APPENDIX 4 – Contract Specifications

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SECTION 100
GENERAL PROVISIONS

SECTION 101—ABBREVIATIONS AND DEFINITIONS OF TERMS

101.01 MEANING OF TERMS—These Specifications are generally written in the imperative mood. In sentences using the imperative mood, the subject, "the Contractor," is implied. Also implied in this language are "shall," "shall be," or similar words and phrases. In the Material sections, the subject may also be a Vendor, Fabricator, or Manufacturer, who may be supplying material, products, or equipment for use on the project. The word "will" generally pertains to decisions or actions of the NRA or the Engineer.

In these Specifications or on the drawings, the following words or similar words refer to actions of the NRA or the Engineer, unless otherwise stated: "directed," "required," "permitted," "ordered," "designated," "prescribed." Also, the words "approved," "accepted," "acceptable," "satisfactory," "considered," or words with similar intent, mean by or to the NRA or the Engineer, subject in each case to the final determination of the Minister, and subject to further review, as permitted by law or permitted elsewhere in these Specifications.

In these Specifications, reference to a subsection of the Specifications includes all general requirements of the section of which the subsection is a part.

In these Specifications, the words "or equal," referring to a product, material, or process, mean "equal as determined by the NRA or the Engineer."

In these Specifications, the words, "as indicated," or "indicated" mean "as indicated or indicated on the prepared contract plans."

101.02 ABBREVIATIONS—The following is a list of abbreviations used in these Specifications, in the proposal, and on the drawings. The list includes the meanings along with the abbreviations.

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
AWG	American Wire Gage
AWS	American Welding Society
PCA	Portland Cement Association
QA	Quality Assurance
QC	Quality Control

SECTION 106—CONTROL OF MATERIAL

106.01 GENERAL—Use material complying with the requirements of these specifications. At the pre-construction conference, submit a list of material to be sampled and tested by the Contractor.

Following contract execution, furnish to the NRA a complete statement of the project construction material's origin, composition, and manufacture.

106.02 MATERIAL—

(a) Preliminary Acceptance and Approval. Have the source(s) of material supply approved before delivery to project.

1. Submit the following: source; description; specified use; QC Plan; and samples of the kind and quality specified, to the Engineer.

Do not deliver material from the source to the project until written acceptance is received from the Engineer. The NRA reserves the right to obtain samples of the material provided by the Contractor for laboratory testing to verify compliance with specifications.

(b) Inspection. Inspect material delivered to the project and stockpile the material passing inspection for use. Do not incorporate questionable material, until material is tested by the Engineer and accepted in writing. The NRA reserves the right to reject questionable material delivered to the project when the test results are not according to the specifications. Furnish assistance to the Engineer, as required to obtain samples.

Allow designated NRA representatives to inspect material being used, or intended to be used, at any time before, during, or after material preparation, while being used during the progress of the work, or after the work has been completed. Furnish or arrange with producers or manufacturers to provide necessary material, labor, tools, and equipment for such inspection.

Inspections and tests, if made at any point other than the point of incorporation in the work, will not guarantee acceptance of the material. Inspection and testing performed by the NRA will not relieve the Contractor's responsibility for QC.

106.03 STORAGE OF MATERIAL—

(a) General. Store material to assure preservation of specified quality and fitness for the work.

Stored material, even though accepted before storage, may again be inspected before use in the work. Locate stored material to facilitate prompt inspection and control.

Do not use private property for storage purposes without written permission of the owner or lessee. Make copies of this permission available to the NRA. Restore storage sites to conditions acceptable to property owners and the NRA.

(b) Storage of Aggregates. Provide a separate stockpile for each aggregate size and type at cement concrete plants.

Do not use aggregates that become segregated or mixed with earth or foreign material.

If divided aggregate bins are used for storage or for proportioning, take measures to prevent mixing of aggregates.

Provide an area for storage of aggregates for use in Portland cement concrete and bituminous concrete. Store aggregates on one of the following constructed according to standard practice:

- Bituminous concrete base course, 100 mm (4 inches) minimum depth.
- Concrete, 100 mm (4 inches) minimum depth.

(c) Control of Aggregates. Have aggregates available for use in cement concrete at the proportioning plant in enough time before batching to allow inspection and testing. Handle the aggregates so they may be field tested and

accepted, before storing them with previously accepted aggregates. Batch fine and coarse aggregates separately. Properly control uniformity of moisture and uniformity of gradation. Provide a system of water sprays, then use when required, to maintain coarse aggregate moisture control.

(d) Storage of Reinforcement. Satisfactorily store reinforcement above ground, in a clean and dry condition on a platform, in an orderly manner, plainly marked to facilitate inspection.

106.04 HANDLING AND TRANSPORTATION OF MATERIAL—

(a) General. Carefully handle material to preserve quality and fitness for the work and to prevent loss, segregation, or inconsistency in quantities after weighing or measuring for incorporation in the work.

(b) Aggregates. In dry batching operations, measure aggregates or weigh before placing in the compartments of the vehicle, unless otherwise specified or permitted. Clean the vehicles and provide tight batch partitions at least 100 mm (4 inches) higher than the batched aggregate level being hauled, to prevent any spillage from one compartment to another.

(c) Bulk Cement. Bulk cement may be used, as specified in Section 701.

If bulk cement is used, transport to the mixer in acceptable metal, rubber, or plastic, watertight containers or compartments.

(d) Bag Cement. If bag cement is used, dump the contents of the correct number of bags required for each batch into the mixer skip. If permitted, bag cement may be transported from storage to the mixer by placing the correct number of bags per batch on the batched aggregate in the aggregate compartments. When transported, the bag cement may be dumped on the aggregate after having been checked by the inspector, and if done not more than 30 m (100 feet) from the mixer. Bag cement that is allowed to lie on the batched aggregates longer than 2 hours, or cement dumped on the batched aggregate longer than 1 hour, will be rejected.

SECTION 109—MEASUREMENT OF QUANTITIES

109.01 MEASUREMENT—

(a) Units of Measure. Work performed under this contract will be measured in the following units shown in the Measurement and Payment sections of the Specifications and in the Schedule of Prices in the proposal, unless otherwise specified:

- **Lump Sum.** Not measured. Indicates complete construction of the item of work, as specified.
- **Each.** Measured by the number of individual items of work completed.
- **Meter (Linear Foot).** Measured parallel to the longitudinal base or foundation upon which items are placed, or along the longitudinal surface of the item.
- (**M. Linear Feet.** 1,000 Linear Feet, to the nearest 0.01 M. feet.)
- **Vertical Meter (Vertical Foot).** Measured vertically to the nearest 0.01 m (0.1 foot), with a minimum vertical measurement of 0.10 m (1 foot), at each unit.
- **Square Meter (Square Foot, Square Yard).** Measured by a two-dimensional area method on the surface of the item.
- **Cubic Meter (Cubic Yard).** Measured by a three-dimensional volume method.
- **Hectare (Acre).** Measured by a two-dimensional area method on the surface to the nearest 0.05 hectare (0.1 acre)**.**
- **Kilogram (Pound).** Measured by actual item net mass (weight) (avoirdupois).
- **Tonne (Ton).** Measured by actual item net mass (weight in short tons) consisting of 1000 kg (2,000 pounds, avoirdupois).
- **Liter (Gallon).** Measured by actual item liquid volume.
- **1000 Liters (M. Gallon).** Measured by actual item liquid volume consisting of 1000 L (1,000 gallons, to the nearest 0.1 M. gallon).
- (**Foot Board Measure.** Measurement by a three-dimensional method of the actual item lumber board foot.)
- (**M. Feet Board Measure.** 1,000 feet board, to the nearest 0.01 M. feet board.)
- **Set.** Measured as an item unit set, consisting of two or more parts together, as specified.
- **Bag.** Measured as an item unit bag.
- (**Bushel.** Measured by actual item dry measure consisting of 32 quarts.)

(b) General. (Measurement will be according to the system of weights and measures recognized by the Cayman Islands. Method of measurement and computation of quantities will conform to generally recognized engineering and construction practice. Computer generated or electronic digital measuring and computing devices are acceptable methods.

When required, weigh material on accurate, acceptable scales, using competent, qualified personnel at locations designated. Weigh empty trucks used to haul material measured by mass (weight) daily, as directed. Mark each

truck with a distinct, legible identification. Trucks may be selected at random and weighed, as directed, to verify the mass (weight) of material by weighing the truck empty and loaded on other acceptable scales.

Use acceptable vehicles to haul material to be measured by volume at the delivery point. Use acceptable vehicles of any size or type, provided the actual body contents can be readily and accurately determined. Load vehicles to at least their water level capacity. Level the loads at the delivery point.

If requested, material measured by the cubic meter (cubic yard) may be weighed and converted to tonnes (tons), if approved in writing by the Engineer. Factors to be used for conversion from mass (weight) measurement to volume measurement or mass (weight) measurement to area measurement will be determined by the Engineer and agreed to by the Contractor before using this method of measurement.

SECTION 112—PROJECT RECORDS

112.01 SCOPE—This section pertains to all project records that were used to prepare and compute the tender; to prepare all schedules used on the project; to record the progress of work on the project; and to record, compute and/or analyze all costs incurred on the project, including those used in the preparation or presentation of claims to the NRA.

112.02 DEFINITION—Charts, graphs, cross-sections, plans, photographs, schedules, reports, accounting statements, accounting ledgers, balance sheets, tender sheets, take-off sheets, cost estimates, cost records, payroll records, financial documents, notes, memoranda, correspondence, and all other records, whether typewritten, handwritten, computerized, microfilmed, photographed, or recorded, that were prepared by or received by the Contractor.

112.03 RETENTION PERIOD—Retain the aforementioned project records for a period of 3 years from the date of receipt of final payment with the following exception:

• If any litigation, claim, or audit is started before the expiration of the 3-year period, retain the records until all litigations, claims, or audit findings involving the records have been resolved.

112.04 INSPECTION—Upon written notice by the Engineer or an authorized agent acting on behalf of the NRA, make available all requested project records for inspection and copying by NRA personnel or those authorized to act on its behalf. Make such records available at a reasonable time and place.

Refusal or repeated failure to present requested project records for inspection or copying may be considered grounds for declaring the Contractor in default.

SECTION 204—EXCAVATION

204.1 DESCRIPTION—This work is excavation for structures.

204.3 CONSTRUCTION—

(a) Foundations. Excavate to a depth that provides a satisfactory foundation, as directed. Do not disturb the foundation area to the extent that it requires removal of additional material to provide a satisfactory bearing. Do not place concrete or masonry until the foundation area has been accepted.

(b) Drilling and Blasting. Drill and blast to complete the excavation to the required lines, with the least disturbance to remaining material. Do not blast within 1.5 meters (5 feet) of the foundation bearing elevation. Remove remaining rock to bearing elevation using mechanical means.

(e) Backfilling. Backfill spaces excavated for, but not occupied by, structures with plain cement concrete per construction drawings.

204.4 MEASUREMENT AND PAYMENT—Cubic Meter (Cubic Yard)

(a) Excavation Within Established Slope Lines. Excavation quantities will be determined for payment as follows:

1. Plan Quantities. Indicated quantities may be used if the Engineer agrees, in writing, that the project has been constructed as indicated and that the indicated quantities may only be used if the borrow section can be isolated.

2. Measured Quantities. If the plans have been altered by construction changes excavation will be measured. Measurement may also be requested, or the Engineer may require measurement, if there is disagreement as to the accuracy of the indicated quantities. The average end-area method, based on horizontal measurement, will be used to compute quantities. If this method produces considerable error, the Engineer will use any other three-dimensional method that will keep the error to a minimum

SECTION 608—MOBILIZATION

608.1 DESCRIPTION—This work is the assembly and set-up of the general plant required to comply with the contract and with local laws and regulations. General plant includes Contractor's offices, shops, plants, storage areas, and sanitary or other facilities. This work includes obtaining the required permits, insurance, bonds, and any other initial items required for the start of the work.

608.2 MATERIAL—Furnish adequate material and furnishings required. These material and furnishings will not be considered a part of the other completed contract items.

608.3 EQUIPMENT – Furnish adequate equipment of the size and type required to complete the work. This work includes the importation and transportation of the required equipment to the project site. The operating cost of the equipment will be paid as part of the work the equipment is used to complete.

608.4 CONSTRUCTION—Construct the required facilities.

608.5 MEASUREMENT AND PAYMENT—Lump Sum

SECTION 609—ENGINEER'S FIELD OFFICE AND INSPECTION FACILITIES

609.1 DESCRIPTION—This work is furnishing, setting up, maintaining, and removing the indicated field office, field laboratory, and/or proportioning plant office for the exclusive use of NRA personnel.

609.2 MATERIAL—

(a) General. Provide offices and laboratories having the minimum floor space specified, along with all required furnishings, equipment, and materials. Furnish office and laboratory facilities that conform to applicable occupational safety and health regulations, including, but not limited to, those governing sanitation, illumination, ventilation, means of egress, medical services and first aid, and fire protection. Ensure that offices and laboratories have at least 2 m (7-foot) ceilings, locking windows, adequate electric lighting, an adequate number of storage cupboards and closets, a mail slot or drop box, and a private entrance secured with lock and key. Ensure that stairway systems installed for access to offices and laboratories include a handrail and non-skid treads. Provide systems to cool interior spaces, as necessary, to maintain an ambient temperature between 18 ºC and 24 ºC (65F and 75F). Maintain acceptable sanitary toilet facilities near or within offices and laboratories. Ensure that the electric supply service is of sufficient capacity to ensure unrestricted operation of all indicated electronic systems, appliances, and equipment. Furnish documentation certifying that indicated equipment requiring calibration has been calibrated within the last 12 months, and continue to have such equipment recalibrated annually for the duration of the project. If required furnishings and/or equipment being provided have been previously used, ensure that such items are in satisfactory condition and fully functional as of the scheduled start of work. Whenever practical, obtain maintenance agreements for specialized equipment, that provide for on site repair service within 1 working day after notification. If equipment cannot be repaired on site, provide a replacement piece within 2 working days after notification.

1. Inspector's Field Office. Set up the indicated field office in an acceptable weatherproof building or trailer. Situate the field office in an acceptable location on or in the immediate vicinity of the project, separate from other construction offices. For field offices where multiple individual partitioned rooms are indicated, submit a floor plan showing the layout of the interior space for approval. Equip the field office as follows:

Floor space, minimum – 65 m2 (700 sf), out to out
Individual Partitioned Rooms – 3
Conference Table and Chairs – 1 table, 6 chairs
Desks and Chairs – 3 each
Plan Racks – 1
Sanitary Electric Water Cooler - 1
Work Tables – 1, minimum size: 760 mm x 2100 mm x 760 mm (2 1/2 feet by 7 feet by 2 1/2 feet) high
Printer Stand(s) –3, specifically designed to accommodate laser and dot matrix printers, with paper storage/feeder tray and paper feed slot. Minimum size: 457 mm x 457 mm x760 mm (18 inches by 18 inches by 2 1/2 feet) high
4-Drawer File Cabinet 2, Fire resistant (D-Label), lockable, metal file cabinet.
2-Drawer File Cabinet 2, Fire resistant (D-Label), lockable, metal file cabinet
Phone Line(s) – 2
Telephone(s) w/ Answering Machine(s) or Voice Mail - 2
Copier – 1
Fax Machine – 1
Digital Camera – 1
Document Scanner – 1
Laser Printer – 1
Color Printer – 1
Surveyor's Level & Measuring Rod – 1
Digital Display Level – 1

Electronic Digitizer– 1
Infrared Thermometer– 1
Non-Destructive Compressive Strength Tester – 1

Unless otherwise approved, a multifunction machine may not be furnished in lieu of a separate copier, fax, printer, and/or document scanner.

2. Field Laboratory. If indicated, provide a laboratory for materials and soils testing. Set up the indicated field laboratory in an acceptable weatherproof building or trailer situated in an acceptable location. Supply a gravity or pressure water system having at least a 400 L (100-gallon) capacity and connected to a service sink with a faucet and acceptable outside drain. Equip the field laboratory as directed by the Engineer**.**

On projects where cement concrete is to be used, furnish and maintain the equipment specified in Section 704.2(a).

(b) Fax Machine. A high-speed desktop facsimile machine capable of transmitting and receiving copies of standard, 216 mm x 279 mm (8 1/2-inch by 11-inch) printed material, pictures, etc. over a standard telephone line.

(c) Digital Camera. A minimum 6-megapixel image resolution digital camera having 6X combined zoom (2X optical, 3X digital) and 2 GB internal memory/removable memory card. JPEG file format. Image quality best up to 127 mm x 178 mm (5 inches by 7 inches). Include batteries, USB, 2 GB backup Compact Flash or Smart Media memory card, and all other operating essentials.

(d) Document Scanner. A flatbed, color scanner having, at a minimum, an optical resolution of 600 x 1200 dpi, a 42-bit color rate, a parallel port or USB interface, text scanning and image editing software, and an external start button. Software provided must support TIFF Group 4-2D and JPEG file formats.

(e) Copier. A digital laser copier having reduction/enlargement functions and capable of accepting maximum 279 mm x 432 mm (11-inch by 17-inch) size originals and producing 279 mm x 432 mm (11-inch by 17-inch) size copies at a minimum rate of 10 letter-size copies per minute. Include sufficient imaging cartridges (toner/drum/developer) to yield a minimum of 5000 copied pages.

(f) Internet Service. Purchase a subscription to an Internet service, for exclusive use by NRA personnel, for the duration of the project. Choose a local service that provides broadband service. Ensure that the subscription package allows for the exchange of electronic mail and includes some means of securing access to the account (e.g., password protection) by at least four different users. If not provided as part of the service, furnish a compatible Internet browser. Demonstrate connectivity with the Internet Service Provider at the time of system installation.

(g) Surveyor's Level and Measuring Rod. A standard, waterproof, surveyor's leveling instrument having, as a minimum, 20x magnification and a sighting range of up to 61 mm (200 feet); with a job accuracy range within 6.4 mm (1/4 inch) at 23.0 m (75 feet). Include a 7.6 m (25-foot) minimum, fiberglass measuring rod, folding leg tripod, rain cover, and carrying case.

(h) Electronic Digitizer. A stationary or portable, high performance digitizer system capable of electronically measuring the exact, net area and perimeter of linear shapes on plan drawings at any scale, in both English and Metric units, and converting those measurements to areas and volumes. Furnish electronic digitizer having a tablet with a minimum 559 mm x 914 mm (22-inch by 36-inch) active area. Include necessary cabling, carrying case, and all other operating essentials.

(i) Digital Display Level. A durable level, a minimum of 1.2 m (4 feet) in length with automatic calibration function, that reads angles with precision and digitally displays readings in degrees, percent slope, and pitch to within 1/10 degree accuracy. Include battery(ies).

(j) Infrared Thermometer. A hand-held, portable, non-contact thermometer capable of measuring temperatures between –20 °C and 250 °C (–4F and 482F) and with a field of view (i.e., spot ratio) of at least 6:1. Include protective case, battery(ies) and all other operating essentials.

(k) Non-Destructive Compressive Strength Tester. An instrument designed to measure the compressive strength of "in cure" and hardened concrete, on site, by using a driving unit and power loads to fire a hardened steel alloy probe into the concrete and correlating the depth of penetration to a compressive strength. Instrument must be capable of measuring concrete strengths up to 51.8 MPa (7,500 pounds per square inch). Include driver unit, electronic depth gauge, probe templates, other related equipment, and enough probes and power loads to perform a total of 25 complete tests.

(l) Consumables

Provide printer copier and fax paper, sufficient for the life of the project, conforming to the following requirements:

- 8 1/2-inch x 11-inch and 8 1/2-inch x 14-inch, 20# white bond paper.
  - All paper becomes NRA property.
- Provide 10, 8 1/2-inch x 11-inch and 14 7/8-inch x 11-inch, and 10, 8 1/2-inch x 11-inch and 8 1/2-inch x 14-inch pressboard or plastic computer paper binders with locking plastic strips as required. All binders become NRA property.
- Provide 12, 3-inch D-Ring, three ring binders, with vinyl covers and having dimensions of 8 1/2-inch x 11-inch. All binders become NRA property.

609.3 CONSTRUCTION—Install the indicated facilities no later than 3 working days after the Notice to Proceed Date. Anchor the facilities to withstand high winds. Maintain the facilities from installation until 30 days after physical work has been satisfactorily completed, unless released earlier by the Engineer. Satisfactorily clean or arrange for the indicated facilities to be cleaned at least once per week. Provide an adequate number of accessible parking spaces immediately adjacent or in close proximity to the offices or laboratory for exclusive use by NRA personnel. Provide proper maintenance of parking areas. Ensure that there is sufficient lighting to illuminate the exterior of offices or laboratory and all parking areas. Designate a specific individual to serve as the contact person for service-related problems. After physical work has been completed, but before release by the Engineer, arrange to meet with the Inspector-in-Charge to examine and determine the condition of all specialized equipment that is contractor-owned. Report any unresolved disputes over the condition of such equipment to the Engineer. Failure to meet with the Inspector-in-Charge or to report problems with the condition of specialized equipment will create a presumption that, except for expected wear resulting from normal usage, the equipment is in good condition and remains fully functional. Specialized equipment that is lost or determined to be damaged beyond repair will be replaced or reimbursement will be made, provided such loss or damage is not the result of carelessness or negligence on the part of the Contractor or any other responsible third party. The Engineer may direct that the facilities be maintained for more than 30 days after physical work has been satisfactorily completed, as necessary, to allow time for NRA personnel to process outstanding project records. Remove and dispose of furnishings, equipment, and materials upon release by the Engineer.

609.4 MEASUREMENT AND PAYMENT—Lump Sum
The NRA will pay for the inspector's field office and inspection facilities, in two equal payments, according to the following schedule:

- When work is completed in an amount equivalent to at least 10% of the original contract amount, excluding the bid price for this item, the NRA will make the first payment.

- When work is completed in an amount equivalent to at least 60% of the original contract amount, excluding the bid price for this item, the NRA will make the second payment.

(a) Price Adjustments. The NRA will make adjustments to the lump sum price bid for the indicated facilities, if applicable, as follows:

1. Time Extensions and Reductions. In the event the time for completion of all contract work is adjusted and a time extension or reduction has been issued, in writing, the NRA will make an appropriate adjustment (payment to the Contractor or rebate to the NRA) to the lump sum price bid for the indicated facilities, as applicable, for the days in excess of or less than the original contract time respectively, at the following daily rate:

$$\text{Daily Price Adjustment Rate} = \frac{0.75 \times \text{Contract Lump Sum Price}}{\text{Original Contract Time in Days}}$$

2. Facilities Maintained for More than 30 Days After Physical Work Completion. In the event the Engineer directs that the facilities be maintained for more than 30 days after the date of physical work completion, as specified in Section 609.3, the NRA will make an appropriate adjustment (payment to the Contractor) to the lump sum price bid for the indicated facilities, as applicable, for the days in excess of 30 until release by the Engineer, according to the Daily Price Adjustment Rate specified in Section 609.4(a)1. The NRA will not make an adjustment if the Engineer directs that the facilities be maintained for more than 30 days after the date of physical work completion due to the Contractor's failure to submit, complete, and/or correct required certificates or documents, as established during the final inspection.

SECTION 686—CONSTRUCTION SURVEYING

686.1 DESCRIPTION—This work is construction surveying for structures. This work is to preserve vertical and horizontal controls, and stationing throughout the construction phase up to and including final inspection, and to provide the NRA inspection force with surveying control points to ensure quality of construction activities.

Construction surveying is classified as follows:

(a) Construction Surveying. Surveying for new construction based on precise horizontal and vertical geometry established from surveys and 1:250 (25) scale or 1:500 (50) scale topographic mapping referenced to the North American Datum Geodetic Reference System of 1927

686.2 MATERIAL—

(a) Tack. Standard Engineer's tack.

(b) Stake. Planed hardwood, 450 mm (18 inches).

(c) Hub. Planed hardwood, 450 mm (18 inches).

(d) Nail. Metal, 10 pennyweight.

(e) Guard Stake. Stake, 450 mm (18 inches), with space to identify the point guarded.

(f) Grade Point. Hub with Engineer's tack; or 60-pennyweight spike.

(g) Reference for Bridge. Hub with Engineer's tack, or iron pin with work center punch.

(h) Paint. Latex, yellow, orange, or white.

(i) Flat. Planed hardwood, 900 mm (36 inches).

(j) PK Nail. Hardened masonry nail.

(k) Flagging. Vinyl material.

(l) Benchmark Discs. Furnished by the NRA.

686.3 CONSTRUCTION—

(a) General. The NRA will provide all pertinent survey information at the preconstruction conference.

Do not begin construction surveying until on or after the Notice to Proceed date. Upon completion of the survey work, return all survey information to the Engineer.

The wall alignment will be established during project design. If there is an extensive time lapse between the design phase and the beginning of work, the Engineer will refurbish the alignment by marking and placing new guard stakes at the pre-established control points.

The Contractor is responsible for verifying the alignment, grades, elevations, and dimensions indicated.

The Contractor is responsible for documenting any design error. Immediately notify the Engineer of any error, omission, or discrepancy upon discovery.

Provide all construction surveying services, material, and equipment needed to stake, mark, reference, and monitor the project. Provide the Engineer with any assistance requested for verification of lines, grades, widths, elevations, and measurements or for QA verification. Record geometric or coordinate ties on all lines produced.

Assume full responsibility for dimensions and elevations taken from control stakes and for the setting of structure location and line and grade stakes.

(b) Construction Surveying. The centerline of the wall alignment will be established, on the ground, at major control points. The maximum interval between referenced major control points will not exceed 300 m (1,000 feet). All major control points will be referenced and vertical benchmarks will be established at appropriate locations.

The Contractor is responsible for the construction stakeout of the project, using the horizontal and vertical control established by the NRA.

The Contractor is responsible for relocation and/or preservation of all horizontal references of major control points and vertical benchmarks established by the NRA.

Provide the Engineer with a comprehensive stakeout schedule for development of the project.

The Contractor is responsible for staking the plan alignments and grade points for temporary construction easements and temporary roadways.

The Contractor is responsible for staking gazetted property lines and temporary easement lines if required.

Provide the Engineer with all coordinate networks used in staking the project, including coordinate geometry, horizontal geometry, and referenced network points.

686.4 MEASUREMENT AND PAYMENT—

(a) Construction Surveying. Lump Sum
For the type indicated.
The NRA will pay for this item, in four payments, according to the following schedule:

- When work representing 10% of the total contract price is completed, excluding the bid price for this item, the NRA will pay 25% of the amount bid for this item.
- When work representing 30% of the total contract price is completed, excluding the bid price for this item, the NRA will pay 25% of the amount bid for this item.
- When work representing 90% of the total contract price is completed, excluding the bid price for this item, the NRA will pay 20% of the amount bid for this item.
- Upon completion of the project, the NRA will pay the remaining 30% of the amount bid for this item.

(b) Unidentified Work. The NRA will pay for unidentified work as follows:

1. Negotiated Price. At an agreed upon price. The NRA and the Contractor will agree upon this price before performing the work.

SECTION 700
MATERIAL

SECTION 701—CEMENT

701.1 GENERAL—Do not use retrieved or reclaimed cement. Do not use cement with a material temperature exceeding 65 ºC (150F) at the time of delivery to the plant.

(a) Handling and Transportation. Section 106.06 and as follows:

For each shipment to the project, furnish two copies of the vendor's bill of lading. Include one copy with the shipment to the project; the vendor shall retain the other copy. Use a form acceptable to the Engineer that contains the following information:

- Statement that material has been tested and conforms to NRA specifications.
- Type of material
- Silo number
- Company lot identification
- Date of shipment
- Producer's name and location
- Consignee's name and location
- Temperature of cement
- Trailer number
- Quantity (tonnes (tons))
- Alkali content (%)—determined according to AASHTO T 105.

Ship bulk cement in clean, acceptable, metal, rubber, or plastic waterproof containers or compartments. Ship bagged cement (42.6 kg (94 pounds) net per bag) in suitable paper bags with the brand, type, and manufacturer's name printed on them. Protect cement bags from the weather. Reject cement bags with net mass (weight) more than 3% below that specified.

(b) Storage. Section 106.05 and as follows:

- Provide storage capacity sufficient to maintain the project construction schedule.
- Store bulk cement in acceptable silos.
- Store bagged cement in enclosed buildings.
- Store bagged cement in stacks not exceeding eight bags in height and cover.

(c) Chemical and Physical Requirements and Testing. AASHTO M 85 and AASHTO M 240.

(d) Limited Number of Sources. Obtain cement for each project from a single source, unless otherwise allowed by the Engineer in writing. If using more than one source, separate cement of different types and from different sources. Use each type and source in continuous, segregated portions of the project. If possible, limit cement used in an individual structure to a single type and source.

SECTION 703—AGGREGATE

703.1 FINE AGGREGATE—

(a) General. Fine aggregate is natural or manufactured sand consisting of hard, durable, and uncoated inert particles reasonably free from clay, silt, vegetation, and other deleterious substances such as reactive chert, gypsum, iron sulfide, amorphous silica, and hydrated iron oxide. Substances that are present in amounts large enough to cause inconsistent performance in the properties of bituminous concrete or plastic or hardened Portland cement concrete are considered deleterious. Spent foundry sand may be used as fine aggregate in asphalt concrete and flowable fill.

Obtain fine aggregate with physical properties conforming to Table A.

1. Natural Sand. Natural sand is fine aggregate resulting from glacial or water action. Fine aggregate produced simultaneously with gravel coarse aggregate may contain crushed particles.

2. Manufactured Sand. Manufactured sand is fine aggregate from the controlled mechanical breakdown of rock, air-cooled blast furnace slag, or air-cooled steel slag into sound, approximately cubical particles. The NRA will accept manufactured sand only if it is the primary product of the crushing operation and sized by a sand classifier.

Fine aggregate manufactured from steel slag may not be used in cement concrete or mortar mixtures.

The NRA will evaluate the quality of fine aggregates by conducting petrographic analysis according to ASTM C 295 and other tests necessary to demonstrate that required construction of acceptable durability can be achieved.

(b) Grading and Quality Requirements.

1. Gradation. Table A lists the extreme limits for determining the suitability of supply sources.

Control the grading of Type A Fine Aggregate so that the fineness modulus of at least nine out of ten consecutive test samples from a single source delivered to a project or plant varies less than ± 0.20 from the average fineness modulus of the consecutive test samples.

2. Material Finer than the 75 µm (No. 200) Sieve. Determine the loss by washing according to AASHTO T-11.

3. Minimum Strength Ratio. AASHTO T 21. If color No. 5 or darker results, determine the minimum strength ratio according to AASHTO T 71.

4. Soundness Test. Determine the percentage of mass (weight) loss after five cycles of immersion and drying using a sodium sulfate solution according to AASHTO T 104.

TABLE A
Fine Aggregate
Grading and Quality Requirements

	Cement Concrete Sand
Sieve Size	**Type A**
9.5 mm (3/8-inch)	100
4.75 mm (No. 4)	95-100
2.36 mm (No. 8)	70-100
1.18 mm (No. 16)	45-85
600 µm (No. 30)	25-65
300 µm (No. 50)	10-30

150 µm (No. 100)	0-10
75 µm (No. 200)	—
Material Finer Than 75 µm (No. 200) Sieve Max. Percent Passing	3
Strength Ratio Min. Percent	95
Soundness Test Max. Loss Percent	10
Fineness Modulus	2.30-3.15

703.2 COARSE AGGREGATE—

(a) General. Coarse aggregate consists of hard, tough, durable, and uncoated inert particles reasonably free from clay, silt, vegetation, and other deleterious substances such as reactive chert, gypsum, iron sulfide, amorphous silica, and hydrated iron oxide. Substances that are present in amounts large enough to cause inconsistent performance in the properties of bituminous concrete or plastic or hardened Portland cement concrete are considered deleterious.

The Engineer will evaluate the quality of coarse aggregates by conducting petrographic analysis according to ASTM C 295 and other tests necessary to demonstrate that required construction of acceptable durability can be achieved.

Furnish coarse aggregate crushed and prepared from one of the materials described below with physical properties conforming to Tables B, C, and D. Obtain coarse aggregate from a source approved by the Engineer before use.

1. Stone. Durable stone free from slate texture or cleavage planes.

2. Gravel. Durable gravel particles. For use in cement concrete, wash thoroughly during production. For all Type A use, the maximum allowable absorption determined according to AASHTO T 85 is 3.0%; however, this restriction does not apply to dredged river gravel used in Portland cement concrete. For all Type B use, the maximum allowable absorption determined according to AASHTO T 85 is 3.5%.

3. Blast Furnace Slag. By-product of a pig-iron making process. Tough, hard, and durable pieces of air-cooled blast furnace slag. Blast furnace slag is excluded from the abrasion requirements. The density (unit weight) of blast furnace slag cannot be less than 1120 kg/m3 (70 pounds per cubic foot).

TABLE B
Coarse Aggregate
Quality Requirements

	Type A	Type B	Type C
Soundness, Max. %	10	12	20
Abrasion, Max. %	45******	45******	55******
Thin and Elongated Pieces, Max. %	15	20	—
Material Finer Than 75 µm (No. 200) Sieve, Max. %	*	*	10
Crushed Fragments, Min. %	55**	55**	50
Compact Density (Unit Weight), Min. kg/m3 (lbs./cu. ft.)	1100 (70)	1100 (70)	1100 (70)
Deleterious Shale, Max. %	2	2	10

Clay Lumps, Max. %	0.25	0.25	3
Friable Particles, Max. % (excluding shale)	1.0	1.0	—
Coal or Coke, Max. %	1	1	5
Glassy Particles, Max. %	4 or 10***	4 or 10***	—
Iron, Max. %	3*****	3*****	3*****
Absorption, Max. %	3.0****	3.5****	—
Total of Deleterious Shale, Clay Lumps, Friable Particles, Coal, or Coke Allowed, Max. %	2	2	15

* See Section 703.2(c)4.
** See Section 703.2(a)2.
*** See Section 703.2(c)10.
**** Gravel only. See Section 703.2(a)2.
***** See Section 703.2(c)11.
****** Blast Furnace Slag excluded. See Section 703.2(a)3.

2. Testing and Documentation. During production, provide the necessary incidental equipment to conduct and document the specified tests.

Perform soundness and abrasion tests at intervals sufficient to ensure the quality of the material. The soundness and abrasion tests may be performed by the producer, a laboratory accredited by the AMRL, or other inspection agency approved by the NRA.

Document the results of tests made during production and make them available to the NRA upon request.

(b) Quality Requirements. The following notes are applicable to Table B.

1. Soundness. Determine the percentage of mass (weight) loss after five cycles of immersion and drying using a sodium sulfate solution. AASHTO T-10. The NRA may accept aggregate failing the test if it can be demonstrated in writing that the aggregate has a satisfactory service record in structures. Acceptable aggregate produced from recycled concrete need not conform to soundness requirements since cementitious material cannot be evaluated with this test.

2. Abrasion. Determine the percentage of mass (weight) loss according to AASHTO T 96.

3. Thin and Elongated Particles. When directed, determine the percentage of particles retained on the 9.5 mm (3/8-inch) sieve that have a ratio greater than 1:5 (5:1) between the maximum and minimum dimensions of an imaginary enclosing rectangular prism. If the material retained on the 9.5 mm (3/8-inch) sieve constitutes less than 5.0% of the total mass (weight) of the test sample, do not determine the percentage of thin and elongated particles.

TABLE C
Size and Grading Requirements for Coarse Aggregates
(Based on Laboratory Sieve Tests, Square Openings)

	Total Percent Passing													
AASHTO Number	**100 mm (4")**	**90 mm (3 1/2")**	**63 mm (2 1/2")**	**50 mm (2")**	**37.5 mm (1 1/2")**	**25.0 mm (1")**	**19.0 mm (3/4")**	**12.5 mm (1/2")**	**9.5 mm (3/8")**	**4.75 mm (No. 4)**	**2.36 mm (No. 8)**	**1.18 mm (No. 16)**	**150 µm (No. 100)**	**75 µm (No. 200) *****
1	100	90-100	25-60		0-15		0-5							
3			100	90-100	35-70	0-15		0-5						
467				100	95-100		35-70		10-30	0-5				
5					100	90-100	20-55	0-10	0-5					
57					100	95-100		25-60		0-10	0-5			
67						100	90-100		20-55	0-10	0-5			
7							100	90-100	40-70	0-15	0-5			
8									85-100	10-30	0-10	0-5		
10									100	85-100			10-30	

*** For 75 µm (No. 200), see Table D.
Note A: A combination of No. 7 and No. 5 may be substituted for No. 57, provided that not more than 50% or less than 30% of the combination is No. 7 size.

4. Material Finer than the 75 µm (No. 200) Sieve. Determine the loss by washing according to AASHTO T11 and Table D.

TABLE D
Material Passing the 75 µm (No. 200) Sieve —
(Based on Laboratory Sieve Tests, Square Openings)

Section	Specification %	Maximum
704	Cement Concrete	1
—	All other uses	2

5. Crushed Fragments. ASTM D 5821

6. Compact Density. AASHTO T 19, for slag.

7. Coal or Coke. Determine the percentage of mass (weight) by visual identification and hand separation. If required, the Engineer will use petrographic analysis to confirm the results.

8. Glassy Particles. Determine the percentage of mass (weight) by visual identification and hand separation. Pieces of slag containing more than 50% glass are considered to be glassy particles. Waste glass is also considered to be glassy particles. For coarse aggregate used in cement concrete, the maximum percentage of glassy particles allowed is 4%. For other uses, the maximum percentage of glassy particles allowed is 10%. Coarse aggregate containing glassy particles consisting of waste glass may not be used in cement concrete or bituminous wearing courses.

9. Metallic Iron. The Engineer will use petrographic analysis to determine the content of metallic iron. Pieces of slag containing metallic iron are considered to be metallic iron. This requirement is waived when aggregate with metallic iron is used in bituminous mixtures or subbase.

10. Clay Lumps. Determine the percentage of mass (weight) by visual identification and hand separation. If required, the Engineer will use petrographic analysis to confirm the results.

SECTION 704—CEMENT CONCRETE

704.1 GENERAL—

(a) Description. Cement concrete is a mixture of Portland cement, fine aggregate, coarse aggregate, water and air-entraining admixture, with or without water reducing admixture, retarding admixture, or pozzolan.

The methods of producing concrete referred to in these Specifications are defined as follows:

1. Plant Mixed Cement Concrete. Concrete proportioned and mixed in either a stationary, commercial, and central plant or a stationary plant located near the project. Concrete is delivered to the work site by truck, agitator truck, or mixer truck.

2. Truck Mixed Cement Concrete. Concrete prepared by dry batching in a proportioning plant and placing the dry ingredients in a truck mixer. Measured water is then added to the truck drum from the plant water system and the concrete is mixed in the truck at the plant. Mixing is not allowed en-route to or at the work site.

3. Volumetric Mixed Cement Concrete. Concrete proportioned and mixed in a truck-mounted mobile mixer. The unit is capable of proportioning concrete ingredients from self-contained bins and mixing the materials with measured water in a self-contained mixer. The concrete is mixed and discharged at the work site.

(b) Material.

- Cement—Section 701
- Fine Aggregate, Type A—Section 703.1
- Coarse Aggregate, Type A, No. 57, (Stone, Gravel, or Slag)—Section 703.2
- Water—Section 720.1
- Admixtures—Section 711.3
- Pozzolan—Section 724

(c) Minimum Compressive Strength. Provide a cement concrete mixture capable of attaining a minimum 28 day compressive strength of 5000 psi

1. Density of Material. Except for admixtures, use the following material densities (unit weights) when proportioning cement concrete:

Type of Material	**Density**
Water	1000 kg/m$_3$ (62.4 pounds per cubic foot)
Cement	1510 kg/m$_3$ (94.0 pounds per cubic foot)
Fine Aggregate	Based on bulk specific gravity as specified in Section 704.1(b)2
Coarse Aggregate	
Stone or Gravel	Based on bulk specific gravity as specified in Section 704.1(b)2
Slag	Based on field tests as specified in Section 704.1(b)2
Pozzolan	Based on the NRA Tests

2. Specific Gravity of Aggregates. For fine and coarse aggregates, use the bulk specific gravity (saturated, surface-dry basis) determined by testing.

If slag is used, test at the site to determine its loose-struck density (unit weight), solid volume per cubic meter (cubic yard), and bulk specific gravity factor (saturated surface-dry basis). Establish the concrete proportions on the basis of the bulk specific gravity factor determined by the test. Check the density (unit weight) of the slag daily to maintain the established solid-volume proportions.

3. Adjustment of Mass (Weight) of Free Water. Adjust the batch mass (weight) of the aggregate to compensate for the free water on the aggregate. Base this adjustment on tests of representative samples taken from aggregate stockpiles.

4. Batching. For plant and truck mixed cement concrete, batch by mass (weight). For volumetric mixed cement concrete, batch by volume.

(d) Design Basis.

1. General. Compute and prepare concrete mix designs according to PCA Design and Control of Concrete Mixtures. Base concrete mix designs on the materials to be used in the work.

Make trial mixtures for each class of concrete and mold and cure test specimens. If the requirements of Section 704.1 (c) cannot be achieved, furnish other acceptable materials or make necessary changes in the mixing procedure to conform to the specified requirements.

At the start of construction, mix a full-sized batch using the type of mixer and the mixing procedure planned for the project. Use this batch to provide the basis for final adjustment of the accepted design.

2. Cement Factor. Use the minimum cement factor (cement or cement and pozzolan combined), except as follows:

Portland cement may be replaced with pozzolan (flyash or ground granulated blast furnace slag) weighing as much as or more than the Portland cement replaced. If pozzolan is used, do not place flyash and ground granulated blast furnace slag in the same mix. The maximum limit of the cement factor may be waived if pozzolan is added to the mix provided the Portland cement portion does not exceed the maximum cement factor specified. If flyash is used, the Portland cement portion may be reduced by a maximum of 15%. If ground granulated blast furnace slag is used, the Portland cement portion may be reduced by a minimum of 25% to a maximum of 50%.

3. Air Content. Design cement concrete to have an air content of 6.0% in the plastic state. Obtain the air content through the addition of a solution of an air-entraining admixture as specified in Section 704.1(e)4. Use the quantity of air-entraining admixture necessary to maintain the plastic concrete air content, determined according to AASHTO T 152 for stone and gravel and AASHTO T 196 for slag coarse aggregate, within a tolerance of ± 1.5% during the work. The plastic concrete air content includes entrapped and entrained air.

If the hardened concrete exhibits deficiencies or the Engineer suspects the hardened concrete to have deficiencies, and, if directed, determine the percent of entrained air in the hardened concrete according to ASTM C 457. Voids 1 mm (40 mils) or more in size are considered entrapped air and voids less than 1 mm (40 mils) in size are considered entrained air. The entrained air in the hardened concrete must be between 3.5% and 8.0%, inclusive.

4. Mix Design Acceptance. Submit a copy of each completed mix design to the Engineer before its use in the work. The NRA reserves the right to review any design through plant production before its use in NRA work at no additional cost to the NRA. The concrete design submitted for review is required to comply with the specified concrete class requirements, supported by slump, air content, and compressive strength test data.

The NRA will accept concrete designs on the basis of the 7-day strength tests (Class high early strength (HES) may be accepted on the basis of 3-day strength tests); however, conduct 28-day tests to show the potential of the design mix. The NRA may also accept designs based on the 28-day tests.

A higher class concrete may be used in place of an indicated lower class concrete if the higher class concrete conforms to all of the requirements of the indicated lower class, and if approved by the NRA.

(e) Testing and Acceptance.

1. QC Plan. Prepare a QC Plan and submit it for review before the start of the project. Include in the QC Plan testing frequencies and action points to initiate corrective measures. Do not start work until the NRA has reviewed the QC Plan. Furnish a copy of the QC Plan to be maintained in the NRA's project field office.

2. Concrete Technician. Provide, and assign to the work, a concrete technician properly instructed and trained to develop the concrete design, to control the quality and gradation of aggregates used, to perform required concrete tests, and to control the operations and concrete deliveries so that the completed mixture conforms to the specifications at the point of placement.

The NRA's concrete plant Inspector will not allow concrete that is considered unacceptable to be shipped to the project. The Inspector will not assume, by act or by word, any responsibility for batch control adjustments; calculations; or for setting of any dials, gauges, scales, or meters. Failure of the Inspector to reject unacceptable concrete will not relieve the Contractor's obligation to provide concrete conforming to the specifications.

2.a Concrete Field Testing Technician – Grade I. Provide, and assign to the work, an ACI certified field testing technician during placement of material to perform the required acceptance testing.

3. Testing Facilities and Equipment. Provide sufficient thermometers, air meters (AASHTO T 196 and T 152) and slump cones (AASHTO T 119) for each separate project operation as needed. Have back-up equipment available to ensure that no tests are missed. Provide sufficient 150 mm x 300 mm (6-inch by 12-inch) cylinder molds and tight-fitting domed caps (AASHTO T 23 and AASHTO T 231) for QC, acceptance, verification, and QA samples. Provide sufficient incidental equipment such as wheelbarrows, shovels, and scoops as needed.

Provide acceptable means to conduct compressive strength testing using a compression machine and capping device conforming to AASHTO T 22. Provide a curing tank conforming to AASHTO T 23 and AASHTO T 231. Provide curing boxes, or other acceptable equipment, conforming to AASHTO T 23 and AASHTO T 231. Provide sufficient high-low thermometers or other temperature recording devices to monitor the temperatures next to the test cylinders. If required, cap cylinders at the testing site under the Engineer's supervision.

Maintain all equipment used for testing in an operable condition. Using an independent agency acceptable to the NRA, calibrate scales, balances, and the compression machine at least once per year. Re-calibrate the compression machine whenever it is relocated. Maintain accurate records of calibration. If the compression machine is out of tolerance or malfunctions, return it to working order within 24 hours or supply a back-up machine until the problem is corrected.

Provide the necessary facilities for inspection.

4. QC Testing. Perform QC testing according to the reviewed QC Plan and as follows:

4.a QC Sampling and Testing of Plastic Concrete. Select an appropriate slump value that will provide a workable mix for the construction element. Do not exceed the following slump upper limits:

Type of Mix	**Slump Upper Limit**
without water reducing admixtures	125 mm (5 inches)
with water reducing admixtures	165 mm (6 1/2 inches)
with high range water reducing admixtures (superplasticizers)	200 mm (8 inches)
mixes specified in Section 704.1(h) (except tremie concrete as specified in Section 1001.2(j))	63 mm (2 1/2 inches)

Perform plastic concrete air and slump tests on a minimum of three consecutive trucks at the beginning of concrete placement operations to determine if material control has been established. Perform slump tests according to AASHTO T 119 and air content tests according to AASHTO T 152 or T 196. Report test data to the concrete technician promptly in order to facilitate necessary changes. Continue testing consecutive trucks until the consistency of the concrete mix is established. Once material control is established, the frequency of testing may be reduced to a minimum of one test per 40 m^3 (50 cubic yards). Select concrete batches for sampling according to the reviewed QC Plan or as directed by the Engineer. Notify the Engineer when sampling and QC testing are to be performed. The Engineer will witness the sampling and QC testing. If a QC test fails to conform to the specified requirements or exceeds the upper or lower action points included in the reviewed QC Plan, increase the testing frequency to every truck until material consistency has been reestablished.

Maintain the cement concrete consistency within 40 mm (1 1/2 inches) of the selected slump value. If the upper slump limit is exceeded on any slump test, the Contractor's technician shall reject the cement concrete. If the initial slump test result falls outside the selected range and has not exceeded the upper limit, immediately perform the air content test. If the air content is within the specified limits, the Contractor may incorporate the material into the work provided two cylinders are molded for compressive strength testing according to AASHTO T 23 and AASHTO T 231 and AASHTO T 22. These cylinders will become the acceptance cylinders and will represent the lot for payment. If more than one truckload of cement concrete exceeds the target slump range, make cylinders from each truck and use the lowest compressive strength cylinders for acceptance. In addition, take one 100 mm (4-inch) core from the hardened concrete and conduct permeability testing according to AASHTO T 277 for informational purposes.

Do not incorporate any concrete into the work that does not conform to the specified requirements.

4.b QC Compressive Strength Test Cylinders. From the same sample of concrete selected for acceptance testing as specified in Section 704.1(d)5, mold a sufficient number of concrete QC cylinders to be tested for 3-day or 7-day compressive strength, 28-day compressive strength, form removal strength, and loading strengths, as specified.

Field cure cylinders according to AASHTO T 23 and AASHTO T 231, for the specified curing period. After concrete curing is discontinued, QC cylinders may be relocated to a pre-approved, acceptable, secure area, to protect them from damage. Provide maintenance and security for the area at no additional cost to the NRA. The secure area must be easily accessible for inspection at all times. Continue to provide the same field cure and protection from the elements on all surfaces of the cylinders as that provided for the in-place concrete the cylinders represent until the cylinders are tested for compressive strength. Remove cylinders from molds at the same time formwork is removed.

Perform QC testing for 3-day or 7-day compressive strength, 28-day compressive strength, and form removal and loading strengths according to AASHTO T 23 and AASHTO T 231. Notify the Engineer when QC testing is to be performed. The Engineer will witness the QC testing.

Unless otherwise directed, use QC test results for 3-day or 7-day compressive strength and form removal and loading compressive strength to determine whether to place additional concrete in areas that will be impacted by the lot of concrete represented by the QC cylinders. Acceptable QC compressive strength test results do not relieve the Contractor's responsibility for providing concrete conforming to the 28-day minimum mix design compressive strength acceptance requirements specified in Section 704.1(d)5.

4.b.1 3-Day or 7-Day QC Compressive Strength. If the 3-day (HES concrete only) or 7-day QC compressive strength test result is greater than or equal to the minimum mix design compressive strength requirement specified in Section 704.1 (c) , the Contractor may discontinue the field cure on the lot of concrete represented by the QC cylinders unless otherwise directed.

If the 3-day (HES concrete only) or 7-day QC compressive strength test result is less than the minimum mix design compressive strength requirement specified in Section 704.1 (c) , continue the field cure on the lot of concrete represented by the QC cylinders until the specified 28-day minimum mix design compressive strength is obtained, or for a maximum of 28 days.

4.b.2 28-Day QC Compressive Strength. If the 28-day QC compressive strength test result is greater than or equal to the 28-day minimum mix design compressive strength specified in Section 704.1 (c) , acceptance of the concrete lot will be based on the compressive strength testing of acceptance cylinders as specified in Section 704.1(d)5.

If the 28-day QC compressive strength test result is less than the 28-day minimum mix design compressive strength specified in Section 704.1 (c), but greater than or equal to the 28-day structural design compressive strength specified in Section 704.1 (c), acceptance of the concrete lot will be based on the compressive strength testing of acceptance cylinders as specified in Section 704.1(d)5, and as follows:

- Perform an investigation of procedures for material sampling, testing, and concrete cylinder molding and curing, and evaluate the concrete mix design and specification compliance to determine possible causes for the QC test result not meeting the specified minimum mix design compressive strength.

• Implement corrective actions as required or as directed by the Engineer including the removal and replacement of said concrete at no additional charge to the NRA.

• Submit an investigation report to the Engineer within ten working days for review and approval.

If the 28-day QC compressive strength test result is less than the 28-day structural design compressive strength specified in Section 704.1 (c), acceptance of the concrete lot will be based on compressive strength testing of cores obtained from the lot of concrete represented by the QC cylinders.

5. Acceptance Testing. Determine the lot size, or portion thereof for partial lots, for material acceptance according to Table B. Establish new lots daily for each class of concrete. Lots must be specific to a particular structural element, except for incidental concrete items. The Contractor may use a lot combining structural elements if allowed in writing before concrete placement and if the following conditions are met:

• The total volume is 80 m^3 (100 cubic yards) or less.

• The combined structural elements are constructed using the same mix design concrete.

• The combined structural elements are cured using identical curing methods and conditions.

Cylinders (and cores when necessary) for this lot will represent all of the combined elements.

TABLE B
Lot Size for Concrete Acceptance

Construction Area	Lot Size
Structural Concrete	80 m^3 (100 cu. yd.)
Incidental Concrete	80 m^3 (100 cu. yd.)

The Engineer will select sample locations for acceptance testing. Perform sampling and testing for acceptance in the presence of the Engineer. Obtain samples of fresh concrete at the point of placement according to AASHTO T 141. Perform concrete temperature tests. Perform air content tests according to AASHTO T 196 or T 152. Reject all concrete not conforming to the specification requirements at the point of placement.

If the results of plastic concrete testing conform to the specification requirements, mold a sufficient number of acceptance cylinders according to AASHTO T 23 and AASHTO T-231 from the same sample of concrete taken for temperature, slump, and air content determination. Standard cure acceptance cylinders according to AASHTO T 23 and AASHTO T-231, for 28 days at an acceptable location. Conduct 28-day compressive strength testing of two acceptance cylinders according to AASHTO T 22. If for any reason two tesSection 704.1 (c) cceptance cylinders are not available for compressive strength testing, obtain two cores of the representative concrete within three working days as directed, and at no additional cost to the NRA. Conduct 28-day compressive strength testing of the cores according to AASHTO T 22.

The NRA will accept the lot of concrete when the 28-day acceptance cylinder compressive strength test result is greater than or equal to the 28-day minimum mix design compressive strength specified in Section 704.1 (c) and when the 28-day QC compressive strength requirements specified in Section 704.1(d)4.b have been met.

If the 28-day acceptance cylinder compressive strength test result is less than the 28-day minimum mix design compressive strength specified in Section 704.1 (c), the Engineer will determine the acceptability of the concrete lot.

6. Verification Testing. The Engineer will perform verification testing on the initial acceptance sample for each type of concrete specified in Table B and a minimum of one verification test for every ten acceptance samples thereafter. Verification testing will consist of testing for temperature, air content, and compressive strength. Verification tests will be performed on concrete from the same sample used for acceptance testing.

The Engineer will obtain the temperature of the sample concurrently with the acceptance sample. Immediately after an acceptable air content test result for acceptance is obtained, the Engineer will test the sample for air content according to AASHTO T 196 or T 152 using the same air meter.

The Engineer will mold two verification cylinders according to AASHTO T 23 and AASHTO T-231. Standard cure the verification cylinders along with the acceptance cylinders according to AASHTO T 23 and AASHTO T-231, for 28 days. Conduct 28-day compressive strength testing of the verification cylinders according to AASHTO T 22 in the presence of the Engineer. Conduct the testing at the same time the acceptance cylinders are tested and using the same equipment.

Verification test results will be compared to the associated acceptance test results and will not be used to determine acceptance of the lot. If there is a difference in test results of more than 3 ºC (5F) for temperature, 1.0% for air content, or 3.5 MPa (500 pounds per square inch) for compressive strength, the Engineer will immediately review the testing procedures, equipment, and personnel used in the acceptance testing and implement corrective measures to ensure the tests are performed within the prescribed tolerances. The Engineer will record the acceptance test results, the verification test results and applicable corrective measures in the Daily Record Book.

(f) Measurement of Material.

1. Cement. AASHTO M 157 and as follows:

For plant and truck mixed concrete, measure by mass (weight). The Contractor may measure the mass (weight) of the cement separately in an enclosed compartment in the aggregate hopper. The Contractor may measure the mass (weight) of the cement and discharge it simultaneously with the aggregates.

For volumetric mixed concrete, measure by volume.

2. Aggregates. AASHTO M 157 and as follows:

For plant or truck mixed concrete, measure by mass (weight) unless otherwise allowed. Base measurements on the material mass-volume (weight-volume) relationship, as specified in Section 704.1(b)1.

For volumetric mixed concrete, measure by volume.

3. Water. AASHTO M 157 except as follows:

Use water-measuring systems capable of discharging the total quantity of measured water into the plant or truck mixer drum in a time not greater than one-fourth of the specified mixing time. For truck mixed concrete, do not add water from the truck water system. Add water only from the plant water measuring system.

4. Admixtures. Incorporate the air-entraining admixture solution into the batch with the mixing water using a suitable visual measuring device. If another type of admixture is used with an air-entraining admixture, add it in solution to another portion of the mix water, as directed, by an additional suitable visual measuring device.

Equip the measuring device with interlocks to prevent discharging during the charge cycle and to prevent charging during the discharging cycle. Provide a means to calibrate the measuring device to within ±3%.

Dispense the air-entraining admixture solution into the batch from a bulk supply tank. For paving, and if directed, provide a bulk supply tank containing sufficient solution for the entire day's concreting operations.

On the dispensing system, provide device(s) capable of detecting and indicating the presence or absence of admixture flow.

5. Pozzolan. If the use of pozzolan is allowed by the specification, add separately and measure cumulatively as specified in Section 704.1(e)1.

(g) Mixing Conditions.

1. During Hot Weather. In hot weather, cool the aggregates and the mixing water as necessary to maintain the concrete temperature within the range of 10 °C to 32 °C (50F to 90F) at the time of placement.

2. Retarding Admixtures. The Contractor may use retarding admixtures, or may be directed to use retarding admixtures, when any of the following conditions are anticipated:

- rapid drying of the concrete as a result of low humidity

• high winds

• high air temperatures

Introduce the retarder into the concrete mixture as specified in Section 704.1(e)4. Adjust the proportions of the design as necessary but do not use the retarder to replace any portion of the specified volume of cement.

Use a retarder that is available in sufficient quantities to provide the required degree of retardation under the prevailing weather conditions at the time of concrete placement.

(h) Mix Designs Using Potentially Reactive Aggregate.

1. Definition of Terms.

1.a Alkalis. Oxides of sodium and potassium generally derived from Portland cement, but may also be available to concrete from other sources such as; admixtures, de-icing salts, and, in rare instances, aggregates. Alkalis are calculated according to AASHTO M 85.

1.b Pozzolan. A siliceous or siliceous and aluminous material that possesses little or no cementitious value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties. The term "pozzolan," as used in Section 704.1(g), includes flyash, ground granulated blast-furnace slag, and silica fume.

1.c Alkali-Aggregate Reaction. A chemical reaction in concrete between alkalis and certain constituents of some aggregates. The products of this reaction, under certain conditions, may cause deleterious expansion within the concrete.

1.d Alkali-Silica Reaction. An alkali-aggregate reaction involving certain siliceous aggregates and some calcareous aggregates containing certain forms of silica.(1)

Note (1)—Siliceous substances that are known to react with alkalis are as follows: opal; chalcedony as a constituent of chert in carbonate rock or sand and gravel particles; tridymite and christobalite, which are high temperature forms of silica found in andesite or rhyolite; acid glasses containing more than 65% silica; or intermediate glasses containing between 55% and 65% silica. Other siliceous substances that are potentially reactive with alkalis are strained quartz as a constituent of granite or granite gneiss and clay minerals as a constituent of graywackes, argillites, phyllites, and siltstones.

2. Aggregate Evaluation. The Contractor may test aggregates according to ASTM C 227 to confirm potential reactivity of fine or coarse aggregate, but not to classify an aggregate as "nonreactive." If ASTM C 227 mortar bars are made with cement having an alkali content greater than 0.80%, aggregates are considered to be "reactive" if expansion is greater than 0.05% at three months or greater than 0.10% at six months.

Use aggregates that are deemed potentially reactive only with cements or cement-pozzolan combinations as specified in Section 704.1(g)3. If one or both of the aggregates (coarse or fine) used in a mix is reactive, mitigation is required as specified in Section 704.1(g)3. This requirement applies to all concrete used in permanent structures on NRA projects.

3. Cement/Cement-Pozzolan Requirements. For use with aggregate deemed potentially reactive as specified in Section 704.1(g)2, provide Portland cement, blended hydraulic cement, or Portland cement-pozzolan combinations conforming to the requirements of Section 704.1(b) and the following:

3.a Portland Cement. Conforming to the optional chemical requirement in AASHTO M 85 for a maximum alkali content of 0.60%.

3.b Blended Hydraulic Cement. Type IS or IP, ASTM C 595.

3.c Portland Cement-Pozzolan Combination. Furnish a combination of Portland cement with an alkali content no greater than 1.40% and flyash, ground granulated blast furnace slag, or silica fume tested and as follows:

• Flyash—Furnish flyash that conforms to the optional chemical requirement in AASHTO M 295 for a maximum alkali content of 1.5% and that produces a 50% minimum reduction in mortar expansion when tested according to ASTM C 441. Use a quantity of flyash equal to a minimum of 15%, by mass, of the total cementitious material. If flyash is added to reduce alkali-silica reactivity, use a quantity of flyash between 15.0% and 25.0%, by mass, of the total cementitious material. If aggregate expansion, when tested according to AASHTO TP 14, is greater than 0.40%, use a quantity of flyash equal to a minimum of 20%, by mass, of the total cementitious material. Flyash may replace no more than 15.0% of the Portland cement; the remaining flyash is to replace the fine aggregate.

• Ground Granulated Blast Furnace Slag—Furnish slag producing a 50% minimum reduction in mortar expansion when tested according to ASTM C 441. Use a quantity of slag between 25.0% and 50.0%, by mass, of the total cementitious material. If aggregate expansion, when tested according to AASHTO TP 14, is greater than 0.40%, use a quantity of ground granulated blast furnace slag equal to a minimum of 40%, by mass, of the total cementitious material.

• Silica Fume—Use a quantity of silica fume between 5% and 10%, by mass, of the total cementitious material. Use of silica fume will be allowed on an experimental basis only, until sufficient experience is gained.

The NRA may waive flyash or ground granulated blast furnace slag requirements if the Contractor presents test results from an independent laboratory showing that a lesser amount of pozzolan will mitigate ASR expansion to below 0.10% when tested according to AASHTO TP 14.

4. Admixture Requirements. Furnish accelerators or other chemical admixtures as specified in Section 711.3.

(i) Extra Cement Concrete. If 25% extra cement is required as specified in Section 1001.3(k)3.a, the extra cement may be replaced with other cementitious material in the same proportions as established in the mix design or Section 704.1(c). Up to 50% of the water dose for the extra cementitious material, based on the water cement ratio of the mix being utilized, may be added. Add additional admixtures as required.

704.2 PLANT AND TRUCK MIXED CEMENT CONCRETE—

(a) Batching Plant. Proportion cement, aggregates, water, and admixtures in a plant conforming to the requirements of AASHTO M 157 for batching plants.
Install a moisture meter to accurately and continuously indicate the variability of the fine aggregate moisture content. If approved, automatic moisture compensating probes for fine and coarse aggregate may be used to control the amount of batched water. Calibrate moisture probes according to the reviewed QC Plan.

(b) Mixers and Agitators. AASHTO M 157. If directed, test air content of individual mixed concrete samples taken approximately at the beginning, the midpoint, and the end of the batch. If the air content varies by more than 1.5%, discontinue the use of the mixer or agitator until the condition is corrected.
If mixing in truck mixers at the plant, use inclined-axis, revolving-drum type mixers or horizontal-axis, revolving-drum high-discharge type mixers.

(c) Mixing and Delivery. Maintain concrete temperature after mixing between 10 °C and 32 °C (50F and 90F) for general concrete. Do not ship concrete exceeding these temperature ranges. Maintain adequate two-way communications between the concrete plant and the work site to provide both uniformity and control of the concrete mixture.

For each truck, furnish a plant delivery slip signed at the plant by the technician or other designated person. Include the following information on the delivery slip:

• Contract number, complete project number or purchase order number.

• The concrete plant supplier code.

• Method of concrete mixing (i.e., central or truck).

• Class of concrete, JMF number, and trial mix number (i.e., trial #1, 2, etc.).

• Number of cubic meters (cubic yards).

• Time of completion of mixing.

• Truck number.

• Number of mixing revolutions, if applicable.

• Total amount of batch water used in each truck (in kilograms (pounds)).

• The total mass (weight) in kilograms (pounds) of the total cementitious materials.

• The types of additives used in each truck (i.e., water reducer, AEA, retarder, etc.).

Submit the plant delivery slip and batcher-mixer slip (as specified in AASHTO M 157) to the Inspector-in-Charge. Do not use any concrete until it is approved for use by the Inspector-in-Charge.

Comply with the requirements of AASHTO M 157, except as follows:

• If mixing in a plant, mix for not less than 50 seconds or more than 90 seconds for normal strength concrete, and not less than 70 seconds for HES concrete.

• If mixing in the truck drum at the plant, mix for not less than 70 or more than 125 truck-drum revolutions, at a mixing speed of not less than six nor more than 18 truck-drum rpm. Upon completion of the designated number of mixing revolutions, reduce the truck-drum speed to not less than two or more than 6 rpm. Do not exceed a total of 300 truck-drum revolutions.

• Deliver the mixed concrete to the work site and discharge within 1 1/2 hours after completion of mixing. Agitate, but do not mix the concrete en-route to the work site.

• In hot weather, under conditions contributing to quick concrete stiffening, or if the concrete temperature is 27 °C (80F) or above, do not allow the time between completion of mixing and discharge to exceed 1 hour. As an alternative to maintaining the concrete temperature below 27 °C (80F), use an approved, set retarding admixture to extend the initial set time and enable the mix to remain workable for the full 1 1/2 hours of allowable mixing time.

• If using mixer or agitator trucks, agitate concrete for at least 20 revolutions immediately before placement. Do not use concrete that has exceeded 45 minutes without agitation.

• If wash water is used to clean the truck drum, completely discharge this wash water before the introduction of the succeeding batch.

• Do not allow concrete to come in contact with aluminum unless the aluminum is coated with an acceptable coating (delivery of concrete in an aluminum truck bed is allowed).

704.3 VOLUMETRIC MIXED CEMENT CONCRETE—

(a) General. Make trial mixtures with a calibrated mixing plant. Provide plant equipment, facilities, and a concrete technician(s) as specified in Section 704.1. Do not begin production until the mixing plant and all equipment and facilities necessary for performing the work have been inspected and accepted. Mixing plants may be truck mounted.

(b) Equipment. Prominently attach a permanent metal plate(s) to the plant plainly marking the gross volume in terms of mixed concrete, the operating speed, the plant auger mixing angle, and the plant mass-calibrated (weight-calibrated) cement constant in terms of a revolution counter or other output indicator, all as rated by the manufacturer.

1. Compartments. Provide separate compartments to carry the ingredients. Cover the aggregate bins and prevent contamination and intermixing of the fine and coarse aggregates during loading and transporting. Keep the cement bins free of moisture and contamination. Provide suitable means to carry water and additives and to incorporate the additives with the mixing water in the mix.

2. Feed System. Provide a feeder system mounted under the compartment bins to deliver the ingredients to the mixing unit. Equip each bin with an accurately controlled individual gate to form an orifice for volumetrically measuring the material drawn from the bin compartment. Do not charge aggregate bins more than 4 hours before mixing.

Set the cement bin feeding mechanism to discharge a given volumetric mass (weight) equivalent of cement at a continuous and uniform rate during the concrete mixing operation. Coordinate the coarse and fine aggregate feeding mechanisms with the cement feeding mechanisms to deliver the required proportions.

3. Mixing Unit. Provide an auger-type mixer incorporated in the plant's discharge chute, or another suitable mixing mechanism that produces concrete of uniform consistency and discharges the mix without segregation. Examine the mixing screw daily and clean as necessary to prevent the build-up of mortar or concrete.

4. Dials and Measuring Devices. Equip the plant with accurate revolution-counter indicators that allow the volumetric mass (weight) equivalent of cement, fine aggregate, and coarse aggregate discharged to be read during the concrete-mixing operation. Equip the counter with a ticket print-out to record this quantity.

Equip the plant with a water flow meter or gauge to indicate the discharge rate of water (by volume) entering the mix and a water meter to register the total amount of water discharged during the mixing operation. Also, equip the plant with suitable gauges for checking the rate of flow of any additive entering the mix. Coordinate the water and additive flow meters with the cement and aggregate feeding mechanisms. Equip the flow meters with scales appropriate for the type and amount of material being measured. Mount a tachometer indicating the drive shaft speed on the plant.

Place gauges, dials, and other devices that indicate the accuracy of concrete proportioning and mixing in full view so that the operator can accurately read or readjust them while concrete is being produced. Provide the operator convenient access to all controls.

(d) Calibration. Use a unit constructed to allow convenient calibration of the gate openings and meters. Conduct a calibration once a year in the presence of NRA representatives. Make satisfactory arrangements with the NRA at least 1 week in advance of calibration. During the yearly calibration, calibrate the cement meter according to the manufacturer's recommendation and check the aggregate gate settings against the calibration data for the plant. Maintain the calibration data in the plant and submit the data to the NRA.

After performing the yearly calibration and before starting work, provide a mix design for review and acceptance and run a yield test to verify the design. Adjustments to correct for yield may require recalibration or a design change.

Conduct a recalibration if there is a change in the source of fine or coarse aggregate or cement. Conduct additional calibrations if directed. Provide each plant with data on the accepted recalibration.

If hydraulic drive units are used, perform the following additional calibration procedure: At the beginning of the actual batching operation, check the cement meter against the count and time used for the cement during the calibration of the individual materials. If a discrepancy occurs, adjust the belt speed of the unit so that the actual cement meter count does not vary from the calibrated meter count by more than two counts per 60 seconds.

(e) Mixing and Delivery. Proportion, measure, and batch cement and aggregates by a volumetric mass (weight) equivalent method. The measuring and batching mechanism is required to produce the specified proportions of each ingredient within the following tolerances:

- Cement, Mass (Weight) 0 to +4%
- Fine Aggregate, Mass (Weight) ±2%
- Coarse Aggregate, Mass (Weight) ±2%
- Admixtures, Mass (Weight) or Volume ±3%
- Water, Mass (Weight) or Volume ±2%

The tolerances are based on a volume/mass (volume/weight) relationship established during the calibration of the measuring devices.

During mixing, maintain the drive shaft speed, as indicated by the tachometer, within 50 rpm of the operating speed. Set the auger mixer angle in the range determined by the manufacturer. Do not exceed one half hour between the continuous placing of succeeding batches.

1. Testing. Conduct slump and air content tests according to AASHTO T 141. Conduct the unit mass (weight) test, the concrete uniformity test, and the output meter calibration test according to AASHTO T 121, C 136, and AASHTO M 157. If there is any doubt in the uniformity of the concrete, perform further testing as directed.

2. Recording. Provide a batcher mixer slip with each load of ingredients. Include the following information on the batcher mixer slip:

- Aggregate gradation and moisture information.
- Class of concrete and the corresponding dial setting, as determined in the design
- Water discharge rate limitations.

Use a separate batcher mixer slip for each class of concrete. Deliver the batcher mixer slip to the Inspector-in-Charge at the work site. Do not use the concrete until the Inspector-in-Charge verifies the data noted on the slip complies with the specifications.

SECTION 705—JOINT MATERIAL

705.1 PREMOLDED EXPANSION JOINT FILLER—Provide cork or sponge rubber or fiber joint fillers conforming to the following requirements:

(a) General. As shown on the Standard Drawings, or as indicated.

When used for joints in structures, furnish pieces at least 2.4 m (8 feet) in length, or as otherwise indicated, and join securely.

(b) Cork or Preformed Rubber. AASHTO M 153 and as follows:

Joint filler modified to include polyurethane bonded recycled rubber, consisting of preformed strips of a durable composite of ground recycled rubber from automobile tires bonded together with polyurethane adhesive, is allowed.

(c) Fiber. AASHTO M 213, except that a specimen at least 100 mm (4 inches) on a side, with a minimum area of 0.01 m2 (16 square inches), is necessary for the compression test. For glass fiber tested for compression, the applied force may be less than the minimum 689 kPa (100 pounds per square inch).

705.2 LONGITUDINAL JOINT MATERIAL—As shown on the Standard Drawings or as indicated. Use tie bars, tiebolts, and key formers, conforming to the following requirements:

(a) Tie Bars.

1. Deformed Tie Bars. Section 709.1(a)1, 709.1(b)1, or 709.1(c), and epoxy coated as specified in Section 709.1(d).

2. Deformed Bent Tie Bars. Section 709.1(a)1 or 709.1(c), and epoxy coated as specified in Section 709.1(d).

(b) Tiebolts. As follows:

- Manufactured from mild steel.
- A 14 mm (9/16-inch) diameter bar with rolled threads or a 16 mm (5/8-inch) diameter bar with cut threads, with a threaded sleeve nut.
- For the nut, steel pipe or hexagonal steel bar (27 mm diameter x 48 mm long (1 1/16 inches diameter by 1 7/8 inches long)), or a high strength steel bar (21 mm diameter x 50 mm long (27/32-inch diameter by 2 inches long)).
- For the assembled tiebolt, a minimum yielding load of 66 700 kN (15,000 pounds) is necessary.
- Epoxy coated, excluding threads, as specified in Section 709.1(c).

(c) Key Former. Manufactured of a material that does not deform during concrete placement.

705.4 JOINT SEALING MATERIAL—

(a) Silicone Joint Sealing Material. Low modulus, nonsag-silicone, sealing material in a nonacid-curing, one part formulation, which requires tooling. Furnish silicone joint sealing material conforming to the following physical requirements:

• Tensile Stress at 150% elongation, kPa (psi), max. (ASTM D 412, Die C) 7-day cure at 25 °C ± 2 °C (77F ± 3F) and 45% to 55 % relative humidity	310 (45)
• Elongation at maximum tensile strength, %, min. (ASTM D 412, Die C)	600
• Extrusion rate, grams/second (grams/minute), min. -18 °C to 38 °C (0F to 100F) (Test for extrusion using an air-powered caulking gun, having a 3 mm (1/8-inch) orifice, at 620 kPa (90 psi))	1.25 (75)
• Specific gravity (ASTM D 792, Method A)	1.010 to 1.515
• Durometer hardness, shore "A" (ASTM D 2240) 7-day cure at 25 °C ± 2 °C (77F ± 3F) and 45 to 55% relative humidity.	10 to 25 @ -18 °C (0F)
• Shelf life, days, min., from date of manufacture.	180
• Ozone and ultraviolet resistance (ASTM C 793)	No chalking, cracking, or bond loss after 5000 hours.
• Flow (MIL S 8802)	Nil
• Bond to cement mortar, kPa (psi), min., primed if required. (Mold three cement mortar briquets according to AASHTO T 132 and moisture cure for at least 28 days. Saw briquets in half, clean, and oven dry to a constant mass (weight) in an oven at 110 °C ± 5 °C. After cooling, bond halves together with approximately 0.3 mm (10 mils) of silicone sealant, cure 7 days at 25 °C ± 2 °C (77F ± 3F) and 45 to 55% relative humidity, and test using clips conforming to AASHTO T 132. Test specimens in tension at loading rate of 0.13 mm/s (0.3 inch/minute).	345 (50)
• Tack free time, minutes, max. (ASTM C 679)	90
• Movement capability and adhesion (ASTM C 719)	Cyclic movement: +100% / -50% (extension/compression), no adhesive or cohesive failure after 10 cycles @ -18 °C (0F)

(b) Rubberized Joint Sealing Material. Low Modulus, ASTM D 3405. Furnish a rubberized joint sealing material conforming to the following physical requirements:

Test	Specification Limits
Cone penetration, non-immersed @ 25 °C (77F), 150 g, 5 s	90 to 150
Flow @ 60 °C (140F) for 5 hours	3.0 mm max.
Resilience @ 25 °C (77F)	60% min.
Bond, non-immersed @ -29 °C (-20F), 200% extension	Pass 3 cycles
Asphalt compatibility @ 60 °C (140F)	Pass
Sealant life at application temperature	8 hours min.

(c) Rubberized Joint Sealing Material. Modified AASHTO M 173. Furnish a rubberized joint sealing material conforming to the following physical requirements:

Test	Specification Limits
Cone penetration, non-immersed @ 25 °C (77F), 150 g, 5 s	50 to 90
Flow @ 60 °C (140F) for 5 hours	1.0 cm max.
Resilience @ 25 °C (77F)	25% to 60%
Ductility @ 25 °C (77F) (ASTM D 113)	40 cm max.
Bond, non-immersed @ -18 °C (0F), 100% extension (Specimen thickness 12.7 mm (1/2 inch))	Pass 5 cycles
Asphalt compatibility @ 60 °C (140F)	Pass
Sealant life at application temperature	8 hours min.

(d) Preformed Closed Cell Polyethylene Joint Filler. ASTM D 3204, Type I, and as follows:

Compressibility:

Pressure necessary to compress test specimen by 25%	min. 35 kPa (5 pounds per square inch)
Pressure necessary to compress test specimen by 85%	max. 205 kPa (30 pounds per square inch)

(e) Asphalt Rubber Sealing Compound. ASTM D 5078.

705.5 GASKETS AND WATERSTOPS—Conforming to the following requirements:

(a) Shipment and Certification. Label shipments with style or code number, lot or batch number, plant, place, and manufacture date.

(b) Gaskets.

1. Elastomeric. ASTM C 443 for rubber gaskets and ASTM C 361 for neoprene gaskets.

2. Flexible Plastic (Hydrocarbon Blend). AASHTO M 198, Type B, with the following exceptions:

- Flash Point, Cleveland Open Cup (C.O.C.) min.,°C (F) 177 (350)
- Fire Point, C.O.C. min.,°C (F) 190 (375)

(c) Waterstops.

1. Metal. ASTM B 370. Copper sheets used for waterstops, of a mass (weight) indicated and containing a minimum copper mass of 99.5%.

2. Polyvinyl Chloride.

2.a Physical Requirements.

- Manufactured from virgin polyvinyl chloride resin with the addition of only those plasticizers, stabilizers, and other materials necessary to ensure aging stability and in-place durability.
- Not factory scrap or reclaimed polyvinyl chloride.
- Brittleness temperature, ASTM D 746 -29 °C (-20F) max.
- Modulus of flexure, ASTM D 747, kPa (lbs/sq. in.) 2800 (400) min.
- Tensile strength, ASTM D 412,
  Die C original, kPa (lbs/sq. in.) 6890 min. (1,000 min.)
  Across job splice, kPa (lbs/sq. in.) 7930 min. (1,150 min.)
- Elongation
  Original, percent 280 min.
  Across job splice, percent 200 min.
- Tear strength, ASTM D 624, Die B
  Original, kN/m (lbs/in.) 46 min. (260 min.)
- Oven aging, ASTM D 673, 70 hours at 100 °C (212F)
  Change in tensile strength, percent change 20 max.
  Change in elongation, percent change 20 max.
- 14-Day extraction, 60 °C/66 °C (140F/150F)
  Change in tensile strength, percent change 40 max.
  Change in elongation, percent change 40 max.

2.b Marking. Permanently label with the manufacturer's name and style or code number, at intervals not exceeding 1.0 m (3 feet).

2.c Acceptance. Material shipped is subject to inspection at the delivery point. If directed, provide samples, selected at random from the shipment, consisting of one portion 1.2 m (4 feet) long and another portion from a job splice consisting of a minimum of 300 mm (12 inches) of splice, within 150 mm (6 inches) of unspliced material on each side. Submit samples to the Engineer for material confirmation and compliance.

705.6 GRAPHITE LUBRICANT—Consisting of flaked graphite and a vehicle, conforming to the following requirements:

	Percent By Mass (Weight)			
	Flaked Graphite[3]		Vehicle	
Type	**Minimum**	**Maximum**	**Minimum**	**Maximum**
Graphite Paste[1]	55	65	35	45
Premixed Graphite Lubricant[2]	39.3	46.4	53.6	60.7

Note (1)—Vehicle containing not less than 52% of fixed oils, with the vehicle remainder of volatile thinners and dryers. Thoroughly mix the paste.

Note (2)—Vehicle containing not less than 24.3% vehicle solids, with the vehicle remainder of volatile thinners and dryers.

Note (3)—Flaked Graphite, composition:

	Percent By Mass (Weight)	
	Minimum	**Maximum**
Graphite Carbon	85	—
Graphite Carbon passing 150 µm (No. 100) sieve	84	92
Graphite Carbon passing 45 µm (No. 325) sieve	46	50

705.7 MORTAR—Mix mortar in an acceptable type of mixer, unless otherwise allowed. Do not use retempered mortar or mortar mixed for more than 1/2 hour, unless otherwise specified.

705.8 CAULKING COMPOUND—Conforming to the following requirements:

(a) For Caulking Pipe Joints. ASTM D 2822

(b) For Other Caulking. ASTM C 834 or C 920

705.9 JOINT BACKING MATERIAL—Expanded, low-density, polyethylene foam conforming to the requirements of ASTM D 5249. When indicated, the foam may be used as a bond breaker between joint filler material and joint sealer.

SECTION 706—CONCRETE BONDING COMPOUND

706.1 Epoxy-Bonding Compound—Provide an epoxy bonding compound conforming to ASTM C 881 and specify Type and Grade as per operation. Submit a copy of the manufacturer's recommendations for proper application to the Engineer. Apply the compound according to the manufacturer's recommendations.

(a) General. If epoxy-bonding compounds are used, the Type and Grade of epoxy must be specified for each specific operation.

1. Application/Operation Specific Types.

- Type I—For use in non-load bearing applications, bonding hardened concrete (28 days or older) to hardened concrete surfaces.
- Type II—For use in non-load bearing applications, bonding freshly mixed concrete to hardened concrete.
- Type III—For use in bonding skid-resistant materials to hardened concrete and as a binder in epoxy mortars or epoxy concretes used on traffic bearing surfaces (or surfaces subject to thermal or mechanical movements).

2. Grades. Flow characteristics.

- Grade 1—Low viscosity
- Grade 2—Medium viscosity
- Grade 3—Non-sagging consistency

3. Classes. Temperature use range.

- Class A—For use below 4 ºC (40F), to the lowest allowable temperature defined by the manufacturer.
- Class B—For use between 4 ºC and 16 ºC (40F and 60F).
- Class C—For use above 16 ºC (60F), to the highest allowable temperature defined by the manufacturer.

706.2 Non-Epoxy-Bonding Compound—Provide a non-epoxy-bonding compound with a minimum 14-day bond strength of 10.3 MPa (1,500 pounds per square inch) as tested according to ASTM C 882. Submit a copy of the manufacturer's recommendations for proper application to the Engineer. Apply the compound according to the manufacturer's recommendations.

SECTION 709—REINFORCEMENT STEEL

709.1 REINFORCEMENT BARS—As indicated and conforming to the following requirements:

(a) Billet-Steel Bars.

1. Deformed. AASHTO M 31M (ASTM A 615M), Grade 420 (Grade 60). Where AASHTO M 31M (ASTM A 615M), Grade 300 (Grade 40) is indicated (non-bridge items only), Grade 420 (Grade 60) may be substituted on a bar-to-bar basis at no additional cost to the Department. If using deformed bent tie bars in pavement structures, use only Grade 300 (Grade 40).

2. Plain. AASHTO M 227/M 227M (ASTM A 663/A 663M) or AASHTO M 255/M 255M (ASTM A 675/A 675M), Grade 485, 515, or 550 (Grade 70, 75, or 80). AASHTO M 31/M 31M (ASTM A 615/A 615M), Grades 300 or 420 (Grade 40 or 60).

(b) Rail-Steel Bars.

1. Deformed. AASHTO M 42/M 42M (ASTM A 996/A 996M), Grade 420 (Grade 60), including supplementary requirements. Do not weld or bend.

2. Plain. AASHTO M 42/M 42M (ASTM A 996/A 996M), Grades 350 or 420 (Grade 50 or 60), including supplementary requirements. Do not weld or bend.

(c) Epoxy Coating (Where Indicated). Coat bars according to ASTM A 775/A 775M, modified as follows:

- Section 5—Materials and Manufacture
  Subsection 5.2. Revise completely to read: "Maintain the certification for the powder coating material at the applicator's site and provide a powder coating material meeting the requirements listed in Annex A1."

- Section 8—Requirements for Coated Bars.
  Subsection 8.1.1. Revise the first sentence to read: "For acceptance purpose, provide a coating thickness after curing of 250 ±50 μm (10 ±2 mils) on 90% of all recorded thickness measurements."

- Coating Color—Light color shades that will reveal rusted or undercoated areas of steel.

Store, handle, and place the epoxy coated bars according to ASTM D 3963/D 3963M.

(d) Low-Alloy Steel Bars.

1. Deformed. ASTM A 706/A 706M, Grade 420 (Grade 60).

709.2 BAR MATS—Steel Bars, Section 709.1, assembled into mats, as shown on the Standard Drawings, by rigidly welding or clipping the bars at joints or points of intersection.

(a) Clips. For mechanical assembly, use 3.8 mm (No. 9 gage) steel wire of sufficient ductility to prevent clip fracture in mat fabrication.

For manual assembly, use 0.74 mm (No. 12 gage) spring steel wire of high elastic limit, conforming to the following chemical analysis:

	Percent	
Element	**Min.**	**Max.**
Carbon	0.45	0.70
Manganese	0.90	1.20
Sulfur	0.00	0.045
Phosphorus	0.00	0.045
Silicon	0.08	0.12

(b) Method of Assembly (Using Clips). Hold the bars in close contact by clips designed to exert constant pressure. Assemble at the point of manufacture, using clips of acceptable design, and fasten by mechanical means.

Use double-latching type clips for manual assembly. Use some form of locking device on the clips' free or latching ends so that when the clips are latched in place, no creeping occurs that would allow the bars to be easily moved from their necessary positions.

Provide, approximately, a 25 mm (1-inch) spread of the clips at intersections for necessary leverage to hold bars at right angles. Latch each alternate clip at right angles to the adjacent clips, to ensure maximum rigidity. Use clips of a length so the material is not stressed beyond the elastic limit during the latching process. A minimum length of 100 mm (3 1/2 inches) is necessary for No. 10 to No. 35 (No. 3 to No. 10) bars.

Other types of clips that ensure equal rigidity may be submitted for acceptance.

(c) Acceptance of Design. Submit designs for acceptance, before use.

709.5 CERTIFICATION—Certify as follows:

Identify the appropriate specification on the certification and include the grade of steel. Forward a copy to the project with the shipment of steel.

SECTION 711—CONCRETE CURING MATERIAL AND ADMIXTURES

711.1 CURING AND PROTECTING COVERS—

(a) White Polyethylene Sheeting. AASHTO M 171, except minimum tensile strength requirements are as follows:

Machine Direction	Cross Machine Direction
1.22 kN/m (7.0 lbs/lin. in.)	1.22 kN/m (7.0 lbs/lin. in.)

(b) White Polyethylene Sheeting—Burlap-Backed.

1. White Polyethylene Sheeting—natural burlap backed. AASHTO M 171.

2. White Polyethylene Sheeting—synthetic burlap backed. AASHTO M 171, except mass (weight) of synthetic burlap backed white polyethylene sheeting is 271 g/m² (8.0 ounces per square yard).

(c) White Polypropylene Sheeting—Polypropylene Fiber Backed.

1. White Polypropylene Sheeting—polypropylene fiber backed, with maximum moisture loss of 0.55 kg/m^2 in 72 hours when testing according to ASTM C 156.

2. Daylight reflectance of white polypropylene sheeting is at least 70% when measured according to ASTM E 1347.

3. White Polypropylene Sheeting—polypropylene fiber backed, weighing not less than 203 g/m^2 (6.0 ounces per square yard).

4. A white sheeting layer with a nominal thickness of 0.1 mm (0.0040 inch) and not less than 0.075 mm (0.0030 inch).

5. Minimum strength requirements are as follows:

Grab Tensile Strength	Grab Tensile Elongation	Puncture
530 N (120 lbs) ASTM D 4632	50% ASTM D 4632	290 N (65 lbs) ASTM D 4833

(d) Burlap. AASHTO M 182, Class 1.

(e) Insulating Mats. Treated new wood fibers, rock wool, or glass fibers, completely enclosed on all sides within weather-proof covers of asphalt-saturated kraft crepe or polyethylene sheeting, and conforming to the following requirements:

- Asphalt-saturated crepe covers manufactured from extra heavy, two-ply, kraft crepe, totaling not less than 0.147 kg/m^2 (30 pounds per 1,000 square feet), on the weather side and of kraft paper or kraft crepe, of not less than 0.073 kg/m^2 (15 pounds per 1,000 square feet), on the reverse side.

- Polyethylene covers manufactured from sheeting of not less than 0.15 mm (6 mils) normal thickness on the weather side and of not less than 0.10 mm (4 mils) normal thickness on the reverse side.

- Fiber bonded to the covers of insulating mats over 610 mm (24 inches) in width, to prevent bunching of the mats during storage, shipping, or handling.

(f) Foam Insulation. Molded, extruded, or spray-applied polyurethane or molded or extruded polystyrene, forming closed-cell foam insulation, with the cells uniformly distributed and conforming to the following requirements:

- Water absorption, percent by volume, tested according to ASTM D 2842—3.0 max.
- Density, kg/m^3 (lbs/cu. ft.), tested according to ASTM D 1622—16 - 96 (1.0 - 6.0)

711.2 CURING COMPOUNDS—

(a) Liquid Membrane-Forming Curing Compound, Clear or White. AASHTO M 148, Type 1-D, clear or translucent and containing a red fugitive dye; Type 2, white pigmented.

(b) Liquid Membrane-Forming Curing Compound, Black. Emulsified asphalt, (Class E-1, Bulletin 25) or cut-back asphalt, (Class RC-70, ASTM D 2028), either conforming to the performance requirements of ASTM C 309 for Type 4.

711.3 CONCRETE ADMIXTURES—Of an approved type and conforming to the following requirements:

(a) General. If tested by precipitation, the chloride ion content is not to exceed the following:

- 1.0% by mass (weight) of the admixture for use in conventional reinforced cement concrete
- 0.1% by mass (weight) of the admixture for use in prestressed concrete

(b) Shipment. Ship and deliver in drums or in bulk. Mark or tag each drum with the batch or lot number and date of manufacture. Forward a bill of lading with each bulk shipment, bearing the same information as necessary for drums. Each shipment will be subject to sampling and testing at any time.

(c) Air Entraining Admixtures. AASHTO M 154

(d) Latex Emulsion Admixture. A nontoxic, film-forming, polymeric emulsion in water to which all stabilizers have been added at the point of manufacture and homogeneous and uniform in composition. Conform to the prequalification requirements specified in Report FHWA-RD-78-35, "Styrene-Butadiene Latex Modifiers for Bridge Deck Overlay Concrete," April 1978.

(e) Other Admixtures. AASHTO M 194

SECTION 720—WATER

720.1 WATER FOR MIXING OR CURING CEMENT CONCRETE, MORTAR, OR GROUT—Use fresh water reasonably clean, free from vegetable matter, oil, acid, alkali, sugar, or other substances injurious to the finished product. If the hydrogen ion concentration of the water, as determined either electrometrically or colorimetrically in conjunction with the necessary indicator, is less than pH 4.5 or more than pH 8.5, test the water according to AASHTO T 26. Compressive strength not less than 95% of that developed from similar samples made with potable water needs to be achieved.

720.2 WATER FOR USE OTHER THAN IN MIXING OR CURING CEMENT CONCRETE, MORTAR, OR GROUT—Suitable clean water may be used without testing. If the water source is relatively shallow, enclose the intake to exclude silt, mud, grass, or other undesirable foreign material.

SECTION 724—POZZOLANS

724.1 GENERAL—Legibly mark the name of the manufacturer, the lot number, and the approximate net mass on each container or, in case of bulk shipment, on the shipping invoice.

The material is subject to assurance sampling and testing by the Engineer.

Obtain material from a single source, unless otherwise allowed in writing. Separate material of different types and from different sources. Use each type and source in continuous segregated portions of the project. If possible, limit material used in an individual structure to a single type or source.

724.2 FLYASH—

(a) For Use with Lime. ASTM C 593, tested according to AASHTO T 135.

(b) For Use with Cement Concrete. AASHTO M 295, Class C, F, or N, except limit Loss on Ignition to a maximum of 6.0%.

724.3 GROUND GRANULATED BLAST FURNACE SLAG—

(a) For Use with Cement Concrete. AASHTO M 302 (ASTM C 989), Grade 100 or 120. Do not use ground granulated blast furnace slag with a material temperature exceeding 82 °C (180F) at time of delivery to the mixer, unless permitted in writing.

724.4 SILICA FUME—

(a) For Use with Cement Concrete. AASHTO M 307 (also called Micro Silica).

SECTION 1000
STRUCTURES

SECTION 1001—CEMENT CONCRETE STRUCTURES

1001.1 DESCRIPTION—This work is construction of bridges, arches, culverts, and other cement concrete work.

1001.2 MATERIAL—

(a) Cement Concrete. Section 704. The cement factor may be increased to obtain high early-strength concrete, with written consent from the Engineer. Do not use Type III high early-strength, non-air-entraining cement.

(b) Concrete Curing Material and Admixtures.

- Curing and Protecting Covers—Section 711.1
- Curing Compounds—Section 711.2(a) (clear only)
- Concrete Admixtures—Section 711.3

(c) Nonstaining, Nonshrinking Grout. Use for minor patching of concrete surfaces. Mix one part cement, two parts fine aggregate, and enough water to provide a consistency stiff enough to place by either manual or mechanical tamping. Do not use more than 0.40 L of water per kilogram (4 1/2 gallons of water per bag) of cement. Mix for 60 seconds, cover to prevent loss of moisture, and allow to stand for 45 minutes. Remix for 60 seconds without further addition of water, then place within 30 minutes after completion of mixing. Use material as follows:

- Cement, Type IP, IS, or II—Section 701
- Fine Aggregate, Type A or C—Section 703.1
- Water—Section 720.1

The Contractor may use premixed grout. Mix according to the manufacturer's instructions.

(d) Forms.

1. Temporary. Use plywood at least 15 mm (5/8 inch) thick or other accepted material made for form work. For final exposed concrete surfaces, use smooth material, free of knots, holes, bulges, and depressions.

2. An alternate form system may be used, if indicated or if accepted in writing by the National Roads Authority (NRA). Submit material details and erection methods of the alternate form system for review and acceptance.

(e) Other Material.

- Premolded Expansion Joint Filler—Section 705.1
- Joint Sealing Material—Section 705.4(b), or (c)
- Waterstops—Section 705.5

- Caulking Compound—Section 705.8
- Reinforcement—Section 1002.2
- Structural Steel—Section 1105
- Coarse Aggregate, No. 57—Section 703.2

(f) Tremie Cement Concrete. Use cement concrete as specified in Section 704, modified as follows:

- Cement Factor (Min)—390 kg/m^3 (7.0 bags per cubic yard)
- Slump—175 mm ± 25 mm (7 inches ± 1 inch)
- Compressive Strength at 7 Days—17 MPa (2,500 pounds per square inch)

Provide admixtures that retard concrete set 1500 mm (5 feet) above and below the tremie pipe outlet, are compatible with the air entrainment agents, and do not allow excessive segregation of the aggregate.

(g) Concrete Bonding Compound. Section 706.1

1001.3 CONSTRUCTION—Construct as shown on the Standard Drawings and as follows:

(a) Forms and Centering.

1. General. Support forms so that deflection does not exceed 12 mm (1/2 inch) under plastic concrete. Before using forms, clean them and obtain approval for use. Use forms that are strong and firm; securely braced; tied together, if required, by means of form ties, tight enough to prevent the leakage of mortar; and strong enough to withstand the action of mechanical vibrators, if used.

Remove dirt, chips, sawdust, and other foreign materials before placing concrete. Except for stay-in-place forms, before placing reinforcing steel, thoroughly coat forms with a release agent. Coat forms for exposed surfaces with a nonstaining release agent.

Adequately brace forms. If forms are insufficiently braced or unsatisfactorily built, the work will be halted, either before or during concrete placement, until such defects have been satisfactorily corrected. Chamfer the edges as indicated. Do not leave wood separators in the completed work.

Do not use form support systems that will cause unacceptable overstress or deformation to permanent bridge members.

Use ties that are adjustable in length, to allow tightening of forms. Use ties that leave no metal in the concrete within 40 mm (1 1/2 inches) of the exposed surface. Do not fit ties with lugs, cones, washers, or other devices to act as spreaders within the form, or devices that leave depressions in back of the exposed surface of the concrete. Flat bands may be used, if the bands conform to the following:

- Not less than 20 mm (3/4 inch) wide.
- Not less than 1.9 mm (14 gage) thick.
- Placed on edge.
- Protected by adequate spreaders to prevent twisting during construction.

Do not use wire ties or thin, narrow, flat bands, except in the construction of endwalls, inlets, and manholes. Where necessary, coat the form ties with a release agent to facilitate removal. Do not damage the concrete on the exposed surface when removing forms and ties. Do not cut ties back from the concrete face.

Before starting construction, obtain acceptance of working drawings required for centering and falsework, as specified in Section 105.02(c). Before placing concrete, obtain acceptance of in-place forms. Camber the

centering to compensate for dead-load deflection and settlement of centering. Provide for gradual and uniform lowering.

Where required, drench the inside of forms with water immediately before placing concrete.

(b) Reinforcement.

1. Reinforcement Bars. Section 1002.3.

Place reinforcement so the indicated cover clearance does not deviate from position by more than ±6 mm (±1/4 inch).

Do not place concrete until the reinforcing placement is accepted.

(c) Consistency of Concrete at the Time of Placement. Do not add water to concrete in the field, unless authorized in writing by the Engineer. If written authorization is obtained, the quantity of water may be increased by a maximum of 5 L/m^3 (1 gallon per cubic yard). Immediately remove free water, soft concrete, or mortar that appears on the surface of the concrete, and correct the cause of this condition.

(d) Mixing Conditions. Section 704.1(f)

(e) Proportioning and Mixing Concrete. Section 704

(f) Placing and Finishing Concrete.

1. General Requirements. At least 15 days before the element of work is started, submit, for review and acceptance, a QC Plan showing the methods, sequence, and schedule for placing concrete. Maintain material on hand and in place, if necessary, for curing and protecting the concrete. Before placing foundation concrete, ensure that the bearing area is firm, reasonably dry, and free of water. The Engineer will inspect the foundation area for bearing capacity before placement If directed, drill or drive a bar into the material below the foundation or footing bottom to a depth sufficient to determine the suitability of the material. Place concrete without segregation. Remove and discard any concrete that is segregated, too wet for use, or not of uniform consistency. Do not drop the concrete mixture a distance greater than 1.2 m (4 feet). Do not allow concrete to come in contact with aluminum, unless the aluminum is coated with an accepted coating.

Do not place consecutive batches adjacent to each other at concrete temperatures differing by more than 11°C (20F).

For succeeding batches, place concrete in the forms within 30 minutes. Place concrete in horizontal layers no more than 380 mm (15 inches) in depth. Fill each part of the form by depositing the concrete as close to its final position as possible. Do not work or flow concrete along the forms from the point of deposit. Work the concrete without displacing the reinforcement. Place concrete so that the upper surface of the concrete is at the indicated elevation after it has been struck off and after initial shrinkage has taken place.

Finish exposed concrete surfaces accurately and evenly, free from open and rough areas, and free from depressions and projections. In walls, place concrete to the required elevation. Strike off with a straightedge and float to the correct elevation. Do not add water or curing agent to the concrete surface to assist in finishing.

In areas where reinforcement extends through a construction joint, do not place concrete adjacent to previously placed concrete until at least 24 hours has elapsed.

2. Use of Vibrating Equipment. Keep sufficient vibration equipment in reserve to guard against a work shutdown, caused by the failure of the equipment in operation.

Use an acceptable mechanical vibrator. Do not attach it to the forms or reinforcement. Use a vibrator capable of transmitting vibration to the concrete with a frequency of not less than 100 impulses per second. Determine the vibrator size by the reinforcement spacing.

When sufficient concrete has been deposited, spade and manipulate it to fill the form. Apply the vibrator to the concrete, at intervals not exceeding 900 mm (3 feet), immediately after the concrete has been deposited. Move the vibrator throughout the mass, completely working the concrete around the reinforcement and other embedded fixtures, and into the corners and angles of the forms. Correct any reinforcement displacement caused by the vibrator before continuing vibration. Move the vibrator slowly to prevent segregation. Do not use vibrators to spread concrete.

Remove and discard concrete segregated by the vibrating operation. Ensure that the vibrator does not penetrate or disturb partially hardened layers. Reinforcement in freshly placed concrete may be vibrated for short durations to ensure proper reinforcement embedment.

3. Placing Concrete in Water.

3.a General. When the depth of water in the foundation area is 25 mm (1 inch) or greater, place concrete only in still water and add 25% more cement than the quantity specified for the concrete being used, as specified in Section 704.1(h).

Hold a concrete placement meeting and present all details of the placement to the Representative. Do not begin concrete placement until the placement procedures, concrete mix design, inspection procedures, and concrete sampling procedures have been accepted.

If the tremie method is selected for placing concrete, submit a concrete placement procedure plan for approval at least 21 calendar days before performing the work, and include the following:

- Concrete mix design.
- Available concrete production capability.
- Availability and capacity of equipment to be used to transfer concrete to the tremie.
- The total volume of concrete to be placed.
- The various placement schemes available.
- Tremie locations.
- Maximum flow distance of concrete.
- Any restrictions to flow, such as reinforcing steel, piles, and internal form bracing.
- The method of sealing the tremies and the emergency restart procedure if the seal is broken.
- An inspection plan detailing sounding locations and the frequency of soundings. Take soundings over the entire placement area on, at least, an hourly basis.
- A concrete sampling and testing plan.

3.b Water Under 600 mm (2 feet) Deep. If placing concrete in water 600 mm (2 feet) deep or less, build the concrete above the water level in one end of the form, then place the concrete on top of the concrete above water, and gradually work ahead so that the smallest possible area of fresh concrete is exposed to the water.

3.c Water Over 600 mm (2 feet) Deep. If concrete is placed in water deeper than 600 mm (2 feet), place in approximately horizontal layers, in a consolidated mass in its final position, using the tremie method or other acceptable method, and do not disturb after placing. Do not place concrete with bottom-dump buckets.

Use tight forms, constructed to retain concrete under water, and maintain still water within the forms. Regulate the consistency of the concrete to prevent segregation of the material.

Before placing tremie concrete, ensure the foundation area is level, and all forms and surfaces are free of mud and silt.

Use a tremie with a smooth interior face; and watertight discharge tube at least 250 mm (10 inches) in diameter, long enough to reach the bottom of the placement, and marked in 300 mm (1-foot) increments. Provide a valve or similar device, including various types of plugs, at the lower end of the discharge tube that closes tightly while the tremie is being charged and lowered into position, and that can be fully opened in the lowered position. Attach tremie tube to a funnel or hopper of at least 0.4 m^3 (1/2-cubic yard) capacity to facilitate transfer of concrete to the tremie. Do not use tremie tubes fabricated from aluminum. Furnish at least two tremie tubes to ensure

continuous concrete placement. Do not place tremie concrete by pumping directly to the bottom of placement. Place tremie concrete only in the presence of the Engineer.

Maneuver the tremie tube by using an accurately controlled crane or hoist that allows free vertical movement of the discharge end of the tube. Keep the concrete level in the tremie tube stable. Maintain the equilibrium level. Keep the discharge end of the tremie tube fully submerged in the freshly deposited concrete. Keep the tremie tube relatively motionless. Do not move the tremie laterally during concrete placement.

Place tremie concrete in one continuous operation. Place concrete at a rate that prevents aggregate segregation and allows flow over the entire placement area. Keep the top surface of concrete as level as possible. Maintain balanced hydrostatic pressures to prevent form failure and movement of water through the plastic concrete.

When the tremie concrete has reached a minimum compressive strength of 17 MPa (2,500 pounds per square inch), proceed with dewatering of forms. Upon completion of dewatering, and in the presence of the Representative, thoroughly inspect the hardened tremie concrete. Remove laitance and other undesirable material by chipping, scraping, or other means that are not detrimental to the sound concrete. Visually inspect tremie slabs 900 mm (3 feet) or less in thickness, and if any areas of the concrete are suspect, drill cores as directed. For slabs greater than 900 mm (3 feet) in thickness, verify concrete integrity by drilling four 50 mm (2-inch) diameter cores, or one 50 mm (2-inch) core for every 9 m^2 (100 square feet) of slab area, whichever is greater. Drill additional cores as directed. Use a double tube core barrel with a diamond bit to obtain the cores. Do not exceed 1500 mm (5 feet) for individual core runs. Drill cores from the top of the tremie slab to within 300 mm (12 inches) of the bottom. Operate drilling equipment at speeds and pressures that ensure satisfactory core recovery. Pull the core at the end of each run. Identify and store to preserve the integrity of the cores. Record the existence of any void areas or other concrete deficiencies. If defective concrete areas or voids are found, fill with pressure grout or cement concrete as directed. Completely fill all core holes as specified in Section 1001.3(k)10. Upon completion of the project, dispose of cores in a satisfactory manner.

4. Final Finishes.

4.a Conventional Finish. Do not brush or bag finish, or paint with grout or neat cement. After the forms are removed, correct irregularities in the exposed concrete surfaces. Exposed surfaces are surfaces above normal ground level or water level, when applicable, and surfaces that will not be concealed by other construction. Irregularities include fins, protrusions, individual holes larger than 25 mm (1 inch) in any dimension, and clusters of smaller holes.

4.b Tooled Finish. Tool finish surfaces as indicated by cutting into the body of the concrete with a pointed tool or bush hammer until the concrete surface shows a grouping of broken aggregate particles in a matrix of mortar.

4.c Other Finishes. Finish surfaces by other methods as indicated.

5. Patching. Saturate holes with water and, immediately, completely fill the holes with nonstaining, nonshrinking mortar. For holes passing entirely through walls, use a plunger-type caulking gun or other device to force the mortar through the wall starting at the back face. Hold a piece of burlap or canvas over the hole on the front face. Then, when the hole is completely filled, strike off the excess mortar until the mortar is flush with the surface. Completely fill holes not passing entirely through the wall by ramming the mortar in place with a suitable tool. Strike off the excess material until the material is flush with the wall surface.

For minor patching, treat concrete surfaces to be patched with a paint coat mixture of neat cement and water. Tamp mortar into place manually, preferably to at least 15 mm (1/2 inch) depth. When possible, overfill spaces being repaired. Allow the excess to stand for 5 minutes, then strike off and finish without excess troweling. Where the space cannot be overfilled, finish immediately. Cure for at least 3 days using an acceptable method that ensures against loss of moisture by evaporation. When required for all or part of the curing period, hold the mortar in place or support by using an acceptable method that ensures retention of the mortar without its drying out.

(g) Connections of Existing and New Concrete.

1. Terms. The terms “new concrete construction,” “fresh concrete,” and “hardened concrete” refer to work performed under the current contract.

The terms “existing concrete structures” and “existing concrete” refer to work performed under a previous contract.

2. General. To connect fresh concrete with hardened or existing concrete, thoroughly clean the connecting surface of laitance and loose and foreign material.

Coat contact surfaces with concrete bonding compound at construction joints, expansion joints, and where indicated as follows:

2.a Epoxy Bonding Compound. Place concrete against contact surface while epoxy bonding compound is still tacky to ensure bond between contact surface and fresh concrete. Wire brush or sandblast hardened epoxy before recoating with fresh epoxy. Use Type II, Grade 2, ASTM C881 epoxy.

2.b Non-Epoxy Bonding Compound. Place concrete against contact surface within the compound manufacturer’s recommended time frame. When recommended time frame has expired, follow manufacturer’s recommendations for recoating contact surfaces.

(h) Curing and Protection of Concrete. Begin curing as soon as the concrete has been placed and is sufficiently hardened. Cure concrete, either by membrane curing or by water curing.

Do not count as a curing day, a day on which the curing temperature drops below 10 °C (50F) at any time during that day, except for flood curing of footings. If at any time during the curing period, the curing temperature falls below 2 °C (35F), the Department will consider the work unsatisfactory and will reject it.

1. Definitions of Temperatures.

1.a Air Temperature. The measured temperature in the degrees Celcius (°C) (Fahrenheit (F)) in the shade, not in the direct rays of the sun.

1.b Curing Temperature. Curing temperature is the temperature of the air immediately adjacent to concrete. Where concrete is not covered by forms or other protective coverings, or where protective coverings are considered inadequate, the curing temperature will be the air temperature. The curing temperature for the first 24-hour period after placing concrete will be considered as not more than the temperature of the concrete at the time of its placement in the forms.

2. Records of Temperature. Provide high-low thermometers to maintain an accurate daily record of air and curing temperatures during cool and cold weather. In the presence of an Inspector, take curing temperatures on the surface of the concrete, at representative locations on a structure. Submit these temperature records daily to the Inspector-in-Charge.

3. Normal Curing and Protection.

3.a Liquid Membrane-Forming Curing Compound. For surfaces cured by the membrane method, finish before application of the curing compound. During the finishing period, and until forms are removed, protect the concrete by the water method of curing.

Apply the compound in two coats, by spraying, to provide a continuous, uniform membrane. For each coat, apply at least 1 L (1 gallon) of compound per 7 m^2 (300 square feet) of concrete.

On formed surfaces, apply the first coat immediately after stripping forms, and after acceptance of the concrete finish. If the surface is dry, soak the concrete with water, and apply the curing compound just as the surface film of water disappears. Apply the second application after the first application has set. During spray-curing operations, keep unsprayed surfaces wet with water.

Apply compound to unformed surfaces immediately after finishing operations have been completed and after the surface film of water has disappeared.

Do not apply membrane-curing compound to construction joint surfaces. Protect exposed steel during application of curing compounds. Water cure these areas, as specified in Section 1001.3(p)3.b.

If membrane is damaged or membrane peels from concrete surfaces, repair immediately.

3.b Water Curing. Use a fog-spray, perforated pipe or hose watering system to keep forms and curing covers saturated during the curing period. For curing and protecting covers on endwalls, inlets, manholes, copings, bridge seats, and similar miscellaneous concrete, keep saturated using an acceptable method. Flood curing of concrete footings will be allowed if the water temperature is 5 °C (40F) or above.

Use covers of either burlap-backed, white polyethylene sheeting, or a double thickness of burlap. For bridge decks, use only a double thickness of burlap. Use one type of cover for the duration of curing, unless a change in type is accepted. Place covers without marring the finished surface. Secure covers to prevent their being lifted and displaced.

Saturate the covers before use and keep saturated during the curing period. Cure for at least 7 days; except for high early-strength concrete. Cure high early-strength concrete for at least 3 days. Cure for the period of time required to obtain the minimum compressive strengths, as determined from previously molded cylinder specimens.

As soon as the concrete has hardened sufficiently, place curing covers on the exposed concrete. If the double thickness of burlap method is used, place burlap so each strip overlaps one-half its width.

As soon as forms or sections of forms are loosened or removed, cover the exposed concrete surfaces with pre-saturated curing covers, then keep saturated for the remainder of the curing period.

(i) Removal of Falsework and Forms and Application of External Loads to Concrete.

1. Removal of Falsework and Forms. Keep forms for walls, not sustaining loads, in place for a minimum of 12 hours after completing placement of concrete. Then, remove forms, provided the concrete has hardened enough to preclude damage resulting from form removal.

At construction joints, keep bulkheads in place for a minimum of 12 hours after placing concrete. Then, remove bulkheads provided the concrete has hardened enough to preclude damage resulting from removal of the bulkheads.

2. Application of External Loads to Concrete.

2.a Dead Loads. Do not begin work on wall construction until 12 hours after placing footings. For footings on piles, do not begin work until 48 hours after placing footings.

2.b Backfilling. Backfill as per the drawings. Do not backfill behind retaining walls, until 7 days after placing last concrete, and then only if concrete has attained the 7-day Minimum Mix Design Compressive Strength as specified in Section 704.

Maintain symmetrical loading on each side of the wall and progress uniformly in placing backfill unless otherwise indicated.

(j) Defective Work. Remove and replace concrete that is bulged, uneven, or that shows honeycombing or marks that cannot be satisfactorily repaired. If directed, remove and replace concrete that has not attained the specified 28 day compressive strength.

1001.4 MEASUREMENT AND PAYMENT—

(a) Cement Concrete. Cubic Meter (Cubic Yard) or Lump Sum

As indicated, for the class specified, for the item indicated.

The NRA will not deduct the volume of reinforcement bars from the measured volume of concrete.

Where it is impractical to measure concrete in cavities or sink holes, the NRA will measure by the volume shown on the certified slips of the delivered batch weights, as recorded by NRA representatives assigned to the work.

The cost of concrete cores, taken to examine tremie-placed concrete, is incidental to the other concrete work.

(b) Reinforcement.

1. Reinforcement Bars. Section 1002.4

Dowel bars required for unplanned joints are incidental to other reinforcement.

SECTION 1002—REINFORCEMENT BARS

1002.1 DESCRIPTION—This work is the furnishing and placement of reinforcement bars for cement concrete construction.

1002.2 MATERIAL—

(a) Reinforcement Steel. Reinforcement bars, Section 709.1. As indicated, provide epoxy coating for reinforcement bars as specified in Section 709.1(c).

(b) Other Material.

- Annealed Iron Wire—ASTM A 684/A 684M
- Cement—Section 701
- Water—Section 720.1
- Welding Material—Section 1105.02(t)

1002.3 CONSTRUCTION—

(a) General. Provide reinforcement free from injurious defects such as cracks and laminations. Provide reinforcement free from frost, dirt, oil, grease, paint, mortar, loose rust, mill scale, and other materials that would reduce bond. The National Roads Authority (NRA) will not reject reinforcement for bonded rust, surface seams, surface irregularities, or mill scale provided the minimum dimensions, cross-sectional area, and tensile properties of a hand wire brushed specimen meet the physical requirements for the size and grade of steel indicated.

Remove loose, scaly, or thick rust. A light powdery coating of rust, formed during project storage, does not require cleaning. The Engineer will reject reinforcement with rusting that has caused detectable reduction in cross-sectional area. Obtain the Engineer's acceptance of in-place reinforcement before concrete is placed. Maintain the reinforcement in the correct position.

Verify the compatibility of the bar schedule with the structure plans and details. Make adjustments to the bar schedule, including reinforcement bar details and quantities, and obtain the Engineer's acceptance before fabrication. The NRA will not grant additional Contract time as a result of adjustments to the bar schedule or to reinforcement bars. With each shipment of reinforcement bars delivered to the project, have the material supplier furnish a bill of lading that provides an itemized listing, as shown on the bar schedule for individual structural units, of all bars in the shipment by quantity, size, length, mark, type, mass (weight), and bending dimensions, as indicated. Include general project identification information as well as any appropriate remarks and plan references (drawing number, description, etc.) on the bill of lading. Submit bills of lading to NRA inspection personnel to verify and document field quantities and for the NRA's project records.

(b) Storage. Section 106.05(d) and as follows:

Store steel reinforcement above the surface of the ground on platforms, skids, or other supports, and protect the steel reinforcement as far as practical from mechanical injury and surface deterioration caused by exposure to conditions producing rust. Keep reinforcement free from frost, dirt, oil, grease, paint, mortar, loose rust, mill scale, and other materials that would reduce bond.

Handle and store epoxy-coated reinforcing steel by methods that will not damage the epoxy coating. Furnish all systems for handling epoxy-coated reinforcement bars with adequately padded contact areas if possible. Pad all bundling bands and lift all bundles with a strong back, multiple supports, or platform bridge to prevent bar-to-bar abrasion from sags in the bar bundle. Do not drop or drag bars or bundles. Transport and store epoxy-coated reinforcing steel on wooden or padded supports.

(c) Field Adjustment. Furnish bars with shapes and dimensions, as indicated. Do not field bend except to make indicated minor adjustments or as otherwise directed. If field bending or straightening is required, see Table A. Do not field bend rail or axle steel.

TABLE A (Metric)
Bend and Straightening Requirements (1) (2)

Bar Size	Carbon Equivalent	Bend Temp. °C	Straighten Temp. °C	Bar Size	Dia. of Former Millimeters Min.
10 15	Unknown	760-810	760-810	10 15	70 100
20	0.55 or less and A 706/ A 706M	20-40 or 760-810	20-40 or 760-810	20	120
25	Any	760-810	760-810	25	150
>25	Bending and straightening not recommended				

(1) Use temperature sticks.
(2) Avoid:
- 230 °C to 320 °C
- 1000 °C and greater

TABLE A (English)
Bend and Straightening Requirements (1) (2)

Bar Size	Carbon Equivalent	Bend Temp. F	Straighten Temp. F	Bar Size	Dia. of Former Inches Min.
4 through 7	Unknown	1400-1500	1400-1500	4 5	3 4
0.55 or less and A 706		70-100 or 1400-1500	70-100 or 1400-1500	6 7	5 6
8	Any	1400-1500	1400-1500	8	8
>8	Bending and straightening not recommended				

(1) Use temperature sticks.
(2) Avoid:
- 450F to 600F
- 1800F and greater

Note:
A. Apply heat to sufficient area to encompass bend area.
B. Apply heat for sufficient time to bring bar center to required temperature.
C. Maintain temperature while bending and/or straightening.
D. Allow free rotation.
E. Bend with smooth continuous application of force.
F. Straighten by moving hickey bar (if used) progressively around bend.

(d) Placing and Fastening.

1. General. Accurately place steel reinforcement as indicated and hold it firmly in position during the placing and settling of concrete using metal chairs or acceptable supports. Do not allow bar spacing to vary from the design spacing by more than 12 mm (1/2 inch). Do not allow the distance from the surface of the formwork to the bars to vary more than 6 mm (1/4 inch) from the design distance. Do not place reinforcement closer than 1.5 times the maximum nominal size of the aggregate used in the concrete mix design. Firmly tie bars at all intersections with annealed iron wire or secure the bars with acceptable metal clips. Tie bundled bars together at not more than 1800 mm (6-foot) centers. For epoxy-coated reinforcement, provide plastic-coated or epoxy-coated tie wire and metal clips. If fabric reinforcement is shipped in rolls, straighten it into flat sheets before placing it. Do not weld cross bars (tack weld) for assembly of reinforcement unless authorized in writing by the Engineer.

2. Support Systems. Support reinforcing steel in its proper position by use of mortar blocks, wire bar supports, supplementary bars, or other devices. Supply such devices of proper height and at sufficiently frequent intervals to maintain the distance between the reinforcing and the formed surface or the top surface of deck slabs within 5 mm (1/4 inch) of that indicated.

Support platforms, supporting men and equipment during concrete placement, directly on the forms and not on the reinforcing steel.

2.a Mortar Block Supports. Furnish mortar blocks of the same strength as the concrete in which they are to be embedded. Ensure that block faces in contact with forms for exposed surfaces do not exceed 50 mm x 50 mm (2 inches by 2 inches) in size, and that their color and texture will match the concrete surface. If used on vertical or sloping surfaces, provide such blocks with an embedded wire for securing the block to the reinforcing. If used in slabs, use either a tie wire or, if the gravitational force of the reinforcing is sufficient to firmly hold the blocks in place, a groove in the top of the block. For epoxy-coated bars, use plastic-coated or epoxy-coated tie wires.

2.b Wire Supports. Furnish wire bar supports, such as ferrous metal chairs and bolsters conforming to industry practice as described in the Manual of Standard Practice of the Concrete Reinforcing Steel Institute. Ensure that chairs or bolsters that bear against the forms for exposed surfaces are either Class 1 - Maximum Protection (Plastic Protected) or Class 2, Type B - Moderate Protection (Stainless Steel Tipped) for which the stainless steel conforms to ASTM A 493, Type 430. For epoxy-coated reinforcement, provide plastic-coated, epoxy-coated, or galvanized wire bar supports and bar clips.

2.c Plastic Supports. Use chairs and bolsters that do not deflect more than 6 mm (1/4 inch) under the minimum point load requirement of 1.56 kN (350 pounds-force). Use supports molded in a configuration that does not restrict concrete flow.

3. Adjustments. Adjust reinforcement used in post-tensioned concrete, or relocate it during the installation of prestressing ducts or tendons, as required to provide planned clearances to the prestressing tendons, anchorages, and stressing equipment, as approved by the Engineer.

(e) Splicing and Lapping. Furnish all reinforcement in the full lengths, as indicated, unless otherwise allowed by the Engineer.

Do not splice bars, except as indicated or directed. If splicing is allowed, lap the reinforcement bars as shown on the Drawings and as indicated, and wire together securely. Do not substitute alternate bars unless allowed by the Engineer. Stagger splices as far as possible.

In lapped splices, place and wire the bars maintaining the minimum distance to the surface of the concrete as indicated.

Only use welded splices if indicated or if the Engineer gives written authorization to do so. Ensure that welding conforms to the Structural Welding Code, Reinforcing Steel, AWS D1.4 of the American Welding Society and applicable special provisions.

Do not use welded splices on epoxy-coated bars. Do not weld so close to epoxy-coated bars to cause any heating of the coating.

(f) Epoxy-Coated Reinforcement Bars. In addition to the above, the following requirements apply if using epoxy-coated reinforcement bars:

1. Storage, Handling, and Placement. Extended storage of coated bars at the jobsite should be avoided. If storage on site is expected to exceed two months, cover the coated bars or bundles with opaque polyethylene or other protective material. Provide ventilation to prevent condensation from forming under the covering.

Store, handle, and place epoxy-coated bars at the jobsite according to ASTM D 3963/D 3963M. Inspect the bars before placement. If the epoxy coating is damaged and the damages do not exceed 2% of the surface area in any 0.3m (1-foot) section of the bars, repair all visible damage according to ASTM D 3963/D 3963M before bar placement. Replace bars if damage to the surface area exceeds 2% in any 0.3m (1-foot) section.

After placement, inspect the bars again and repair areas damaged during placement.

2. Welding. Do not weld.

3. Appurtenances. Use plastic-coated or epoxy-coated tie wire. Use chairs and metal supports that are epoxy-coated, plastic-coated, or galvanized. The Contractor may submit alternate support devices for acceptance. Use a minimum coating thickness of 75 μm to 100 μm (3 mils to 4 mils) on appurtenances.

1002.4 MEASUREMENT AND PAYMENT—

(a) Reinforcement Bars. Kilogram (Pound) or Lump Sum
As indicated for the type specified.
Annealed iron wire, chairs, and ties are incidental to the mass (weight) of the reinforcement bar.

SECTION 1006—DRILLED CAISSONS

1006.1 DESCRIPTION—This work is construction of cement concrete drilled caisson foundations consisting of shaft sections with or without casings left in place, and with or without rock sockets or belled footings, all formed within drilled excavations.

The following definitions apply:

(a) End Bearing Drilled Caisson. Cast-in-place foundation element consisting of shaft section with or without enlarged bearing area at its base, and deriving the majority of its compression load capacity through load transfer to the shaft base.

(b) Bell Footing. Enlargement at base of shaft.

(c) Bearing Strata. Layer(s) of soil or rock providing principal support at base of shaft.

(d) Rock Stratum. A stratum of geomaterial having an unconfined compressive strength equal to or greater than 1.7 MPa (250 pounds per square inch) that cannot be drilled with conventional earth augers or underreaming tools, thus requiring the use of special rock augers, core barrels, air tools, blasting, or hand excavation.

(e) Shaft Section in Soil. Length of caisson shaft from top of shaft to top of rock stratum.

(f) Shaft Section in Rock. Length of caisson shaft from top of rock stratum to top of rock socket.

(g) Rock Socket. Length of caisson in rock stratum below the shaft, providing a fixed connection between the caisson and the rock stratum.

(h) Permanent Casing. Steel pipe, typically of cylindrical shape, installed by drilling, driving, or vibrating that when filled with concrete, becomes a permanent part of the drilled caisson.

(i) Temporary Casing. Protective steel pipe, typically of cylindrical shape, installed by drilling, driving, or vibrating, that provides lateral earth support during shaft excavation, cleaning, and inspection; controls groundwater infiltration; and is removed as part of the concrete placement operation.

(j) Obstruction. A natural or manmade object above designated rock socket elevation that cannot be drilled with conventional earth augers or underreaming tools, and that requires the use of special rock augers, core barrels, air tools, blasting, or hand excavation.

1006.2 MATERIAL—

(a) Casing. Smooth, clean, rust-free metal casing of sufficient strength to withstand handling and installation stresses and the pressure of concrete, water, and the surrounding earth; and to prevent water seepage.

(b) Class A Cement Concrete. Section 704, with high-range water-reducing (HRWR) admixture and a slump of 125 mm to 200 mm (5 inches to 8 inches).

(c) Reinforcement Bars. Section 1002.2. Use deformed bars.

(d) Bentonite Slurry. A mixture of fully hydrated bentonite and clean fresh water of adequate unit mass (weight). Submit manufacturer's specifications, type, and properties of the slurry to the Engineeer for approval.

(e) Welding Material. Section 1105.02(t)

1006.3 CONSTRUCTION—

(a) Excavation. Excavate to the dimensions and elevations indicated, or as directed. Unless otherwise indicated, bore excavations for vertical caissons plumb to within a tolerance equal to 2% of the shaft length; and for battered caissons, as indicated, to within a tolerance equal to 5% of the shaft length but not more than 300 mm (1 foot). If holes are more than 150 mm (6 inches) out of plumb, redesign the footing that is to be supported by the caissons. If caissons are out of tolerance, make needed corrections to the structure at no additional expense to the National Roads Authority (NRA). Do not place the top of a caisson out of the indicated position by more than 1/24 of the shaft diameter or 75 mm (3 inches), whichever is less. If belled footings are required, excavate to form a bearing area of the size and shape indicated. The Contractor may blast if allowed by the Engineer. Submit blasting plan to the Engineer for review and acceptance at least three weeks before the start of blasting operations. Do not disturb formations below or outside the limits of the caisson under construction or any previously constructed caissons adjacent to the excavation.

Do not excavate within three diameters of caissons with new concrete until 24 hours after concrete placement.

If satisfactory foundation materials are encountered at other than the indicated elevations, adjust drilling depths as directed.

If a caving condition or excess groundwater is encountered, discontinue the drilling operation and employ a construction method that prevents caving and groundwater infiltration, such as the installation of casings. As an alternate, the Contractor may drill in a bentonite slurry with removal of cuttings or dewatering, or other construction methods that control the size of the excavation, provided the Contractor can demonstrate the ability to perform such work to the satisfaction of the Engineer.

Remove, as directed, caked material from the sidewalls and loose cuttings from the bottom of the excavation so that such material will not cause unanticipated settlement, reduce caisson capacity, or affect concrete strength.

If bentonite slurry is used to support the caisson excavation, provide slurry mix design for review and acceptance before caisson construction. As a minimum, provide mix design criteria for density, viscosity, shear strength, and pH and procedures for mixing, QC, maintaining level in excavation, cleaning, reuse, and disposal.

Provide casing through soil and broken or unstable rock at all times during hand cleaning and inspection of the excavation. If joining two or more sections of casing to obtain the required length, weld sections together as specified in Section 1105.03(m) to develop the full tensile strength of each section.

(b) Probe Holes. Provide downward pressure control air track drilling machinery of a type or types approved by the Engineer, complete with all the accessories. Provide drilling rig(s) of sufficient size and capacity to carry on drilling operations in an efficient manner, and provide holes of adequate size, (minimum of 3-inches in diameter), through the bedrock. Equip the drill rigs with pressure gauges to accurately, (within 1% of maximum pressure) indicate increases and decreases in drilling air pressure on the drill bit. Drill 50 mm (2-inch) diameter unsampled holes at the specified locations, to the specified depth below the bottom of the excavation (caisson or rock socket), or as directed. The Representative will use the rate of drilling of the holes to determine whether there is satisfactory material or rock of sufficient thickness and type to support the required load, and to locate the presence of open joints, voids, soft rock, or other deleterious material that may be inadequate for support of the required load.

(c) Inspection. Do not place concrete until the foundation excavation has been inspected and accepted. If access to the bottom of the excavation for visual inspection cannot be provided because of inability to dewater the excavation using acceptable pumping methods, provide drilling logs and core samples, or other acceptable data, for determining the condition of the excavation and the quality of the foundation material. As a minimum, inspect each shaft that cannot be dewatered with an underwater video camera.

Provide video camera for inspection and the determination of the depth of rock socket. This camera should be capable of both horizontal and vertical viewing of the caisson walls as well as the bottom with its depth and compass orientation known at all times. Record each caisson on a VHS tape for cross hole correlation in the event of subsurface irregularities.

Perform this work in the presence of the Engineer. Schedule construction appropriately to allow 48 hours of video review time of each caisson prior to the construction of each. Review each tape in the presence of the Engineer prior to moving to the next caisson to assure tape quality. Await written approval to the contractor from the Engineer prior to caisson construction.

Follow safety practices as specified in Section 107.08 and include, as a minimum, the following items specifically required for inspection of drilled caisson excavations:

- Cover open excavations immediately upon completion or, if work is discontinued for any period of time, with a cover capable of preventing persons from falling into or entering the excavation without proper authorization. Secure the cover by approved methods.

- Provide casing through soil cavities and broken or unstable rock for inspection of the excavation.

(d) Reinforcement. Section 1002.3 and as follows:

Do not place reinforcement bars until all loose material has been removed from the bottom of the excavation and immediately before the start of concreting operations. Support reinforcement a minimum of 75 mm (3 inches) above bearing level and from the sides using precast concrete spacer blocks or other approved spacer devices, and secure it in position so that the required concrete cover is maintained throughout concrete placement.

Vibration of the concrete is required, unless the clear distance between bars is more than three times the bar diameter or three times the maximum aggregate size. Unless otherwise indicated or specified, place No. 20 (No. 6) deformed bars vertically around the circumference at a 150 mm (6-inch) spacing, and No. 10 (No. 4) bars as tie bars on 250 mm (12-inch) centers. Furnish bars with hooks meeting seismic requirements.

(e) Dewatering. Unless otherwise specified, dewater all excavations before placing concrete. A drilled caisson excavation is considered dry if less than 75 mm (3 inches) of groundwater is present in the bottom of the excavation at the start of concrete placement and the groundwater infiltration rate is less than 6 mm (1/4 inch) rise per minute. Remove water that has accumulated in the excavation after final inspection and before concrete placement using approved methods.

(f) Concrete Placement. Submit the method of concrete placement, including details on equipment, rate of placement, concrete head, etc., to the Engineer for review and acceptance three weeks before anticipated first placement. Do not start concrete placement without written acceptance. Mix, place, vibrate, and cure concrete as specified in Section 1001.3. Place concrete within 18 hours of the completion of excavation and within three hours of final inspection. Keep the excavation free from accumulated seepage water and loose material until concrete is placed. Place the concrete for each caisson in one continuous operation. Thoroughly work and vibrate the upper 1.5 m (5 feet) of concrete. If the Engineer determines that water seepage will be detrimental to the quality of the caisson or hinder proper placement of concrete by the free fall method, fill the excavation to the surrounding groundwater level with clean, fresh water and place concrete to the cutoff elevation by the tremie method, as specified in Section 1001.3(k)3.c, in one continuous operation. Provide documentation to satisfactorily demonstrate experience in the use of tremie or pumping procedures for placement of concrete for drilled caissons, and submit details of the placement method for review and acceptance. Do not allow concrete to come in contact with aluminum during placement.

1. Placement by Free Fall Method. Place concrete by free fall only in dry, clean, unobstructed excavations that are at least 750 mm (30 inches) in diameter. Provide a hopper and a section of rigid pipe not less than 1.5 m (5 feet) long and 250 mm (10 inches) in diameter to direct concrete fall and avoid impact with reinforcement on the sides of the excavation. Unless otherwise directed, limit depth of free fall to 7.6 m (25 feet).

2. Placement by Tremie Method. Place concrete using a rigid, watertight, ferrous metal tremie pipe, as specified in Section 1001.3(k)3.c. Begin placement with the tremie pipe discharge within 150 mm (6 inches) off of the bottom of the excavation. Maintain a concrete head of at least 1.5 m (5 feet) above the discharge at all times.

3. Placement by Pumping Method. Pump only if concrete placement cannot be done by other means. Place concrete by pumping through a flexible; ferrous metal, rubber, or plastic pipe with a minimum diameter of 150 mm (6 inches). Do not allow the concrete to segregate during pumping. If directed, pump 28 L (1 cubic foot) of concrete into a container so that the Inspector may verify that the concrete is not segregating during the pumping operation.

Begin pumping with the pipe discharge positioned not more than 150 mm (6 inches) off of the bottom of the excavation. Maintain a concrete head of not less than 1.5 m (5 feet) above the discharge at all times. Keep the pump hopper continuously filled with concrete to prevent entrapment of air in the discharge.

4. Placement within Casing. Use the free fall or tremie method to place concrete in dewatered excavations supported by casing. Pump concrete within casing only if placement cannot be done by other means. Use the tremie method to place concrete under water in casing supported excavations.

If the top of shaft elevation is below ground level at the time of concrete placement, provide an oversized casing from ground elevation to a point below the top of shaft to prevent extraneous material from falling into fresh concrete during and after placement. Keep the oversized casing in place until concrete has cured at least 24 hours.

For permanently cased drilled caissons that carry lateral loads, grout the area between casing and excavation to provide adequate bearing.

5. Placement Under Bentonite Slurry. Use the tremie method to place concrete in excavations supported with bentonite slurry. Pump concrete under bentonite slurry only if placement cannot be done by other means. Displace slurry with concrete beginning at the bottom of the excavation and proceeding upward, forcing the slurry out of and away from the top of the excavation.

(g) Casing Removal. If temporary casing is used, withdraw each section, except the final section, in partial stages, as concrete is deposited, at a rate that keeps the bottom of the casing below the top of the fresh concrete. During removal, ensure that there is no reduction in shaft cross-section and that displacement of steel reinforcement is less than 50 mm (2 inches) upward and less than 50 mm (2 inches) downward per 6 m (20 feet) of shaft length. Maintain the specified 75 mm (3-inch) reinforcement bar clearance at bearing level and on the sides during casing removal. If observations indicate otherwise, reduce the rate of casing removal and establish a head of concrete within the casing sufficient to offset the forces tending to cause concrete arching or displacement of the reinforcing cage. As concrete is deposited, withdraw the final section of casing to a point 600 mm (2 feet) below existing ground elevation and allow it to remain for approximately 2 hours, depending on the temperature. Then, completely withdraw the section or cut it off flush with existing ground. If cavities or unstable materials are encountered and the danger exists of losing concrete or of the concrete becoming mixed with extraneous material, cut off the casing at the top of shaft elevation and leave in place.

(h) Records. Prepare and submit detailed inspection reports for each shaft, and include the following information:

- Accurate location and dimensions of the excavation.
- Accurate top and bottom elevations.
- Measurement data for plumbness.
- Methods of excavation used.
- Description of materials encountered during excavation.
- Description of groundwater conditions encountered.
- Description of obstructions encountered and whether or not obstruction removal was achieved.
- Description of temporary or permanent casing placed including purpose, length, and wall thickness, and anchorage or sealing methods used, if any.
- Measurements of slurry quality including, as a minimum, density, viscosity, shear strength, and pH.
- Elevation at which bearing material was encountered. Description of bearing material. Probe holes made, along with method of probing, rate of drilling in rock, samples taken, tests made, and conclusions reached with regard to adequacy of bearing material.
- Shaft, bell footing, and rock socket measurements.

- Description of clean-out methods and adequacy of initial clean-out and final clean-out just before concrete placement.
- Record of depth of water in excavation and rate of water infiltration before concrete placement.
- Record of reinforcing steel inspection for position and adequacy.
- Method of concrete placement and casing removal, if any. Record of concrete head during removal of casing. Record of concrete elevation when vibration started.
- Difficulties encountered including soil inclusion, voids, shaft squeeze-in, and casing collapse.
- Concreting curves showing actual versus theoretical volume of concrete required to fill caisson excavation.
- Condition of concrete delivered to site including record of slump, density, air content, and other tests. Record of cylinders made for compression testing.
- Any deviations from the specifications.

(i) Qualifications. Construct the caissons with a supervisor and workforce experienced in the construction of drilled caissons, and meeting the following qualifications:

- Submit a list containing at least five projects that, together, demonstrate a minimum of three years experience in the construction of drilled caissons, including the proposed method of concrete placement. Include a brief description of each project, and the name and telephone number of owner's representative knowledgeable in each project listed.
- Furnish the name of a degreed engineer, with at least 10 years of experience in the design and construction of drilled caissons, who is to direct the work.
- Furnish the names of drill operators and on-site supervisors under the direction of the degreed engineer. Each drill operator and on-site supervisor must have at least 1 year of experience in the construction of drilled caissons.
- Do not use only the company names of consultants or manufacturers to meet the requirements of this section; use the names of the personnel.
- Submit documentation of staff qualifications to the Engineer and allow at least 21 calendar days for approval.

1006.4 MEASUREMENT AND PAYMENT—

(a) Drilled Caissons, Shaft Section.

1. Shaft Section in Soil. Meter (Linear Foot)
Measured from the shaft top to the top of rock.

2. Shaft Section in Rock. Meter (Linear Foot)
Measured from the top of rock to the shaft bottom.

(b) Drilled Caissons, Bell Footing. Each

(c) Drilled Caissons, Rock Socket. Meter (Linear Foot)

Measured from the shaft bottom to the socket bottom. For uneven rock surfaces, measure length of rock excavation from the rock surface at shallowest depth to the socket bottom.

(d) Permanent Casing for Drilled Caissons. Meter (Linear Foot)

The Department will measure and pay for temporary casing left in place, as specified in Section 1006.3(i), as permanent casing.

(e) Test Holes. Meter (Linear Foot)

Augering through overburden, from existing ground surface to the elevation at which NW (NX) core boring is to begin (bottom of caisson or rock socket excavation as specified in Section 1006.3(b)), is incidental to this work.

(f) Probe Holes. Meter (Linear Foot)

(g) Exploratory Drilling. Meter (Linear Foot)

(h) Obstructions. Meter (Linear Foot)

The unit price includes mobilization of drilling equipment.

SECTION 1007 - LIMITED MOBILITY GROUTING

1007.1 DESCRIPTION - The work includes all labor, plant, equipment, materials, and the performance of all operations in connection with drilling grout holes, mixing, transporting and injecting the grouting materials, care and disposal of drill cuttings, waste materials and waste grout; cleaning and restoration of the work areas upon completion of the work, and all such other operations as are incidental to the drilling and Limited Mobility (LM) grouting. LM grouting is considered specialty geotechnical work that must be performed in compliance with this document by an experienced Contractor. A representative of the National Roads Authority will be on-site, full-time, to oversee all operations.

(a) Purpose. The locations of LM grout injections are shown on the drawings. The grouting will improve the bedrock for support of drilled shafts. LM grouting injected into the void spaces or the soil-filled cavities of the bedrock will increase the bedrock quality by filling the void spaces and replacing soft, loose soil-filling in cavities with high internal friction grout that will improve stress transfer between rock units in the bearing zone of the structure foundations. The LM grout shall be incapable of flowing under its own weight into the rock fractures. It is the intent of this procedure to limit the extent of grout travel to those areas providing support to the structure and to develop improved bearing and a mechanically interlocked rock mass within this area of support.

(b) Definitions

Back Pressure: Residual pressure in the grout hole in the absence of grout flow.

Grouted Support Zone: The top ten feet of rock below the shaft head in the area indicated on the drawings.

Grout Take: Quantity of grout measured in cubic feet per vertical foot of grout hole in any stage.

Injection Riser: A flush-joint steel pipe, having at least a 2-inch inside diameter, installed tightly in a drilled hole through which grout is injected.

Limited Mobility Grouting: The controlled injection of stiff, low slump, mortar-like soil-cement grout that penetrates into cavities, displaces loose or soft soil in rock cavities and fills the open void spaces into which it is injected, without dislodging the rock or traveling into small fractures and joints.

Production Drill Hole: Any boring advanced for the purpose of facilitating grouting.

Split Spacing: The procedure of locating successive grout holes midway between two previously drilled and grouted holes.

Soil Cement Grout: A mixture of Portland cement, soil and water mixed to a uniform consistency similar to a mortar with a maximum slump of 2-inch.

Stage: A partial or complete length of hole that is grouted as a unit. The actual length of a stage depends upon grouting conditions encountered.

1007.2 MATERIALS –

(a) Grout. Composed of water, cement, and soil and may contain added mineral filler, water reducing agent or other approved additive as required for the work. Provide grout with a maximum slump of 2-inch and a minimum 28-day compressive strength of 1,500 psi.

(b) Water. Conform to Section 720.1.

(c) Cement. Conform to Section 701.

(d) Soil. Composed of silty sand classified 'SM' in accordance with the Unified Soil Classification System, free of clay lumps, roots, and aggregate larger than 3/8". Provide material having particles with rounded or cubical shapes and with the ratio of the smallest to largest dimension of the grains greater than 0.5. The soil may be manufactured as a combination of separately processed sizes or classification, the different components may be batched separately, or blended prior to delivery to the mixing plant. The soil may consist of a mixture of clean concrete sand with mineral fillers added in lieu of silt. Provide soil meeting the following guidelines:

Sieve Designation U.S. Std. Square Mesh	Cumulative Percentage by Weight Passing
3/8"	100
4	80-100
10	50-100
200	10-30

and: PI<5; LL<30

Provide a soil mixture that produces a mix with the minimum amount of fines to meet the grout requirements.

(e) Concrete Sand. Provide aggregates to be mixed with mineral fillers. Sand that conforms to the requirements of, Section 703.1(c), Type A2 Fine Aggregate.

(f) Mineral Filler. Fly ash conforming to the requirements of, Section 724.2(b).

(g) Water Reducing Agent. A compound possessing characteristics which will increase the flowability of the mixture, assist in dispersal of the cement grains, and neutralize the setting shrinkage of the grout. Bentonite or other high plasticity clays are prohibited at concentrations greater than 1 % by dry weight.
FINE GRAVEL: Mineral aggregates of crushed or natural stones being retained between the standard No. 4 and 3/8" sieves that should be added to the grout where large takes occur. Size should be limited by the capability of the pumping equipment and set by the contractor.

1007.3 CONSTRUCTION –

(a) Contractor Qualifications.

1. Contract a specialty limited mobility grouting contractor for this portion of the work.

2. The approved specialty limited mobility grouting subcontractor shall have the following qualifications:

- Be a Specialist regularly engaged in low slump limited mobility grouting work.
- Provide references to substantiate having completed successfully at least three similar limited mobility grouting projects within the last five years.
- Provide a full-time grouting superintendent with at least 5 years experience in the methods and procedures required by these specifications.
- Have the indicated equipment in good working condition required to perform the work outlined in this specification.

(b) Submittals.

1. Contractor Qualifications: Submit the information necessary to show compliance of Grouting Subcontractor with qualifications 30 days prior to the start of work. Submit the grouting Subcontractor's financial statements, job descriptions, references that may be contacted, key personnel resumes and lists of

equipment in possession to be used on this project. Include among the references, owners and engineers familiar with the contractor's performance of limited mobility grouting on specific projects.

Provide the grouting subcontractor's detailed information concerning at least three similar limited mobility grouting projects within the past five years, including the following information for each project:

- Name and Location of Project
- Total Dollar Value of the Limited Mobility Grouting Portion of the Work
- Quantity of Limited Mobility Grout Placed
- Equipment Used
- Grout Mix Design
- Drilling Methods and Depths
- Name of Site Superintendent or Foreman in Charge of the Grouting
- Name, Phone Number and Address of Owner
- Name, Phone Number and Address of Design Engineer

Submit all of the above information at least 30 days prior to the start of the grouting work.

2. Equipment and Materials List: Submit lists of equipment and materials to be used, for approval by the Engineer. Submit appropriate documentation regarding the control of materials. Demonstrate the grouting subcontractor's equipment to be capable of injecting the required mix at the required pressures at the site, prior to commencement of grouting by preparing a test injection at a location designated by the Engineer. Demonstrate all monitoring and measurement devices and orient the Engineer to the equipment operation and arrangement as part of this demonstration. Replace any equipment found to be inadequate of achieving the project requirements at no cost to the Authority.

3. Submit a plan describing operations for drilling and grouting to achieve improvement of the grout support zone for the approval by the Authority. Include location, sequence, depth of injections, anticipated volumes and rates, methods of drilling, sealing and extracting risers, mixing, pumping and delivery of grout, and all other aspects of the grouting on the plan.

Approximate locations of grout holes are shown on the drawings. This plan is preliminary and for information purposes only. Adjust the grouting plan as necessary for equipment access, subsurface structures, and other factors affecting the drilling and grouting. Do not exceed 5-foot spacing between injections. Submit plan to the Engineer 30 days prior to drilling.

4. Grout Mix Design: Submit a grout mix design to achieve the specified strength, pumpability, and slump for approval by the Engineer.

(c) Material Delivery, Storage, and Handling.

- Store sufficient quantities of each material at the site to ensure that grouting operations will not be delayed by material shortages. Store all materials and prevent exposure to excessive temperature.
- Properly store all bulk and bagged materials to prevent damage from moisture or contamination. Discard any cement, sand, mineral filler, and water reducing agent that is damaged by moisture or contamination.

- In the event fine gravel is found to contain foreign matter or oversize particles, screen the material to attain the required particle sizes indicated. No additional payment will be made for screening.

(d) Equipment.

1. General: Provide drilling and grouting equipment of a type, capacity, and mechanical condition necessary for doing the work, as indicated. Provide equipment capable of re-circulation of the grout to purge the lines and adjust the grout consistency between injections, providing accurate control of grout injection rate and measuring volume injected into each stage. Conform the power, equipment, operation and the layout thereof, to all applicable requirements of Local, and National regulations and codes.

Submit an equipment list for the Engineer's review indicating the manufacturer, model, type, and capacity of all equipment to be used. Prior to commencement of work, demonstrate in the presence of the Engineer at the job site that the mechanical condition of the equipment is satisfactory by pumping a test mix and performing a test injection. Any deficiencies noted shall be corrected before proceeding further. Substitution of any piece of equipment after commencement of the work shall not be permitted unless approval is given by the Engineer. If during the course of grouting, the Engineer determines that any piece of equipment is not operating satisfactorily, the Engineer will require it to be removed immediately and replaced with one meeting the Engineer's approval.

2. Drilling and Riser Equipment: Provide grout injection risers consisting of flush-joint steel pipes having at least a 2-inch inside diameter. Risers shall be sufficiently strong to resist the forces of drilling, installation, grouting and extraction. Provide drilling equipment sufficient to penetrate concrete, soil, rock and other materials that may be encountered during the installation of risers to the depths indicated. Use short riser lengths to permit accurate readings of the riser mounted pressure gage at all times. The drilling equipment shall be capable of installing the risers to the depths required on the approved Grouting Plan, with less than 1/4 inch annulus between the riser pipe and the inside of the drilled hole. The drilling equipment may be pneumatic, hydraulic, percussion or rotary. It is required that the drilling equipment be of a type that advances the riser during drilling. The riser must be capable of penetrating rock to the required depth. Disposable knock-off points are to be used to prevent intrusion of materials into the riser.

3. Pump: Provide a positive displacement grout pump, piston-type with a constant controllable rate of output. Provide pump capable of injecting stiff soil-cement grout with a slump of 2-inch or less at controllable rates from 0.05 cfm to 2 cfm at pressures of at least 600 psi, measured at the riser. The volume displacement rate of the pump shall be calibrated by pumping into a container of known volume of at least 1 cf or larger. A stroke counter or other approved volume measurement device shall be used to provide a record of volume injected in each stage. Provide equipment for the calibration of the volume measurement device and perform calibration at the start of the work and at other times as required by the Engineer.

4. Pressure gages: Provide calibrated new pressure gages with capacities of zero to at least 600 psi, but no greater than 1000 psi. Provide pressure gages marked in 10 psi divisions for the full scale with a minimum accuracy of ½ divisions. Provide a sufficient number of each to cover replacement and recalibration without any delay in work. Provide gages with a minimum face diameter of 3 inches. Submit calibration certificates for each gage. Place gages at the top of the injection riser and at the pump. Provide and maintain gage savers as necessary to provide accurate readings throughout the work. Alternate digital pressure monitoring devices may be acceptable if calibrated to equal or greater accuracy and approved by the Engineer.

5. Grout Plant: Provide an on-site grout plant capable of mixing, stirring, pumping, and delivering the grout as indicated. Maintain the grout plant in optimum operating condition at all times. Replace any grout hole lost or damaged due to mechanical failure of equipment or inadequacy of grout supply by drilling and grouting another hole at the Contractor's expense. Furnish at least one mechanically driven, screw or pug mill type grout mixer capable of effectively mixing and stirring stiff soil-cement grout having a slump of 2-inch or less. Provide mixing equipment capable of continuously metering quantities of materials in the grout mix. A batch mixer may be used in place of the previously noted grout mixer, where quantities of materials are measured and blended into each batch. Provide a mixer with means of dispensing stiff soil cement grout directly to the grout pump in sufficient quantities.

6. Measurement Equipment:

a. Grout Measurement: Provide equipment for performing accurate and rapid measurements of grout quantities injected and quantities of water, soil, cement, and additives used for mixing. Demonstrate and calibrate all measurement systems and equipment before the start of grouting. Provide measurement equipment capable of measuring grout quantities to the nearest 0.1 cu. ft.

b. Movement Monitoring: Provide equipment necessary to detect movements of the ground surface. Provide a rotating laser level or other approved means to measure ground surface movement at a minimum of 3 points during the grouting to detect heaving of the ground surface. Provide monitoring equipment capable of accurately measuring movements of 0.1 inch or less.

c. Hole Alignment: Locate grout holes within 0.1 feet of the plan location and align grout holes within 1 degree of planned angle.

(e) Mixes.

1. Grout Mixes: Proportion mixes as specified in the approved mix design. Provide a mortar grout consisting of cement, soil and water. Add mineral filler and fluidifier or other approved additives as needed per the approved mix design.

2. Mix Proportions: Vary the constituents of the grout to include any or all of the additives, to achieve a pumpable mix with a maximum slump of 2-inch. In certain instances, approved by the Engineer, grout with up to a 2.5 inch slump may be utilized. Thicken or otherwise modify the mix so that grout does not form lenses or exude from the ground surface around the injection pipe. Reduced slump and/or addition of fine gravel may be required where open voids are encountered.

Provide grout consisting of cement, soil and water sufficient to meet the above maximum slump with a minimum 28-day compressive strength of 1,500 psi in accordance with ASTM C109. Provide grout with an infinite egress time (i.e. zero flow) when tested with a Marsh Funnel (flow cone).

(f) Drilling and Installation of Riser.

1. Drill and install riser 10 ft below the proposed shaft head in accordance with the approved Grouting Plan. Drill additional holes and install risers if directed by the Engineer. All grout holes must extend at least 10 feet below the top of rock. The riser shall be a minimum 2-inch diameter flush joint pipe installed from the ground surface to the bottom of the grout hole.

2. Where air or water circulating equipment is used, maintain continuous circulation and control the air or water pressure to prevent fracturing of the bedrock. Should any heaving or other displacement be noted during drilling, cease drilling until the procedure can be modified to prevent such damage.

3. Maintain a log of observations including hole number, top of hole elevation, total depth of riser installed, drilling methods used, depth of soil overburden, top of bedrock elevation, possible voids, fractured zones, and other conditions noted during the drilling for each grout hole.

4. Fit the riser tightly within the drill hole. Backfill the annulus using uniformly graded fine dry sand (such as play sand) to achieve a tight fit.

5. Set grout risers in the order shown on the approved Grouting Plan.

6. Risers withdrawn during limited mobility grouting may be reused after cleaning to remove any grout.

7. Secure knock-off bits against falling off before completion of the riser installation. Where knock-off bits or driving points are used, extract the pipe a few inches and knock off the bit or point immediately after the completion of drilling.

(g) Grouting.

1. Limited Mobility Grouting Plan: Include provisions to prevent damage to subsurface structures and utilities. Modify the plan to include avoidance of utilities such that no drilling is done within 2 feet of existing pipes or conduits and no grout is injected within 5 feet of pipes or conduits horizontally or vertically.

2. Procedures: Perform all grouting operations at the presence of the Engineer who shall monitor pumping rates, and pressures used. Perform additional grouting as directed by the Engineer. Monitor grouting and maintain records in accordance with "Record keeping" outlined below. Specific procedures will be determined by subsurface conditions; however, the procedures shall be in general accordance with the following guidelines:

- Pump grout using a high pressure piston type grout pump through minimum 2-inch inside diameter grout lines at pressures to 600 psi, or greater, as measured at the riser. Avoid sharp bends and diameter reductions in the lines and fittings. Control injection rate to prevent pressure building up too rapidly during injection. Control pressure by adjusting the injection rate smoothly and without interruption.

- Perform grouting as defined earlier in 2-foot stages, with the top of the final stage at the proposed shaft head elevation. Just prior to grouting each stage, extract the riser the required stage length.

A stage will be judged complete when one of the following refusal criteria is met:

a. Grout flow ceased at maximum injection pressure (at least 600 psi at the riser).

b. Ground or structure movement is detected.

c. More than 8 cf of grout is injected in a given stage at a back-pressure of 100 psi or greater.

d. More than 100 cf of grout is injected in a stage while following this sequence:

1. If 20 cf of grout has been injected without a 10 psi increase in back-pressure, twenty percent of fine gravel, by volume, shall be added to the grout mix and injection resumed.

2. If after the addition of fine gravel to the mix, a total of 50 cf of grout has been injected without a 10 psi increase in back-pressure, suspend grouting in that hole for at least 15 minutes to allow the initial grout to set. Once the grout has set, resume injection of grout mix containing fine gravel.

3. After resuming grout injection, if a total of 100 cf of grout has been injected in a stage, terminate injection in that stage and the stage shall be judged complete.

4. If the grout take in two consecutive stages exceed 100 cf per stage suspend grouting in that hole for 24 hours prior to grouting the next stage.

Upon meeting one or more refusal criteria, extract the riser the required stage length. Repeat the grouting process to the top of the final stage. Inject grout continuously as the riser is withdrawn between stages. Backfill grout holes with grout to the surface. Grout holes in an alternating pattern, using split spacing for successive holes, wherever possible, to allow soil pressure to dissipate and grout to set between successive injections.

Secure risers against lifting under the grout pressures in the hole. Where a riser lifts under pressure from the grout, reinstall the riser to the required depth at the Contractor's expense, secure, and regrout.

Continuously monitor ground and structure movement while pumping grout. Monitor potential movements within a minimum radius of 20 feet from the injection point or to whatever distance is required to monitor and prevent uncontrolled heave or damage to existing structures. Monitor a minimum of three points on the ground surface as

directed by the Engineer and additional points as required to prevent damage to existing structures and facilities. Monitor all points continuously during grout injection. Note any heave on the grouting log indicating the nature and magnitude of the movement and stage of grouting when it occurred.

3. Record Keeping: Maintain logs of stage depths, changes in grout mix, and grout injections in each stage including pressures, takes, refusal criteria for each location grouted, remarks concerning movement monitoring and other information about the grouting operation.

4. Upon completion of grouting at the locations indicated on the approved Grouting Plan, review the grout takes with the Engineer. Additional injections will be required at locations between the initial grout holes wherever two adjacent holes have takes more than 25 cf for any stage. Install additional split-spaced risers at the location designated by the Engineer, to the same depth criteria as the other grout holes. Grout the additional hole(s) as outlined above.

(h) Hole Layout & Tolerances.

1. Grout Hole Layout: Layout grout holes in accordance with the approved Grouting Plan.

2. Grout Hole Tolerances: Do not deviate grout holes more than 1 degree from the planned orientation. Maintain bottom of holes within 3 inches of the planned location. Holes may be angled from the planned orientation, if approved by the inspector, to avoid obstructions, provided that the same required spacing between grout injections, both horizontally and vertically is achieved, within the grout support zone.

(i) Restoration. Remove and properly dispose of all excess grout or other debris generated as part of the work. Fill all holes with grout to the surface through the riser as it is extracted. Repair damage to structures and utilities caused by grouting. Restoration must be completed to the satisfaction of the Engineer prior to final payment.

(j) Quality Control.

1. General: Establish and maintain quality control for all operations to assure compliance with the specification and maintain records of quality control for all operations. Assure that satisfactory drilling and grouting equipment is provided and kept in good mechanical condition, that the work complies with all requirements of the specifications, and that work areas are protected and properly cleaned up.

2. Grout Testing: Perform slump tests to maintain consistency of the grouting operation and as requested by the Engineer. Test slump on each batch of grout delivered and at the discharge of the grout pipe at the riser. Perform slump tests at least twice daily and whenever a change in grout consistency or appearance is noted. Provide at least one gradation analysis of the soil used in the grout for every 2,000 cubic feet of grout and whenever a change in the appearance of the grout or the soil is noted. Take samples of grout at least once per day for strength testing as directed. Prepare, cure and test the grout samples in accordance with AASHTO T23.

3. Reporting: Furnish a copy of these records, and a record of any corrective action taken, to the Engineer.

1007.4 MEASUREMENT AND PAYMENT – Payment for the items specified below constitutes full compensation for all plant, labor, equipment, and materials to satisfactorily furnish, place, and maintain the items of work. Materials, equipment or operations not specifically noted for payment, but necessary for satisfactorily completing the final work, are considered incidental to the various items of work.

(a) Mobilization: Lump Sum. This item will include mobilization of personnel and equipment necessary for limited mobility grouting. Materials, equipment or operations not specifically noted for payment, but necessary for satisfactory completion of the work, are considered incidental to this work item.

(b) Drilling and Installation of Riser: Linear feet. No payment will be made for holes unsuitable for grouting or failing to meet layout and/or tolerance requirements.

(c) Soil-Cement Grout: Cubic feet. No payment will be made for grout wasted, or due to mechanical failure and scheduling conflict, or grout rejected for failing to meet slump and/or strength requirements.

SECTION 1105—STRUCTURAL STEEL

1105.01 MATERIAL—

(a) Structural Steel.

1. General. AASHTO M 160/M 160M (ASTM A 6/A 6M)

2. Carbon Steel. AASHTO M 270/M 270M (ASTM A 709/A 709M), Grade 250 (Grade 36), ASTM A 36.

3. High-Strength Low-Alloy Structural Steel for Welding.

3.a High-Strength Low-Alloy Structural Steel with 345 MPa (50,000 pounds per square inch) Minimum Yield Point to 100 mm (4 inches) Thick. AASHTO M 270/M 270M (ASTM A 709/A 709M), Grade 345W (Grade 50W), ASTM A 588 (Grades A, B, and C only – see Note 1).

4. Supplemental Requirements for Notch Toughness. Provide structural steel conforming to the supplementary notch toughness requirements for the longitudinal Charpy V-notch tests specified for Zone 2 in Table S1 of the applicable AASHTO Materials Specifications. Unless otherwise indicated, the supplemental requirements are mandatory for the following load-carrying member components subject to tensile stress:

- Rolled shapes

If directed at a preconstruction meeting, provide samples for Charpy V-Notch testing from steel used in fabricating fracture-critical plates and shapes. Obtain the samples from plates delivered to the fabricator.

(a) Storage of Materials. Section 106.05 and as follows:
Place materials stored aboveground on platforms, skids, or other supports. Place and support materials to avoid overstress, deformation, or damage. Exercise special care for curved members. Keep materials free from dirt, grease, and other foreign materials. Ensure proper drainage and protect materials from corrosion.

(b) Welding Material. ANSI/AASHTO/A WS D1.5-2002 Bridge Welding Code, modified as specified in Section 1105.02(a)l.

1105.02 FABRICATION—

(a) Welding. Conduct welding, welder qualifications, prequalification of weld details, and inspection of welds according to the ANSI/AASHTO/AWS Bridge Welding Code D1.5-2002. Unless otherwise indicated or specified, for tubular structures, conduct welding, welder qualifications, prequalification of weld details, and inspection of welds according to ANSI/AASHTO/AWS D1.1-2002 subject to the following limitations:

- Do not use grade 60 electrodes.
- Use only low-hydrogen electrodes.
- Provide a minimum preheat and interpass temperature of at least 10 ºC (50F).

Do not weld or tack brackets, clips, shipping devices or other material not indicated or specified in the Special Provisions to any member unless shown on the shop drawings and approved.

1. Weld structural steel according to the ANSI/AASHTO/AWS Bridge Welding Code D1.5-2002 with the following modifications:

- Section 1.1.3. Revise completely as follows:
  All references to acceptance or approval will denote acceptance or approval by the Engineer.

- Section 1.3.2. Delete this section.

- Section 1.3.6, Welding of Ancillary Products. Delete items (1) and (2).

- Section 2.3.3, Plug and Slot Welds. Delete this section.

- Section 9, Details of Plug and Slot Welds. Delete this section.

- Section 4.1.6. Delete this section.

- Table 4.2, Matching Filler Metal Requirements for WPSs Qualified in Accordance with 5.13. Delete all references to electroslag or electrogas welding.

- Section 4, Part E, Electroslag Welding (ESW) and Electrogas Welding (EGW). Delete this part.

- Section 4, Part F, Plug and Slot Welds. Delete this part.

- Section 5.3, Duration. Add the following:
  Unless directed.

- Section 5.14, Electroslag and Electrogas Welding. Delete this section.

- Table 5.4, Additional PQR Essential Variable Changes Requiring WPS Requalification for Electroslag or Electrogas Welding. Delete this table.

- Section 5.16.4. Delete Item (2).

- Section 5.19.5.2, ESW and EGW Specimens. Delete this section.

- Section 6.7.1. Revise completely as follows:
  Non-destructively test complete penetration groove welds as specified in Section 1105.02(a)6.

- Section 6.7.1.1. Delete this section.

- Section 6.7.1.2(2). Revise completely as follows:
  Twenty-five percent of each joint subject to compression or shear.

- Section 6.7.1.2(2)(d). Delete this section.

- Section 6.7.2.1. Revise the first sentence as follows:
  At least 300 mm (12 inches) will be tested in every 3 m (10-foot) length and 300 mm (12 inches) of such welds less than 3 m (10 feet) in length of each size of weld and type joint in main members including the end connections of such members.

- Section 2.17.6.1. Revise second sentence as follows:
  Connections or splices made with fillet welds will be designed for the average of the calculated stress and the strength of the member, but no less than 75% of the strength of the member.

2. Do not weld to flanges in tension areas unless indicated.

3. Show types of steel on shop drawings.

4. Do not use electroslag or electrogas welding.

5. Do not use the gas metal arc welding (GMAW) process for main load-carrying members, including rolled shapes, web-to-web welds, web-to-flange welds, flange-to-flange welds, and stiffener and connection plate welds to flanges or webs, truss members, or gusset plates. The Contractor may use the GMAW process for welding drainage material, expansion dams, X-frames, diaphragms, bearings, bracing, and other secondary material, unless otherwise indicated.

The Contractor may use the gas shielded flux cored arc welding (FCAW) process for shop application only of stiffener and connection plate welds to flanges and webs, gusset plates, drainage material, expansion dams, X-frames, diaphragms, bearings, bracing, other main load-carrying members or secondary material, unless otherwise indicated. Do not use FCAW on primary member welds, including girders, trusses and fracture critical members (e.g., web splicing, flange splicing, or web-to-flange weld), unless otherwise indicated.

6. Non-destructively test all groove welds in main members according to the ANSI/AASHTO/AWS Bridge Welding Code D1.5-2002. Unless otherwise indicated or specified, use radiographic testing on butt joints. Use radiographic or ultrasonic testing for corner or "T" joints. Use magnetic particle testing according to ANSI/AASHTO/AWS D1.5-2002, Section 6.7.2.

(b) Oxyfuel Gas Cutting and Plasma Arc Cutting. Cut steel and weld metal using oxyfuel gas, air plasma arc, or oxygen plasma arc processes. Conduct cutting for all processes according to the ANSI/AASHTO/AWS Bridge Welding Code D1.5-2002 with the modifications specified in Section 1105.02(a)1. Air plasma arc cutting and oxygen plasma arc cutting may be used for AASHTO M 270/M 270M (ASTM A 709/A 709M), Grades 250, 345, 345W, and 485W (Grades 36, 50, 50W, and HPS 70W) and for stainless steels. Do not cut materials thicker than 16 mm (5/8 inch) with air plasma arc cutting. Do not cut materials thicker than 25 mm (1 inch) with oxygen plasma arc cutting. Do not apply water to the base metal during any cutting process except as otherwise indicated. Do not cut fracture critical members with either air plasma arc cutting or oxygen plasma arc cutting.

- Maintain uniform and even contact when assembling adjacent bearing surfaces. Unless a closer tolerance is indicated or specified, do not exceed a gap of 1.0 mm (0.040 inch) between bearing surfaces. Machine all sliding surfaces of base plates.

- Do not machine any surfaces of fabricated members until all fabrication and welding of the assembly or subassembly is complete. Machine heat-treated components after completion of heat treating.

(c) Abutting Joints. Mill or saw-cut abutting joints in compression members of columns to obtain a square joint and uniform bearing. Do not allow the opening at other joints not required to be faced to exceed 10 mm (3/8 inch).

(d) Welded Connections. Ensure that surfaces and edges to be welded are smooth, uniform, clean, and free of defects that would adversely affect the quality of the weld. Prepare edges according to the ANSI/AASHTO/AWS Bridge Welding Code D1.5-2002.