, tools and labor necessary to complete the work.
- B. Refer to Section 1.6 for surfaces in contact with concrete, Paragraph 1.7 for contact and inaccessible surfaces, and Paragraph 1.8 for machine finished surfaces.
- C. The fabricated steel shall not be loaded for shipment until the shop paint is dry and has been inspected and approved by the Engineer. Structural steel shall not be loaded for shipment sooner than 24 hours after application of paint. No painting shall be done after the material has been loaded for shipment.

3.4 FIELD PAINTING

- A. Field painting following shop painting and steel erection shall include the furnishing of all field applied paint, the cleaning of all surfaces as required, the application of the prime and intermediate coats on all surfaces not painted in the shop and on all shop painted surfaces damaged during handling and erection, the application, drying and protection of the finish paint coat and the supplying of all materials, tools and labor necessary to complete the work, including signs and emblems, and to protect surfaces not to be painted from contamination.

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- B. Field painting of steel not previously shop painted shall include the furnishing of all field applied paint, the cleaning of all surfaces, the application of the field applied paint coat, or coats as specified; and the supplying of all materials, tools and labor necessary to complete the work, including signs and emblems, and to protect surfaces not to be painted from contamination.

3.5 REMOVAL OF UNACCEPTABLE COATINGS

- A. All coatings applied improperly or which fail to dry or adhere properly, or do not evidence a normal, workmanlike appearance shall be remedied or completely removed and replaced under the direction of the Engineer and at the expense of the Contractor.
- B. When the final field coat does not have a uniform color and appearance throughout the structure, it shall be corrected by the use of whatever additional coats or other corrective measures found to be necessary. Freshly applied paint which has not yet set shall be removed with the use of suitable solvents. Removal of dried paint films shall be either by means of blast cleaning, scraping, or other methods meeting the approval of the Engineer.

3.6 INSPECTION

- A. All material and workmanship shall be subject to inspection by the Company's inspector.
- B. The Contractor shall provide all reasonable facilities, labor, materials, equipment, scaffolding and assistance for the safe and convenient conduct of all inspections.
- C. All surfaces will be inspected and approved prior to completion or proceeding to the next order of work.
- D. Such inspections shall not relieve the Contractor's responsibility for furnishing qualified labor, materials and workmanship in strict accordance with these specifications.
- E. Any work performed or results achieved which are not in strict accordance with these specifications shall be redone to meet these specifications at the Contractor's expense.

3.7 GALVANIZED STEEL

- A. When designated on the plans or in the special provisions, steel shall be galvanized as follows:
 - 1. Steel members, fabrications, and assemblies shall be galvanized after fabrication by the hot dip process in accordance with ASTM A123.
 - 2. Bolts, nuts and washers and iron and steel hardware components shall be galvanized in accordance with ASTM A153.
- B. After galvanizing, all elements shall be free of fins, abrasions, rough or sharp edges, and other surface defects. The galvanized coating shall be continuous, adherent, as smooth and evenly distributed as possible and free from any defect that is detrimental to the coated article.
- C. Damaged galvanized surfaces shall be thoroughly cleaned to remove all contaminants including weld slag, weld splatter, and rust and shall then be painted with two coats of galvanized repair paint meeting the requirements of Paragraph 2.2B.

3.8 PETROLATUM APPLICATION

- A. Petrolatum application shall include the furnishing of petrolatum as specified in Section 2.3, the cleaning of surfaces to remove loose rust, scale and dirt; the application of an approximately 1/32 inch thick coating on surfaces designated on the plans, in the special provisions or by the Engineer; and the supplying of all materials, tools and labor necessary to complete the work.

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PART 4 MEASUREMENT AND PAYMENT**4.1 PROTECTIVE COATINGS FOR STEEL SURFACES**

- A. Protective coatings for steel surfaces including surface cleaning and preparations, shop painting, field painting, hot dip galvanizing of steel items and petrolatum application shall be considered as incidental to other items of work and no measurement nor direct payment will be made therefor.

END OF SECTION

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SECTION 04700 STRUCTURE MONITORING

PART 1 GENERAL

1.1 DESCRIPTION

- A. This section covers the monitoring of existing bridge structures during construction. All monitoring shall be performed using qualified personnel and materials with a previous track record of monitoring railroad bridges. The Contractor must provide resumes and qualifications of specific staff and/or subcontractors that will perform the monitoring work as described.

PART 2 MATERIAL

2.1 CONTINUOUS SUBSTRUCTURE MONITORING SYSTEM

- A. The Contractor shall provide a system capable of continuously monitoring the existing bridge substructure during construction. The minimum requirements for the Substructure Monitoring System are as follows:
1. System shall measure tilt, vibration, and temperature for each substructure element.
 2. All monitoring instruments shall be IP67 rated or higher.
 3. Monitoring shall be continuous and autonomous.
 4. Monitoring data shall be collected continuously and stored for a minimum of 30 days.
 5. Monitoring equipment shall be capable of storing data in the event the connection to send the data remotely is lost. Once a connection is reestablished, all data collected in the down period must be synced and uploaded.
 6. Tilt sensors shall be capable of reporting measurements without a settling period.
 7. Monitoring data shall be accessible remotely via a secure log-in on an internet web page.
 8. Monitoring data shall be automatically backed up on a remote database.
 9. Monitoring system shall be configured to automatically send alerts via text, email, or voice if a pre-defined threshold is exceeded.
- B. The monitoring system shall be installed a minimum of two weeks, but preferably two months, prior to the start of construction to establish a baseline structural response. The Contractor shall be responsible for installing the instrumentation and providing continuous support, data interpretation, and data management for the duration of construction.
- C. The Contractor shall be responsible for protecting and preserving the monitoring instrumentation and shall replace any instrumentation destroyed, lost, or moved.

PART 3 EXECUTION

3.1 MONITORING PLAN

- A. Prior to the start of work, the contractor must submit a detailed monitoring plan for the structure. This should include location and type of all monitoring equipment and the identification of high-risk construction activities, such as drilled shaft construction, pile driving, etc.

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3.2 BASELINE SURVEY

- A. A baseline survey shall be conducted prior to the start of construction. The baseline survey scope of work shall consist of the following items at a minimum:
 - 1. Develop surveying plan.
 - 2. Install targets, prisms, or benchmarks on piers, abutments, and any other points as designated by the Engineer or Monitoring Plan.
 - 3. Set up control points and vertical datum outside the bridge.
 - 4. Survey each pier, abutment, and monitoring point.
 - 5. Create baseline survey map using a plan view or satellite view. Each monitoring point and control point shall be designed on the survey map.
- B. The baseline survey shall be carried out by qualified surveyors. The Contractor shall be responsible for protecting and preserving the established control points and will make no change or relocation without the prior written approval of the Engineer or Monitoring Subcontractor. The Contractor will report to the Engineer and Monitoring Subcontractor whenever any reference point is lost or destroyed or requires relocation because of necessary changes in grades or locations. The Contractor will replace and accurately relocate all reference points so lost, destroyed, or moved.

3.3 CONSTRUCTION SURVEY

- A. The Contractor shall survey all monitoring points during construction. The interval of surveying shall be determined by the Engineer and Monitoring Subcontractor. The Contractor shall be capable of conducting a survey within 1 hour in the event of an alert triggered by the Substructure Monitoring System during construction activities. The Construction Survey data shall be reported to the Monitoring Subcontractor for inclusion in the weekly monitoring report.
- B. In the event that the monitoring equipment loses power or breaks down, the Contractor will be responsible to perform a survey of the monitoring points immediately and reestablish the automated system as soon as feasible. If the monitoring system cannot be restored in a timely manner, the Contractor shall perform twice daily surveys (before and after work) of all monitoring points until the system is working continuously and autonomously.

3.4 REPORTING

- A. A baseline report shall be produced prior to construction start that summarizes the baseline survey and monitoring period. This report should clearly outline where equipment was placed, what assumptions about the nature of the structure were made, system log-in information, site and climate characteristics that may affect the bridge and any other pertinent reference information.
- B. Thresholds shall be developed that provide for the natural movement of the bridge due to environmental stimulation and that will not create alerts for normal railroad use. The creation of these bridge specific thresholds shall be created by a qualified engineer with experience in structure monitoring.
- C. During construction, the Contractor shall be responsible for submitting to BNSF a weekly report summarizing all monitoring data and survey data. The weekly report shall take into consideration the specific construction activities carried out during the week and if/how the existing bridge was affected by such activities.
- D. In the event of an alert above the established project thresholds, the Contractor shall be prepared to submit a summary report interpreting the alert and what construction activity possibly contributed to the alert.

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PART 4 MEASUREMENT AND PAYMENT**4.1 STRUCTURE MONITORING**

- A. All costs associated with monitoring movement of the existing piers and abutments as described are included in the cost of "Structure Monitoring."

END OF SECTION

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SECTION 04800 WATERPROOFING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Dampproofing
- B. Joint Waterproofing

1.2 DESCRIPTION

- A. Dampproofing:
 - 1. When called for on the plans, the dirt side of structures shall be dampproofed using one asphaltic prime coat and two coats of hot asphalt.
 - 2. All dampproofing materials shall be applied when temperature is above 40 degree F. and rain is not likely before completion of the application.
- B. Joint Waterproofing:
 - 1. When called for on the plans, the construction joint between the footing and neat work of piers, abutments and retaining walls shall be primed and waterproofed with two layers of treated fabric 18 inches wide, alternated with three coats of hot asphalt.
 - 2. All joint waterproofing materials shall be applied when temperature is above 40 degree F and rain is not likely before completion of the application.

PART 2 MATERIALS

2.1 DAMPPROOFING AND JOINT WATERPROOFING MATERIALS

- A. **Asphaltic Primer:** shall meet the requirements of the ASTM Designation: D 41.
- B. **Asphalt:** for dampproofing and joint waterproofing shall be Type 2 meeting the requirements of the ASTM Designation: D 449.
- C. **Asphalt Treated Cotton Fabric:** for joint waterproofing shall meet the requirements of the ASTM Designation: D 173.
- D. Others approved by the Engineer

2.2 STORING MATERIAL

- A. Waterproofing materials shall be stored in a manner to preclude damage. These materials shall be kept dry at all times and shall be stored in a warm area prior to use in cold weather and out of direct sunlight in hot weather.
- B. Asphaltic panels shall be stored so as to prevent warping and breaking.

PART 3 EXECUTION

3.1 DAMPPROOFING

- A. **Surface Preparation:** After all surface defects have been repaired and the curing requirements have been met, the specified clean and dry concrete surfaces shall be primed using material

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meeting the requirements of Paragraph 2.1A at a coverage rate of 1-1/4 gallons per 100 square feet. The prime coat may be brushed or sprayed on and, when necessary, may be thinned with mineral spirits up to 15 percent to facilitate application; however, no increase in area over that to be covered by the unthinned primer will be permitted. The application of primer shall be allowed to cure properly before applying the hot asphalt.

- B. **Application:** After the prime coat is dry, the hot asphalt meeting the requirements of Paragraph 2.1B shall be applied in two separate coats at a coverage rate of 4 gallons per 100 square feet for each coat. The asphalt shall be heated to not more than 350 degrees to permit uniform covering. The direction of application of the second coat shall be at 90 degrees to the direction of application of the first coat using care to insure that the surface of the concrete is completely sealed.
- C. **Backfilling:** A minimum drying time of 24 hours is required before backfilling. Cover or backfill within 72 hours after application. Backfill with care to avoid damage to dampproofed areas. Backfill shall not be placed until the structure has been inspected by the Engineer and approved for backfilling.

3.2 JOINT WATERPROOFING

- A. **Surface Preparation:** The asphaltic prime coat shall be applied in accordance with Paragraph 3.1A.
- B. **Application:** After the prime coat is dry, 18 inch wide treated fabric meeting the requirements of Paragraph 2.1C shall be centered over the construction joint and laid into a 4 gallons per 100 square feet mopping of hot asphalt meeting the requirements of Paragraph 2.1B. This same procedure shall be followed in applying the second layer of treated fabric after which a final mopping of hot asphalt at the same rate shall be applied. Splices in the treated fabric shall be lapped a minimum of 2 inches.

PART 4 MEASUREMENT AND PAYMENT

4.1 DAMPPROOFING

- A. Dampproofing will be measured by the square yard of surface area designated on the plans or directed by the Engineer to be dampproofed.
- B. Dampproofing shall be paid for at the contract unit price per square yard of dampproofing in place. This price shall include full compensation for furnishing all materials, unless otherwise specified, and all equipment, tools, labor and incidentals necessary to apply the dampproofing and complete the work.

4.2 JOINT WATERPROOFING

- A. Joint waterproofing will be measured by the lineal foot of joint between the neat work and the footing which is designated on the plans or by the Engineer to be waterproofed.
- B. Joint waterproofing shall be paid for at the contract unit price per lineal foot of waterproofing in place. This price shall include full compensation for furnishing all materials, unless otherwise specified, and all equipment, tools, labor and incidentals necessary to apply the waterproofing and complete the work.

END OF SECTION

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SECTION 04810

DECK WATERPROOFING SYSTEM

PART 1 GENERAL REQUIREMENTS

1.1 DESCRIPTION

- A. These specifications shall govern the furnishing and installation of bridge deck waterproofing system.
- B. Waterproofing system shall be 120 mil acrylic-based, cold spray applied, seamless elastomeric waterproofing membrane as manufactured by Stirling-Lloyd, 420 Sackett Road, North Haven, Connecticut 06473, (203) 230-9448, or equal.
- C. Spray applied waterproofing systems shall have one layer of integrated ballast mat placed on the deck surface only to the limits indicated, (total thickness of approximately 1/4")
- D. After the deck waterproofing work has started, no vehicular or equipment traffic shall be allowed on the bridge until after the work is complete and an adequate ballast cushion has been placed on the deck. The waterproofing shall be protected against damage from any source.

PART 2 MATERIALS

- A. Materials shall be as indicated on the Plans, the BNSF Standard Construction Specifications and these Special Provisions.
- B. An integrated ballast mat (IBM) system manufactured by Bridge Preservation, LLC, or approved equal shall be used on the deck surface as indicated.
- C. Materials shall conform to requirements set forth in Chapter 8, Part 29 of the AREMA Manual for Railway Engineering and the BNSF Standard Construction Specifications.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

- A. Decks shall be clean, dry, smooth and free of fins, sharp edges, loose material, oil and grease. Grinders shall be utilized, if necessary, to remove protrusions that would puncture the waterproofing membrane.
- B. Concrete decks shall have a wood float finish and shall cure for not less than 7 days before waterproofing application. Surfaces shall be free of form release agents and wax base curing compounds; if these contaminants are present, they shall be removed by abrasive blast cleaning.
- C. Joints between steel deck plates shall be filled with hot-poured asphalt or a filler approved by the Engineer.
- D. The area to be waterproofed shall be thoroughly swept, vacuumed or air blown to remove all dust, dirt and loose foreign material. After the deck is clean, it shall be maintained in a clean condition until completion of waterproofing.

3.2 APPLICATION OF MEMBRANE

- A. Primer shall be applied to concrete decks with a brush or roller at a rate of 250 to 350 square feet per gallon until the surface is completely coated. Primer shall dry 1 hour or more, until tack-free, prior to application of membrane. If not covered with membrane within 36 hours, the surface shall be re-primed. Steel decks shall not be primed.

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- B. Construction and control joints shall be covered by 16 gage galvanized sheet metal, of the width shown on the plans, centered on the joint. Joints in sheet metal shall be lapped 2 inches and corners of sheet metal shall be rounded to a 1/2-inch radius.
 - 1. An inverted strip of membrane (plastic side down) 6 inches wider than the sheet metal shall be centered over the sheet metal and the joint. This shall be covered over with a full width of membrane placed rubberized asphalt side down centered on the joint prior to placing membrane over the entire deck surface.
- C. Inside corners shall be filled with a 1/2-inch fillet of mastic.
 - 1. All inside and outside corners shall receive an initial 12-inch wide strip of membrane placed rubberized asphalt side down and centered along the axis of the corner.
- D. Membrane shall be laid with laps parallel to the long direction of the deck. If there is a deck slope normal to the laps, membrane shall be laid from the low point to the high point across the fall line so that the laps shed water as do shingles on a roof. Membrane shall be rolled onto the surface using care to eliminate any wrinkles or air spaces so that a smooth surface results. Succeeding strips of membrane shall be laid with a minimum 2-1/2 inch side or end overlap.
- E. The 2-1/2 inch overlap shall be rolled down firmly and completely using a rubberized wheel-type roller weighing approximately 100 lbs.
- F. Membrane applied to sloping or vertical surfaces shall be rolled down firmly over the entire area covered.
- G. Outside edges of membrane shall be rolled as specified in Paragraphs E and F and shall be finished with a trowelled bead of mastic.
- H. Areas within 6 inches of drains and protrusions shall receive a double layer of membrane and mastic shall be liberally applied to the seams and the contact area between the membrane and drain or protrusion.
- I. A careful inspection of the membrane shall be made and any holes, tears, misaligned or wrinkled seams or other discontinuities shall be patched with a piece of membrane extending at least 2-1/2 inches beyond the imperfection.

3.3 APPLICATION OF MEMBRANE PROTECTION

- A. The protective cover shall be placed over the membrane as soon as practicable within 24 hours after the membrane has been laid. Dirt and other foreign material shall be removed from the surface of the membrane before the protective cover is placed.
- B. Asphaltic panels on horizontal surfaces shall be laid without bond coat. Semi-mastic shall be used to bond asphaltic panels to sloping and vertical surfaces. The bond coat shall be applied with a brush at a rate of 50 square feet per gallon to completely coat the surface. Asphaltic panels shall be placed while the bond coat is still tacky.
- C. The first layer of asphaltic panels on the horizontal surface shall be laid with joints staggered not less than 18 inches, and a second layer of asphaltic panels shall be laid with joints staggered not less than 18 inches from the joints in the first layer. Following application of the bond coat, one layer of asphaltic panels shall then be placed and rolled firmly on any sloping or vertical surfaces. All joints in asphaltic panels shall be laid tight and shall be completely sealed with semi-mastic.
 - 1. Within 24 hours of placing asphaltic panels on sloping or vertical surfaces, 1" x 3" redwood timbers shall be installed, as shown on the plans, to secure the top of the asphaltic panels in place.
- D. Within 48 hours of placing membrane protection and prior to placing any wheels from vehicular or equipment traffic onto the bridge deck, a minimum 4 inch thick layer of ballast shall be dumped and spread uniformly covering the asphaltic panels. Care shall be taken to ensure that asphaltic panels are not shifted from their placed position.

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- E. Where edges or protrusions of asphaltic panels are exposed to prolonged sunlight exposure, coat exposed areas with Fibre Aluminum Roof Coating meeting ASTM Designation: D 2824, Type 2 at a rate of 12 square feet per gallon, (1/8 inch thickness).

PART 4 MEASUREMENT AND PAYMENT

4.1 BRIDGE DECK WATERPROOFING

- A. Bridge deck waterproofing will be measured by the square yard of surface that is waterproofed in accordance with the plans or as directed by the Engineer.
- B. Bridge deck waterproofing shall be paid for at the contract unit price per square yard of acceptable bridge deck waterproofing in place. This price shall include full compensation for furnishing all materials, including galvanized sheet metal and waterproofing retainer assemblies at ends of concrete decks, unless otherwise specified, and for all labor, tools, equipment, supervision, and incidentals necessary to complete the work in accordance with the plans and specifications.

END OF SECTION

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SECTION 04900

ELASTOMERIC BEARING PADS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Plain Elastomeric Bearing Pads
- B. Laminated Elastomeric Bearing Pads

1.2 DESCRIPTION

- A. Elastomeric bearing pads covered by this section includes plain pads consisting of elastomer only and laminated pads consisting of alternate laminations of elastomer and steel sheets.

1.3 CERTIFICATION

- A. The bearing pad supplier shall certify that the elastomer, and steel sheets if used, in the bearing pads that are furnished for each order conform to all of the requirements of Sections 2.1 and 2.2. The certification shall be supported by a certified copy of the test results.

PART 2 MATERIALS

2.1 ELASTOMER

- A. Elastomer for Plain Elastomeric Bearing Pads shall be polyurethane based on diphenylmethane diisocyanate and polytetramethylene ether glycol containing less than 2% non-reacted ingredients such as pigments, fillers and plasticizers, and shall comply with the current AREMA Manual for Railway Engineering, Chapter 15, Part 5 – Bearing Design and Construction, except as modified below:

Material Property and Test	ASTM Designation	Values
Hardness, Durometer, Shore A points	D2240	70 (±5)
Minimum Tensile Strength	D412, Die B	2500 psi
Minimum Elongation at break		300%
Heat Resistance, Oven aged 70 hrs. at 100°C	D573	
Change in durometer hardness, max. Shore A points		+5
Change in tensile strength, max		-10%
Change in ultimate elongation, max		-10%
Compressive Strain, method B	D575	
at 800 psi, Shape Factor = 8, max strain		7%
At 400 psi, Shape Factor = 6, max stain		7%
Compression set, 22 hrs. at 70°C, method B, max	D395	35%
Low Temperature Brittleness, at -40°F	D2137	No failure

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- B. Elastomer for Laminated Elastomeric Bearing Pads shall be polychloroprene (neoprene) and shall comply with the current AREMA Manual for Railway Engineering, Chapter 15, Part 5 – Bearing Design and Construction.

2.2 STEEL SHEETS

- A. Steel sheets for use in laminated bearing pads shall meet the requirements of ASTM A1011, Grade 36 or ASTM A1008, Grade 40.

2.3 METHYL ETHYL KETONE

- A. Methyl ethyl ketone for use in cleaning of elastomeric bearing pads shall meet the requirements of ASTM D740, Type 1 or Type 2.

2.4 GEL TYPE EPOXY

- A. The gel type epoxy shall be a two component, epoxy-resin bonding system conforming to the requirements of ASTM C881, Type IV, Grade 2, Class B or C. The class supplied shall be governed by the range of temperatures for which the material is to be used.

PART 3 EXECUTION

3.1 PLAIN BEARING PADS

- A. Plain bearing pads shall be cast in molds under pressure and heat and may be molded individually, cut from previously molded strips or slabs molded to the full thickness of the finished bearings, or extruded and cut to length. Plain bearing pads shall be fully vulcanized, uniform and integral units of such construction that the bearing pad cannot be separated by any mechanical means into separate, definite and well-defined elastomeric layers. Evidence of layered construction shall be cause for rejection.
- B. Cutting of plain bearing pads from previously molded strips or slabs shall be performed in such a manner as to avoid heating of the material and to produce an edge, with no tears or other jagged areas, having a surface roughness that does not exceed ANSI/ASME B46.1, 250.

3.2 LAMINATED BEARING PADS

- A. Laminated bearing pads shall have alternate layers of elastomer and steel sheets as shown on the design drawings, and shall be cast in individual molds under heat and pressure to form an integral unit of such construction that the bearing pad cannot be separated by any mechanical means into separate, definite and well-defined elastomeric layers. Evidence of layered construction shall be cause for rejection.
- B. The top and bottom steel sheets and the edges of all steel sheets shall be uniformly covered with not less than 1/8 inch of elastomer. The maximum cover of elastomer over the edges of steel sheets shall be 1/4 inch. Steel sheets shall be abrasive blast cleaned to remove all rust, mill scale, and other contaminates, and shall be free of sharp edges and burrs.

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3.3 TOLERANCES

- A. For both plain and laminated bearing pads the permissible variation from the dimensions and configuration required by the plans and these specifications shall be as follows:

Overall Vertical dimensions	
Average total thickness 1 ½" or less	-0, +1/8"
Average total thickness over 1 ½"	-0, +1/4"
Overall horizontal dimensions	-0, +1/4"
Thickness of individual layers of elastomer (laminated bearing pads only)	±1/8"
Variation from a plane parallel to the theoretical surface	
Top	1/8"
Sides	¼"
Individual Steel Sheets	1/8"
Size of holes or slots	-0, +1/8"
Position of holes or slots	±1/8"

3.4 INSTALLATION

- A. Elastomeric bearing pads shall be installed in accordance with the plans. Substructure bearing surfaces to receive the bearing shall be level, smooth, and finished to the correct elevation. The entire bearing surface shall be fully loaded under all conditions.
- B. Top and bottom elastomer surfaces shall be level under dead load only. Tapered load plates bonded to the bearing, tapered sole plates on the bridge span, or epoxy mortar between the bearing and the bridge span, as specified on the plans, shall compensate for span grade, rotation, or camber.
- C. Welding of bridge span members to the bearing load plate is not permitted unless there is more than 1-1/2 inches of steel between the weld and the elastomer. The temperature of the steel plate in contact with the elastomer shall not exceed 400 degrees F during the welding process.
- D. Bearing areas on bridge seats and precast concrete beams, which are to receive epoxy materials, shall be abrasive blast cleaned to remove all form oil and curing agents and shall be in a dust free condition. Bearing areas on steel bearing plates, which are to receive epoxy materials, shall be cleaned of all dirt, grease, and other contaminants before epoxy materials are applied.
- E. Clean top and bottom surfaces of bearing pads with methyl ethyl ketone to remove all traces of mold release agents. When mating surfaces are clean and dry, gel type epoxy as specified in Paragraph 2.4A shall be applied to a 5 mil thickness on the areas of the bridge seat where elastomeric bearing pads are to be placed, and on the bottom side of the elastomeric bearing pads and then the pads shall be set and held in the proper location on the bridge seat until the epoxy takes its initial set. Pads must be held down with sufficient weight to ensure total pad contact on the bridge seat.
- F. When epoxy mortar is specified to compensate for span, grade, rotation, or camber, mortar consisting of equal parts by volume of gel type epoxy as specified in Paragraph 2.4A and dry silica sand, mixed in accordance with manufacturer's directions, shall be spread on top of bearing pads to a thickness of approximately 1/8 inch just before setting beams in order to obtain uniform bearing.

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The beams shall be set in the proper location on the bearing pads before the epoxy mortar takes its initial set. Scrape excess mortar from around bearing pads after beams are set.

PART 4 MEASUREMENT AND PAYMENT

4.1 ELASTOMERIC BEARING PADS

- A. Elastomeric bearing pads will be measured by each elastomeric bearing pad.
- B. Elastomeric bearing pads will be paid for at the contract unit price per each elastomeric bearing pad in place. This price shall include full compensation for furnishing all materials, and for all labor, tools, equipment, and incidentals necessary to complete the work.

END OF SECTION

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SECTION 05000 CULVERTS

SECTION 05100 GENERAL INFORMATION FOR CULVERTS

SECTION 05200 PIPE CULVERTS

SECTION 05300 PRECAST CONCRETE BOX CULVERTS

SECTION 05400 JACKING OF REINFORCED CONCRETE PIPE

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SECTION 05100

GENERAL INFORMATION FOR CULVERTS

PART 1 GENERAL

1.1 INTRODUCTION

- A. The information contained in this document is intended to be used by BNSF Railway Company employees to supplement the information in Sections 04500 and 05100 of the current BNSF Railway Company Standard Construction Specifications.
- B. This section covers the following:
1. PREFABRICATED CORRUGATED STEEL PIPE
 - (a) Includes Pipe, Pipe-Arch and Perforated Underdrain Pipe
 2. CORRUGATED STRUCTURAL STEEL PLATE PIPE
 - (a) Includes Pipe, Pipe-Arch, Arch and Arch Liner
 3. STEEL TUNNEL LINER PLATE
 4. SMOOTH STEEL PIPE USED AS A DRAINAGE CULVERT
 5. REINFORCED CONCRETE CULVERT PIPE
 6. PRECAST CONCRETE BOX CULVERT
 7. HIGH-DENSITY POLYETHYLENE (HDPE) PIPE
 - (a) Used as a Culvert, Culvert Liner and Perforated Underdrain Pipe
 8. POLYVINYL CHLORIDE (PVC) PIPE
 - (a) Used as a Perforated Underdrain Pipe

1.2 SPECIFICATIONS

- A. Corrugated steel pipe, corrugated structural steel plate pipe, smooth steel pipe and reinforced concrete culvert pipe will be furnished according to Section 05100 of the current BNSF Railway Company Standard Construction Specifications. Except for certain additions and/or modifications, Section 05100 of the current BNSF Railway Company Standard Construction Specifications refers directly to the following Sections of Chapter 1, Parts 4 and 5, and Chapter 8, Part 10, of the current American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering:

Prefabricated Corrugated Steel Pipe, Pipe-Arch and Perforated Underdrain Pipe (Galvanized and aluminum coated)	Chapter 1, Section 4.3
Coated Corrugated Steel Pipe and Pipe-Arch (Polymeric coated)	Chapter 1, Section 4.4
Corrugated Structural Steel Plate Pipe, Pipe-Arch and Arch (Galvanized)	Chapter 1, Section 4.6
Steel Tunnel Liner Plate (Galvanized)	Chapter 1, Section 4.20
Smooth Steel Pipe	Chapter 1, Section 5.3.4.1
Reinforced Concrete Culvert Pipe	Chapter 8, Part 10

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- B. Precast concrete box culvert shall be fabricated by the wet cast method, except where fabrication by the dry cast method is approved by the BNSF Director-Bridge Engineering.
1. Precast concrete box culvert fabricated by the wet cast method will be furnished according to Section 04500 of the current BNSF Railway Company Standard Construction Specifications and the current BNSF Railway Company Specifications for Precast Concrete Box Culverts (Fabricated by the Wet Cast Method). Except for certain additions and/or modifications, the current BNSF Railway Company Specifications for Precast Concrete Box Culverts (Fabricated by the Wet Cast Method) refers directly to Chapter 8, Parts 1 and 16, of the current American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering.
 2. Precast concrete box culvert fabricated by the dry cast method may be used if approved by the Director-Bridge Engineering, and will be furnished according to Chapter 8, Parts 1 and 16, of the current AREMA Manual for Railway Engineering. In addition, all applicable provisions of the current BNSF Railway Company Specifications for Precast Concrete Box Culverts (Fabricated by the Dry Cast Method) shall be met, including requirements of and testing procedures for cement alkali content, as well as coarse and fine aggregate potential reactivity.
- C. High-density polyethylene (HDPE) pipe shall be manufactured in accordance with the applicable following specifications.
1. Solid high-density polyethylene (HDPE) pipe shall be manufactured from PE3408 premium grade, high density, extra high molecular weight, polyethylene resin, and shall meet or exceed the requirements of ASTM D1248, Type III, Class C, Category 5, Grade P34.
 2. Corrugated HDPE pipe under 54-inch diameter shall meet or exceed the requirements of AASHTO M 294 or AASHTO MP 6, as applicable.
 3. Any use of HDPE pipe in railway track fills larger than 6 inches is subject to the approval of the Director-Bridge Engineering
- D. Polyvinyl chloride (PVC) pipe shall be manufactured in accordance with the applicable following specifications:
1. PVC pipe shall be manufactured only from virgin, low-filler cell class PVC resin (12454 per ASTM D1784).
 2. PVC pipe shall meet or exceed the requirements of AASHTO M 304.

1.3 REFERENCES

- A. BNSF Railway Company (BNSF) Standard Construction Specifications Section 03200 - Excavation and Embankments
- B. Section 03500 - Lime or Fly-Ash Stabilized Subgrade Section 03600 - Cement Stabilized Subgrade Section 04100 - Structure Excavation and Backfill Section 04400 - Concrete Construction
- C. Section 04500 - Precast Concrete Construction Section 05100 - Pipe Culverts
- D. American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering
 1. Chapter 1, Part 1, Section 1.2.4.3 - Subsurface Drainage Chapter 1, Part 3 - Natural Waterways
 2. Chapter 1, Part 4 - Culverts
 3. Chapter 1, Part 5, Section 5.3 - Specifications for Pipelines Conveying Nonflammable Substances
 4. Chapter 8, Part 10 - Reinforced Concrete Culvert Pipe
 5. Chapter 8, Part 16 - Design and Construction of Reinforced Concrete Box Culverts
- E. American Iron and Steel Institute (AISI) Handbook of Steel Drainage and Highway Construction Products

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- F. National Corrugated Steel Pipe Association (NCSPA) Installation Manual for Corrugated Steel Pipe, Pipe Arches and Structural Plate
- G. American Concrete Pipe Association Concrete Pipe Handbook
- H. American Concrete Pipe Association Concrete Pipe Design Manual
- I. BNSF Specifications for Precast Concrete Box Culverts (Fabricated by the Wet Cast Method)
- J. BNSF Specifications for Precast Concrete Box Culverts (Fabricated by the Dry Cast Method)

1.4 HYDROLOGY AND HYDRAULICS

- A. Hydrologic and Hydraulic methodology shall be in accordance with the current BNSF Railway "Hydrologic and Hydraulic Design Criteria".
- B. Culverts carrying full design flows are generally characterized by outlet flow velocities that can result in channel erosion at the outlet of the culvert. Outlet flow velocities of culverts carrying full design flow usually exceed 6 feet per second and may be as high as 15 feet per second. Channel velocities in excess of 6 feet per second can usually result in channel erosion in unprotected soil channels, with or without vegetal channel lining. Culvert design should include the design of channel protection and energy dissipaters at the outlet of the culvert, where necessary.

PART 2 MATERIALS

2.1 GENERAL

- A. Sizes, minimum gages and heights-of-cover limits for the most commonly used types of corrugated steel pipe, pipe-arch, arch and arch liner in railway track fills are given in Appendix A, Tables 1-1 through 1-6, inclusive. The values in the tables are based on the use of a suitable backfill material compacted to minimum of 90% of standard density.
 - 1. For prefabricated galvanized corrugated steel pipe or pipe-arch (polymeric coated) and aluminum coated prefabricated steel pipe or pipe-arch used in railway track fills, the minimum wall thickness shall be 12 gage. For prefabricated galvanized corrugated steel pipe without polymeric coating used in railway track fills, the minimum wall thickness shall be 10 gage.
 - 2. For structural steel plate pipe and structural steel plate pipe-arch used in railway track fills, the minimum gages shall be 10 gage for top and side plates and 8 gage for invert plates, unless invert paving is to be placed in the field in which case invert plates may be the same gage as the top and side plates (minimum 10 gage).
 - 3. Corrugated pipe under 36 inch diameter and corrugated pipe-arch smaller than 35 inch by 24 inch shall not be used as a culvert in railway track fills without approval of the Director-Bridge Engineering at locations where the Railway Company has maintenance responsibility.
 - 4. Corrugated pipe from 84 inch diameter to 120 inch diameter may be either prefabricated corrugated steel pipe or structural steel plate pipe depending upon material and labor costs, site conditions, availability and type of equipment for installation, available headroom under an existing bridge superstructure and the available height-of-cover for the specific installation.
 - 5. Diameter of corrugated metal underdrain pipe shall be a minimum of 6 inches, and will seldom exceed 15 inches. Pipe in this range of diameters shall be specified with a minimum wall thickness of 16 gage.
 - 6. When necessary to specify prefabricated corrugated steel pipe and pipe-arch in vehicular roadway fills, gages should be selected from appropriate tables in the current edition of the American Iron and Steel Institute (AISI) Handbook of Steel Drainage and Highway Construction Products.
- B. Prefabricated corrugated steel pipe and pipe-arch shall be fabricated in accordance with the applicable Specifications in Paragraph 1.2, except as modified hereinafter:

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1. Prefabricated corrugated steel pipe and pipe-arch shall be of the following classes with respect to corrugations (See Table 2-1):
 - (a) Class I - Annular corrugations
 - (b) Class II - Helical corrugations
 - (c) For Class II corrugated steel pipe and pipe-arch, the ends of individual pipe sections shall be re-rolled to form circumferential corrugations extending at least four corrugations from the pipe end.
 - (d) Fabricator may furnish either Class I or Class II corrugated steel pipe or pipe-arch with either applicable type seam for Class II pipe or pipe-arch when class or seam type is not specified.
 - (e) Prefabricated corrugated steel pipe-arch with 2-2/3 inch by 1/2 inch corrugations in sizes greater than 57 inch by 38 inch shall not be furnished.
 - (f) Prefabricated corrugated steel pipe-arch with 3 inch by 1 inch corrugations or 5 inch by 1 inch corrugations in sizes smaller than 60 inch by 46 inch shall not be furnished.
2. Prefabricated corrugated steel pipe and pipe-arch shall be of the following cross-sectional shapes:
 - (a) Shape 1 - Pipe, full circular cross section
 - (b) Shape 3 – Pipe-arch cross section

Table 2-1 Corrugations for Corrugated Steel Pipe and Pipe-Arch

Class	Diameter	Nominal Size (Note 2)	Maximum Pitch (Note 1)	Minimum Inside Radius
I	8" to 48"	2-2/3" x 1/2"	2-3/4"	11/16"
	54" to 96"	3" x 1"	3-1/4"	9/16"
II	6" to 10"	1-1/2" x 1/4"	1-7/8"	9/32"
	12" to 48"	2-2/3" x 1/2"	2-3/4"	11/16"
	54" to 120"	3" x 1"	3-1/4"	9/16"
	54" to 120"	5" x 1"	5-1/4"	1-9/16"
Note 1: Pitch shall be measured at right angles to the corrugations.				
Note 2: Depth of corrugations shall not overrun by more than 5 percent.				

3. Coupling bands:
 - (a) When the corrugated steel pipe diameter or pipe-arch span is less than or equal to 42 inches, coupling bands may be standard one-piece coupling bands, two-piece coupling bands, or two-piece riveted-on coupling bands.
 - (b) Corrugated metal underdrain pipes may be field jointed with bands per Paragraph 2.1.B.3.a. or with smooth sleeve-type coupler. The sleeve-type coupler may be either plastic or galvanized steel.
 - (c) Two-piece riveted-on coupling bands shall be furnished when the corrugated steel pipe diameter or pipe-arch span exceeds 42 inches.
 - (d) Bands with projections shall not be furnished.
 - (e) Internal coupling bands shall be used where placement from within the structure is required.
 - (f) Bolts for coupling bands shall be 6 inches long and threaded within 1 inch of the head.

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- (g) Gaskets are recommended with pipe-arch bands.
- 4. Protective coatings for prefabricated corrugated steel pipe and pipe-arch:
 - (a) All prefabricated corrugated galvanized steel pipe and pipe-arch and prefabricated corrugated aluminum coated steel pipe shall be fabricated from coated steel sheets.
 - (b) Polymeric coated prefabricated corrugated galvanized steel pipe and pipe-arch shall be polymeric coated in accordance with current AASHTO Specification M 246.
- 5. Shipping:
 - (a) Corrugated steel pipe and pipe-arch having invert paving shall be shipped with paving at bottom.
 - (b) Blocking shall be placed between all corrugated steel pipe or pipe-arch sections when loaded to prevent longitudinal movement during shipment. This blocking is in addition to the customary straps to the floor surface.
- C. Corrugated structural steel plate pipe, pipe-arch and arch shall be fabricated in accordance with the applicable Specifications in Paragraph 1.2, except as modified hereinafter:
 - 1. Protective coatings for corrugated structural steel plate pipe, pipe-arch and arch:
 - (a) All galvanized corrugated structural steel plate pipe shall be galvanized by the fabricator.
 - 2. Circumferential seams shall be staggered.
- D. Corrugated steel pipe for jacking and earth boring and smooth steel pipe for jacking, earth boring and pipe ramming shall be fabricated in accordance with the applicable Specifications in Paragraph 1.2, except as modified hereinafter:
 - 1. Corrugated pipe:
 - (a) Only Class I, Shape 1, corrugated steel pipe with a minimum 8 gage wall thickness shall be used.
 - (b) Corrugated steel pipe shall be punched and match marked for field bolting.
 - (c) Two-piece loose coupling bands shall be used for connecting the inlet and outlet sections.
 - 2. Smooth steel pipe:
 - (a) Smooth steel pipe used as a drainage culvert, regardless of the method of installation, shall be in accordance with ASTM A139, with a specified minimum yield strength (SMYS) of at least 35,000 psi. Steel pipe in accordance with ASTM A139, Grade B, has a SMYS of 35,000 psi, and is satisfactory for this application.
 - (b) Smooth steel pipe used as a drainage culvert with an outside diameter less than 36 inches or a wall thickness less than 0.500 inch shall not be used without approval of the Director-Bridge Engineering at locations where the Railway Company has maintenance responsibility. Sizes, minimum wall thickness and heights-of-cover limits for smooth steel pipe used as a drainage culvert in railway track fills are given in Appendix A, Table 1-7. Weights for selected diameter and wall thickness combinations of smooth steel pipe are given in Appendix A, Table 1-8.
 - 3. Protective coatings:
 - (a) All prefabricated corrugated galvanized steel pipe and prefabricated corrugated aluminum coated steel pipe shall be fabricated from coated steel sheets. All galvanized corrugated structural steel plate pipe shall be galvanized by the fabricator.
 - (b) Smooth steel pipe used as a drainage culvert shall have an increased wall thickness to allow for corrosion and therefore requires no protective coating.
- E. Steel tunnel liner plates shall be fabricated in accordance with the applicable Specifications in Paragraph 1.2, except as specified hereinafter:
 - 1. Two-flanged tunnel liner plates shall be used.

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F. Reinforced concrete culvert pipe shall be fabricated in accordance with the applicable Specifications in Paragraph 1.2, except as specified hereinafter:

1. The reinforced concrete pipe units shall be cast in an established manufacturer's plant that is certified under the American Concrete Pipe Association (ACPA) "Quality Cast" Plant Certification Program, unless otherwise approved by the BNSF Director-Bridge Engineering.
2. The materials for reinforced concrete culvert pipe shall meet the requirements of the following specifications for the classes and sizes specified:

Type	ASTM
Circular Pipe	C76
Arch Pipe	C506
Elliptical Pipe	C507
D-Load	C655

3. Class of reinforced concrete culvert pipe:

(a) AREMA Design Procedure:

1. Reinforced concrete culvert pipe for a specific site may be designed by the procedure per Chapter 8, Part 10, of the current AREMA Manual for Railway Engineering.
2. Reinforced concrete culvert pipe designed per Paragraph 2.1.F.3.a.1. and subject to railway track loads shall be a minimum of Class III (minimum strength of D = 1350), even if the analysis indicates that a lower D-Load is satisfactory.

(b) Alternate Design Procedure:

1. If the reinforced concrete culvert pipe is not designed by the procedure in Paragraph 2.1.F.3.a.1, or if soil conditions are questionable, or if continuous Railway Company inspection is not provided to insure proper workmanship, Class V reinforced concrete culvert pipe (minimum strength of D = 3000) per Table 2-2 may be used at sites with heights-of-cover up to 14 feet:

Table 2-2 Class V Reinforced Concrete Pipe Wall Requirements

Pipe Diameter (Inches)	Class and Wall of Reinforced Concrete Pipe
Less than 48	Class V Wall B pipe
48 to 72, inclusive	Class V Wall C pipe
78 to 144, inclusive	Class V pipe meeting ASTM C655 criteria

2. Where the height-of-cover exceeds 14 feet, the reinforced concrete culvert pipe must be designed by the procedure per Paragraph 2.1.F.3.a.1.
4. Sections of reinforced concrete pipe shall be furnished with holes and U-bolts for fastening the sections together.
5. All materials being supplied shall be subject to inspection or test at any time during their manufacture or installation. Causes for rejection, unless approved repairs can be made, may include any of the following imperfections and variations, all of which apply to either the point of manufacture or the point of installation:
 - (a) Failure to conform to any applicable requirements of applicable ASTM specification.
 - (b) Fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint.
 - (c) Defects that indicate imperfect proportioning, mixing or molding.

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- (d) Surface defects indicating honeycomb or open-texture.
 - (e) Damaged or cracked ends where such damage would prevent making a satisfactory joint.
 - (f) Any continuous crack or concrete separation having a surface width of 0.01 inch or more and extending for a length of 12 inches or more, regardless of depth or position on the pipe.
 - (g) A piece of any size broken out of the pipe.
 - (h) Any shattering or flaking of concrete at a crack.
 - (i) Delamination of the concrete.
 - (j) Separations or "blisters".
 - (k) A variation from a true circle of the specified diameter by more than one percent (1%).
 - (l) A wall thickness less than allowable specified in applicable ASTM specification. A wall thickness more than required by specification shall not be cause for rejection. Pipe having localized variations in wall thickness exceeding those specified will be accepted if the three edge bearing strength and minimum steel cover requirements are met.
 - (m) Exposure of reinforcement arising from misplacement or cage twist.
 - (n) The pipe fails the D-load test.
6. The basis for acceptance of the pipe materials shall be by one of the following:
- (a) The D-load bearing strength test, compliance with these specifications, inspection of the pipe manufacture, and inspection of the completed pipe.
 - (b) The structural design details, materials, tests, inspection of the manufacturing process, and inspection of the completed pipe.
 - (c) Acceptance of certification with these specifications.
- G. Reinforced concrete culvert pipe for jacking and earth boring shall be fabricated in accordance with the applicable Specifications in Paragraph 1.1, except as modified hereinafter:
- 1. Reinforced concrete pipe shall be circular pipe, Class V, Wall C.
 - 2. Reinforced concrete pipe shall be tongue and groove design.
 - 3. Watertight joint gaskets shall be used.

2.2 END FINISH

- A. Unless shown otherwise on the plans or in the special provisions, the type of end finish on pipe and pipe-arch is to be as follows:
- 1. Corrugated steel pipe:
 - (a) 36 inch diameter to 66 inch diameter, inclusive - Ends square.
 - (b) 72 inch diameter to 120 inch diameter, inclusive - Ends step beveled to match embankment slope.
 - (c) The height of the step bevel is to be one-quarter of the pipe diameter.
 - 2. Structural steel plate pipe:
 - (a) All diameters - Ends step beveled to match embankment slope.
 - (b) The height of the step bevel is to be one-quarter of the pipe diameter.
 - 3. Corrugated steel pipe-arch:
 - (a) All sizes - Ends square.
 - 4. Structural steel plate pipe-arch:
 - (a) 6 feet-1 inch by 4 feet-7 inch to 9 feet-6 inch by 6 feet-5 inch, inclusive - Ends square.

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- (b) 9 feet-9 inch by 6 feet-7 inch to 12 feet-6 inch by 7 feet-11 inch, inclusive - Ends beveled to top of corner plates to match embankment slope.
- 5. Reinforced concrete culvert pipe:
 - (a) For installation using conventional backfill, reinforced concrete culvert pipe may be either bell and spigot design or tongue and groove design, unless otherwise specified.
 - (b) For installation by jacking, reinforced concrete culvert pipe shall be tongue and groove design.
 - (c) Watertight joint gaskets are recommended and must be specified for any installation subject to pressure flow.
- B. Where beveled ends are proposed for culverts per Paragraph 2.2.A, the end bevel shall not be less than 1.5 to 1.
- C. Where beveled ends are proposed for skewed culverts, the effect of such beveling on the structural strength of the pipe should be investigated.
- D. Precast concrete box culverts shall be tongue and groove design, unless otherwise specified.

2.3 MATERIAL INSPECTION

- A. Culvert material is not inspected by the Railway Company before shipment. However, it should be inspected in the field immediately after receipt for compliance with the requisition and the physical requirements of the applicable Section 04500 or Section 05100 of the current BNSF Railway Company Standard Construction Specifications or the current BNSF Railway Company Specifications for Precast Concrete Box Culverts. Any irregularities should be reported to the Director-Bridge Engineering before beginning installation.

2.4 FLOW LINE LENGTH FOR CULVERT

- A. All prefabricated corrugated steel pipe and pipe-arch, all structural steel plate pipe and pipe-arch, regardless of end finish, shall be ordered by flow line length. The material requisition or order should clearly indicate that the specified length is the flow line length.
- B. Calculation of flow line length of a railroad culvert:
 - 1. The flow line length of a culvert where the culvert is aligned normal (perpendicular) to the centerline of track can be calculated as:

$$L = A + 2C(H/V)$$

where:

L = Flow line length of culvert (aligned perpendicular to the track)

A = Width of top of embankment crown

C = Vertical distance from top of embankment crown to flow line at centerline of embankment cross section (top of tie to flow line distance minus 1.8 feet)

H = Horizontal component of embankment side slope

V = Vertical component of embankment side slope

- 2. The flow line length of a culvert when the culvert is aligned on a skew can be calculated as:

$$L_s = L / \cos \alpha + R \tan \alpha$$

which can also be expressed as:

$$L_s = (A + 2C(H/V)) / \cos \alpha + R \tan \alpha$$

where:

Ls = Flow line length of skewed culvert

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A =Width of top of embankment crown

C =Vertical distance from top of embankment crown to flow line at centerline of embankment cross section (top of tie to flow line distance minus 1.8 feet)

H =Horizontal component of embankment side slope

V =Vertical component of embankment side slope

R =Rise of culvert

α =Angle between line normal (perpendicular) to centerline of track and skew line

2.5 ORDERING CULVERTS

- A. For prefabricated corrugated steel pipe and pipe-arch, the ordered lengths of the culvert sections must be such that no field joining of the culvert sections shall take place within 7 feet of the vertical centerline of any track, except under the following conditions:
1. Where prefabricated corrugated steel pipe or pipe-arch is used to extend an existing culvert for new railway track embankment construction, the joining of the culvert extension to the existing culvert may take place at the applicable end of the existing culvert, regardless of the relationship of the location of the joint to the vertical centerline of any proposed track.
 2. Where prefabricated corrugated steel pipe or pipe-arch is used on a foundation material not subject to potential settlement, such as rock or other incompressible foundation material, the field joining of the culvert sections may take place at any location, regardless of the relationship of the location of the joint to the vertical centerline of any track.
 3. Where prefabricated corrugated steel pipe or pipe-arch is used as a culvert liner and grouted in place, the field joining of the culvert sections may take place at any location, regardless of the relationship of the location of the joint to the vertical centerline of any track.
- B. Information required on culvert material requisition or order:
1. Type of culvert.
 2. Quantity and length of each culvert section.
 3. Total flow line length (for corrugated metal pipe and pipe-arch).
 4. Diameter or size of culvert.
 5. For corrugated metal culvert – Class (if required), Shape, gage and corrugation size.
 - (a) For corrugated steel pipe to be installed by jacking - Class, Shape, gage and corrugation size.
 - (b) For smooth steel pipe - wall thickness.
 - (c) For reinforced concrete culvert pipe - Class and Wall, end finish, and, if required, watertight joint gaskets.
 6. For corrugated metal culvert - requirement for type of coating(s) and, if required, fabricator-applied paving.
 7. For prefabricated corrugated metal culvert – quantity, width and type of coupling bands.
 8. Special requirements such as extra bands required when used as an extension to an existing culvert, use as siphon, or use as a let down pipe, lifting lugs, end sections, grout plugs, wire struts, or punching, piece marking and match marking of sections or plates.
 - (a) The installation of lifting lugs on all prefabricated corrugated pipe 48-inch diameter or greater, and all prefabricated corrugated pipe-arch 57 inch by 38 inch or greater, should be specified when ordering pipe. Lifting lugs should also be installed on any pipe where required for ease in handling and installation.
 9. Date of delivery.
 10. Reference to applicable specification, where required.

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- (a) For corrugated metal culvert - Per Section 05100 of the current BNSF Railway Company Standard Construction Specifications.
- (b) For smooth steel pipe - Per ASTM A139, with a specified minimum yield strength (SMYS) of at least 35,000 psi.
- (c) For reinforced concrete culvert pipe - Per Section 05100 of the current BNSF Railway Company Standard Construction Specifications.
- (d) For precast concrete box culvert - Per current BNSF Railway Company Specifications for Precast Concrete Box Culverts (Fabricated by the Wet Cast Method) or current BNSF Railway Company Specifications for Precast Concrete Box Culverts (Fabricated by the Dry Cast Method).

11. Any additional necessary information.

2.6 ORDERING CULVERTS FOR EMERGENCY WORK

- A. This section applies specifically to prefabricated corrugated steel pipe 48" in diameter and greater and is independent of coating type and length. For all other culvert types the specifications noted in this document remain applicable.
- B. For emergency/restoration work (i.e. derailments, washouts, landslides, etc...) where the need to replace or add a culvert under the track structure has been identified, a minimum 8 gage wall thickness shall be used for all pipes 48" in diameter and greater. Any other gage and material types for this application are subject to the approval of the BNSF Director-Bridge Engineering.

PART 3 CULVERT SELECTION

3.1 GENERAL CRITERIA

- A. Corrugated steel pipe and pipe-arch, structural steel plate pipe and pipe-arch, and smooth steel pipe used as drainage structure should be used to carry runoff from intermittent streams. When smooth steel pipe is used as a culvert, the pipe should not be placed in locations where water stands for long periods of time. Immersion of a smooth steel pipe in standing water accelerates the corrosion of the steel and shortens the useful life of the culvert. If a smooth steel pipe is used where water does stand, the flow line of the culvert should be set at least six inches above the standing water surface. Also, the inside of any culvert can be more easily inspected if water is not standing in the structure. Corrugated aluminum alloy pipe shall not be used.
- B. Unless otherwise instructed by the Director-Bridge Engineering, when a pipe culvert is specified at a given site, it will be mandatory that corrugated steel pipe or pipe-arch, structural steel plate pipe or pipe-arch, or smooth steel pipe be used when a fill or foundation is of plastic clay.
- C. Corrugated steel pipe-arch should only be used when headroom is limited or where it is desired to hold the water level to an elevation that will not damage adjacent property. Corrugated aluminum alloy pipe-arch shall not be used.
- D. Precast concrete box culvert may be used where the design flow and headroom are such that the box culvert is the best alternative to construction of a bridge, where standing water precludes the use of a steel pipe culvert, where minimum cover criteria preclude the use of a steel pipe culvert, or where soil or water chemistry precludes the use of a steel or corrugated aluminum coated steel pipe culvert.
- E. Corrugated aluminum alloy pipe for BNSF train loading applications is prohibited for installation under any BNSF track. Any consideration for its use is subject to the approval of the BNSF Director-Bridge Engineering.

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- F. When a corrugated steel pipe is to be jacked, pipe and coupling bands for inlet and outlet sections shall meet the requirements in Paragraph 2.1.D.1. The material requisition or order should state that the pipe is to be jacked.
- G. Where length and/or size of corrugated steel pipe limit a jacking operation, the installation of smooth steel pipe should be considered.
- H. If installation by jacking a corrugated steel pipe is decided on, the requisition should call for grout plugs to be provided if the nature of the fill material is such that grouting will be necessary between the outside of the pipe and the inside surface of the excavation and the grouting process will require the use of grout plugs.
- I. When watertight joints are required, sewer type bands should be called for on the requisition.

3.2 CULVERT END TREATMENTS (HEADWALLS, WINGWALLS, INVERTS, APRONS, SLOPE PAVING AND END WALLS)

- A. The factors and conditions requiring the use of culvert end treatments, such as headwalls, wingwalls, inverters and aprons, are covered in Chapter 1, Part 4, Section 4.16, of the current AREMA Manual for Railway Engineering.
- B. Normally headwalls will not be required.
 - 1. Where headwalls are required, headwalls may be concrete or metal.
- C. The following end treatments may be used to protect against potential embankment scour at the culvert inlet:
 - 1. Reinforced concrete slope paving with toe wall.
 - 2. Precast articulating concrete block mat system.
 - 3. Flexible concrete revetment wall.
- D. The following end treatments may be used to protect against potential flow line degradation at the culvert outlet:
 - 1. Grouted rip rap.
 - 2. Precast articulating concrete block mat system.
 - 3. Flexible grout mat.
 - 4. Cast-in-place concrete apron.
 - 5. Reinforced concrete slope paving with toe wall, per Paragraph 3.2.C.1.
 - 6. Steel sheeting toe wall with concrete cap connection to pipe.
 - 7. Precast or cast-in-place concrete end walls (toe walls) may be used with precast concrete box culverts.

3.3 CULVERT USED AS A STOCK PASS

- A. Culvert used as stock pass shall be prefabricated corrugated galvanized steel pipe or pipe-arch with mesh-reinforced concrete invert paving, galvanized structural steel plate pipe or pipe-arch with mesh-reinforced concrete invert paving, or reinforced concrete box culvert.
- B. Pipe culvert used as a stock pass shall preferably have a minimum diameter or rise of 96 inches. Where minimum height-of-cover requirements do not permit the use of a pipe culvert with a 96-inch diameter or rise, a minimum diameter or rise of 84 inches may be used, after the approval of the BNSF Director-Bridge Engineering.
- C. At locations where the culvert will not be subject to standing water, and minimum height-of-cover requirements and natural ground line elevations would not permit the use of a culvert with a minimum diameter or rise of 96 inches, the invert elevations of the culvert may be set 6 inches

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below flow line or natural ground line to compensate for the 6-inch-thick mesh-reinforced concrete invert paving, thereby providing an additional 6 inches of cover.

- D. A reinforced concrete box culvert may be used as an alternative to a pipe culvert. Reinforced concrete box culvert used as a stock pass shall have a minimum 5-foot span and 7-foot rise. A reinforced concrete box is the most expensive alternative (based on initial cost).

3.4 SLIP LINING EXISTING CULVERTS

- A. Slip lining existing culverts subject to railway track loading may be performed using prefabricated corrugated galvanized steel pipe, smooth high-density polyethylene pipe, corrugated high-density polyethylene pipe or, under certain conditions, smooth steel pipe. Corrugated aluminum coated steel pipe or corrugated aluminum alloy pipe shall not be used. Prefabricated corrugated galvanized steel pipe and corrugated high-density polyethylene pipe are the least expensive materials (based on initial cost). High-density polyethylene pipe used for slip liners shall have a minimum pipe stiffness of 46 p.s.i.
- B. Culvert liners may be designed for wall buckling only, without consideration of wall bending. For corrugated galvanized steel pipe liners and smooth or corrugated high-density polyethylene pipe liners so designed, the space between the existing culvert and the liner must be completely filled with a lean cement grout applied by low-pressure (5 psi) pumped grouting, or gravity-flow grouting. Care must be taken to avoid distorting the pipe during the grouting process. For smooth steel pipe liners, the space between the existing culvert and the liner must be completely filled with a lean cement grout applied by either high-pressure pumped grouting, low-pressure pumped grouting or gravity-flow grouting.

3.5 HIGH-DENSITY POLYETHYLENE (HDPE) PIPE

- A. Smooth high-density polyethylene (HDPE) pipe or corrugated HDPE pipe may be used as a liner for existing culverts subject to railway track loading. HDPE pipe liners may be specified at a location subject to acid, alkali or other materials or conditions which are known to be detrimental to the life of corrugated steel culverts, and the HDPE pipe liner can be shown to be hydraulically adequate for the design runoff.
- B. Corrugated HDPE pipe may be used as a culvert in applications not subject to railway track loading, and approved by local agencies where applicable. Corrugated HDPE pipe may be specified at a location subject to acid, alkali or other materials or conditions which are known to be detrimental to the life of corrugated steel culverts, and the HDPE pipe can be shown to be hydraulically adequate for the design runoff.
- C. Perforated HDPE pipe may be used as an underdrain pipe subject to railway loading. The diameter of the perforated HDPE pipe shall not exceed six (6) inches. Minimum cover shall not be less than two (2) feet below bottom of tie. The perforated HDPE pipe shall be certified by the manufacturer as satisfactory insofar as design for E80 railway load.
- D. Any other use of and type of HDPE pipe in railway track fills at a specific location shall be subject to the approval of the BNSF Director-Bridge Engineering.

3.6 POLYVINYL CHLORIDE (PVC) PIPE

- A. Perforated PVC pipe may be used as an underdrain pipe subject to railway loading. The diameter of the perforated PVC pipe shall not exceed six (6) inches. Slot geometry and placement shall provide a minimum of 1.90 square inches/lineal foot opening for each diameter. Minimum cover shall not be less than two (2) feet below bottom of tie. The perforated PVC pipe shall be certified by the manufacturer as satisfactory insofar as design for E80 railway load.
- B. Any other use of and type of PVC pipe in railway track fills at a specific location shall be subject to the approval of the BNSF Director-Bridge Engineering.

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3.7 SELECTION OF PROTECTIVE COATINGS

- A. All prefabricated corrugated galvanized steel pipe and prefabricated corrugated aluminum coated steel pipe shall be fabricated from coated steel sheets. All galvanized corrugated structural steel plate pipe shall be galvanized by the fabricator.
- B. Smooth steel pipe used as a drainage culvert shall have an increased wall thickness to allow for corrosion and therefore requires no protective coating.
- C. Polymeric Coated:
 - 1. Under certain site conditions, polymeric coated corrugated galvanized steel pipe may be substituted for paved corrugated galvanized steel pipe. The flow of water must be non-abrasive, i.e. the anticipated velocity of water in the culvert must be low and/or no abrasive granular materials should be present in runoff water. Water supply ditches and drainage ditches with very gentle stream bed profiles and controlled water surface elevations are examples of locations where polymeric coated corrugated galvanized steel pipe may be used.
- D. Aluminum Coated:
 - 1. Corrugated aluminum coated steel pipe may be substituted for paved corrugated galvanized steel pipe. Corrugated aluminum coated steel pipe should only be used where soil pH is between 5 and 8.5 and should not be used in alkaline environments or near concrete. Corrugated aluminum coated steel pipe should not be used as a grouted-in-place culvert liner or where backfill materials consist of limestone screenings, stabilized soil or a controlled low-strength material (CLSM).

PART 4 EXECUTION

4.1 SPECIFICATIONS

- A. Corrugated steel pipe, corrugated structural steel plate pipe and reinforced concrete culvert pipe shall be installed in accordance with Section 05100 of the current BNSF Railway Company Standard Construction Specifications, and the following Sections of Chapter 1, Parts 4 and 5, and Chapter 8, Part 10, of the current AREMA Manual for Railway Engineering:

Prefabricated Corrugated Steel Pipe and Pipe-arch, Corrugated Structural Steel Plate Pipe, Pipe-arch and Arch	Chapter 1, Section 4.12
Earth Boring and Jacking Culvert Pipe	Chapter 1, Section 4.18
Installing Culverts Inside Existing Culverts	Chapter 1, Section 4.19.5
Steel Tunnel Liner Plates	Chapter 1, Section 4.20
Installing Casing Pipe	Chapter 1, Section 5.3.5.1
Reinforced Concrete Culvert Pipe	Chapter 8, Section 10.4

- B. Precast concrete box culverts shall be installed in accordance with Section 04500 of the current BNSF Railway Company Standard Construction Specifications, and Chapter 8, Part 16, of the current AREMA Manual for Railway Engineering.

4.2 MATERIAL HANDLING

- A. Material shall be handled to final position in such a manner as to prevent its damage. Corrugated pipes or structural steel plate materials shall not be dropped to, or dragged over, the ground, but shall be handled with rolling slings, on skids, or with cranes.
- B. Corrugated steel pipe, when paved, shall be stored with paved invert at bottom.

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- C. Corrugated steel pipe may be polymeric coated and paved, and any damage to coating or paving shall be repaired according to manufacturer specifications.
- D. Bent or otherwise damaged corrugated pipe or structural steel plate materials shall be straightened and repaired, if feasible, before being placed in final position.
- E. Materials must be properly stored if extended time will elapse prior to installation. Pipe coatings or pipe materials affected by UV rays or temperature extremes should be stored under a protective shelter until they can be properly installed. In the case of structural steel plate pipes, plates should be stored in a manner where moisture will drain rather than collect in the plates. Protected storage is preferred. Stacking plates to provide proper drainage and ventilation helps prevent storage stains.
- F. Culvert pipes shall be handled carefully to avoid damaging the protective or metallic coatings and denting the metal or changing its shape in any manner. The use of lifting lugs is encouraged when such use will minimize possible damage to the pipe. Lifting lugs should be used on all polymeric coated pipe.
- G. Precast concrete units or elements shall be assembled in accordance with the manufacturer's instructions. All units or elements shall be handled with reasonable care and shall not be rolled or dragged over gravel or rock. Care shall be taken during storage, hoisting and handling of the units to prevent cracking or damage, and to prevent the units from striking rock or other hard objects during placement. Cracks in an installed precast concrete culvert that exceed 0.01-inch width will be appraised by the BNSF Director-Bridge Engineering. Cracks determined to be detrimental shall be sealed by a method approved by the BNSF Director-Bridge Engineering.

4.3 SUBSURFACE EXPLORATION AND ANALYSIS

- A. A subsurface exploration and analysis shall be made when any of the following conditions occur:
 - 1. Where a culvert is to be installed as a replacement for a bridge, and the face-to-face distance between the ends of the bridge exceeds the width of the proposed culvert foundation, the necessary subsurface exploration and analysis shall be made. The analysis shall investigate the ability of the native soils under the bridge to support the bridge fill material dead loads plus railway track live loads without excessive settlement, and to support the load of the proposed culvert without excessive longitudinal vertical displacement of the culvert.
 - 2. Where unsuitable material (peat, muck, etc.) is encountered at or below invert elevation under the proposed culvert foundation, the necessary subsurface exploration and analysis shall be made. The analysis shall investigate the ability of the native soils to support the fill material dead loads plus railway track live loads without excessive settlement, and to support the load of the proposed culvert without excessive longitudinal vertical displacement of the culvert.
- B. If the analysis per applicable Paragraph 4.3.A.1. or Paragraph 4.3.A.2. indicates that the properties of the native soils are inadequate for the loads, the analysis shall also include recommendations of economically viable alternative corrective measures or treatments that should be undertaken at the project location.

4.4 FOUNDATION PREPARATION - CORRUGATED PIPE AND STRUCTURAL STEEL PLATE PIPE

- A. The foundation shall be a smoothed and compacted surface extending for the full length of the pipe and conforming to bottom of pipe grade or camber and will hereafter be referred to as the foundation line. The foundation bed shall be free of boulders, tree stumps, cut-off piling, and other projections. Suitable longitudinal camber to allow for settlement of pipe due to consolidation of foundation material or under high fills will be provided when required. Generally, enough camber can be obtained by installing the upstream half of the flexible culvert on a flatter grade than the downstream half, with the culvert inlet and outlet invert elevations matching the design elevations. Camber

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should be not more than 1/2 of 1 percent (0.5%) of the total length of the structure. Shaping to pipe contour is not required.

- B. Where acceptable foundation material is present, the width of the foundation line shall be a minimum of 4 feet plus the pipe diameter or pipe-arch span. For multiple lines of pipe the above width shall be increased by the sum of the distances between pipe or pipe-arch centers.
- C. In some locations where the soil below flow line is stable and flow line can be raised, bedding material may be placed on top of existing ground, working the material into the existing ground as the flow line is raised.
- D. Where there is solid rock or other unsuitable material, such as boulders, or unstable material that may deform the pipe during minor settlement, at the foundation line, it will be necessary to provide suitable bedding for pipes.
- E. Where bedding is found necessary, natural material shall be excavated, with vertical sides, to a depth of 1 foot or more below the foundation line and backfilled with selected material to the foundation line. Selected bedding backfill shall be compacted to the full amount required by Section 03200, Excavation and Embankment, of the current BNSF Railway Company Standard Construction Specifications, up to an elevation 1 foot below the proposed flow line elevation. The final 1 foot of bedding material shall be placed in 4-to-6-inch lifts and shall be uncompacted granular material. The width of excavation and bedding backfill shall be the pipe diameter or pipe-arch span in solid rock and boulders, and in other unsuitable material, the width shall be three pipe diameters or pipe-arch spans for single line of pipe, and for multiple lines of pipe, this width shall be increased by the distances between pipe or pipe-arch centers.

4.5 FOUNDATION PREPARATION - REINFORCED CONCRETE CULVERT PIPE

- A. Trenches shall be excavated in accordance with the bank stability requirements to a width sufficient to allow for proper joining of the pipe and thorough compaction of the bedding and backfill material under and around the pipe. Where feasible, trench walls shall be vertical. The completed trench bottom shall be firm and cleaned for its full length and width.
- B. If rock strata, boulders, tree stumps, cut-off piling and other projections are encountered under the culvert within the limits of the required bedding, these projections shall be removed and replaced with bedding material.
- C. Where specifically requested, the pipe trench bottom may be cambered longitudinally to provide for expected settlement.
- D. Where specified on the plan or in the special provisions, the excavation for a pipe to be placed within new track embankment fill shall be made after the embankment has been completed to a specified height above the top of the pipe.
- E. If the foundation is incapable of supporting the pipe loads, an adequate support shall be supplied by excavating the unstable soil and backfilling with compacted material, or by such other means as may be specified or approved by the BNSF Director-Bridge Engineering.

4.6 PROTECTION OF FOUNDATIONS

- A. The method of construction shall, by diversion ditches, dikes, or other means, keep the foundations free of water at all times after the work is started, and until the embankment is placed over the pipe. Any channel work necessary to allow free flow through the pipe shall be completed before the embankment is placed.

4.7 PLACING PREFABRICATED CORRUGATED PIPE

- A. Where two or more lines of pipe are used, there shall be a minimum of one-half pipe diameter but not less than 3 feet, or one-half pipe-arch span but not less than 3 feet, clear distance apart. For

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new track construction, where practicable, a space of 10 feet may be provided between lines of pipe to facilitate compacting fill material around the pipe with heavy equipment.

- B. Pipe having riveted seams shall be laid with outside laps of circumferential joints pointing upstream, longitudinal laps on the sides and asphalt paving on the flow line.
- C. Prefabricated corrugated steel pipe and pipe-arch are normally ordered in lengths of the culvert sections such that no field joining of the culvert sections shall take place within 7 feet of the vertical centerline of any track. For culverts so ordered, the culvert sections must be placed so that no field joining of the culvert sections shall take place within 7 feet of the vertical centerline of any track.
- D. Pipe sections shall be firmly joined together with coupling bands. All dirt or other foreign materials must be kept out from between pipe and band. Outside coupling bands should be slipped over the end of one section, and the adjoining section brought within 1 inch of the first. Band shall be made to fit snugly and equally on each pipe section and bolted to produce a tight joint. The lower half of two-piece coupling bands for pipe having riveted seams may be furnished already connected to one of the pipe sections, and in such cases the end having the fixed half band shall be placed downstream. Band couplers and ends of pipe under the bands may be lubricated with an approved oil or solvent. Excess asphalt at joints may be removed by an application of heat, if necessary.
- E. At locations where the existing corrugated pipe is to be extended with new pipe, the joining end of the existing pipe shall be free of breaks, cracks or other defects. If the end of the existing corrugated pipe is not suitable for making a proper joint, the amount of pipe necessary to allow making of an approved joint shall be removed or trimmed.

4.8 FIELD STRUTTING OF CORRUGATED PIPE

- A. Strutting to maintain the vertical diameter of prefabricated corrugated steel pipe should generally not be necessary with proper installation and compaction of the backfill material, but it is permissible if the fill height, nature of fill, or diameter of pipe warrants. Struts can consist of horizontal wires or vertical timbers, except, in the case of limited height-of-cover per Paragraph 4.8.B, only vertical timber struts shall be used.
- B. When the distance from base of rail to the top of pipe will be less than the dimensions given in Table 4-1, corrugated pipes may be field strutted using vertical timber struts to prevent excessive reduction of the vertical diameter of the pipe during track placement and surfacing.

Table 4-1. Height-of-Cover Criteria for the Use of Timber Struts

Pipe Diameter (Inches)	Base of Rail to Top of Pipe (Feet)
48	4.0
54 to 66, inclusive	4.5
72 to 96, inclusive	5.0
102 to 108, inclusive	5.5
114 to 120, inclusive	6.0

- C. Vertical timber struts shall be placed after embankment is compacted to top of corrugated pipe but before any embankment is placed over the pipe. No equipment shall pass over the corrugated pipe until struts are in place and the lesser of either the full cover or three feet of embankment is in place over the pipe.
- D. Vertical timber struts shall consist of minimum size 6-inch by 6-inch longitudinal timbers at the invert and top of corrugated pipe separated by minimum size 6-inch by 6-inch timber posts at 3 foot centers. Struts shall be shimmed tight using hard wood wedges nailed securely in position. Placement of struts shall be limited to the portion of corrugated pipe located within 12 feet of centerline of tracks.

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- E. Struts reduce hydraulic capacity of culverts due to obstruction of opening and/or buildup of water-born debris. Unless otherwise directed, struts shall be left in place until the embankment material cover over the culvert has been compacted, track laying has been completed and the ballast has consolidated. The struts shall then be removed promptly.
- F. Strutting of structural steel plate pipe is not recommended and should not be required.
- G. Prefabricated corrugated steel pipe-arch and structural steel plate pipe-arch shall not be strutted.

4.9 PLACING STRUCTURAL STEEL PLATE PIPE

- A. Structural steel plate pipe shall be erected at the site, in accordance with detailed plans or instructions.
- B. Where two or more lines of structural steel plate pipe are used, they shall be a minimum of one-half pipe diameter but not less than 3 feet, or one-third of pipe-arch span but not less than 3 feet, clear distance apart. For new track construction, where practicable, a space of 10 feet may be provided between lines of pipe to facilitate compacting fill material around the pipe with heavy equipment.
- C. Structural steel plate pipes may be made up of corrugated plates of variable gages. The invert plate may be two gages heavier than the plates for the sides and top of the pipe section, and heavier gage plates may be used in the center sections than at the end sections of the pipe. Plates shall be piece marked by the manufacturer. An erection diagram will be provided by the manufacturer and must be followed without exception.
- D. Structural steel plate pipes are to be assembled at the site with as few bolts as possible until all plates are in place. Three or four untightened bolts near the center of each plate along the longitudinal and circumferential seams are sufficient, and after several rings have been assembled the remaining bolts can be inserted, the corner bolts being the last. Bolts are to be tightened progressively from one end of the structure to the other after assembly has been completed, and shall be check-tightened in the same manner to be sure none are left loose. All bolts shall be tightened with proper tools, either hand or power wrenches, initially to a minimum of 100 ft-lbs and a maximum of 300 ft-lbs of torque.
- E. Where heavy camber is necessary, erection procedures may be modified, but only as specifically approved by the Director-Bridge Engineering for each such case.
- F. At locations where the existing structural steel plate pipe is to be extended with new plates, the joining end of the existing pipe shall be free of breaks, cracks or other defects. Existing beveled plates shall be removed so that extension can be made using standard plates.
- G. Identification tag, supplied by the manufacturer, shall be attached near the top of and inside of pipe at upstream end.
- H. Bolt holes for culvert extensions can be initially flame cut and then shall be reamed to the specified hole size.

4.10 PLACING REINFORCED CONCRETE CULVERT PIPE

- A. Pipe laying shall begin at the downstream end of the culvert. The bell or groove end of the pipe shall be placed upstream. No culvert shall be put into service until a suitable outlet is provided for the water.
- B. Elliptical pipe shall be placed with the vertical axis within 5 degrees of a vertical plane through the longitudinal axis of the culvert.
- C. Pipe bedding and placement, specified on the plans or in the special provisions, shall conform to one of the Installations illustrated in Table 8-10-1 of Chapter 8, Part 10 of the AREMA Manual for Railway Engineering. When pipe cannot be placed on a prepared surface but must instead be placed on an unprepared surface, the installation shall be considered to be a Type 4 Installation.

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Type 4 Installations should only be used for emergency work, and is not permitted for permanent installations unless authorized by the BNSF Director-Bridge Engineering. For typical Type 4 Installations, see AREMA Figure 8-10-1 and Table 8-10-1.

- D. Where bell and spigot pipe is used, a shallow excavation shall be made underneath the bell of sufficient depth so that the bell does not rest on the bedding material.
- E. Proper facilities shall be provided for hoisting and lowering the sections of culvert into the trench without disturbing the prepared foundation and the sides of the trench.
- F. The ends of the section shall be carefully cleaned before the section is jointed. Pipe sections shall be joined so that the ends are fully entered and the inner surfaces are flush and even.
- G. Joints shall comply with the details shown on the plans or specified in the special provisions. Each joint shall be sealed to prevent infiltration of soil fines or water as required by the contract documents.
- H. Sections shall be fastened together with U-bolts as shown on the plans or in the special provisions.

4.11 PLACING PRECAST CONCRETE BOX CULVERT

- A. Joining ends of precast box culvert units shall be accurately formed in accordance with details shown on the plans so that when the box units are placed together they will make a continuous line of units with a smooth interior free of appreciable irregularities in the flow line, all compatible with specified tolerances. Precast box culvert units shall be laid with the bell or groove end upstream.
- B. Box units shall be placed on fully compacted pervious backfill material meeting the requirements of Paragraph 4.11.C.1. The material shall be at least 1 foot in thickness and shall extend at least 1 foot beyond each side of the outer limits of the box units. The side slope at the edges of the material shall be one-to-one. Any excavation shall be protected during construction by protective shoring, where required.
 - 1. Pervious backfill material shall consist of crushed rock or crushed gravel, or combinations thereof. Pervious backfill material shall conform to the following grading requirements:

Sieve Size	% Passing
1-1/2 inch	100
1 inch	90-100
3/4 inch	40-85
1/2 inch	10-40
3/8 inch	0-15
No. 4	0-5

- C. The ends of the box units shall be carefully cleaned before the box units are jointed. Box units shall be joined so that the ends are fully entered and the inner surfaces are flush and even.
 - 1. Plywood strips may be placed on top of the foundation bed at the box unit joints to prevent foundation material from entering the joint area as each box unit is placed. The plywood strips need not be removed after placement of the box units.
- D. Sections shall be fastened together with heavy-duty couplers as shown on the plans or in the special provisions.
- E. Following installation of box units, lifting devices shall be removed as indicated on the plans or approved shop drawings. Holes in concrete shall be filled with non-shrink grout. Recesses in concrete shall be patched with epoxy mortar.

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- F. When multiple lines of box units are used, a 1-1/2 inch minimum space shall be left between adjacent sections. After the precast units are in place and backfill has been placed to mid-height of the precast concrete box units on each side, the space between the lines of the box units shall be filled with concrete having a 7 day design compressive strength of 2500 psi. The concrete shall be in accordance with Section 04400, Concrete Construction, of the current BNSF Railway Company Standard Construction Specifications, except the maximum size coarse aggregate shall be 3/8 inch. If shown in the plans, multiple lines of box units may be bolted together in accordance with the plans and special provisions.

4.12 USE OF CONTROLLED LOW-STRENGTH MATERIAL (CLSM) AND CONTROLLED LOW-STRENGTH MATERIAL – CONTROLLED DENSITY FILL (CLSM-CDF)

- A. Controlled low-strength material (CLSM) is a self-compacted, cementitious material used primarily as a backfill in lieu of compacted fill. Several terms currently used to describe this material include flowable fill, backfill, trenchfill, unshrinkable fill, controlled density fill (CDF), flowable mortar, flowable grout, plastic soil-cement, soil-cement slurry, cellular concrete and foamed concrete. CLSM mixes fall into two categories: flowable fill (Regular CLSM), which have a typical unit weight greater than 50 lbs/ft³; and low density CLSM (LD-CLSM), which have a typical unit weight lower than 50 lbs/ft³. Regular CLSM-CDF mixes should be used for railway fill and culvert backfill applications, with unconfined compressive strengths less than 150 psi at 28 days to allow for future excavation.
- B. Flowability can be varied from very stiff to very fluid and be expressed by use of the standard concrete slump cone (ASTM C143), flow cone (ASTM C939), or a 3 inch x 6 inch open-ended cylinder modified flow test.
1. The standard concrete slump cone may be used with a wide range of CLSM mixtures. Flowability ranges associated with the standard concrete slump cone can be expressed as follows:
 - (a) Low flowability – slump less than 6 inches
 - (b) Normal flowability – slump 6 to 8 inches
 - (c) High flowability – slump more than 8 inches
 2. The flow cone should only be used with very fluid CLSM mixtures containing aggregates not greater than 1/4 inch in size.
 3. The modified flow test using the 3 inch x 6 inch open-ended cylinder should only be used with CLSM mixtures containing primarily fine aggregate.
- C. A major consideration in using highly flowable CLSM is the hydrostatic pressure it exerts. Where fluid pressure is a concern, CLSM may be placed in lifts, with each lift being allowed to harden before placement of the next lift. Examples where multiple lifts may be required are in the case of limited strength forms, flexible wall culverts that may experience wall buckling, or where culvert buoyancy may be a problem. Maximum depth of each lift should not exceed three feet.
- D. Hardening time is the approximate period of time required for CLSM to go from the plastic state to a hardened state. A hardened state is defined as an minimum load bearing strength of 20 psi as measured with a penetrometer using the 1.124" diameter head (per ASTM D1558). The penetration can be considered acceptable when a person weighing at least 150 lbs, placing full body weight on a 3-1/2 inch by 3-1/2 inch wooden block, cannot penetrate the CLSM more than one inch. Hardening time is greatly dependent on the type and quantity of cementitious material in the CLSM. Normal factors affecting the hardening time are:
1. Type and quantity of cementitious material
 2. Permeability and degree of saturation of surrounding soil which is in contact with CLSM
 3. Fluidity of CLSM

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4. Proportioning of CLSM
 5. Mixture and ambient temperature
 6. Humidity
 7. Depth of CLSM fill
- E. Fast setting mixtures for CLSM-CDF shall achieve a hardened state as defined in Paragraph 4.12.D. in two hours or less. Chemical admixtures may be used to accelerate hardening.
- F. Mix design of CLSM has been done in many states, and an applicable state specification may exist. However, due to desired shorter hardening times, a state specification mix design may not be appropriate for a particular railway application. Increasing the cement content, or the use of chemical admixtures, to reduce the hardening time should be explored with the supplier, where necessary. The following summary can be made regarding the materials currently used in various states to manufacture CLSM:
1. Cement – Cement contents generally range from 50 to 200 lb/yd³, depending upon strength and hardening time requirements. Increasing cement content while maintaining all other factors equal, that is, water, fly ash, aggregate and ambient temperature, will normally increase strength and reduce hardening time.
 2. Fly ash – Class F fly ash contents range from none to as high as 2000 lb/yd³ where fly ash serves as the aggregate filler. Class C fly ash is used in quantities of up to 350 lb/yd³. Class C fly ash must be low cementitious. The use of high quantities of Class C fly ash may result in rapid loss of flowability of the CLSM mix due to flash set. Lime (CaO) content of fly ash should not exceed 10 percent by weight in order to inhibit undesirable long-term strength increase of the CLSM mix. The quantity of fly ash used will be determined by availability and flowability needs of the project.
 3. Aggregate – The majority of specifications call for the use of fine aggregate. The amount of fine aggregate varies with the quantity needed to fill the volume of the CLSM after considering cement, fly ash, water and air contents. In general, the quantities range from 2600 to 3100 lb/yd³. Coarse aggregate is generally not used in CLSM mixes as often as fine aggregates. When used, however, the coarse aggregate content is approximately equal to the fine aggregate content.
 4. Water – More water is used in CLSM than in concrete. Water serves as a lubricant to provide high flowability characteristics and promote consolidation of the materials. Water contents typically range from 325 to 580 lb/yd³ (39 to 70 gal/yd³) for most CLSM mixes containing aggregate. Water content for Class F fly ash and cement only mixes can be as high as 1000 lb/yd³ (120 gal/yd³) to achieve good flowability. This wide range is due primarily to the characteristics of the materials used in CLSM and the degree of flowability desired. Water contents will be higher with mixtures using finer aggregates.
- G. USDOT general standard specification, composition of CSLM mix:

Property	Specification
Cement content	50 pounds per cubic yard min.
Slump	6 – 8 inches
Aggregate particle size	1 inch max.
Aggregate passing No. 200 sieve	10% max.
7-day compressive strength	220 pounds per square inch max.

- H. If an acceptable state specification for a CLSM mix design is not available, the following are two example CLSM mix designs:
1. CLSM mix design example:

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Material	Lb/Yd3
Cement	50
Coarse Aggregate (AASHTO No. 57 or 67)	1700
Fine Aggregate (AASHTO M6)	1845
Water (39 gal/yd3, or as needed)	325

- (a) Water shall be such that the CLSM flows into place properly without excessive segregation.
- (b) An aggregate that meets the following gradation specification may be substituted if the cement content is increased to 100 lb/yd3:

Sieve Size	% Passing
1 inch	100
No. 200	0-10

- (c) 30 lbs/yd3 of cement and 30 lbs/yd3 of fly ash (Class C or F) may be substituted for 50 lbs/yd3 of cement.
- (d) 60 lbs/yd3 of cement and 60 lbs/yd3 of fly ash (Class C or F) may be substituted for 100 lbs/yd3 of cement.

2. CLSM mix design example:

Material	Lb/Yd3
Cement	100
Fly Ash	250
Fine Aggregate (AASHTO M6)	2990
Water (21pprox.. 55 gal/yd3)	450

- I. Project types which may necessitate the use of CLSM backfill include the installation of two or more lines of large diameter (or span) culverts as a replacement for a driven bent trestle bridge, the installation of one or more lines of culverts between bridge abutments and/or piers as a replacement for a bridge with that type of substructure, or the trench installation of a culvert. Where CLSM backfill is used, the following minimum limits (width, height and length) of CLSM backfill shall apply:

1. Width:

- (a) Driven bent trestle bridges – Out to out of bents adjacent to the culvert(s).
- (b) Bridge abutments and/or piers – Face to face of abutments and/or piers.
- (c) Trench installation – Face to face of the walls of the excavated trench.

2. Height:

- (a) For round, elliptical or pipe-arch culverts – To a level of one (1) foot above the elevation at the maximum width of the culvert(s).
- (b) For concrete box culverts – To the top of the box culvert(s).

3. Length:

- (a) The horizontal distance that represents the live load distribution perpendicular to the track(s) at the elevation of the top of the culvert(s). The live load distribution may be assumed to spread laterally outward from each end of the tie at a slope of 1/2 to 1 from the bottom of the tie to the top of culvert(s).

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4.13 BACKFILL AND EMBANKMENT – CORRUGATED PIPE AND STRUCTURAL STEEL PLATE PIPE

- A. Backfill Around Pipes: Where the pipe foundation line is below natural ground, compacted backfill placed in accordance with Paragraph 4.13.B. shall be placed around the pipe in the area within the limits of the embankment section which was removed as channel excavation. The upper limit of this backfill shall be the top of pipe elevation or the elevation of natural ground surface as it existed before any excavation was made, whichever is lower. Embankment above natural ground shall be placed in accordance with Paragraph 4.13.B. For new track construction, when the upper limit of backfill is the top of pipe elevation, a 3 foot depth of material shall be placed above the pipe without compaction. This material shall be compacted in accordance with Paragraph 4.13.B. at the time the roadbed receives its final finish.
- B. Embankment Around Pipes:
1. The placing of embankment around pipes is to be started only after assembly and erection work has been completed in every detail. Embankment material to be placed around pipes must be an approved material. Approved materials include:
 - (a) Limestone screenings
 - (b) Stabilized soil (soil stabilized with lime, fly ash or cement)
 - (c) Controlled low-strength material (CLSM) (See Section 4.12)
 - (d) Materials (a) and (b) require compaction; material (c) is self-compacting.
 2. Embankment under the haunches, along each side for a minimum width equal to the pipe diameter, and over the pipe is to receive special handling both as to placing and as to compaction, and is to be made before the adjacent roadbed embankment is placed. Embankment around pipes shall be brought up in compacted layers, with each layer having a depth of less than 6 inches before compaction, on both sides of the pipe at the same time keeping the fill at the same elevation on both sides. The depth of layers should be decreased to 4 inches with some types of hand tampers.
 3. Embankment shall be hand tamped directly under the haunches throughout the width beyond the reach of machine compacting equipment. All material, except as noted below, shall be compacted to the full amount required by Section 03200, Excavation and Embankments, of the current BNSF Railway Company Standard Construction Specifications. Only approved compaction methods and equipment shall be used.
 4. For new track construction, the embankment directly above the pipe for a distance of one-third pipe diameter, but not less than 3 feet is to be placed without compaction.
 5. For new track construction, where the distance from subgrade to top of pipe is less than 3 feet, the excess material shall be left in place until the roadbed receives its final finish. At this time the material over the pipe to a depth of 1 foot below subgrade elevation shall be compacted to the full amount required by the Section 03200, Excavation and Embankments, of the current BNSF Railway Company Standard Construction Specifications.
 6. Care must be taken to prevent water from leaking through the fill or along the side of the pipe (piping). When granular materials have been used for bedding or backfill, the ends of such material must be sealed against infiltration. This can be done by using impervious embankment material, such as well-tamped clay or concrete fill, for three feet at both ends of the pipe.
- C. Trench Bedding:
1. Materials for backfill on each side of the pipe for the full width of the trench and to an elevation of 1 foot above the top of the pipe shall be fine, readily compacted soil, granular material or CLSM, and shall not contain frozen lumps, stones that would be retained on a 2 inch sieve, chunks, highly plastic clay, or other objectionable material. Granular backfill material shall have 100% passing a 3/4 inch sieve, not less than 95% passing a 1/2 inch sieve, and not less than

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- 95% retained on a No. 16 sieve. Oversized material shall be removed at the source of the material.
2. When the top of the pipe is even with or below the top of the trench, backfill material shall be placed at or near the optimum moisture content and compacted in layers not exceeding 6 inches (compacted) on both sides of the pipe for the full required length. CLSM placed in 3 foot maximum lifts may be substituted for placed and compacted backfill material.
 3. Backfill material shall be placed and compacted for the full depth of the trench. CLSM placed in 3 foot maximum lifts may be substituted for placed and compacted backfill material.
 4. When the top of the pipe is above the top of the trench, backfill shall be placed at or near optimum moisture content and compacted in layers not exceeding 6 inches (compacted) and shall be brought up evenly on both sides of the pipe for its full length to an elevation 1 foot above the top of the pipe. CLSM placed in 3 foot maximum lifts may be substituted for placed and compacted backfill material to an elevation equal to the top of the trench, but not lower than 1 foot above the elevation at the maximum width of the pipe. The width of backfill on each side of the pipe for the portion above the top of the trench shall be equal to twice the diameter of the pipe or 12 feet whichever is less. The backfill material used in the trench section and the portion above the top of the trench for a distance on each side of the pipe equal to the horizontal diameter and to 1 foot above the top of the pipe shall conform to the requirements for backfill in Paragraph 4.13.C.1. The remainder of the backfill shall meet the requirements for embankment construction.
 5. The width of the trench shall be a minimum of 1.5 times the outside width of the pipe, and need not be more than two feet greater than the outside diameter of the pipe, in order to completely fill the void.
- D. For locations where a culvert is to be installed as a replacement for a bridge, the remainder of the embankment shall be placed and compacted to the full amount required by Paragraph 3.6 of Section 03200, Excavation and Embankments, of the current BNSF Railway Company Standard Construction Specifications. Embankment material shall consist of one of or a combination of approved materials listed in Paragraph 4.13.B.1., or a satisfactory local borrow material. Suitability of local borrow materials must be determined by soils laboratory testing of proposed borrow materials. Compaction of embankment materials other than CLSM must be to a density of not less than 95% of the standard laboratory density, with the top 3 feet (below top of subgrade) to a density of not less than 95% of the standard laboratory density at a moisture content within -1 to +3 percentage points of optimum moisture content. Optimum moisture content can only be determined by soils laboratory testing of proposed embankment materials, and satisfactory compaction of placed embankment materials at the specified moisture content can only be accurately determined by field testing of placed embankment materials. Where there is seepage of subsurface water from the fill adjacent to the bridge ends or evidence of a water-saturated fill adjacent to the bridge ends, whether these conditions are intermittent or continuous, provisions for drainage of subsurface water must be incorporated in the bridge embankment fill. Provisions for drainage of subsurface water include the installation of perforated pipe cross drains or French drains at the bridge ends to intercept and convey the drainage of any subsurface water that is present.
1. Before removal of the bridge superstructure, embankment may be placed and compacted to a maximum height that allows the use of compaction equipment.
 2. Before removal of the bridge superstructure, if CLSM is used as embankment material, embankment may be placed to a maximum height that allows the removal of the bridge superstructure.
 3. After removal of the bridge superstructure, the remaining height of embankment shall be placed and compacted.
- E. For locations where a culvert is to be installed as a replacement for a bridge, the bridge superstructure must be removed, except as approved by the BNSF Director-Bridge Engineering.

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1. For the following types of existing structures, superstructure to be removed includes:
 - (a) Open deck timber pile trestles - Timber caps, timber bracing and timber stringers are to be removed; steel or concrete caps need not be removed if all voids in and under the caps are filled with an approved material per Paragraph 4.13.B.1.
 - (b) Ballast deck timber pile trestles - Timber caps, timber bracing and timber stringers are to be removed; steel or concrete caps need not be removed if all voids in and under the caps are filled with an approved material per Paragraph 4.13.B.1.
 - (c) Concrete trestles - Concrete spans are to be removed; concrete caps need not be removed if all voids under the caps are filled with an approved material per Paragraph 4.13.B.1.
 - (d) Timber or steel bridges with concrete substructure and timber caps on substructure - Timber caps and timber stringers or timber caps, steel spans and deck are to be removed.
 - (e) Open deck steel bridges - Steel spans are to be removed.
 - (f) Ballast deck steel bridges - Steel spans and deck are to be removed.
2. Subject to the approval of the Director-Bridge Engineering, superstructure need not be removed for the following types of existing structures:
 - (a) Concrete trestles with solid concrete beams, where CLSM is used to fill all voids under the spans and caps.
 - (b) Steel bridges, where CLSM is used to fill all voids under and inside the spans.
 - (c) Other types of superstructure, where approved.

4.14 BACKFILL AND EMBANKMENT - REINFORCED CONCRETE CULVERT PIPE

A. General:

1. The backfill around the culvert shall be placed in accordance with the bedding requirements illustrated in Figure 8-10-1 and Table 8-10-1 of Chapter 8, Part 10 of the AREMA Manual for Railway Engineering, and other requirements of these specifications.
2. All culverts that are to carry track load shall have the backfill thoroughly compacted to a minimum density of 95% as determined by ASTM Designation: D698, and as specified elsewhere in the special provisions for adjacent embankment.
3. Where the pipe is placed on a shaped subgrade (see AREMA Figures 8-10-2 and 8-10-4) extreme care shall be taken not to over-excavate the shaped surface so that point loading shall not occur on the pipe bottom.

B. Embankment Bedding (See AREMA 10.4.3.2):

1. Where rock or noncompressible foundation material is encountered, the hard unyielding material should be excavated below the elevation of the bottom of the pipe or pipe bell to a depth in accordance with Table 8-10-1, or 1/2 inch for each foot of fill over the top of the pipe, whichever is greater, but not more than 3/4 of the diameter (or horizontal span) of the pipe.
2. For a negative projecting embankment condition, the width of the excavation, B_d , should be at least 1.33 times the outside width of the pipe, B_c , and with a minimum of two feet greater than the outside diameter of the pipe for thorough filling and compaction of the void space under the pipe haunch.

C. Trench Bedding:

1. Materials for backfill on each side of the pipe for the full width of the trench and to an elevation of 1 foot above the pipe shall not contain frozen lumps, stones that would be retained on a 2 inch sieve, chunks, highly plastic clay, or other objectionable material. Granular backfill material shall have 100% passing a 3/4 inch sieve, not less than 95% passing a 1/2 inch sieve, and not less than 95% retained on a No. 16 sieve. Oversized material shall be removed at the source of the material.

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2. When the top of the pipe is even with or below the top of the trench, backfill material shall be placed at or near the optimum moisture content and compacted in layers not exceeding 6 inches (compacted) on both sides of the pipe for the full required length.
3. Backfill material shall be placed and compacted for the full depth of the trench, unless induced trench installation is used.
4. When the top of the pipe is above the top of the trench, backfill shall be placed at or near optimum moisture content and compacted in layers not exceeding 6 inches (compacted) and shall be brought up evenly on both sides of the pipe for its full length to an elevation 1 foot above the top of the pipe. The width of backfill on each side of the pipe for the portion above the top of the trench shall be equal to twice the diameter of the pipe or 12 feet, whichever is less. The backfill material used in the trench section and the portion above the top of the trench for a distance on each side of the pipe equal to the horizontal diameter and to 1 foot above the top of the pipe shall conform to the requirements for backfill in Paragraph 4.14.C.1. The remainder of the backfill shall meet the requirements for embankment construction.
5. The width of the trench, B_d , shall be a minimum of 1.33 times the outside width of the pipe, B_c , but not less than two feet greater than the outside diameter of the pipe in order to completely fill the void.

D. Induced Trench Bedding:

1. The Induced Trench method shall not be used when the pipe is subjected to track loading without making a complete investigation of the settlements involved.
2. When the Induced Trench method is used, design and installation shall follow the recommendations set forth in the references in AREMA 10.3.2. The embankment shall be completed as required in 4.14.C, to a height above the pipe equal to the vertical outside diameter of the pipe plus one foot. A trench equal in width to the outside horizontal diameter of the pipe, in depth equal to the vertical outside diameter of the pipe, and to the length shown on the plans shall then be excavated to within one foot of the top of the pipe, trench walls being as nearly vertical as possible. This trench shall be loosely filled with highly compressible material. Construction of the embankment above the pipe shall then proceed in a normal manner using regular fill material.
3. The length of the Induced Trench method shall be shown on the plans or specified by the Engineer.
4. When the Alternate Induced Trench method is used, the embankment shall be constructed in a normal manner to a height above the culvert bedding elevation equal to twice the outside diameter of the pipe. A trench as required shall then be excavated with the walls as nearly vertical as possible, and the pipe bedded and backfilled to one foot above the pipe as called for in Paragraph 4.14.C. The remaining portion of the trench shall then be loosely filled with highly compressible material. Construction of embankment shall then proceed in a normal manner.
5. In no case shall the length of compressible material extend to the ends of the culvert.
6. Rock fill shall not be dumped over the culvert without a sufficient cushion of earth to prevent breakage of the pipe.

- E. For locations where a culvert is to be installed as a replacement for a bridge, the remainder of the embankment shall be placed and compacted as per Paragraph 4.13.D.
- F. For locations where a culvert is to be installed as a replacement for a bridge, the bridge superstructure must be removed per Paragraph 4.13.E.

4.15 BACKFILL AND EMBANKMENT - PRECAST CONCRETE BOX CULVERT

A. Backfill:

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1. Backfill material shall be placed in uniform horizontal layers not exceeding 8 inches in thickness before compaction. The backfill shall be brought up uniformly on all sides of the structure. The backfill shall be compacted to the density shown on the plans, in the special provisions, as specified for the adjacent ground, or to a minimum of 95% of the maximum dry density determined in accordance with the Standard Proctor compaction test (ASTM D698) if not otherwise specified.
- B. Embankment:
 1. Embankment material to be placed around precast concrete box culverts must be an approved material. Approved materials include:
 - (a) Limestone screenings
 - (b) Stabilized soil (soil stabilized with lime, fly ash or cement)
 - (c) Controlled low-strength material (CLSM) (See Section 4.12)
- C. Materials (a) and (b) require compaction; material (c) is self-compacting.
 1. Care must be taken to prevent water from leaking through the fill or along the side of the concrete box culvert (piping). When granular materials have been used for bedding or backfill, the ends of such material must be sealed against infiltration. This can be done by using impervious embankment material, such as well-tamped clay or concrete fill, for three feet at both ends of the concrete box culvert.
- D. For locations where a culvert is to be installed as a replacement for a bridge, the remainder of the embankment shall be placed and compacted as per Paragraph 4.13.E.
- E. For locations where a culvert is to be installed as a replacement for a bridge, the bridge superstructure must be removed per Paragraph 4.13.E.

4.16 JACKING CULVERT PIPE, EARTH BORING AND PIPE RAMMING

- A. General:
 1. Corrugated steel pipe and smooth steel pipe material shall be in accordance with Paragraph 2.1.D.
 2. Reinforced concrete pipe shall be in accordance with Paragraph 2.1.E.
 3. Manufacturer shall punch and match mark all sections of corrugated steel pipe for field bolting.
 4. Sewer type bands for watertight joints shall be provided for corrugated steel pipes when shown on the plans or special provisions.
 5. Full penetration welds meeting the requirements of the American Welding Society (AWS) D1.1 shall be used to join sections of smooth steel pipe.
 6. Pipe damaged in jacking or boring operations shall be repaired in place. Pipe damage beyond repair shall be removed and replaced.
 7. Excessive voids shall not be permitted in the jacking process. If the installation process results in significant voids, grout plugs shall be installed in pipe and all voids between the outside of the pipe and inside surface of the excavation shall be filled by pressure grout as soon as possible after the completion of the installation. The grout mix shall be an approved grout, consisting of cement, sand, and a workability additive.
- B. Jacking:
 1. Heavy duty jacks suitable for forcing the pipe through the embankment shall be provided. In operating jacks, even pressure shall be applied to all jacks used. A suitable jacking head and suitable bracing between the jacks and the jacking head shall be provided so that pressure will be applied to the pipe uniformly around the ring of the pipe. Joint cushioning material of plywood or other material may be used. Plywood cushioning material shall be 3/4-inch minimum thickness. Cushioning rings may be made up of single or multiple pieces. A suitable jacking

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- frame or backstop shall be provided. The pipe to be jacked shall be set on guides, properly braced together, to support the section of the pipe and to direct the pipe in the proper line and grade. The whole jacking assembly shall be placed so as to line up with the direction and grade of the pipe. In general, the embankment material shall be excavated just ahead of the pipe, the material removed through the pipe, and the pipe forced through the embankment with jacks, into the space thus provided.
2. The excavation for the underside of the pipe, for at least one-third of the circumference of the pipe, shall conform to the contour and grade of the pipe. Over-excavation to provide not more than 2 inches of clearance may be provided for the upper half of the pipe. This clearance shall be tapered to zero at the point where the excavation conforms to the contour of the pipe. Over-excavation in excess of 1 inch shall be pressure grouted the entire length of the installation.
 3. The distance that the excavation shall extend beyond the end of the pipe depends on the character of the material but shall not exceed 2 feet.
 4. Preferably, the pipe shall be jacked from the low or downstream end. The final position of the pipe shall not vary from the line and grade shown on the plans, or established by the Engineer, by more than 1/8 inch in 1 foot. The variation shall be regular and in one direction and the final flow line shall be in the direction shown on the plans.
 5. A cutting edge of steel plate around the head end of the pipe extending a short distance beyond the end of the pipe may be used with inside angles or lugs to keep the cutting edge from slipping back onto the pipe.
 6. Work should be done continuously to minimize the tendency of the material to "freeze" around the pipe.
- C. Boring:
1. The boring shall proceed from a pit provided for the boring equipment and personnel. The location of the pit shall be approved by the Railway Company. The boring shall be done mechanically either using a pilot hole or by the auger method.
 2. When the pilot hole method is used, an approximate 2-inch diameter pilot hole shall be bored the entire length of the crossing and shall be checked for line and grade on the opposite end of the bore from the work pit. This pilot hole shall serve as the centerline of the larger diameter hole to be bored.
 3. When the auger method is used, a smooth steel pipe of the appropriate diameter equipped with a cutter head to mechanically perform the excavation shall be used. Augers shall be of sufficient diameter to convey the excavated material to the work pit.
 4. Excavated material shall be disposed of in an approved manner. The use of water or other fluids in connection with the boring operation will be permitted only to the extent necessary to lubricate cuttings; jetting will not be permitted.
 5. In unconsolidated soil formations, a gel-forming colloidal drilling fluid consisting of at least 10 percent of high grade carefully processed bentonite may be used to consolidate cuttings of the bit, seal the walls of the hole, and furnish lubrication for subsequent removal of cuttings and immediate installation of the pipe.
 6. Allowable variation from line and grade shall be as specified in Paragraph 4.16.B.4. Overcutting in excess of 1 inch shall be remedied by pressure grouting the entire length of the installation.
 7. Any excavation shall be backfilled, compacted and resurfaced in order to restore the surface as near as possible to the original or specified contours.
- D. Pipe Ramming (Driving):
1. Pipe ramming is the process of forming a bore by driving an open-ended smooth steel pipe using a percussive hammer and only displacing the wall thickness of the pipe. Only smooth steel pipe may be installed by pipe ramming.

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2. The pipe ramming shall proceed from a pit provided for the ramming equipment and personnel. The location of the pit shall be approved by the Railway Company.
3. The soil may be removed from the pipe during the ramming process using a screw auger or screw conveyor system. The removal process should progress in such a manner that a soil "plug" remains in the leading end of the pipe until the completion of the installation of the total length of each line of the pipe.
4. The soil may remain in the pipe until the bore has been completed and then may be removed by water, augering, jet-cutting or compressed air.
5. A gel-forming colloidal drilling fluid consisting of at least 10 percent (10%) of high grade carefully processed bentonite may be used to furnish lubrication for the pipe ramming.
6. All material must be removed from the installed pipe, and the removed material shall be disposed of in an approved manner. The use of water or other fluids in connection with the ramming operation will be permitted only to the extent necessary to furnish lubrication for the pipe ramming. Jetting during the pipe installation will not be permitted.
7. Any excavation shall be backfilled, compacted and resurfaced in order to restore the surface as near as possible to the original or specified contours.
8. Pipe wall thickness shall be determined by the contractor installing the pipe, however, thickness must comply with the values specified in Table 1-7 in Appendix A.

4.17 STEEL TUNNEL LINER PLATES

A. General:

1. This part of the specifications covers the installation of tunnel liner plates in tunnels constructed by conventional tunnel methods and the installation of tunnel liner plates inside of existing tunnels, culverts or structures. For the purposes of these specifications, tunnels excavated by full face, heading and bench, or multiple drift procedures are considered conventional methods. Liner plates used with any construction procedure utilizing a full or partial shield, a tunneling machine or other piece of equipment which will exert a force upon the liner plates for the purpose of propelling, steering or stabilizing the equipment are considered special cases and are not covered by these specifications.
2. Cold formed steel tunnel liner plates shall conform to Paragraph 1.2.E and shall be of the sizes and dimensions required on the plans. Steel tunnel liner plates shall be installed at the locations designated on the plans, and in conformity with established lines and grades. The completed liner shall consist of a series of steel liner plates assembled with staggered longitudinal joints.
3. All plates shall be connected by bolts on both longitudinal and circumferential seams or joints and shall be so fabricated as to permit complete erection from the inside.
4. Grout holes 2 inches or larger in diameter shall be provided as shown on the plans to permit grouting as the erection of tunnel liner plates progresses.

B. Installation:

1. Liner plates shall be assembled in accordance with the manufacturer's instructions.
2. Coated plates shall be handled in such a manner as to prevent bruising, scaling, or breaking of the coating. Any plates that are damaged during handling or placing shall be replaced, except that small areas with minor damage may be repaired.
3. Voids between the liner plate and the tunnel wall or existing tunnel, culvert or structure shall be force-grouted. The grout shall be forced through the grouting holes in the plates with such pressure that all voids will be completely filled. The grout mix and the frequency of grouting shall be approved by the Railway Company.

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4.18 UNDERDRAIN PIPE

- A. Corrugated steel underdrain pipe shall be in accordance with Paragraphs 1.2.A and 2.1.A.5. HDPE underdrain pipe shall be in accordance with Paragraphs 1.2.C and 3.5.C. PVC underdrain pipe shall be in accordance with Paragraphs 1.2.D and 3.6.A.
- B. Minimum cover shall not be less than two (2) feet below bottom of tie for underdrain pipe subject to railway loading.
- C. Perforations shall be oriented so as to be at the bottom of the installed underdrain pipe.
- D. Underdrain pipe may be installed with or without filter fabric (or equal) wrap.

4.19 METHODS OF FILLING EXISTING CULVERT

- A. If a new structure or culvert is replacing an existing culvert and the existing culvert is not removed during excavation, or an existing culvert is to be retired without removal, the existing culvert should be completely filled with highly flowable controlled low-strength material (CLSM), lean cement pumped grout, or a combination of either sand and lean cement pumped grout or sand and highly flowable CLSM. A highly flowable CLSM may be used to fill existing culverts for lengths up to 200 feet. If a combination of sand and highly flowable CLSM, or sand and lean cement pumped grout, is used to fill the existing culvert, both ends of the existing culvert must be completely sealed with a minimum of three feet of concrete, lean cement pumped grout or CLSM to prevent water from migrating through the existing culvert.

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PART 5 TABLES AND FIGURES

Table 1-1. Heights-of-Cover Limits for Prefabricated Corrugated Steel Pipe In Railway Track Fill

Diameter In Inches	Minimum Cover In Feet	Specified Wall Thickness in Inches & (Gage)		
		0.109 (12)	0.138 (10)	0.168 (8)
		Maximum Cover in Feet for 2-2/3"x1/2" or 2"x1/2" Corrugations		
24	2	64	-	-
30	2	51	-	-
36	2	43	45	50
42	2	74	77	81
48	2	64	68	71
54	2.5	57	60	63
60	2.5	51	54	56
66	3	-	49	51
72	3	-	45	47
78	3.5	-	-	43
		Maximum Cover in Feet for 3"x1" or 5"x1" Corrugations		
36	2	98	117	134
42	2	84	103	115
48	2	73	88	98
54	2.5	65	78	87
60	2.5	58	70	78
66	3	53	66	71
72	3	49	58	65
78	3.5	45	54	60
84	3.5	42	50	56
90	4	39	47	52
96	4	36	44	49
102	4.5	34	41	46
108	4.5	32	39	43
114	5	28	37	41
120	5	26	35	39

Notes:

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1. Cover is defined as the distance from base of rail to top of pipe.
2. When using prefabricated corrugated galvanized steel pipe without polymeric coating, the minimum wall thickness shall be 0.138" (10 gage).
3. When using prefabricated galvanized corrugated steel pipe (polymeric coated) and aluminum coated prefabricated corrugated steel pipe, the minimum wall thickness shall be 0.109" (12 gage).
4. Unless otherwise approved, prefabricated corrugated steel pipe from 12" to 48" diameter shall be furnished with 2-2/3"x1/2" corrugations; over 48" diameter shall be furnished with either 3"x1" or 5"x1" corrugations

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Table 1-2. Heights-of-Cover Limits for Structural Steel Plate Pipe and Tunnel Liner Plate Pipe in Railway Track Fill

Diameter In Inches	Minimum Cover In Feet	Specified Wall Thickness in Inches & (Gage)					
		0.138 (10)	0.168 (8)	0.188 (7)	0.218 (5)	0.249 (3)	0.280 (1)
		Maximum Cover in Feet for 6"x2" Corrugations					
60	2.5	55	70	75	90	105	120
66	3	50	65	70	85	100	110
72	3	50	65	70	85	100	110
78	3.5	45	60	65	80	95	105
84	3.5	45	60	65	80	95	105
90	4	40	55	60	75	90	100
96	4	40	55	60	75	90	100
102	4.5	35	50	55	65	80	85
108	4.5	35	50	55	65	80	85
114	5	30	45	50	60	70	80
120	5	30	45	50	60	70	80
126	5.5	30	40	45	55	65	70
132	5.5	30	40	45	55	65	70
138	6	25	35	40	50	60	65
144	6	25	35	40	50	60	65
156	6.5	25	30	40	45	55	60
168	7	20	30	35	40	50	55
180	7.5	20	30	30	40	45	50

Notes:

1. Cover is defined as the distance from base of rail to top of pipe.
2. Invert plates to be two gages heavier than side and top plates, except that 1 gage is the heaviest gage available and that 5 gage invert plates are to be specified with 8 gage side and top plates.
3. Pipe having a greater diameter than listed in the table must have the approval of the Director-Bridge Engineering.

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Table 1-3. Heights-of-Cover Limits for Prefabricated Corrugated Steel Pipe-Arch in Railway Track Fill

Span x Rise In Inches	Specified Wall Thickness in Inches & (Gage)		
	0.109 (12)	0.138 (10)	0.168 (8)
	Minimum and Maximum Cover in Feet for 2-2/3"x1/2" or 2"x1/2" Corrugations		
35 x 24	-	2 – 16	-
42 x 29	-	2 – 16	2 - 15
49 x 33	-	2 – 16	4 - 15
57 x 38	-	2 – 16	-
	Minimum and Maximum Cover in Feet for 3"x1" or 5"x1" Corrugations		
60 x 46	2 – 31	-	-
66 x 51	2 – 31	-	-
73 x 55	2.5 – 31	-	-
81 x 59	2.5 – 25	-	-
87 x 63	2.5 – 24	-	-
95 x 67	2.5 – 24	-	-

Notes:

- Cover is defined as the distance from base of rail to top of pipe-arch
- When using prefabricated corrugated galvanized steel pipe-arch without polymeric coating, the minimum wall thickness shall be 0.138" (10 gage).
- When using prefabricated galvanized corrugated steel pipe-arch (polymeric coated) and aluminum coated prefabricated corrugated steel pipe-arch, the minimum wall thickness shall be 0.109" (12 gage).
- Unless otherwise approved, prefabricated corrugated steel pipe-arch in sizes from 35"x24" to 57"x38" shall be furnished with 2-2/3"x1/2" corrugations.

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Table 1-4. Heights-of-Cover Limits for Structural Steel Plate Pipe-Arch in Railway Track Fill

Span x Rise In Feet - Inches	6"x2" Corrugations - 18" Corner Radius	
	Minimum and Maximum Cover in Feet	Specified Wall Thickness in Inches & (Gage)
6 - 1 x 4 - 7 To 8 - 10 x 6 - 1	3 - 12	For All Pipe-Arch Sizes: 0.138 (10) Top & Side Plates 0.168 (8) Invert Plates
9 - 4 x 6 - 3 To 10 - 11 x 7 - 1	4 - 10	
11 - 5 x 7 - 3 To 12 - 6 x 7 - 11	5 - 9	

Notes:

- Cover is defined as the distance from base of rail to top of pipe-arch.
- Pipe-arch having a greater span than listed in the table must have the approval of the BNSF Director-Bridge Engineering.

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Table 1-5. Heights-of-Cover Limits for Structural Steel Plate Arch in Railway Track Fill

Span In Feet	Specified Wall Thickness in Inches & (Gage)					
	0.138 (10)	0.168 (8)	0.188 (7)	0.218 (5)	0.249 (3)	0.280 (1)
	Minimum and Maximum Cover in Feet for 6"x2" Corrugations					
5	2.5 - 36	2.5 - 44	2.5 - 50	2.5 - 58	2.5 - 67	2.5 - 75
6	3 - 30	3 - 37	3 - 41	3 - 48	3 - 55	3 - 62
7	4.5 - 24	3 - 32	3 - 35	3 - 41	3 - 47	3 - 53
8	6.5 - 20	3.5 - 26	3 - 31	3 - 36	3 - 41	3 - 47
9	9 - 16	5 - 23	4 - 26	3.5 - 32	3.5 - 37	3.5 - 41
10		7.5 - 19	5 - 23	4 - 28	4 - 33	4 - 37
11		9 - 16	6.5 - 20	4.5 - 25	4 - 29	4 - 34
12			9 - 17	5 - 22	5 - 26	5 - 31

Notes:

1. Arches are available in a range of spans and rises. See manufacturer's handbooks for available sizes.
2. Cover is defined as the distance from base of rail to top of arch.
3. Listed gages may be used for any combination of span and rise which meet the following criteria

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Table 1-6. Heights-of-Cover Limits for Structural Steel Plate Arch and Tunnel Liner Plate Arch For Installation as Liners Inside Existing Arch-type Structure In Railway Track Fill

Span In Feet	Specified Wall Thickness in Inches & (Gage)					
	0.138 (10)	0.168 (8)	0.188 (7)	0.218 (5)	0.249 (3)	0.280 (1)
	Maximum Cover in Feet for 6"x2" Corrugations					
5	60	78	87	102	117	132
6	50	65	73	97	104	110
7	43	56	62	73	84	94
8	37	49	55	64	73	82
9	33	43	48	57	65	73
10	29	39	44	51	58	66
11	25	35	40	46	53	60
12	22	32	36	42	48	55
13	20	29	33	39	45	51
14	18	26	31	36	42	47
15	15	24	28	34	39	44
16	-	22	25	32	36	41
17	-	20	23	29	34	38
18	-	-	21	26	31	35
19	-	-	18	23	28	32
20	-	-	-	21	25	29
21	-	-	-	18	22	26
22	-	-	-	-	20	23
23	-	-	-	-	-	20
24	-	-	-	-	-	18

Notes:

1. Arches are available in a range of spans and rises. See manufacturer's handbooks for available sizes.
2. Cover is defined as the distance from base of rail to top of arch liner.
3. Listed gages may be used for any combination of span and rise which meet the following criteria:
 $0.30 \leq \text{RISE}/\text{SPAN} \leq 0.50$
4. Arch liner with span and rise combination not meeting this criteria, and arch liner having a greater span than listed in the table, must have the approval of the BNSF Director-Bridge Engineering.
5. Space between existing structure and arch liner shall be completely filled with soundly placed pressure grout consisting of a mixture of one-part cement to three parts sand, plus a workability additive.

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Table 1-7. Minimum Wall Thickness for Smooth Steel Pipe Used as a Culvert in Railway Track Fill

Pipe Outside Diameter In Inches	Cover in Feet								Maximum Cover
	4	5	6	7	8	9	10	Greater Than 10	
	Minimum Wall Thickness in Inches								
36	0.562	0.562	0.562	0.500	0.500	0.500	0.500	0.500	19
38	0.625	0.563	0.562	0.562	0.500	0.500	0.500	0.500	17
40	0.625	0.625	0.562	0.562	0.562	0.500	0.500	0.500	15
42	0.687	0.625	0.625	0.562	0.562	0.562	0.562	0.500	13
44	0.687	0.625	0.625	0.562	0.562	0.562	0.562	0.562	18
46	0.687	0.687	0.625	0.625	0.562	0.562	0.562	0.562	16
48	0.750	0.687	0.687	0.625	0.625	0.625	0.562	0.562	14
50	0.750	0.687	0.687	0.625	0.625	0.625	0.625	0.625	18
52	0.812	0.750	0.687	0.687	0.625	0.625	0.625	0.625	16
54	0.812	0.750	0.750	0.687	0.687	0.625	0.625	0.625	15
56	0.812	0.750	0.750	0.687	0.687	0.687	0.687	0.625	13
58	0.875	0.812	0.750	0.750	0.687	0.687	0.687	0.687	17
60	0.875	0.812	0.812	0.750	0.750	0.687	0.687	0.687	15
62	0.875	0.812	0.812	0.750	0.750	0.750	0.687	0.687	14
64	0.937	0.875	0.812	0.812	0.750	0.750	0.750	0.750	17
66	0.937	0.875	0.875	0.812	0.812	0.750	0.750	0.750	16
68	1.000	0.937	0.875	0.812	0.812	0.750	0.750	0.750	14
70	1.000	0.937	0.875	0.875	0.812	0.812	0.812	0.750	13
72	1.000	0.937	0.937	0.875	0.812	0.812	0.812	0.812	16

Notes:

1. Cover is defined as the distance from base of rail to top of pipe.
2. Steel pipe shall be in accordance with ASTM Designation: A139, with a specified minimum yield strength (SMYS) of at least 35,000 psi.
3. Smooth steel pipe with a diameter, cover and wall thickness combination not in the table must have the approval of the BNSF Director-Bridge Engineering.

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Table 1-8. Weight per Lineal Foot for Smooth Steel Pipe

Pipe Outside Diameter In Inches	Wall Thickness in Inches								
	0.500	0.563	0.625	0.688	0.750	0.813	0.875	0.938	1.000
	Weight Per Lineal Foot in Pounds								
36	190	213	236	260	283	306	329	352	374
38	200	225	250	274	299	323	347	372	396
40	211	237	263	289	315	341	366	392	417
42	222	249	276	304	331	358	385	412	438
44	233	261	290	319	347	375	403	432	460
46	243	273	303	333	363	393	422	452	481
48	254	286	317	348	379	410	441	472	502
50	265	298	330	363	395	427	460	492	524
52	275	310	343	377	411	445	478	512	545
54	286	322	357	392	427	462	497	532	567
56	297	334	370	407	443	480	516	552	588
58	307	346	383	422	459	497	534	572	609
60	318	358	397	436	475	514	553	592	631
62	329	370	410	451	491	532	572	612	652
64	339	382	423	466	507	549	590	632	673
66	350	394	437	480	523	567	609	652	695
68	361	406	450	495	539	584	628	672	716
70	371	418	464	510	555	601	647	693	738
72	382	430	477	524	571	619	665	713	759
74	393	442	490	539	587	636	684	733	780
76	404	454	504	554	603	653	703	753	802
78	414	466	517	569	619	671	721	773	823
80	425	478	530	583	635	688	740	793	845
82	436	490	544	598	651	706	759	813	866
84	446	502	557	613	667	723	778	833	887

Note:

1. Steel pipe shall be in accordance with ASTM Designation: A139, with a specified minimum yield strength (SMYS) of at least 35,000 psi.

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Table 1-9. Weight per Lineal Foot for Reinforced Concrete Box

12" Walls with 12" Haunches											
		Span (Ft)									
		3	4	5	6	7	8	9	10	11	12
Rise (Ft)	3	2700	3000	3300	3600	3900	4200	4500	4800	5100	5400
	4	3000	3300	3600	3900	4200	4500	4800	5100	5400	5700
	5	3300	3600	3900	4200	4500	4800	5100	5400	5700	6000
	6	3600	3900	4200	4500	4800	5100	5400	5700	6000	6300
	7	3900	4200	4500	4800	5100	5400	5700	6000	6300	6600
	8	4200	4500	4800	5100	5400	5700	6000	6300	6600	6900
	9	4500	4800	5100	5400	5700	6000	6300	6600	6900	7200
	10	4800	5100	5400	5700	6000	6300	6600	6900	7200	7500
	11	5100	5400	5700	6000	6300	6600	6900	7200	7500	7800
	12	5400	5700	6000	6300	6600	6900	7200	7500	7800	8100
8" Walls with 8" Haunches											
		Span (Ft)									
		3	4	5	6	7	8	9	10	11	12
Rise (Ft)	3	1770	1970	2170	2370	2570	2770	2970	3170	3370	3570
	4	1970	2170	2370	2570	2770	2970	3170	3370	3570	3770
	5	2170	2370	2570	2770	2970	3170	3370	3570	3770	3970
	6	2370	2570	2770	2970	3170	3370	3570	3770	3970	4170
	7	2570	2770	2970	3170	3370	3570	3770	3970	4170	4370
	8	2770	2970	3170	3370	3570	3770	3970	4170	4370	4570
	9	2970	3170	3370	3570	3770	3970	4170	4370	4570	4770
	10	3170	3370	3570	3770	3970	4170	4370	4570	4770	4970
	11	3370	3570	3770	3970	4170	4370	4570	4770	4970	5170
	12	3570	3770	3970	4170	4370	4570	4770	4970	5170	5370

Notes:

- Weights in **bold** letters are for standard size reinforced concrete boxes fabricated by the wet cast method furnished by Coreslab – Omaha.
- Precast reinforced concrete boxes are manufactured in 4', 6', 8' and 12' lengths.
- Design of standard reinforced concrete boxes is based on a 2' to 10' range of cover.

END OF SECTION

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SECTION 05200 PIPE CULVERTS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Prefabricated Corrugated Steel Pipe and Pipe-Arches
- B. Bituminous Coated Corrugated Steel Pipe and Pipe-Arches
- C. Corrugated Aluminum Alloy Pipe
- D. Corrugated Structural Steel Plate Pipe, Pipe-Arches, and Arches
- E. Earth Boring and Jacking Culvert Pipe
- F. Steel Tunnel Liner Plates
- G. Polymeric Coated Galvanized Corrugated Steel Pipe
- H. Reinforced Concrete Culvert Pipe
- I. See General Provisions for utility and permitting requirements and sections that apply.

1.2 DESCRIPTION

- A. These specifications shall govern the fabricating, furnishing, and installation of pipe culverts of the types and construction stated in Section 1.1 all in accordance with these specifications, the special provisions and the details shown on the plans.
- B. The size, type, length, wall thickness, coating/paving requirements and location of pipe culverts will be shown on the plans or as directed by the Engineer. (The minimum diameter of pipe culverts under the BNSF RR shall be 36 inches, unless otherwise directed by the engineer.)
- C. Where corrugated pipe is referred to in these specifications, the same shall include corrugated steel pipe, corrugated steel pipe-arch and corrugated aluminum alloy pipe unless otherwise noted. Corrugated aluminum pipe-arch shall not be used.
- D. Where structural steel plate pipe is referred to in these specifications, the same shall include structural steel plate pipe-arch unless otherwise noted. Structural aluminum alloy plate pipe and pipe-arch shall not be used.
- E. Where pipe is referred to in these specifications all of the above noted acceptable types of pipe are included unless otherwise noted.

PART 2 MATERIALS

2.1 PREFABRICATED CORRUGATED STEEL PIPE AND PIPE-ARCHES

- A. Prefabricated corrugated steel pipe and pipe-arches shall be aluminized steel pipe, bituminous coated galvanized steel pipe or uncoated galvanized steel pipe as specified on the plans or in the special provisions.
- B. Fabrication and materials shall be in accordance with Chapter 1, Part 4, Section 4.3 of the AREMA Manual for Railway Engineering except as specified hereinafter:
 - 1. Article 4.3.1.2
 - (a) Fabricator may furnish either Class I or Class II corrugated steel pipe or pipe-arch with either applicable type seam for Class II pipe or pipe-arch when class or seam type is not specified.

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2. Article 4.3.3

- (a) When step beveled ends are specified on corrugated steel pipes, the vertical step at the top and the bottom of the pipe is to be one-quarter of the pipe diameter in height.

3. Article 4.3.3.1

- (a) The following table shall govern in lieu of Table 4.3.1 - Corrugations:

Class	Diameter	Nominal Size	Pitch Max. ¹	Min. Inside Radius ²
I	8" – 48"	2 2/3" x 2"	2 3/4"	11/16"
I	54" – 96"	3" x 1"	3 1/4"	9/16"
II	6" – 10"	1 1/2" x 1/4"	1 7/8"	9/32"
II	12" – 48"	2 2/3" x 2"	2 3/4"	11/16"
II	54" – 120"	3" x 1"	3 1/4"	9/16"
II	54" – 120"	5" x 1"	5 1/4"	1 9/16"

4. Article 4.3.4

- (a) For Class II corrugated steel pipe and pipe-arch, the ends of individual pipe sections shall be re-rolled to form circumferential corrugations extending at least two corrugations from the pipe end.
- (b) Bands with projections shall not be furnished. Corrugated locking bands shall be furnished. ("Hugger" type or approved equal.)
- (c) Two-piece bands shall be furnished when the corrugated steel pipe diameter or pipe-arch span exceeds 42 inches.
- (d) Bolts for coupling bands shall be 6 inches long and threaded within 1 inch of the head.

5. Article 4.3.5.4

- (a) In Table 4.3.5, corrugated steel pipe-arch with 2-2/3 inches by 1/2 inch corrugations in sizes greater than 57 inches by 38 inches shall not be furnished.
- (b) In Table 4.3.6, corrugated steel pipe-arch in sizes smaller than 60 inches by 46 inches shall not be furnished.

6. Shipping

- (a) Corrugated steel pipe and pipe-arch having invert paving shall be shipped with paving at bottom.
- (b) Blocking shall be placed between all corrugated steel pipe or pipe-arch sections when loaded to prevent longitudinal movement during shipment. This blocking is in addition to the customary straps to the floor surface.

2.2 BITUMINOUS COATED CORRUGATED STEEL PIPE AND PIPE ARCHES

- A. Bituminous coated galvanized corrugated steel pipe and pipe-arches shall be in accordance with Chapter 1, Part 4, Section 4.4.1 of the AREMA Manual for Railway Engineering.

¹ The pitch shall be measured at right angles to the corrugations

² The depth shall not underrun by more than 5%

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Nominal Diameter (in)	Nominal Corrugation (in)	Minimum Width of Lap - Riveted (in)	Material Thickness (in)	Material Thickness US Std. Gage	Rivet Diameter (in)	Maximum Cover (ft)
24	2-2/3 x 1/2	2	0.109	12	3/8	65'
30	2-2/3 x 1/2	2	0.109	12	3/8	50'
36	2-2/3 x 1/2	2	0.109	12	3/8	40'
42	2-2/3 x 1/2	3	0.138	10	3/8	70'
42	3 x 1	3	0.109	12	7/16	70'
48	2-2/3 x 1/2	3	0.138	10	3/8	65'
48	3 x 1	3	0.109	12	7/16	70'
54	2-2/3 x 1/2	3	0.168	8	3/8	60'
54	3 x 1	3	0.138	10	7/16	75'
60	2-2/3 x 1/2	3	0.168	8	3/8	55'
60	3 x 1	3	0.138	10	7/16	70'
66	3 x 1	3	0.138	10	7/16	60'
72	3 x 1	3	0.168	8	7/16	65'
84	3 x 1	3	0.168	8	7/16	55'
96	3 x 1	3	0.168	8	7/16	45'
120	3 x 1	3	0.168	8	7/16	41'

2.3 CORRUGATED ALUMINUM ALLOY PIPE

- A. Fabrication and materials shall be in accordance with Chapter 1, Part 4, Section 4.5 of the AREMA Manual for Railway Engineering except as specified hereafter:
 1. Article 4.5.1.2
 - (a) Fabricator may furnish either Class I or Class II corrugated aluminum alloy pipe with either applicable type seam for Class II pipe when class or seam type is not specified.
 2. Article 4.5.3
 - (a) When step beveled ends are specified on corrugated aluminum alloy pipes, the vertical step at the top and the bottom of the pipe is to be one-quarter of the pipe diameter in height.
 3. Article 4.5.3.2

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(a) The following table shall govern in lieu of Table 4.5.3.

Class	Diameter	Pitch Min. ³	Pitch Max.	Depth ⁴
I	12"-30"	2 ¼"	2 ¾"	2"
I	36"-72"	2 ¾"	3 ¼"	1"
II	6", 8", or 10"	1 3/8"	1 7/8"	¼"
II	12"-30"	2 ¼"	2 ¾"	2"
II	36"-72"	2 ¾"	3 ¼"	1"

4. Article 4.5.4

- (a) Bands with projections shall not be furnished. Corrugated locking bands shall be furnished. ("Hugger" type or approved equal.)
- (b) Bolts for coupling bands shall be 6 inches long and threaded within 1 inch of the head.
- (c) Coupling bands utilizing a slip seam shall not be furnished.

2.4 CORRUGATED STRUCTURAL STEEL PLATE PIPE, PIPE-ARCHES, AND ARCHES

- A. Fabrication and materials shall be in accordance with Chapter 1, Part 4, Section 4.6 of the AREMA Manual for Railway Engineering except as specified hereinafter:
 - 1. Article 4.6.3.1
 - (a) Circumferential seams shall be staggered.
 - 2. Article 4.6.4.1
 - (a) When step beveled ends are specified on pipes, the vertical step at the top and the bottom of the pipe is to be one-quarter of the pipe diameter in height.

2.5 PIPE FOR EARTH BORING AND JACKING

- A. Corrugated steel pipe used for earth boring and jacking shall be in accordance with Chapter 1, Part 4, Section 4.3 of the AREMA Manual for Railway Engineering except as specified hereafter:
 - 1. Only Class I, Shape I corrugated steel pipe of 8 gage wall thickness shall be used.
 - 2. Corrugated steel pipe shall be punched and match marked for field bolting.
- B. Smooth steel pipe used for earth boring and jacking shall be in accordance with ASTM A139, Grade B, with a minimum yield strength of 35,000 psi.

2.6 STEEL TUNNEL LINER PLATES

- A. Fabrication and materials shall be in accordance with Chapter 1, Part 4, Section 4.16 of the AREMA Manual for Railway Engineering except as specified hereinafter:
 - 1. Article 4.16.1.2
 - (a) Two-flanged tunnel liner plates shall be used.

³ The pitch shall be measured at right angles to the corrugations

⁴ The depth shall not underrun by more than 5%

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2.7 REINFORCED CONCRETE CULVERT PIPE

- A. The materials for reinforced concrete culvert pipe shall meet the requirements of the following specifications for the classes and sizes specified:

Circular Pipe	C76
Arch Pipe	C506
Elliptical Pipe	C507
D-Load	C655

- B. Sections of reinforced concrete pipe shall be furnished with holes and U-bolts for fastening the sections together.

2.8 POLYMERIC COATED GALVANIZED CORRUGATED STEEL PIPE

- A. Polymeric Coated Galvanized Corrugated steel pipe shall be in accordance with Chapter 1, Part 4, Section 4.4.2 of the AREMA manual (which states the polymeric coating shall be in accordance with AASHTO M 246).

2.9 END FINISH

- A. Unless shown otherwise on the plans or in the special provisions, the type of end finish on pipes and pipe-arches is to be as follows:

1. Corrugated Pipe:
 - (a) 36-inch dia. to 90- inch dia., inclusive - ends square.
 - (b) 96-inch dia. to 120-inch dia., inclusive - ends step beveled to match embankment slope.
 - (c) The height of the step bevel is to be one-quarter of the pipe diameter.
2. **Structural Steel Plate Pipe:** All diameters - end step beveled to match embankment slope. The height of the step bevel is to be one-quarter of the pipe diameter.
3. **Corrugated Steel Pipe-Arch:** All sizes - ends square.
4. **Structural Steel Plate Pipe-Arch:** 6 feet-1 inch by 4 feet-7 inch to 9 feet-6 inch by 6 feet-5 inch, inclusive - ends square. 9 feet-9 inch x 6 feet-7 inch to 12 feet-6 inch by 7 feet-11 inch, inclusive - ends beveled to top of corner plates to match embankment slope.
5. **Reinforced Concrete Culvert Pipe:** Pipe may be either bell and spigot, or tongue and groove design unless otherwise specified.

2.10 VERTICAL ELONGATION

- A. All corrugated pipe and structural steel plate pipe 48-inch diameter and larger, except where used as a liner, shall be formed in the fabricating plant to a five percent (5%) vertical elongation.
- B. Pipe-arches shall not be struttred or vertically elongated.

2.11 HANDLING

- A. Material shall be handled to final position in such a manner as to prevent its damage. Corrugated pipes or structural steel plate materials shall not be dropped to, or dragged over, the ground, but shall be handled with rolling slings, on skids, or with cranes.
- B. Corrugated steel pipe, when paved, shall be stored with paved invert at bottom.
- C. Corrugated steel pipe may be asphalt coated and paved, and any damage to coating or paving shall be repaired by the Contractor applying two coats of bituminous materials supplied by the

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Contractor. No extra payment will be allowed for this repair material or work unless authorized in writing by the Engineer.

- D. Bent or otherwise damaged corrugated pipe or structural steel plate materials shall be straightened and repaired, if feasible and as directed by the Engineer, before being placed in final position. No extra payment will be allowed for this work unless authorized in writing by the Engineer.
- E. Materials must be properly stored if extended time will elapse prior to installation. Pipe coatings or pipe materials affected by UV rays or temperature extremes should be stored under a protective shelter until they can be properly installed. In the case of structural steel plate pipes, plates should be stored in a manner where moisture will drain rather than collect in the plates. Protected storage is preferred. Stacking plates to provide proper drainage and ventilation helps prevent storage stains.
- F. Culvert pipes shall be handled carefully to avoid damaging the protective or metallic coatings and denting the metal or changing its shape in any manner. The use of lifting lugs shall be required when such use will minimize possible damage to the pipe.
- G. Precast concrete units or elements shall be assembled in accordance with the manufacturer's instructions. All units or elements shall be handled with reasonable care and shall not be rolled or dragged over gravel or rock. Care shall be taken to prevent the units from striking rock or other hard objects during placement. Cracks in an installed precast concrete culvert that exceed 0.01-inch width will be appraised by the Engineer. Cracks determined to be detrimental shall be sealed by a method approved by the Engineer.

2.12 PIPE CONNECTIONS

- A. Pipe connections shall be shown on the plans or as stated in the specifications.
- B. Concrete collars or expanding bands, as shown on the plans, shall be used for pipe connections and attached so as to not be pulled apart. The cost for this connection is incidental to the unit price for culvert pipe and will not be paid as a separate line item.
- C. Prior to performing any pipe/culvert extensions, the pipe shall be cleaned out. The pipes shall be free of any obstructions that could impede the flow. The clean out of the pipe/culvert is incidental to the cost of performing the pipe extension and shall be included in the contract unit price for pipe extensions.

2.13 PIPE ABANDONMENT

- A. All pipes/culverts being abandoned will be filled and capped off as indicated on the plans and special provisions. No abandoned pipes will be left open, unless otherwise directed by the Engineer. The abandoned pipes will be indicated on the plans.

PART 3 EXECUTION

3.1 FOUNDATION PREPARATION - CORRUGATED PIPE AND STRUCTURAL STEEL PLATE PIPE

- A. The foundation shall be a smoothed and compacted surface conforming to bottom of pipe grade or camber and will hereafter be referred to as the foundation line. The foundation bed shall be free of boulders, tree stumps, cut-off piling, and other projections. Suitable camber to allow for settlement of pipe due to consolidation of foundation material will be provided when required. Shaping to pipe contour is not required.
- B. When acceptable foundation material is present, the width of the foundation line shall be a minimum of 4 feet plus the pipe diameter or pipe-arch span. For multiple pipes the above width shall be increased by the sum of the distances between pipe or pipe-arch centers.

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- C. Where there is solid rock or other unsuitable material, such as boulders, or unstable material that may deform the pipe during minor settlement, at the foundation line, it will be necessary to provide suitable bedding for pipes. Such work will only be undertaken at the specified direction of the Engineer.
- D. Where bedding is found necessary, natural material shall be excavated, with vertical sides, to a depth of 1 foot or more below the foundation line as directed by the Engineer and backfilled with selected material to the foundation line. Selected bedding backfill shall be compacted to the full amount required by Section 03200, Excavation and Embankment. The width of excavation and bedding backfill shall be the pipe diameter or pipe-arch span in solid rock and boulders, and in other unsuitable material, the width shall be three pipe diameters or pipe-arch spans for single pipes, and for multiple pipes, this width shall be increased by the distances between pipe or pipe-arch centers.
- E. Soft, spongy or otherwise unsuitable material encountered at the established and approved grade shall be removed and backfilled with granular material as directed by the Engineer. Excavation of unsuitable soils will be made in accordance with the unit price for excavation. Payment for backfilling and compacting with suitable soils will be made at the contract unit price for embankment.

3.2 FOUNDATION PREPARATION - REINFORCED CONCRETE CULVERT PIPE

- A. Trenches shall be excavated in accordance with the bank stability requirements to a width sufficient to allow for proper jointing of the pipe and thorough compaction of the bedding and backfill material under and around the pipe. Where feasible, trench walls shall be vertical. Maximum trench width shall be in accordance with the plans or special provisions or as specified by the Engineer. The completed trench bottom shall be firm and cleaned for its full length and width.
- B. If rock strata, boulders, tree stumps, cut-off piling and other projections are encountered under the culvert within the limits of the required bedding, these projections shall be removed and replaced with bedding material.
- C. Where specifically requested, the pipe trench bottom may be cambered longitudinally to provide for expected settlement. If camber of the pipe trench is required, the indicated camber will be shown on the plans or in the special provisions.
- D. Where specified on the plan or in the special provisions, the excavation for a pipe to be placed within embankment fill shall be made after the embankment has been completed to a specified height above the top of the pipe.
- E. If the foundation is incapable of supporting the pipe loads, an adequate support shall be supplied by excavating the unstable soil and backfilling with compacted material, or by such other means as may be specified or approved by the Engineer.
- F. Where an unsuitable material (peat, muck, etc.) is encountered at or below invert elevation during excavation, the necessary subsurface exploration and analysis shall be made and corrective treatment shall be as directed by the Engineer.
- G. For Class B or Class C Beddings, the subgrade should be undercut and replaced with compacted granular material, if necessary, so that a firm foundation free of protruding rocks is provided. Special care may be necessary with Class A or other unyielding foundation to cushion the pipe from shock when blasting can be anticipated in the area. Bedding classes are in accordance with Chapter 8, Part 10 of the AREMA Manual for Railway Engineering.

3.3 PROTECTION OF FOUNDATIONS

- A. The Contractor shall by diversion ditches, dikes, or other means, keep the foundations free of water at all times after the work is started, and until the embankment is placed over the pipe. Any channel

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work necessary to allow free flow through the pipe shall be completed before the embankment is placed.

3.4 PLACING CORRUGATED PIPE

- A. Where two or more pipes are used, there shall be a minimum of 3 feet, or one-half pipe diameter or pipe-arch span, clear distance apart, whichever is greater. Where practicable, in the opinion of the Engineer, a space of 10 feet may be provided between pipes to facilitate the compaction of fill material around the pipes with heavy equipment.
- B. Pipe having riveted seams shall be laid with outside laps of circumferential joints pointing upstream, longitudinal laps on the sides and asphalt paving on the flow line.
- C. Pipe sections shall be firmly joined together with connecting bands. All dirt or other foreign materials must be kept out from between pipe and band. Outside connecting bands should be slipped over the end of one section, and the adjoining section brought within 1 inch of the first. Band shall be made to fit snugly and equally on each pipe section and bolted to produce a tight joint. The lower half of two-piece connecting bands for pipe having riveted seams may be furnished already connected to one of the pipe sections, and in such cases the end having the fixed half band shall be placed downstream. Band couplers and ends of pipe under the bands may be lubricated with oil or solvent, which has been approved by the Engineer. Excess asphalt at joints may be removed by an application of heat, if necessary. Where corrugated pipe is to be placed in an irrigation ditch, continuous waterway or spring area, rubber gaskets shall be placed around the first re-rolled corrugation at each end of the pipe before the band is placed to keep the joint watertight.
- D. At locations where the existing corrugated pipe is to be extended with new pipe, the joining end of the existing pipe shall be free of breaks, cracks or other defects. If in the judgment of the Engineer the end of the existing corrugated pipe is not suitable for making a proper joint, the Contractor shall, as directed by the Engineer, remove or trim the amount of pipe necessary to allow making of an approved joint. Such removal and/or trimming will be considered incidental to the cost of the pipe and no direct payment will be made therefor.
- E. Pipe-arches shall not be strutted.
- F. Identification tag, supplied by manufacturer, shall be attached near top of and inside of pipe at upstream end.

3.5 FIELD STRUTTING OF CORRUGATED PIPE

- A. When the distance from base of rail to the top of pipe will be less than the dimensions given below, corrugated pipes shall be field strutted by the Contractor using contractor supplied material.

Pipe Diameter	Base of Rail to Top of Pipe (ft)
48"	4.0
54" – 66"	4.5
72" – 96"	5.0
102" – 108"	5.5
114" – 120"	6.0

- B. Struts shall be placed after embankment is compacted to top of corrugated pipe but before any embankment is placed over the pipe. No equipment shall pass over the corrugated pipe until struts are in place and 3 feet of embankment is in place over the pipe.

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- C. Struts shall consist of 6 inch by 6-inch longitudinal timbers at the invert and top of corrugated pipe separated by 6 inch by 6-inch timber posts at 3-foot centers. Struts shall be shimmed tight using hard wood wedges nailed securely in position. Placement of struts shall be limited to the portion of corrugated pipe located within 12 feet of centerline of tracks.
- D. Unless otherwise directed by the Engineer, struts shall be left in place until track laying is completed after which Company forces will remove the struts.
- E. The furnishing and placing of field strutting material shall be considered incidental to pipe placement, and no direct payment will be made therefor.

3.6 PLACING STRUCTURAL STEEL PLATE PIPE

- A. Structural steel plate pipe shall be erected at the site, in accordance with detailed plans or instructions of the Engineer.
- B. Where two or more structural steel plate pipes are used, they shall be a minimum of one-half pipe diameter or one-third of pipe-arch span apart. Where practicable, in the opinion of the Engineer, a space of 10 feet may be provided between pipes to facilitate compacting fill material around the pipe with heavy equipment.
- C. Structural steel plate pipes may be made up of corrugated plates of variable gages. The invert plate may be two gages heavier than the plates for the sides and top of the pipe section, and heavier gage plates may be used in the center sections than at the end sections of the pipe. An erection diagram will be provided and must be followed without exception.
- D. Strutting of structural steel plate pipe, if required, shall be as directed by the Engineer.
- E. Structural steel plate pipes are to be assembled at the site with as few bolts as possible until all plates are in place. Three or four untightened bolts near the center of each plate along the longitudinal and circumferential seams are sufficient, and after several rings have been assembled the remaining bolts can be inserted, the corner bolts being the last. Bolts are to be tightened progressively from one end of the structure to the other after assembly has been completed and shall be check-tightened in the same manner to be sure none is left loose. All bolts shall be tightened with proper tools, either hand or power wrenches, initially to a minimum of 100 ft lbs. and a maximum of 300 ft lbs. of torque.
- F. Where heavy camber is necessary, erection procedures may be modified, but only as specifically approved by the Engineer for each such case.
- G. At locations where the existing structural steel plate pipe is to be extended with new plates, the joining end of the existing pipe shall be free of breaks, cracks or other defects. The Contractor shall remove existing beveled plates so that extension can be made using standard plates. Such removal will be considered incidental to the cost of the pipe, and no direct payment will be made therefor.
- H. Identification tag, supplied by manufacturer, shall be attached near top of and inside of pipe at upstream end.
- I. Bolt holes for culvert extensions can be initially flame cut then shall be reamed to the specified hole size.
- J. In Stock underpasses and vehicular underpasses which are to receive concrete invert paving, the area to be covered by concrete shall be clean and dry. Wire mesh reinforcement may be tack welded to bolts.

3.7 PLACING REINFORCED CONCRETE CULVERT PIPE

- A. Pipe laying shall begin at the downstream end of the culvert. The bell or groove end of the pipe shall be placed upstream. No culvert shall be put into service until a suitable outlet is provided for the water.

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- B. Elliptical pipe shall be placed with the vertical axis within 5 degrees of a vertical plane through the longitudinal axis of the culvert.
- C. Pipe bedding and placement, specified on the plans or in the special provisions, shall conform to one of the Bedding Classes illustrated in Figures 10.4.2.2A through 10.4.2.2E of Chapter 8, Part 10 of the AREMA Manual for Railway Engineering. When pipe cannot be placed on a prepared surface but must instead be placed on an unprepared surface, the bedding shall be considered to be Class D Bedding. Class D Bedding should only be used for emergency work and is not permitted for permanent installations unless authorized by the Engineer. For typical Class D Bedding see Figures 10.4.2.2A and 10.4.2.2C.
- D. When bell pipe is used, a shallow excavation shall be made underneath the bell of sufficient depth so that the bell does not rest on the bedding material.
- E. Proper facilities shall be provided for hoisting and lowering the sections of culvert into the trench without disturbing the prepared foundation and the sides of the trench.
- F. The ends of the section shall be carefully cleaned before the section is jointed. Pipe sections shall be joined so that the ends are fully entered, and the inner surfaces are flush and even.
- G. Joints shall comply with the details shown on the plans or specified in the special provisions. Each joint shall be sealed to prevent infiltration of soil fines or water as required by the contract documents.
- H. Sections shall be fastened together with U-bolts as shown on the plans or in the special provisions.

3.8 BACKFILL AND EMBANKMENT - CORRUGATED PIPE AND STRUCTURAL STEEL PLATE PIPE

- A. **Backfill Around Pipes:** When the pipe foundation line is below natural ground, compacted backfill, placed in accordance with Paragraph B shall be placed around the pipe in the area within the limits of the embankment section which was removed as channel excavation. The upper limit of this backfill shall be the top of pipe elevation or the elevation of natural ground surface as it existed before any excavation was made, whichever is lower. Embankment above natural ground shall be placed in accordance with Paragraph B. When the upper limit of backfill is the top of pipe elevation, a 3-foot depth of material shall be placed above the pipe without compaction. This material shall be compacted in accordance with Paragraph B at the time the roadbed receives its final finish.
- B. **Embankment Around Pipes:**
 - 1. The placing of embankment around pipes is to be started with the approval of the Engineer only after assembly and erection work has been completed in every detail. Embankment material to be placed around pipe must be approved by the Engineer.
 - 2. Embankment under the haunches, along each side for a minimum width equal to the pipe diameter, and over the pipe is to receive special handling both as to placing and as to compaction. Except as modified by the provisions of Paragraph 3, embankment shall be hand tamped directly under the haunches throughout the width beyond the reach of machine compacting equipment. Embankment around pipes shall be brought up in compacted layers with a depth of less than 6 inches before compaction on both sides of the pipe at the same time keeping the fill at the same elevation on both sides. All material, except as noted in Paragraphs 3 and 4, shall be compacted to the full amount required by SECTION 03200. Compaction methods and equipment shall be approved by the Engineer.
 - 3. If the Engineer permits the clear distance between multiple pipes, or the clear distance between pipe and cut face, to be less than 3 feet, lean concrete slurry shall be used to fill under the haunches and to a minimum depth of the spring lines of the pipe installation. The concrete slurry mix shall be approved by the Engineer. Care shall be taken to ensure that the concrete slurry does not float the pipes above their intended elevation.

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4. The embankment directly above the pipe for a distance of one-third pipe diameter, but not less than 3 feet is to be placed without compaction.
5. Where the distance from subgrade to top of pipe is less than 3 feet, the excess material shall be left in place until the roadbed receives its final finish. At this time the material over the pipe to a depth of 1 foot below subgrade elevation shall be compacted to the full amount required by the SECTION 03200.
6. Care must be taken to prevent water from leaking through the fill or along the side of the pipe. When granular materials have been used for bedding or backfill, the ends of such material must be sealed against infiltration. This can be done by using impervious embankment material for 3 feet at both ends of the pipe.

3.9 BACKFILL AND EMBANKMENT - REINFORCED CONCRETE CULVERT PIPE

1. General:
 2. The backfill around the culvert shall be placed in accordance with the bedding requirements illustrated in Figures 10.4.2.2A through 10.4.2.2E of Chapter 8, Part 10 of the AREMA Manual for Railway Engineering, and other requirements of these specifications.
 3. All culverts that are to carry track load shall have the backfill thoroughly compacted to a minimum density of 95% as determined by ASTM D698, and as specified elsewhere in the special provisions for adjacent embankment.
 4. Where the pipe is placed on a shaped subgrade, see Figures 10.4.2.2A, and 10.4.2.2C, extreme care shall be taken not to over-excavate the shaped surface so that point loading shall not occur on the pipe bottom.
- B. Embankment Bedding (See Figures 10.4.2.2A and 10.4.2.2B):
1. Where rock or noncompressible foundation material is encountered, the hard unyielding material should be excavated below the elevation of the concrete cradle (Class A) or the bottom of the pipe or pipe bell (Class B & C Beddings) for a depth of at least 6 inches or 1/2 inch for each foot of fill over the top of the pipe whichever is greater, but not more than 3/4 of the diameter (or horizontal span) of the pipe.
 2. For the Negative Projecting Embankment Condition, the width of the excavation, Bd, should be at least 1.5 times the outside width of the pipe, Bc, and with a minimum of two feet greater than the outside diameter of the pipe for thorough filling and compaction of the void space under the pipe haunch.
- C. Trench Bedding (See Figures 10.4.2.2C and 10.4.2.2D):
1. Materials for backfill on each side of the pipe for the full width of the trench and to an elevation of 1 foot above the top of the pipe shall be fine, readily compacted soil or granular material, and shall not contain frozen lumps, stones that would be retained on a 2-inch sieve, chunks, highly plastic clay, or other objectionable material. Granular backfill material shall have 100% passing a 3/4-inch sieve, not less than 95% passing a 1/2 inch sieve, and not less than 95% retained on a No. 16 sieve. Oversized material shall be removed at the source of the material, except as directed by the Engineer.
 2. When the top of the pipe is even with or below the top of the trench, backfill material shall be placed at or near the optimum moisture content and compacted in layers not exceeding 6 inches (compacted) on both sides of the pipe for the full required length.
 3. Backfill material shall be placed and compacted for the full depth of the trench unless induced trench installation is used.
 4. When the top of the pipe is above the top of the trench, backfill shall be placed at or near optimum moisture content and compacted in layers not exceeding 6 inches (compacted) and shall be brought up evenly on both sides of the pipe for its full length to an elevation 1 foot above the top of the pipe. The width of backfill on each side of the pipe for the portion above

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the top of the trench shall be equal to twice the diameter of the pipe or 12 feet whichever is less. The backfill material used in the trench section and the portion above the top of the trench for a distance on each side of the pipe equal to the horizontal diameter and to 1 foot above the top of the pipe shall conform to the requirements for backfill in Paragraph 1. The remainder of the backfill shall meet the requirements for embankment construction.

5. The width of the trench, Bd, shall be a minimum of 1.5 times the outside width of the pipe, Bc, and two feet greater than the outside diameter of the pipe in order to completely fill the void.

D. Induced Trench Bedding (See Figure 10.4.2.2E):

1. The Induced Trench method shall not be used when the pipe is subjected to track loading.
2. When the Induced Trench method is used, the embankment shall be completed as required in Paragraph C, to a height above the pipe equal to the vertical outside diameter of the pipe plus one foot. A trench equal in width to the outside horizontal diameter of the pipe, in depth equal to the vertical outside diameter of the pipe, and to the length shown on the plans shall then be excavated to within one foot of the top of the pipe, trench walls being as nearly vertical as possible. This trench shall be loosely filled with highly compressible material. Construction of the embankment above the pipe shall then proceed in a normal manner using regular fill material.
3. The length of the Induced Trench method shall be shown on the plans or specified by the Engineer.
4. When the Alternate Induced Trench method is used, the embankment shall be constructed in a normal manner to a height above the culvert bedding elevation equal to twice the outside diameter of the pipe. A trench as required shall then be excavated with the walls as nearly vertical as possible, and the pipe bedded and backfilled to one foot above the pipe as called for in Paragraph C. The remaining portion of the trench shall then be loosely filled with highly compressible material. Construction of embankment shall then proceed in a normal manner.
5. In no case shall the length of compressible material extend to the ends of the culvert.
6. Rock fill shall not be dumped over the culvert without a sufficient cushion of earth to prevent breakage of the pipe.

3.10 EARTH BORING AND JACKING CULVERT PIPE

A. General:

1. Materials shall be in accordance with Paragraphs 2.5A or 2.5B.
2. Manufacturer shall punch and match mark all sections of corrugated steel pipe for field bolting.
3. Sewer type bands for watertight joints shall be provided for corrugated steel pipes when shown on the plans or special provisions.
4. Full penetration welds meeting the requirements of AWS D1.1 shall be used to join sections of smooth steel pipe.
5. Pipe damaged in jacking or boring operations shall be repaired in place to the satisfaction of the Engineer. Pipe damage beyond repair shall be removed and replaced. Repair or removal and replacement of damaged pipe shall be done at the Contractor's expense.
6. Excessive voids shall not be permitted in the jacking process. If the installation process results in significant voids, grout plugs shall be installed in pipe and all voids between the outside of the pipe and inside surface of the excavation shall be filled by pressure grout as soon as possible after the completion of the installation. The grout mix shall be approved by the Engineer.
7. If the grade of the pipe at the jacking or boring end is below the ground surface, suitable pits or trenches shall be excavated for the purposed of conducting the jacking or boring operation and for placing end joints of the pipe. The pits shall be 30 feet from centerline of the track.

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Excavations greater than five (5) feet in depth shall be protected in accordance with OSHA Trench Safety Guidelines.

8. Where pipe is required to be installed under railroad embankments, highways, streets, or other facilities by jacking or boring methods, installation shall be made in such a manner that it will not interfere with the operation of the railroad, street, highway, or other facility, and shall not weaken or damage any embankment or structure.
9. Pipe damaged in jacking or boring operations shall be repaired in place to the satisfaction of the Engineer. Pipe damaged beyond repair will be removed and replaced. Repair or removal and replacement of damaged pipe will be done at the Contractor's expense.
10. The pits or trenches excavated to facilitate jacking or boring operations shall be backfilled immediately after the installation of the pipe has been completed.

B. Jacking:

1. Heavy duty jacks suitable for forcing the pipe through the embankment shall be provided. In operating jacks, even pressure shall be applied to all jacks used. A suitable jacking head and suitable bracing between the jacks and the jacking head shall be provided so that pressure will be applied to the pipe uniformly around the ring of the pipe. Joint cushioning material of plywood or other material may be used as approved by the Engineer. Plywood cushioning material shall be 3/4-inch minimum thickness. Cushioning rings may be made up of single or multiple pieces. A suitable jacking frame or backstop shall be provided. The pipe to be jacked shall be set on guides, properly braced together, to support the section of the pipe and to direct the pipe in the proper line and grade. The whole jacking assembly shall be placed so as to line up with the direction and grade of the pipe. In general, the embankment material shall be excavated just ahead of the pipe, the material removed through the pipe, and the pipe forced through the embankment with jacks, into the space thus provided.
2. The excavation for the underside of the pipe, for at least one-third of the circumference of the pipe, shall conform to the contour and grade of the pipe. Over-excavation to provide not more than 2 inches of clearance may be provided for the upper half of the pipe. This clearance shall be tapered to zero at the point where the excavation conforms to the contour of the pipe. Over-excavation in excess of 1 inch shall be pressure grouted the entire length of the installation.
3. The distance that the excavation shall extend beyond the end of the pipe depends on the character of the material but shall not exceed 2 feet. This distance shall be decreased when directed by the Engineer.
4. Preferably, the pipe shall be jacked from the low or downstream end. The final position of the pipe shall not vary from the line and grade shown on the plans, or established by the Engineer, by more than 1/8 inch per 1 foot. The variation shall be regular and in one direction and the final flow line shall be in the direction shown on the plans.
5. The Contractor may use a cutting edge of steel plate around the head end of the pipe extending a short distance beyond the end of the pipe with inside angles or lugs to keep the cutting edge from slipping back onto the pipe.
6. Work should be done continuously to minimize the tendency of the material to "freeze" around the pipe.

C. Boring:

1. The boring shall proceed from a pit provided for the boring equipment and workmen. The location of the pit shall be approved by the Engineer. The boring shall be done mechanically either using a pilot hole or by the auger method.
2. When the pilot hole method is used, an approximate 2-inch pilot hole shall be bored the entire length of the crossing and shall be checked for line and grade on the opposite end of the bore from the work pit. This pilot hole shall serve as the centerline of the larger diameter hole to be bored.

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3. When the auger method is used, a smooth steel pipe of the appropriate diameter equipped with a cutter head to mechanically perform the excavation shall be used. Augers shall be of sufficient diameter to convey the excavated material to the work pit.
4. Excavated material shall be disposed of by the Contractor, as approved by the Engineer. The use of water or other fluids in connection with the boring operation will be permitted only to the extent necessary to lubricate cuttings; jetting will not be permitted.
5. In unconsolidated soil formations, a gel-forming colloidal drilling fluid consisting of at least 10 percent of high grade carefully processed bentonite may be used to consolidate cuttings of the bit, seal the walls of the hole, and furnish lubrication for subsequent removal of cuttings and immediate installation of the pipe.
6. Allowable variation from line and grade shall be as specified in Paragraph B.4. Overcutting in excess of 1 inch shall be remedied by pressure grouting the entire length of the installation.

3.11 STEEL TUNNEL LINER PLATES

A. General:

1. This specification covers the installation of tunnel liner plates in tunnels constructed by conventional tunnel methods and the installation of tunnel liner plates inside of existing tunnels, culverts or structures. For the purposes of these specifications, tunnels excavated by full face, heading and bench, or multiple drift procedures are considered conventional methods. Liner plates used with any construction procedure utilizing a full or partial shield, a tunneling machine or other piece of equipment which will exert a force upon the liner plates for the purpose of propelling, steering or stabilizing the equipment are considered special cases and are not covered by these specifications.
2. This work shall consist of furnishing cold formed steel tunnel liner plates conforming to Paragraph 2.6 and of the sizes and dimensions required on the plans and installing such plates at the locations designated on the plans or by the Engineer, and in conformity with the lines and grades established by the Engineer. The completed liner shall consist of a series of steel liner plates assembled with staggered longitudinal joints.
3. All plates shall be connected by bolts on both longitudinal and circumferential seams or joints and shall be so fabricated as to permit complete erection from the inside.
4. Grout holes 2 inches or larger in diameter shall be provided as shown on the plans to permit grouting as the erection of tunnel liner plates progresses.

B. Installation:

1. Liner plates shall be assembled in accordance with the Manufacturer's instructions.
2. Coated plates shall be handled in such a manner as to prevent bruising, scaling, or breaking of the coating. Any plates that are damaged during handling or placing shall be replaced at the Contractor's expense, except that small areas with minor damage may be repaired by the Contractor as directed by the Engineer.
3. Voids between the liner plate and the tunnel wall or existing tunnel, culvert or structure shall be force-grouted. The grout shall be forced through the grouting holes in the plates with such pressure that all voids will be completely filled. The grout mix and the frequency of grouting shall be approved by the Engineer.
4. Full compensation for backpacking or grouting shall be considered as included in the contract price paid, and no separate payment will be made therefor.

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PART 4 MEASUREMENT AND PAYMENT

4.1 PIPE CULVERTS

- A. Pipe culverts of the various types and sizes will be measured, along the pipe centerline, at the invert, by the lineal foot in place.
- B. Payment for furnishing and installing the respective culvert will be made at the contract unit price per lineal foot for the size and type of structure indicated on the plans or as directed by the Engineer, which payment will constitute full compensation for furnishing, unless otherwise specified; transporting, unloading, storing, and handling, connections, collars, coating, bedding and bedding material, trenching, excavation, placement, compaction, backfill, care and diversion of water, shoring, and all incidental labor and material necessary to complete the construction of pipe culverts as required by the specifications and plans.
- C. Payment for structure drain pipe is provided for in SECTION 04100.

4.2 EARTH BORING AND JACKING CULVERT PIPE

- A. Corrugated steel pipe and smooth steel pipe bored and/or jacked in place will be measured, along the pipe centerline, by the lineal foot in place.
- B. Corrugated steel pipe and smooth steel pipe bored and/or jacked in place shall be paid for at the contract unit price per lineal foot of the types and sizes in place. This price shall include full compensation for furnishing, unless otherwise specified; excavation, backfilling, disposal of surplus material, unloading, storing and transporting the pipe; and for furnishing all tools, equipment and labor to bore and/or jack the pipe in place and grout along the pipe when necessary.

4.3 STEEL TUNNEL LINER PLATES

- A. Steel tunnel liner plates will be measured, along the centerline of the assembled plates, by the lineal foot in place.
- B. Steel tunnel liner plates shall be paid for at the contract unit price per lineal foot of the types and sizes in place. This price shall include full compensation for furnishing, unless otherwise specified; and for all labor, tools, equipment, supplies, supervision, and incidentals necessary for unloading, storing, and transporting the plates; placing the plates; removal and disposal of material resulting from excavation; and force-grouting the voids and completing the work in accordance with the plans, special provisions, and these specifications.

END OF SECTION

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SECTION 05300

PRECAST CONCRETE BOX CULVERTS

PART 1 GENERAL

1.1 GENERAL

- A. This Specification is for the fabrication of Precast Concrete Box Culverts manufactured by the dry or wet cast method for use on BNSF Railway Company (BNSF) projects.
- B. The Fabricator shall furnish all labor, plant, materials, equipment and services necessary to fabricate the precast concrete units in accordance with BNSF Plans and these Specifications.

1.2 DEFINITIONS

- A. The word "Engineer" in this Specification shall mean the BNSF Assistant Vice President – Engineering Services & Structures (or their duly authorized representative).
- B. The word "Inspector" in this Specification shall mean the duly authorized representative of the BNSF Assistant Vice President – Engineering Services & Structures.
- C. The word "Fabricator" in this Specification shall mean the fabricator or manufacturer of the concrete products.
- D. The word "Supplier" in this Specification shall mean the supplier of materials or components for use in the concrete products.
- E. The words "outside testing laboratory" in this Specification shall mean a test laboratory independent of the Fabricator or Supplier and which meets the requirements of ASTM E329 and is approved by the Engineer.

1.3 STANDARD SPECIFICATIONS

- A. Design, materials, test procedures for concrete and related work shall conform with and to the current editions of the following except where other requirements are stated in this Specification. The current edition of each Manual, Standard, Specification or Guide shall be used:
American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering, Ch 8, Parts 1& 16, except where particularly modified or extended by these Specifications or on the plans.
American Concrete Institute (ACI) Guides and Specifications:
Concrete Reinforcing Steel Institute (CRSI) Manual of Standard Practice
American Society for Testing and Materials (ASTM) Standards
- B. The Fabricator shall become familiar with these Specifications and shall have copies readily available for quality control and production personnel use at the casting yard.
- C. The above Specifications shall govern except in those instances where BNSF requirements are more stringent.

1.4 DESIGN AND SHOP DRAWINGS

- A. The design shall be the responsibility of the Fabricator. The Fabricator shall furnish shop drawings developed using Table 1 or 2 & Figure 1 for all box culverts with 2 to 10 feet of cover. For any other condition or for site-specific design, the Fabricator shall furnish design calculations and shop drawings in accordance with Paragraph E, "Design Criteria".

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- B. The Fabricator shall prepare shop detail drawings for all box culverts and shall obtain the BNSF approval of them before proceeding with the fabrication. Fabricator shall submit 3 copies for approval. After approval furnish 6 copies for the BNSF use.
- C. Approval drawings should be furnished to the attention of the appropriate Manager Structures Design, BNSF RR, 4515 Kansas Ave, Kansas City, KS 66106. After the fabrication is completed, the Fabricator shall furnish the BNSF electronic format shop detail drawings covering all items fabricated. The electronic format shop drawings shall conform to the current BNSF Structures CAD Requirements (see Appendix B).

1.5 DESIGN CRITERIA

- A. Design calculations, including allowable stresses, shall be in accordance with the current AREMA Manual for Railway Engineering, Chapter 8, except as modified hereinafter below, and shall be based on floor, slab, and walls acting as continuous frame with the bending moments and shears determined by an accepted method of analysis.
- B. The transverse distribution of the loads shall be as calculated by the procedure described in AREMA 8-16-5, Figure 1.
- C. Unless otherwise directed soil pressure coefficients used in calculating loads in load cases below shall be 0.4 minimum and 1.0 maximum.
- D. The following loading cases shall be considered in the analysis with maximum bending moments and shears developed governing the design:
 - 1. Loading Case 1 – Live load + Impact + Dead load on the slab with active soil load only on the walls calculated using minimum soil pressure coefficient.
 - 2. Loading Case 2 – Live load + Impact + Dead load on the slab with active soil load and live load surcharge on the walls calculated using minimum soil pressure coefficient.
 - 3. Loading Case 3 – Live load + Impact + Dead load on slab with active soil load and live load surcharge on the walls calculated using maximum soil pressure coefficient.
 - 4. Loading Case 4 – Dead load only on the slab with active soil load and live load surcharge on the walls calculated using maximum soil pressure coefficient.
- E. The minimum design cover for reinforcement shall be 2". This minimum cover limitation does not apply at the mating surfaces of joints.
- F. Two copies of the design calculations and the drawings shall be sent to the BNSF for review. The drawings shall show in detail all elements of the construction; dimensions; and reinforcing bar sizes, spacing, cover, and splice lengths. The calculations and drawings shall be stamped by a Registered Professional Engineer.

1.6 JOINTS

- A. Dry cast: The precast reinforced box sections shall be produced in accordance with ASTM C1433, Section 8.1, and 8.2, except that the minimum area of the outer cage circumferential reinforcement shall be determined by the box culvert design in accordance with Paragraph E, "Design Criteria".
- B. Wet cast: The precast reinforced box sections shall be produced with male and female ends. The ends shall be of such design, and the ends of box culverts so formed, that when the sections are laid together they will make a continuous line of box sections with a smooth interior free of appreciable irregularities in the flowline, compatible with the dimension tolerances given in Paragraph X.

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1.7 CASTING PLANT STANDARDS

- A. Dry cast: The units shall be cast in an established manufacturer's plant that is certified under the American Concrete Pipe Association (ACPA) "Quality Cast" Plant Certification Program, unless otherwise approved by the Engineer.
- B. Wet cast: The units shall be cast in an established manufacturer's casting plant that conforms in all respects to the latest requirements of the PCI "Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products" (Publication Number MNL-116), unless otherwise approved by the Engineer. The manufacturer shall be certified by the PCI Plant Certification Program in Product Group and Category B1 and shall furnish proof of the certification to the Engineer prior to the start of fabrication.

PART 2 MATERIALS

2.1 CEMENT

- A. Dry cast: Cement shall conform to the requirements of ASTM C1433, Section 6.2.
- B. Wet cast: Cement shall be either Type IP or Type III, conforming to ASTM C150. The false set penetration, when tested in accordance with ASTM C359, shall not be less than 50mm initially, 35mm at intermediate times and 40mm after remix.
- C. Cement mill certificates shall be provided weekly by each Supplier to the Fabricator and shall meet the requirements of the following tests on the cement used that week:
 - ASTM C 204 - Fineness by air permeability
 - ASTM C 359 - False set. Penetration at 3, 5, 8, 11 minutes and after remix.
 - ASTM C 191 - Setting time ASTM C191
 - ASTM C 109 - Compressive Strength, at 1 day, 3 days and 7 days
 - ASTM C 114 - Chemical analysis, with calculated alkalis as Na₂O equivalent. The Fabricator shall obtain a statement signed by an officer or chemist of the cement manufacturer, certifying that the cement furnished does not exceed 0.6% alkali equivalent, as measured by the percent of sodium oxide plus 0.658 times the % of potassium oxide. A statement shall be furnished to the Engineer prior to the start of fabrication from cement that is proposed to be used.
- D. The results of the above tests shall be kept on file at the Fabricator's quality control department and reviewed for compliance, and shall be available for the Inspector's review.
- E. Every three months, a randomly chosen sample of cement shall be analyzed for alkali content in accordance with ASTM C114 by an outside laboratory selected jointly with BNSF and the Fabricator. Copy of results of such testing shall be furnished directly to BNSF. Costs for testing shall be borne by the Fabricator.
- F. Fabricator to maintain a 1 quart minimum sample of cement in an airtight container at the plant until the results are determined and analyzed. Each sample shall be clearly identified by date.
- G. Certification shall be submitted directly to the Engineer before beginning fabrication and shall be furnished from job materials every 3 months. Cost of testing shall be borne by the Fabricator.
- H. The Fabricator shall provide suitable means for storing and protecting the cement against dampness. Cement which for any reason, has hardened or become partially set or which contains lumps of caked cement will be rejected and not used in the work. Cement shall be used in the order that it is received.

2.2 ADMIXTURES

- A. Only liquid admixtures may be used.
- B. All admixtures must be from the same manufacturer.

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- C. The use of calcium chloride or any admixture containing chloride ions will not be permitted.
- D. Dry Cast Admixtures shall be used only with the approval of the Engineer.
- E. Wet Cast Admixtures:
 - 1. Air entraining admixtures shall conform to ASTM C260 and shall be used to produce $7\% \pm 1\%$ entrained air in the concrete after all admixtures have been incorporated.
 - 2. Water reducing admixtures shall be used only with the approval of the Engineer and shall conform to ASTM C 494, Types A, B, D, or E.
 - 3. High-range water reducers (superplasticizers) and retarding admixtures, in quantities appropriate for the ambient temperatures, may be permitted, subject to approval of the Engineer.

2.3 POZZOLANS

- A. Flyash, Type C, meeting the requirements of ASTM C618 may be used as a cement replacement with the approval of the Engineer. Type F may be used to modify potentially reactive aggregates. This mix shall be subject to the requirements of ASTM C1260. Flyash may replace up to 15%, by weight, of the cement.
- B. Dry cast: Use of flyash to replace more than 15%, by weight, of the cement may be used with the approval of the Engineer.

2.4 DRY CAST AGGREGATES

- A. Aggregates shall comply with ASTM C 33.
- B. If the coarse aggregate is supplied in more than one size, each size shall be stored separately.
- C. Washed aggregate to be drained, in stockpiles, before use. All aggregate shall be free from ice when used.
- D. Evaluation of potential alkali reactivity to ASTM C1260 with job cement.
 - 1. Separate tests are required for each aggregate source and each cement.
 - 2. Tests required: 1 at the beginning of fabrication.
- E. Abrasion to ASTM C131. Loss of weight not to exceed 40%.
 - 1. Tests required: 1 at the beginning of fabrication.
- F. Soundness to ASTM C88.
 - 1. Tests required: 1 at the beginning of fabrication.
- G. Fine aggregate Organic Impurities to ASTM C40.
 - 1. Tests required: 1 at the beginning of fabrication.
- H. Fine aggregate fineness modulus not less than 2.3, nor more than 3.1.
- I. Aggregate considered potentially reactive by the Engineer shall not be used.
- J. Coarse and fine aggregates shall be stored separately and in such a manner as to avoid the inclusion of dirt and other foreign material in the concrete. Aggregates shall be unloaded and piled in such a manner as to maintain the uniform grading of the sizes. Stockpiles of coarse aggregates shall be built in horizontal layers, not by end dumping, to avoid segregation.
- K. A hard base shall be provided to prevent contamination from underlying material and overlap of the different sizes shall be prevented by suitable walls or ample spacing between piles. Stockpiles shall not be contaminated by swinging aggregate filled buckets or clams over the various stockpiled aggregate sizes. Crushed slag shall be wetted down when necessary to insure not less than 3 percent (3%) moisture content.

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2.5 WET CAST AGGREGATES - COARSE

- A. Aggregates shall be natural and comply with ASTM C33 Class 4S Size 57 (Maximum size of aggregate is 1"). The maximum size of the coarse aggregate shall not be larger than 1/5 of the narrowest dimension between forms of the member for which the concrete is used, nor larger than 1/2 of the minimum clear space between rebar.
 - 1. Tests required: 1 at the beginning of the contract and 1 at each quarter
- B. If the coarse aggregate is supplied in more than one size, each size shall be stored separately.
- C. Washed aggregate to be drained, in stockpiles, before use. All aggregate shall be free from ice when used.
- D. Petrographic examination to ASTM C295.
 - 1. Tests required: 1 at the beginning of the contract and 1 at each quarter.
- E. Evaluation of potential alkali reactivity to ASTM C1260 with job cement.
 - 1. Separate tests are required for each aggregate source and each cement.
 - 2. Tests required: 1 at the beginning of the contract and 1 at each quarter.
- F. Abrasion to ASTM C131. Loss of weight not to exceed 40%.
 - 1. Tests required: 1 at the beginning of the contract and 1 at each quarter.
- G. Soundness to ASTM C88.
 - 1. Tests required: 1 at the beginning of the contract and 1 at each quarter.
- H. Aggregate considered potentially reactive by the Engineer shall not be used.

2.6 WET CAST AGGREGATES – FINE

- A. Washed aggregate to be drained, in stockpiles, before use. All aggregate shall be free from ice when used.
- B. Petrographic examination to ASTM C295.
 - 1. Tests required: 1 at the beginning of the contract and 1 at each quarter.
- C. Evaluation of potential alkali reactivity to ASTM C1260 with job cement.
 - 1. Separate tests are required for each aggregate source and each cement.
 - 2. Tests required: 1 at the beginning of the contract and 1 at each quarter.
- D. Organic Impurities to ASTM C40.
 - 1. Tests required: 1 at the beginning of the contract and 1 at each quarter.
- E. Soundness to ASTM C88.
 - 1. Tests required: 1 at the beginning of the contract and 1 at each quarter.
- F. Fineness modulus not less than 2.3, nor more than 3.1.
- G. Aggregate considered potentially reactive by the Engineer shall not be used.
- H. Coarse and fine aggregates shall be stored separately and in such a manner as to avoid the inclusion of dirt and other foreign material in the concrete. Aggregates shall be unloaded and piled in such a manner as to maintain the uniform grading of the sizes. Stockpiles of coarse aggregates shall be built in horizontal layers, not by end dumping, to avoid segregation.
- I. A hard base shall be provided to prevent contamination from underlying material and overlap of the different sizes shall be prevented by suitable walls or ample spacing between piles. Stockpiles shall not be contaminated by swinging aggregate filled buckets or clams over the various stockpiled aggregate sizes. Crushed slag shall be wetted down when necessary to insure not less than 3 percent (3%) moisture content.

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2.7 WATER

- A. Water used in mixing and curing concrete including free water on aggregates, shall be potable and free from any pronounced taste, odor, or color that would indicate the presence of oils, acids, alkalis, salts, sugars, vegetable matter, or other substances that may be deleterious to concrete or reinforcement and shall not contain more than 1000 parts per million of chlorides as Cl nor more than 1000 parts per million of sulfates as SO₄.
- B. Questionable water shall be tested in accordance with and shall meet the requirements of ASTM D512 and ASTM D516.

2.8 PROPORTIONING CONCRETE – DRY CAST

- A. The mixture shall be proportioned in accordance with ASTM C 1433, Section 9.1

2.9 PROPORTIONING CONCRETE – WET CAST

- A. General
 - 1. Concrete shall be composed of cement, aggregates, and water of the qualities herein specified and in the required proportions. These ingredients shall be well mixed and brought to a proper consistency.
 - 2. All concrete shall be air-entrained. The entrained air may be produced through the use of air entraining cement, by the use of an air entraining admixture at the concrete mixer, or through a combination of both.
- B. Measurement of Materials
 - 1. The unit measure for cement shall be the pound.
 - 2. Material shall be measured by weighing. The apparatus provided for weighing the aggregates and cement shall be suitably designed and constructed for this purpose. The accuracy of all weighing devices shall be such that successive quantities can be measured to within one percent of the desired amount. The mixing water shall be measured by volume or by weight. The water-measuring device shall be susceptible to control accuracy to plus or minus one-half percent.
 - 3. The accuracy of the material weighing and water measuring devices shall be subject to check at all times. The Fabricator shall provide suitable weights approved by the Engineer for this purpose and shall assist the Engineer in making all tests.
- C. Cement Content
 - 1. a. A minimum of 700 pounds of cement and/or cementitious materials per cubic yard (CY).
- D. Water - Cement Ratio
 - 1. Maximum of 0.40.
 - 2. Required concrete compressive strength shall be as shown on the plans.
 - 3. Free water content of the aggregates shall be included in the total water in determining the total water-cement ratio.
 - 4. Moisture in the aggregate shall be measured by methods satisfactory to the Engineer, which will give results to within one pound for each 100 pounds of aggregate. Moisture contents shall be run daily for each mix design. Aggregates incorporated in the mix should be surface saturated dry (SSD).
- E. Mix Design
 - 1. Designs are to be submitted for approval before any concrete is used under this contract. Minimum of 60% coarse aggregate shall be used.

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2.10 STEEL REINFORCEMENT

- A. Dry Cast:
 - 1. All steel reinforcement shall conform to the requirements of ASTM C1433, Section 6.5, unless shown otherwise on the plans.
 - 2. Mill certification required for all reinforcement.
- B. Wet Cast
 - 1. All steel bars for reinforcement shall be deformed bars and shall conform to the requirements of ASTM A615 Grade 60, unless shown otherwise on the plans.
 - 2. Reinforcing steel to be welded shall comply with ASTM A706.
 - 3. Spiral reinforcement shall be hot rolled plain round rod or cold drawn wire. The plain round rod shall conform to the requirements of ASTM A615 Grade 60; wire shall conform to ASTM A82. Mill certification required for all reinforcement.
- C. Reinforcement shall be fabricated in accordance with Chapter 7 of the CRSI Manual of Standard Practice. Standard bending tolerances are applicable unless otherwise specified on the plans. Reinforcement shall be bent cold to conform accurately to the dimensions and shapes shown on the approved drawings. Bends shall be made accurately in a suitable bending machine.
- D. Re-bending, Placement and Storage
 - 1. Reinforcement shall not be straightened or rebent in a manner that will injure the material. Bars with kinks or bends not shown on the plans shall not be used. Heating of reinforcement shall be permitted only with the approval of the Engineer.
 - 2. All reinforcement shall be set in the positions shown on the plans and held securely in place. Placement tolerances shall be in accordance with Chapter 8 of CRSI Manual of Standard Practice.
 - 3. At the time of initiating fabrication of precast concrete box culvert units, the Engineer shall be notified in advance and have the right of inspection of the placement of the reinforcement and to give permission to place the concrete. All precast concrete box units fabricated in violation of this provision shall be rejected.
 - 4. Reinforcing bar supports, chairs, their selection and placement, unless otherwise provided, shall be in accordance with Chapter 3 of CRSI Manual of Standard Practice. Wire supports shall be Class 1, plastic protected bar supports.
 - 5. Splices, if not shown on the plans, shall occur at the neutral moment area and should be alternated.
 - 6. Minimum as-manufactured cover shall be 1 ½" with zero minus tolerance. This minimum cover limitation does not apply at the mating surfaces of joints.
 - 7. Reinforcement to be securely tied in place using uncoated tie wires. Tie wires to be minimum 18 gauge.
 - 8. Reinforcement shall be stored upon platforms, skids or other supports in such a manner as to avoid contact with the ground. If reinforcement is to remain in storage for more than a month it shall be covered to protect it from the weather. If reinforcement accumulates heavy rust, dirt, mud, loose scale, paint, oil, or any other foreign substance during storage, it shall be cleaned before being used. Severe deterioration is a basis for rejection.

2.11 EMBEDDED ITEMS OTHER THAN REINFORCING STEEL

- A. Embedded items shall be accurately located as shown on the plans.
- B. Pipe sleeves shall be Dywidag Spiro Duct with a coating rating of no less than G 60, meeting requirements of ASTM A653.
- C. All threaded items to be free of concrete and grout deposits.

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2.12 HARDWARE

- A. Fabricator to furnish the following:
- B. Couplers shall be heavy-duty (H.D.) couplers, per details in Figure 1. The following guidelines shall determine the number of couplers per joint:
- C. For box spans less than 8' wide and less than 5' high, furnish 2 couplers per joint (1 per side).
- D. For box spans less than 8' wide and 5' high and over, furnish 4 couplers per joint (2 per side).
- E. For box spans 8' wide and over, furnish 6 couplers per joint (2 @ top and 2 per side).
- F. Gaskets shall be furnished for each joint of each section. Gaskets shall be Ram Neck, Rubber Neck or equal.

PART 3 EXECUTION

3.1 FORMS

- A. Dry Cast: Forms shall be in accordance with ASTM C1433, Section 9.3.
- B. Wet Cast: Steel forms shall be used for casting the precast units. Casting beds and forms shall be sufficiently rigid to prevent deflection under load. Forms must be watertight. A minor amount of bleed water is allowed, but no paste may come through any joints.

3.2 QUALITY ASSURANCE AND INSPECTION

- A. The Engineer, or their authorized representative, shall have free entry at all times to all contract work. Two weeks' notice shall be given to the beginning of contract work so that the Inspector may be present.
- B. All products shall be inspected by the Fabricator's Quality Control Department. Any personnel involved in the testing of fresh concrete shall be certified by the American Concrete Institute (ACI) as a "Field Testing Technician", Grade 1. The Fabricator shall designate one individual as full-time railroad inspector. This individual shall be certified by ACI as a "Concrete Construction Inspector, Level II", and ACI "Concrete Transportation Construction Inspector". Certifications must be current, and the Fabricator shall furnish copies of certification prior to the start of fabrication.

3.3 CONCRETE QUALITY

- A. The water-soluble chloride content of the concrete shall not exceed 0.06% expressed as chloride ion by weight of cement. This shall be measured by an outside testing laboratory on hardened concrete from a release cylinder or on individual materials in the mix when mix proportions are developed and thereafter by tests at three-month intervals which include materials from all sources in use.
- B. The minimum compressive strength is 5000 psi or as otherwise noted on the plans.
- C. Wet Cast:
 - 1. The average shall be determined by using a minimum of three cylinders. All cylinders must break at or above the minimum compressive strength.
 - 2. Cylinders may be either 6"x12" or 4"x 8". They must be cast in steel molds. They shall be air-dried adjacent to the product for release and dry cured for 28-day strengths.
 - 3. Maximum slump after adding high-range water reducers (superplasticizers), shall be 8". Testing shall be done and recorded at point of casting.
 - 4. Concrete truck mixed concrete shall receive 70-100 revolutions at mixing speed of 6 to 18 rpm. After mixing, run at agitating speed, 2-6 rpm. After addition of water or admixtures mix a minimum of 3 minutes. Maximum number of revolutions is 300. Truck counter to be checked

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at the start. Total load to be discharged before 90 minutes has elapsed. Truck must have plate-showing capacity. Premix to 80%. Central batch to 63% (shrink mix).

3.4 DURABILITY – WET CAST

- A. One product, at the start of production and thereafter every two months is to be selected jointly with the Fabricator and Inspector for air void content and durability tests. These tests are to be performed by an independent testing laboratory.
- B. The air void content shall be measured in accordance with ATSM C457 on the top, center, and bottom of a 4"x8' cored cross section from a precast product. The measured air void content shall not be less than 6% and the air void spacing factor shall not exceed 0.008". In place cylinders may be used rather than coring.
- C. The durability factor shall be measured in accordance with ASTM C666 on a minimum of 4 prisms of concrete taken adjacent to the samples used for tests in Section T.2. The durability factor shall not be less than 90%.
- D. The cost of durability testing shall be borne by the Fabricator. Results are to be furnished directly to BNSF from the outside testing laboratory.
- E. NOTE: It is highly recommended that a "test" product utilizing approved materials, mix design, and methods as detailed heretofore in these specifications be cast, tested and approved to the above durability requirements well in advance of beginning production.

3.5 PRODUCTION, SCHEDULING AND MARKING

- A. The Fabricator shall furnish a schedule, updated weekly, which shall include the fabrication of all concrete items covered by these Specifications. This shall be provided to the Inspector.
- B. The Fabricator shall designate one individual as the Engineer's primary contact for scheduling and changes, materials acquisition, coordination of shipments, etc.
- C. In addition to the designation of one full time inspector as detailed in Paragraph R, the Fabricator shall designate one individual as the Engineer's primary contact for scheduling and changes, materials acquisition, coordination of shipments, etc.
- D. Each item shall be clearly marked by one of the following two methods, but all units produced shall be marked using the same method:
 - 1. Each item shall be clearly marked to show its mark number, the date of manufacture, lifting weight, BNSF bridge number and Fabricating Plant Identification (including city and state). Marking shall be done with black paint stencil, using a minimum of 2 inch high letters on the outside vertical side of each box section.
 - 2. Each item shall be clearly marked in accordance with ASTM C1433, Section 15, except that the railroad (Cooper's) design loading shall be substituted for the table number. In addition, the lifting weight and BNSF bridge number shall also be marked on each item.
- E. Products shall be marked in accordance with the ACPA "Quality Cast" Plant Certification Program system of marking acceptable products. In addition, the following system of color-coding may be used on all products and shall consist of spray paint dots on each end of each product:
 - 1. Green: Acceptable, ready for shipment.
 - 2. Orange: Reject, to be removed from inventory.
 - 3. Yellow: Needing repair, but ultimately will be accepted.
 - 4. Blue: Hold pending further inspection or testing.

3.6 CONCRETE TESTING – DRY CAST

- A. All concrete testing shall comply with ASTM C1433, Section 10.

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- B. The cost of all concrete testing shall be borne by the Fabricator.

3.7 CONCRETE TESTING – WET CAST

- A. All concrete testing shall comply with ASTM C172 Sampling Freshly Mixed Concrete, and shall occur and be recorded at the point of casting.
- B. Two concrete test cylinders shall be made and tested by the Fabricator for each batch of concrete. One test cylinder shall be made, cured and tested at 28 days per ASTM C31 and ASTM C39. One cylinder shall be made and tested per ASTM C31 and ASTM C39 but shall be cured along with the precast unit to closely approximate the actual strength of the unit. This cylinder shall be broken prior to removal from form.
- C. Unit weights shall be made on each batch per ASTM C138.
- D. Slump tests shall be made on each batch per ASTM C143.
- E. Ambient temperature and concrete temperature to be made for each batch.
- F. All fresh concrete tests are to be made from the same sample.
- G. The cost of all concrete testing shall be borne by the Fabricator.
- H. Minimum of one test per batch of concrete. A batch is defined as initial mixing of all concrete ingredients before the addition of water.

3.8 CONCRETE PLACEMENT

- A. Concrete shall not be placed in the forms until:
 - 1. All reinforcing steel has been completed and has been inspected and approved by the Fabricator's Quality Control representative and by the Engineer.
 - 2. All fresh concrete testing has been done and complies with minimum requirements.
- B. Concrete shall be vibrated internally and externally to provide thorough consolidation and compaction. An extra vibrator shall be available at all times at the point of casting. Vibrator head to be sized to fit between smallest dimension between reinforcement.
- C. The temperature of the mixed concrete when placed shall not exceed 90° F. The temperature of the forms and reinforcing steel shall not exceed 90° F. When the temperature of the forms and reinforcement exceed 90° F., it shall be cooled by acceptable methods to an ambient temperature of 90° F or lower. If water is used to cool forms and steel, all standing water shall be removed by compressed air or other suitable means.
- D. Fabricating plants with demonstrated facilities for protection of the concrete during cold weather may, with the approval of the Engineer, cast precast units when production procedures meet the following criteria:
 - 1. When the ambient temperature is below 32° F., the forms and reinforcing steel shall be preheated to attain form and steel temperature of at least 40° F.
 - 2. No concrete may be placed when the wind chill temperature is 0° F or lower.
 - 3. Air temperature and wind velocity shall be measured at the plant in order to determine equivalent wind chill, by methods approved by the Engineer.
- E. Concrete placement shall be a continuous operation as far as possible from start to completion of each precast unit.
- F. Cold joints are not permitted.
- G. Wet Cast:
 - 1. Placement shall follow the guidelines as detailed in ACI 309, and in no case shall the thickness of a lift be placed to a depth greater than the length of the vibrator head. Concrete shall not be

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allowed to flow through the form. The concrete shall be placed as close as possible to its final location.

2. Concrete to be deposited against concrete. Limit drops to 5 ft. Concrete shall not be moved with vibrators. Care should be taken to prevent vibrators from touching forms. Limited delay in concrete placing will be permitted to conform to construction procedure; however, concreting shall in all cases be continued before preceding concrete attains its initial set. Cold joints are not permitted.

3.9 DIMENSIONAL TOLERANCES – DRY CAST

- A. Dimensional tolerances shall be in accordance with ASTM C1433, Section 11, except that in no case shall the as-manufactured cover of reinforcement be less than 1 ½". This minimum as-manufactured cover limitation does not apply at the mating surfaces of joints.

3.10 DIMENSIONAL TOLERANCES

- A. Internal Dimensions:

Width $\pm \frac{1}{4}"$

Height $\pm \frac{1}{2}"$

- B. Overall Dimensions:

Width & Height $\pm \frac{1}{2}"$

Slab & Wall Thickness $\pm \frac{1}{4}"$

Haunch Dimension $\pm \frac{1}{4}"$

Length $\pm \frac{1}{2}"$

- C. Lifting Inserts

Location $\pm \frac{1}{2}"$

Resulting Tilt $\pm 1/8"$

- D. The maximum variation in the position of the reinforcement shall be $\pm \frac{1}{2}"$.

- E. In no case shall the as-manufactured cover of reinforcement be less than 1 ½". This minimum as-manufactured cover limitation does not apply at the mating surfaces of joints.

3.11 LAITANCE

- A. All laitance accumulated on steel core and forms must be removed before reuse.

3.12 CURING

- A. Dry Cast curing shall be in accordance with ASTM C1433, Section 9.2.
- B. Slow cool down, moist cure. Curing compound shall be used on all, as cast, exposed surfaces. Compound shall comply with ASTM C309, Type 2, Class B. Coverage should be 100 Sq. Ft per gallon. Compound to be resin based. Application to provide a complete membrane (should appear as white paper). Care should be taken to avoid coating protruding reinforcing bar that will be used for field-cast additions to the box culvert.
 1. All concrete covered under these specifications may also be cured by accelerated means: either steam or moist heat. In freezing weather, or when there is the likelihood of freezing temperature during the curing period, suitable means must be provided before concreting for maintaining all concrete surfaces at a temperature of not less than 50° F.

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2. The temperature of concrete surfaces shall be determined by thermometers placed against the surface of the concrete.
 3. Covering or housing of the form must be so placed as to permit free circulation of air above and around the concrete within the enclosure, and to exclude air currents from the outside. Care shall be taken to maintain the specified temperature continuously and uniformly in all parts of the enclosure.
 4. Steam curing shall be done in an enclosure capable of containing the live steam in order to minimize moisture and heat losses. The application of steam shall be delayed from 2 to 4 hours after final placement of the concrete to allow the initial set of the concrete to take place. If retarders are used, the application of steam may be increased to from 4 to 6 hours. The steam shall be at 100% relative humidity to prevent loss of moisture and to provide excess moisture for proper hydration of cement. Application of steam shall not be directly on the concrete.
- C. During application of the steam, the ambient air temperature shall increase at a rate not to exceed 40° F. per hour until a maximum of 150° F. is reached. The curing shall continue for a minimum of 12 hours (see Section Q Concrete Quality). In discontinuing steam, the ambient air shall decrease at a rate not to exceed 40° F. per hour until a temperature has been reached about 20° F. above the temperature of the air to which the concrete is exposed. The concrete shall not be exposed to temperatures below freezing for 24 hours after discontinuation of steam.

3.13 SURFACE FINISH

- A. See AREMA Manual for Railway Engineering, Chapter 8, Section 1.18 and 1.19.

3.14 HOLES FOR LIFTING DEVICES AND COUPLERS

- A. Fabricator shall provide four (4) holes in the top slab of precast concrete box culvert units for lifting the units. The number, diameter and location of holes shall be shown on the shop drawings.
- B. Fabricator shall provide holes for heavy-duty couplers fabricated in accordance with Paragraph O, "Hardware". The number of holes provided at each end of the box units at each joint shall be in accordance Paragraph O, "Hardware". The number, diameter and location of holes shall be shown on the shop drawings.

3.15 3.12 REPAIRS

- A. Repairs may be made for bug holes or discoloration. These may consist of grinding, grouting (cement and sand), chipping and stoning with the approval of the Engineer. Rock pockets, excessive cracking, poor vibration shall be cause for rejection. All open porous surfaces to be sealed. Tarp marks or other construction deformities may be repaired. Small cracks not exceeding 1/16" may be repaired by epoxy injection. Broken edges shall be cut 1-1/2" deep for repair. No feathering of broken areas is allowed.

3.16 HANDLING, STORAGE, WEIGHING AND SHIPPING

- A. Design of lifting devices shall be the responsibility of the Fabricator, unless detailed on the plans.
- B. A storage area shall be provided for the exclusive storage of BNSF products. At no time may other customers units be stored in this area. This area shall be of sufficient size to permit the orderly storage of units by size and type. Units shall be stored in such a way as to permit the Inspector's access to all sides at all times, and the Fabricator's access for shipment without additional moving. Units shall be stored with the top up. Care shall be taken during storage, hoisting, and handling of the precast units to prevent cracking or damage. Units damaged by improper storage or handling shall be replaced or repaired to the satisfaction of the Engineer by the Fabricator at their expense.

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Transportation of precast units shall not be undertaken until the full 28-day concrete strength has been achieved, or by order of the Engineer.

- C. A representative sample of each type of each product shall be weighed by a method accurate to within 250 lbs. by using a load-indicating device.
- D. For shipment by railroad car, plans, including all details of the proposed lifting and transportation methods including loading, blocking and securing materials shall be submitted to the Engineer before shipping may commence. The Fabricator shall load, block and tie down the precast units on rail cars to the satisfaction of the local railroad car inspector at no additional cost to BNSF. Regardless of the method of shipment, all units shall be shipped oriented with the top up.
- E. The Fabricator shall provide facsimile copies of shipping notices covering all materials shipped each day by railroad car number or by truck number or other truck identification. One copy shall be furnished to each of the following:
 - 1. Manager Structures Design and
 - 2. Structures Supervisor (as shown on the Purchase Order)

3.17 WRITTEN REPORTS

- A. Furnish to BNSF reports of daily pour data for each product. These shall include, but not be limited to: reinforcing steel reference, set-up check list, concrete pour check list, i.e. time of day, temperature (ambient and concrete), number of yards, unit weight, and/or other admixtures, mix design, curing time start and end, cylinder breaks at stripping and at 28 days, average and maximum temperatures, weight of piece and post pour inspection. Reports to be made on the form included as Appendix A or on a form approved by the Engineer.

END OF SECTION

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SECTION 05400

JACKING OF REINFORCED CONCRETE PIPE

PART 1 GENERAL

1.1 GENERAL

- A. This Specification is for the design and installation by jacking of reinforced concrete pipe for use on BNSF Railway Company (BNSF) projects.
- B. This Specification both includes and supplements applicable portions of Section 05100 of the current BNSF Railway Company Standard Construction Specifications.
- C. The Contractor shall furnish all labor, materials, equipment and services necessary to install reinforced concrete pipe in accordance with BNSF Plans and these Specifications.

1.2 DEFINITIONS

- A. The word "Engineer" in this Specification shall mean the BNSF Assistant Vice President – Engineering Services & Structures (or their duly authorized representative).
- B. The word "Contractor" in this Specification shall mean the contractor or its sub-contractor responsible for the installation of the reinforced concrete pipe.
- C. The word "Supplier" in this Specification shall mean the supplier or manufacturer of materials for use in installation of the reinforced concrete pipe.

PART 2 MATERIAL AND DESIGN

2.1 MANUFACTURING PLANT STANDARDS

- A. The reinforced concrete pipe units shall be cast in an established manufacturer's plant that is certified under the American Concrete Pipe Association (ACPA) "Quality Cast" Plant Certification Program, unless otherwise approved by the Engineer.

2.2 SPECIFICATIONS FOR AND DESIGN OF REINFORCED CONCRETE PIPE

- A. Reinforced concrete pipe for jacking will be furnished according to Section 05100 of the current BNSF Railway Company Standard Construction Specifications. Except for certain additions and/or modifications, Section 05100 of the current BNSF Railway Company Standard Construction Specifications refers directly to Chapter 8, Part 10, of the current American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering, except as modified hereinafter:
 - 1. Reinforced concrete pipe shall be Class V, Wall C.
 - 2. Reinforced concrete pipe shall be tongue and groove design.
 - 3. Watertight joint gaskets shall be used, unless otherwise approved by the Engineer.
- B. Reinforced concrete pipe shall have the specified inside diameter. The pipe will be designed and manufactured in accordance with all applicable portions of ASTM C76 for Class V, Wall C, except as modified by Section 2.2 (C). The strength test requirements in pounds per linear foot of pipe under the three-edge-bearing method shall be the D-load (test load expressed in pounds per linear foot of diameter, conducted per ASTM Designation: C497) to produce a 0.01-inch crack, multiplied by the internal diameter of the pipe in feet.

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- C. The pipe will be designed for jacking with additional reinforcement provided to withstand the jacking pressures. Grout injection ports shall be furnished through the pipe wall at intervals not exceeding five (5) feet.
- D. The following information shall be clearly marked on each section of pipe:
 - 1. Class and ASTM specification.
 - 2. Date of manufacture.
 - 3. Name or trademark of the manufacturer.
 - 4. Identification of the plant.
 - 5. The "Q Cast" stamp to certify that the pipe was produced at an ACPA certified plant.

2.3 BASIS FOR REJECTION OF PIPE MATERIAL

- A. The Supplier of the reinforced concrete pipe furnished by the Contractor shall be approved by the Engineer before delivery is started. All materials being supplied shall be subject to inspection or test at any time during their manufacture or installation. Causes for rejection, unless repairs can be made subject to approval of the Engineer, may include any of the following:
 - 1. Failure to conform to any applicable requirements of ASTM C76.
 - 2. Fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint.
 - 3. Defects that indicate imperfect proportioning, mixing or molding.
 - 4. Surface defects indicating honeycomb or open-texture.
 - 5. Damaged or cracked ends where such damage would prevent making a satisfactory joint.
 - 6. Any continuous crack or concrete separation having a surface width of 0.01 inch or more and extending for a length of 12 inches or more, regardless of depth or position on the pipe.
 - 7. A piece of any size broken out of the pipe.
 - 8. Any shattering or flaking of concrete at a crack.
 - 9. Delamination of the concrete.
 - 10. Separations or "blisters".
 - 11. A variation from a true circle of the specified diameter by more than one percent (1%).
 - 12. A wall thickness less than allowable specified in ASTM C76. A wall thickness more than required by specification shall not be cause for rejection. Pipe having localized variations in wall thickness exceeding those specified will be accepted if the three edge bearing strength and minimum steel cover requirements are met.
 - 13. Exposure of reinforcement arising from misplacement or cage twist.
 - 14. The pipe fails the D-load test.
- B. The imperfections and variations noted above apply to either the point of manufacture or the point of installation.

2.4 BASIS FOR ACCEPTANCE OF PIPE MATERIAL

- A. The basis for acceptance of the pipe materials shall be by one of the following:
 - 1. The D-load bearing strength test, compliance with these specifications, inspection of the pipe manufacture, and inspection of the completed pipe.
 - 2. The structural design details, materials, tests, inspection of the manufacturing process, and inspection of the completed pipe.
 - 3. Acceptance of certification with these specifications.

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PART 3 EXECUTION

3.1 JACKING OF REINFORCED CONCRETE PIPE

- A. Variations from theoretical alignment and grade at the time of completion of jacking shall not exceed one percent (1%) of the distance from the jacking point.
- B. Heavy duty jacks suitable for forcing the pipe through the embankment shall be provided. In operating jacks, even pressure shall be applied to all jacks used. A suitable jacking head and suitable bracing between the jacks and the jacking head shall be provided so that pressure will be applied to the pipe uniformly around the ring of the pipe. Joint cushioning material of plywood or other material may be used. Plywood cushioning material shall be 3/4-inch minimum thickness. Cushioning rings may be made up of single or multiple pieces. A suitable jacking frame or backstop shall be provided. The pipe to be jacked shall be set on guides, properly braced together, to support the section of the pipe and to direct the pipe in the proper line and grade. The whole jacking assembly shall be placed so as to line up with the direction and grade of the pipe. In general, the embankment material shall be excavated just ahead of the pipe, the material removed through the pipe, and the pipe forced through the embankment with jacks, into the space thus provided.
- C. If a forward steel cutting shield is to be utilized, it must be designed to withstand Coopers E-80 live load surcharge plus dead loads. Design must be submitted to and approved by the Engineer prior to use under a railway track.
- D. If the Contractor intends to construct a pilot tunnel, supports for the tunnel must be designed to withstand Cooper E80 live load surcharge plus dead loads. Design of the pilot tunnel must be submitted to and approved by the Engineer.
- E. The driving ends of the pipe 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 pipe showing signs of failure shall be removed and replaced with a new section.
- F. The diameter of the excavated hole shall not exceed the outer diameter of the pipe being jacked by more than two (2) inches unless approved by the Engineer. The use of water under pressure for jetting or sluicing will not be permitted to facilitate boring, pushing or jacking operations. Some boring processes may require water or slurry to lubricate the cutter or pipe, and, under such conditions, is considered dry boring. When material tends to cave in from outside these limits, a shield shall be used ahead of the first section of pipe. The face of excavation shall not extend beyond the end of the pipe more than one foot unless permitted by the Engineer. Areas resulting from caving or excavating outside the above limits shall be immediately backfilled with sand or mortar by a method which will fill the voids before the jacking process proceeds. Upon completion of the jacking operations, all voids around the outside face of the pipe shall be pressure grouted through the wall injection ports for the entire length of the installation.
- G. Grouting equipment must be at the job site and available for use in the event of unplanned track settlement.
- H. All tracks will remain in use at all times except for those tracks designated by agreement between the BNSF and the Contractor to facilitate either the jacking pit or the receiving pit. Portions of the total pipe installation may be designated by the Engineer that, at the option of the Contractor, can be installed by open cut and cover method. Once jacking operations has commenced, it shall be continued uninterrupted around the clock until the conduit has been jacked under all live tracks, except that no pipe movement will be allowed while a train is passing over any tracks designated by the Engineer as main tracks.
- I. Extreme care must be used when moving the pipe under all tracks. The BNSF will furnish a Railroad Flagman at all times to monitor track conditions. It must be understood that very slight settlements could result in a derailment. If settlement occurs at any track, all jacking operations shall cease until BNSF forces can make repairs. Although BNSF forces will be continuously on call and will respond

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to correct track settlements as soon as possible, no additional compensation will be made for the subsequent delays to the Contractor. Except when otherwise agreed to by the BNSF, the cost of both the Railroad Flagman and repairs to track settlements shall be the responsibility of the Contractor.

- J. No equipment or materials can be operated or stored within fifteen (15) feet of the centerline of any railroad track that is subject to train traffic, without first receiving permission from the BNSF. Excavations must not be made unless plans and specifications are submitted to and approved by the Engineer. Shoring shall be designed to withstand railroad live load surcharge as well as normal soil dead loads and construction equipment surcharge. Refer to BNSF – UP Guidelines for Temporary Shoring.
- K. No equipment is to be operated over the tracks unless it is at a public road crossing protected with gates and flashers. Contractor shall receive instructions from the Railroad Flagman for any other track crossing or encroachment on BNSF right of way within 25 feet of the centerline of any track. Contractor's employees must be aware that trains and railroad cars can be moved at any time on any track in either direction without warning. It is especially important that Contractor's employees be on the lookout for train movements when working in a noisy environment.

3.2 SUBSURFACE DATA

- A. No subsurface soils information will be provide or implied. A pre-bid meeting may include a sample random excavation with a backhoe in the general area of the jacked pipe. The Contractor is to draw their own conclusions from observations of the random excavation.

3.3 PIT EXCAVATION, BACKFILL AND DISPOSAL OF EXCAVATED SOILS

- A. Excavated soils from the jacking operations may be transported to BNSF property as designated by the Engineer. The soils shall be spread uniformly over an area designated by the Engineer. The soils shall be graded to drain. There will be no specific compaction requirements beyond that which will occur as a result of machine compaction while performing the uniform grading operations.
- B. Whenever practical, receiving pits should not be excavated until pipe has been fully jacked into final position under the track.
- C. At the discretion of the Engineer, all excavated pits must be backfilled and compacted to a minimum of 95% Proctor where future track construction could induce railroad load influence into the pit excavation limits. At all other locations, pit may be backfilled and compacted to a minimum of 90% Proctor.

3.4 CUT AND COVER INSTALLATION

- A. For those portions of the total pipe installation so designated by the Engineer that, at the option of the Contractor, can be installed by open cut and cover method, the pipe bedding and backfill must meet Class B conditions as defined by the American Concrete Pipe Association (ACPA) Design Manual. For those portions of the pipe installation so designated by the Engineer which support track ties and rails, those track ties and rail will be removed by BNSF forces at the request of the Contractor. Any track ties and rail removed by BNSF forces will be re-installed by BNSF forces, using material supplied by the BNSF. Except when otherwise agreed to by the BNSF, the total cost of removal and re-installation of track ties, rail and ballast shall be the responsibility of the Contractor.

3.5 SEALING ANNULAR SPACE AT JOINTS OF PIPE

- A. The annular space in the inside joints of the pipe shall be filled with jointing material and finished smooth at the completion of the entire installation. Each joint shall be sealed to prevent leakage and infiltration. Sealing materials shall conform to one or more of the following:

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1. Cement Mortar: Mortar shall be composed of one part Portland cement and two parts sand by volume. Sand shall be well graded and of such size that all will pass a No. 8 sieve. The materials shall be mixed to a consistency suitable for the purpose intended. All mortar shall be used within 30 minutes after the mixing water has been added. Subject to approval by the Engineer, admixtures of inert materials may be used in the mortar to facilitate workability.
2. Rubber Gasketed Joints: Rubber gasketed joints shall conform to the requirements of ASTM Designation: C 433 and shall be flexible and able to withstand expansion, contraction, and settlement. All rubber gaskets shall be stored in as cool place as practicable, preferably at 70 degrees F. or less, and in no case shall the rubber gaskets be exposed to direct rays of the sun for more than 72 hours.
3. Resilient Materials and Other Joint Sealants: Resilient joint materials and other joint materials which will prevent leakage and infiltration may be used if approved by the Engineer.

3.6 CRACKS

- A. Cracks in an installed reinforced concrete culvert that exceed 0.01-inch width will be appraised by the Engineer. Cracks determined to be detrimental shall be sealed by a method approved by the Engineer.

END OF SECTION



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SECTION 06000 ELECTRICAL

SECTION 06100 BASIC ELECTRICAL REQUIREMENTS

SECTION 06200 GENERAL TESTING OF ELECTRICAL WORK

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SECTION 06100

BASIC ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.1 DESCRIPTION

- A. This Section applies to the site electric work which consists of providing all necessary labor, equipment and materials required for the complete site electrical installation in accordance with these specifications and as indicated in the Contract Drawings.
- B. Work Included:
 - 1. Equipment and materials to be furnished and installed by the Contractor shall include, but not be limited to, the following:
 - (a) Electric Service and Main Distribution Equipment
 - (b) Grounding and Bonding
 - (c) Power Distribution Panelboards
 - (d) Feeders and Branch Circuits
 - (e) Raceways
 - (f) Manholes and Handholes
 - (g) High Voltage Pull Box
 - (h) Conductors, Wire and Cable
 - (i) Pull Boxes and Junction Boxes
 - (j) Pull Wires
 - (k) Spare Raceways (Empty)
 - (l) Nameplates, Labels, and Tags
 - (m) Outlets and Boxes
 - (n) Motor Connections and Controls, Motor Starters
 - (o) Disconnect Switches for All Motors
 - (p) Equipment Power Wiring, Control Wiring and Connections
 - (q) Contactors and Remote Control Switches and Relays
 - (r) Time Switches and Photo Controls
 - (s) Equipment Mounting and Supports
 - (t) Acceptance Tests
 - (u) Staging
 - (v) Guarantee
 - (w) Spare Parts
- C. Above list is given as a general guide to identify the major parts of the Work. General arrangement of the equipment is shown on the Contract Drawings and The Contractor is responsible for the takeoffs and quantities.
- D. It is the intent of the Specifications and Contract Drawings that the electrical project be a complete and finished work, tested and ready for operation. Any apparatus, appliance, material or work not shown on Contract Drawings, but mentioned in the Specifications or vice versa, or any incidental accessories necessary to make the work complete in all respects and ready for operation, shall be furnished, delivered and installed by the Contractor without additional expense to the Owner.

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1.2 RELATED WORK

- A. This Section includes general administrative and procedural requirements for electrical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Section 1.1 B:
1. Submittals
 2. Coordination drawings
 3. Inspection
 4. Record documents
 5. Operation and maintenance manuals
 6. Delivery, storage, and handling
 7. Manufacturer's technical representative
 8. Rough-ins
 9. Electrical installations
 10. Preparation for operation
 11. Tests
 12. Demonstration of complete electrical systems
 13. Structural supports
 14. Temporary power
 15. Cutting and patching

1.3 REFERENCE STANDARDS

- A. All Work shall conform to these Specifications and to the applicable requirements of the latest edition of the following codes, regulations and standards.
1. American National Standards Institute (ANSI).
 2. American Society for Testing and Materials (ASTM).
 3. Institute of Electrical and Electronic Engineers (IEEE).
 4. Latest Edition of National Electric Code (NEC).
 5. National Electrical Manufacturers Association (NEMA).
 6. Occupational Safety and Health Administration (OSHA).
 7. Illuminating Engineering Society of North America (IES).
 8. Insulated Cable Engineers Association (ICEA).
 9. Underwriters' Laboratories, Inc. (UL).
- B. Requirements of Commonwealth Edison (ComEd).
- C. Any law or regulation of the State or other local regulating body having jurisdiction over this work shall apply.

1.4 SUBMITTALS

- A. General: Drawings and data to be submitted by the Contractor for all Work and equipment are specified herein and under the respective items of equipment and materials to be furnished and shall be provided in accordance with the Clauses of the Special Conditions and Requirements of the General Conditions
- B. Shop Drawings: Complete shop drawings and technical data shall be submitted for review for all equipment. As a minimum, shop drawings shall include bills of materials, front views, assembly

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drawings, elementary diagrams, connection diagrams, and complete list of spare parts. Overall dimensions and minimum clearance dimensions shall also be shown for all equipment. Diagrams for control equipment shall be in accordance with ANSI Standards.

- C. Shop drawings shall be submitted for, but not limited to, the following:
 - 1. Pull boxes larger than 12 inches
 - 2. Terminal cabinets and boxes
 - 3. Panelboards
 - 4. Disconnect switches, and associated enclosures
 - 5. Cables and terminations for 600 volt cables
 - 6. Raceway and supports
 - 7. Pad-mounted transformers
 - 8. Lighting fixtures
 - 9. Light Poles
 - 10. Light lowering devices
- D. Provide coordination graphs and a family of current characteristic curves for all types and sizes of protective relays, circuit breakers and fuses.
- E. Each drawing shall be marked with user name, purchaser name, location of facilities,
- F. Contract number, purchase order number, item number.
- G. Wiring Diagrams: Schematic and terminal to terminal connection wiring diagrams shall be submitted for the following items:
 - 1. Lighting controls
 - 2. Motor control equipment
- H. Catalog Cuts: Catalog cuts shall be marked to indicate the item, model, capacities and other characteristics listed in the table or on printed sheets. Catalog cuts shall be submitted for, but not limited to, the following:
 - 1. Boxes and enclosures
 - 2. Grounding connectors
 - 3. Lighting fixtures including ballasts
 - 4. Molded case circuit breakers
 - 5. Pushbuttons
 - 6. Manholes and handholes
 - 7. Relays, control and indicating devices
 - 8. Safety switches
 - 9. Control switches
 - 10. Terminal blocks
 - 11. Conduit and fittings
 - 12. Thermostats
 - 13. Lighting controls
 - 14. Pad-mounted transformers
 - 15. Medium voltage cable
- I. Spare Parts List: Submit an itemized list of spare parts, as recommended by the manufacturers for all electrical equipment to be supplied under this Contract. The list shall include current unit prices and sources of supply.
- J. Drawings and data to be submitted:

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1. Front views, floor plans, and mounting details for all equipment showing dimensions necessary for installing equipment, equipment base details and entrance locations for main power cables, buses and control cables.
2. Elementary diagrams of power and control circuits.
3. List of standard symbols and nomenclature
4. Tabulation of electrical and mechanical characteristics of the various components, including:
 - (a) Description of equipment
 - (b) Manufacturer
 - (c) Outline drawings showing arrangement of equipment, overall dimensions and approximate weights.
 - (d) Cable characteristics
 - (e) Bills of material
 - (f) Floor plans showing final equipment layout of all the equipment.
5. Test procedures and reports requiring submittals as specified in this Division.
6. Operation and maintenance instructions.

1.5 COORDINATION DRAWINGS

- A. Coordinate with all trades as necessary to facilitate timely completion, avoid the necessity for cutting and patching and to ensure proper operation of all equipment.
- B. Furnish to appropriate trades, drawings and instructions necessary for construction of concrete bases, concrete encasement and other construction required to accommodate installations under this Division.
- C. Obtain all wiring diagrams and other instructions required for proper electrical connection of equipment installed or furnished under other Divisions hereof.

1.6 RECORD DOCUMENTS

- A. Maintain a neatly marked set of records drawings at the construction site showing the installed location and routing of conduits, cables, pull boxes, junction boxes, and outlets as well as other record (as-built) data. Keep record drawings current (with the Work and subject to inspection by the Engineer at any time. Deliver final record (as-built) drawings to the Engineer prior to the issuance of the certificate of Final Completion in accordance with the requirements of this Contract.

1.7 OPERATION AND MAINTENANCE MANUALS

- A. Furnish to the Engineer 12 bound and indexed copies of an approved operations and instruction manual for the following:
 - B. Panelboards
 - C. Lighting control panels
 - D. Pad mounted transformers
- E. The books shall provide comprehensive detailed information on the approved installation, operation and use, troubleshooting, parts list, lubrication and periodic maintenance, together with the source of replacement parts and service for the items of equipment and the systems covered.
- F. Where items of equipment and/or systems work in conjunction with one another the interconnections shall be shown on a single sheet, folded out if necessary. A schematic wiring diagram and a description of operation shall be included.

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- G. Where separate items of equipment specified herein are combined into a single sealed self-contained unit, the drawings and required data shall treat each item of equipment in such self-contained unit as separate items. Referring to such self-contained unit as one item of equipment will not be acceptable.
- H. The operation and maintenance manual shall be submitted for approval in accordance with Clause in Division 1 entitled "Working Drawings and Catalog Cuts."

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.
- B. Deliver equipment in factory-fabricated containers or wrappings, which offer proper protection from construction debris and physical damage.
- C. Store equipment in original wrappings in a clean dry place. Protect from weather, dirt, fumes, and water.
- D. Handle carefully to prevent damage, breaking and scouring. Do not install damaged units or components, replace with new.

PART 2 EXECUTION

2.1 ROUGH-INS

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.
- B. Refer to equipment specifications in Divisions 2 through 16 for rough-in requirements. (BNSF Electrical Specifications if Provided)

2.2 ELECTRICAL INSTALLATIONS

- A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment.
- B. All electrical installations shall be in accordance with the applicable standards of ANSI, IEEE, NEC, NEMA, OSHA and the Division of Labor of the applicable State in which the work is being performed, unless specified otherwise. Place the equipment accurately in position, level the equipment, properly assemble all equipment which requires assembling, including bus and incoming wires, and adjust and make ready for service the electrical equipment and material required by these Specifications or shown on the Contract Drawings. After the installation is complete, clean each piece of equipment to the satisfaction of the Engineer. All work shall be done in an orderly and workmanlike manner and shall present a neat appearance when completed.
- C. Provide excavation and backfilling as necessary for burial of ground cables, duct banks and conduits as shown on the Contract Drawings. Install all underground concrete duct bank and ground grid prior to the placement of concrete floor slab.
- D. Embed conduits, ground cables and anchoring devices as specified and shown on the Contract Drawings and coordinate this work with subcontractors and the Engineer so as not to interfere with or delay their work.
- E. Dissimilar Metals:
 - 1. Dissimilar metals as used herein shall be those which are incompatible in the presence of moisture, as determined from their position in the electrochemical series or from test data. Where dissimilar metals come in contact, paint the joint both inside and out with approved paint so as to exclude moisture from the joint, or provide a suitable barrier separating the metals.

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2. Transitions in conduit from one metal to a dissimilar metal shall only be made at boxes or other enclosures except where otherwise specified herein or shown on the Contract Drawings.
- F. Furnish the services of installation supervisors as required or specified herein, without cost to the Engineer. The presence of the installation supervisor shall in no way relieve responsibility for the complete and proper installation of the equipment.
- G. All equipment installed by the Contractor shall be in accordance with the approved shop drawings and the manufacturer's recommendations and shall operate to the satisfaction of the Engineer. Correct by repair or replacement, damage to or failure of any part of any of the items of the equipment which, in the opinion of the Engineer, has been caused by faulty mechanical or electrical assembly. Perform necessary tests to demonstrate that the electrical and mechanical operation of the equipment is satisfactory and meets the requirements of these Specifications at no additional cost to the Engineer.
- H. The Engineer reserves the right to require minor changes in location of equipment without incurring additional costs.
- I. Preserve technical data, instructions and manuals furnished with electrical equipment. This material shall be neatly organized, bound and incorporated in the operation and maintenance manuals.
- J. Receiving, Inspecting and Storing:
 1. All equipment shall be received and inspected immediately upon delivery.
 2. Equipment, regardless of whether it is to be installed immediately or stored for some time before installation, shall be kept in a clean dry place. Heaters installed in equipment to prevent formation of moisture shall be energized. Blocks and wires used to hold moving parts in position during shipping and handling shall remain in place until the equipment has been completely installed. The equipment shall be moved by means of lifting eyes, jacking pads, or other means provided by the manufacturer for that purpose.
 3. Equipment shall be installed and assembled in accordance with the Contract Drawings and instructions furnished by the manufacturer. It shall be protected at all times during construction, including furnishing and installing tarpaulins during painting.

2.3 PREPARATION FOR OPERATION

- A. Electrical equipment shall be properly installed, adjusted, connected and tested by the Contractor before such equipment will be taken over by the Engineer for operational service, unless the Contractor is specifically relieved from performing part of the Work in writing by the Engineer. All circuits shall be checked for proper insulation resistance by a multi-voltage megohmmeter, and for continuity, grounds, and tightness of connections.
- B. Pending continuity tests, all electrical circuits shall be tested for proper polarity via a standard polarity meter prior to equipment hand over and operational service. All shipping block of instruments and mechanisms shall be removed. All equipment shall be thoroughly cleaned inside and outside of all dirt, grease, grit, cable and conductor strippings, metal filings, or any other foreign matter.
- C. All items shall be properly cleaned and finish painted, or touch-up painted, as required by the Engineer.
- D. Identification markers and nameplates shall be properly and accurately installed by the Contractor.

2.4 TESTS

- A. General:
 1. Make all required tests to establish that the equipment has been properly installed in accordance with the Contract requirements. Upon completing the installation of each item,

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- carefully inspect and check the equipment for correct and complete assembly of all parts and components in accordance with the manufacturer's drawings and instruction manuals and as directed by the Engineer.
2. Furnish all electrical test equipment and all meters, instruments and miscellaneous equipment and perform all work required or as directed by the Engineer to complete all tests specified herein. In addition to tests specified elsewhere, perform ground system resistance tests, insulation resistance (megohmmeter) tests on all power and control cables, motors, lighting systems, and miscellaneous electrical equipment to include polarity testing of all electrical circuits/receptacles.
 3. Complete all equipment checks, lubrication checks, and all artificial loading of starters and circuit breakers. Furnish the Engineer seven copies of all test data taken for tests performed by the Contractor which shall be properly signed by an authorized Contractor's representative. The test data forms used for tabulating the information required shall be furnished by the Contractor and shall be acceptable to the Engineer.
 4. Submit test records to the engineer no later five working days after successful completion of the test.
- B. Final Field Tests:
1. Each acceptance test shall be witnessed by the Engineer unless the Contractor is otherwise advised.
 2. All tests shall be scheduled by the Contractor with the Engineer's approval and no testing shall be performed without his approval.
 3. The testing shall be performed by and under the immediate supervision of the Contractor.
 4. Manufacturers shall be notified of the tests by the Contractor and shall be permitted to witness high voltage or other tests performed on their equipment if they so request.
 5. Low Voltage Wiring and Equipment:
 - (a) Insulation tests as well as polarity testing shall be applied at each lighting and appliance panelboard and each distribution panel or switchboard rated 600 volts or less, after wiring is complete but before utilization devices are installed.
 - (b) Tests shall be made using a 1,000 volt DC megohmmeter and an appropriate polarity meter which has been approved by the Engineer.
 - (c) All buses, feeders, and branch circuits shall be tested for insulation and continuity. Each phase shall be insulation-tested to each other phase and to ground.
 - (d) Motors shall be tested phase-to-ground.
 - (e) Insulation resistance reading after 60 seconds of less than two megohms shall be cause for rejection of that device or portion of the system. The suspect item or system element shall be replaced and retested at no additional cost to the Engineer.
- C. Controls:
1. Electrical controls, circuits and systems shall be tested by trial operation of control equipment after all wiring is completed to see that each interlock and control function operates in accordance with the Contract Drawings, Specifications, and where indicated, the description of operation for the equipment functioning during testing, the Contractor shall simulate the intended operating condition in the associated control circuits.
 2. Locate the cause of any malfunction and make the necessary wiring and/or equipment changes or corrections to obtain the particular system's intended operation. Such changes shall be included in the test report.
 3. Control panels shall be operated through all design functions. This shall include remote operation of all equipment and actuation of alarms and indicating devices according to design requirements.

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4. Complete operational tests shall be given to all relays and control devices to show that the equipment performs all design functions and meets the Specifications.
5. Annunciator testing shall include the checking of each point by closing the trouble contact and observing the panel operation. Correct functioning of all lamps, alarm cut-off, reset relays, etc., shall be checked.

D. Acceptance Tests by the Contractor

1. After completion of the tests specified above in paragraphs 1, 2, 3, 4, and 5, performed under the supervision of the Engineer such tests as deemed necessary or advisable to determine that the transformers, power distribution systems, and the control systems are ready for operation.
2. Remove covers and panels, disconnect and reconnect wiring and provide power to equipment and wiring as required to permit performance of these tests at no additional cost to the Owner.
3. Provide two electricians acceptable to the Engineer during acceptance tests. The Engineer shall schedule the times the electricians have to be available, which may be any time during the day or night and on holidays, as needed.
4. The systems to be tested shall include all Engineer furnished equipment, Contractor-furnished equipment, and related equipment and systems, control and interlock circuits and devices, protective relays and sensors.
5. Prior to acceptance and operation, all electrical equipment must be rechecked for proper continuity, insulation, labeling, polarity, and voltage to ensure a safe work/user environment.

2.5 DEMONSTRATION OF COMPLETE ELECTRICAL SYSTEMS

- A. After the electrical systems to be installed by the Contractor have been completed and the various components contained therein have been checked and tested for satisfactory installation and proper operation. The various systems shall be operated a sufficient number of times to demonstrate to the Engineer that all equipment, components, and materials for each such completed system have been properly installed and will perform the desired operation. Such demonstration of all power and control circuitry, lighting system, grounding system and other similar complete systems shall be considered an integral part of the work of the Contract.
- B. As determined by the Progress Schedule required to be submitted by the Contractor elsewhere in the Specification, systems may be completed in stages such as to permit testing, adjustments, and subsequent demonstration of proper operation of a completed element of the overall system.
- C. In such cases, notify the Engineer, in writing, that such element of the system has been completed and is ready for demonstration for conformity with system requirements, and the Engineer will schedule performance of such demonstration. However, such demonstration of the operability of elements of systems shall not be construed as acceptability of same and will only serve to expedite complete installation of such systems.
- D. Acceptance will only be made on satisfactory demonstration of the operability of the system as a whole. If required by the Engineer, such demonstrations shall be performed in the presence of the manufacturer's installation supervisors for the various components involved in such systems or segments of systems.
- E. If, in the opinion of the Engineer, test results show improper adjustment, operation, or performance of any equipment, and such deficiencies are due to negligence or faulty equipment supplied by the Contractor or unsatisfactory installation by the Contractor, the Contractor shall furnish all plant, labor, equipment and materials required to remedy the situation to the satisfaction of the Engineer and at no additional cost to the Engineer.
- F. Record Reports:
 1. During each of the aforementioned tests, maintain a comprehensive set (quantity of duplicates to be determined by the Engineer) of test reports defining the specific condition in which the

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apparatus is left, after it has been given approval for use in its intended service. The completed reports shall become the property of the Engineer.

2. A checklist type report for each individual item of major electrical equipment shall include, but not be limited to, the following identification data defining:
 - (a) Equipment name.
 - (b) Item tag number.
 - (c) Manufacturer.
 - (d) Type of class.
 - (e) Application.
 - (f) Installation location.
 - (g) Voltage rating.
 - (h) Date of test.
 - (i) Ambient conditions.
 - (j) Tester's signature.
3. Among the specific test requirements, all equipment shall be visually inspected and evaluated on the report as to its general condition both exterior and interior.
4. Unless otherwise directed by the Engineer, the forms used for testing shall be those which are available by the particular equipment manufacturers.

2.6 STRUCTURAL SUPPORTS

- A. All equipment and raceways shall be securely and rigidly supported. Design and detail all structural steel members and equipment anchors where required and submit design calculations and shop drawings. Calculations and drawings shall be signed and sealed by a Professional Engineer.

2.7 TEMPORARY POWER

- A. The Contractor is responsible for providing adequate temporary power during all times of construction.

PART 3 MEASUREMENT AND PAYMENT

3.1 BASIC ELECTRICAL WORK

- A. Measurement for Payment Items shall be by the units indicated below, to the limits shown on the Contract Drawings.
- B. Payment for Conduit shall be per the bid tab and shall constitute full payment for labor, materials, equipment and incidentals necessary to perform this work. The price shall include all costs for excavation, bedding, all conduits, backfill, and all work in accordance with the Contract Drawings and Specifications.
- C. Payment for Conductor shall be per the bid tab and shall constitute full payment for labor, materials, equipment and incidentals necessary to perform this work. The price shall include all costs for wires, aerial and underground cables, installation, connections, splices, and all work in accordance with the Contract Drawings and Specifications.
- D. Payment for Equipment and Apparatus shall be per the bid tab and shall constitute full payment for labor, materials, equipment and incidentals necessary to perform this work. The price shall include all costs for distribution panelboards, aboveground conduits, switch gear, pad-mounted switches, diesel generators, transfer switches, transformers, and all work in accordance with the Contract Drawings and Specifications.

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- E. Payment for Lighting Control Panel shall be per the bid tab and shall constitute full payment for labor, materials, equipment and incidentals necessary to perform this work. The price shall include all costs for Lighting Control Panel, connections, and all work in accordance with the Contract Drawings and Specifications.

END OF SECTION

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SECTION 06200

GENERAL TESTING OF ELECTRICAL WORK

PART 1 GENERAL

1.1 DESCRIPTION

- A. This Section covers the general testing of electrical work as specified herein and in other Sections of these Specifications. The work shall include all other tests that may be required by the utility company, or other governing body, board, or agency having jurisdiction.

1.2 RELATED WORK

- A. Coordinate the work of this Section with all other Sections of this Specification.

1.3 REFERENCE STANDARDS

- A. Comply with all applicable local, state and federal codes, specifications, standards and recommended practices, and in particular:
 - 1. NEC - National Electrical Code.

1.4 SUBMITTALS

- A. Submit a written report of all tests made and results obtained.

1.5 QUALITY ASSURANCE

- A. Testing shall be performed by competent personnel employed by the Contractor, and as required by the Engineer. Instruments and equipment used for testing shall be suitable for the purpose and shall be accurately calibrated to industry standards.

PART 2 EXECUTION

2.1 TESTING

- A. Tests shall be completed to the satisfaction of the Engineer and Owner before final turnover.
- B. The Engineer and Owner shall be the sole reviewer of the test results. The Engineer and Owner may require the performance of such additional tests as is deemed necessary to determine that the systems, equipment, materials, and workmanship are ready for final review. Such additional testing required by the Owner shall be at no additional cost.
- C. All safety devices shall be actuated in a manner that clearly demonstrates their workability and operation.
- D. Upon completion of the various phases of the work or at convenient times during its progress as directed by the Engineer, the apparatus and wiring installed by the Contractor shall be tested to determine proper installation and operation. Tests shall include but are not limited to the following:
 - 1. A visual check of wire and cable connections for conformance with the Contract Drawings.
 - 2. Continuity check of all power and control cables.
 - 3. Insulation resistance tests of all power feeder cables. Such tests shall be made by a megger at a voltage specified elsewhere in the specifications. The Contractor shall include a copy of the readings in the test reports to be submitted.

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4. All lighting fixtures, switches, and outlets shall be energized and tested for proper polarity via a polarity test with an approved polarity meter prior to operational utility.
5. Pending acceptable polarity test results, all electrical equipment shall be tested for safe operation.
- E. The Contractor shall provide all necessary instruments and personnel for the tests. If in the opinion of the Engineer or Owner the results of such tests show that the work is not in compliance with the requirements of the Specifications and Drawings, the Contractor shall make all additions or changes necessary to comply with the specifications and put the system in proper working condition, and shall bear the expenses for all subsequent tests which are necessary to determine whether the work is satisfactory. Any additional work or subsequent tests shall be carried out at the directives of the Owner.
- F. All test procedures shall be submitted in writing to the Owner for review. Items tested and dates of tests shall be listed. Acceptance criteria shall be included. Test results shall be included. Name of person/persons conducting test shall be included.

PART 3 MEASUREMENT AND PAYMENT

3.1 GENERAL TESTING OF ELECTRICAL WORK

- A. Measurement of General Testing of Electrical Work will be by the unit and size installed, tested and accepted in accordance with these specifications and the Contract Drawings.
- B. Payment is incidental to construction and installation, unless otherwise specified by the Engineer.

END OF SECTION