PART IV

SPECIFICATIONS

(Construction and Material)

Plum Creek Watershed – REHABILITATION

Floodwater Retarding Structure Site 12

Hays County, Texas

United States Department of Agriculture
Natural Resources Conservation Service

PLUM CREEK WATERSHED
SITE 12 REHABILITATION
HAYS COUNTY, TEXAS

SPECIFICATIONS

SPONSORED BY:

PLUM CREEK CONSERVATION DISTRICT
HAYS COUNTY SOIL AND WATER CONSERVATION DISTRICT
CALDWELL-TRAVIS SOIL AND WATER CONSERVATION DISTRICT

COOPERATING WITH
NATURAL RESOURCES CONSERVATION SERVICE
OF THE
U.S. DEPARTMENT OF AGRICULTURE

DECEMBER 2024

1. Specifications:

Construction Specification No.	Title	Date
2	Clearing and Grubbing	5/01
3	Structure Removal	5/01
5	Pollution Control	1/14
6	Seeding, Sprigging and Mulching	9/18
7	Construction Surveys	1/09
8	Mobilization and Demobilization	5/01
9	Traffic Control	5/01
11	Removal of Water	5/01
21	Excavation	5/01
23	Earthfill	2/20
24	Drainfill	5/01
26	Topsoiling	5/01
27	Diversions and Waterways	5/01
31	Concrete for Major Structures	9/18
34	Steel Reinforcement	9/18
36	Roller Compacted Concrete	9/18
41	Reinforced Concrete Pressure Pipe Conduits	1/14
45	Plastic Pipe	1/09
53	Ductile-Iron Pipe	5/01
61	Rock Riprap	9/18
71	Water Control Gates	5/01
81	Metal Fabrication and Installation	5/01
82	Painting Metalwork	11/05
91	Chain Link Fence	9/18
92	Field Fence	1/09
94	Contractor Quality Control	1/09
95	Geotextile	1/14
99	Conduit Abandonment	2/15

Material Specification No.	Title	Date
521	Aggregates for Drainfill and Filters	2/22
522	Aggregates for Portland Cement Concrete	2/22
523	Rock for Riprap	4/22
524	Aggregates for Roller Compacted Concrete	2/22
531	Portland Cement	2/22
532	Supplementary Cementitious Materials	2/22
533	Chemical Admixtures for Concrete	2/22
534	Concrete Curing Compound	5/23
535	Preformed Expansion Joint Filler	2/22
536	Sealing Compound for Joints for Concrete & Concrete Pipe	4/22
539	Steel Reinforcement (for concrete)	7/22
541	Reinforced Concrete Pressure Pipe	2/22
547	Plastic Pipe	4/22
553	Ductile-Iron Pipe	2/22
571	Slide Gates	4/22
581	Metal	4/22
582	Galvanizing	2/22
591	Field Fencing Materials	4/22
592	Geotextile	4/22

2. Definitions:
   Contracting Local Organization (CLO) – Plum Creek Conservation District
   Owners –Hays County SWCD, Caldwell-Travis SWCD, and Plum Creek Conservation District
   Contracting Officer – Designated representative from the Plum Creek Conservation District.
   Government - Natural Resources Conservation Service (NRCS)
   Service - NRCS
   Engineer - NRCS Construction Engineer
   Contracting Officer's Representative (COR) - NRCS Construction Engineer
   Government Representative (GR) – NRCS Construction Engineer
   Inspector - NRCS Construction Inspector (on-site)
   Quality Assurance (QA) - NRCS Construction Inspector (on-site)
   Quality Control (QC) - Contractor's Construction Inspector (on-site)

3. Drawings:
   Site No. 12 Rehabilitation, Drawing No. TX-EN-0744, Sheets 1 through 61 plus Cover Sheet.

4. Location:
   Structure Site No. 12 is located approximately 5.3 miles southeast of Buda, Hays County, Texas. The main site access shall be along FM 2001, with alternate access from Williamson Road.

5. Time to be allowed for completion of contract is 697 calendar days. (holidays and weather days not included)

Construction Specification 2—Clearing and Grubbing

1. Scope

The work consists of clearing and grubbing and disposal of trees, snags, logs, brush, stumps, shrubs, and rubbish from the designated areas.

2. Protection of existing vegetation

Trees and other vegetation designated to remain undisturbed shall be protected from damage throughout the duration of the construction period. Any damages resulting from the contractor's operations or neglect shall be repaired by the contractor.

Earthfill, stockpiling of materials, vehicular parking, and excessive foot or vehicular traffic shall not be allowed within the drip line of vegetation designated to remain in place. Vegetation damaged by any of these or similar actions shall be replaced with viable vegetation of the same species, similar condition, and like size unless otherwise approved by the contracting officer.

Any cuts, skins, scrapes, or bruises to the bark of the vegetation shall be carefully trimmed and local nursery accepted procedures used to seal damaged bark.

Any limbs or branches 0.5 inch or larger in diameter that are broken, severed, or otherwise seriously damaged during construction shall be cut off at the base of the damaged limb or branch flush with the adjacent limb or tree trunk. All roots 1-inch or larger in diameter that are cut, broken, or otherwise severed during construction operations shall have the end smoothly cut perpendicular to the root. Roots exposed during excavation or other operations shall be covered with moist earth or backfilled as soon as possible to prevent the roots from drying out.

3. Marking

The limits of the area(s) to be cleared and grubbed will be marked by stakes, flags, tree markings, or other suitable methods. Trees to be left standing and uninjured will be designated by special markings placed on the trunk about 6 feet above the ground surface.

4. Clearing and grubbing

All trees not marked for preservation and all snags, logs, brush, stumps, shrubs, rubbish, and similar materials shall be cleared from within the limits of the designated areas. Unless otherwise specified, all stumps, roots, and root clusters that have a diameter of 1 inch or larger shall be grubbed out to a depth of at least 2 feet below subgrade for concrete structures and 1 foot below the ground surface at embankment sites and other designated areas.

5. Disposal

All materials cleared and grubbed from the designated areas shall be disposed of at locations shown on the drawings or in a manner specified in section 7. The contractor is responsible for complying with all local rules and regulations and the payment of any and all fees that may result from disposal at locations away from the project site.

6. Measurement and payment

Method 1—For items of work for which specific units prices are established in the contract, the cleared and grubbed area is measured to the nearest 0.1 acre. Payment for clearing and grubbing is made for the total area within the designated limits at the contract unit price. Such payment will constitute full

compensation for all labor, equipment, tools, and all other items necessary and incidental to the completion of the work.

Method 2—For items of work for which specific unit prices are established in the contract, the length of the cleared and grubbed area is measured to the nearest full station (100 feet) along the line designated on the drawing or identified in the specifications. Payment for clearing and grubbing is made for the total length within the designated limits at the contract unit price. Such payment will constitute full compensation for all labor, equipment, tools, and all other items necessary and incidental to the completion of the work.

Method 3—For items of work for which specific unit prices are established in the contract, each tree, stump, and snag having a diameter of 4 inches or larger and each log having a diameter of 4 inches or larger and a length of 10 feet are measured before removal. The size of each tree and snag is determined by measuring its trunk at breast height above the natural ground surface. The size of each log is determined by measuring the butt and by measuring its length from butt to tip. The size of each stump is measured at the top. Diameter is determined by dividing the measured circumference by 3.14.

Payment for clearing and grubbing of each tree, stump, and snag having a diameter of 4 inches or larger and each log having a diameter of 4 inches or larger and a length of 10 feet or larger is made at the contract unit price for its size designation as determined by the following schedule:

Measured diameter (in)	Size designation (in)
4 to 8	6
8 to 12	10
12 to 24	18
24 to 36	30
36 to 60	48
Over 60	60

The sum of such payments shall constitute full compensation for clearing and grubbing (including the clearing and grubbing of smaller trees, stumps, snags, logs, brush, shrubs, and roots), applicable permits and associated fees, and rubbish removal. Such payment shall constitute full compensation for all labor, equipment, tools, and all other items necessary and incidental to the completion of the work.

Method 4—For items of work for which specific lump sum prices are established in the contract, payment for clearing and grubbing is made at the contract lump sum price. Such payment shall constitute full compensation for all labor, equipment, tools, and all other items necessary and incidental to the completion of the work.

All Methods—The following provisions apply to all methods of measurement and payment. Compensation for any item of work described in the contract, but not listed in the bid schedule will be included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 7.

7. Items of work and construction details

7. Items of work and construction details

In Section 5, Disposal, all materials removed from the cleared and grubbed areas shall be buried or burned at areas approved by the Engineer. All disposal methods shall be in accordance with state and local regulations.

Burning shall be accomplished at such times and manner as to minimize the annoyance or discomfort of the inhabitants of the area and not create nuisance conditions.

In Section 6, Measurement and payment, Method 4 shall apply.

Locations for buried materials shall be designated at the time of the showing of the site to prospective bidders. Buried material shall have a minimum earthfill cover of not less than 3 feet. The cover shall be placed in two lifts with each lift compacted by traversing the entire surface with one tread track of the material placement equipment. The top lift shall be mounded at least 6 inches higher than the surrounding undisturbed area to prevent unsightly depressions after settlement. The finished surface of the disposal area shall be uniformly graded to prevent ponding of water.

All trees, snags, logs, brush, shrubs, stumps, and rubbish that are felled, detached, or otherwise dislocated in or near stream channels shall be disposed of as specified or removed to higher ground prior to the end of each workday. The Contractor is to take precaution, when temporarily stockpiling cleared and grubbed materials, to guard against such cleared and grubbed materials being floated or transported off the worksite by rainstorm runoff.

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 1, Clearing and Grubbing

(1) This item shall consist of all clearing and grubbing and disposal within the work limits. This includes the disposal of existing brush piles and downed debris required for construction of the works of improvement as shown on the drawings.

(2) The actual limits of required clearing and grubbing will be as designated or staked at the time of the showing the site to prospective bidders.

(3) Existing brush piles and downed debris shall be disposed as specified above and shall be designated, and/or marked at the time of the showing the site to prospective bidders.

(4) Upon completion of the clearing and grubbing operation, all areas which have been cleared and grubbed shall be dressed to be reasonably smooth by blading, dragging or floating. The entire area shall be reasonably free of abrupt mounds, dips and windrows to provide a clear area for construction staking.

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Construction Specification 3—Structure Removal

1. Scope
The work shall consist of the removal, salvage, and disposal of structures (including fences) from the designated areas.

2. Marking
Method 1—Each structure or structure part to be removed will be marked with stakes, flags, paint, or other suitable method.

Method 2—The area boundaries from which structures must be removed will be marked using stakes, flags, paint, or other suitable method. Structures to remain undisturbed or to be salvaged will be designated by special markings.

3. Removal
Method 1—All structures designated for removal in the contract shall be removed to the specified extent and depth.

Method 2—Within the areas so marked, all visible and buried structures identified shall be removed to the specified extent and depth.

4. Salvage
Structures or structure parts that are designated to be salvaged shall be carefully removed and neatly placed in the specified or approved storage location. Salvaged structures that are capable of being disassembled shall be dismantled into individual members or sections. Such structures shall be neatly and systematically match marked with paint before disassembly. All connectors and other parts shall be marked to indicate their proper location within the structure and shall be fastened to the appropriate structural member or packed in suitable containers.

Material from fences designated to be salvaged shall be placed outside the work area on the property on which the fence was originally located. Fence wire shall be rolled into uniform rolls of suitable size and neatly piled with other salvaged materials. Posts and rails shall be neatly stacked.

5. Disposal of refuse materials
Refuse materials resulting from structure removal shall be disposed of in a manner and at locations specified in section 7 of this specification or in an acceptable manner and at locations approved by the contracting officer. Disposal by burning shall be in accordance with local rules and regulations.

6. Measurement and payment
Method 1—For items of work for which specific unit prices are established by the contract, payment for the removal of each structure unit, except fences, is made at the contract unit price. Fences removed or removed and salvaged are measured to the nearest linear foot. Payment for fence removal or removal and salvage is made at the contract unit prices for each type and size of fence.

Such payment will constitute full compensation for all labor, equipment, tools, applicable permits and associated fees for burning and disposal of refuse, and all other items necessary and incidental to the completion of the work.

Method 2—For items of work for which specific lump sum prices are established by the contract, payment for structure removal is made at the contract lump sum price.

Such payment will constitute full compensation for all labor, equipment, tools, applicable permits and associated fees for burning and disposal of refuse, and all other items necessary and incidental to the completion of the work.

All Methods—The following provisions apply to all methods of measurement and payment. Compensation for any item of work described in the contract, but not listed as a contract line item number in the bid schedule, is included in the payment for the item of work to which it is made subsidiary. Such items and items to which they are made subsidiary are identified in section 7 of this specification.

7. Items of work and construction details

7. Items of work and construction details

In Section 2, Marking, Method 1 shall apply.

In Section 5, Disposal, rubbish or non-woody material shall be disposed of by the Contractor at sites of his own choosing away from the construction site as approved by the Engineer. Woody materials shall be disposed by burning and/or burying at areas designated in Construction Specification 2, Clearing and Grubbing. All disposal methods shall be in accordance with state and local regulations.

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 2, Structure Removal, Existing Fences

(1) This item shall consist of the removal and disposal of all designated fences in the construction area.

(2) The limits of fences to be removed shown on the drawings are approximate. Additionally, some fences may exist within the construction areas that are not delineated on the drawings. The actual limits of fences required to be removed will be marked on the site at the time of the showing of the site to prospective bidders.

(3) In Section 3, Removal, Method 2 shall apply. The fences shall be removed to the bottom of the footing and/or post.

(4) In Section 6, Measurement and payment, Method 1 shall apply.

b. Bid Item 3, Structure Removal, Existing Principal Spillway

(1) This item shall consist of the removal and disposal of the existing principal spillway inlet; designated conduit sections; and concrete cradle as shown on the drawings.

(2) The existing principal spillway conduit may be used for dewatering and may remain open until the new principal spillway system, RCC stilling basin, and outlet channel installation are complete.

(3) In Section 3, Removal, Method 1 shall apply. The limits of removal shall be as shown on the drawings.

(4) In Section 6, Measurement and payment, Method 2 shall apply.

(5) The item of work subsidiary to this bid item is Excavation, Structure Removal as specified in Construction Specification 21.

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Construction Specification 5—Pollution Control

1. Scope

The work consists of installing measures or performing work to control erosion and minimize the production of sediment and other pollutants to water and air from construction activities.

The following BioPreferred® product categories are applicable to this specification: — mulch and compost materials

erosion control materials

fertilizers

dust suppressants

agricultural spray adjuvants

2. Material

Silt fence shall conform to the requirement of Materials Specification 592, Geotextile. All other material furnished shall meet the requirements of the material specifications listed in section 8 of this specification.

3. Erosion and sediment control measures and works

The measures and works shall include, but are not limited to, the following:

Staging of earthwork activities—The excavation and moving of soil materials shall be scheduled to minimize the size of areas disturbed and unprotected from erosion for the shortest reasonable time.

Seeding—Seeding to protect disturbed areas shall occur as soon as reasonably possible following completion of that earthwork activity.

Mulching—Mulching to provide temporary protection of the soil surface from erosion.

Diversions—Diversions to divert water from work areas and to collect water from work areas for treatment and safe disposition. They are temporary and shall be removed and the area restored to its near original condition when the diversions are no longer required or when permanent measures are installed.

Stream crossings—Culverts or bridges where equipment must cross streams. They are temporary and shall be removed and the area restored to its near original condition when the crossings are no longer required or when permanent measures are installed.

Sediment basins—Sediment basins collect, settle, and eliminate sediment from eroding areas from impacting properties and streams below the construction site(s). These basins are temporary and shall be removed and the area restored to its original condition when they are no longer required or when permanent measures are installed.

Sediment filters—Straw bale filters or geotextile silt fences trap sediment from areas of limited runoff. Sediment filters shall be properly anchored to prevent erosion under or around them. Silt fences shall be installed and maintained in accordance with ASTM D6462. These filters are temporary and shall be removed and the area restored to its original condition when they are no longer required or when permanent measures are installed.

Waterways—Waterways for the safe disposal of runoff from fields, diversions, and other structures or measures. These works are temporary and shall be removed and the area restored to its original condition when they are no longer required or when permanent measures are installed.

Other—Additional protection measures as specified in section 8 of this specification or required by Federal, State, or local government.

4. Chemical pollution

The contractor shall provide watertight tanks or barrels or construct a sump sealed with plastic sheets to collect and temporarily contain chemical pollutants, such as drained lubricating or transmission fluids, grease, soaps, concrete mixer washwater, or asphalt, produced as a by-product of the construction activities. Pollutants shall be disposed of in accordance with appropriate state and Federal regulations. At the completion of the construction work, tanks, barrels, and sumps shall be removed and the area restored to its original condition as specified in section 8 of this specification. Sump removal shall be conducted without causing pollution.

Sanitary facilities, such as chemical toilets, or septic tanks shall not be located next to live streams, wells, or springs. They shall be located at a distance sufficient to prevent contamination of any water source. At the completion of construction activities, facilities shall be disposed of without causing pollution as specified in section 8 of this specification.

5. Air pollution

The burning of brush or slash and the disposal of other materials shall adhere to state and local regulations.

Fire prevention measures shall be taken to prevent the start or spreading of wildfires that may result from project activities. Firebreaks or guards shall be constructed and maintained at locations shown on the drawings.

All public access or haul roads used by the contractor during construction of the project shall be sprinkled or otherwise treated to fully suppress dust. All dust control methods shall ensure safe construction operations at all times. If chemical dust suppressants are applied, the material shall be a commercially available product specifically designed for dust suppression and the application shall follow manufacturer's requirements and recommendations. A copy of the product data sheet and manufacturer's recommended application procedures shall be provided to the engineer 5 working days before the first application.

6. Maintenance, removal, and restoration

All pollution control measures and temporary works shall be adequately maintained in a functional condition for the duration of the construction period. All temporary measures shall be removed and the site restored to near original condition.

7. Measurement and payment

Method 1—For items of work for which specific unit prices are established in the contract, each item is measured to the nearest unit applicable. Payment for each item is made at the contract unit price for that item. For water or chemical suppressant items used for dust control for which items of work are established in section 8 of this specification, measurement for payment will not include water or chemical suppressants that are used inappropriately or excessive to need. Such payment will constitute full compensation for the completion of the work.

Method 2—For items of work for which lump sum prices are established in the contract, payment is made as the work proceeds and supported by invoices presented by the contractor that reflect actual costs. If the total of all progress payments is less than the lump sum contract price for this item, the balance remaining for this item will be included in the final contract payment. Payment of the lump sum contract price will constitute full compensation for completion of the work.

Method 3—For items of work for which lump sum prices are established in the contract, payment will be prorated and provided in equal amounts on each monthly progress payment estimate. The number of months used for prorating shall be the number estimated to complete the work as outlined in the contractor's approved construction schedule. The final month's prorate amount will be provided with the final contract payment. Payment as described will constitute full compensation for completion of the work.

All Methods—The following provisions apply to all methods of measurement and payment. Compensation for any item of work described in the contract, but not listed in the bid schedule is included in the payment for the item of

work to which it is made subsidiary. Such items, and the items to which they are made subsidiary, are identified in section 8 of this specification.

8. Items of work and construction details

7. Items of work and construction details

This construction site is greater than five (5) acres in area and is subject to the Texas Pollutant Discharge Elimination System (TPDES) requirements administered by the Texas Commission on Environmental Quality (TCEQ). Rules for the TPDES process relative to construction sites are contained in the TPDES General Permit NO. TXR150000. A copy of General permit No. TXR150000 may be found at the TCEQ website.

In conformance with TPDES General Permit TXR150000, a Storm Water Pollution Prevention Plan (SWP3) is required for the construction site. The Contractor shall prepare a SWP3 in accordance with the TPDES general permit requirements. The SWP3 shall include a detailed work sequence outline that defines and delineates the proposed construction operation and includes the minimum pollution control practices indicated on the construction drawings, as well as any additional measures that may be required to meet TPDES requirements. The SWP3 and any subsequent amendments shall be signed by the Contractor and submitted to the Contracting Officer prior to issuance of the Notice to Proceed. A copy of the approved SWP3, as amended, will be maintained at the construction site by the Contractor. A copy of the permit shall be attached to the SWP3.

A copy of the Notice of Intent (NOI) shall be posted at the site until the TPDES permit number is issued for the site. An 8 ½" x 11" notice shall be posted at the site giving the following information about the permit: permit number, contact name, contact phone and project description. If a permit number has not been issued, a copy of the NOI shall be posted with the notice.

If the Contractor identifies sediment control items, which are considered essential to the anticipated construction operation, but which are not reflected by the contract bid schedule, a written request for a contract modification will be provided to the Contracting Officer. The request will identify the items, operation, and provide an assessment of changes to the contract cost and performance time.

TPDES also requires an NOI and Notice of Termination (NOT) to be filed with TCEQ. The Contractor will be responsible for submitting the Contractor's copy of the NOI to the Engineer at least five business days before work begins. When the contract is completed, the Contractor shall provide the NRCS Project Engineer a copy of the NOT that he/she will file with the TCEQ.

In conformance with TPDES requirements, the Inspector and the Contractor (or the Contractor's Quality Control person) shall perform periodic inspections of the sediment control practices. Inspections will be conducted bi-weekly (first work day of each week) and within 24 hours of any rainfall event of more than 0.5 inches at the construction site. After each inspection, a written report will be prepared which summarizes the status of inspected items. The reports will (a) evaluate effectiveness, (b) identify maintenance needs and/or (c) recommend remedial corrective action and will be prepared and signed by the Engineer and the Contractor. The report shall be filed on site in the same location as the SWP3. The Contractor shall be responsible for identified corrective maintenance needs.

In Section 3, Erosion and sediment control measures and works – Sediment filters shall be limited to geotextile silt fences.

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 4, Pollution Control

(1) This item shall consist of performing all work and furnishing all materials necessary to accomplish the work defined in Section 1 of this specification,

including all works required to prepare and implement the Storm Water Pollution Prevention Plan; installation of the rock sediment filter; installation of stabilized construction entrance; and maintenance of the fabric sediment filters, rock sediment filter, and stabilized construction entrance, but not the installation of the fabric sediment filters.

(2) The rock sediment filter and stabilized construction entrance shall be installed as shown on the drawings and otherwise needed to control sediment from leaving the construction site.

(3) Removal of temporary pollution works such as the stabilized construction entrance, rock sediment filter, as well as fabric sediment filters shall be in accordance with the SWP3 and approved by the Engineer.

(4) In Section 7, Measurement and payment, Method 3 shall apply.

b. Bid Item 5, Silt Fence

(1) This item shall consist of furnishing and installing silt fence to the lengths and locations designated on the drawings and otherwise needed to control sediment from leaving the construction site. Maintenance of installed silt fence shall be paid for under the bid item for Pollution Control.

(2) In Section 3, Erosion and sediment control measures and works, sediment filters shall be limited to geotextile sediment filters supported by steel wire mesh or prefabricated polymer mesh and meet the general requirements defined in Table 2 *"Temporary Silt Fence Material Property Requirements Under High Water Flow Conditions"* of ASTM D6461. For all conditions, post spacing for silt fence shall not exceed four (4) feet.

(3) In Section 7, Measurement and payment, Method 1 shall apply.

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Construction Specification 6—Seeding, Sprigging, and Mulching

1. Scope

The work consists of preparing the area for treatment; furnishing and placing seed, sprigs, mulch, fertilizer, inoculant, lime, and other soil amendments; and anchoring mulch in designated areas as specified.

The following BioPreferred® product categories are applicable to this specification:

— mulch and compost materials

— erosion control materials

— fertilizers

— agricultural spray adjuvants

2. Material

Seed—All seed must conform to the current rules and regulations of the State where it is being used and must be from the latest crop available. It must meet or exceed the standard for purity and germination listed in section 7.

Seed must be labeled in accordance with State laws and U.S. Department of Agriculture rules and regulations under the Federal Seed Act in effect on the date of invitations for bids. Bag tag figures are evidence of purity and germination. No seed may be accepted with a test date of more than 9 months before the date of delivery to the site.

Seed that has become wet, moldy, or otherwise damaged in transit or storage will not be accepted. The percent of noxious weed seed allowable must be as defined in the current State laws relating to agricultural seeds. Each type of seed must be delivered in separate sealed containers and fully tagged unless an exception is granted in writing by the contracting officer.

Fertilizer—Unless otherwise specified, the fertilizer must be a commercial-grade fertilizer. It must meet the standard for grade and quality specified by State law. Where fertilizer is furnished from bulk storage, the contractor must furnish a supplier's certification of analysis and weight. When required by the contract, a representative sample of the fertilizer must be furnished to the contracting officer for chemical analysis.

Inoculants—The inoculant for treating legume seeds must be a pure culture of nitrogen-fixing bacteria prepared specifically for the species and must not be used later than the date indicated on the container or as otherwise specified. A mixing medium, as recommended by the manufacturer, must be used to bond the inoculant to the seed. Two times the amount of the inoculant recommended by the manufacturer must be used, except that four times the amount must be used when seed is applied using a hydraulic seeder. Seed must be sown within 24 hours of treatment and must not remain in the hydraulic seeder longer than 4 hours.

Lime and other soil amendments—Lime must consist of standard ground agriculture limestone, or approved equivalent. Standard ground agriculture limestone is defined as ground limestone meeting current requirements of the State department of agriculture. Other soil amendments must meet quality criteria and application requirements specified in section 7.

Mulch tackifiers—Asphalt emulsion tackifiers must conform to the requirements of ASTM D977, Specification for Emulsified Asphalt. The emulsified asphalt may be rapid setting, medium setting, or slow setting. Nonasphaltic tackifiers required because of environmental considerations must be as specified in section 7.

Straw mulch material—Straw mulch must consist of wheat, barley, oat or rye straw, hay, grass cut from native grasses, or other plants as specified in section 7. The mulch material must be air-dry, reasonably light in color, and must not be musty, moldy, caked, or otherwise of low quality. The use of mulch that contains noxious weeds is not permitted. The contractor must provide a method satisfactory to the contracting officer for determining weight of mulch furnished.

Other mulch materials—Mulching materials, such as wood cellulose fiber mulch, mulch tackifiers, synthetic fiber mulch, netting, and mesh may be required for specialized locations and conditions. These materials, when specified, must be accompanied by the manufacturer's recommendations for methods of application.

3. Seeding mixtures, sod, sprigs, and dates of planting

The application rate per acre for seed mixtures, sprigs, or sod and date of seeding or planting must be as shown on the plans or as specified in section 7.

4. Seedbed preparation and treatment

Areas to be treated must be dressed to a smooth, firm surface. On sites where equipment can operate on slopes safely, the seedbed must be adequately loosened (4 to 6 inches deep) and smoothed. Depending on soil and moisture conditions, disking or cultipacking, or both, may be necessary to properly prepare a seedbed. Where equipment cannot operate safely, the seedbed must be prepared by hand methods by scarifying to provide a roughened soil surface so that broadcast seed will remain in place.

If seeding is to be accomplished immediately following construction operations, seedbed preparation may not be required except on a compacted, polished, or freshly cut soil surface.

Rocks larger than 6 inches in diameter, trash, weeds, and other debris that will interfere with seeding or maintenance operations must be removed or disposed of as specified in section 7.

Seedbed preparation must be discontinued when soil moisture conditions are not suitable for the preparation of a satisfactory seedbed as determined by the responsible engineer.

5. Seeding, sprigging, fertilizing, mulching, and stabilizing

All seeding or sprigging operations must be performed in such a manner that the seed or sprigs are applied in the specified quantities uniformly in the designated areas. The method and rate of seed application must be as specified in section 7. Unless otherwise specified, seeding or sprigging must be accomplished within 2 days after final grading is completed and approved.

Fertilizer, lime, and other soil amendments must be applied as specified in section 7. When specified, the fertilizer and soil amendments must be thoroughly incorporated into the soil immediately following surface application.

The rate, amount, and kind of mulching or mesh must be as specified in section 7. Mulches must be applied uniformly to the designated areas. They must be applied to areas seeded not later than 2 working days after seeding has been performed. Straw mulch material must be stabilized within 24 hours of application using a mulch crimper or equivalent anchoring tool or by a suitable tackifier. When the mulch crimper or equivalent anchoring tool is used, it must have straight blades and be the type manufactured expressly for and capable of firmly punching the mulch into the soil. Where the equipment can be safely operated, it must be operated on the contour. Hand methods must be used where equipment cannot safely operate to perform the work required.

The tackifier must be applied uniformly over the mulch material at the specified rate, or it must be injected into the mulch material as it is being applied. Mesh or netting stabilizing materials must be applied smoothly but loosely on the designated areas. The edges of these materials must be buried or securely anchored using spikes or staples as specified in section 7.

The contractor must maintain the mesh or netting areas until all work under the contract has been completed and accepted. Maintenance must consist of the repair of areas damaged by water erosion, wind, fire, or other causes. Such areas must be repaired to reestablish the intended condition and to the design lines and grades required by the contract. The areas must be refertilized, reseeded, and remulched before the new application of the mesh or netting.

6. Measurement and payment

Method 1—For items of work for which specific unit prices are established in the contract, each area treated is measured as specified in section 7 and the area is calculated to the nearest 0.1 acre. Payment for treatment is made at the contract unit price for the designated treatment, which will constitute full compensation for completion of the work.

When specified as an item of work, mesh or netting is measured to the nearest square yard of surface area covered and accepted. Payment is made at the contract unit price and will constitute full compensation for completion of the work.

Method 2—For items of work for which specific lump-sum prices are established in the contract, the quantity of work will not be measured for payment. Payment for this item is made at the contract lump- sum price for the item and constitutes full compensation for the completion of the work.

Method 3—For items of work for which lump-sum prices are established in the contract, payment is made as the work proceeds. Progress payments are determined as specified in section 7. Payment of the lump sum contract price constitutes full compensation for completion of the work.

All Methods—The following provisions apply to all methods of measurement and payment. Compensation for any item of work described in the contract but not listed in the bid schedule is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 7.

7. Items of work and construction details

7. Items of work and construction details

In Section 5, Seeding, sprigging, fertilizing, mulching, and stabilizing, straw mulch material shall consist of coastal bermudagrass or a native bluestem mix and the rate of application shall be 2-1/2 tons per acre. Mulches shall be stabilized by a non-asphaltic tackifier or by a mechanical crimper. Unless otherwise recommended by the manufacturer, non-asphaltic tackifier shall be applied at a rate of 40 pounds per acre. The contractor shall submit the manufacturer's product data and installation instructions for the tackifier to the Contracting Officer for approval of the product.

When working on slopes which are steeper than 3:1 horizontal to vertical, all rubber tire equipment on the slope will be held with truck or tractor and winch line with the truck or tractor operating along the crown of the embankment or other suitable flat surface. As an alternative, track (crawler) equipment with a low center of gravity may be used to perform work on slopes without a winch line requirement when operated in accordance with applicable OSHA requirements.

Disturbed areas and slopes in the reservoir area below the elevation of the lowest un-gated outlet shall not be chisel plowed or disked. Permanent vegetation is not required below the elevation of the lowest un-gated outlet. Plowing shall be on the approximate contour. Plowing will not be permitted when the ground is frozen or wet to the point that rutting would occur during the plowing process. The ground surface shall be left reasonably smooth and free of windrows, ridges, or depressions.

Fertilizer shall be of the pelleted form and shall be uniformly mixed. Prior to planting the grasses, fertilizer shall be applied and worked into the soil by disking with a weighted tandem disk to a depth of approximately 4 inches. No fertilizer shall be applied when the ground is excessively wet, frozen, or otherwise in an untillable condition. The rate of application of fertilizer shall be based on a routine soil fertility test conducted for vegetation establishment in accordance with the soil sampling and testing procedures outlined at http://soiltesting.tamu.edu/files/soilwebform.pdf

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 6, Permanent Vegetation Establishment, Sprigging

(1) This item shall consist of preparing the seedbed and furnishing and applying sprigs, straw mulch, tackifer and fertilizer to the designated areas as shown on the drawings and as specified herein.

(2) In Section 6, Measurement and payment, Method 1 will apply.

(3) The method of permanent vegetation establishment shall be sprigging of the site with Coastal Bermudagrass sprigs.

(4) Sprigging shall be conducted with a mechanical sprigging machine. Coastal bermudagrass sprigs shall be applied at the rate of 24 bushels or 32 cu. ft. per acre. The distance between rows shall not exceed 20 inches. Sprigs shall be placed in moist soil approximately 3 inches deep and packed. Hand sprigging may be used in addition to the sprigging machine in inaccessible areas.

(5) Coastal bermudagrass sprigs shall consist of healthy, uninjured, live stolons and rhizomes free from excessive foreign matter. Excess top growth shall be removed before sprigs are harvested. Sprigs shall be obtained from a source within a radius of 100 miles of the works of improvement to be planted. Sprigs shall not be cut or chopped shorter than 4 inches. Care shall be exercised to see that harvested sprigs do not lie exposed to the sun for more than 30 minutes

before they are stacked in piles and covered or loaded for transporting to the planting site. Harvested sprigs shall be watered in route to the planting site and kept covered and moist until planted. Not more than 30 hours shall elapse between initial harvest and planting the sprigs.

(6) In lieu of sprigging, and upon approval of the Contracting Officer, the area designated for sprigging may be seeded with a mix and seeding rate determined by the Engineer to establish permanent vegetation. The contract will be modified, and the Contracting Officer will negotiate a fair and reasonable adjustment to the contract price and performance time with the Contractor for the change from sprigging to seeding.

(7) Payment for permanent vegetation establishment shall only be considered after a finding of 85 percent coverage by the planted vegetation is determined by the Engineer and the findings approved by the Contracting Officer.

(8) Sprigging to establish permanent vegetation shall be conducted between February 15 and May 1; and August 15 and September 30.

(9) If sprigging dates do not meet with the construction schedule, the Contractor must follow the SWP3 and TCEQ requirements for temporary vegetation until such time that the permanent vegetative cover can be established. The temporary vegetative cover shall be as recommended by the local NRCS field office and approved by the Contracting Officer. During this period, Contractor also must comply with SWP3 requirements such as periodic pollution control inspections, etc., and must also protect and maintain completed structural work. There will be no adjustment to contract price or performance time.

b. Bid Item 7, Irrigation System

(1) This item shall consist of furnishing and installing a temporary solid set sprinkler irrigation system as needed to irrigate the areas as designated in Section 7.a. of this specification.

(2) The contractor shall furnish to the contracting officer, in writing, a proposed plan for the irrigation system and application 30 days before installing the irrigation system. The plan shall show the layout, size of all components, sprinkler head spacing, and methods to determine the application and distribution efficiencies. Acceptance of this plan or the waiving of the plan requirement will not relieve the contractor of the responsibilities for completing the specified work.

(3) The system shall be adequate to apply the volume of water and meet the application requirements specified in Sections 7.c. (2) and 7.c. (3) of this specification. The application of irrigation shall not cause runoff. The application shall be uniform ensuring that at any point the irrigated area shall be within 20 percent of the required application.

(4) The contractor shall furnish all equipment, operators, maintenance, operating supplies, and materials needed to install the system. The contractor shall furnish in-line, propeller type water meter (s) with volumetric calibration. The meter(s) shall be installed so that all water applied for the irrigation of vegetated areas under the contract will be metered.

(5) Unless otherwise noted, the system shall be removed upon completion of all irrigation applications and upon approval of the Engineer.

(6) In Section 6, Measurement and payment, Method 2 will apply.

c. Bid Item 8, Irrigation Water

(1) This item shall consist of applying irrigation water to the areas designated in Section 7.a. of this specification. It shall include the cost of water and labor.

(2) The estimated application rate and schedule of irrigations will be as follows: 1st irrigation 2 inches, 2nd, 3rd and 4th irrigations ½ inch at 2-day intervals and then twice a week for the next 4 weeks at ½ inch applications. Additional irrigation or adjustment in the application rates may be required as determined and approved by the Engineer and shall be executed with a modification to the contract to specify the change and make an equitable adjustment in contract price and performance time as may be warranted by the change.

(3) All areas will be irrigated with a sprinkler irrigation system. The total irrigation at any one time will be based on need as determined by the Engineer. The irrigation system shall produce a reasonable uniform distribution of the required application over the irrigated area without excessive runoff or erosion. The watering efficiency shall not be less than 85%. Adjustments in sprinkler spacing, nozzle sizes, pressures, or in the gross water applied shall be made when needed to accomplish the above objectives.

(4) The contractor shall be responsible for the water source.

(5) In Section 6, Measurement and payment, Method 1 will apply. Measurement for payment will be 1,000 gallon units and will be measured to the nearest 1,000 gallons based on the applied volume determined from the readings of the in-line water meter(s). An adjustment in the volume of water shall be applied for application efficiency less than 85 percent.

Construction Specification 7—Construction Surveys

1. Scope

The work consists of performing all surveys, measurements, and computations required by this specification.

2. Equipment and material

Equipment for construction surveys shall be of a quality and condition to provide the required accuracy. The equipment shall be maintained in good working order and in proper adjustment at all times. Records of repairs, calibration tests, accuracy checks, and adjustments shall be maintained and be available for inspection by the engineer. Equipment shall be checked, tested, and adjusted as necessary in conformance with manufacturer's recommendations.

Material is field notebooks, stakes, templates, platforms, equipment, spikes, steel pins, tools, and all other items necessary to perform the work specified.

3. Quality of work

All work shall follow recognized professional practice and the standards of the industry unless otherwise specified in section 9 of this specification. The work shall be performed to the accuracy and detail appropriate for the type of job. Notes, sketches, and other data shall be complete, recorded neatly, legible, reproducible and organized to facilitate ease in review and allow reproduction of copies for job documentation. Survey equipment that requires little or no manual recording of field data shall have survey information documented as outlined in section 9 of this specification.

All computations shall be mathematically correct and shall include information to identify the bid item, date, and who performed, checked, and approved the computations. Computations shall be legible, complete, and clearly document the source of all information used including assumptions and measurements collected.

If a computer program is used to perform the computations, the contractor shall provide the engineer with the software identification, vendor's name, version number, and other pertinent data before beginning survey activities. Computer generated computations shall show all input data including values assigned and assumptions made.

The elevations of permanent and temporary bench marks shall be determined and recorded to the nearest 0.01 foot. Differential leveling and transit traverses shall be of such precision that the error of vertical closure in feet shall not exceed plus or minus 0.1 times the square root of the traverse distance in miles. Linear measurements shall be accurate to within 1 foot in 5,000 feet, unless otherwise specified in section 9 of this specification. The angular error of closure for transit traverses shall not exceed 1 minute times the square root of the number of angles turned.

The minimum requirements for placing slope stakes shall be at 100-foot stations for tangents, as little as 25 feet for sharp curves, breaks in the original ground surface and at any other intermediate stations necessary to ensure accurate location for construction layout and measurement. Slope stakes and cross sections shall be perpendicular to the centerline. Significant breaks in grade shall be determined for cross sections. Distances shall be measured horizontally and recorded to the nearest 0.1 foot. Side shots for interim construction stakes may be taken with a hand level.

Unless otherwise specified in section 9 of this specification, measurements for stationing and establishing the location of structures shall be made to the nearest 0.1 foot.

Elevations for concrete work, pipes, and mechanical equipment shall be determined and recorded to the nearest 0.01 foot. Elevations for earth work shall be determined and recorded to the nearest 0.1 foot.

4. Primary control

The baselines and bench marks for primary control, necessary to establish lines and grades needed for construction, are shown on the drawings and have been located on the job site.

These baselines and bench marks shall be used as the origin of all surveys, layouts, and measurements to establish construction lines and grades. The contractor shall take all necessary precautions to prevent the loss or damage of primary control points. Any stakes or control points lost or damaged by construction activity will be reestablished by the contractor or at contractor expense.

5. Construction surveys

Before work starts that requires contractor performed surveys, the contractor shall submit in writing for the engineer's review: the name, qualifications, and experience of the individuals to be assigned to the survey tasks.

Method 1—Contractor performed surveys shall include:

- checking and any supplemental or interim staking
- performing quantity surveys, measurements, and computations for progress payment
- other surveys as described in section 9 of this specification

Method 2—Contractor performed surveys shall consist of all work necessary for:

- establishing line and grade for all work
- setting slope stakes for all work
- checking and any supplemental or interim staking
- establishing final grade stakes
- performing quantity surveys, measurements, and computations for progress payment
- other surveys as described in section 9 of this specification

Method 3—Contractor performed surveys shall consist of all work necessary for:

- establishing line and grade for all work
- setting slope stakes for all work
- checking and any supplemental or interim staking
- establishing final grade stakes
- performing quantity surveys, measurements, and computations for progress payments
- performing original (initial) and final surveys for determinations of final quantities
- other surveys as described in section 9 of this specification.

6. Staking

The construction staking required for the item shall be completed before work on any item starts. Construction staking shall be completed as follows or as otherwise specified in section 9 of this specification:

Clearing and grubbing—The boundary of the area(s) to be cleared and grubbed shall be staked or flagged at a maximum interval of 200 feet, closer if needed, to clearly mark the limits of work. When contractor staking is the basis for determining the area for final payment, all boundary stakes will be reviewed by the engineer before start of this work item.

Excavation and fill—Slope stakes shall be placed at the intersection of the specified slopes and ground line. Slope stakes and the reference stakes for slopes shall be marked with the stationing, required cut or fill, slope ratio, and horizontal distance from the centerline or other control line. The minimum requirements for placing slope stakes is outlined in section 3, Quality of work.

Structures—Centerline and offset reference line stakes for location, alignment, and elevation shall be placed for all structures.

7. Records

All survey data shall be recorded in fully identified standard hard-bound engineering survey field notebooks with consecutively numbered pages. All field notes and printed data shall include the purpose or description of the work, the date the work was performed, weather data, sketches, and the personnel who performed and checked the work. Electronically generated survey data and computations shall be bound, page numbered, and cross referenced in a bound field notebook containing the index for all survey activities. All work shall follow recognized professional practice.

The construction survey records shall be available at all times during the progress of the work for examination and use by the engineer and when requested, copies shall be made available. The original field notebooks and other records shall be provided to and become the property of the owner before final payment and acceptance of all work.

Complete documentation of computations and supporting data for progress payments shall be submitted to the engineer with each invoice for payment as specified in section 9 of the specification. When the contractor is required to conduct initial and final surveys as outlined in section 5, Construction Surveys, notes shall be provided as soon as possible after completion to the engineer for the purpose of determining final payment quantities.

8. Payment

Method 1—For items of work for which lump sum prices are established in the contract, payment is made as the work proceeds, after presentation of correct and accurate invoices by the contractor showing related costs and evidence of the charges of suppliers, subcontractors, and others for supplies furnished and work performed. Invoices for the total amount of the contract price will not be accepted until all surveys are complete and required documentation has been determined complete. If the total of such payments is less than the lump sum contract price for this item, the unpaid balance will be included in the final contract payment. Payment of the lump sum contract price will constitute full compensation for completion of all work under the bid item.

Method 2—For items of work for which lump sum prices are established in the contract, payment is made as the work proceeds with progress payment amounts determined as a percentage of the total work planned as projected from the contractor's approved construction schedule. Payment of the lump sum contract price will constitute full compensation for completion of all work under this bid item.

All Methods—Payment will not be provided under this item for the purchase price of materials or equipment having a residual value.

Compensation for any item of work described in the contract, but not listed in the bid schedule will be included in the payment for the item of work to which it is made subsidiary. Such items and the item to which they are made subsidiary are identified in section 9 of this specification.

9. Items of work and construction details

9. Items of work and construction details

In Section 3, Quality of work, electronic models created for the purpose of aiding the Contractor in stake out and/or quantity computations, as well as field layout and staking shall be prepared and/or performed by a Professional Engineer (PE) or Registered Public Land Surveyor (RPLS) licensed in Texas.

In Section 5, Construction surveys, Method 2 shall apply.

In Section 6, Staking, Excavation and fill, shall include all centerline and offset reference lines staked to the minimum requirements for placing slope stakes as outlined in Section 3, Quality of work. Sufficient survey data shall be provided to document that the surveyed works meet the project requirements. Adequacy of provided survey data shall be determined by the Engineer.

In Section 8, Payment, Method 2 shall apply.

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 9, Construction Surveys

(1) This item shall consist of performing all work required by Section 1 of this specification.

(2) All surveys shall proceed from benchmarks, reference points, and/or stakes set or established by the Government. The benchmarks are shown on the drawings.

(3) Initial and final surveys for determinations of final quantities will be performed by the Government.

(4) In Section 5, Construction Surveys, the surveys conducted by the Contractor shall include, but not be limited to:

(a) Those required to check all excavation, earthfill, and topsoil slopes as work progresses to ensure such slopes and finished grades/subgrades are maintained at those specified.

(b) Earthfill, excavated, and topsoiled slopes shall be checked at least each five feet of vertical interval and corrected to planned slopes.

(c) Those required to set “bluetops” for subgrades and finished grades of all excavations, earthfills, topsoil areas, and appurtenances to the work.

(5) The item of work subsidiary to this bid item is Establishment of Permanent Reference Markers (PRM), as specified in Construction Specification 31.

Construction Specification 8—Mobilization and Demobilization

1. Scope

The work consists of the mobilization and demobilization of the contractor's forces and equipment necessary for performing the work required under the contract. It does not include mobilization and demobilization for specific items of work for which payment is provided elsewhere in the contract. Mobilization will not be considered as work in fulfilling the contract requirements for commencement of work.

2. Equipment and material

Mobilization shall include all activities and associated costs for transportation of contractor's personnel, equipment, and operating supplies to the site; establishment of offices, buildings, and other necessary general facilities for the contractor's operations at the site; premiums paid for performance and payment bonds including coinsurance and reinsurance agreements as applicable; and other items specified in section 4 of this specification.

Demobilization shall include all activities and costs for transportation of personnel, equipment, and supplies not required or included in the contract from the site; including the disassembly, removal, and site cleanup of offices, buildings, and other facilities assembled on the site specifically for this contract.

This work includes mobilization and demobilization required by the contract at the time of award. If additional mobilization and demobilization activities and costs are required during the performance of the contract as a result of changed, deleted, or added items of work for which the contractor is entitled to an adjustment in contract price, compensation for such costs will be included in the price adjustment for the item or items of work changed or added.

3. Payment

Payment will be made as the work proceeds, after presentation of paid invoices or documentation of direct costs by the contractor showing specific mobilization and demobilization costs and supporting evidence of the charges of suppliers, subcontractors, and others. When the total of such payments is less than the lump sum contract price, the balance remaining will be included in the final contract payment. Payment of the lump sum contract price for mobilization and demobilization will constitute full compensation for completion of the work.

Payment will not be made under this item for the purchase costs of materials having a residual value, the purchase costs of materials to be incorporated in the project, or the purchase costs of operating supplies.

4. Items of work and construction details

4. Items of work and construction details

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 10, Mobilization and Demobilization

(1) This item shall consist of performing all items of work for mobilization and demobilization as required by Sections 1 and 2 of this specification.

(2) The mobilization operation shall include but not be limited to the items in Section 2 of this specification and the following items of work:

(a) Access to the work area shall be from FM 2001. The Contractor shall construct a site access at the approximate location shown on the drawings or otherwise approved by the Engineer. The site access shall conform to all applicable TxDOT requirements for a driveway access point from a state highway and include all necessary improvements to facilitate drainage and safety. The minimum width of the site access shall be 20 feet to accommodate 2-way traffic.

(b) An all-weather access road to the construction campsite shall be constructed and maintained by the Contractor. The access road shall be a minimum of 14 feet wide and be graded and smoothed to provide a surface which can be easily traversed by automobiles. The road shall be maintained in a smooth rut-free condition throughout the contract period. Culverts shall be installed at crossings of low areas where significant concentrations of runoff water accumulate and cause ponding of water. Culverts installed as a part of this item of work shall have sufficient strength to support the anticipated loads imposed by construction traffic, shall be of sufficient size to carry at least the 2-year runoff, and shall be removed at the end of the contract period. If damage occurs to the culverts due to construction activities, those culverts shall be replaced. Minimum culvert size shall be 18 inch i.d. and a minimum of 24 feet long. A minimum of 18 inches of compacted fill shall be placed over top of the pipe before construction equipment is allowed to pass.

(c) As a part of this bid item the Contractor shall furnish a facility at the construction campsite suitable for use as a Field Office for the Contracting Local Organization and Government. The facility shall contain not less than 240 square feet (8-ft-wide by 30-ft-long) having a minimum 7-ft-high ceiling. The facility shall be constructed in a workmanlike manner and shall be weather-tight. It shall have not less than three windows and one door. It shall have a cabinet top range (either gas or electric) with a minimum of two burners or elements and may be either built in or portable. A microwave oven 0.80 cubic feet in size and having a minimum power rating of 650 watts output, as well as a 2.5 cubic feet (minimum) refrigerator shall be provided. A substantial workbench and a table, each 3-ft-wide by 8-ft-long with the work surface 42" above floor level and covered with laminated plastic, shall be provided. Cabinet storage shelves shall be included with the workbench. Two standard 60" x 30" office desks with drawers and leg space, as well as one 48” x 30” adjustable top drafting table shall be provided. Two office swivel chairs and 4 straight chairs shall be provided. The floor

shall have a heavy-duty vinyl or similar covering. Walls, ceilings and floors shall be constructed in such a manner as to provide a minimum of 1.5 inches of space between inside and outside surfaces. The 1.5-inch space shall be filled with a high-density insulation material. A closet (30" wide x 42" long) having a 28" wide door shall be included. The facility shall be wired for electricity with a minimum of three ceiling fixtures and a minimum of three wall outlets on each long wall. The facility shall be plumbed and connected to a permanent source of pressurized water. The Contractor shall furnish a source of potable drinking water inside the Government's field trailer and shall maintain a supply of potable drinking water throughout the contract period. A flush toilet and a wash basin (lavatory) shall be provided within a private area, and shall be properly connected to a sanitary sewer or sanitary holding tank. If a sanitary holding tank is utilized, it shall be serviced as frequently as necessary to maintain the flush toilet and wash basin in proper working order and to minimize objectionable odor. A thermostatically controlled means that is capable of maintaining the temperature inside the facility at 75 degrees in the summer with refrigerated air and 80 degrees in the winter, for heating and air conditioning the facility shall be provided. The facility shall be built in such a manner that it is substantial and can be easily moved. A prefabricated building or trailer will be an acceptable facility if approved by the Contracting Officer. The Contractor shall furnish and install all utilities to the facility. The facility shall be maintained in good condition throughout the contract period by the Contractor, except for damages caused by negligence of the Government or Contracting Local Organization (CLO). The facility shall be separate and apart from any building or facilities of the Contractor and shall be for sole use of the Government or Contracting Local Organization (CLO).

(d) The facility shall be securely anchored or tied-down to provide maximum possible stability against overturning by high winds. Flashing or skirting shall be installed around the facility from floor level to ground level.

(e) Access to the door to the facility from the ground shall be provided by substantial steps leading to a landing having a minimum size of 5 feet wide by 6 feet long. Substantial handrails shall be provided for the steps and the landing.

(f) The facility shall be enclosed by a six (6) foot high chain link fence placed to provide a minimum of six (6) feet clearance between the fence and the outside walls of the facility. One (1) gate four (4) feet in width shall be installed in the fence.

(g) The Contractor shall furnish and install electrical service to the facility. The electrical service provided shall meet the requirements of the latest National Electric Code for providing electric service to the government facility. The service shall be adequate to address all anticipated electrical loads and meet the minimum voltage and amperage requirements indicated by the selected trailer and trailer manufacturer recommendations. The Contractor shall be responsible for supply of power to the facility office throughout the contract period. If a portable

generator is used to supply electrical power, the Contractor shall be responsible for the complete operation and maintenance of the generator. The generator shall remain in continuous operation 24 hours per day and shall be located a minimum of 100 feet from the facility and shielded so as to minimize the noise in the facility.

(h) As a part of this bid item, the Contractor shall provide and maintain a printer with copying and scanning capabilities for standard bond letter (8.5 x 11) and tabloid (11 x 17) paper sizes through the entire contract period in the Government Field Office. The printer shall allow printing/scanning through either wi-fi, blue-tooth, and/or a usb thumb drive. Contractor maintenance of the specified printer shall include all necessary toner, ink, and all other incidental maintenance requirements needed to allow the Government to print, scan, or make paper copies of job-related items through the entire contract period.

(i) The facility and all utilities shall be in place at the worksite prior to the start of work requiring continuous inspection and no later than 15 days after receipt of the Notice to Proceed.

(3) The demobilization operation shall include but not be limited to the following items of work:

(a) All debris, trash, tires, equipment, equipment parts, chains, cables, and other such items resulting from the construction operation shall, at the Contractor's expense, be removed from the work site and be salvaged by the Contractor, or disposed of in an appropriate manner which meets all Federal, State and Local Regulations.

(b) All disturbed areas shall be bladed or smoothed to blend the area with the surrounding land surface. The bladed or smoothed surface shall be free of abrupt mounds, windrows, depressions or other irregularities that would prevent the safe operation of ordinary farm equipment thereon. The finished surface shall prevent diversion of surface runoff and shall prevent standing or ponding water.

(c) All traffic control devices, warning signs, barricades and any other material used for traffic control shall be removed.

(d) All buildings, trailers, chain link fence, storage sheds, sanitary facilities and other such items shall be removed from the worksite when construction work is completed.

(e) All utilities shall be removed from the site as required by the owner of the utility after construction work is completed.

(f) The access road shall be bladed to be smooth and shall be left in a rut-free condition. If road base/rock is used on the access road it shall be removed after construction work is completed.

(g) The constructed site access shall remain in-place and be bladed to be smooth and left in a rut-free condition. All culverts, ditches, and installed safety appurtenances shall be left in working order in accordance with TxDOT requirements.

(4) The item of work subsidiary to this bid item is Traffic Control as specified in Construction Specification 9.

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Construction Specification 9—Traffic Control

1. Scope

The work shall consist of establishing traffic control and maintaining safe, convenient use of public roads and rights-of-way.

2. Traffic and access

The contractor's operations shall cause no unnecessary inconvenience to the public. The public rights-of-way shall be maintained at all times unless interruption is authorized by proper local authority. Contractor's authorized closing or detour plans shall be provided to the engineer for approval.

Safe and adequate access shall be provided and maintained to all public protection devices and to all critical utility control locations. Facility access shall be continuous and unobstructed unless otherwise approved.

3. Storage of equipment and material in public streets

Construction materials and equipment shall not be stored or parked on public streets, roads, or highways. During any material or equipment loading or unloading activities that may temporarily interfere with traffic, an acceptable detour shall be provided for the duration of the activity. Any associated expense for this activity is the responsibility of the contractor.

Excavated material, including suitable material that is intended for adjacent trench backfill or other earth backfill as specified in section 5 of this specification, shall not be stored on public streets, roads, or highways that remain in service for the public. Any waiver of this requirement must be obtained from the proper local authority and approved by the engineer. All excess and unsuitable material shall be removed from the site as soon as possible. Any spillage shall be removed from roadways before they are used by the public.

4. Street closures, detours, and barricades

The contractor shall comply with the requirements of all applicable responsible units of government for closure of any street, road, or highway. The contractor shall provide the required barriers, guards, lights, signs, temporary bridges, and flaggers together with informing the public of any detours and construction hazards by the most suitable means available, such as local newspapers or radio stations. The contractor is also responsible for compliance with additional public safety requirements that may arise during construction. The contractor shall furnish, install, and, upon completion of the work, promptly remove all signs, warning devices, and other materials used in the performance of this work.

Unless otherwise specified, the contractor shall notify, in writing, the fire chief, police chief, county sheriff, state patrol, schools that operate school buses, or any other government official as may be appropriate no less than 7 days before closing, partly closing, or reopening any street, road, or highway.

Unless otherwise specified, the contractor shall furnish to the engineer a written plan showing the proposed method of signing, barricading for traffic control, and safety for street detours and closures.

All temporary detours will be maintained to ensure use of public rights-of-way is provided in a safe manner. This may include dust control, grading, and graveling as required in section 7 of this specification.

5. General and specific references

All signs, signals, barricades, use of flaggers, and other traffic control and public safety devices shall conform to the general requirements set forth in the Manual of Uniform Traffic Control Devices (MUTCD) and the latest edition of *Standard Highway Signs and Standard Alphabets for Highway Signs* and/or OSHA *Construction Industry Standards (29 CFR Part 1926), Subpart G, Signs, Signals, and Barricades* unless otherwise specified in section 7 of this specification.

6. Measurement and payment

For items of work for which specific lump sum prices are established in the contract, payment for the work is made at the contract lump sum price. Progress payments will be made based upon the percentage of estimated total time that traffic control will be required unless otherwise specified in section 7 of this specification. Payment will constitute full compensation for all flaggers, labor, materials, equipment, and all other items necessary and incidental to completion of the work.

Compensation for any item of work described in the contract, but not listed in the bid schedule will be included in the payment for the item of work to which it is made subsidiary. Such items and items to which they are made subsidiary are identified in section 7 of this specification.

7. Items of work and construction details

7. Items of work and construction details

In Section 4, Street closures, detours, and barricades, the Contractor shall furnish a written plan showing the proposed method of signing, barricading for traffic control, use of flaggers, etc. to be approved by TxDOT and/or Hays County, as appropriate, as well as this contract's Engineer.

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Subsidiary Item, Traffic Control

(1) This item shall consist of performing all items of work for traffic control as required by Sections 1 and 2 of this specification.

(2) Separate payment will not be made for this item of work. Compensation for this item will be included in the payment for the bid item Mobilization and Demobilization.

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Construction Specification 11—Removal of Water

1. Scope

The work consists of the removal of surface water and ground water as necessary to perform the construction required by the contract in accordance with the specifications. It shall include: (1) constructing, installing, building, and maintaining all necessary temporary water containment facilities, channels, and diversions; (2) furnishing, installing, and operating all necessary pumps, piping, and other facilities and equipment; and (3) removing all such temporary works and equipment after their intended function is no longer required.

2. Diverting surface water

The contractor shall install, maintain, and operate all cofferdams, channels, flumes, sumps, and all other temporary diversion and protective works needed to divert streamflow and other surface water through or around the construction site. Control of surface water shall be continuous during the period that damage to construction work could occur. Unless otherwise specified and/or approved, the diversion outlet shall be into the same drainageway that the water would have reached before being diverted.

The contractor shall furnish the contracting officer, in writing, a proposed plan for diverting surface water before beginning any construction activities for which a diversion is required, unless waived in section 8 of this specification. Acceptance of this plan or the waiving of the plan requirement will not relieve the contractor of the responsibilities related to this activity during the process of completing the work as specified.

3. Dewatering the construction site

Foundations, cutoff trenches, and all other parts of the construction site shall be dewatered and kept free of standing water and muddy conditions as necessary for the proper execution of the work. The contractor shall furnish, install, operate, and maintain all drains, sumps, pumps, casings, well points, and all other equipment required to properly dewater the site as specified. Dewatering systems that cause a loss of soil fines from the foundation areas will not be permitted.

The contractor shall furnish the contracting officer, in writing, a proposed plan for dewatering before commencing with any construction activity for which dewatering may be required, unless waived in section 8 of this specification. Acceptance of this plan or the waiving of the plan requirement will not relieve the contractor of the responsibilities for completing the specified work.

4. Dewatering borrow areas

The contractor shall maintain all borrow areas free of surface water or otherwise provide for timely and effective removal of surface and subsurface water that accumulates within the borrow area, unless waived in section 8 of this specification. Borrow material shall be processed as necessary to achieve proper and uniform moisture content at the time of placement.

If pumping to dewater borrow areas is included as a bid item of work in the bid schedule, each pump discharge pipe shall be equipped with a water meter. The meter shall be such that the measured quantity of water is accurate within 3 percent of the true quantity. The contractor shall provide necessary support to perform accuracy tests of the water meter when requested by the contracting officer.

5. Erosion and pollution control

Removal of water from the construction site, including the borrow areas, shall be accomplished so that

erosion and the transporting of sediment and other pollutants are minimized. Dewatering activities shall be accomplished in a manner that the water table water quality is not altered. Pollution control activities shall not conflict with the requirements of Construction Specification 5, Pollution Control, if it is a part of this contract.

6. Removal of temporary works

When temporary works are no longer needed, the contractor shall remove and return the area to a condition similar to that which existed before construction. Areas where temporary works were located shall be graded for sightly appearance with no obstruction to natural surface waterflows or the proper functioning and access to the works of improvement installed. The contractor shall exercise extreme care during the removal stages to minimize the loss of soil sediment and debris that was trapped during construction.

Pipes, casings, and any other material used to dewater the site shall be removed from temporary wells. The wells shall be filled to ground level with clean gravel or other suitable material approved by the contracting officer. The contractor shall exercise extreme care to prevent pollution of the ground water by these actions.

7. Measurement and payment

***Method 1*—**Items of work listed in the bid schedule for removal of water, diverting surface water, and dewatering construction sites and borrow areas are paid for at the contract lump sum prices. Such payment will constitute full compensation for all labor, equipment, tools, and all other items necessary and incidental to the completion of the work.

***Method 2*—**Items of work listed in the bid schedule for removal of water, diverting surface water, dewatering construction sites, and dewatering borrow areas are paid for at the contract lump sum prices. Such payment will constitute full compensation for furnishing, installing, operating, and maintaining the necessary trenches, drains, sumps, pumps, and piping and for all labor, equipment, tools, and all other items necessary and incidental to the completion of the work. The exception is that additional payment for pumping to dewater borrow areas and the removal of water will be made as described in the following paragraph.

If pumping to dewater borrow areas is a contract bid item, payment is made at the contract unit price, which shall be the price per 1,000 gallons shown in the bid schedule. Such payment will constitute full compensation for pumping only. Compensation for equipment and preparation and for other costs associated with pumping is included in the lump sum payment for removal of water or the lump sum payment for dewatering the borrow areas. Payment is made only for pumping that is necessary to dewater borrow areas that cannot be effectively drained by gravity or that must have the water table lowered to be usable as a suitable borrow source. Pumping for other purposes will not be included for payment under this item.

***All Methods*—**The following provisions apply to all methods of measurement and payment. Compensation for any item of work described in the contract, but not listed in the bid schedule is included in the payment for the contract line item to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 8 of this specification.

8. Items of work and construction details

8. Items of work and construction details

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 11, Removal of Water

(1) This item shall consist of all operations necessary to accomplish the work defined in Section 1 of this specification, including that work required to control water from entering the new principal spillway.

(2) The new principal spillway conduit installation area, as well as the RCC chute spillway area shall be protected from the entry of water from the reservoir until the dam is reconstructed to the full design cross-section over the conduit and the RCC chute spillway is complete. Water will not be permitted to enter the new principal spillway conduit until the inlet riser, impact basin and outlet channel are constructed and fully operational. Water will not be permitted to engage the RCC spillway until all RCC, rock riprap armoring, and the outlet channel are constructed and fully operational.

(3) A written dewatering system plan for protection of the new principal spillway conduit installation and RCC chute spillway from reservoir water are required. The means of protection shall be designed, complete with sealed plans and specifications, by a Professional Engineer licensed in Texas. The plan requirements shall follow the guidance presented in Technical Release 210-60, "*Earth Dams and Reservoirs*", March 2019, Part 1-General, Streamflow During Construction, page 1-5. The plans shall be submitted to the Engineer prior to start of construction operations.

(4) In the event that a coffer dam is constructed, the written plan shall address material moisture and compaction requirements, as well as address protection of the coffer dam from wave erosion.

(5) Any rock riprap removed from the existing wave berm for the implementation of the dewatering system plan shall be cleaned and replaced to its designed cross section, including any geotextile bedding associated with the restoration of this area. Any additional rock needed for the restoration of this area shall meet the requirements of Construction Specification 61 and be at the Contractor's expense.

(6) In addition to the dewatering system plan, a written plan for diverting surface waters and for dewatering borrow and designated excavations for the site are required. The written plan shall include information on how potentially saturated or overly wet borrow materials can be prepared for use as earthfill. The Contractor's plans for diverting surface waters and dewatering the site shall be submitted to the Engineer prior to the start of construction operations.

(7) Within the scope of this item, the contractor shall provide dewatering capacity sufficient to maintain a water level which allows excavation in the borrow area to the grades specified on the drawings during periods of low flow. Additional dewatering capacity to draw the water level down to this level within 10 days shall be provided in the event of flooding which inundates the borrow area. In any case, when accumulations of water in the borrow areas prevent excavation, borrow operations from these areas will be suspended until suitable conditions again prevail.

(8) Excavation for the installation of the principal spillway conduit, inlet riser, impact basin, RCC chute, rock riprap, and outlet channels shall be kept free of water during placement of concrete, pipe, RCC, drainfill, rock, and/or backfilling. The water table at a concrete or RCC structure location shall be kept 2 feet below the subgrade of the concrete during and for a minimum of seven days after concrete placement. The water table at a backfill or rock riprap location shall be maintained a minimum of 2 feet below the backfill/rock riprap surface.

(9) In Section 7, Measurement and payment, Method 1 shall apply. Payment will be made as the work proceeds with progress payment amounts determined as a percentage of the total work planned as projected from the Contractor's approved construction schedule. The final month's prorate amount will be provided with the final contract payment.

Construction Specification 21—Excavation

1. Scope

The work shall consist of the excavation required by the drawings and specifications and disposal of the excavated materials.

2. Classification

Excavation is classified as common excavation, rock excavation, or unclassified excavation in accordance with the following definitions.

Common excavation is defined as the excavation of all materials that can be excavated, transported, and unloaded using heavy ripping equipment and wheel tractor-scrapers with pusher tractors or that can be excavated and dumped into place or loaded onto hauling equipment by excavators having a rated capacity of one cubic yard or larger and equipped with attachments (shovel, bucket, backhoe, dragline, or clam shell) appropriate to the material type, character, and nature of the materials.

Rock excavation is defined as the excavation of all hard, compacted, or cemented materials that require blasting or the use of ripping and excavating equipment larger than defined for common excavation. The excavation and removal of isolated boulders or rock fragments larger than 1 cubic yard encountered in materials otherwise conforming to the definition of common excavation shall be classified as rock excavation. The presence of isolated boulders or rock fragments larger than 1 cubic yard is not in itself sufficient cause to change the classification of the surrounding material.

For the purpose of these classifications, the following definitions shall apply:

Heavy ripping equipment is a rear-mounted, heavy duty, single-tooth, ripping attachment mounted on a track type tractor having a power rating of at least 250 flywheel horsepower unless otherwise specified in section 10.

Wheel tractor-scraper is a self-loading (not elevating) and unloading scraper having a struck bowl capacity of at least 12 cubic yards.

Pusher tractor is a track type tractor having a power rating of at least 250 flywheel horsepower equipped with appropriate attachments.

Unclassified excavation is defined as the excavation of all materials encountered, including rock materials, regardless of their nature or the manner in which they are removed.

3. Blasting

The transportation, handling, storage, and use of dynamite and other explosives shall be directed and supervised by a person(s) of proven experience and ability who is authorized and qualified to conduct blasting operations.

Blasting shall be done in a manner as to prevent damage to the work or unnecessary fracturing of the underlying rock materials and shall conform to any special requirements in section 10 of this specification. When specified in section 10, the contractor shall furnish the engineer, in writing, a blasting plan before blasting operations begin.

4. Use of excavated material

Method 1—To the extent they are needed, all suitable material from the specified excavations shall be used in the construction of required permanent earthfill or rockfill. The suitability of material for specific purposes is determined by the engineer. The contractor shall not waste or otherwise dispose of suitable excavated material.

Method 2—Suitable material from the specified excavations may be used in the construction of required earthfill or rockfill. The suitability of material for specific purposes is determined by the engineer.

5. Disposal of waste materials

Method 1—All surplus or unsuitable excavated materials are designated as waste and shall be disposed of at the locations shown on the drawings.

Method 2—All surplus or unsuitable excavated materials are designated as waste and shall be disposed of by the contractor at sites of his own choosing away from the site of the work. The disposal shall be in an environmentally acceptable manner that does not violate local rules and regulations.

6. Excavation limits

Excavations shall comply with OSHA Construction Industry Standards (29CFR Part 1926) Subpart P, Excavations, Trenching, and Shoring. All excavations shall be completed and maintained in a safe and stable condition throughout the total construction phase. Structure and trench excavations shall be completed to the specified elevations and to the length and width required to safely install, adjust, and remove any forms, bracing, or supports necessary for the installation of the work. Excavations outside the lines and limits shown on the drawings or specified herein required to meet safety requirements shall be the responsibility of the contractor in constructing and maintaining a safe and stable excavation.

7. Borrow excavation

When the quantities of suitable material obtained from specified excavations are insufficient to construct the specified earthfills and earth backfills, additional material shall be obtained from the designated borrow areas. The extent and depth of borrow pits within the limits of the designated borrow areas shall be as specified in section 10 or as approved by the engineer.

Borrow pits shall be excavated and finally dressed to blend with the existing topography and sloped to prevent ponding and to provide drainage.

8. Overexcavation

Excavation in rock beyond the specified lines and grades shall be corrected by filling the resulting voids with portland cement concrete made of materials and mix proportions approved by the engineer. Concrete that will be exposed to the atmosphere when construction is completed shall meet the requirements of concrete selected for use under Construction Specification 31, Concrete for Major Structures, or 32, Structure Concrete, as appropriate.

Concrete that will be permanently covered shall contain not less than five bags of cement per cubic yard. The concrete shall be placed and cured as specified by the engineer.

Excavation in earth beyond the specified lines and grades shall be corrected by filling the resulting voids with approved, compacted earthfill. The exception to this is that if the earth is to become the subgrade for riprap, rockfill, sand or gravel bedding, or drainfill, the voids may be filled with material conforming to the specifications for the riprap, rockfill, bedding, or drainfill. Before correcting an overexcavation

condition, the contractor shall review the planned corrective action with the engineer and obtain approval of the corrective measures.

9. Measurement and payment

For items of work for which specific unit prices are established in the contract, the volume of each type and class of excavation within the specified pay limits is measured and computed to the nearest cubic yard by the method of average cross-sectional end areas or by methods outlined in section 10 of this specification. Regardless of quantities excavated, the measurement for payment is made to the specified pay limits except that excavation outside the specified lines and grades directed by the engineer to remove unsuitable material is included. Excavation required because unsuitable conditions result from the contractor's improper construction operations, as determined by the engineer, is not included for measurement and payment.

***Method 1*—**The pay limits shall be as designated on the drawings.

***Method 2*—**The pay limits shall be defined as follows:

a. The upper limit shall be the original ground surface as it existed before the start of construction operations except that where excavation is performed within areas designated for previous excavation or earthfill, the upper limit shall be the modified ground surface resulting from the specified previous excavation or earthfill.
b. The lower and lateral limits shall be the neat lines and grades shown on the drawings.

***Method 3*—**The pay limits shall be defined as follows:

a. The upper limit shall be the original ground surface as it existed before the start of construction operations except that where excavation is performed within areas designated for previous excavation or earthfill, the upper limit shall be the modified ground surface resulting from the specified previous excavation or earthfill.
b. The lower and lateral limits shall be the true surface of the completed excavation as directed by the engineer.

***Method 4*—**The pay limits shall be defined as follows:

a. The upper limit shall be the original ground surface as it existed before the start of construction operations except that where excavation is performed within areas designated for previous excavation or earthfill, the upper limit shall be the modified ground surface resulting from the specified previous excavation or earthfill.
b. The lower limit shall be at the bottom surface of the proposed structure.
c. The lateral limits shall be 18 inches outside of the outside surface of the proposed structure or shall be vertical planes 18 inches outside of and parallel to the footings, whichever gives the larger pay quantity, except as provided in d below.
d. For trapezoidal channel linings or similar structures that are to be supported upon the sides of the excavation without intervening forms, the lateral limits shall be at the underside of the proposed lining or structure.
e. For the purposes of the definitions in b, c, and d, above, any specified bedding or drainfill directly beneath or beside the structure will be considered to be a part of the structure.

***All methods*—**The following provisions apply to all methods of measurement and payment.

Payment for each type and class of excavation is made at the contract unit price for that type and class of excavation. Such payment will constitute full compensation for all labor, materials, equipment, and all other items necessary and incidental to the performance of the work except that extra payment for backfilling overexcavation will be made in accordance with the following provisions.

Payment for backfilling overexcavation, as specified in section 8 of this specification, is made only if the excavation outside specified lines and grades is directed by the engineer to remove unsuitable material and if the unsuitable condition is not a result of the contractor's improper construction operations as determined by the engineer.

Compensation for any item of work described in the contract, but not listed in the bid schedule is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 10 of this specification.

10. Items of work and construction details

10. Items of work and construction details

In Section 4, Use of excavated material, Method 1 shall apply. There is no guarantee that materials obtained from the specified excavations may be used directly in specified fill areas. Separate stockpiling of selected materials, based on their engineering properties, to ensure their availability for use in specific zones of fill areas may be required. Stockpiling shall be conducted on areas shown on the construction drawings or as approved by the Engineer. Additional compensation will not be made for stockpiling of excavated materials. Cost for stockpiling of excavated materials shall be included in the compensation for the bid item for excavation.

Prior to performing designated excavations, the ground surface shall be stripped of vegetation and topsoil. The depth of this stripping shall be sufficient to remove soil containing significant vegetative or organic matter. The depth of stripping is estimated to be 6 inches, on average. The upper limit for pay limit determination (Section 9, Method 3) shall be the ground surface as it exists prior to stripping the surface vegetation and topsoil.

Suitable materials resulting from the required excavations shall be used to construct the specified fills except materials suitable for topsoil shall be stockpiled at the location designated by the Engineer. Unsuitable materials shall be placed in the waste areas shown on the drawings.

In Section 5, Disposal of waste materials, Method 1 shall apply. The disposal of the excavated materials shall include transporting, depositing, and spreading the materials to and on the designated waste areas. The finished surface of the waste area(s) shall be uniform and conform to the topography. The finished surface shall be graded to have positive drainage away from the embankment and constructed works. The waste materials shall be compacted in maximum 12-inch lifts by a minimum of four (4) passes with a tamping roller. The weight of the roller shall not be less than 3500 pounds per foot of linear drum length weighted and shall not be less than 1500 pounds per foot of linear drum length empty. The moisture content of the waste materials should be adjusted to be at or slightly above the plastic limit as determined from NRCS feel method or other appropriate methods. A soil is at its plastic limit when a sample can be rolled between the hands to form a 1/8” thread without cracking or breaking apart. Soil that can be rolled to a 1/16” thread without cracking or breaking apart is too wet. Other methods for determining soil moisture content shall be approved by the Engineer. Additional compensation for disposal of excavated materials and dressing of the surface of waste areas (including topsoiling) will not be made. Costs will be included in the compensation for the bid item for excavation.

In Section 9, Measurement and payment, Method 3 shall apply. The neat lines and grades shown on the drawings shall be considered the true surface of the completed excavation unless otherwise approved by the Engineer. After the limits of excavation shown on the drawings are complete, the Engineer will examine the completed surface and mark areas that need additional excavation to remove low density materials. The actual depths and extent of these excavations will be determined after examination of materials encountered.

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 12, Excavation, Common

(1) This item shall consist of all excavation required for reconstruction of the embankment, including all wet excavation required for the installation of the new principal spillway riser, 42-inch I.D. principal spillway pipe, impact basin, RCC spillway, rock riprap lined outlet, rock riprap lined wave berm, outlet channels, and vegetative auxiliary spillway excavation as shown on the drawings.

(2) Items of work subsidiary to this bid item are:

(a) Excavation, Common, Foundation Stripping as specified in Section 10.b. of this specification as it applies to this bid item.

b. Subsidiary Item, Excavation, Common, Foundation Stripping

(1) This item shall apply to the areas receiving earthfill that do not require other excavations before earthfill placement. This excavation consists of removing weeds, grass, roots and soils containing significant vegetative or organic material from the ground surface (including any waste areas) prior to placing earthfill in required areas. The depth of stripping shall be sufficient to remove the vegetative material and soil containing significant organic matter and is estimated to be 3 to 12 inches (on average). The total required volume of stripping shall not exceed that obtained by assuming a depth of 6 inches.

(2) Separate payment will not be made for this item. Compensation for this item will be included in the payment for the respective bid item for Excavation, Common.

c. Subsidiary Item, Excavation, Common, Borrow

(1) This item shall consist of all excavation from within the borrow areas required to complete the specified earthfills as designated on the drawings.

(2) All excavated slopes within the limits of borrow areas shall be maintained to be no steeper than five horizontal to one vertical.

(3) Sediment/waste overburden located in the designated borrow area below the ordinary high-water mark (OHWM- elev. 606.2) shall remain in the reservoir area below the OHWM and not transported to other designated waste areas. Any mounds or stockpiles of the sediment/waste overburden that result from borrow operations below the OHWM shall be uniformly spread over the final excavated borrow surface(s) below the OHWM and maintained as described in items (4) and (5), below.

(4) All borrow areas shall be maintained to provide positive drainage to natural and constructed drainage ways. Dressing and grading of borrow areas to accomplish this drainage shall be accomplished as borrow excavation progresses. Additional compensation will not be made for this work as herein specified.

(5) All borrow areas shall be maintained to be contiguous with no berms, ridges or mounds remaining that extend more than two feet above the lowest point in adjacent borrow areas. All berms, ridges, and mounds shall be removed to meet this height limitation. Additional compensation will not be made for this work as herein specified.

(6) Separate payment will not be made for this item. Compensation for this item will be included in the payment for the respective bid items for Earthfill, Standard; and Earthfill, Beneath RCC, as appropriate.

d. Subsidiary Item, Excavation, Common, Drainfill

(1) This item includes all excavations outside the limits of other designated excavations required for the installation of the drainage systems and bearing pads as shown on the drawings.

(2) Separate payment will not be made for this item. Compensation for this item will be included in the payment for the bid item for Drainfill.

e. Subsidiary Item, Excavation, Common, Concrete Structures

(1) This item includes all excavations outside the limits of other designated excavation, required for the installation of the principal spillway system and appurtenances including the principal spillway outlet structure.

(2) Separate payment will not be made for this item. Compensation for this item will be included in the payment for the respective bid items for Concrete, Structural and Concrete, Pipe Cradle, as appropriate.

f. Subsidiary Item, Excavation, Common, Rock Riprap

(1) This item includes all excavations outside the limits of other designated excavations required for the installation of the rock riprap as shown on the drawings.

(2) Separate payment will not be made for this item. Compensation for this item will be included in the payment for the bid item for Rock Riprap.

g. Subsidiary Item, Excavation, Structure Removal

(1) This item includes all excavations required for the removal of the existing principal spillway system as shown on the drawings.

(2) Separate payment will not be made for this item. Compensation for this item will be included in the payment for the bid item for Structure Removal, Existing Principal Spillway.

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Construction Specification 23—Earthfill

1. Scope

The work consists of the construction of earth embankments, other earthfills, and earth backfills required by the drawings and specifications.

Earthfill is composed of natural earth materials that can be placed and compacted by construction equipment operated in a conventional manner.

Earth backfill is composed of natural earth material placed and compacted in confined spaces or adjacent to structures (including pipes) by hand tamping, manually directed power tampers or vibrating plates, or their equivalent.

2. Material

All fill material shall be obtained from required excavations and designated borrow areas. The selection, blending, routing, and disposition of material in the various fills shall be subject to approval by the engineer.

Fill materials shall contain no frozen soil, sod, brush, roots, or other perishable material. Rock particles larger than the maximum size specified for each type of fill shall be removed prior to compaction of the fill.

The types of material used in the various fills shall be as listed and described in the specifications and drawings.

3. Foundation preparation

Foundations for earthfill shall be stripped to remove vegetation and other unsuitable material or shall be excavated as specified.

Except as otherwise specified, earth foundation surfaces shall be graded to remove surface irregularities and shall be scarified parallel to the axis of the fill or otherwise acceptably scored and loosened to a minimum depth of 2 inches. The moisture content of the loosened material shall be controlled as specified for the earthfill, and the surface material of the foundation shall be compacted and bonded with the first layer of earthfill as specified for subsequent layers of earthfill.

Earth abutment surfaces shall be free of loose, uncompacted earth in excess of 2 inches in depth normal to the slope and shall be at such a moisture content that the earthfill can be compacted against them to produce a good bond between the fill and the abutments.

Rock foundation and abutment surfaces shall be cleared of all loose material by hand or other effective means and shall be free of standing water when fill is placed upon them. Occasional rock outcrops in earth foundations for earthfill, except in dams and other structures designed to restrain the movement of water, shall not require special treatment if they do not interfere with compaction of the foundation and initial layers of the fill or the bond between the foundation and the fill.

Foundation and abutment surfaces shall be no steeper than one horizontal to one vertical unless otherwise specified. Test pits or other cavities shall be filled with compacted earthfill conforming to the specifications for the earthfill to be placed upon the foundation.

4. Placement

Earthfill shall not be placed until the required excavation and foundation preparation have been completed and the foundation has been inspected and approved by the engineer. Earthfill shall not be placed upon a frozen surface nor shall snow, ice, or frozen material be incorporated in the earthfill matrix.

Earthfill shall be placed in approximately horizontal layers. The thickness of each layer before compaction shall not exceed the maximum thickness specified in section 10 or shown on the drawings. Materials placed by dumping in piles or windrows shall be spread uniformly to not more than the specified thickness before being compacted.

Hand compacted earth backfill shall be placed in layers whose thickness before compaction does not exceed the maximum thickness specified for layers of earth backfill compacted by manually directed power tampers.

Earth backfill shall be placed in a manner that prevents damage to the structures and allows the structures to assume the loads from the earth backfill gradually and uniformly. The height of the earth backfill adjacent to a structure shall be increased at approximately the same rate on all sides of the structure.

Earthfill and earth backfill in dams, levees, and other structures designed to restrain the movement of water shall be placed to meet the following additional requirements:

(a) The distribution of materials throughout each zone shall be essentially uniform, and the earthfill shall be free from lenses, pockets, streaks, or layers of material differing substantially in texture, moisture content, or gradation from the surrounding material. Zone earthfills shall be constructed concurrently unless otherwise specified.

(b) The surface of each layer shall be scarified parallel to the axis of the fill to a depth of not less than 2 inches before the next layer is placed.

(c) The top surface of embankments shall be maintained approximately level during construction with two exceptions: A crown or cross-slope of about 2 percent shall be maintained to ensure effective drainage, or as otherwise specified for drainfill or sectional zones.

(d) Dam embankments shall be constructed in continuous layers from abutment to abutment except where openings to facilitate construction or to allow the passage of streamflow during construction are specifically authorized in the contract.

(e) Embankments built at different levels as described under (c) or (d) above shall be constructed so that the slope of the bonding surfaces between embankment in place and embankment to be placed is not steeper than 3 feet horizontal to 1 foot vertical. The bonding surface of the embankment in place shall be stripped of all material not meeting the requirements of this specification and shall be scarified, moistened, and recompacted when the new earthfill is placed against it. This ensures a good bond with the new earthfill and obtains the specified moisture content and density at the contact of the inplace and new earthfills.

5. Control of moisture content

During placement and compaction of earthfill and earth backfill, the moisture content of the material being placed shall be maintained within the specified range.

The application of water to the earthfill material shall be accomplished at the borrow areas insofar as practicable. Water may be applied by sprinkling the material after placement on the earthfill, if necessary. Uniform moisture distribution shall be obtained by disking.

Material that is too wet when deposited on the earthfill shall either be removed or be dried to the specified moisture content prior to compaction.

If the top surface of the preceding layer of compacted earthfill or a foundation or abutment surface in the zone of contact with the earthfill becomes too dry to permit suitable bond, it shall either be removed or scarified and moistened by sprinkling to an acceptable moisture content before placement of the next layer of earthfill.

6. Compaction

Earthfill—Earthfill shall be compacted according to the following requirements for the class of compaction specified:

Class A compaction—Each layer of earthfill shall be compacted as necessary to provide the density of the earthfill matrix not less than the minimum density specified in Section 10 or identified on the drawings. The earthfill matrix is defined as the portion of the earthfill material finer than the maximum particle size allowed in the reference compaction test method specified (ASTM D698 or ASTM D1557).

Class B compaction—Each layer of earthfill shall be compacted to a mass density not less than the minimum density specified.

Class C compaction—Each layer of earthfill shall be compacted by the specified number of passes of the type and weight of roller or other equipment specified or by an approved equivalent method. Each pass shall consist of at least one passage of the roller wheel or drum over the entire surface of the layer.

Earth backfill—Earth backfill adjacent to structures shall be compacted to a density equivalent to that of the surrounding inplace earth material or adjacent required earthfill or earth backfill. Compaction shall be accomplished by hand tamping or manually directed power tampers, plate vibrators, walk-behind, miniature, or self-propelled rollers. Unless otherwise specified heavy equipment including backhoe mounted power tampers or vibrating compactors and manually directed vibrating rollers shall not be operated within 3 feet of any structure. Towed or self-propelled vibrating rollers shall not be operated within 5 feet of any structure. Compaction by means of drop weights operating from a crane or hoist is not permitted.

The passage of heavy equipment will not be allowed:

- Over cast-in-place conduits within 14-days after placement of the concrete
- Over cradled or bedded precast conduits within 7 days after placement of the concrete cradle or bedding
- Over any type of conduit until the backfill has been placed above the top surface of the structure to a height equal to one-half the clear span width of the structure or pipe or 3 feet, whichever is greater, except as may be specified in section 10.

Compacting of earth backfill adjacent to structures shall not be started until the concrete has attained the strength specified in section 10 for this purpose. The strength is determined by compression testing of test cylinders cast by the contractor's quality control personnel for this purpose and cured at the work site in the manner specified in ASTM C 31 for determining when a structure may be put into service.

When the required strength of the concrete is not specified as described above, compaction of earth backfill adjacent to structures shall not be started until the following time intervals have elapsed after placement of the concrete.

Structure	**Time interval** (days)
Vertical or near-vertical walls with earth loading on one side only	14
Walls backfilled on both sides simultaneously	7
Conduits and spillway risers, cast-in-place (with inside forms in place)	7
Conduits and spillway risers, cast-in-place (inside forms removed)	14
Conduits, pre-cast, cradled	2
Conduits, pre-cast, bedded	1
Cantilever outlet bents (backfilled both sides simultaneously)	3

7. Reworking or removal and replacement of defective earthfill

Earthfill placed at densities lower than the specified minimum density or at moisture contents outside the specified acceptable range of moisture content or otherwise not conforming to the requirements of the specifications shall be reworked to meet the requirements or removed and replaced by acceptable earthfill. The replacement earthfill and the foundation, abutment, and earthfill surfaces upon which it is placed shall conform to all requirements of this specification for foundation preparation, approval, placement, moisture control, and compaction.

8. Testing

During the course of the work, the contractor shall perform quality control tests, as applicable, to identify earthfill and earth backfill materials; determine the reference maximum density and optimum moisture content; and document that the moisture content of material at the time of compaction and the density of earthfill and earth backfill in place conform to the requirements of this specification.

Determining Reference Maximum Density and Optimum Moisture Content—For Class A compaction, the reference maximum density and optimum moisture content shall be determined in accordance with the compaction test and method specified on the drawings or in section 10.

Documenting Specification Conformance—In-place densities of earthfill and earth backfill requiring Class A compaction shall be measured in accordance with ASTM D1556, D2167, D2937, D6938 or D8167. Moisture contents of earthfill and earth backfill at the time of compaction shall be measured in accordance with ASTM D2216, D4643, or D6938. Values of moisture content determined by ASTM D2216 are considered the true value of the soil moisture. Values of moisture content determined by ASTM D4643 or D6938 shall be verified by comparison to values obtained by ASTM D2216. Values of in-place density and moisture content determined by these tests shall be compared to the minimum density and moisture content range specified on the drawings or in section 10.

Correction for Oversize Particles—If the materials to be used for earthfill or earth backfill contain more than 5 percent by dry weight of oversize rock particles (particles larger than those allowed in the specified compaction test and method), corrections for oversize particles shall be made using the appropriate procedures explained in ASTM D4718.

9. Measurement and payment

For items of work for which specific unit prices are established in the contract, the volume of each type and compaction class of earthfill and earth backfill within the specified zone boundaries and pay limits is measured and computed to the nearest cubic yard by the method of average cross-sectional end areas. Unless otherwise specified in section 10, no deduction in volume is made for embedded items, such as, but not limited to, conduits, inlet structures, outlet structures, embankment drains, sand diaphragm and outlet, and their appurtenances.

The pay limits shall be as defined below, with the further provision that earthfill required to fill voids resulting from overexcavation of the foundation, outside the specified lines and grades, will be included in the measurement for payment only under the following conditions:

- Where such overexcavation is directed by the engineer to remove unsuitable material, and
- Where the unsuitable condition is not a result of the contractor's improper construction operations as determined by the engineer.

Earthfill beyond the specified lines and grades to backfill excavation required for compliance with OSHA requirements will be considered subsidiary to the earthfill bid item(s).

Method 1—The pay limits shall be as designated on the drawings.

Method 2—The pay limits shall be the measured surface of the foundation when approved for placement of the earthfill and the specified neat lines of the earthfill surface.

Method 3—The pay limits shall be the measured surface of the foundation when approved for placement of the earthfill and the measured surface of the completed earthfill.

Method 4—The pay limits shall be the specified pay limits for excavation and the specified neat lines of the earthfill surface.

Method 5—The pay limits shall be the specified pay limits for excavation and the measured surface of the completed earthfill.

Method 6—Payment for each type and compaction class of earthfill and earth backfill is made at the contract unit price for that type and compaction class of earthfill. Such payment will constitute full compensation for all labor, material, equipment, and all other items necessary and incidental to the performance of the work.

Method 7—Payment for each type and compaction class of earthfill and earth backfill is made at the contract unit price for that type and compaction class of earthfill. Such payment will constitute full compensation for all labor, material, equipment, and all other items necessary and incidental to the performance of the work except furnishing, transporting, and applying water to the foundation and earthfill material. Water applied to the foundation and earthfill material is measured and payment made as specified in Construction Specification 10.

All methods—The following provisions apply to all methods of measurement and payment. Compensation for any item of work described in the contract, but not listed in the bid schedule is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 10 of this specification.

10. Items of work and construction details

10. Items of work and construction details

The maximum equipment compacted layer thickness shall be 9 inches before compaction and the maximum allowable equipment compacted particle size shall be 6 inches. Backfill adjacent to concrete works shall not contain particles larger than 1 inch in diameter. The maximum loose lift thickness allowed for hand compaction shall be 6 inches.

Immediately prior to placement of the initial fill layer on earthen foundations, the stripped foundation shall be loosened to a depth of approximately 6 inches and, after any necessary moisture adjustment, shall be compacted with a minimum of six complete passes of the compacting equipment.

After being deposited on the fill, each lift of fill material shall be spread, bladed and smoothed to the extent necessary to insure that the surface is free of abrupt mounds, depressions or windrows to provide a smooth uniform surface for operation of plowing and compaction equipment.

Each lift of fill material shall then be disked, bladed and plowed to an acceptable degree and depth so as to thoroughly loosen, blend, and bond the material with the preceding lift before compaction is started.

The minimum disk blade size shall be 34” in diameter. An increase in the weight of the plow; an increase in disc size; a decrease in thickness of lifts being placed, or any combination of these may be required to accomplish the blending and bonding herein specified.

All surfaces shall be closely examined immediately prior to the placement of all earthfills and backfills. All materials that exhibit drying cracks, slaking, or other evidences of being unstable or unsuitable, shall be removed or reworked by scarification, wetting, and compaction to the affected depths prior to the placement of fill. Additional compensation will not be made for removing or reworking the foundation or fill materials to meet the requirements herein specified.

In Section 9, Measurement and payment, Method 4 and 6 shall apply.

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 13, Earthfill, Standard

(1) This item shall consist of all fill and backfill necessary for the completion of Zone 1, Zone 3, and Zone 5 materials for the embankment and the vegetated auxiliary spillway, as well as the select backfill located beneath the principal spillway conduit as shown on the drawings.

(2) In Section 6, Compaction, Class A compaction shall apply. Material placement information shall be as shown on the drawings for Zone 1, Zone 3, and Zone 5 materials.

(3) The foundation on which earthfill is to be placed that has not had previous excavation performed shall be properly prepared as outlined in Section 3 of this specification.

(4) The Item of work subsidiary to this bid item is Excavation, Common, Borrow, as specified in Construction Specification 21.

b. Bid Item 14, Earthfill, Beneath R.C.C.

(1) This item shall consist of all fill and backfill necessary for the completion of Zone 2, Zone 4, and Zone 6 embankment materials as shown in the drawings.

(2) In Section 6, Compaction, Class A compaction shall apply. Material placement information shall be as shown on the drawings for Zone 2, Zone 4, and Zone 6 materials.

(3) The foundation on which earthfill is to be placed that has not had previous excavation performed shall be properly prepared as outlined in Section 3 of this specification.

(4) The Item of work subsidiary to this bid item is Excavation, Common, Borrow, as specified in Construction Specification 21.

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Construction Specification 24—Drainfill

1. Scope

The work consists of furnishing, placing, and compacting drainfill required in the construction of structure drainage systems.

2. Material

Method 1—Drainfill material shall conform to the requirements of Material Specification 521, Aggregates for Drainfill and Filters. A minimum of 30 days before delivery of materials to the site, the contractor shall inform the engineer in writing of the source(s) from which drainfill material will be obtained. The contractor shall provide the engineer free access to the source(s) for the purpose of obtaining samples for testing.

Method 2—Drainfill material shall be sand, gravel, or crushed stone, or mixtures thereof, obtained from the specified sources. The material shall be selected as necessary to avoid the inclusion of organic matter, clay balls, excessive fine particles, or other substances that would interfere with their free-draining properties.

3. Base preparation

Foundation surface and trenches shall be clean and free of organic matter, loose soil, foreign substance, and standing water when the drainfill is placed. Earth surfaces upon or against which drainfill will be placed shall not be scarified.

4. Placement

Drainfill shall not be placed until the subgrade has been inspected and approved by the engineer. Drainfill shall not be placed over or around pipe or drain tile until the installation of the pipe or tile has been inspected and approved.

Drainfill shall be placed uniformly in layers not to exceed 12 inches thick before compaction. When compaction is accomplished by manually controlled equipment, the layers shall not exceed 8 inches thick. The material shall be placed to avoid segregation of particle sizes and to ensure the continuity and integrity of all zones. No foreign material shall be allowed to become intermixed with or otherwise contaminate the drainfill.

Traffic shall not be permitted to cross over drains at random. Equipment cross-overs shall be maintained, and the number and location of such crossovers shall be established and approved before the beginning of drainfill placement. Each crossover shall be cleaned of all contaminating material and shall be inspected and approved by the engineer before the placement of additional drainfill material.

Any damage to the foundation surface or the trench sides or bottom occurring during placement of drainfill shall be repaired before drainfill placement is continued.

The upper surface of drainfill constructed concurrently with adjacent zones of earthfill shall be maintained at a minimum elevation of 1 foot above the upper surface of adjacent earthfill.

Drainfill over and/or around pipe or drain tile shall be placed to avoid any displacement in line or grade of the pipe or tile.

Drainfill shall not be placed adjacent to structures until the concrete has attained the strength specified in section 9 of this specification. The strength shall be determined by compression testing of concrete test cylinders cast and field cured at the project site in accordance with ASTM Method C 31 for determining when a structure may be placed into service.

When the required strength of the concrete is not specified as described above, placement of drainfill adjacent to concrete structures shall not be commenced until the following item intervals have elapsed following placement of the concrete:

Structure type	Time interval (days)
Vertical or near-vertical wall with earth loading on one side only (retaining walls and counterforts)	14
Walls backfilled on both sides simultaneously	7
Conduits and galleries, cast-in-place	
(with inside forms in place)	7
(inside forms removed)	14
Conduits, precast, cradled	2
Conduits, precast, bedded	1
Cantilever outlet bents backfilled on both sides simultaneously	3

5. Control of moisture

The moisture content of drainfill material shall be controlled as specified in section 9 of this specification. When additional water is required, it shall be applied in a manner to avoid excessive wetting to adjacent earthfill. Except as specified in section 9 of this specification, control of moisture content will not be required.

6. Compaction

Drainfill shall be compacted according to the following requirements for the class of compaction specified:

Class A compaction—For drainfill materials with more than 70 percent passing the 3/4 inch sieve, each layer of drainfill shall be compacted to a minimum dry density of not less than the density specified in section 9 of this specification as determined by ASTM D 698. For drainfill materials with 70 percent or less passing the 3/4 inch sieve, each layer of drainfill shall be compacted to a relative density of not less than 70 percent as determined by ASTM D 4254.

Class I compaction—Each layer of drainfill shall be compacted by a minimum of two passes over the entire surface with a steel-drum vibrating roller weighing at least 5 tons and exerting a vertical vibrating force of not less than 20,000 pounds at a minimum frequency of 1,200 times per minute, or by an approved equivalent method.

Class II compaction—Each layer of drainfill shall be compacted by one of the following methods or by an approved equivalent method. (A pass is defined as at least one complete coverage of the roller wheel, tire, or drum over the entire surface for each layer.)

a. A minimum of two passes over the entire surface with a pneumatic-tired roller exerting a minimum pressure of 75 pounds per square inch.

b. A minimum of four passes over the entire surface with the track of a crawler-type tractor weighing at least 20 tons.
c. Controlled movement of the hauling equipment so that the entire surface is traversed by not less than one tread track of the loaded hauling equipment.

Class III compaction—No compaction will be required beyond that resulting from the placing and spreading operations.

When compaction other than Class III compaction is specified, material placed in trenches or other locations inaccessible to heavy equipment shall be compacted by manually controlled pneumatic or vibrating tampers as specified in section 9 of this specification.

Heavy equipment shall not be operated within 2 feet of any structure. Vibrating rollers shall not be operated within 5 feet of any structure. Compaction by means of drop weights operating from cranes, hoists, or similar equipment will not be permitted.

7. Testing

The contractor shall conduct such tests as necessary to verify that the drainfill material and the inplace drainfill meets the specification requirements.

The engineer shall be granted access to perform such tests as are required to verify that the drainfill materials and the drainfill in place meets the requirements of the specifications. These tests are not intended to provide the contractor with information needed to assure that the materials and workmanship meet the specification requirements. These verification tests will not relieve the contractor of the responsibility of performing required tests for that purpose.

8. Measurement and payment

Method 1—For items of work for which specific unit prices are established in the contract, the volume of drainfill within the neat lines shown on the drawings are measured and computed to the nearest cubic yard. Where the engineer directs placement of drainfill outside the neat lines to replace unsuitable foundation material, the volume of such drainfill is included. The volume included is only to the extent that the unsuitable condition is not a result of the contractor's improper construction operation in the determination of the engineer.

Payment for drainfill is made at the contract unit price for each type of drainfill, complete in place. Except as otherwise specified in section 9 of this specification, such payment will constitute full compensation for all labor, equipment, material, and all other items necessary and incidental to the performance of the work.

Method 2—For items of work for which specific unit prices are established in the contract, the quantity of drainfill placed within the specified limits is computed to the nearest 0.1 ton by actual weight. Where the engineer directs placement of drainfill outside the neat lines to replace unsuitable foundation material, the weight of such drainfill is included. The weight included is only to the extent that the unsuitable condition is not a result of the contractor's improper construction operation in the determination of the engineer.

Payment for drainfill is made at the contract unit price for each type of drainfill, complete in place. Except as otherwise specified in section 9 of this specification, such payment will constitute full compensation for all labor, equipment, material, and all other items necessary and incidental to the performance of the work.

Compensation for any item of work described in the contract, but not included in the bid schedule is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 9 of this specification.

9. Items of work and construction details

9. Items of work and construction details

In Section 2, Material, Method 1 shall apply. The percentage of drainfill materials that is finer than the No. 200 U.S. Standard Sieve Size (0.074 millimeters) shall be not more than 3 percent when determined in accordance with the procedures contained in ASTM C117. Fines shall be non-plastic when tested in accordance with ASTM D4318.

Fine and compatible coarse drainfill gradations are shown in the drawings.

In Section 5, Control of moisture, fine drainfill shall be in wet or near saturated condition when placed. Each layer of fine drainfill shall be saturated immediately prior to compaction. No control of moisture is required for coarse drainfill.

In Section 6, Compaction, for fine drainfill, Class A compaction with the following exceptions shall apply:

The compacted dry density shall be a minimum of 95 percent of the maximum dry density as determined by the method in ASTM D698.

The ASTM D698 test procedure shall be modified to consist of a 1-point test performed on a representative sample of oven-dried drainfill.

In Section 6, Compaction, for coarse drainfill, Class III compaction shall apply.

In Section 8, Measurement and payment, Method 1 shall apply. A deduction in volume will not be made for embedded conduits.

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 15, Drainfill

(1) This item shall consist of furnishing and installing the fine and coarse drainfills required for the foundation trench drain, chimney drain/filter, filter diaphragm, RCC spillway drainage system and weep holes, impact basin drainage system, as well as the coarse drainfill for the riser and RCC sidewalls bearing pads to the limits and gradations shown on the drawings.

(2) Drainfill shall be placed in such a manner as to prevent segregation of particle sizes.

(3) When trenches for construction of the filter/drainage system are excavated through earthfill (or backfills), the trench depth shall be limited to five (5) feet maximum and shall include sufficient “overcut depth” to insure complete removal of earth contaminants of previously placed drainfill.

(4) Use of forms having projections that cause disturbance of adjacent drainfill materials or of in-place embankment materials when being withdrawn will not be permitted.

(5) The items of work subsidiary to this bid item are:

(a) Excavation, Common, Drainfill as specified in Construction Specification 21.

(b) Riser and RCC Sidewall Bearing Pad Geotextile as specified in Construction Specification 95.

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Construction Specification 26—Topsoiling

1. Scope
The work consists of furnishing and spreading topsoil to specified depths at locations shown on the drawings.

2. Quality of topsoil
Topsoil shall consist of friable surface soil reasonably free of grass, roots, weeds, sticks, rocks, or other unsuitable material. Additional quality requirements, if any, are in section 7 of this specification.

3. Furnishing
Method 1—Topsoil shall be salvaged from designated earth surfaces that will be disturbed by construction activities. After designated sites have been cleared and grubbed, the topsoil shall be removed from the designated areas and stockpiled at locations shown on the drawings or acceptable to the engineer. Unsuitable material encountered during removal of topsoil shall be disposed of at locations shown on the drawings or approved by the engineer, or it will be otherwise hauled and disposed of at locations removed from the construction site. The contractor is responsible for complying with all local rules and regulations and the payment of any and all fees that may result from the disposal at locations outside the construction work limits.

Method 2—Topsoil shall be furnished from an offsite source designated by the contractor. The engineer shall be granted access to the source for inspection and acceptance before delivery to the site. Test results and samples shall be provided when specified in section 7 of this specification.

4. Stockpiling
Stockpiles of topsoil shall not conflict with the requirements of Construction Specification 5, Pollution Control, when made a part of this contract.

5. Spreading
Method 1—Spreading shall not be conducted when the ground or topsoil is frozen, excessively wet, or otherwise in a condition detrimental to uniform spreading operations. Surfaces designated to receive a topsoil application shall be lightly scarified just before the spreading operation.

Following the spreading operation, the topsoil surface shall be left reasonably smooth and without ruts or surface irregularities that could contribute to concentrated waterflow downslope.

Method 2—Spreading shall not be performed when the ground or topsoil is frozen, excessively wet, or otherwise in a condition detrimental to uniform spreading operations. Surfaces designated to receive a topsoil application shall be lightly scarified just before the spreading operation. Where compacted earthfills are designated to be topsoiled, the topsoil shall be placed concurrently with the earthfill and shall be bonded to the compacted fill with the compacting equipment.

Following the spreading operation, the topsoil surface shall be left reasonably smooth and without ruts or surface irregularities that could contribute to concentrated waterflow downslope.

6. Measurement and payment
Method 1—The total surface covered by topsoil is measured and the area(s) computed to the nearest square yard. Payment for furnishing and placing topsoil is made at the contract unit price.

***Method 2*—**The total surface covered by topsoil, except the surface area of embankments, levees, dikes, and other earthfills not included for payment, is measured and the area(s) computed to the nearest square yard.

Payment for topsoil spread on the surface of embankments, levees, dikes, and other earthfills is included in the measurement and payment for that item of earthfill where topsoil application occurred.

***Method 3*—**For items of work for which specific unit prices are established in the contract, the volume of topsoil furnished and spread is computed to the nearest cubic yard by the method of average cross-sectional end areas from surveys of the excavated topsoil stockpile or, if not stockpiled, cross-sectional surveys of the borrow area(s). Payment for furnishing and spreading topsoil is made at the contract unit price.

***All methods*—**The following provisions apply to all methods of measurement and payment. Compensation for any item of work described in the contract, but not listed in the bid schedule is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 7 of this specification.

***All payment methods*—**Payment will constitute full compensation for all labor, equipment, material, and all other items necessary and incidental to the completion of the work. This includes excavating, stockpiling, hauling, spreading, and the wasting of unsuitable excavated material.

7. Items of work and construction details

7. Items of work and construction details

In Section 3, Furnishing, Method 1 shall apply.

In Section 5, Spreading, Method 1 shall apply. After spreading the topsoil on the required areas, a minimal amount of compacted effort shall be applied by passing over the entire surface with at least one pass of a dozer track. Care shall be taken to avoid over compaction that will hinder the establishment of grass. Final grade of topsoil shall be 0.1' +/- of the designed finished grade.

Topsoil shall be processed by pulverizing and shall have the moisture content adjusted to be at or slightly above the plastic limit as determined from NRCS feel method or other appropriate methods. A soil is at its plastic limit when a sample can be rolled between the hands to form a 1/8" thread without cracking or breaking apart. Soil that can be rolled to a 1/16" thread without cracking or breaking apart is too wet. Other methods for determining soil moisture content shall be approved by the Engineer. The moisture content of the backfill materials when placed shall be adjusted as necessary to meet the requirements.

Topsoil shall be placed to a depth of 6 inches normal to the slope.

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 16, Topsoiling

(1) This item shall consist of salvaging of approved topsoil from required excavations; from the stripping operations; and from borrow areas and placing and spreading it on all areas designated in the construction drawings to receive topsoil including the embankment; vegetative auxiliary spillway dikes, channel, and flare; outlet channels; and all exposed excavated slopes.

(2) Topsoil shall be placed after the earthfill placement has been completed.

(3) Upstream borrow areas and associated cut slopes that are above elevation 606.2 shall be topsoiled.

(4) In Section 6, Measurement and payment, Method 1 shall apply.

b. Subsidiary Item, Topsoil, Diversions

(1) This item shall consist of salvaging of approved topsoil prior to constructing the auxiliary spillway flare and stub diversions and placing and spreading it on the subgrade to complete the diversion to its designed dimensions as indicated in the construction drawings.

(2) Separate payment will not be made for this item. Compensation for this item will be included in the payment for the bid item for Diversions.

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Construction Specification 27—Diversions and Waterways

1. Scope
The work consists of all excavations, shaping, grading, and earthfills required to construct the diversions and waterways as shown on the drawings or as staked in the field.

2. Material
The earth material used in constructing the earthfill portions of the diversions or waterways shall be suitable material obtained from required excavations or earth material obtained from designated borrow areas. Material for earthfills shall be free from frozen material, brush, roots, sod, stones over 6 inches in diameter, or other objectionable material.

3. Foundation preparation
Foundations for earthfill shall be stripped to remove vegetation and other unsuitable materials or shall be excavated as specified.

Except as otherwise specified, earth foundation surfaces shall be graded to remove surface irregularities and shall be scarified parallel to the axis of the earthfill or otherwise acceptably scored and loosened to a minimum depth of 2 inches. The moisture content of the loosened material shall be controlled as specified for the earthfill, and the surface material of the foundation shall be compacted and bonded with the first layer of earthfill as specified for subsequent layers of earthfill.

Earth abutment surfaces shall be free of loose, uncompacted earth in excess of 2 inches in depth normal to the slope and shall be at such a moisture content that the earthfill can be compacted against them to produce a good bond between the earthfill and the abutments.

4. Placement
Earthfill material shall not be placed until the required foundation preparation is complete, inspected, and approved for placement. Earthfill shall not be placed upon a frozen surface. Earthfill shall be placed in horizontal layers not exceeding 9 inches in thickness. The moisture content of the earthfill materials shall be sufficient to obtain firm and suitable compaction. Compaction shall be obtained by routing the hauling and spreading equipment over the earthfill material so that the entire surface of each layer is traversed by not less than one track tread of the loaded equipment, or equivalent methods approved by the engineer.

5. Excavation
Excavation shall be to the lines and grades shown on the drawings or as staked in the field. All surplus and unsuitable material is designated as waste and shall be disposed of at locations shown on the drawings or at a location approved by the engineer.

6. Measurement and payment
***Method 1*—**For items of work for which specific unit prices are established in the contract, the length of waterway or diversion is determined to the nearest linear foot by measurement along the centerline of the waterway or diversion. Such payment will constitute full compensation for all labor, material, equipment, and all other items necessary and incidental to the performance of the work.

***Method 2*—**For items of work for which specific lump sum prices are established in the contract, the quantity of waterways or diversions is not measured for payment. Payment for waterways and diversions is made at the contract lump sum price and shall constitute full compensation for all labor, material,

equipment, and all other items necessary and incidental to the performance of the work.

***Method 3*—**The pay limits for excavation and earthfill shall be as designated on the drawings. Payment for excavation and earthfill to construct the waterways and diversions is separately measured and computed to the nearest cubic yard by the method of average cross-sectional end areas. Payment for excavation and earthfill is made at the unit price bid and shall constitute full compensation for all labor, material, equipment, and all other items necessary and incidental to the performance of the work.

***All methods*—**The following provisions apply to all methods of measurement and payment. Compensation for any item of work described in the contract, but not listed in the bid schedule is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 7 of this specification.

7. Items of work and construction details

7. Items of work and construction details

In Section 3, Foundation Preparation, prior to performing designated earthfills and/or excavations, the ground surface shall be stripped of vegetation and topsoil. The depth of this stripping shall be sufficient to remove soil containing significant vegetative or organic matter. The depth of stripping is estimated to be 6 inches, on average.

Suitable materials resulting from the required excavations shall be used to construct the specified fills except materials suitable for topsoil shall be stockpiled at the location designated by the Engineer. Unsuitable materials shall be placed in the waste area shown on the drawings

Finished grade of the diversions and/or waterways shall include 6 inches of topsoil salvaged from foundation stripping activities.

In Section 6, Measurement and payment, Method 1 shall apply.

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 17, Diversions

(1) This item shall consist of all work required to construct the stub diversions and auxiliary spillway flare diversion as shown in the construction drawings.

(2) The locations of the stub diversions shown on the drawings are approximate. The final locations shall be designated by the Engineer.

(3) The item of work subsidiary to this bid item is Topsoil, Diversions as specified in Construction Specification 26.

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Construction Specification 31—Concrete for Major Structures

1. Scope

The work consists of furnishing, forming, placing, finishing, and curing portland cement concrete as required to build the structures designated in section 25 of this specification.

The following BioPreferred® product category is applicable to this specification.

— Concrete release fluids (a.k.a., form-release agents)

2. Material

Aggregates must conform to the requirements of section 25 and Material Specification 522, Aggregates for Portland Cement Concrete, unless otherwise specified.

Portland cement must conform to the requirements of Material Specification 531, Portland Cement, for the specified type. One brand only of any type of cement may be used in any single structure as defined in section 25.

Fly ash must conform to the requirements of Material Specification 532, Supplementary Cementitious Materials.

Blast-furnace slag used as a partial substitution of portland cement in concrete must conform to the requirements of Material Specification 532, Supplementary Cementitious Materials.

Silica fume must conform to the requirements of Material Specification 532, Supplementary Cementitious Materials.

Air-entraining admixtures must conform to the requirements of Material Specification 533, Chemical Admixtures for Concrete. If air-entraining cement is used, any additional air-entraining admixture must be of the same type as that in the cement.

Plasticizing admixtures must conform to the requirements of Material Specification 533, Chemical Admixtures for Concrete.

Water-reducing or retarding admixtures must conform to the requirements of Material Specification 533, Chemical Admixtures for Concrete.

Accelerating and water-reducing and accelerating admixtures, if specified in section 25, must conform to the requirements of Material Specification 533, Chemical Admixtures for Concrete.

Curing compound must conform to the requirements of Material Specification 534, Concrete Curing Compound.

Preformed expansion joint filler must conform to the requirements of Material Specification 535, Preformed Expansion Joint Filler.

Sealing compound for joints must conform to the requirements of Material Specification 536, Sealing Compound for Joints in Concrete and Concrete Pipe.

Waterstops must conform to the requirements of Material Specifications 537, Nonmetallic Waterstops, and 538, Metal Waterstops, for the specified kinds.

Dowels must be a plain, round steel bar conforming to the requirements of Material Specification 539, Steel Reinforcement (for concrete).

Metal plates must conform to the requirements of Material Specification 581, Metal, for structural quality or commercial or merchant quality steel. Structural quality must be used only if specifically designated in the drawings or specifications.

Water used in mixing and curing concrete must be clean and free from injurious amounts of oil, salt, acid, alkali, organic matter, or other deleterious substances.

3. Concrete mix design

Method 1
Responsibilities—The contractor is responsible for the design and proportioning of the concrete. Job mixes must be prepared to meet the quality, consistency, and strength of concrete specified.

Submittals—At least 15 calendar days before the placement of any concrete, the contractor must provide the engineer with full documentation to support each job mix and any admixtures to be used in the work. The contractor must furnish test results to the engineer for each admixture showing that it meets the requirements of Material Specification 533, Chemical Admixtures for Concrete. Job mixes are reviewed and accepted or rejected by the engineer within 8 calendar days following the date of submittal. After a job mix has been accepted, neither the source, character, nor gradation of the aggregates nor the type or brand of cement or admixtures may be changed without prior notice to the engineer. Revisions or changes in a job mix that are determined to be significant by the engineer must follow the same submittal and acceptance process as that for the initial job mix.

Design criteria—The class of concrete must be as specified in section 25 and in accordance with the following specified compressive strength.

Class of concrete	**Specified compressive strength (f'_c) at 28 days (lb/in^2)**
5000	5,000
4000	4,000
3000	3,000
2500	2,500

Maximum water-cement ratio must be 0.50, unless otherwise specified.

Unless otherwise specified the air content (by volume) of the concrete at the time of placement must be:

Maximum size aggregate	**Air content (%)**
3/8 inch to l inch	5 to 7
Over l inch	4 to 6

The consistency of all concrete must allow it to be placed without segregation or excessive laitance. Unless otherwise specified, the slump must be:

Type of structural section	Slump (inches)
Massive sections, pavements, footings	2 ± 1
Heavy beams, thick slabs, thick walls (>12 inches)	3 ± 1
Columns, light beams, thin slabs, thin walls (12 inches or less)	4 ± 1

Superplasticized concrete must contain either a water-reducing, high range admixture (ASTM C494, Type F or G) or a plasticizing admixture (ASTM C1017) at a dosage rate that reduces the quantity of water required to produce a concrete mix within the above slump range by 12 percent or more or produces an increase in the slump of at least 2 inches above the slump of the design mix containing no water reducer or plasticizing admixture.

A water-reducing admixture (ASTM C494, Type F or G), a plasticizing admixture (ASTM C1017), or both may be added to an approved job mix without resubmittal and reapproval of the job mix if the following requirements are met:

a. The admixture must be introduced into the concrete mix as specified by the manufacturer and be compatible with other admixtures in the job mix.

b. The water content must be equal to or less than that required in the job mix without the admixture.

c. The cement content must be the same as that required in the job mix without the admixture.

d. The air content must be within the specified range.

e. The slump must not exceed 7.5 inches unless the contractor demonstrates before placement that the job mix can be placed without segregation or excessive laitance at a slump greater than 7.5 inches. The concrete must retain the increased slump for not less than 30 minutes.

f. If the admixture is added at the job site, the slump of the concrete before the addition of the admixture must not exceed the slump specified above for concrete that does not contain the admixture.

Calcium chloride or other corrosive accelerators may not be used unless otherwise specified.

Fly ash may be used as a partial substitution for portland cement in an amount not greater than 25 percent (by weight) of cement in the concrete mix unless otherwise specified.

Ground granulated blast-furnace slag may be used as a partial substitution for portland cement in amounts between 25 to 70 percent (by weight) of cement in the concrete mix unless otherwise specified.

Silica fume may be used as a partial substitution for portland cement in an amount ranging from 5 to 10 percent (by weight) of cement in the concrete mix unless otherwise specified.

Job mix criteria—Proportioning of concrete for job mixes must be based on the standard deviation computed from compressive strength tests of previous batch records or established by laboratory trial mixes. Unless otherwise specified, a compressive strength test is the average of the compressive strengths of two standard cured cylinders prepared and tested in accordance with section 4.

For a job mix based upon the standard deviation computed from compressive strength tests of previous batch records, the previous batches must represent similar material and conditions to those expected for the job mix and have a strength within 1,000 pounds per square inch of the specified compressive strength (f'_c) at 28 days for the class of concrete specified. The contractor must provide to the engineer copies of the facility's previous batching records that show the compressive strength results and the batch mix design used.

For a job mix based upon a laboratory trial mix, the trial mix must contain the actual material to be used in the final job mix, have a slump within 0.75 inches of the maximum allowable slump, and have an air content within 0.5 percent of the maximum allowable air content. The contractor must provide the engineer with copies of the actual compressive strength test records for the trial mix from the testing facility performing the test.

The trial job mix or previous batch records must include the water-reducing admixture when a water-reducing admixture is used in a concrete mix specifically to improve the physical properties of the hardened concrete or change portions of the mix components.

In meeting strength requirements, the selected job mix proportions must produce an average strength, f_{cr}, exceeding the specified compressive strength, f'_c, by the amount specified.

n	s_{30}	f_{cr}
>30	1.00 s	The larger of these
25	1.03 s	two equations:
20	1.08 s	$f'_c + 1.34\ s30$
15	1.16 s	$f'_c + 2.33\ s30 – 500$
<15		$f'_c + 1{,}000$ for $f'_c < 3{,}000$
		$f'_c + 1{,}200$ for $3{,}000 \leq f'_c \leq 5{,}000$
		$1.10\ f'_c + 700$ for $f'_c > 5{,}000$

Where—
n = number of consecutive compressive strength tests
s_{30} = standard deviation adjusted to 30 tests, lb/in^2
f_{cr} = required average compressive strength, lb/in^2
f'_c = specified compressive strength of concrete, lb/in^2
s = standard deviation (lb/in^2) computed as $\{[sum(Xi-Xa)^2]/[n-1]\}^{1/2}$
where:
Xi = individual strength test result, lb/in^2
Xa = average of n strength test results, lb/in^2

Method 2
Responsibilities—The engineer is responsible for the design and proportioning of the job mix. The initial job mix must be as specified in section 25. The engineer may adjust the initial job mix proportions to establish the designated job mix. The engineer will provide the contractor with a copy of each job mix as soon as the material and proportions have been determined. After the job mix has been designated, neither the source, character, nor gradation of the aggregates nor the type or brand of cement or admixtures may be changed without prior approval of the engineer. During the course of the work, the engineer may adjust the job mix proportions and batch weights whenever necessary to meet special job conditions.

The contractor, for each class of concrete, is responsible for—

a. Taking the following actions and furnishing the engineer with the following information at least 35 calendar days before any placement of concrete, unless otherwise designated:

(1) Select the source of aggregates and sample and test the gradations of aggregates available.
(2) Select the brand and type of cement.
(3) Select the brand of admixtures and obtain manufacturer's test data and recommendation of use.
(4) Identify the concrete production facility, the type of mixer, and the mixing methods that will be used.
(5) Provide from the concrete production facility consecutive compressive strength test records and batching records for concrete mixes that have material, proportions, and compressive strengths within 1 000 pounds per square inch of the proposed design mix.

b. Batching at least 3 cubic yards of the initial job mix, in the presence of the engineer, for testing and evaluation not less than 30 calendar days before any placement of concrete.

4. Inspecting and testing

During the course of the work, the engineer performs quality assurance testing as required to verify the concrete meets the contract requirements. The engineer must have free entry to the plant and equipment furnishing concrete under the contract. Proper facilities must be provided for the engineer to inspect material, equipment, and processes and to obtain samples of the concrete. All tests and inspections are conducted so as not to interfere unnecessarily with the manufacture, delivery, and placement of the concrete.

Any portion of a batch may be tested by the engineer for any of the purposes shown below. Samples taken for testing must be representative of that part of the batch.

a. Determining uniformity of the batch.

b. Checking compliance with requirements for slump and air content when the batch is discharged over an extended period.

c. Checking compliance of the concrete with the specifications when the whole amount being placed in a small structure, or a distinct part of a larger structure, is less than full batch.

If concrete is conveyed to the placement location by pumping or conveyor belts, the samples must be collected at the discharge end.

When a plasticizing admixture is added to the concrete mix at the job site, slump tests are made both before the addition of the admixture to the concrete mix and after the admixture has been incorporated into the concrete mix.

The tests on concrete are performed by the following methods unless otherwise specified:

Type of test	**Test method (ASTM designation)**
Sampling	C172
Slump test	C143
Air content	C231 or C173
Compression test specimens	C31 or C42
Compressive strength testing	C39
Unit weight	C138
Temperature	C1064

A strength test for concrete is the average of two standard cured concrete cylinders prepared in accordance with ASTM C31 from the same sample of concrete and tested in accordance with ASTM C39 at 28 days, unless

otherwise specified. If one cylinder shows manifest evidence of improper sampling, molding, curing, or testing, it must be discarded and the strength of the remaining cylinder must then be considered the compressive strength of the concrete. Should both cylinders show such defects, the entire test must be discarded.

If both cylinders are discarded or in-place concrete that was not sampled is in question, the in-place concrete may be sampled by coring in accordance with ASTM C42. For core tests, these requirements must be followed:

a. At least three representative cores must be taken from each area of concrete in question. If one or more of the cores shows signs of being damaged before testing, it must be replaced by a new one.

b. Test cores must be prepared for testing in accordance with moisture conditioning in ASTM C42 unless the engineer determines that the concrete in the structure will be dry under service conditions. If the concrete is determined to be dry under service conditions, the cores must be air dried (temperature 60°F to 80°F and relative humidity less than 60%) for 7 days before testing and must be tested dry.

5. Handling and measurement of material

Aggregates must be stored or stockpiled in such a manner that separation of coarse and fine particles of each size is avoided and that various sizes do not become intermixed before proportioning. Methods of handling and transporting aggregates must avoid contamination, excessive breakage, segregation, degradation, or intermingling of various sizes.

Unless otherwise specified, scales must be beam type or spring-less dial type. They must be accurate when static load tested to plus 0.4 percent of the total capacity of the scales. All exposed fulcrums, clevises, and similar working parts of scales must be kept clean.

Measuring tanks for mixing water must be of adequate capacity to furnish the maximum amount of mixing water required per batch. Tanks must be equipped with outside taps and valves to verify their calibration unless other means are provided for readily and accurately determining the amount of water in the tank.

The quantities of each component of the concrete mix must be measured by the following methods and to the accuracy indicated below:

Cement, fly ash, slag—Cement, except as otherwise specifically permitted, must be measured by weight or in bags on which the weight is plainly marked. When cement, fly ash, and slag are supplied in bulk and are measured by weight, they must be weighed on a scale separate from that used for other material and in a hopper entirely free and independent of the hopper used for weighing the aggregate. When fly ash or slag is used in the job mix, the cement and the fly ash or slag may be weighed separately or cumulatively by weighing the cement first and then adding the fly ash or slag to arrive at the composite weight. The weight of the cement and the combined weight of the cement and fly ash or slag must be within plus or minus 1 percent of the required weight of the cementitious material. When cement is measured in bags, no fraction of a bag may be used unless weighed.

Aggregates—Aggregates must be measured by weight unless otherwise specifically permitted. Mix proportions must be based on saturated, surface-dry weights. The batch weight of each aggregate is the required saturated, surface-dry weight corrected by the weight of surface moisture it contains. The weight of each of the specified aggregates must be within plus or minus 2 percent of the required weight.

Mixing water—Mixing water consists of water added to the batch, ice added to the batch, water occurring as surface moisture on the aggregates, and water introduced in the form of admixtures. The added water must be measured by weight or volume to an accuracy of l percent of the required total mixing water. Added ice must be measured by weight. Wash water must not be used as part of the mixing water for succeeding batches.

Admixtures—Dry admixtures must be measured by weight. Paste or liquid admixtures must be measured by weight or volume. The admixtures must be within plus or minus 3 percent of the required weight or volume for each specific admixture.

6. Mixers and mixing

Mixers are either stationary parts of a central mixing plant or portable equipment, such as revolving drum truck mixers and volumetric batching/continuous mixing truck mixers. Mixers must be capable of thoroughly mixing the concrete ingredients into a uniform mass within the specified mixing time and of discharging the mix without segregation. Each mixer or agitator must bear a manufacturer's rating plate indicating the gross volume of the drum, the capacity of the drum or container in terms of the volume of mixed concrete, and the minimum and maximum mixing speeds of rotation of the drum, blades, or paddles. When the truck mixer is used for truck-mixed concrete as described in section 6a(2) or for shrink-mixed concrete as described in section 6a(3), the capacity of the drum or container in terms of the volume of mixed concrete must not exceed 63 percent of the gross volume of the drum. When the truck mixer is used to transport central-mixed concrete as described in section 6a(1), the capacity of the drum or container in terms of the volume of mixed concrete must not exceed 80 percent of the gross volume of the drum. The mixer must be operated in accordance with these recommendations.

Concrete must be uniform and thoroughly mixed when delivered to the forms in a freshly mixed and unhardened state. Variations in slump of more than 1 inch within a batch is considered evidence of inadequate mixing and must be corrected by changing batching procedures, increasing mixing time, changing mixers, or other means. Mixing time must be within the limits specified below unless the contractor demonstrates by mixer performance tests that adequate uniformity is obtained by different times of mixing.

No mixing water in excess of the amount called for by the job mix may be added to the concrete during mixing or hauling or after arrival at the delivery point. Water to compensate for up to a 1-inch loss in slump may be added, not to exceed the design maximum water cement ratio. Withholding some of the mixing water until the concrete arrives on the job, then adding the remaining water and turning the mixer 30 revolutions at mixing speed is allowed to overcome transporting conditions. When loss of slump or workability cannot be offset by these measures, complete mixing must be performed by onsite batching and mixing or by using a combination of centrally batching and transporting material to the site and adding remainder of material onsite.

Concrete may be furnished by ready-mix methods, by volumetric batching and continuous mixing at the site, or by batch mixing at the site.

a. Ready-mixed concrete

Ready-mixed concrete must be mixed, transported, and placed in a freshly mixed and unhardened state. The contractor must furnish the engineer a batch ticket showing amount of concrete in cubic yards, the time of loading, the time the load was discharged, the revolution counter reading at the time of loading and discharge, and the type and actual quantity of each material including all admixtures used in each batch of concrete. The batch ticket must include information necessary to calculate the water-cementitious materials ratio.

Truck mixers and truck agitators must be equipped with revolution counters by which the number of revolutions of the drum or blades may be readily verified. Ready-mixed concrete must be mixed and delivered by one of the following methods:

(1) Central-mixed concrete—Central-mixed concrete is mixed completely in a stationary mixer and transported to the point of delivery either in a truck agitator, a truck mixer operating at agitating speed, or non-agitating equipment.

When a truck agitator or a truck mixer is used as an agitator and transports concrete that has been completely mixed in a stationary mixer, mixing during transportation must be at the speed designated by the manufacturer of the equipment as agitating speed. When concrete is transported in a truck mixer or truck agitator, the volume of the mixed concrete must not exceed 80 percent of the gross volume of the drum. The total number of revolutions of the truck mixer or truck agitator must not exceed 200 before discharge of the concrete, unless otherwise specified.

The use of non-agitating equipment to transport concrete to the site of the work is permitted only if the consistency and uniformity of the concrete as discharged at the point of delivery meet the requirements of this

specification. Bodies of non-agitating hauling equipment must be constructed so that leakage of the concrete mix, or any part thereof, does not occur. Concrete hauled in open-top vehicles must be protected from rain and from more than 20 minutes exposure to the sun and wind when the air temperature is above 75 degrees Fahrenheit.

(2) Truck-mixed concrete—Truck-mixed concrete is completely mixed in a truck mixer. The total volume of all ingredients to be mixed in a revolving drum truck mixer must not exceed 63 percent of the gross volume of the drum. The concrete ingredients must be mixed between 70 and 100 revolutions of the drum or blades at the speed designated by the manufacturer as mixing speed. Mixing in excess of 100 revolutions must be at the speed designated by the manufacturer of the equipment as agitating speed.

(3) Shrink-mixed concrete—Shrink-mixed concrete is partly mixed at a central plant and the mixing is completed in a truck mixer. The mixing time in the central plant mixer is the minimum required to intermingle the ingredients. The volume of the mixed concrete in a truck mixer must not exceed 63 percent of the gross volume of the truck drum. The mixing must be completed in a truck mixer. The number of revolutions of the truck mixer drum or blades must be between 50 and 100 revolutions at the speed designated by the manufacturer as mixing speed. Mixing in excess of 100 revolutions must be at the speed designated by the manufacturer of the equipment as agitating speed.

b. Volumetric batching and continuous mixing at the site

Equipment used for volumetric batching and continuous mixing at the site is commonly referred to as mobile concrete mixers. Unless otherwise specified, volumetric batching and continuous mixing at the construction site is permitted. The batching and mixing equipment must conform to the requirements of ASTM C685 and must be demonstrated before placement of concrete by tests with the job mix to produce concrete meeting the specified proportioning and uniformity requirements. Concrete made by this method must be produced, inspected, and documented in conformance with ASTM C685.

c. Batch mixing at the site

This method of batching and mixing concrete is either by batching and mixing all material onsite using paving mixers or stationary construction mixers or by using a combination of centrally batching part of the mix, transporting it to the site, and adding the rest of the material and mixing onsite.

Paving mixers or stationary construction mixers and associated transport vehicles must be in accordance with recommended practices described in method 1 for central mixed concrete. The time for mixing a batch of concrete in the mixer drum must be according to manufacturer's recommendations, but not less than 1 minute plus 0.25 minute for each cubic yard of concrete being mixed (8 yd^3 batch = 3 minutes).

When a combination of centrally batching and transporting material to the site and adding rest of material onsite is used, the contractor must prepare a written plan detailing how the batching and mixing of the concrete material will be accomplished and controlled. This written batching and mixing plan must be submitted to the engineer for review and approval not less than 10 working days before the placement of concrete. The volume of the mixed concrete in a truck mixer must not exceed 63 percent of the gross volume of the drum.

The contractor must furnish the engineer a batching ticket for each batch of fresh concrete. The ticket shows the type, brand, and amount of cement; the type, name, and amount of each admixture; total water added to the batch, which includes free water on the aggregate; maximum size of aggregate; the type and dry weight of fine aggregate; the type and dry weight of coarse aggregate; the time of loading (the time that water was introduced to the cement); and the time the load was discharged.

7. Forms

Forms must be of good quality wood, plywood, steel, or other approved material and must be mortar tight. The forms and associated falsework must be substantial and unyielding and must be constructed so that the finished concrete conforms to the specified dimensions and contours. Form surfaces must be smooth and free from holes, dents, sags, or other irregularities and must be maintained in this condition throughout the work. Forms must be coated with a non-staining form release agent before being set into place. Acceptable tolerances for formed structure members are specified in section 23.

When a superplasticized concrete mix is used, forms must be designed to withstand the increased pressures of the superplasticized concrete and the increased impact forces resulting from larger drop heights used in placing the superplasticized concrete. Form release agents must be specifically formulated, when specified, for use with plasticized concrete or documentation from the release agent manufacturer must be provided stating that formed concrete surfaces made using the form release agent with plasticized concrete have not varied significantly from nonplasticized concrete surfaces made using the same form release agent. If the form release agent is not specifically formulated for use with plasticized concrete and, after observing its performance, it is suspected the release agent is responsible for causing increased surface imperfections (bug-holes), a release agent specifically formulated for use with plasticized concrete must be used for all formed concrete to be subsequently placed.

Metal ties or anchorages that will be embedded in the concrete must be equipped with cones, she-bolts, or other devices that permit their removal to a depth of at least 1 inch without injury to the concrete. Ties designed to break off below the surface of the concrete must not be used without cones. If approved fiberglass or plastic form ties are used, the tie ends must be cut flush with the finished concrete and ground smooth.

All edges that will be exposed must be chamfered unless finished with molding tools as specified in section 18.

8. Preparation of forms and subgrade

Before placement of concrete, the forms, embedments, and subgrade must be free of chips, sawdust, debris, water, ice, snow, extraneous oil, mortar, or other harmful substances or coatings. Any form release agent on the reinforcing steel or other surfaces required to be bonded to the concrete must be removed.

Rock surfaces must be cleaned by high pressure air-water cutting, sandblasting, or wire brush scrubbing, as necessary, and must be wetted immediately before placement of concrete. The earth surface must be firm and damp. Placement of concrete on mud, dried earth, non-compacted fill, or frozen subgrade is not permitted. All ice, snow, and frost must be removed, and the temperature of all surfaces, including the reinforcing steel and other steel inclusions, to be in contact with the new concrete must be no colder than 40 degrees Fahrenheit.

Items to be embedded in the concrete must be positioned accurately and anchored firmly.

Weep holes in walls or slabs must be formed with nonferrous material.

9. Conveying

Concrete must be delivered to the site and discharged completely into the forms within 1.5 hours after the introduction of the mixing water to the cement and aggregates or the introduction of the cement to the aggregates. In hot weather or under conditions contributing to quick stiffening of the concrete, or when the temperature of the concrete is 85 degrees Fahrenheit or above, the time between the introduction of the cement to the aggregates and discharge must not exceed 45 minutes.

Superplasticized concrete may be conveyed and placed when the temperature of the concrete is below 95 degrees Fahrenheit and the slump of the concrete remains within the allowable slump range.

The engineer may allow an appropriate extension of time when the setting time of the concrete is increased a corresponding amount by the addition of an approved admixture. In any case, concrete must be conveyed from the mixer to the forms as rapidly as practicable by methods that prevent segregation of the aggregates or loss of mortar.

10. Placing

Concrete must not be placed until the subgrade, forms, steel reinforcement, and other embedments are inspected and approved by the engineer. For walls and columns, subsequent higher placements of concrete must not be placed until the concrete below the new placement has gained sufficient strength to support the concrete dead load and any superimposed loads without distress. Placement sequences and timing must consider form removal timing covered in section 16.

If a placement plan is required in section 25, concrete must not be placed until the placement plan has been reviewed and approved by the engineer. The contractor must have all equipment and material required for curing available at the site ready for use before placement of concrete begins.

Concrete must be placed only in the presence of the engineer. The contractor must give reasonable notice to the engineer before each placement. Such notice must be far enough in advance to give the engineer adequate time to verify that the subgrade, forms, steel reinforcement, and other preparations comply with specifications. Other preparations include, but are not limited to, the concrete batching plant, mixing and delivery equipment and system, placing and finishing equipment and system, schedule of work, workforce, and heating or cooling facilities, as applicable. All deficiencies are to be corrected before concrete is delivered for placing.

Concrete must be placed and consolidated to prevent segregation of the mix components. The concrete must be deposited as closely as possible to its final position in the forms. It must be worked into the corners and angles of the forms and around all reinforcement and embedded items to prevent segregation of aggregates or excessive laitance. The depositing of concrete must be regulated so that the concrete can be consolidated with a minimum of lateral movement. Concrete placement against a sloping surface must start at the lowest elevation and work upwards to the highest elevation.

Concrete other than architectural concrete must not be dropped more than 5 feet vertically unless suitable equipment is used to prevent segregation. Architectural concrete must not be dropped more than 3 feet vertically unless suitable equipment is used to prevent segregation. When a superplasticized concrete mix is used, concrete other than architectural concrete must not be dropped more than 12 feet vertically and architectural concrete must not be dropped more than 10 feet vertically unless suitable equipment is used to prevent segregation.

11. Layers

Slab concrete must be placed to design thickness in one continuous layer unless otherwise specified. Formed concrete must be placed in horizontal layers not more than 20 inches deep. Where a superplasticized concrete mix is used, formed concrete may be placed in horizontal layers not more than 5 feet deep.

Successive layers of fresh concrete between construction joints must be placed at a rate fast enough that the preceding layer is still plastic and can be easily mixed with the fresh concrete such that seams (cold joints) or plane of weakness do not occur. If the surface of a previously placed layer of concrete has taken a set to the degree that it will not flow and mix with the succeeding layer when vibrated, the contractor must discontinue placing concrete and must make a construction joint according to the procedure specified in section 13. If placing is discontinued when a layer is incomplete, the ends of the incomplete layer must be formed by a vertical bulkhead.

12. Consolidating

All concrete must be consolidated with internal type mechanical vibrators capable of transmitting vibration to the concrete at frequencies not less than 8,000 impulses per minute, unless otherwise specified or approved before placement. Vibration must be supplemented by spading, rodding, and hand tamping as necessary to ensure smooth and dense concrete along the form surface, in corners, and around embedded items. The contractor must provide a sufficient number of vibrators to properly consolidate the concrete immediately after it is placed. A sufficient number of standby vibrators must be kept onsite during the placement of concrete.

Vibration must compact the concrete and bring it into intimate contact with the forms, reinforcing steel, and other embedded items while removing voids and pockets of entrapped air. The location, insertion, duration, and removal of the vibrators must be such that maximum consolidation of the concrete is achieved without causing segregation of the mortar and coarse aggregate or causing water or cement paste to flush to the surface. Vibration must be applied to the freshly deposited concrete by rapidly inserting the vibrator and slowly, in an up and down motion, removing the vibrator at points uniformly spaced at not more than 1.5 times the radius of the area visibly effected by vibration. Generally, this is at 5 to 10 seconds per foot on 14-inch spacings or less. The area visibly effected by the vibrator must overlap the adjacent, just vibrated area. The vibrator must extend vertically into the previously placed layer of

fresh concrete by at least 6 inches at all points. This ensures effective bond between layers. In thin slabs the vibrator(s) should be sloped toward the horizontal to allow operations in a fully embedded position.

Vibration must not be applied directly to the reinforcement steel, the forms, or other embedded items unless otherwise specified. Vibration must not be applied to concrete that has hardened to the degree that it does not become plastic when vibrated. If surface vibrators are used, they may contact forms when consolidating thin slabs.

The use of vibrators to transport concrete in the forms or conveying equipment is not permitted.

Surface vibrators may be used to consolidate slabs 8 inches and less in thickness. Slabs more than 8 inches thick must be consolidated with internal vibration and may be augmented through use of surface vibrator, such as vibrating screeds, plate or grid vibratory tampers, or vibratory roller screeds. If concrete is to be consolidated using surface vibration methods, the contractor must detail how this work is to be performed in writing to the engineer for review and approval. This report must be submitted no less than 30 calendar days before placing concrete by this method. It includes equipment selection and specifications.

13. Construction joints

Construction joints must be made at the locations shown on the drawings unless otherwise specified or approved by the engineer. If construction joints are needed that are not shown on the drawings, they must be placed in locations approved by the engineer.

Where a feather edge would be produced at a construction joint, as in the top surface of a sloping wall, an insert form must be used so that the resulting edge thickness on either side of the joint is not less than twice the maximum aggregate diameter used in the concrete mix.

Non-vertical construction joints in structural elements, such as walls and columns, must be consolidated and screeded to grade unless otherwise specified. Construction joints must be covered and wet cured for 7 days or until concrete placement resumes unless otherwise specified.

Steel tying and form construction next to concrete in place must not be started until the concrete has cured at least 12 hours. Before new concrete is deposited on or against concrete that has hardened, the forms must be retightened. New concrete must not be placed until the hardened concrete has cured at least 12 hours.

Method l—The surface of construction joints must be cleaned of all unsatisfactory concrete, laitance, coatings, stains, or debris by sandblasting or high-pressure air-water cutting, or both. Sandblasting can be used after the concrete has gained sufficient strength to resist excessive cutting, and high-pressure air-water cutting can be used as soon as the concrete has hardened sufficiently to prevent the jet from displacing the coarse aggregates. The surface of the concrete in place must be cut to expose clean, sound aggregate, but not so deep as to undercut the edges of larger particles of the aggregate. After cutting, the surface must be thoroughly washed to remove all loose material. If the surface is congested by reinforcing steel, is relatively inaccessible, has cured beyond the ability to cut with air-water blasting, or disturbing the concrete before it is hardened is considered undesirable, cleaning of the joint by air or water jets is not permitted. The sandblasting method is required after the concrete has hardened.

Immediately before new concrete is placed, all construction joints must be wetted and standing water removed.

Method 2—The surface of construction joints must be cleaned of all unsatisfactory concrete, laitance, coatings, stains, or debris by washing and scrubbing with a wire brush or wire broom, or by other means approved by the engineer. Immediately before new concrete is placed, all construction joints must be wetted and standing water removed.

14. Expansion and contraction joints

Expansion and contraction joints must be made only at locations shown on the drawings. Exposed concrete edges at expansion and contraction joints must be carefully tooled or chamfered, and the joints must be free of mortar and concrete. Joint filler must be fully exposed for its entire length with clean and true edges.

Where open joints or weakened plane "dummy" joints are specified, joints formed in fresh concrete must be constructed by the insertion and subsequent removal of a wood strip, metal plate, or other suitable template. This must be done so that the corners of the concrete do not chip or break. The edges of the fresh concrete at the joints must be finished with an edging tool before the joint strips are removed. Open joints or weakened plane dummy joints may also be saw-cut joints conforming to the depth and extent specified.

Preformed expansion joint filler must be held firmly in the correct position as the concrete is placed.

15. Waterstops

Waterstops must be held firmly in the correct position as the concrete is placed. Joints in metal waterstops must be brazed or welded. Joints in rubber or plastic waterstops must be cemented, welded, or vulcanized as recommended by the manufacturer. Joints must be watertight and of a strength equivalent to that specified in Material Specification 537. Intersecting waterstop joints must be prefabricated and supplied by the same manufacturer providing the waterstop.

16. Removal of forms, supports, and protective coverings

Forms, supports, and protective coverings must be removed as soon as practical after the concrete has gained sufficient strength to support its own weight and superimposed loads. Removal must be done so that the concrete surface is not damaged and sudden or excessive stresses are not induced. The minimum period from completion of the concrete placement to the removal of the forms must be based on either strength tests or cumulative times.

Strength tests—The strength of the in-place concrete is determined by testing concrete cylinders specifically cast for this purpose and cured adjacent to the member in accordance with the ASTM C31 method for determining removal time. Unless otherwise specified, forms supporting the weight of the concrete member may be removed after the concrete strength is 70 percent of that specified for the class of concrete. Forms not supporting the weight of the concrete member or other superimposed loads may be removed after the concrete strength has reached the strength specified in section 25.

Cumulative time—The total accumulated time, not necessarily continuous, that the air adjacent to the concrete is above 50 degrees Fahrenheit and the specified concrete curing has occurred concurrently will be determined. Forms may be removed after the total accumulated time shown:

Accumulated form removal times

Forms		**Time** [1/]
Sides of slabs or beams		12 hours
Undersides of slabs or beams	Clear span	[2/]
	< 10 ft.	4 days
	10 - 20 ft.	7 days
	> 20 ft.	14 days

Sides of walls or columns	Height above form	3/ 4/
	< 10 ft.	12 hours
	< 20 ft.	24 hours
	> 20 ft.	72 hours

1/ Table values apply to normal concrete. Values for concrete that contains cements or admixtures that significantly retard or accelerate strength gain will be determined by the engineer and based on actual design mix data.

2/ Values apply to members designed to support significant superimposed loads. Values for members designed for only self-weight when placed in service must be 50 percent greater.

3/ Values apply to members not subject to significant horizontal loads. Additional time or re-bracing is needed for members subject to significant wind or other horizontal loads.

4/ Subsequent higher lifts may be placed after 12 hours.

17. Finishing formed surfaces

All formed concrete surfaces must be true and even, and must be free from over-tolerance depressions, holes, projections, bulges, or other defects in the specified surface finish or alignment, unless otherwise specified in section 25. Depressions are measured as the distance from the bottom of a 5-foot-long template or straight edge.

A surface to be backfilled or otherwise concealed when construction is completed must have the following surface treatment unless otherwise specified:

- Repair defective concrete.
- Fill all form tie holes.
- Correct surface depressions deeper than 1 inch.
- Remove or smooth fins and abrupt projections that exceed 0.75 inch.

A surface to be permanently exposed, where other finishes are not specified, must have the following treatment:

- Repair defective concrete.
- Fill all form tie holes.
- Remove or smooth all abrupt irregularities greater than 0.25 inch in depth or projection.
- Treat all depressions and irregularities so that they do not exceed 0.5 inch in depth.

Form bolt and tie holes and other holes of similar size and depth must be repaired and filled as specified in section 20.

18. Finishing unformed surfaces

All exposed surfaces of the concrete must be accurately screeded to grade and then float finished unless otherwise specified. The float finish must result in a surface that has no irregularities of more than 0.25 inch when checked with a template or straight edge that is 10 feet long.

All exposed surfaces of concrete must be accurately struck off to grade after placement and consolidation are completed. Following strikeoff, the surface must be immediately smoothed by darbying or bull floating before any free water has bled to the surface. The concrete must then be allowed to rest until the bleed water and water sheen

have left the surface and the concrete has stiffened to where it will sustain foot pressure with only about 0.25-inch indentation. At this time all joints and edges that are exposed to view and are not chamfered must be finished with edging tools. After edging and hand jointing is complete, all exposed surfaces must be floated with wood or magnesium floats. The floating should work the concrete no more than necessary to remove screed, edger, and jointer marks and to produce a compact surface uniform in texture.

Water must not be sprinkled or added to the surface of the concrete during the darbying, bull floating, floating, or other finishing operations to facilitate finishing.

19. Curing

Freshly placed concrete must be cured a minimum of 7 days in accordance with the recommended practices set forth in this section. A curing process must be started as soon as the concrete has hardened sufficiently to prevent surface damage. Curing concrete, including exposed surfaces of formed concrete and concrete in forms, must be maintained at a satisfactory moisture content for at least 7 days following placement. If forms are removed before the end of the 7-day curing period, the interrupted curing process must be reestablished and maintained until a full 7-day curing period is achieved. A satisfactory moisture condition is—

- Continuous or frequent application of water or use of a saturated cover material, such as canvas, cloth, burlap, earth, or sand.
- Prevention of excessive water loss from the concrete by use of an impermeable coating (curing compound) or covering (plastic, paper).

The application of water or covering must not erode, mar, or otherwise damage the concrete. Plastic film or paper must meet the requirements of ASTM C171. Black covering must not be used when concreting in hot weather.

Except as otherwise specified in section 25, curing compound may be used for exposed surfaces or formed surfaces after patching and repair are completed. Curing compounds must not be used on a surface that is to receive additional concrete, paint, tile, or other coatings unless the contractor demonstrates that the membrane can be satisfactorily removed or can serve as a base for the later application.

Curing compound must be thoroughly mixed before applying and be agitated during application. Except as otherwise specified in section 25, the compound must be applied at a pressure of 75 to 100 pounds per square inch. A continuously agitating pressure sprayer is used for application at a uniform rate of not less than 1 gallon per 175 square feet of surface. Manual hand pump sprayers must not be used for curing concrete surfaces exceeding 400 square feet unless otherwise specified. For individual concrete placements or repairs having a surface area of 400 square feet or less, curing compound may be applied with a soft-bristled brush, paint roller, or hand sprayer. The compound must form a uniform, continuous, adherent film that must not check, crack, or peel and must be free from pinholes or other imperfections.

All surfaces covered with curing compound must be continuously protected from damage to the protective film during the required curing period.

A surface subjected to heavy rainfall or running water within 3 hours after the compound has been applied or that is damaged by subsequent construction operations during the curing period must be resprayed in the same manner as for the original application.

Water for curing must be clean and free from any substances that cause discoloration of the concrete.

20. Concrete patching, repair or replacement

Patching—All form bolts, metal ties, and similar forming restraints must be removed to a depth of 1 inch below the surface of the concrete and their cavities repaired unless otherwise specifically permitted or specified. Small cavities, large air holes, minor honeycombed areas, and other superficial imperfections that require patching to meet the specified finish requirements must be thoroughly cleaned and filled. Holes left by bolts or straps that pass

through the concrete section must be filled solid with a dense, well-bonded, non-shrink patching material. Dry-pack mortar and replacement concrete must follow the appropriate procedure detailed in the “Repair and Maintenance” chapter of the Concrete Manual, Bureau of Reclamation, U.S. Department of the Interior. Proprietary patching material must be appropriate for the type of repair, used within the manufacturer's recommended limits, and applied according to the manufacturer's recommendations.

Repair or replacement—The contractor must repair or replace concrete that does not meet the requirements of this specification. Before starting any repair or replacement work, the contractor must prepare a written plan for the repair or replacement. The primary reference for material and repair methods for the plan must be the appropriate sections of the “Repair and Maintenance” chapter of the Concrete Manual, Bureau of Reclamation, U.S. Department of the Interior. The repair plan must be submitted to the engineer for review at least 10 days before any repair or replacement work. Approval of the plan will be authorized in writing by the contracting officer.

When proprietary patching material is proposed in the plan, the manufacturer's data sheets and written recommendations must be included in the plan.

Repair material or replacement concrete must have properties, color, and texture similar to and compatible with the concrete being repaired or replaced. Repair or replacement concrete work may only be performed when the engineer is present.

Curing of repaired or replaced concrete must be started immediately after finish work is completed and as specified in section 19 or as specified by the manufacturer of proprietary compounds.

21. Concreting in cold weather

Methods for concreting in cold weather must be performed when, for more than 3 consecutive days, the following conditions exist:

- The average daily air temperature at the job site is less than 40 degrees Fahrenheit. (The average daily air temperature is the average of the highest and lowest temperatures occurring during the period from midnight to midnight.)
- The air temperature at the job site is less than, or equal to, 50 degrees Fahrenheit for more than half of any 24-hour period.

Concrete must be protected against freezing during the first 24 hours after placement whether or not the average weather conditions specified above for cold weather concreting exist. The following provisions also apply unless otherwise specified:

a. When the cement is added to the mix, the temperature of the mixing water must not exceed 140 degrees Fahrenheit nor the temperature of the aggregate exceed 150 degrees Fahrenheit.

b. The temperature of the concrete at the time of placing must be within the placement temperature range shown below, unless otherwise specified.

Least dimension of section, inches	**Placement temperature, °F**
Less than 12	55 – 75
12 to 36	50 – 70
36 to 72	45 – 65

Greater than 72	40 – 60

c. The minimum temperature of the concrete for the first 72 hours after placement must not be less than the minimum temperature shown above. Concrete structures must be immediately protected after concrete placement by covering, housing, insulating, or heating concrete structures sufficiently to maintain the minimum temperature adjacent to the concrete surface. If the minimum temperature requirements are not met and the concrete did not freeze, the protection time will be extended a period equal to twice the number of hours the temperature was below the minimum temperature.

d. Exhaust flue gases from combustion heaters must be vented to the outside of the enclosure. The heat from heaters and ducts must be directed in such a manner as to not overheat or dry the concrete in localized areas or to dry the exposed concrete surface.

e. At the end of the protection period, the concrete must be allowed to cool gradually. The maximum decrease at the concrete surface in a 24-hour period must not exceed 40 degrees Fahrenheit.

22. Concreting in hot weather

Methods for concreting in hot weather must be in accordance with the requirements set forth below.

For the purpose of this specification, hot weather is defined as the weather condition at the jobsite that causes acceleration in the rate of moisture loss or rate of cement hydration of freshly mixed concrete, including an ambient temperature of 80 degrees Fahrenheit or higher, and an evaporation rate that exceeds 0.2 pounds per square foot per hour. The rate of moisture loss and rate of cement hydration may be accelerated if one or a combination of the following conditions exists:

- High ambient temperature
- High concrete temperature
- Low relative humidity
- Wind velocity
- Solar radiation

Whenever the above conditions exist or when climatic conditions are such that the temperature of the concrete may reasonably be expected to exceed 90 degrees Fahrenheit at the time of delivery to the worksite or during the placement operations, the following provisions apply:

a. The contractor must maintain the temperature of the concrete below 90 degrees Fahrenheit during mixing, conveying, and placing.

b. Exposed concrete surfaces that tend to dry or set too rapidly must be continuously moistened using fog sprays or other means to maintain adequate moisture during the time between placement and finishing. Water must not be sprinkled or added directly to the surface of the concrete before finishing.

c. Finishing of slabs and other exposed surfaces must be started as soon as the condition of the concrete allows and must be completed without delay. Water must not be sprinkled or added to the surface of the concrete during the darbying, bull floating, floating, or other finishing operations to facilitate finishing.

d. Formed surfaces must be kept completely and continuously wet from the time the concrete takes initial set to when the forms are removed. After the forms are removed, the concrete surfaces must be kept completely and continuously wet for the duration of the curing period or until curing compound is applied in accordance to section 21.

e. Exposed and unformed concrete surfaces, especially flat work placed with large areas of surface, must be kept completely and continuously wet for the duration of the curing period or until curing compound is applied in accordance to section 19. The concrete must be protected against thermal shock from rapid cooling (5°F per hour

or more than 40°F per 24-hour period) of the concrete by application of curing water or temperature changes during the first 24 hours of the curing period.

f. When any single or combination of conditions might result in very rapid setting or drying of the concrete, extreme conditions exist. For flat work and slab construction, extreme conditions exist when the evaporation rate exceeds 0.2 pound per square foot per hour. The engineer may—

(1) Restrict placement to the most favorable time of the day.

(2) Restrict the depth of layers to assure coverage of the previous layer while it will still respond readily to vibration.

(3) Suspend placement until conditions improve.

(4) Restrict the removal of forms, repair, and patching to small areas that can be protected with curing compound immediately.

The evaporation rate for flat work and slab construction may be determined by calculating the evaporation rate from a cake pan having a surface area of at least 1 square foot or by other methods approved by the engineer or designated in section 25.

23. Acceptance of the concrete work

Acceptance of the concrete work will be a cumulative acceptance process based upon progressively meeting the requirements of the specifications and drawings for—

- Fresh concrete.
- Concrete strength and durability.
- Structure dimensions.
- Structure appearance.

Fresh concrete—Fresh concrete conforming to the mix proportions and quality requirements of the approved job mix and the handling and placement requirements of previous sections will be satisfactory.

Concrete strength—A strength test is the average of the compressive strengths of two standard cured cylinders prepared and tested in accordance with section 4, unless otherwise specified. The strength of the hardened concrete is satisfactory if the following requirements are met:

a. If method 1 from section 3 is specified and the concrete work is less than 75 total cubic yards for the class of concrete specified, the compressive strength of the concrete is satisfactory if no individual strength test falls more than 500 pounds per square inch below the specified compressive strength (f'_c) for the respective class of concrete.

b. If method 1 from section 3 is specified and the concrete work is 75 total cubic yards or more for the class of concrete specified, the compressive strength of the concrete is satisfactory if both of the following requirements are met:

(1) No individual strength test falls more than 500 pounds per square inch below the specified compressive strength (f'_c) for the class of concrete specified.

(2) The average of any three consecutive strength tests is not less than the specified compressive strength (f'_c) for the class of concrete specified.

The contractor must take steps to increase the average of subsequent strength tests when the average of any three consecutive strength tests falls below the specified concrete strength (f'_c).

c. The engineer determines the structural adequacy and evaluates the durability of the in-place concrete when the concrete strength based on the standard cured concrete cylinders is unsatisfactory. The engineer determines the need for additional quality assurance testing.

d. The contractor may core the concrete, have the cores tested by a certified testing laboratory at the contractor's expense, and submit test results to the engineer for consideration and evaluation of concrete strength adequacy when the concrete strength based on the standard cured concrete cylinders is unsatisfactory.

e. Sampling and testing concrete by coring must conform to section 4. The strength of the concrete based upon concrete cores is satisfactory if both of the following requirements are met:

(1) The average compressive strength of the three cores equal or exceed 85 percent of the specified compressive strength (f'_c).

(2) The compressive strength of any individual core does not fall below 75 percent of the specified compressive strength (f'_c).

f. If method 2 from section 3 is specified, the engineer is responsible for the concrete job mix design and the quality concrete that results from the job mix.

The hardened concrete is satisfactory if the required batch tickets or other documentation acceptable to the engineer clearly show that the batch ingredients and weights of each ingredient including all admixtures conforms to the job mix provided by the engineer. Random periodic inspection of the batching operations may be made by the engineer to verify that ingredients and ingredient proportions conform to the batching documentation.

If the concrete ingredients, proportions, or admixtures varies from the job mix provided by the engineer, the concrete may be rejected if, in the judgment of the engineer, the variance will significantly affect the strength or durability of the concrete or will adversely affect the life expectancy or other components of the structure.

Structure dimensions and appearance

The appearance of the concrete must meet the requirements of sections 17 and 18.

The dimensions of formed members, unless otherwise specified, are satisfactory if they conform to the requirements of the specifications, the locations shown on the drawings, and are within acceptable tolerances:

a. Variation from plumb for walls and column must be no more than 0.2 percent of the total wall or column height.

b. Variation from specified elevations for slabs, floors, or other horizontal members must be no more than 0.2 percent of the length of the member in the direction of grade.

c. Variations in the cross-sectional dimensions of columns and beams and in the thickness of walls and above-grade slabs must be no more than minus 0.25 inch or plus 0.5 inch from the shown dimensions.

24. Measurement and payment

For items of work for which specific unit prices are established in the contract, concrete is measured to the neat lines or pay limits shown on the drawings, and the volume of concrete is computed to the nearest 0.1 cubic yard. No deduction in volume is made for chamfers, rounded or beveled edges, or for any void or embedded item that is less than 5 cubic feet in volume. Where concrete is placed against the sides or bottom of an excavation without intervening forms, drainfill, or bedding, the volume of concrete required to fill voids resulting from over-excavation outside the neat lines or pay limits is included in the measurement for payment where such over-excavation is directed by the engineer to remove unsuitable foundation material. However, this payment is only to the extent that the unsuitable condition is not a result of the contractor's improper construction operations, as determined by the engineer.

Method l—Payment for each item of concrete is made at the contract unit price for that item. The payment for concrete will constitute full compensation for completion of the concrete work, including joint fillers, waterstops, dowels or dowel assemblies, and metal plates, but not including reinforcing steel or other items listed for payment elsewhere in the contract.

Method 2—Payment for each item of concrete is made at the contract unit price for that item. The payment for concrete constitutes full compensation for completion of the concrete work, including joint fillers, waterstops, metal plates, dowels, and other assemblies. It does not include furnishing and placing reinforcing steel or furnishing and handling cement or other items listed for payment elsewhere in the contract.

Cement is measured by dividing the volume of concrete accepted for payment by the yield of the applicable job mix. The yield is determined by the procedure specified in ASTM C138. If the amount of cement actually used per batch exceeds the amount in the job mix specified by the engineer, the measurement is based on the amount of cement specified by the engineer for the job mix. Unless otherwise stated in section 25, a bag of cement is considered 94 pounds. Payment for each type of cement will be made at the contract unit price for furnishing and handling that type of cement and such payment will constitute full compensation for furnishing and handling the cement.

All methods—The following provisions apply to all methods of measurement and payment. Compensation for any item of work described in the contract, but not listed in the bid schedule, will be included in the payment for the item of work to which it is make subsidiary. Such items and the items to which they are made subsidiary are identified in section 25 of this specification.

25. Items of work and construction details

25. Items of work and construction details

Concrete items installed in conformance with this specification shall be of concrete made with Type II or V cement. In-lieu of Type II or Type V cement, Type IL(X%)(MS or HS) blended cements as specified in ASTM C595 may be used upon approval of the Engineer.

The percent limestone (X%) in the blended cement shall not exceed 15% by mass of the cement provided. Concrete mix designs using blended cements with the percent limestone (X%) greater than 10% shall include sufficient testing in accordance with ASTM C109 to document there is no loss in compressive strength as a result of the included limestone content as compared to Type II or V cements.

Blended cements that do not indicate sulphate exposure requirements will require additional testing under ASTM C1012. Documentation of passing test results supporting the sulfate exposure designation as described in ACI 318-19 for exposure class S1 for (MS) and S2 for (HS) shall be provided.

Class 2 coarse aggregate shall be Size No. 7, 57, 67, or 467. Bituminous preformed expansion joint filler shall be according to ASTM D994. Sponge rubber expansion joint filler shall be according to ASTM D1752. The slump range for all concrete shall be 4 inches plus or minus 1 inch.

In Section 3, Concrete mix design, Method 1 shall apply. All concrete shall equal or exceed Class 4000.

In Section 13, Construction joints, Method 1 shall apply.

In Section 20, Concrete patching, repair or replacement, all patching and repair reference documents shall include the U.S. Department of the Interior Bureau of Reclamation "*Guide to Concrete Repair*", Second Edition, August 2015 or later revision and other documents deemed appropriate as approved by the Engineer.

In Section 24, Measurement and payment, Method 1 shall apply.

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 18, Concrete, Structural

(1) This item shall consist of furnishing and placing all concrete required for construction of the concrete principal spillway inlet, impact basin, and baffle blocks as shown on the drawings.

(2) In addition to the finishing of all formed concrete surfaces and slabs in conformance with Section 17 of this specification, all concrete surfaces that will be exposed to air and water, shall be finished by a complete carborundum stone rubbing in accordance with the latest revision of ACI 301 to establish a smooth-rubbed surface, followed by treatment with a heavy-duty, cement-based coating such as "MasterSeal 581" manufactured by Master Builder Solutions. A product of equal quality may be used. The coating material to be used shall be approved by the Engineer.

(a) The cement-based coating shall be in powder form, free from lumps or aggregates, and easily dispersed in water to a smooth and homogeneous consistency. The coating shall be suitable for application to wetted masonry or concrete surfaces with a fiber brush, roller, or special spray equipment.

(b) The coating materials shall be heavy-bodied with ability to fill and seal pores and voids and provide a waterproof finish. The coating material shall be applied in such a manner that all cavities or surface pits, pockmarks, or holes not filled as otherwise specified are completely filled with the surface finish of coating materials.

(c) Products applied as surface finish shall be applied in conformance with the manufacturer's recommendations with the additional requirement that all concrete surfaces shall be cleaned by wet or dry sandblasting, steam cleaning, or other method approved by the Engineer that insures a clean surface to which the surface finish product readily adheres and which is free of all unsatisfactory concrete, laitance, coatings, stains, and debris that would prevent the coating from adhering tightly to the prepared concrete surfaces.

(d) The surface finish shall present a uniform appearance and shall be free of check marks, blisters, cracking, and other evidence of non-uniformity, inconsistencies, and imperfections. Such area(s) of non-uniformities, checks, blisters, cracks, and other imperfections shall be removed, and the surface finish reapplied to present uniform appearance in accordance with the requirements of this section.

(e) The color of the final cured coating shall conform to the MasterSeal color “Gray”.

(f) The coating shall meet the following specifications:

(1) Compressive Strength – 4,200 psi in 7 days, 6030 psi in 28 days (Test Method ASTM C109).

(2) Tensile Strength -- 250 psi in 7 days, 440 psi in 28 days (Test Method ASTM C190).

(3) Flexural Strength -- 360 psi in 7 days, 1027 psi in 28 days (Test Method ASTM C348).

(4) The coating shall dry to the touch in 4 hours and hard-dry within 48 hours (ASTM C1640).

(5) Freeze-Thaw Cycling -- No cracking or declamation after 200 cycles (Test Method ASTM C666, Method B).

(6) Weatherometer -- After 5000 hours of weatherometer exposure, there shall be no checking, cracking, or loss of adhesion, and the degree of chalking shall be No. 8 (ASTM D822 and ASTM G26).

(7) Resistance to wind-driven rain – after 8 hours exposure rated as excellent as per Federal Specification (TT-P-0035).

(3) The item of work subsidiary to this bid item is Excavation, Common, Concrete Structures as specified in Construction Specification 21 as it applies to this bid item.

b. Bid Item 19, Concrete, Pipe Cradle

(1) This item shall consist of furnishing and placing all concrete required for the construction of the principal spillway conduit cradle as shown in the construction drawings.

(2) The item of work subsidiary to this bid item is Excavation, Common, Concrete Structures as specified in Construction Specification 21 as it applies to this bid item.

c. Subsidiary Item, Establishment of Permanent Reference Markers (PRM)

(1) This item shall consist of all work and materials (except the benchmark cap) required for the establishment of permanent reference markers. The brass or aluminum cap for the PRM will be furnished by the NRCS prior to casting/pouring the concrete.

(2) The required number and approximate locations of the markers are shown on the drawings. The actual location of the markers shall be as staked by the Engineer.

(3) Markers shall be cast in place, non-reinforced, concrete cylinders or precast, non-reinforced, concrete cylinders installed flush with the ground line and with a standard benchmark cap mounted on the top.

(4) The concrete cylinder shall have a minimum diameter of 10 inches and depth of 2 feet, except a lesser depth may be approved where rock is encountered. Earth forming will be permitted for cast-in-place markers.

(5) No surface finish will be required for that portion of the marker which will be below ground. If precast markers are used, backfill shall be thoroughly tamped in 4-inch layers.

(6) Separate payment will not be made for this item. Compensation for this item will be included in the payment for the bid item Construction Surveys.

d. Subsidiary Item, Concrete, Metal Cleanout Covers

(1) This item shall consist of the concrete required for the trench drain and RCC drain metal cleanout covers as shown in the construction drawings.

(2) Separate payment will not be made for this item of work. Compensation for this item will be included in the payment for the bid item for Plastic Pipe, PVC, 6” I.D.

Construction Specification 34—Steel Reinforcement

1. Scope

The work consists of furnishing and placing steel reinforcement for reinforced concrete or pneumatically applied mortar.

2. Material

Steel reinforcement must conform to the requirements of Material Specification 539, Steel Reinforcement (for concrete). Before reinforcement is placed, the surface of the bars and fabric and any metal supports must be cleaned to remove any loose, flaky rust, mill scale, oil, grease, or other undesirable coatings or foreign substances. Epoxy-coated steel reinforcement must be free of surface damage. After placement, the reinforcement must be maintained in a clean and serviceable condition until it is completely embedded within the concrete.

3. Bar schedule, lists and diagrams

Any supplemental bar schedules, bar lists or bar-bending diagrams required in section 10 of this specification to accomplish the fabrication and placement of steel reinforcement must be provided by the contractor. Before reinforcement is placed, the contractor must furnish four copies of any such lists or diagrams to the contracting officer for approval. Acceptance of the reinforcement is not based on approval of these lists or diagrams, but on inspection of the steel reinforcement after it has been placed, tied, and supported and is ready to receive concrete.

4. Bending

Reinforcement must be cut and bent in compliance with the requirements of the American Concrete Institute Standard 315. Bars must not be bent or straightened in a manner that will injure or weaken the material. Bars with kinks, cracks, or improper bends must be rejected.

5. Splicing bar reinforcement

Method 1—Splices of reinforcement may only be made at locations shown on the drawings and provided by the steel schedule. Placement of bars at the lap splice locations shown, when not in contact, must not be farther apart than one-fifth the shown lap length and in any case no greater than 6 inches.

Method 2—Splices of reinforcement must be limited to those locations shown on the drawings. Splice lengths must be determined before fabrication and meet the requirements of ACI Standard 318, Building Code Requirements for Reinforced Concrete, based upon design information in section 10 of this specification. Bar placement drawings and schedules must be provided for approval before fabrication. The drawings must show all splice locations, layouts, and lap dimensions.

6. Splicing welded wire reinforcement

Unless otherwise specified, welded wire reinforcement must be spliced in the following manner:

End-to-end—Adjacent sections must be spliced end-to-end (longitudinal lap) by overlapping a minimum of one full mesh plus 2 inches plus the length of the two end overhangs. The splice length is measured from the end of the longitudinal wires in one piece of fabric to the end of the longitudinal wire in the lapped piece of fabric.

Side-to-side—Adjacent sections must be spliced side to side (transverse lap) a minimum of one full mesh plus 2 inches. The splice length must be measured from the centerline of the first longitudinal wire in one piece of fabric to the centerline of the first longitudinal wire in the lapped piece of fabric.

7. Placing

Reinforcement must be accurately placed and secured in position to prevent its displacement during the placement of concrete. Tack welding of bars is not permitted. Metal chairs, metal hangers, metal spacers, and concrete chairs may be used to support the reinforcement. Metal hangers, spacers, and ties must be placed in such

a manner that they are not exposed in the finished concrete surface. The legs of metal chairs or side form spacers that may be exposed on any face of slabs, walls, beams, or other concrete surfaces must have a protective coating or finish. The coating or finish must be hot dip galvanized, epoxy coated, plastic coated, or stainless steel. Metal chairs and spacers not fully covered by a protective coating or finish must have a minimum cover of 0.75 inch of concrete over the unprotected metal part. The exception is that those with plastic coatings may have a minimum cover of 0.5 inch of concrete over the unprotected metal part. Precast concrete chairs must be manufactured of the same class of concrete as specified for the structure and must have the tie wires securely anchored in the chair or a V-shaped groove at least 0.75 inch in depth molded into the upper surface to receive the steel bar at the point of support. Precast concrete chairs must be clean and moist at the time concrete is placed.

High-density or structural plastic rebar accessories designed to ensure maximum concrete bond may be substituted for metal or concrete accessories in spacer applications as approved by the contracting officer. Exposure of plastic rebar accessories at the finished concrete surface must be kept to a minimum. Plastic rebar accessories, when used, must be staggered along adjacent parallel bars and must be placed at intervals no closer than 12 inches. Plastic rebar accessories must not be used in concrete sections 6 inches or less in thickness.

Reinforcement must not be placed until the prepared site has been inspected and approved. After placement of the reinforcement, concrete must not be placed until the reinforcement has been inspected and approved by the responsible engineer.

8. Storage

Steel reinforcement stored at the work site must be placed on platforms, skids, or other supports. This is done so that contact with the ground is avoided and the material is protected from mechanical damage and/or corrosion.

9. Measurement and payment

Method 1—For items of work for which specific unit prices are established in the contract, the weight of steel reinforcement placed in the concrete in accordance with the drawings is determined to the nearest pound by computation from the placing drawings. Measurement of hooks and bends is based on the requirements of ACI Standard 315. Computation of weights of reinforcement is based on the unit weights established in tables 34–1 and 34–2 of this specification. Computation of weights for welded wire reinforcement not shown in table 34–2 must be based on ACI Standard 315. The area of welded wire reinforcement placed in the concrete in accordance with the drawings is determined to the nearest square foot by computation from the placing drawings with no allowance for required laps. The weight of steel reinforcing in extra splices or extra-length splices approved for the convenience of the contractor or the weight of supports and ties is not included in the measurement for payment.

Payment for furnishing and placing reinforcing steel is made at the contract unit price. Such payment constitutes full compensation for all labor, material, equipment, and all other items necessary and incidental to the completion of the work including preparing and furnishing bar schedules, lists, or diagrams; furnishing and attaching ties and supports; and furnishing, transporting, storing, cutting, bending, cleaning, and securing all reinforcements.

Method 2—For items of work for which specific unit prices are established in the contract, the weight of bar reinforcement placed in the concrete in accordance with the drawings is determined to the nearest pound by computation from the placing drawings. Measurement of hooks and bends is based on the requirements of ACI Standard 315. Computation of weights of bar reinforcement is based on the unit weights established in table 34–1 of this specification. The weight of steel reinforcing in extra splices or extra length splices approved for the convenience of the contractor or the weight of supports and ties is not included in the measurement for payment.

The area of welded wire reinforcement placed in the concrete in accordance with the drawings is determined to the nearest square foot by computation from the placing drawings with no allowance for required laps.

Payment for furnishing and placing bar reinforcing steel is made at the contract unit price for bar reinforcement. Payment for furnishing and placing welded wire reinforcing steel is made at the contract unit price for welded wire reinforcement. Such payment constitutes full compensation for all labor, material, equipment, and all other items necessary and incidental to the completion of the work including preparing and furnishing bar schedules, lists, or

diagrams; furnishing and attaching ties and supports; and furnishing, transporting, cutting, bending, cleaning, and securing all reinforcement.

All Methods—The following provisions apply to all methods of measurement and payment. Compensation for any item of work described in the contract, but not listed in the bid schedule, is included in the payment for the item of work to which it is made subsidiary. Such items to which they are made subsidiary are identified in section 10 of this specification.

Table 34–1 Standard reinforcing bars

- - Bar size designations - -		Weight (lb/ft)
English	**Metric**	
3	10	0.376
4	13	0.668
5	16	1.043
6	19	1.502
7	22	2.044
8	25	2.670
9	29	3.400
10	32	4.303
11	36	5.313
14	43	7.650
18	57	13.600

1/ The bar diameter (inches) equals the bar size number divided by eight. For example, the diameter of a #4 bar is 4 ÷ 8 = 0.5 inch.

2/ The metric bar size has been rounded to a whole number that represents the approximate diameter of the bar in millimeters.

Table 34–2 Rectangular welded wire reinforcement

Style designation [1/]		Weight
by W-number	by steel wire gauge (former designation)	(lb/100 ft^2)
6 × 6 – W1.4 × W1.4	6 × 6 – 10 × 10	21
6 × 6 – W2.1 × W2.1	6 × 6 – 8 × 8	30
6 × 6 – W2.9 × W2.9	6 × 6 – 6 × 6	42
6 × 6 – W4.0 × W4.0	6 × 6 – 4 × 4	58
4 × 4 – W1.4 × W1.4	4 × 4 – 10 × 10	31
4 × 4 – W2.1 × W2.1	4 × 4 – 8 × 8	44
4 × 4 – W2.9 × W2.9	4 × 4 – 6 × 6	62
4 × 4 – W4.0 × W4.0	4 × 4 – 4 × 4	85
4 × 12 – W2.1 × W0.9 [2/]	4 × 12 – 8 × 12	25
4 × 12 – W2.5 × W1.1 [2/]	4 × 12 – 7 × 11	31

1/ Style designation is defined in ACI Standard 315 of the American Concrete Institute.

2/ Welded smooth wire reinforcement with wires smaller than size W1.4 is manufactured from galvanized wire.

10. Items of work and construction details

10. Items of work and construction details

In Section 5, Splicing bar reinforcement, Method 1 shall apply.

In Section 7, Placing, if during the placement of the concrete, any reinforcement is displaced more than one-half inch from its designated position, that reinforcement shall be entirely removed and placed in proper position. Inspection and approval of the reinforcement by the Engineer will not relieve the Contractor of the responsibility of insuring the reinforcement is held in place and is not displaced during the placement of the concrete.

In Section 9, Measurement and payment, Method 1 shall apply.

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 20, Reinforcing Steel

(1) This item shall consist of furnishing and placing all steel reinforcement (including dowels) required for the construction of all reinforced concrete works under this contract.

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Construction Specification 36—Roller Compacted Concrete

1. Scope

The work consists of furnishing all materials, tools, equipment, and mixing plant and performing all labor for the mixing, transporting, forming, placing, compacting, and curing of roller compacted concrete (RCC) as required to install the structure(s) as shown on the drawings and designated in section 22 of this specification and the test section designated in the same section.

The following BioPreferred® product category is applicable to this specification:

— Concrete release fluids (a.k.a., form-release agents)

2. Material

Portland cement must conform to the requirements of Material Specification 531, portland cement. Type-III portland cement must not be used.

Pozzolan must conform to the requirements of Material Specification 532, Supplementary Cementitious Materials. Fly ash must be class F unless otherwise specified. The source of pozzolan must consistently supply material with similar chemical and physical properties.

Combined aggregates must conform to the requirements of Material Specification 524, Aggregates for Roller Compacted Concrete, unless otherwise specified.

Water incorporated into the mix or used for curing RCC must be clean and free from injurious amounts of oil, salt, acid, alkali, organic matter, turbidity, or other deleterious substances. Water must conform to the requirements of ASTM C 94 except that wash water may not be used for mixing RCC.

Water-reducing, set-retarding admixture must conform to ASTM C494, type D.

Curing compound must conform to the requirements of Material Specification 534, Concrete Curing Compound. Curing compound must be furnished in containers that have not been previously opened and that have the original manufacturer's labels attached.

Bonding mortar must consist of cement, sand, water, and a water-reducing, set-retarding admixture to retard the set and control the consistency of the mortar. The cement, water, and admixture must be as specified. Sand must comply with ASTM C33 for fine aggregate. The mortar must be mixed in the proportions 1 part cement to 2.5 parts sand, by weight. Water content must be sufficient to provide a spreadable consistency. In combination with the admixture, the maximum water-to-cementitious materials ratio must be 0.45. The mortar slump must be 7 to 9 inches when tested in accordance with ASTM C143. The admixture must be included at the manufacturer's recommended dosage so that the initial set time is retarded at least 3 hours when the ambient air temperature is 95 degrees Fahrenheit.

Material testing—The contractor must test materials or provide certified test results to ensure all materials conform to the specified requirements. All nonconforming materials must be promptly removed from the job site, including those that have been incorporated into the work.

Aggregate sampling must be in accordance with ASTM D75.

Aggregate samples must be taken from stockpiles, belt feeders from bins, the mix plant feed conveyor belts, the mixer feed conveyer belt, or from the pug mill discharge while only aggregate is discharged from the pugmill.

When obtaining aggregate samples from stockpiles, samples must be obtained from various parts of the stockpiles, but never from the perimeter of the lower third of the pile.

The contractor must provide access for material sampling and performance of quality assurance testing activities at material storage sites.

Sampling—The contractor must provide suitable platforms, tools, equipment, and labor necessary for obtaining representative samples of materials to be used for the contractor's quality control testing and for the Government's quality assurance testing. Samples may be taken from stockpiles, aggregate bins and feed belts, entrance to the mixer, mixer discharge, gob hopper discharge, points in transit, or the placement area.

Material handling and processing—Transportation of cement and pozzolan to the batching plant must be accomplished in weather-tight trucks, conveyors, or other means that will completely and thoroughly protect the cementitious materials from exposure to moisture and contaminants.

The temperature of cement and pozzolan when delivered to the job site must not exceed 160 degrees Fahrenheit. The temperature of the cement and pozzolan must be determined by direct insertion of a thermometer into the material in the delivery truck. The temperature of air to transport cement into storage containers or silos must not exceed 180 degrees Fahrenheit. It may be assumed that the temperature of the air in the transfer pipe is the same as the temperature on the outside surface of the transport pipe. The temperature of the air must be determined by measuring the temperature on the outside of the transport pipe with a surface thermometer.

Immediately upon receipt at the job site, cement and pozzolan must be stored in dry, weather-tight, ventilated structures. All storage facilities must permit easy access for inspection and identification. Sufficient cement and pozzolan must be stored onsite at all times to complete a minimum of 24 hours of placement at the planned average production rate, unless otherwise specified. Cement and pozzolan that have been stored at the site for the longest period must be used first, unless otherwise specified.

Aggregates must be transported to the site in two or more components that will be combined in the mix plant to meet the overall aggregate gradation. Aggregate components must be of a gradation that will minimize segregation prior to introduction into the mixer. Aggregates must be stored in stockpiles in the designated contractor use area. Aggregate components must be stockpiled separately. Aggregates must be handled and stockpiled in a manner to prevent intermixing between dissimilar aggregates and to prevent contamination of the aggregate. Coarse and fine aggregates must remain separated until they are introduced into the mixing plant. For plants that mix in discrete batches, the coarse and fine aggregates must be fed separately into the batch hopper. For mix plants that mix continuously, the coarse and fine aggregates must remain separated until they are dropped onto the belt that delivers the aggregates to the mixing compartment. The contractor must develop and utilize methods that reliably and consistently withdraw and transport the aggregates from the stockpile without contamination or segregation. Segregated or contaminated aggregates must not be used in production of the RCC and must be disposed of in locations specified in section 22.

A 2-week supply of aggregates, based on the average planned weekly production rate, must be stockpiled at the mixing plant location or other approved location, prior to RCC production unless otherwise specified.

Sufficient water must be available for mixing and curing to complete a minimum of 24 hours of placement at the average planned production rate.

3. Submittals

Manufacturer’s certifications and test reports in no way relieve the contractor of the responsibility for furnishing materials that meet the specified requirements. Manufacturer’s certifications and test reports must be produced and dated within the 6 months preceding the delivery of the submittal. The test method used must be noted on all test reports. Any deviation from standard test methods must be detailed in the test report and the reason for the deviation must be given.

Trial mix production submittals—The submittals listed below must be provided, in writing, for approval no later than 30 days before trial mix production, unless otherwise specified. Trial mix production must not proceed before approval of these submittals.

a. The name and qualifications of the laboratory that will perform the mix design.

b. The sources from which the cementitious materials will be obtained along with a certified mill test report for each type of cement, pozzolan, and blended cement that will be used to produce RCC. The certified mill test report must verify that the cement, pozzolan, or blended cement conforms to the applicable material specification.

c. The source from which the aggregate will be obtained and certified test results showing that all aggregates conform to the specification.

d. The source from which the water will be obtained and the certified test results showing that water to be used in the mix conforms to ASTM C 94.

e. The source of the admixture along with certified test results showing that the admixture conforms to the specification.

RCC preproduction submittals—The submittals listed below must be provided, in writing, to the engineer for approval. The submittal for the job mix and bonding mortar must be furnished 30 days before delivery of any RCC or bonding mortar component materials to the site. The submittal for the plant and equipment, personnel, and test section plan must be provided no later than 30 days before delivery of the plant or equipment to the site. RCC materials or equipment must not be delivered to the site before approval of these submittals.

Job mix

a. A certified statement of materials, mix proportions (reported for saturated surface dry aggregate), theoretical air-free density (TAFD), moisture/density curves (wet density only), Vebe time, air content, unit weight of mix in air pot just prior to testing air content, and all compressive strength test results for each of the three mixes required in the development of the RCC job mix.

b. Gradation of each of the aggregate component and combined aggregates used in each mix developed in the mix design program.

c. The compacted bulk density and voids in each of the aggregate components and combined aggregates used in each mix developed in the mix design program.

d. A statement of materials and mix proportions used in each mix developed in the mix design program.

e. A statement of materials and mix proportions proposed to be used in manufacturing the RCC job mix.

Bonding mortar

a. A statement of materials and mix proportions to be used in manufacturing the bonding mortar.

Plant and equipment

a. The planned RCC component material production, transportation, and storage and temperature control procedures. Anticipated peak production capacity, normal production capacity, and onsite storage volumes must be included in the plan.

b. Mixing plant manufacturer's data and operating instructions and the plant layout to include a schematic drawing of the plant and materials storage with a narrative description providing its peak capacity, normal anticipated production rate, and results of the most recent uniformity tests conducted within the previous 12 months. The proposed location of the mixing plant relative to the placement site must be provided.

c. A narrative description and a layout of the equipment and methods to be used for delivering and depositing RCC at the placement site.

d. The type and expected number of pieces of equipment required for all placing, spreading, and compaction of the RCC.

e. The plan for obtaining the specified vertical surfaces.

f. The method and procedure for curing of the in-place RCC, including the type of curing compound if used.

g. The method and procedure that will be implemented to provide protection of RCC from temperature extremes, including the type of external heating equipment and insulating materials to be used.

Personnel

a. The names and qualifications of the onsite quality control person, supervisor, and plant operator who will direct the batching, mixing, and placing of RCC.

Test section plan

a. The contractor's proposed location for the test section and equipment, materials, personnel, and methods to construct the test section as specified. The submittal must include plans for the pre- and post-test section briefings.

Test section submittals—Within 24-hours of completing the tests or test section, the following information must be transmitted to the engineer in writing:

a. Results of moisture and density tests used to compute the apparent maximum density (AMD). Include the results of all density tests made of RCC in the test section.

b. Lift maps of the test section.

c. Results of compressive strength tests.

d. Air content and unit weight of RCC.

e. Production plan that includes RCC production methods, materials, plant, equipment, and personnel as modified based on the results from the performance of the test section that have been documented to produce RCC that meets the requirements of the specification.

Unless otherwise specified, 7 days prior to beginning RCC production, submit a final written plan for RCC production methods, materials, plant, equipment, and personnel that will produce RCC that meets the requirements of this specification.

RCC production submittals—The following submittals must be provided in writing within 24 hours after delivery tickets, records, or test results are produced, unless otherwise specified:

a. Delivery tickets for cement and pozzolan must include the source, date manufactured or produced, type or class, contractor's name, project name, and a certification that the material meets the specification requirements.

b. Delivery tickets for aggregates must include the source, material description, date, and certification that the material meets the specification requirements.

c. Delivery tickets for bonding mortar must include name and location of batch plant, ticket number, load and truck number, date, destination, class of cementitious materials, mix proportions, quantity of bonding mortar, time mixer drum charged with cement, and recording of revolution counter (transit-mixed concrete). If bonding mortar is produced on site, the above required information must be provided as applicable.

d. Records of climatic conditions must be collected on a daily basis and reported on a weekly basis.

e. Mix plant production records and summary of daily material use and RCC produced must be submitted before the start of the next production shift. Production records must include a comparison of actual materials used to the approved job mix.

f. Results of RCC moisture and wet density tests.

g. Results of uniformity tests.

h. Results of compressive strength tests.

i. Results of RCC temperature tests.

j. Lift maps must be submitted before the start of the next production shift.

4. Personnel

There must be a supervisor who is responsible for all aspects of the RCC operation and a plant operator who is solely responsible for batching and mixing. There must be an onsite quality control inspector dedicated to RCC quality control. The supervisor, plant operator, and quality control inspector must have responsible experience on at least one previous RCC job in the same position for which they are being considered for the current job.

There must be at least one person whose sole responsibility is the oversight of the RCC curing activities.

5. RCC mix design

The contractor is responsible for the mix design and selection of all materials to be used in the design mix. The materials and proportions so stated, when approved, constitute the job mix. The job mix must be prepared to meet the quality, consistency, and strength of the RCC specified.

The contractor must conduct the mix design program at a materials testing laboratory staffed by American Concrete Institute (ACI) Certified Grade II Concrete Laboratory Testing Technicians.

Trial mix design parameters—The aggregate gradation must be as specified. The bulk density and voids in each of the aggregate components and the combined aggregate must be determined according to ASTM C 29.

The density, relative density, and absorption must be determined according to ASTM C 127 for coarse aggregate and ASTM C 128 for fine aggregate.

The air content of each mix must be determined according to ASTM C 231. The volume and tare weight of the air pot must be determined according to ASTM C 138. After consolidating the RCC in the air pot and just prior to testing to determine the air content, the weight of the RCC and pot must be determined according to ASTM C 138. The density of the RCC that is consolidated in the pot at the time of testing must be computed.

The minimum compressive strength for the RCC job mix must be as specified in section 22 of this specification.

Unless otherwise specified in section 22—

- A minimum of three separate mixes must be developed in the laboratory.
- Pozzolans must comprise at least 20 percent (by volume) but must not exceed 50 percent (by volume) of the cementitious materials.
- The remainder of the cementitious materials must be comprised of portland cement.
- A compaction curve (wet density only) must be developed for each mix to determine the water content that corresponds to the maximum wet density of each mix. Compaction tests must be performed in accordance with ASTM D 1557, adapted as follows:
    - The mold specified for Method C must be used.
    - All mix components must be included.
    - When the maximum size aggregate in the mix is larger than 3/4 inch, place the material in three layers into the mold and compact each layer with 94 blows of the hammer.
- A Vebe test must be performed on each trial mix design to determine the Vebe consistency time in seconds and the wet density in pounds per cubic foot. The Vebe test must be performed according to ASTM C 1170. The Vebe consistency time must range from a minimum of 15 seconds to a maximum of 30 seconds.

Theoretical air free density—The theoretical air free density (TAFD) must be computed for each of the three laboratory mixes in the mix design program. The TAFD is the maximum wet density that can be attained for a specific mix assuming there is no air (entrapped or entrained) in the mix. The TAFD must be computed by dividing the sum of the individual weights of the mix components by the sum of the individual absolute volumes of the mix components. The absolute volume is the volume of the solid matter in the particles, exclusive of the volume of voids between the particles. The absolute volume of each mix component is determined as per ACI 211. The saturated surface dry weight and density of the aggregate must be used when computing the TAFD.

Laboratory compressive strength—Fifteen compressive strength cylinders from each RCC mixture must be prepared in accordance with ASTM C 1176 or C 1435 and weighed to determine the density of the RCC within each cylinder. Any cylinder that weighs less than 98 percent of the weight of the heaviest cylinder must be discarded and another cylinder prepared and weighed until all 15 cylinders have a weight that is at least 98 percent of that of the heaviest cylinder. The water content of each mixture, from which cylinders are made, must be within 0.5 percent of the water content that corresponds to the maximum wet density determined in accordance with ASTM D 1557. Three cylinders from each RCC mixture must be tested at 7, 14, 28, 90, and 180 days for compressive strength in accordance with ASTM C 39.

The average of the two closest 28-day strength values represent the 28-day compressive strength of the mix. The 28-day compressive strength of at least one of the mix designs must be 75 percent to 100 percent of the specified strength. The 28-day compressive strength of at least one of the mix designs must be 100 percent to 125 percent of the specified strength. The 28-day compressive strength of the remaining mix design must approximate the specified strength.

The cementitious materials content that will be used for the job mix will be based on the results of the 28-day compressive strengths of the three laboratory mix designs. The 28-day compressive strengths of each of the three laboratory mix designs will be plotted to form a curve showing the relationship of the cementitious materials content to the 28-day compressive strength of the laboratory mix designs. A cementitious material content must be selected from this curve corresponding to the 28-day compressive strength specified in section 22. The proposed job mix must be proportioned to contain the selected cementitious materials content and must be submitted for approval.

After the job mix has been approved, neither the source, character, or grading of the aggregates; nor the source mill, type, brand, or quantity of the cement; nor the source, type, or quantity of the pozzolan; nor the type, brand, or quantity of the chemical admixtures used may be changed without approval. Changes to the approved job mix require submittal and approval of a new job mix that complies with the requirements of this specification.

6. Test section

Prior to RCC production, the contractor must construct a test section as part of the RCC placement operations. RCC production is defined as the mixing of RCC to be incorporated into the work and the placing and compacting of RCC, to the specified density, within the specified lines and grades of the structure. Unless otherwise specified in section 22, the test section must be installed at an approved location proposed by the contractor. If the contractor constructs the test section in a location that will be incorporated into the RCC structure, it must be located in a noncritical part of the structure, and it must be removed if it fails to meet the requirements of this specification. If the contractor constructs the test section in a location that will not be incorporated into the structure, the contractor must remove and dispose of the test section upon completion of the testing requirements unless otherwise specified.

All RCC that is incorporated into the structure and placed prior to determining the AMD must be compacted to a density that is at least 96 percent of the TAFD. All RCC incorporated into the structure after the AMD is determined must be compacted to specification requirements.

The test section must be used to demonstrate all techniques, materials, plant and equipment, and personnel to be used for RCC construction and quality control. Additional techniques, materials, equipment, and personnel must be demonstrated in the test section as specified in section 22. Information gained will be used to evaluate the practical effectiveness of all techniques, materials, plant and equipment, and personnel to make minor adjustments to the mix and to determine the AMD of the approved job mix. The contractor must allow for numerous stops and starts to facilitate the testing that is required to determine the AMD.

The test section must be of sufficient size to allow the complete RCC placement and compaction operation to be conducted with the equipment operating at normal operating speeds.

When the test section is placed on soil, a minimum of two 12-inch lifts must be placed, and tests for determining the AMD must be conducted on the uppermost lift.

A section must be constructed to determine the adequacy of the procedures implemented to construct vertical surfaces. Any surface that is not horizontal is, within this specification, considered to be a vertical surface. Unless otherwise specified in section 22, the tolerance of vertical surfaces must conform to the requirements of section 18. The finish and appearance of formed and unformed vertical surfaces must comply with the requirements specified in section 17.

The contractor and engineer must conduct the pre-test section briefing to review the field status related to the preparedness, capability, and readiness of the contractor to construct the test section according to the approved plan. After test section construction and before RCC production, the contractor and engineer must conduct the post-test section briefing to discuss adjustments to the techniques, materials, plant, equipment, and personnel that will be used in RCC production. The contractor must submit in writing a final plan for RCC production methods, materials, plant, equipment, and personnel that will produce RCC that meets the requirements of this specification. Unless otherwise specified, the plan must be submitted no later than 7 days prior to beginning RCC production. Written approval of the plan must be required prior to beginning RCC production.

Apparent maximum density—AMD is the maximum RCC density of the approved job mix that can be attained by compacting the RCC with the production roller defined in section 13 of this specification. The AMD must be greater than or equal to 98 percent of the TAFD. The AMD of the RCC must be determined from the test section.

To determine the AMD, the RCC lift must be compacted by successive passes of the production roller over the entire lift surface. (Note: The act of rolling forward past a point and then rolling in reverse past the same point is considered two passes.) Between passes of the production roller, in-place wet density tests (ASTM C 1040) must be made at a depth of 12 inches. Density tests must be initiated after the second pass of the production roller. A minimum of two density tests must be performed at a depth of 12 inches and at approved locations. Successive passes of the production roller, followed by density tests at the 12-inch depth, must be made until the density of the lift no longer increases. When it appears that continued compaction will not increase the density, make two more passes of the production roller, each followed by a density test to document that the density is no longer increasing. Once it has been determined that the density measurement at the 12-inch depth is no longer increasing, density tests must be taken in two locations at depths of 2, 4, 6, 8, 10, and 12 inches. If the maximum and minimum density values obtained in one test hole vary more than 2 percent of the maximum value obtained at that test hole, the contractor must modify operations until this variation is no more than 2 percent.

When the density of the lift no longer increases and the density measurements taken at the specified depths vary no more than 2 percent of the highest value measured at one location, the density must be measured at the 10-inch depth at six approved locations. If more than one of these density measurements results in values less than 96 percent of the TAFD, the contractor must modify operations and repeat the process for determining the AMD. The AMD is the average of the in-place density test values that are greater than or equal to 96 percent of the TAFD of the job mix. If the AMD is less than 98 percent of the TAFD of the job mix, the contractor must modify operations to attain an AMD that is at least 98 percent of the TAFD.

If a new job mix is approved during production of RCC, a new TAFD will be computed and a new AMD will be determined as previously specified.

Air content and density—The air content of the mix must be determined according to ASTM C231 modified to use an impact hammer and tamping plate for compacting the AERCC in two equal lifts. The compaction of AERCC must be performed as described in ASTM C1435, taking care not to compact each layer more than necessary for the complete mortar ring formation. The tamping plate must have a diameter that is equal to the diameter of the inside of the air pot minus 3/8 to 5/8 inches. The volume and tare weight of the air pot must be determined according to ASTM C138. After consolidating the RCC in the air pot and just prior to testing to determine the air content, the weight of the RCC and pot must be determined according to ASTM C138. The density of the RCC that is consolidated in the pot at the time of testing must be computed.

Compressive strength tests—Fifteen compressive strength cylinders must be prepared from the mix in accordance with ASTM C1176 or C1435 and weighed to determine the density of the RCC within each cylinder. Any cylinder that weighs less than 98 percent of the weight of the heaviest cylinder must be discarded and another cylinder prepared and weighed until all 15 cylinders have a weight that is at least 98 percent of that of the heaviest cylinder. Three cylinders must be tested at 7, 14, 28, 90, and 180 days, respectively, for compressive strength in accordance with ASTM C39.

Unless otherwise specified in section 22 of this specification, the contractor must extract 10 intact vertical core samples, in accordance with ASTM C42, from a portion of the test section that has been placed to the specified density and cured in accordance with this specification. Core specimens must be taken 13 days after the RCC is placed. The contractor must test two samples at 14, 28, 56, 90, and 180 days, respectively, for compressive strength in accordance with ASTM C42. Cores must have a minimum length equal to one lift thickness and a nominal diameter of 6 inches.

7. Mix plant

The plant must either be a batch-type pugmill or a continuous-flow pugmill. The pugmill must be a twin shaft paddle-type mixer and must have adequate capacity to produce a uniform RCC mix at a rate that will conform to the production schedule. The plant must have a minimum capacity of 100 tons per hour.

The plant must have demonstrated satisfactory reliable performance on similar mixes on other RCC projects with little or no down time because of mixer breakdown or other production-related problems, excluding normal maintenance. Satisfactory reliable performance of the proposed plant must be documented by mixer uniformity tests from recent production work showing that the plant produced a mix of similar proportions that met the requirements for production rate and uniformity set forth in this specification.

The results of uniformity tests that are conducted after the plant is set up and calibrated may be substituted for documentation of reliable past plant performance provided the results of the uniformity testing are in compliance with the requirements of table 36–2. RCC produced during uniformity tests required herein must not be incorporated into the test section or any permanent structure.

The contractor must perform trial runs of the mixing and proportioning equipment, including uniformity tests if required.

Accuracy. Facilities must be provided for the accurate measurement and control of each of the materials entering the RCC mix. Delivery of materials as they are discharged from the mixer and from any gob hoppers must be within the tolerances shown in table 36–1.

Table 36–1 Tolerances in proportioning the various ingredients

Material	Tolerance
Pozzolan, mass	± 2 %
Cement, mass	± 2 %
Aggregate, mass	± 3 %
Water, mass or volume	± 2 %
Chemical admixture, mass or volume	± 3 %

Component monitoring systems. The systems that meter individual mix components must be interlocked with the plant control and must warn the operator and shut down the plant if any component is not feeding into the mixing chamber.

Aggregate bins. A separate bin must be provided for each gradation of aggregate supplied for the RCC job mix. The bins and associated conveyors must be capable of discharging and conveying the aggregates at a uniform rate without clogging, under all conditions.

Portland cement and pozzolan silos. All onsite storage facilities and connection hoses must be properly labeled with readily visible signage. The storage silos must be weather tight to prevent moisture and contaminants from accessing the portland cement and pozzolan. Blended cement/pozzolan products mixed by the cement manufacturer are permitted. Silos must be capable of dispensing at a uniform rate without clogging or bridging of the materials.

Portland cement, pozzolan, and aggregate feed. For a continuous-flow pugmill, the portland cement, pozzolan, and aggregates must be uniformly, continuously, and simultaneously fed into the mixing mechanism at the appropriate ratios. Each bin opening must be provided with a gate that can be maintained at the necessary opening size to consistently provide the correct feed rate. The bins must be of sufficient size to ensure a uniform flow of aggregate at a constant rate. Portland cement and pozzolan must be fed continuously by a feed device that is adjustable to ensure a uniform flow of cement and pozzolan at a constant rate for proportions established by the approved job mix. Feed devices must be capable of gradual adjustment while in operation.

Water dispenser. A suitable water facility must be provided that is capable of metering and dispensing the mix water within the specified tolerances. The mechanism for delivering water to the mixers must be free from leakage. The meter must measure the weight of water being added in pounds per unit time for continuous-flow pugmills, and weight per batch for batch-type pugmills. The valve must be capable of gradual adjustment during the mixing process to compensate for varying moisture contents in the aggregates.

Admixture dispenser. The liquid admixture dispensing system must be capable of metering and dispensing within the specified tolerances. The dispenser must be designed and installed in such a manner that will permit convenient checking of its accuracy and will assure uniform distribution of the liquid admixture with water to the materials entering the mixer. The system must be leak-free and designed and installed to prevent backflow or siphoning.

Mixing mechanism. The mixing mechanism must be capable of combining the materials into a uniform mixture and discharging this mixture without segregation. The mixing mechanism must produce a mix that meets the uniformity requirements listed in table 36–2.

Uniformity tests. When a continuous-flow pugmill is used, the three samples for obtaining uniformity tests must be taken from RCC produced near the beginning, the middle, and the end of a production run lasting a minimum of 1 minute. When a batch-type pugmill is used, the samples must be taken from RCC produced from three separate batches. Each batch must be similar in size, be produced by charging the mixer in a similar manner, be mixed at the same mixing speed and mix retention time as the other two batches, and be representative of a normal production run.

Table 36–2 Requirements for uniformity

Test	Allowable max. difference [1/]	ASTM standard
Water content of full mix (% by weight)	10%	C566
(Select one of the ASTM standard tests listed)		D2216
		D3017
		D4643
		D4959
Coarse aggregate content (% by weight)	10%	C685 (annex)
Density (lb/ft^3) of full mix	2%	C1170
Compressive strength at 14 days (lb/in^2)	15%	C39 [2/]

1/ The allowable maximum difference = 100 multiplied by the (maximum value – minimum value) divided by the average of three tests.

2/ Cylinders must be made in accordance with ASTM Standard C1176 or C1435.

Mix record. The mix plant must be capable of continually producing an RCC mix record. The record must show the weight of portland cement, pozzolan, water, aggregate, and weight or volume of chemical admixture that is processed through the plant during a specific time interval. The time interval must not exceed 30 minutes. The aggregate must be reported in terms of saturated surface dry weight processed through the plant during a specific time interval. The RCC mix record must be produced at all times when the plant is producing a mix. The aggregate moisture must be tested daily whenever RCC is being produced. The mix plant record must include the aggregate moisture content tests upon which the batch proportions are based.

A summary shift record must be provided. The record must include the total quantity of each constituent in the mix, total quantity of RCC produced, and a comparison of the quantity of each constituent mixed per cubic yard to that of the job mix.

Noise pollution. The plant must be operated to comply with all applicable regulations pertaining to noise pollution.

Pollution control. The plant must be operated to comply with all applicable regulations pertaining to air and water quality.

8. Mixing

The plant must be operated according to the manufacturer’s recommendations. The mixing mechanism must be maintained in satisfactory operating condition and must be cleaned after each production run. All supply bins and silos must be kept sufficiently full to ensure a uniform and constant flow of all materials.

All RCC produced from the beginning of startup must be disposed of at the location or locations specified in section 22 of this specification until a uniform mix of the required proportions is consistently being discharged from the mixer.

After a batch-type pugmill has been calibrated and has produced the job mix with the specified uniformity, the mix retention time must not be reduced.

Uniformity—RCC uniformity must be monitored by continuous visual inspection by the plant operator and by periodic visual inspection by contractor quality control personnel. The mix must be visually inspected for uniformity by contractor quality control personnel at the beginning of each production run and at least once each hour during the production run. If it becomes apparent that the mixer is not producing a uniform mix of the proportions specified, RCC production must be promptly discontinued until the problems that caused the uniformity problem are discovered and corrected.

If a uniformity problem is suspected, the contractor must conduct the tests listed in table 36–2, determine the maximum difference and compare to the allowable maximum difference, and take appropriate corrective measures.

Adjustments must be made to the mixing plant as necessary to obtain the required uniformity and consistency of the RCC mix when uniformity test results indicate that the requirements for uniformity are not being met. The production and placement of RCC may proceed without waiting for the compressive strength results if the results of the other three tests listed in table 36–2 are within the allowable maximum difference and the issues that caused a uniformity problem are resolved.

9. Conveying

The RCC mix must be conveyed from mixer to placement area as rapidly as practicable by methods that prevent segregation, contamination, and loss of water. The total length of time from the end of mixing until the RCC has been placed, spread, and compacted must not exceed 45 minutes.

The contractor must provide baffles to limit free fall of mixed RCC to a maximum of 5 feet at the discharge end of conveyors, within hoppers, and at other locations where the potential for segregation may occur. Chutes that tend to cause segregation, such as an inclined chute, will not be permitted.

Communications—Telephone, radio, or other voice communication must be provided between all interim storage hoppers, the batch plant control, and the placement locations. The contractor must provide the Government inspector the same form of communication.

Temporary storage containers—Gob hoppers must be used for storage wherever the mixed RCC is temporarily accumulated prior to being loaded into hauling equipment and when direct conveyor systems do not otherwise provide continuous delivery to the final placement location. Gob hoppers must be configured to allow free flow of RCC without segregation or choking.

Conveyor belts—The conveyor system design and layout must provide for adequate capacity, speed, reach, and pivot points to convey RCC to all placement areas.

Conveyor belts must be designed, erected, operated, and maintained in a manner that meets production requirements and does not segregate materials. RCC must not be exposed on any belt for a period exceeding 5 minutes without being protected from the drying elements of wind and sun. RCC must not be exposed on any belt during rainfall unless it is protected from the rain.

Hauling equipment—Equipment must be maintained in good operating condition and must not be permitted onto the RCC surface when vehicle fluids are leaking or when there is a potential for contamination to the RCC.

RCC may be hauled using trucks, front-end loaders, or scrapers. Hauling equipment that ruts, scores, mars, or indents the RCC surface must not be operated directly on previously compacted RCC surfaces. Hauling equipment must not track mud or other contaminants onto previously placed RCC and must not be operated directly on uncompacted RCC. All hauling vehicles must be operated in a manner that prevents tight turns, sudden stops, or other actions that cause damage or displacement to previously compacted RCC. The contractor must implement necessary measures to prevent contamination or damage of the previously compacted RCC.

10. Weather

Adverse weather—In adverse weather (heavy rain, severe cold, heavy snow, and hot temperature) where the conditions specified herein for RCC construction cannot be maintained, an interruption in placing operations is required.

Weather station—The contractor must install and maintain a weather station onsite at all times during performance of the test section and the production and placement of RCC. The weather station must be located at an approved location near the RCC structure. The weather station must record wind speed, ambient temperature, humidity, and the rate and cumulative volume of rainfall. A record of climatic conditions at the designated location including wind speed, ambient temperature, humidity, and rainfall rate and volume must be recorded daily.

Wet weather placement—RCC must be protected from rainfall-induced erosion and must not be placed during rainfall events at a rate equal to or greater than 0.1 inch in 20 minutes. Placement during a light mist may continue when covered belt conveyors rather than hauling vehicles are used to convey the mix. Placement of RCC will not be permitted when rainwater accumulates on compacted RCC surfaces.

Cold weather placement—RCC must not be placed when the ambient air temperature drops below 35 degrees Fahrenheit or the temperature of the RCC mix is less than 40 degrees Fahrenheit.

Hot weather placement—The maximum temperature of the RCC at time of placement must be as specified in section 22. After placing, but prior to compaction, the temperature of the mix must be determined according to ASTM C 1064. When the RCC temperature is within 2 degrees of the specified limit, it must be measured every hour. Introduction of chilled water and/or ice, shading and/or cooling of the aggregates, or other measures may be required in the production of RCC to maintain the RCC temperature within the specified requirements. If the RCC temperature exceeds the maximum specified temperature, RCC placement must be suspended until cooler weather or additional measures to reduce the RCC temperature results in a reduction of the placement temperature of the RCC to or below the specified maximum temperature.

11. Foundation preparation

Prior to the start of RCC placement, the foundation must be excavated or filled to the specified lines and grades as shown on the drawings. The foundation must be free of standing water and any organic or loose materials. All surfaces where RCC installation is specified must be damp and have a surface temperature not less than 35 degrees Fahrenheit at time of placement. Placement of RCC on mud, dried earth, uncompacted fill, standing water, or frozen subgrade is not permitted.

Earthen foundations—Earthen foundation surfaces must be prepared by adjusting the moisture content and compacting the foundation. The moisture content, depth, and degree of compaction required must be as specified in section 22. If the earthen foundation is allowed to dry after compaction, it must be moistened prior to placing RCC. The foundation surface must be firm and damp.

Rock foundations—Rock foundations must be cleaned and prepared as specified in Construction Specification 63, Treatment of Rock Surfaces. The slope of the finished foundation surface must not be steeper than one horizontal to one vertical. Rock surfaces must be damp at the time of RCC placement.

12. Placing and spreading

The placement of RCC into the structure must be such that once placement begins, it is performed without interruption until RCC placement and compaction complies with specification requirements within the geometric limits planned for that placement period. The contractor must obtain the concurrence of the engineer when establishing the geometric limits of RCC to be placed and compacted in any placement period.

All equipment used on the RCC fill must be maintained in good operating condition at all times. Equipment must not drip or spill oil or other contaminants onto the RCC. Any equipment that contaminates the RCC mixture must be promptly removed from contact with the RCC and repaired or replaced. Any contaminated RCC mixture must be removed and replaced.

Placing and spreading must be performed with equipment that does not mar or contaminate the surface of the compacted RCC. Track-type equipment must not operate directly on compacted RCC unless the tracks are equipped with rubber pads. Equipment used to deposit, spread, or compact must not turn on previously compacted RCC.

Layout of the placement area—The RCC must be spread in level lifts across the entire area of the structure. The direction of RCC placement must be parallel to the long axis of the structure so that the number of lanes and the number of edge joints are minimized. Transverse joints of adjacent lanes must be offset by no less than 20 feet horizontally.

Placing—RCC mix, bonding mortar, portland cement, neat cement grout, or concrete must not be placed on previously placed layers that have not been compacted to the specified density.

Roller compacted concrete mix must be deposited as near to its final location as possible. When haul vehicle delivery is used, depositing must be accomplished with a dump-spread action while the placing vehicle is moving. Belt placement must discharge with a spreading action that does not segregate the material. RCC must not be deposited directly against formwork or other vertical surfaces. Piles that form when placing RCC must not contact forms or vertical surfaces. Neither the discharge height nor the pile height of RCC must exceed 5 feet.

Spreading—Spreading of the RCC must be completed within 10 minutes following depositing. RCC must be spread into an uncompacted, uniform lift thickness that can be compacted to produce a lift of the specified thickness and density. In areas requiring special compaction, it may be necessary to deposit, spread, and compact the RCC in several layers to produce a lift of the specified thickness and density.

Equipment must not operate directly on any surface that has been cleaned and prepared to receive a subsequent lift of RCC.

Spreading of RCC material must be performed with a track-type bulldozer in a manner that will not cause damage to previously compacted RCC.

With RCC placement at or near its final location, spreading will typically be limited to leveling the RCC into uniform lifts. In isolated or confined placement locations, the RCC may be deposited and spread up to a maximum distance of 50 feet provided segregation does not occur, specified spreading time is not exceeded and the time specified between mixing and a completion of compaction is not exceeded. The contractor must conduct placing and spreading operations in a manner that will prevent segregation of RCC.

If segregation of RCC occurs during the spreading operation, it must be corrected by immediately reworking the RCC. Reworking must be performed using techniques that do not damage previously compacted RCC. This may require removing the RCC from the lift surface to accomplish reworking, then transporting the mix back onto the surface after mix uniformity has been achieved. If reworking the RCC does not produce a uniform mix, or if the specified time between mixing and compaction is exceeded, the segregated RCC must be wasted and replaced.

If a uniformity problem is suspected, uniformity tests must be performed from material taken from the placement area following spreading of the material and/or other points in the RCC production process as required to identify the source of the problem. Three individual samples of the material must be taken at the sample location at intervals of 5 minutes or more. Uniformity tests must be conducted in accordance with table 36–2. The maximum difference between the resulting values must be compared to the allowable maximum difference and appropriate corrective measures be employed.

13. Compaction

The entire surface area of each RCC lift must be compacted to the specified density, as determined from the apparent maximum density (AMD) specified in section 6, with adequate compaction overlap to ensure complete compaction of the RCC.

The in-place wet density of the compacted RCC measured at a depth of 10 inches must not be less than 98 percent of the AMD.

Uniformity of density must be achieved within each lift. The difference between density measurements at any two depths must not exceed 2 percent of the greater of the two values.

The wet density of the compacted RCC must be tested in accordance with ASTM C1040. The moisture content of the compacted RCC must be tested in accordance with ASTM D3017. Unless otherwise specified in section 22, a minimum of three moisture and density tests will be performed on each lift of RCC with no less than one density measurement and moisture measurement for each 100 cubic yards of RCC compacted.

Production compaction must be performed with production rollers as defined in this section. RCC compacted with production rollers must be compacted in single lifts that are 12 inches thick (plus or minus 1 inch) after the specified density has been achieved.

Production rollers must be single or double drum, large, self-propelled vibratory rollers. The rollers transmit a centrifugal force to the surface through smooth steel drum or drums by means of revolving weights, eccentric shafts, or other equivalent methods. Production rollers must impart a centrifugal force of at least 450 pounds per inch of drum width at the operating frequency during compaction. Production rollers must operate at a vibrating frequency of at least 1,500 vibrations per minute and have a drum diameter of 4 to 6 feet and a drum width of 5 to 8 feet. The amplitude of vibration of the roller must be between 0.03 and 0.07 inch. The roller must not travel at greater than 2 feet per second during the compaction operation.

Production rollers must be used in open areas where they can compact RCC to the specified density within the specified time and without damage to the structure, forms, foundation, or appurtenances. Rollers may only be operated in the vibratory mode while actively compacting the RCC. After the RCC has been deposited and spread, rollers may be operated in static mode to smooth and/or firm up the surface, but must operate in the vibratory mode to compact the RCC to the specified density. Compaction must be completed with the roller operated in the static mode, as necessary, to achieve the specified density near the surface of the lift.

The contractor must select the combination of frequency of vibration, amplitude of vibration, and speed of operation that result in the specified density at the fastest production rate while meeting all other requirements.

Placement and compaction of RCC must be completed without damaging the structure, other structures, forms, foundation, or other embedded appurtenances. Any appurtenance damaged by the compaction process must be repaired or removed and replaced at the contractor’s expense.

Special compaction techniques must be performed using special compaction rollers and power tampers in areas where production rollers cannot maneuver or will cause damage to the structure, forms, foundation, or appurtenances. RCC must be deposited, spread, and compacted in 4- or 6-inch-thick layers as required to obtain uniform specified density throughout the 12-inch lift with limited compaction to avoid drying the surface.

The individual layers that compose one lift must be deposited, spread, and compacted within 1 hour from the time the first layer within that lift is placed.

Special compaction rollers must be vibratory rollers that are capable of operating in confined areas and adjacent to forms, foundation, or appurtenances without damage to the RCC structure or appurtenances. Special compaction rollers must produce a centrifugal force of at least 150 pounds per linear inch of drum width for each drum of a double drum unit and 300 pounds per linear inch of drum width for a single drum unit. Special compaction rollers must be operated at a speed less than 2 feet per second during the compaction operation.

Power tampers must develop a force per blow of at least 3,500 pounds per square foot. The maximum layer thickness to be compacted by power tampers must be plus or minus 6 inches after the specified density has been achieved.

The contractor must maintain at least one special compaction roller and two tampers in operating condition at the site during RCC placement.

Manually directed vibratory plate compactors may be used to shape, smooth, and level the surface, but must not be used as a substitute for vibratory rollers and power tampers.

14. Record testing

Unless otherwise specified in section 22, one set of RCC cylinders for compressive strength tests must be obtained for each 1,000 cubic yards of RCC placed to be used for compressive strength testing.

Each set must consist of 15 compressive strength cylinders prepared in accordance with ASTM C 1176 or C 1435 and weighed to determine the density of the RCC within each cylinder. Any cylinder that weighs less than 98 percent of the weight of the heaviest cylinder must be discarded and another cylinder prepared and weighed until all 15 cylinders have a weight that is at least 98 percent of that of the heaviest cylinder. Three cylinders must be tested for compressive strength in accordance with ASTM C 39 at 7, 14, 28, 90, and 180 days, respectively, after the specimens are molded.

Unless otherwise specified in section 22 of this specification, the contractor must extract two sets of vertical core RCC samples in accordance with ASTM C 42. Each set must be sampled from RCC that has been placed in the structure at no less than 1 week apart. Each set must contain eight intact cores taken from the structure at approved locations. Cores must have a minimum length equal to one lift thickness and a nominal diameter of 6 inches. Core specimens must be obtained no earlier than 20 days after placement. The contractor must test two samples at 28, 56, 90, and 180 days, respectively, after placement for compressive strength in accordance with ASTM C 42.

15. Lift joints

The term joint, as used in this specification, applies to all surfaces that will eventually be covered by RCC mix, bonding mortar, portland cement, neat cement grout, or conventional concrete.

The joint treatment method must be as specified in section 22.

Joint condition—Three potential joint conditions will exist during construction: fresh joint, intermediate joint, and cold joint. The condition of a joint is defined on the basis of joint maturity or time of exposure. Joint maturity is defined as the product of the average RCC surface temperature (AST) in degrees Fahrenheit and the time of exposure (TE) in hours. Joint maturity is expressed in degree-hours (deg F-hr) and is calculated as—

——————————>

Joint maturity in deg F-hr = (AST) □ (TE).

The TE is the period, expressed to the nearest quarter hour, beginning when the compaction of RCC is completed and ending when covered by the subsequent placement of RCC, bonding mortar, portland cement, neat cement grout, or conventional concrete.

Whenever the joint condition is defined on the basis of joint maturity, the AST must be determined hourly during the exposure period by measuring the RCC surface temperature at various locations with a surface thermometer. The temperature must be measured in degrees Fahrenheit and the temperature readings averaged to determine the AST.

A **fresh joint** is defined as a joint having maturity of 400 deg F-hr or less. In lieu of determining the joint maturity, a fresh joint may be defined as a joint with a TE of 4 hours or less.

An **intermediate joint** is defined as a joint having a maturity greater than 400 deg F-hr, but less than or equal to 1,600 deg F-hr. In lieu of determining the joint maturity, an intermediate joint may be defined as a joint with a TE of more than 4 hours, but less than 16 hours.

A **cold joint** is defined as a joint having a maturity of over 1,600 deg F-hr. In lieu of determining the joint maturity, a cold joint may be defined as a joint with a TE of 16 hours or more.

Joint treatment—All joint surfaces must be kept continuously moist, clean, and uncontaminated until placement of succeeding RCC lifts. Water that ponds on a finished surface must be removed prior to placing RCC.

The surface of previously placed RCC must be free of soil, dust, or other contaminants prior to being covered with joint treatment material or another layer or lift of RCC. Cleaning of previously placed RCC lifts must be accomplished by pressurized water and/or air or other methods provided that the surface of the in-place layer is not damaged by the cleaning operation.

The contractor must have a pressure washer and a blowpipe onsite capable of delivering a combined air-water mixture, with the ability to adjust the pressure, volume, and proportion of air and water.

Edge joints that are exposed for more than 30 minutes must be trimmed back no less than 9 inches to an RCC surface, that has been compacted to the specified density and beveled at a slope of one horizontal to one vertical. Immediately before placing RCC against a trimmed surface, the joint condition must be determined and the specified joint treatment must be applied.

Any surface to be covered with RCC, a bonding material or conventional concrete that is damaged to the extent that over 25 percent of the exposed coarse aggregate is undercut must be treated as a cold joint. Coarse aggregate with less than half of it surface area remaining embedded and bonded to the RCC is considered undercut.

All RCC materials removed by cleaning, brooming, smoothing, beveling, or trimming layers must be collected and removed from the structure.

Treatment Method I. Remove any loose materials and contaminants from the lift joint surface. The lift joint surface must be cleaned using moderate-pressure air immediately before spreading the next RCC lift. Maintain the surface in a moistened condition.

Treatment Method II. Perform Treatment Method I. Before the placement of RCC on the joint surface, uniformly distribute a layer of dry portland cement over the surface. The portland cement must be applied at a rate of 0.5 to 1 pound per square foot of surface. The amount of water applied to the lift surface before, during, or after distributing the cement must be of sufficient quantity to dampen all of the cement. The ratio of water to cement must be limited to that which will produce a tacky paste. Water applied after the cement is distributed must be applied in a fine mist to prevent the displacement of cement. The cement must be applied immediately ahead of placing the next layer or lift of RCC. The cement must not be exposed on the surface more than 10 minutes before being covered with RCC. Portland cement paste that does not meet these requirements must be removed from the structure and disposed of, and the treatment method must be repeated.

Treatment Method III. Perform Treatment Method I. Before the placement of RCC, the joint surface must be covered with a layer of the bonding mortar specified in section 2. The thickness of the bonding mortar must be 0.25 to 0.5 inch. The bonding mortar must be covered with the next layer or lift of RCC while the mortar is still fluid. In no case may the bonding mortar remain uncovered for more than 30 minutes. Bonding mortar must be placed in a manner that will avoid segregation. Bonding mortar that does not meet these requirements must be removed from the structure and disposed of, and the treatment method must be repeated.

16. Curing and protection

Curing—Curing of RCC must begin immediately after compaction. All exposed and completed RCC surfaces must be cured for a minimum of 14 days at or above 40 degrees Fahrenheit following placement. All repairs, including those required to fill holes associated with form anchorages and coring, must be cured for a minimum of 7 days at or above 40 degrees Fahrenheit following repair.

If the RCC is wet cured, the RCC must be maintained in a continuously damp condition for the entire curing period. The continuous application of water supplemented by the use of a saturated cover material or an impermeable covering must be required to obtain the continuously damp condition. The application of water or cover material must not erode, mar, or otherwise damage the RCC. Plastic or paper covering must meet the requirements of ASTM C 171. Only white or reflective coverings may be used during hot weather as defined by ACI 305.

In lieu of wet curing, RCC that will not be covered with subsequent joint treatment, RCC, or conventional concrete may be treated with a curing compound as specified in section 2, unless otherwise specified in section 22. Areas to be cured with curing compound must be kept continuously moist until curing compound is applied. Curing compound must be thoroughly mixed before applying and must be agitated during application. A continuously agitating pressure sprayer must be used to apply the curing compound at a uniform rate of not less than double the curing compound manufacturer's recommended rate for conventional concrete curing. Manual hand pump sprayers may not be used. A brush or paint roller must be used in areas that are near unmasked surfaces that will be covered with subsequent joint treatment, RCC, or conventional concrete. The curing compound must form a uniform, continuous, adherent film that will not check, crack, or peel and be free from pinholes or other imperfections. Multiple applications of curing compound may be necessary to achieve the specified coverage. When multiple applications are required, the second application must be applied at a 90 degree angle to the first application. During the curing period, curing compound must be reapplied 7 days after the initial application. In areas where the curing compound is damaged, it must be reapplied immediately.

Curing compound must not be applied to areas that are to be repaired or patched. Areas to be repaired or patched must be kept continuously moist until the repair is made. Curing compound or wet curing must then be implemented to conform to curing requirements specified herein. Any curing compound applied to areas that are to be repaired or patched must be removed prior to applying the repair material.

Regardless of the curing method used, curing activities must not be discontinued or interrupted until the RCC has remained at or above 40 degrees Fahrenheit for a total of 14 days. This will require extending the curing period by the number of days that the RCC temperature drops below 40 degrees Fahrenheit during the curing period.

Protection—The temperature of RCC must be maintained at or above 35 degrees Fahrenheit from the time the RCC is placed until 7 days after the curing period. When ambient temperatures are expected to be below 32 degrees Fahrenheit, measures must be implemented to protect the RCC from freezing. The protection must remain in place

until ambient temperatures remain continuously above 35 degrees Fahrenheit for 24 hours. Protective measures must not hinder the specified curing of the RCC.

RCC must be protected from damage by precipitation, vehicular traffic, or other causes.

17. Vertical surfaces

Unless otherwise specified in section 22, all formed RCC vertical surfaces that are subject to exposure must be finished to ensure a minimum of 80 percent of the surface area is free from honeycomb or other voids and is uniform in appearance. Forms must remain in place for a minimum 12 hours after the RCC is installed and until they can be removed without damage to the RCC.

Forming is not required for vertical RCC surfaces that are not subject to permanent exposure.

The finish and appearance of unformed vertical surfaces must comply with the requirements specified in section 22.

18. Tolerances

Any variation in the face or surface of the finished RCC must be within the tolerances stated herein.

The structures must be constructed to the lines and grades depicted on the drawings.

The thickness of compacted lifts of RCC must be 12 inches plus or minus 1 inch.

The allowable tolerance of all exposed formed surfaces must be plus or minus 0.1 foot from specified line. Abrupt changes must not exceed 0.05 foot in any exposed formed surface.

Limit gradual overbuild of exposed unformed RCC faces to 0.5 foot. Under build will not be allowed.

Do not exceed 0.1 foot in 10 feet variation in an unformed, exposed RCC face as measured in a straight line along the length and height of the face, or 0.5 foot over the entire length of the structure. Abrupt changes must be less than 0.1 foot.

The elevation of any horizontal RCC surface must be plus or minus 0.1 foot of the specified grade except that the elevation of a finished top of dam or spillway crest must be no more than 0.1 foot above the specified elevation.

19. Repair of RCC

Repair or replacement—The contractor must repair or replace RCC that does not meet the requirements of this specification. Before starting any repair or replacement work, the contractor must prepare a written plan for the repair or replacement. The primary reference for material and repair methods for the plan must be the appropriate sections of the American Concrete Institute's Manual of Concrete Inspection. The repair plan must be submitted for review and approval at least 10 days before any repair or replacement work.

Patching—All form bolts, metal ties, and similar forming restraints must be removed to a depth of 1 inch below the surface of the RCC and their cavities repaired unless otherwise specifically permitted or specified in section 22. Small cavities, large air holes, minor honeycombed areas, holes created from test coring, and other superficial imperfections that require patching to meet the specified finish requirement must be thoroughly cleaned and filled. Holes left by bolts or straps that passes through the RCC must be filled solid with a dense, well-bonded nonshrink patching material. Dry-pack mortar and replacement concrete must follow the appropriate procedure detailed in the Repair and Maintenance chapter of the Concrete Manual, Bureau of Reclamation, U.S. Department of the Interior. Proprietary patching material must be appropriate for the type of repair used within the manufacturer's recommended limits and applied according to the manufacturer's recommendations.

When proprietary patching material is proposed in the plan, the manufacturer's data sheets and written recommendations must be included in the plan.

Repair material or replacement concrete must have properties, color, and texture similar to and compatible with the concrete being repaired or replaced.

Curing of repaired or replaced concrete must be started immediately after finish work is completed as specified in section 16 or as specified by the manufacturer of proprietary compounds.

20. Cleanup of spillage

All loose gravel and uncompacted RCC material must be removed from the structure for disposal in approved locations or as specified in section 22 and must not be recycled into the RCC mix.

21. Measurement and payment

For items of work for which specific unit prices are established in the contract, the volume of RCC is measured and computed to the nearest cubic yard by the method of average cross-sectional end areas. Unless otherwise specified in section 22, no deduction in volume is made for embedded items, such as (but not limited to) conduits, inlet structures, outlet structures, embankment drains, sand diaphragm and outlet, and their appurtenances.

The volume of RCC must be determined by measuring from the surface of the foundation when approved for RCC placement to the specified neatlines of the completed RCC structures, unless otherwise specified in section 22.

If the test section is not incorporated into the RCC structure, the volume of RCC placed into the construction of the test section will be added to the volume computation of the completed RCC structure to determine the total volume of RCC for payment. If the test section is incorporated into the RCC structure, no addition volume of RCC must be included for payment.

When the test section is paid for under a separate bid item, the test section will not be measured for payment. Payment will be made at the contract lump sum price for the test section and will constitute full compensation for the completion of the test section including any removal and disposal as applicable.

Payment for the RCC, for which a specific unit price is established in the contract, will be computed to the nearest cubic yard. Payment constitutes full compensation for furnishing all labor, materials (except cementitious materials), equipment, tools transportation, and all other items necessary and incidental to the construction and removal of the test section and construction of the RCC structure, including joint treatment, trimming and removal, repair, replacement, patching, curing, protection, site cleanup, and disposal of spillage and waste materials. Payment for treatment of rock foundation surfaces, if any, will not be included in the payment for RCC. Payment will not be made for RCC material that is wasted or rejected for failure to comply with this specification.

Payment for each cementitious component of the RCC, for which a separate bid item is included in the contract, includes the quantity incorporated into the RCC structure and test section. This quantity is computed based on statement of delivery tickets. Payment will not be made for any cementitious materials not incorporated into the structure or test section.

Payment for the cementitious materials for which specific unit prices are established in the contract will be to the nearest 0.1 ton of cementitious materials.

Compensation for any item of work described in the contract but not listed in the bid schedule will be included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 22.

22. Items of work and construction details

22. Items of work and construction details

In Section 2, Material, Portland cement shall be Type II or V. In-lieu of Type II or Type V cement, Type IL(X%)(MS or HS) blended cements as specified in ASTM C595 may be used upon approval of the Engineer.

The percent limestone (X%) in the blended cement shall not exceed 15% by mass of the cement provided. Concrete mix designs using blended cements with the percent limestone (X%) greater than 10% shall include sufficient testing in accordance with ASTM C109 to document there is no loss in compressive strength as a result of the included limestone content as compared to Type II or V cements.

Blended cements that do not indicate sulphate exposure requirements will require additional testing under ASTM C1012. Documentation of passing test results supporting the sulfate exposure designation as described in ACI 318-19 for exposure class S1 for (MS) and S2 for (HS) shall be provided.

In Section 5, RCC mix design, the minimum compressive strength shall be 2,700 psi at 28 days.

In Section 6, Test section, the location of the test section shall be the downstream cutoff wall as shown in the drawings.

In Section 10, Weather, the maximum temperature of the RCC at time of placement shall be 85 degrees F.

In Section 11, Foundation preparation, the earthen foundation upon which RCC will be placed and has not been previously compacted shall be reworked and compacted to 100% Standard Proctor Maximum Density. Placement moisture shall be from optimum upward.

The final excavated surface of the foundation area shall be examined and approved by the Engineer prior to placement of any RCC. All earthen surfaces on which RCC is placed shall be damp and at a surface temperature in excess of 35 degrees F.

In Section 12, Placing and spreading, the maximum temperature of the RCC at time of placement shall not exceed 85 degrees F.

In Section 12, Placing and spreading, a construction joint oriented parallel to a vertical wall that is transversely intersected by another lift shall not be allowed. Construction joints along a vertical wall shall be installed no closer than 10 feet from the vertical wall/transverse lift intersection. Final construction joint location shall be approved by the Engineer.

In Section 15, Lift joints, Treatment Method I shall be used for fresh joints, intermediate joints and cold joints throughout the entire structure, except for the areas adjacent to the reinforced concrete baffles, Treatment Method III shall be used. Refer to the construction drawings for areas where Treatment Method III is required.

In Section 17, Vertical surfaces, the Contractor shall provide a written plan for constructing the specified vertical surfaces to the Contracting Officer for approval.

In Section 18, Tolerances, formwork for vertical surfaces shall be continuous and rigid enough to ensure no more than 0.1 feet of horizontal deflection from the previous/lower 12-inch lift and no more than 0.2 feet of overall horizontal deflection from the designed vertical surface location.

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 21, Roller Compacted Concrete

(1) This item shall consist of furnishing and placing all roller compacted concrete (RCC) required for the construction of the RCC auxiliary spillway as shown on the drawings.

(2) The Contractor shall provide a drawing showing the layout of the mixing plant for the RCC. The layout shall be located on-site within the work limits and at the location designated on the drawings. The drawing shall designate a temporary disposal area(s) for segregated or contaminated aggregates; non-uniform, initial batch mixes; and/or rejected RCC materials as required in Section 2, Section 8, and Section 20. Prior to construction completion, the materials in these temporary area(s) shall be removed and disposed of at an approved off-site location. All state and local laws pertaining to mixing or batching plants shall be adhered.

(3) The RCC auxiliary spillway shall be constructed in typical 12-inch thick lifts (after compaction). Lifts with thicknesses other than 12 inches after compaction shall be at the locations and thicknesses shown in the construction drawings.

(4) Sawed control joints shall be installed to the locations and depths described in the drawings or otherwise approved by the engineer. Upon completion, sawed joints that are not covered with RCC shall be backfilled with a sealing compound in accordance with Material Specification 536.

(5) The Contractor shall remove and replace damaged or defective RCC. The Engineer will determine the required extent of removal, replacement or repair and advise the Contractor, in writing, of this determination. Approval of the Contractor's repair shall not be considered a waiver of Engineer's right to require complete removal of defective work if the completed work does not produce RCC of the required quality and appearance.

(6) During construction of the sidewalls, a minimum level working surface shall be provided. The working surface shall have a minimum width of 14 feet at an elevation of 4 feet above the subgrade and shall uniformly increase to a minimum width of 24 feet at an elevation 12 feet above the subgrade. Twelve (12) feet of this minimum width may include the width of the RCC sidewalls. The portion of the working surface that is not part of the completed work shall be removed after sidewall is completed.

(7) The earthfill placement adjacent to the RCC sidewalls shall be placed concurrently with each lift of the RCC.

(8) Weep holes shall be installed in the stilling basin as shown on the drawings.

(9) Cranes and heavy equipment shall not be allowed on the RCC after placement unless approved by the Engineer.

b. Bid Item 22, Cementitious Materials

(1) This item shall consist of furnishing and handling the cement and pozzolan required for the production of RCC required for the auxiliary spillway.

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Construction Specification 41—Reinforced Concrete Pressure Pipe Conduits

1. Scope

The work shall consist of furnishing and installing reinforced concrete pressure pipe conduits, fittings, and accessories as shown on the drawings and/or specified herein.

2. Material

Reinforced concrete pressure pipe, fittings, and accessories shall conform to the requirements of Material Specification 541, Reinforced Concrete Pressure Pipe.

Portland Cement Concrete for bedding and cradles shall conform to the requirements of Construction Specification 31 for the specified class of concrete.

Joint sealing compound shall conform to the requirements of Material Specification 536, Sealing Compound for Joints in Concrete and Concrete Pipe.

Preformed expansion joint filler shall conform to the requirements of Material Specification 536, Sealing Compound for Joints in Concrete and Concrete Pipe.

Filter fabric shall conform to Material Specification 592, Geotextile.

3. Laying the pipe

The pipe shall be set to the specified line and grade and temporarily supported on precast concrete blocks or wedges. Concrete blocks and wedges used to temporarily support the pipe during placement of concrete bedding or cradle, or both, shall be a class of concrete equal to or stronger than the concrete used to construct the bedding or cradle. Bell and spigot pipe shall be laid with the bells or grooves facing upstream unless otherwise specified in section 7 or shown on the drawings. Pipe may be installed by initially placing the upstream section of pipe and progressing with placement of the remaining sections of pipe in the downstream direction; however, care must be taken to avoid contaminating the joint with soil or bedding as the bell end is slid over the spigot of the adjoining pipe.

Just before each joint is connected, the connecting surface of the bell and spigot or spigots and sleeve shall be thoroughly cleaned and dried. Also, the rubber gasket and the inside surface of the bell or sleeve shall be lubricated with a light film of soft vegetable soap compound (flax soap). The rubber gasket shall be stretched uniformly as it is placed in the spigot groove to ensure a uniform volume of rubber around the circumference of the pipe.

Method 1—The joint shall be connected by sliding the bell over the spigot or by sliding the spigot into the bell and applying a pulling or jacking force in a manner that will allow the spigot to enter squarely into the bell.

Method 2—The joint shall be connected in accordance with the manufacturer's instructions.

Use with either method—When the spigot has been seated to within 0.5 inch of its final position, the position of the gasket in the joint shall be checked around the entire circumference of the pipe by means of a metal feeler gauge. In any case where the gasket is found to be displaced, the joint shall be disengaged and properly reconnected. After the position of the gasket has been checked, the spigot shall be completely pulled into the bell and the section of pipe shall be adjusted to line and grade.

4. Filling joints

Before the placement of the bedding or cradle, the exterior annular space between the ends of the pipe sections shall be cleaned and completely filled with joint sealing compound. Before the compound is applied, the surface against which it is to be placed shall be cleaned of all dust, lubricant, and other substances that would interfere with a bond between the compound and the pipe. If recommended by the

manufacturer of the compound, the concrete surface shall be coated with a primer in accordance with the manufacturer's recommendations. Primers shall be applied to the concrete surface only and shall not come in contact with the gasket or gasket sealing surface. Unless the compound or primer is specifically recommended for use on moist concrete, the surface shall be dry when the compound or primer is applied.

The joint sealing compound shall be allowed to cure until it is sufficiently firm to prevent the entry of concrete or earth into the joint. Unless otherwise specified in section 7 of this specification, before placing bedding or earth backfill (excluding concrete) containing particles larger than 0.25 inch in maximum dimension within 6 inches of the joint sealing compound, the compound shall be covered with a strip of 16-gauge to 24-gauge metal at least 2-inches wider than the space between the ends of the pipe sections. Instead of metal strips, the joints shall be covered by a minimum of 2-foot-wide, 4-ply thick filter fabric. Filter fabric shall be wrapped completely around the joint and overlapped a minimum of 12 inches at the top of the pipe. Lap shall be securely fastened to ensure filter fabric fits snugly during backfill operations. Filter fabric is centered on the joint. It shall conform to Material Specification 592, table 2, Nonwoven, class II.

5. Pressure testing

Method 1—Pressure testing of the completed conduit is not required.

Method 2—Before placing any concrete or earthfill around the conduit or filling the pipe joints, the conduit shall be tested for leaks in the following manner:

The ends of the conduits shall be plugged and a standpipe with a minimum diameter of 2 inches shall be attached to the upstream plug. The conduit shall be braced at each end to prevent slippage. The conduit and the standpipe shall be filled with water. The water level in the standpipe shall be maintained at least 10 feet above the invert of the upstream end of the conduit for at least 2 hours. Any leaks shall be repaired, and the conduit shall be tested again as described. The procedure shall be repeated until the conduit is watertight.

The pipe joints shall show no leakage. Damp spots developing on the surface of the pipe are not considered as leakage.

Method 3—Before placing any concrete or earthfill around the conduit or filling the pipe joints, the conduit shall be air tested in accordance with ASTM C924. The conduit shall be braced on each end to prevent slippage. All end plugs used for the air test shall be capable of resisting the internal pressure and must be securely braced.

All testing equipment to be used shall be furnished by the contractor and shall be inspected and approved by the engineer. The pressure gauges used shall be graduated to read in increments of 0.1 pounds per square inch and calibrated to provide accuracy within 10 percent plus or minus of the standard gauge. The contractor has the option of prewetting the conduit or line before testing. Any conduit that fails to pass this test must be repaired by a method satisfactory to the engineer. After the repairs are made, the conduit shall be retested until it passes the test requirements.

Method 4—Before placing concrete or earth backfill around the conduit joint to be tested or filling the pipe joints, the joint shall be tested in accordance to ASTM C 1103, Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Sewer Line. The test pressure shall be as specified in section 7 of this specification. Any joints showing leaks shall be relaid or repaired, and the joint shall be retested. The procedure shall be repeated until the joint passes the test.

6. Measurement and payment

Method 1—For items of work for which specific unit prices are established in the contract, the quantity of each size, type, and class of pipe is determined to the nearest 0.l foot by measurement of the laid length of pipe along the invert centerline of the conduit. Payment for each size, type, and class of reinforced concrete pressure pipe is made at the contract unit price for that size, type, and class of pipe. Such

payment constitutes full compensation for furnishing, transporting, and installing the pipe complete in place. This includes accessories, such as wall fittings, joint gaskets, coupling bands, sleeves, or collars, and all other items necessary and incidental to the completion of the work except the special fittings and appurtenances listed separately in the bid schedule. Payment for each special fitting and appurtenance is made at the contract price for that type and size of fitting or appurtenance.

Method 2—For items of work for which specific unit prices are established in the contract, the quantity of each size, type, and class of pipe is determined as the sum of the nominal laying lengths of the pipe sections used. Payment for each size, type, and class of reinforced concrete pressure pipe is made at the contract unit price for that size, type, and class of pipe. Such payment constitutes full compensation for furnishing, transporting, and installing the pipe complete in place. This includes accessories, such as wall fittings, joint gaskets, coupling bands, sleeves or collars, and all other items necessary and incidental to the completion of the work except the special fittings and appurtenances listed separately in the bid schedule. Payment for each special fitting and appurtenance is made at the contract price for that type and size of fitting and appurtenance.

All Methods—The following provisions apply to all methods of measurement and payment. Compensation for any item of work described in the contract, but not listed in the bid schedule, is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 7 of this specification.

7. Items of work and construction details

7. Items of work and construction details

In Section 3, Laying the pipe, Method 1 shall apply.

In Section 5, Pressure testing, Method 1 shall apply.

In Section 6, Measurement and payment, Method 2 shall apply.

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 23, Concrete Pressure Pipe, 42" C-301

(1) This item shall consist of furnishing and installing the 42" I.D. conduit and spigot wall fitting for the new principal spillway as shown on the drawings.

(2) The drawings are presented for conduit assembly consisting of basic pipe sections, 10' in length. Pipe sections of other lengths shall not be used unless approved by the Engineer. Where the length of the pipe section furnished differs from the basic 10' length, the resulting total length of the principal spillway conduit shall not be less than that specified on the drawings.

(3) Each section of pipe shall be supported at minimum of (2) locations along its length. The supports should be located no further than 2 feet from each end of a section. Methods of support which allow the weight of the pipe to bear on the pipe joint will not be permitted. Supports shall be support blocks or opposing wedges as shown on drawing.

Construction Specification 45—Plastic Pipe

1. Scope

The work consists of furnishing and installing plastic pipe (except corrugated polyethylene pipe) and the necessary fittings and appurtenances as shown on the drawings or as specified herein.

2. Material

Pipe, fittings, and gaskets shall conform to the requirements of Material Specification 547, Plastic Pipe, and as specified in section 14 of this specification or as shown on the drawings.

Perforated pipe shall conform to the requirements of Material Specification 547, Plastic Pipe, and as specified in section 14 of this specification or as shown on the drawings.

Unless otherwise specified, concrete shall conform to the requirements of Construction Specification 32, Structure Concrete, and section 8 of this specification.

Unless otherwise specified, earth backfill shall conform to the requirements of Construction Specification 23, Earthfill.

Unless otherwise specified, drainfill shall conform to the requirements of Construction Specification 24, Drainfill.

3. Handling and storage

Pipe shall be delivered to the job site and handled by means that provide adequate support to the pipe and do not subject it to undue stresses or damage. When handling and placing plastic pipe, care shall be taken to prevent impact blows, abrasion damage, and gouging or cutting (by metal edges and/or surface or rocks). The manufacturer's special handling requirements shall be strictly observed. Special care shall be taken to avoid impact when the pipe must be handled at a temperature of 40 degrees Fahrenheit or less.

Pipe shall be stored on a relatively flat surface so that the barrels are evenly supported. Unless the pipe is specifically manufactured to withstand exposure to ultraviolet radiation, it shall be covered with an opaque material when stored outdoors for 15 days or longer.

4. Excavation

Excavation shall be in accordance with Construction Specification 21, Excavation, and section 14 of this specification or as shown on the drawings.

The pipe foundation shall be excavated a minimum of 4 inches lower than the pipe grade shown on the drawings or staked in the field whenever bedrock, boulders, cobbles, or other material that may cause pipe damage is encountered at planned pipe grade.

5. Laying the pipe

Plastic pipe conduits complete with fittings and other related appurtenances shall be installed to the lines and grades shown on the drawings or specified in section 14 of this specification. The pipe shall be installed so that there is no reversal of grade between joints unless otherwise shown on the drawings. The pipe shall not be dropped or dumped on the bedding or into the pipe trench. The ground surface near the pipe trench shall be free of loose rocks and stones greater than 1 inch in diameter. This ensures that rock will not be displaced and impact the pipe.

Just before placement, each pipe section shall be inspected to ensure that all foreign material is removed from inside the pipe. The pipe ends and the couplings shall be free of foreign material when assembled. At the completion of a work shift, all open ends of the pipeline shall be temporarily closed off using a suitable cover or plug. Care shall be taken to prevent distortion and damage during hot or cold weather. During unusually hot weather (daytime high temperature of more than 90 °F), the pipe assembled in the trench shall be lightly backfilled or shaded to keep it as near to ground temperature as possible until final backfill is placed. Backfill operations should be performed during daily construction periods when the ground temperature and the temperature of the pipe do not vary more than 40 degrees Fahrenheit.

Perforated pipe shall be installed with the perforations down and oriented symmetrically about the vertical centerline. Perforations shall be clear of any obstructions on the inside and outside of the pipe when the pipe is approved by the engineer for backfill.

During installation, the pipe shall be firmly and uniformly bedded throughout its entire length, to the depth and in the manner specified in section 14 of this specification or as shown on the drawings. Bell-holes shall be placed in bedding material under bells, couplings, and other fittings to assure the pipe is uniformly supported throughout its entire length. Blocking or mounding beneath the pipe to bring the pipe to final grade is not permitted.

6. Pipe embedment

Earth bedding—The pipe shall be firmly and uniformly placed on compacted earthfill bedding or an inplace earth material bedding of ample bearing strength to support the pipe without noticeable settlement. The earth material on which the pipe is placed shall be of uniform density to prevent differential settlement.

Unless otherwise specified, a groove that closely conforms to the outside surface of the pipe shall be formed in the bedding. The depth of the groove shall be equal to or greater than 0.3 of the pipe diameter.

Earth bedding shall be compacted to a density not less than adjacent undisturbed inplace earth material or be compacted earth backfill. Earthfill material used for compacted earth bedding shall be free of rocks or stones greater than 1 inch in diameter and earth clods greater than 2 inches in diameter. The pipe shall be loaded sufficiently during the compaction of bedding under the haunches and around the sides of the pipe to prevent displacement from its final approved placement.

Sand, gravel, or crushed rock bedding—When sand, gravel, or crushed rock bedding is specified, the pipe shall be firmly and uniformly placed on the bedding material. Material for bedding shall not exceed 1 inch in diameter. Unless otherwise specified in section 14 of this specification or shown on the drawings, the coarse-grained bedding material shall be carefully placed and compacted to a depth equal to or greater than 0.3 of the diameter of the pipe above the bottom of the pipe. The pipe shall be loaded sufficiently during backfilling and compaction around the sides to prevent displacement of the pipe from its final approved placement.

Pipe encased in drainfill—The pipe shall be firmly and uniformly placed on bedding of specified drainfill. Drainfill shall be placed and compacted as specified in section 14 of this specification or as shown on the drawings to form a continuous uniform support around the entire circumference of the pipe. The pipe shall be loaded sufficiently during backfilling around the sides and during compaction to prevent displacement of the pipe.

7. Backfill

Initial backfill—Unless otherwise specified, initial backfill to 6 inches above the top of the conduit is required. Earth haunching and initial backfill material shall consist of soil material that is free of rocks,

stones, or hard clods more than 1 inch in diameter. Coarse backfill material shall be the specified sand, gravel, crushed rock, or drainfill material.

Initial backfill shall be placed in two stages. In the first stage (haunching), backfill is placed to the pipe spring line (center of pipe). In the second stage, it is placed to 6 inches above the top of the pipe.

The first stage material shall be worked carefully under the haunches of the pipe to provide continuous support throughout the entire pipe length. The haunching backfill material shall be placed in layers that have a maximum thickness of about 6 inches and are compacted as specified in section 14 of this specification or as shown on the drawings. During compaction operations, care shall be taken to ensure that the tamping or vibratory equipment does not come in contact with the pipe and the pipe is not deformed or displaced.

When pressure testing is not specified, the pipe shall be covered with a minimum of 6 inches of backfill material as soon as possible following assembling of the pipe in the trench, but not later than within the same day that placement has occurred. When pressure testing is specified, sufficient backfill material shall be placed over the pipe to anchor the conduit against movement during pressure testing activities.

Final backfill—Final backfill shall consist of placing the remaining material required to complete the backfill from the top of the initial backfill to the ground surface, including mounding at the top of the trench. Final backfill material within 2 feet of the top of the pipe shall be free of debris or rocks larger than 3 inches nominal diameter. Coarse backfill material shall be the specified sand, gravel, crushed rock, or drainfill. Final backfill shall be placed in approximately uniform, compacted layers. Final backfill compaction requirements shall be as specified in section 14 of this specification or as shown on the drawings.

Vehicles or construction equipment shall not be allowed to cross the pipe until the minimum earth cover and required density as specified in section 14 of this specification has been obtained.

8. Pipe encasement in concrete

Concrete encasement shall be carefully placed to form a continuous uniform support around the entire circumference of the pipe as specified in section 14 of this specification or as shown on the drawings. Pipes encased in concrete shall be securely anchored to prevent movement of the pipe during concrete placement. A clear distance of 1.5 inch shall be maintained between the pipe and the reinforcing steel.

The concrete for the encasement shall conform to the requirements of Construction Specification 32, Structure Concrete, for Class 3000M concrete unless otherwise specified.

9. Joints

Unless otherwise specified in section 14 of this specification or shown on the drawings, joints shall be either bell and spigot type with elastomeric gaskets, coupling type, solvent cement bell and spigot, or jointed by butt heat fusion. When a lubricant is required to facilitate joint assembly, it shall be a type having no deleterious affect on the gasket or pipe material.

Pipe joints shall be watertight at the pressures specified except where unsealed joints are indicated.

Pipe shall be installed and joined in accordance with the manufacturer's recommendations. Laying deflections and joint fitting or stab depths shall be within the manufacturer's recommended tolerances.

When solvent cement joints are specified for PVC or ABS pipe and fittings, they shall be made in accordance with the following ASTMs and the related appendix of each ASTM; D 2855 for PVC pipe and fittings and D 2235 for ABS pipe and fittings.

Flanged, banded, heat-fusion, or elastomeric-sealed mechanical joints shall be used when joining polyethylene (PE) and high density polyethylene (HDPE) pipe and fittings unless otherwise specified in section 14 of this specification or as shown on the drawings.

Pipe ends shall be cut square and be deburred to provide a uniform, smooth surface for the jointing process. Reference marks shall be placed on the spigot ends to assist in determining when proper seating depth has been achieved within the joint.

10. Fittings

Unless otherwise specified, steel fittings, valves, and bolted connections shall be painted or coated as recommended by the manufacturer.

Fittings for nonpressure pipe shall be of the same or similar material as the pipe and shall provide the same durability, watertightness, and strength as the pipe unless otherwise specified.

11. Thrust blocks and anchors

When specified, concrete thrust blocks and anchors shall be installed as shown on the drawings or specified in section 14 of this specification.

The concrete for the thrust blocks and anchors shall conform to the requirements of Construction Specification 32, Structure Concrete, for Class 3000M concrete unless otherwise specified in section 14 of this specification.

The thrust block cavity shall be hand dug into undisturbed soil or previously placed compacted backfill. The cavity shall be formed with soil or wood to hold the freshly placed concrete without displacement until an initial set has occurred.

When excavation beyond the designated trench widths and depths as shown on the drawings or specified in section 14 of this specification occurs at locations where installation of concrete thrust blocks is required, the contractor shall install an alternative thrust block provision. The concrete thrust block shall have a thickness of one pipe diameter and a contact face area that shall be formed against the pipe as shown on the drawings or specified in section 14 of this specification. Backfill shall be placed on all sides of the thrust block and to the sides of the excavation. It shall be compacted as specified for initial backfill.

12. Pressure testing

Method 1—Pressure testing of the completed conduit is not required.

Method 2—The conduit shall be tested for leaks in the following manner:

a. Before pressure testing:

(1) Joints of the assembled pipeline shall be allowed to cure as recommended by the manufacturer.

(2) Pipeline shall be flushed and cleaned.

(3) All concrete anchors and thrust blocks shall be in place and allowed to cure for a minimum of 3 days.

(4) Earth backfill shall be sufficient to anchor the conduit against movement during the pressure testing and shall be compacted as specified in Section 14 of this specification or as shown on the drawings.

(5) The conduit shall be braced, anchored, or both, at each end to restrict all potential pipe movement.

(6) The ends of the conduit shall be plugged. The upstream plug shall have a standpipe installed vertically having a minimum diameter of 2 inches and shall be equipped with a shutoff valve. All high points in the line shall be vented to evacuate air pockets. The conduit and the standpipe shall be slowly filled with water such that no air is entrapped during the filling operation. After filling is complete, all vents shall be closed.

b. During pressure testing, the water level in the standpipe shall be continuously maintained at a minimum of 10 feet above the highest invert elevation of the conduit for no less than 2 hours unless otherwise specified in section 14 of this specification or as shown on the drawings.

The volume of water leakage in the 2-hour test period shall be recorded. The maximum allowable leakage (L) in gallons per hour shall not exceed 0.02 times the nominal pipe diameter (D) in inches for each 1,000 feet of pipe line, which is about 50 pipe joints (L = 0.02 x D).

c. When observed leakage exceeds the allowable, leaks shall be sealed by replacement of pipe and fittings as necessary. The conduit shall be retested as described above. This procedure shall be repeated until the conduit leakage does not exceed the allowable specified above.

The contractor shall be fully responsible for any and all work required to correct leakage exceeding the amount specified.

Method 3—The conduit shall be tested for leaks in the following manner:

a. Before pressure testing:

(1) Joints of the assembled pipeline shall be allowed to cure as recommended by the manufacturer.

(2) Pipeline shall be flushed and cleaned.

(3) All concrete anchor and thrust blocks shall be in place and allowed to cure for at least 3 days.

(4) Earth backfill shall be sufficient to anchor the conduit against movement during the pressure testing and compacted as specified in section 14 of this specification or as shown on the drawings.

(5) The conduit shall be braced and/or anchored at each end to prevent all potential pipe movement.

(6) The ends of the conduit shall be plugged, and a pressure gauge shall be attached to the upstream and downstream ends. All high points along the pipeline shall be vented to permit the complete removal of all air within the pipeline. The conduit shall be slowly filled with water such that no air is entrapped during the filling operations.

b. The testing pressure specified in section 14 of this specification shall be continuously maintained at the upstream gauge for a minimum of 2 hours. The pressure at the downstream gauge shall not exceed the pressure rating of the pipe.

c. The volume of water leakage for the 2-hour test period shall be recorded. Maximum allowable leakage shall be in accordance with the following:

Allowable leakage for plastic pipe
(gal/hr/1,000 feet, or 50 pipe joints) [1/]

Nominal pipe size (in)	Test pressure in the pipeline (lb/in^2) 50	100	150	200
	- - - - - - - - Allowable leakage - - - - - - -			
4	.19	.27	.33	.38
6	.29	.41	.50	.57
8	.38	.54	.66	.76
10	.48	.68	.83	.96
12	.57	.81	.99	1.15
14	.67	.95	1.16	1.34
15	.72	1.02	1.25	1.44
16	.76	1.07	1.32	1.52
18	.86	1.22	1.49	1.72

1/ Computation basis

$$L = \frac{ND\sqrt{P}}{7,400}$$

where:
L = allowable leakage in gallons per hour
N = number of joints (pipe and fittings)
D = nominal diameter of pipe in inches
P = test pressure in pounds per square inch

d. When observed leakage exceeds the allowable, leaks shall be sealed by replacement of pipe and fittings as necessary. The conduit shall be retested as described in this section. The procedure shall be repeated until the conduit leakage does not exceed the allowable specified above.

   The contractor shall be fully responsible for any and all work required to correct leakage exceeding the amount specified.

13. Measurement and payment

Method 1—For items of work for which specific unit prices are established in the contract, the quantity of each kind, size, and class of pipe is determined to the nearest foot by measurement of the laid length along the crown centerline of the conduit. Payment for each kind, size, and class of pipe is made at the contract unit price for that kind, size, and class. Such payment constitutes full compensation for furnishing, transporting, and installing the pipe including excavation, shoring, backfill, bedding, thrust blocks, and all fittings, appurtenances, and other items necessary and incidental to the completion of the work. Payment for appurtenances listed separately in the bid schedule is made at the contract prices for those items.

Method 2—For items of work for which specific unit prices are established in the contract, the quantity of each kind, size, and class of pipe is determined as the sum of the nominal laying lengths of the sections used. Payment for each kind, size, and class of pipe is made at the contract unit price for the kind, size,

and class. Such payment constitutes full compensation for furnishing, transporting, and installing the pipe including excavation, shoring, backfill, bedding, thrust blocks, and all fittings, appurtenances, and other items necessary and incidental to the completion of the work. Payment for appurtenances listed separately in the bid schedule is made at the contract prices for those items.

Method 3—For items of work for which specific unit prices are established in the contract, the quantity of each kind, size, and class of pipe is determined to the nearest foot by measurement of the laid length along the crown centerline of the conduit. Payment for each kind, size, and class of pipe is made at the contract unit price for the kind, size, and class. Such payment constitutes full compensation for furnishing, transporting, and installing the pipe including shoring, all fittings, thrust blocks, appurtenances, and other items necessary and incidental to the completion of the work. Payment for appurtenances listed separately in the bid schedule is made at the contract prices for those items.

Method 4—For items of work for which specific unit prices are established in the contract, the quantity of each kind, size, and class of pipe is determined as the sum of the nominal laying lengths of the pipe sections used. Payment for each kind, size, and class of pipe is made at the contract unit price for that kind, size, and class. Such payment constitutes full compensation for furnishing, transporting, and installing the pipe including shoring, all fittings, thrust blocks, appurtenances, and other items necessary and incidental to the completion of the work. Payment for appurtenances listed separately in the bid schedule is made at the contract prices for those items.

Methods 3 and 4—Excavation, backfill, and bedding is paid separately under their respective bid items.

All measurement and payment methods—Compensation for any items of work described in the contract, but not listed in the bid schedule, is included in the payment for the item of work to which it is made subsidiary. Such items and items to which they are made subsidiary are identified in section 14 of this specification.

14. Items of work and construction details

14. Items of work and construction details

In Section 2, Material, the P.V.C. plastic pipe shall be either AWWA C900, pressure class 200 or ASTM D1785, Schedule 80.

In Section 6, Pipe embedment, earth bedding and pipe encased in drainfill shall apply. In addition to the details stated in Section 6 for bedding of P.V.C. pipe, the bedding shall be as shown on the drawings.

In Section 7, Backfill:

a. Initial backfill of P.V.C. pipe shall be as shown on the drawings and as specified in Section 6, Pipe embedment.

b. Final backfill of P.V.C. pipe shall be as shown on the drawings and as specified in Section 6, Pipe embedment.

c. Compaction of the initial and final backfill shall be as specified in Construction Specification 24 for drainfill and Construction Specification 23 for earth backfill.

In Section 10, Fittings, fittings shall be P.V.C. and shall have a design pressure rating and external load-carrying capacity equal to or exceeding that specified for the pipe to which it is attached. P.V.C. fittings shall be one-piece injection molded or fabricated from P.V.C. pipe and one-piece injection molded P.V.C. fittings. Fittings that are fabricated from one-piece injection molded P.V.C. manufactured for solvent weld construction shall have a maximum 2'-0" stub of spigot or bell, as appropriate, solvent welded in place to permit installation of elastomeric gasket bell and spigot pipe to maintain articulation. The stubs shall be selected to permit the bell to face upstream.

In Section 12, Pressure testing, Method 1 shall apply.

In Section 13, Measurement and payment, Method 3 shall apply.

In Material Specification 547, Section 3, Perforations, item c. shall not apply. Slotted pipe shall be used. Slot dimensions and geometry shall be as shown on the drawings.

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 24, Plastic Pipe, PVC, 6" I.D.

(1) This item shall consist of furnishing and installing the 6-inch diameter slotted and non-perforated P.V.C. along with all necessary fittings, couplings, and all other items and appurtenances necessary and incidental to completion of the work as shown on the drawings.

(2) This item shall consist of all 6" I.D. plastic pipe required for the RCC, foundation trench drain, and the filter diaphragm as shown on the drawings.

(3) The P.V.C. pipe shall have a minimum of 2 feet of cover before traversing wheeled equipment over the pipe.

(4) One-way, backflow prevention, filter check valves such as those manufactured by Jet Filter Systems or other equivalent devices as approved by the Engineer shall be installed in the 6" pipe outlets for the RCC spillway and impact basin at the locations indicated on the drawings. A total of four (4) are required for the impact basin and five (5) are required for the chimney filter outlet in the RCC spillway.

(5) Rodent guards for the RCC drainage system outfall lines shall be as indicated in the construction drawings. A total of fifteen (15) are required.

(6) The items of work subsidiary to this bid item are:

(a) Concrete, Metal Cleanout Covers as specified in Construction Specification 31.

(b) Ductile-Iron Pipe as specified in Construction Specification 53.

(c) Rodent Guards as specified in Construction Specification 81.

(d) Metal Cleanout Covers as specified in Construction Specification 81.

b. Bid Item 25, Plastic Pipe, PVC, 4" I.D.

(1) This item shall consist of furnishing and installing the 4-inch diameter slotted and non-perforated P.V.C. along with all necessary fittings, couplings, and all other items and appurtenances necessary and incidental to completion of the work as shown on the drawings.

(2) This item shall consist of all 4" I.D. plastic pipe required for the impact basin drainage system as shown on the drawings.

(3) The P.V.C. pipe shall have a minimum of 2 feet of cover before traversing wheeled equipment over the pipe.

(4) One-way, backflow prevention, filter check valves such as those manufactured by Jet Filter Systems or other equivalent devices as approved by the Engineer shall be installed in the 4" pipe outlets for the impact basin at the locations indicated on the drawings. A total of four (4) are required.

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Construction Specification 53—Ductile-Iron Pipe

1. Scope
The work consists of furnishing and installing ductile-iron pipe, fittings, and appurtenances as specified in section 9 of this specification and as shown on the drawings.

2. Material
Ductile-iron pipe and fittings shall conform to the requirements of Material Specification 553, Ductile-Iron Pipe. Thickness class of pipe and rated working pressure shall be as specified in section 9 of this specification or as shown on the drawings.

Unless otherwise specified, special fittings and appurtenances shall be the same material as the pipe.

3. Laying and bedding the pipe
Pipe shall be installed to the lines and grades shown on the drawings with bell socket ends aligned upstream unless otherwise specified. The pipe shall be installed in accordance with the manufacturer's recommendations, unless otherwise specified. Two copies of the pipe manufacturer's installation instructions shall be provided to the engineer before any pipe placement. The pipe shall be firmly and uniformly bedded within the trench throughout the entire length of the pipe section to the depth and in the manner specified. Bell holes for flanged, push-on, or mechanical joint pipe shall be provided as necessary to allow space for joint assembly and to permit the pipe barrel to be uniformly supported on the bedding.

4. Joints and connections
Pipe joints shall conform to the details shown on the drawings and shall be sound and watertight at the pressures specified in section 9 of this specification.

5. Handling the pipe
The contractor shall furnish all equipment and facilities needed to handle, store, and place the pipe without damaging the pipe, lining, encasement, or coating. Pipe coating, encasement, or lining that is damaged shall be repaired using methods recommended by the manufacturer unless otherwise specified in section 9 of this specification.

6. Pressure testing
Pressure testing of the conduit, when specified, shall be conducted as follows:

a. Placement of backfill before pressure testing shall be as specified in section 7 of this specification.

b. Before pressure testing, the pipeline shall be flushed and free of all foreign material.

c. The pipeline shall not be pressure tested until concrete for anchor and thrust blocks has attained the minimum specified compressive strength unless other specified methods of thrust restraint are provided.

d. The total conduit or continuous section of conduit to be tested shall be filled with clean water at a rate not to exceed the maximum specified and tested at the pressure(s) specified in section 9 of this specification.

e. The section of conduit being tested shall be allowed to stand full of water for a minimum of 24 hours before the start of pressure and leakage tests. Test pressures shall be held constant for 2 hours. When the amount of water loss exceeds the maximum allowable loss specified in section 9 of this specification, the leak(s) shall be repaired or otherwise corrected and the conduit shall be re-

tested. The testing procedure shall be repeated until the requirements of the specifications are met.

7. Backfill

***Method 1*—**Backfill in accordance with section 9 of this specification shall be accomplished only in sufficient amount to hold the conduit in place during testing, with the following exceptions:

a. Compacted backfill shall be placed to its final depth as shown on the drawings at vertical and horizontal deflection points, road crossings, and thrust blocks. Backfill shall be placed so that conduit and joint displacement does not occur.
b. All joints and connections shall be completely exposed for visual observation during testing, except at locations described in the exception above.

***Method 2*—**Backfill in accordance with section 9 of this specification shall be to the final depth as shown on the drawings for the section of conduit being tested.

***Use with either method*—**The contractor shall be fully responsible for any and all work required to correct any leakage when the leakage test results in water loss that exceeds the amount specified in section 9 of this specification.

8. Measurement and payment

For items of work for which specific unit prices are established in the contract, the quantity of each size, and thickness class of pipe is determined to the nearest foot by measurement of the installed length of pipe along the crown centerline of the conduit. Payment for each size and thickness class of pipe is made at the contract unit price for that size and thickness class of pipe. Such payment constitutes full compensation for furnishing, transporting, handling, and installing the pipe and necessary fittings and appurtenances complete in place.

Compensation for any item of work described in the contract, but not listed, is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 9 of this specification.

9. Items of work and construction details

9. Items of work and construction details

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Subsidiary Item, Ductile-Iron Pipe

(1) This item shall consist of furnishing and installing the ten feet long, 6-inch I.D. ductile iron pipe as the termination joint for the 6-inch I.D. P.V.C. outfall line as described on the drawings.

(2) Separate payment will not be made for this item of work. Compensation for this item will be included in the payment for Plastic Pipe, PVC, 6" I.D.

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Construction Specification 61-—Rock Riprap

1. Scope

The work consists of the construction of rock riprap revetments and blankets, including filter or bedding where specified.

2. Material

Rock riprap must conform to the requirements of Material Specification 523, Rock for Riprap, or if so specified, must be obtained from designated sources. It must be free from dirt, clay, sand, rock fines, and other material not meeting the required gradation limits.

At least 30 days before rock is delivered from other than designated sources, the contractor must designate in writing the source from which rock material will be obtained and provide information satisfactory to the contracting officer that the material meets contract requirements. The contractor must provide the responsible engineer free access to the source for the purpose of obtaining samples for testing. The size and grading of the rock must be as specified in section 8.

Rock from approved sources must be excavated, selected, and processed to meet the specified quality and grading requirements at the time the rock is installed.

Based on a specific gravity of 2.65 (typical of limestone and dolomite) and assuming the individual rock is shaped midway between a sphere and a cube, typical size/weight relationships are:

Sieve size of rock	Approx. weight of rock	Weight of test pile
16 inches	300 pounds	6,000 pounds
11 inches	100 pounds	2,000 pounds
6 inches	15 pounds	300 pounds

When specified in section 8 or when it is necessary to verify the gradation of the rock riprap, a particle size analysis must be performed in accordance with ASTM D5519, Test Method A or B. The analysis must be performed at the work site on a test pile of representative rock. The mass of the test pile must be at least 20 times the mass of the largest rock in the pile. The results of the test are compared to the gradation required for the project. Test pile results that do not meet the construction specifications must be cause for the rock to be rejected. The test pile that meets contract requirements must be left on the job site as a sample for visual comparison. The test pile must be used as part of the last rock riprap to be placed.

Filter or bedding aggregates when required must conform to Material Specification 521, Aggregates for Drainfill and Filters, unless otherwise specified. Geotextiles must conform to Material Specification 592, Geotextile.

3. Subgrade preparation

The subgrade surface on which the rock riprap, filter, bedding, or geotextile is to be placed must be cut or filled and graded to the lines and grades shown on the drawings. When fill to subgrade lines is required, it must consist of approved material and must conform to the requirements of the specified class of earthfill.

Rock riprap, filter, bedding, or geotextile must not be placed until the foundation preparation is completed and the subgrade surface has been inspected and approved.

4. Equipment-placed rock riprap

The rock riprap must be placed by equipment on the surface and to the depth specified. It must be installed to the full course thickness in one operation and in such a manner as to avoid serious displacement of the underlying material. The rock for riprap must be delivered and placed in a manner that ensures the riprap in place is reasonably homogeneous with the larger rocks uniformly distributed and firmly in contact one to another with the smaller rocks and spalls filling the voids between the larger rocks. Some hand placing may be required to provide a neat and uniform surface.

Rock riprap must be placed in a manner to prevent damage to structures. Hand placing is required as necessary to prevent damage to any new and existing structures.

5. Hand placed rock riprap

The rock riprap must be placed by hand on the surface and to the depth specified. It must be securely bedded with the larger rocks firmly in contact one to another without bridging. Spaces between the larger rocks must be filled with smaller rocks and spalls. Smaller rocks must not be grouped as a substitute for larger rock. Flat slab rock must be laid on its vertical edge except where it is laid like paving stone and the thickness of the rock equals the specified depth of the riprap course.

6. Filter or bedding

When the contract specifies filter, bedding, or geotextile beneath the rock riprap, the designated material must be placed on the prepared subgrade surface as specified. Compaction of filter or bedding aggregate is not required, but the surface of such material must be finished reasonably smooth and free of mounds, dips, or windrows.

7. Measurement and payment

Method 1—For items of work for which specific unit prices are established in the contract, the quantity of each type of rock riprap placed within the specified limits is computed to the nearest ton by actual weight. The volume of each type of filter or bedding aggregate is measured within the specified limits and computed to the nearest cubic yard by the method of average cross-sectional end areas. For each load of rock riprap placed as specified, the contractor must furnish to the responsible engineer a statement-of-delivery ticket showing the weight to the nearest 0.1 ton.

Payment is made at the contract unit price for each type of rock riprap, filter, or bedding. Such payment is considered full compensation for completion of the work.

Method 2—For items of work for which specific unit prices are established in the contract, the quantity of each type of rock riprap placed within the specified limits is computed to the nearest 0.1 ton by actual weight. The quantity of each type of filter or bedding aggregate delivered and placed within the specified limits is computed to the nearest 0.1 ton. For each load of rock riprap placed as specified, the contractor must furnish to the engineer a statement-of-delivery ticket showing the weight to the nearest 0.1 ton. For each load of filter or bedding aggregate, the contractor must furnish to the responsible engineer a statement-of-delivery ticket showing the weight to the nearest 0.1 ton.

Payment is made at the contract unit price for each type of rock riprap, filter, or bedding. Such payment is considered full compensation for completion of the work.

Method 3—For items of work for which specific unit prices are established by the contract, the volume of each type of rock riprap and filter or bedding aggregate is measured within the specified limits and computed to the nearest cubic yard by the method of average cross-sectional end areas.

Payment is made at the contract unit price for each type of rock riprap, filter, or bedding. Such payment is considered full compensation for completion of the work.

Method 4—For items of work for which specific unit prices are established by the contract, the volume of

each type of rock riprap, including filter and bedding aggregate, is measured within the specified limits and computed to the nearest cubic yard by the method of average cross-sectional end areas.

Payment is made at the contract unit price for each type of rock riprap, including filter and bedding. Such payment is considered full compensation for completion of the work.

Method 5—For items of work for which specific unit prices are established by the contract, the quantity of each type of rock riprap placed within the specified limits is computed to the nearest ton by actual weight. For each load of rock for riprap placed as specified, the contractor must furnish to the responsible engineer a statement-of-delivery ticket showing the weight to the nearest 0.1 ton.

Payment is made at the contract unit price for each type of rock riprap, and includes compensation for any aggregate or geotextile installed as specified for filter or bedding. Such payment is considered full compensation for completion of the work.

Method 6—For items of work for which specific unit prices are established by the contract, the volume of each type of rock riprap is measured within the specified limits and computed to the nearest cubic yard by the method of average cross-sectional end areas.

Payment is made at the contract unit price for each type of rock riprap and includes compensation for any aggregate or geotextile installed as specified for filter or bedding. Such payment is considered full compensation for completion of the work.

All methods—The following provision applies to all methods of measurement and payment. Compensation for any item of work described in the contract, but not listed in the bid schedule, is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 8.

No separate payment is made for testing the gradation of the test pile. Compensation for testing is included in the appropriate bid item for riprap.

8. Items of work and construction details

8. Items of work and construction details

In Section 7, Measurement and payment, Method 1 shall apply.

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 26, Rock Riprap

(1) This item shall include furnishing and placing the rock riprap required to extend the upstream wave berm; and construct the rock lined outlets below the impact basin and RCC chute spillway, as well as the rock scour pads as shown on the drawings.

(2) Rock for use as riprap shall comply with the requirement of Material Specification 523, Rock Type 1.

(3) The gradation requirements for rock placed at each location are shown on the construction drawings.

(4) Prior to delivery of rock to the construction site, the Contractor shall provide a sample load of rock weighing at least five (5) tons and shall furnish certified test results (or other evidence satisfactory to the Engineer) showing that the rock sample furnished complies with the specified gradation. This rock sample shall be deposited on the construction site at designated location and maintained at this location until rock placement has been completed. This sample shall be used as a frequent reference for judging the gradation of the riprap supplied. Any difference of opinion between the Engineer and the Contractor concerning gradation of the riprap being delivered on the site shall be resolved by dumping and checking the gradation of one random truck load of riprap.

(5) In the event such additional checking procedure becomes necessary, the mechanical equipment, preparation of a sorting site, and labor needed to prove the gradation by weighing shall be provided by the Contractor at no additional cost.

(6) Rock will be subject to additional testing beyond the ASTM's listed in Material Specification 523 when, in judgement of the Engineer, delivered rock has defects that may not have been detected by the specified laboratory tests. These defects may result in accelerated weathering. Any rock delivered that experiences degradation when selected samples are placed in water for a time period of 7 days will be in non-compliance with this specification.

(7) If, at any time, the rock is delivered to the construction site, separation or segregation of the smaller rock fraction from the larger rock fraction has occurred, the rock shall be reworked as necessary to ensure a reasonably uniform distribution of the various sizes prior to placement of the rock. Due care shall be exercised during this rework operation (if required) to prevent inclusion of earth or other undesirable materials in the riprap.

(8) The Contractor shall have various layers in the source rock quarry tested in accordance with ASTM D5240 if the rock quality is in question as determined by the Engineer.

(9) Riprap delivery shall be made only during scheduled working hours, and delivery tickets shall be furnished to the Engineer.

(10) Riprap may be equipment placed. Equipment shall not be allowed on the rock during or after placement.

(11) The items of work subsidiary to this bid item are:

(a) Excavation, Common, Rock Riprap as specified in Construction Specification 21.

(b) Replacing Salvaged Rock Riprap as specified in 8.b, below.

b. Subsidiary Item, Replacing Salvaged Rock Riprap

(1) This item shall consist of salvaging, cleaning, and replacing the upstream wave berm rock removed to install the new principal spillway conduit, as well as any water control features that tie into the embankment that are required as part of Construction Specification 11, Removal of Water.

(2) Salvaged rock shall be pressure washed to remove any sediment and/or debris and stockpiled for re-use.

(3) If separation or segregation of the smaller rock fraction from the larger rock fraction occurs during salvaging, the rock shall be reworked as necessary to insure a reasonably uniform distribution of the various rock sizes prior to placement of the rock. Due care shall be exercised during salvaging operation to prevent the inclusion of earth or other undesirable materials into the rock riprap matrix.

(4) Riprap may be equipment placed. Equipment shall not be allowed on the rock during or after placement.

(5) Separate payment will not be made for this item of work. Compensation for this item will be included in the payment for the bid item for Rock Riprap.

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Construction Specification 71—Water Control Gates

1. Scope
The work consists of furnishing and installing water control gates including gate stems, hoists, lifts, and other appurtenances.

2. Material
The gates furnished shall conform to the requirements of Material Specifications 571, 572, and 573, as appropriate, and as specified in section 8 of this specification and on the drawings. All gates shall be furnished complete with hoisting equipment and other specified appurtenances.

3. Installing gates
The contractor shall install the gates in a manner that prevents leakage around the seats and binding of the gates during normal operation.

Surfaces of metal against which concrete will be placed shall be free from oil, grease, loose mill scale, loose paint, surface rust, and other debris or objectionable coatings.

Anchor bolts, thimbles, and spigot frames shall be secured in true position within the concrete forms and maintained in alignment during concrete placement.

Concrete surfaces against which rubber seals will bear or against which flat frames or plates are to be installed shall be finished to provide a smooth and uniform contact surface.

When a flat frame is installed against concrete, a layer of concrete mortar shall be placed between the gate frame and the concrete.

When a gate is attached to a wall thimble, a mastic or resilient gasket shall be applied between the gate frame and the thimble in accordance with the recommendations of the gate manufacturer.

Wall plates, sills, and pin brackets for radial gates shall be adjusted and fastened by grouting and bolting after the gates have been completely assembled in place.

4. Installing hoists and lifts
Gate stems, stem guides, and gate lifts shall be carefully aligned so that the stem shall be parallel to the guide bars or angles on the gate frame following installation.

5. Radial gate seals
The rubber seals for radial gates shall be installed so that the seals contact the walls or wall plates throughout the entire gate length when the gate is in the closed position.

6. Operational tests
After the gate(s) and hoist(s) (or lifts) have been installed, they shall be cleaned, lubricated, and otherwise serviced by the contractor in accordance with the manufacturer's instructions. The contractor shall test the gate and hoist by operating the system several times throughout its full range of operation. The contractor shall make any changes or adjustments necessary to ensure satisfactory operation of the complete gate system.

7. Measurement and payment

The number of each type, size, and class of gate is counted. Payment for furnishing and installing each type, size, and class of gate shall be made at the contract unit price for that type, size, and class of gate. Such payment constitutes full compensation for all labor, equipment, material, and all other items necessary and incidental to the completion of the work including furnishing and installing anchor bolts and all specified appurtenances and fittings.

Compensation for any item of work described in the contract, but not listed in the bid schedule is included in the payment for the item of work to which it is made subsidiary. Such items and items to which they are made subsidiary are identified in section 8 of this specification.

8. Items of work and construction details

8. Items of work and construction details

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 27, Slide Gate, 18” x 18”

(1) This item shall consist of furnishing and installing the 18” x 18” slide gate on the principal spillway inlet including the wall thimble, gate, stem, stem guides, lift pedestal, hand wheel, wedges, and all associated appurtenances.

(2) The gate shall conform to the requirements of Material Specification 571 for Type MHS-2, and shall be Class 55-20, Square Opening or approved equivalent as recommended by the manufacturer and approved by the Engineer.

(3) Anchor bolts shall be stainless steel.

(4) The gate frame shall be of the flat back or flange back type.

(5) The gate stem shall be the rising type and shall be stainless steel and be of sufficient diameter as recommended by the manufacturer to withstand the thrusts encountered in operation of the specified type and class gate.

(6) Stem guides shall be adequately spaced and of sufficient number as recommended by the manufacturer to properly support the stem during operation of the gate.

(7) The wall bracket shall be as recommended by the manufacturer.

(8) Hoist or lift shall be of the handwheel type as recommended by the manufacturer.

(9) The gate shall be designed to operate satisfactorily at any degree of opening.

(10) The wall thimble shall be of cast iron and shall be Type F, twelve (12) inches in length and shall have a square opening.

(11) All bolts shall be furnished with flat washers and lock washers or with flat washers and double nuts for lock nuts. All washers and nuts shall be of the same materials and have the same coatings as the bolts on which applied.

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Construction Specification 81—Metal Fabrication and Installation

1. Scope
The work consists of furnishing, fabricating, and erecting metalwork, including the metal parts and fasteners of the composite structures.

2. Material
Unless otherwise specified, material shall conform to the requirements of Material Specification 581, Metal. Steel shall be structural quality unless otherwise specified. Castings shall be thoroughly cleaned and subjected to careful inspection before installation. Finished surfaces shall be smooth and true to assure proper fit. Galvanizing shall conform to the requirements of Material Specification 582, Galvanizing.

3. Fabrication
Fabrication of structural steel shall conform to the requirements of Specification for the Design, Fabrication and Erection of Structural Steel for Buildings (Riveted, Bolted and Arc-Welded Construction), American Institute of Steel Construction.

Fabrication of structural aluminum shall conform to the requirements in the Aluminum Design Manual available from The Aluminum Association.

4. Erection
The frame of metal structures shall be installed true and plumb. Temporary bracing shall be placed wherever necessary to resist all loads to which the structure may be subjected, including those applied by the installation and operation of equipment. Such bracing shall be left in place as long as may be necessary for safety.

As erection progresses the work shall be securely bolted up, or welded, to resist all dead load, wind, and erection stresses. The contractor shall furnish such installation assisting bolts, nuts, and washers as may be required.

No riveting or welding shall be performed until the structure is stiffened and properly aligned.

Rivets driven in the field shall be heated and driven with the same care as those driven in the shop.

All field welding shall be performed in conformance to the requirements for shop fabrication except those that expressly apply to shop conditions only.

5. Protective coatings
Items specified to be galvanized shall be completely fabricated for field assembly before the application of the zinc coatings. Galvanized items shall not be cut, welded, or drilled after the zinc coating is applied.

Items specified to be painted shall be painted in conformance to the requirements of Construction Specification 82 for the specified paint systems.

6. Measurement and payment
***Method 1*—**The work is not measured. Payment for metal fabrication and installation is made at the contract lump sum price in the contract. Such payment constitutes full compensation for all labor,

equipment, material, and all other items necessary and incidental to the completion of the work including connectors and appurtenances, such as rivets, bolts, nuts, pins, studs, washers, hangers, and weld metal.

***Method 2*—**The weight of metal installed complete in place shall be determined to the nearest pound. Unless otherwise specified, the weight of metal shall be computed by the method specified in section 3 of the Code of Standard Practice for Steel Buildings and Bridges, American Institute of Steel Construction, except that the following unit weights shall also be used, as appropriate, as the basis of computation:

Material	Unit weight (lb/ft^3)
Aluminum alloy	173
Bronze or copper alloy	536
Iron, malleable	470
Iron, wrought	487

Payment for furnishing, fabricating, and installing metalwork is made at the contract unit price for the specified types of labor, material, equipment, and all other items necessary and incidental to the completion of the work.

***Method 3*—**The work is not measured. Payment for furnishing, fabricating, and installing each item of metalwork is made at the contract price for that item. Such payment constitutes full compensation for all labor, equipment, material, and all other items necessary and incidental to the completion of the work including connectors and appurtenances, such as rivets, bolts, nuts, pins, studs, washers, hangers, and weld metal.

***All methods*—**The following provisions apply to all methods of measurement and payment. Compensation for any item of work described in the contract, but not listed in the bid schedule, is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 7 of this specification.

7. Items of work and construction details

7. Items of work and construction details

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 28, Principal Spillway Metal Work

(1) This item shall consist of furnishing, fabricating, and installing all metal works for the new principal spillway system. These items shall include the trash rack, manhole ring, and manhole cover.

(2) In Section 6, Measurement and payment, Method 3 shall apply.

(3) All metal parts, with the exception of the manhole frame and cover, as well as any stainless steel hardware, shall be galvanized after fabrication.

b. Subsidiary Item, Rodent Guards

(1) This item shall consist of furnishing, fabricating, galvanizing, and installing the rodent guards of the specified type and specified number for the designated RCC drain outlets and foundation trench drain outlet as shown on the drawings.

(2) Separate payment will not be made for this item of work. Compensation for this item will be included in the payment for the bid item for Plastic Pipe, PVC 6" I.D.

c. Subsidiary Item, Metal Cleanout Covers

(1) This item shall consist of furnishing, fabricating, galvanizing, and installing the metal cleanout covers of the specified type and locations as shown on the drawings.

(2) Separate payment will not be made for this item of work. Compensation for this item will be included in the payment for the bid item for Plastic Pipe, PVC 6" I.D.

d. Subsidiary Item, Posts, Mounting Brackets, and Anchor Plates

(1) This item shall consist of furnishing, fabricating, galvanizing, and installing the posts and mounting brackets for the RCC chute spillway chain link fence and the posts and anchor plates for the impact basin chain link fence as shown in the drawings.

(2) Separate payment will not be made for this item of work. Compensation for this item will be included in the payment for the bid item for Chain Link Fence.

e. Subsidiary Item, Stiles

(1) This item shall consist of furnishing, fabricating, galvanizing, and installing the fence stiles as shown on the drawings.

(2) Separate payment will not be made for this item of work. Compensation for this item will be included in the payment for the bid item for Fence, Barbed Wire.

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Construction Specification 82—Painting Metalwork

1. Scope

The work consists of cleaning metal surfaces and applying paints and protective coatings.

2. Paint

For the purpose of this specification, paints and coatings shall be designated by types as defined below.

Materials for systems requiring two or more coats shall be supplied by the same manufacturer.

Unless otherwise specified and before application, the contractor shall furnish in writing to the engineer for approval a plan outlining procedures proposed for painting metalwork and a list of material including name of manufacturer, pertinent product identification names and numbers, and product data sheets. Data shall reflect the requirements set forth in this section.

Type 1 - Alkyd primer. Alkyd based, rust inhibitive primer shall be lead and chromate free. Primer shall have a minimum of 54 percent solids, by volume. Color availability shall be red, gray, and white. Primer shall be able to be applied satisfactory at 2 to 3 mils dry-film thickness in one coat.

Type 2 - Alkyd enamel (gloss). Alkyd based enamel shall be lead free. It shall have a minimum of 49 percent solids, by volume. Alkyd enamel shall be able to be applied satisfactory at 2 to 3 mils dry-film thickness in one coat. Finish shall be gloss.

Type 3 - Alkyd enamel (semigloss). Alkyd based enamel shall be lead free. It shall have a minimum of 55 percent solids, by volume. Alkyd enamel shall be able to be applied satisfactory at 2 to 3 mils dry-film thickness in one coat. Finish shall be semigloss.

Type 4 - Epoxy polyamide primer. Epoxy polyamide primer shall be lead and chromate free. It shall have a minimum of 56 percent solids, by volume. Epoxy primer shall be able to be applied satisfactory at 4 to 6 mils dry-film thickness in one coat. Color availability shall be red, gray, and white. Epoxy primer shall conform to AWWA Standard C 210 and AWWA Standard D 102.

Type 5 - Epoxy polyamide (intermediate or finish). Epoxy polyamide shall be lead free. It shall have a minimum of 56 percent solids, by volume. Epoxy polyamide shall be able to be applied satisfactory at 4 to 6 mils dry-film thickness in one coat. Finish shall be semigloss. Epoxy finish shall conform to AWWA C 210 and AWWA D 102.

Type 6 - Acrylic polyurethane (gloss). Acrylic polyurethane shall be lead free. It shall have a minimum of 74 percent solids, by volume. Polyurethane shall be able to be applied satisfactory at 3 to 5 mils dry-film thickness in one coat. Finish shall be gloss.

Type 7 - Acrylic polyurethane (semigloss). Acrylic polyurethane shall be lead free. It shall have a minimum of 58 percent solids, by volume. Polyurethane shall be able to be applied satisfactory at 3 to 5 mils dry-film thickness in one coat. Finish shall be semigloss.

Type 8 - Vinyl acid wash treatment. Pretreatment primer for galvanized and nonferrous metal. Pretreatment primer shall have a minimum of 8 percent solids, by volume. The applied dry-film thickness of pretreatment primer shall not exceed 0.5 mil. Steel primed with pretreatment primer shall be topcoated within 6 to 8 hours in humid conditions.

T***ype 9 - Single package moisture cured urethane primer.*** Urethane primer shall have a minimum of 50 percent solids, by volume. Primer shall be able to be applied satisfactory at 2 to 3 mils dry-film thickness in one coat. Color shall be metallic aluminum.

Type 10 - Coal tar epoxy. Coal tar epoxy shall have a minimum of 75 percent solids, by volume, and conform to the requirements of NRCS Material Specification 583 Coal Tar Epoxy Paint (Steel Structures Paint Council PS No. 16, Type I). Coal tar epoxy shall be able to be applied satisfactory at 8 to 15 mils dry-film thickness in one coat.

3. Tinting

Tinting shall not be performed in the field unless otherwise specified.

4. Surface preparation

Surfaces to be painted shall be thoroughly cleaned before the application of paint or coatings. Surface preparations required by this specification are as designated by SSPC (Steel Structures Painting Council) and are summarized by the methods listed in this section.

***Method 1*—**Near white blast (SSPC-SP10). All surfaces to be coated shall be prepared by removing all grease and oil using steam cleaning or solvent cleaning methods per method 5. After degreasing is completed, sand or grit blasting shall be performed to remove all dirt, rust, mill scale, and other foreign material or residue. The cleaned, finished surface shall be a minimum of 95 percent free of all visible foreign material or residue.

***Method 2*—**Commercial blast (SSPC-SP6). All surfaces to be coated shall be prepared by removing all grease and oil using steam cleaning or solvent cleaning methods per method 5. After degreasing is completed, sand or grit blasting shall be performed to remove all dirt, rust, mill scale, or other foreign material or residue. The cleaned, finished surface shall be a minimum of 67 percent free of all visible foreign material or residue.

***Method 3*—**Brush-off blast cleaning (SSPC-SP7). All surfaces to be coated shall be prepared by removing all grease and oil using steam cleaning or solvent cleaning methods per method 5. After degreasing is completed, sand or grit blasting shall be performed to remove dirt, rust, mill scale, or other foreign material or residue. Mill scale, rust, and paint are considered tightly adherent if they cannot be removed by lifting with a dull putty knife.

***Method 4*—**Hand tool cleaning (SSPC-SP2). All surfaces to be coated shall be prepared by removing all oil or grease using steam cleaning or solvent cleaning methods per method 5. After degreasing is completed, nonpower handtools shall be used to remove loose, detrimental foreign material. Adherent mill scale, rust, and paint need not be removed.

***Method 5*—**Solvent cleaning (SSPC-SP1). Surfaces to be coated shall be prepared by removing all visible oil, grease, soil, drawing and cutting compounds, and other soluble contaminants from surfaces with solvents or commercial cleaners using various methods of cleaning, such as wiping, dipping, steam cleaning, or vapor degreasing.

5. Paint systems

For the purposes of this specification, systems of painting and coating metalwork are designated as defined in this section.

***Paint system A*—**Consists of the application of one primer coat of type 1 and two or more coats of type 2 (gloss) or type 3 (semigloss) to provide a minimum dry-film thickness of 6 mils.

***Paint system B*—**Consists of the application of one primer coat of type 9 and two or more coats of type 2 (gloss) or type 3 (semigloss) to provide a minimum dry-film thickness of 6 mils.

***Paint system C*—**Consists of the application of one coat of type 4 and one or more coats of type 5 to provide a minimum dry-film thickness of 8 mils.

***Paint system D*—**Consists of the application of one coat of type 4 primer, one coat of type 5, and one coat of type 6 (gloss) or type 7 (semigloss) to provide a minimum dry-film thickness of 11 mils.

***Paint system E*—**Consists of the application of one coat of type 9 and one coat of type 6 (gloss) or type 7 (semigloss) to provide a minimum dry-film thickness of 5 mils.

***Paint system F*—**Consists of the application of two coats of type 10 at a dry-film thickness of 8 mils. per coat. Total system shall provide a minimum dry-film thickness of 16 mils.

***Paint system G*—**Consists of the application of two coats of type 4 and two coats of type 9 paint. Total system shall provide a minimum dry-film thickness of 14 mils.

6. Application of paint

Surfaces shall be painted immediately after preparation or within the same day as prepared with a minimum of one coat of the primer type specified. Remaining surfaces not required to be painted shall be protected against contamination and damage during the cleaning and painting operation.

Paints shall be thoroughly mixed immediately before application.

After erection or installation of the metalwork, all damage to shop-applied coating shall be repaired and all bolts, nuts, welds, and field rivet heads shall be cleaned and painted with one coat of the specified priming paint.

Initial priming coats shall be applied by brush except on surfaces accessible only to spray equipment. All other coats may be applied by brush or spray. Each coat shall be applied in such a manner to produce a paint film of uniform thickness with a rate of coverage within the guidelines and limits recommended by the paint manufacturer and as outlined in section 2 of this specification.

The drying time between coats shall be as prescribed by the paint manufacturer, but not less than that required for the paint film to thoroughly dry. The elapsed time between coats in paint system F shall not exceed 24 hours. If for any reason the critical recoat time is exceeded, the coated surface shall be treated with the manufacturer's recommended tackifier solvent or brush blasted to roughen the surface.

The finished surface of each coat shall be free from runs, drops, ridges, laps, or excessive brushmarks and shall present no variation in color, texture, and finish. The surface of each dried coat shall be cleaned as necessary before application of the next coat.

7. Atmospheric conditions

Paint application shall not be performed when the temperature of the item to be painted or the surrounding air is less than 50 degrees Fahrenheit. Painting shall be performed only when the humidity and temperature of the surrounding air and the temperature of the metal surfaces are such that evaporation rather than condensation results during the time required for application and drying. The surface shall be dry and a minimum of 5 degrees Fahrenheit above the dew point. Surfaces protected from adverse atmospheric conditions by special cover, heating, or ventilation shall remain so protected until the paint is thoroughly dry.

8. Tests

Dry-film thickness on ferrous metal shall be determined by the use of a nondestructive magnetic instrument, such as an Elcometer or Mikrotest gauge. Instruments shall have been calibrated within 1 month before use. Film thickness on nonferrous metal shall be determined with film gauges during the application process. Systems with film thickness less than specified shall be brought into conformance by the application of one or more additional coats of the specified material.

9. Payment

For items of work for which lump sum prices are established in the contract, payment is made as the work proceeds, but after presentation of invoices by the contractor supporting actual related costs and evidence of the charges of suppliers, subcontractors, and others for supplies furnished and work completed. If the total of such payments is less than the lump sum contract price for this item, the unpaid balance is included in the next appropriate contract payment. Payment of the lump sum contract price constitutes full compensation for completion of the work.

Compensation for any item of work described in the contract, but not listed in the bid schedule, is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 10 of this specification.

10. Items of work and construction details

10. Items of work and construction details

In Section 2, Paint**,** Type 4, and Type 5 shall apply.

In Section 4, Surface preparation**,** Method 1 shall apply.

In Section 5, Paint systems**,** Paint system C shall apply.

Items of work to be performed in conformance with this specification and the construction detail therefore are:

a. Subsidiary Item, Painting Metalwork

(1) This item shall consist of all operations necessary to perform the work described in Section 1 of this specification and shall apply to the chain link fence post and bracket/anchor plate assemblies after galvanization.

(2) The final color shall be black.

(3) All paint and coating specification information shall be provided to the Contracting Officer for future reference.

(4) Separate payment will not be made for this item of work. Compensation for this item will be included in the payment for the bid item for Chain Link Fence.

Construction Specification 91—Chain Link Fence

1. Scope
The work consists of furnishing and installing chain link fencing complete with all posts, braces, gates, and all other appurtenances.

2. Material
The material for the chain link fence must be as follows:

Galvanized
Chain link fence fabric must conform to the requirements of ASTM A392, 2-inch mesh and 9-gauge galvanized steel wire. Zinc coating must be class 2.

Posts and fence framework must conform to the requirements of ASTM F1043 Group 1A, for Heavy Industrial Fence. Coatings must be a type A galvanized coating for internal and external surfaces. Steel pipe posts must conform to the requirements of ASTM F1043 and F1083.

Fence fittings must conform to the requirements of ASTM F626. Fittings must be galvanized steel. Wire ties and clips must be 9 gauge.

Gates, gateposts, and gate accessories must conform to the requirements of ASTM F900. Coating must be the same as selected for adjoining fence and framework.

Barbed wire must be 12.5 gauge and must conform to the requirements of ASTM A121, chain link fence grade.

Galvanized and PVC coated
Chain link fence fabric must conform to the requirements of ASTM F668 for class 2a or 2b, 2-inch mesh, and 9-gauge galvanized steel wire. The fabric must have a polymer top coating of the color specified in section 6.

Posts and fence framework must conform to the requirements of ASTM F1043 Group 1A, for Heavy Industrial Fence. Coatings must be a type-A galvanized coating for internal and external surfaces and covered with a polymer top coating of color as specified in section 6.

Fence fittings must conform to the requirements of ASTM F626. Fittings must be galvanized steel with a polymer top coating of color as specified in section 6.

Any damage to the coating must be repaired in accordance with the manufacturer's recommendations, or the damaged fencing material must be replaced. The contractor must provide the engineer a copy of the manufacturer's recommended repair procedure and materials before correcting damaged coatings.

3. Installing fence posts
Unless otherwise specified, line posts must be placed at intervals of 10 feet measured from center to center of adjacent posts. In determining the post spacing, measurement is made parallel with the ground surface.

Posts must be set in concrete backfill in the manner shown on the drawings.

Posts set in the tops of concrete walls must be grouted into preformed holes to a depth of 12 inches.

Posts may be attached to base plates that are bolted to the concrete. Bolts must be epoxied into drilled holes to a depth recommended by the bracket manufacturer. Alternatively, the base plates may have a stem that is epoxied into a hole in the concrete or a saddle that is bolted with a minimum of two bolts that pass from side to side through the wall. Bolts must be stainless steel with stainless steel lock washers and nuts.

All corner posts, end posts, gateposts, and pull posts must be embedded, braced, and trussed as shown on the drawings or in accordance with appropriate industry practice if not otherwise shown or specified.

4. Installing wire fabric

Fencing fabric must not be stretched until at least 4 days after the posts are grouted into walls or 7 days after the posts are set in the concrete backfill.

Fencing fabric must be installed on the side of the posts designated on the drawings.

The fabric must be stretched taut and securely fastened by means of tie clips to the posts at intervals not exceeding 15 inches and to the top rails or tension wires at intervals not exceeding 2 feet. Care must be taken to equalize the fabric tension on each side of each post.

Barbed wire must be installed as shown on the drawings and must be pulled taut and fastened to each post or arm with the tie wires or metal tie clips.

5. Measurement and payment

***Method 1*—**The length of fence is measured to the nearest 0.1 foot along the fence, including gates. Payment is made at the contract unit price for the specified height of fence. Such payment constitutes full compensation for all labor, material, equipment, and all other items necessary and incidental to the completion of the work.

***Method 2*—**The length of fence is measured to the nearest 0.1 foot along the fence, excluding gate openings. Payment is made at the contract unit price for the specified height of fence. The number of each size and type of gate installed is determined. Payment is made at the contract unit price for that type and size of gate. Such payment constitutes full compensation for all labor, material, equipment, and all other items necessary and incidental to the completion of the work.

***All methods*—**The following provisions apply to all methods of measurement and payment. Compensation for any item of work described in the contract, but not listed in the bid schedule, is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 6 of this specification.

6. Items of work and construction details

6. Items of work and construction details

In Section 2, Material, Galvanized and PVC coated shall apply with the exception of the fence post and bracket/anchor plate assemblies. All fence posts shall be welded to their appropriate mounting bracket or anchor plate and then hot dipped galvanized. Following the hot dipped galvanization, each post and bracket/anchor plate assembly shall be painted in a color that matches the PVC coating in accordance with Construction Specification 82. The PVC coating shall be black.

In Section 5, Measurement and Payment, Method 1 shall apply.

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 29, Chain Link Fence

(1) This item shall consist of furnishing all materials required and all work necessary for installation of the chain link safety fence on top of the impact basin and RCC chute spillway as shown on the drawings.

(2) Items of work subsidiary to this bid item are:

(a) Posts, Mounting Brackets, and Anchor Plates as specified in Construction Specification 81.

(b) Painting Metalwork as specified in Construction Specification 82.

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Construction Specification 92—Field Fence

1. Scope
The work shall consist of furnishing and installing field fence, including gates and fittings.

2. Material
Material for field fence shall conform to the requirements of Material Specification 591. All wooden posts shall be of the same species, when available.

Unless otherwise specified, surfacing, cutting, and boring of preservative treated wooden posts and braces shall be completed before treatment. If field cutting or field repair of treated material is approved, all cuts and abrasions shall be carefully trimmed and coated with copper naphthenate preservative containing a minimum of 2.0 percent copper metal. The treatment preservative shall be applied according to the product label. Any excess preservative not absorbed by the wood member shall be cleaned from the surface prior to the use of the member. Bored holes for connectors or bolts may be treated by pumping coal-tar roofing cement meeting ASTM D5643 into the holes using a caulk gun or similar device. After assembly, any unfilled holes shall be plugged with tightly fitting wooden plugs that have been treated with preservative as specified.

3. Setting posts
Concrete or wood posts shall be set in holes and backfilled with earth except where otherwise specified. Wood posts may be driven when approved by the engineer. Steel posts shall be driven unless otherwise specified.

Holes for installing fence posts shall be at least 6 inches larger than the diameter or side dimension of the posts.

Earth backfill around posts shall be thoroughly tamped in layers not thicker than 4 inches and shall completely fill the posthole up to the ground surface. Concrete backfill around posts shall be rodded into place in layers not thicker than 12 inches and shall completely fill the posthole to the surface of the ground. Backfill, either earth or concrete, shall be crowned-up around posts at the ground surface.

No stress shall be applied to posts set in concrete for a period of not less than 24 hours following the development of a firm set of the concrete.

4. Corner assembly
Unless otherwise specified in section 11, corner assemblies shall be installed at all points where the fence alignment changes 15 degrees or more.

5. End panels
End panels shall be built at gates and fence ends.

6. Pull post assembly
Pull post assembly (bracing within a section of straight fence) shall be installed at the following locations:

a. In straight fence sections, at intervals not to exceed 660 feet.

b. At any point where the vertical angle described by two adjacent reaches of wire is upward and exceeds 10 degrees (except as provided in section 11 of this specification).

c. At the beginning and end of each curved fence section.

7. Attaching fencing to posts
The fencing shall be stretched and attached to posts as follows:

a. The fencing wire or netting shall be placed on the side of the post opposite the area being protected except for installation along curved sections.

b. The fencing wire or netting shall be placed on the outside for installation along curved sections.

c. The fencing wire or netting shall be fastened to each end post, corner post, and pull post by wrapping each horizontal strand around the post and tying it back on itself with not less than three tightly wound wraps.

d. The fencing wire or netting shall be fastened to wooden line posts by means of steel staples. Woven-wire fencing shall be attached at alternate horizontal strands. Each strand of barbed wire shall be attached to each post. Steel staples shall be driven diagonally with the grain of wood and at a slight downward angle and shall not be driven so tightly as to bind the wire against the post.

e. The fencing wire or netting shall be fastened to steel or concrete line posts with either two turns of 14 gauge galvanized steel or iron wire or in accordance with recommendations provided by the post's manufacturer.

f. Wire shall be spliced by means of a Western Union splice or by suitable splice sleeves applied with a tool designed for that purpose. The Western Union splice shall have no less than eight wraps of each end about the other. All wraps shall be tightly wound and closely spaced. Splices made with splice sleeves shall have a tensile strength no less than 80 percent of the strength of the wire being spliced.

8. Stays

Stays shall be attached to the fencing at the spacing outlined in section 11 or as shown on the drawings to ensure maintenance of the proper spacing of the fence wire strands.

9. Crossings at depressions and watercourses

Where fencing is installed parallel to the ground surface, the line posts subject to upward pull shall be anchored.

a. If the fence wire or netting is installed parallel to the ground surface, the line posts subject to uplift shall be anchored by means of extra embedment or by special anchors as detailed on the drawings.

b. If the fence wire is installed with the top wire straight and parallel to the ground surface on either side of the depression, extra length posts shall be used to allow normal post embedment. Unless otherwise specified, excess space between the bottom of the fence and the ground shall be closed with extra strands of barbed wire or with netting.

10. Measurement and payment

Method 1—The length of each type and kind of fence is measured to the nearest foot along the profile of the fence, including gate openings. Payment for each type and kind of fence is made at the contract unit price for that type and kind of fence. Such payment constitutes full compensation for completion of the work, including fabricating and installing gates.

Method 2—The length of each type and kind of fence is measured to the nearest foot along the profile of the fence, excluding gate openings. Payment is made at the contract unit price for the specified height of fence. The number of each size and type of gate installed is determined. Payment is made at the contract unit price for that type and size of gate. Such payment constitutes full compensation for all labor, material, equipment, and all other items necessary and incidental to the completion of the work.

All methods—The following provisions apply to all methods of measurement and payment. Compensation for any item of work described in the contract, but not listed in the bid schedule, is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 11 of this specification.

11. Items of work and construction details

11. Items of work and construction details

In Section 10, Measurement and payment, Method 1 shall apply.

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 30, Fence, Barbed Wire

(1) This item shall consist of furnishing all materials required and constructing fences of the type designated on the drawings.

(2) The approximate location of the fences to be constructed is shown on the construction drawings. The final location of the fences (including corners, gates, pull and brace panels, stiles and special anchorage) shall be as staked by the Engineer.

(3) The items of work subsidiary to this bid item are Stiles as specified in Construction Specification 81.

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Construction Specification 94—Contractor Quality Control

1. Scope

The work consists of developing, implementing, and maintaining a quality control system to ensure that the specified quality is achieved for all materials and work performed.

2. Equipment and materials

Equipment and material used for quality control shall be of the quality and condition required to meet the test specifications cited in the contract. Testing equipment shall be properly adjusted and calibrated at the start of operations and the calibration maintained at the frequency specified. Records of equipment calibration tests shall be available to the engineer at all times. Equipment shall be operated and maintained by qualified operators as prescribed in the manufacturer's operating instructions, the references specified, and as specified in section 10 of this specification. All equipment and materials used in performing quality control testing shall be as prescribed by the test standards referenced in the contract or in section 10.

All equipment and materials shall be handled and operated in a safe and proper manner and shall comply with all applicable regulations pertaining to their use, operation, handling, storage, and transportation.

3. Quality control system

Method 1—The contractor shall develop, implement, and maintain a system of quality control to provide the specified material testing and verification of material quality before use. The system activities shall include procedures to verify adequacy of completed work, initiate corrective action to be taken, and document the final results. The identification of the quality control personnel and their duties and authorities shall be submitted to the contracting officer in writing within 15 calendar days after notice of award.

Method 2—The contractor shall develop, implement, and maintain a system adequate to achieve the specified quality of all work performed, material incorporated, and equipment furnished before use. The system established shall be documented in a written plan developed by the contractor and approved by the contracting officer. The system activities shall include the material testing and inspection needed to verify the adequacy of completed work and procedures to be followed when corrective action is required. Daily records to substantiate the conduct of the system shall be maintained by the contractor. The quality control plan shall cover all aspects of quality control and shall address, as a minimum, all specified testing and inspection requirements. The plan provided shall be consistent with the planned performance in the contractor's approved construction schedule. The plan shall identify the contractor's onsite quality control manager and provide an organizational listing of all quality control personnel and their specific duties. The written plan shall be submitted to the contracting officer within 15 calendar days after notice of award. The contractor shall not proceed with any construction activity that requires inspection until the written plan is approved by the contracting officer.

All methods—The quality control system shall include, but not be limited to, a rigorous examination of construction material, processes, and operation, including testing of material and examination of manufacturer's certifications as required, to verify that work meets contract requirements and is performed in a competent manner.

4. Quality control personnel

Method 1—Quality control activities shall be accomplished by competent personnel. A competent person is: One who is experienced and capable of identifying, evaluating, and documenting that materials and processes being used will result in work that complies with the contract; and, who has authority to take prompt action to remove, replace, or correct such work or products not in compliance. Off-site testing laboratories shall be certified or inspected by a nationally recognized entity. The Contractor shall submit to the Contracting Officer, for approval, laboratory certification or inspection information. The Contractor

shall submit to the Contracting Officer, for approval, the names, qualifications, authorities, certifications, and availability of the competent personnel who will perform the quality control activities.

Method 2—Quality control activities shall be accomplished by competent personnel who are separate and apart from line supervision and who report directly to management. A competent person is one who is experienced and capable of identifying, evaluating, and documenting that material and processes being used will result in work that complies with the contract, and who has authorization to take prompt action to remove, replace, or correct such work or products not in compliance. Offsite testing laboratories shall be certified or inspected by a nationally recognized entity. The Contractor shall submit to the Contracting Officer, for approval, laboratory certification or inspection information. The contractor shall submit to the contracting officer, for approval, the names, qualifications, authorities, certifications, and availability of the competent personnel who will perform the quality control activities.

5. Post-award conference

The contractor shall meet with the contracting officer before any work begins and discuss the contractor's quality control system. The contracting officer and the contractor shall develop a mutual understanding regarding the quality control system, including procedures for correcting quality control issues.

6. Records

The contractor's quality control records shall document both acceptable and deficient features of the work and corrective actions taken. All records shall be on forms approved by the contracting officer, be legible, and be dated and signed by the competent person creating the record.

Unless otherwise specified in section 10 of this specification, records shall include:

a. Documentation of shop drawings including date submitted to and date approved by the contracting officer, results of examinations, any need for changes or modifications, manufacturer's recommendations and certifications, if any, and signature of the authorized examiner.

b. Documentation of material delivered including quantity, storage location, and results of quality control examinations and tests.

c. Type, number, date, time, and name of individual performing quality control activities.

d. The material or item inspected and tested, the location and extent of such material or item, and a description of conditions observed and test results obtained during the quality control activity.

e. The determination that the material or item met the contract provisions and documentation that the engineer was notified.

f. For deficient work, the nature of the defects, specifications not met, corrective action taken, and results of quality control activities on the corrected material or item.

7. Reporting results

The results of contractor quality control inspections and tests shall be communicated to the engineer immediately upon completion of the inspection or test. Unless otherwise specified in section 10, the original plus one copy of all records, inspections, tests performed, and material testing reports shall be submitted to the engineer within one working day of completion. The original plus one copy of documentation of material delivered shall be submitted to the engineer before the material is used.

8. Access

The contracting officer and the engineer shall be given free access to all testing equipment, facilities, sites, and related records for the duration of the contract.

9. Payment

Method 1—For items of work for which lump sum prices are established in the contract, payment is made as the work proceeds, after presentation by the contractor of invoices showing related costs and evidence of charges by suppliers, subcontractors, and others for furnishing supplies and work performed. If the total of such payments is less than the lump sum contract price for this item, the remaining balance is included in the final contract payment. Payment of the lump sum contract price constitutes full compensation for completion of the work.

Payment is not made under this item for the purchase cost of material and equipment having a residual value.

Method 2—For items of work for which lump sum prices are established in the contract, payment is prorated and paid in equal amounts on each monthly estimate. The number of months used for prorating shall be the number estimated to complete the work. The final month's prorate amount is made with the final payment. Payment as described above constitutes full compensation for completion of the work.

Payment is not made under this item for the purchase cost of material and equipment having a residual value.

All methods—Compensation for any item of work described in the contract, but not listed in the bid schedule, is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 10.

10. Items of work and construction details

10. Items of work and construction details

In Section 3, Quality control system, Method 2 shall apply, except that the written plan shall be submitted to the Contracting Officer within 10 calendar days after notice of award.

In Section 4, Quality control personnel, Method 2 shall apply.

In Section 9, Payment, Method 2 shall apply.

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 31, Contractor Quality Control

(1) This item shall consist of furnishing all equipment, tools, materials, and labor and performing all work to accomplish the work defined in Section 1 of this specification.

(2) The burden of proof that work performed meets contract requirements rests upon the Contractor. Quality assurance inspections and tests by the Government are for the sole benefit of the Contracting Local Organization (CLO). The use of such words as "as approved by the Engineer or Contracting Officer" and words of like import in the specifications or drawings which refer to approval by the Contracting Officer are considered to be a part of the Government's Quality Assurance program and do not relieve the Contractor in any part for the Contractor's Quality Control Responsibilities as specified.

(3) Quality Control is defined as a rigorous examination and inspection of construction materials, processes and operations to verify that the work being performed meets contract requirements and shall be performed by a qualified Inspector employed by or under contract to the Contractor.

(4) The Contractor's quality control system shall be approved and operational before commencement of work. The Contractor’s Quality Control Personnel shall submit to the on-site NRCS Inspector Daily Quality Control Reports, for each day the Contractor is on site performing work.

(5) Quality control tests shall be conducted in accordance with the standard test methods identified in the specifications. The Contractor shall provide all equipment required to perform all quality control tests. Testing equipment shall meet the requirements as specified by ASTM test methods and be properly calibrated and serviced.

(6) All mention of inspection or Inspector in (7) and (8) below is referring to work performed by the Contractor's Quality Control Personnel unless otherwise noted.

(7) The degree of quality control specified shall be defined as:

(a) Periodic review or inspection is defined as the intermittent presence of the Inspector to observe construction operations and/or perform tests and take measurements as needed to determine and document that the work being performed complies with the specifications.

(b) Full-time inspection is defined as the full-time presence of the Inspector to observe one or more construction operations and/or perform tests and take measurements at critical points in various operations to determine and document that the work being performed complies with the

specifications and to be available for consultation in case of emergency or changes in work conditions.

(c) Continuous inspection is defined as the continuous presence of the Inspector to observe one construction operation and/or perform tests and take measurements at critical points in the operation to determine and document that the work being performed complies with the specifications and to be immediately available for consultation in case of emergency or changes in work conditions.

(8) The Contractor's inspection system shall include the following items of work that will require the Contractor's quality control. Any item of work not listed below shall be performed or constructed as shown on the drawings and as specified in the construction and material specifications.

(a) The Contractor's inspection on all items not listed in (b) through (m) below shall consist of periodic review of those items to assure that all contract specifications are being met and that the items are being properly installed or carried out.

(b) Seeding, Sprigging, and Mulching - Quality control shall consist of determining that the vegetative materials supplied comply with the specifications; that the areas to be vegetated are properly prepared, smoothed and graded; and that sprigging is performed as specified. Full-time inspection shall be required.

(c) Excavation - Quality control shall consist of full-time inspection to determine that all excavation is being accomplished as specified and that the specified excavation has removed all required or unsuitable materials and that grades are properly documented. The Inspector shall determine that all materials selected for use in backfill of the specified works are free of undesirable materials and that all materials are placed in the designated waste, stockpile or fill areas.

Earthfill - Quality control shall consist of full-time inspection of earthfill placement. The Inspector shall select materials from the required excavations, stockpiles and/or borrow area(s) to insure the completed earthfills are constructed in accordance with the drawings and specifications. Dispersion testing shall be performed using the NRCS crumb test or other methods approved by the Engineer to ensure highly dispersive materials are not included in the earthfill matrix. Any material that results in a rating greater than two (2) while using the NRCS crumb test or 30 using a double hydrometer shall be considered highly dispersive and routed to the appropriate waste area or buried as indicated in the drawings. Materials that result in a rating of two (2) shall be blended with available non-dispersive materials to form a uniform matrix prior to placement. The Inspector shall route the various materials to the proper zones and determine the suitability of each type of material for a particular zone.

The Inspector shall select and obtain representative samples of the materials and have moisture-density curves made (according to ASTM D698 test procedures) of each Unified Soil Classification material to be placed in the specified earthfills using Class A compaction. Moisture density curves shall be completed as necessary to provide data needed

when earthfill operations begin and may be needed as earthfill progresses to insure correct selection and specified compaction of earthfill materials. A "One-Point Family of Curves Method" (hereafter referred to as the one point method) shall be employed to determine the optimum moisture and maximum density values for all earthfill materials. The procedure for performing the one-point method is as follows: (1) construct a family of curves using compaction test data compiled on soil samples tested in accordance with the procedure set forth in ASTM D698, (2) make a one-point compaction test specimen from soil material representing the earthfill material that is being placed (moisture content shall be on the dry side of optimum), (3) plot the one-point moisture-density values, obtained from the test, on the family of curves, (4) using the curves above and below the plotted point as a guide, draw a new compaction curve through the plotted point, (5) use this curve as the control for the moisture and density of the material being placed. Unless otherwise directed by the Engineer, at least one one-point test shall be conducted for every three in-place moisture density tests that are taken. More frequent tests shall be required if compaction requirements are not being obtained or if compaction requirements are not being met or if earthfills are being placed in critical areas such as conduit and concrete backfills and cutoff backfills.

In the event that compaction correlation or requirements are not being met, continuous inspection shall be required during all earthfill and backfill placement to determine that foundation conditions are satisfactory; that earthfills materials are of the type selected for placement and are free of undesirable materials; that proper compaction and moisture requirements are being maintained; and that hand and mechanical compaction are being accomplished as specified.

(d) Drainfill - Quality control shall consist of full-time inspection of drainfill placement. It shall include testing of the gradation of drainfill material; determining that the material complies with specified qualities and that the specified compaction is accomplished and the grades are properly documented. The Inspector shall have at least one sieve analysis prepared for each type of drainfill placed. These analyses shall be made from materials as delivered to the job site. If changes in gradation of drainfill appear to develop, additional sieve analysis shall be made.

(e) Reinforced Concrete - Quality control shall consist of continuous inspection during the placement of concrete. In addition, the Inspector shall assure that the concrete design mix meets contract requirements and that proper certifications are provided. The Inspector shall inspect all formwork prior to concrete placement to assure integrity of the forms and compliance with design detail with proper documentation. Slump, time of cement induction, and temperature and air content measurements shall be determined on each mixer load of concrete prior to placement to assure compliance with specifications. Three sets of compressive strength cylinders (4 cylinders each) will be taken from each pour. One cylinder from each set shall be tested at 7 days and the other two tested at 28 days. The remaining cylinder shall be tested, if necessary, to verify results of a suspect cylinder. The Inspector shall also assure that the concrete is cured according to specifications, the forms removed as specified and the concrete is repaired and finished as required.

(f) Steel Reinforcement - Quality control shall consist of continuous inspection during steel and concrete placement. The Inspector shall also determine that the steel reinforcement complies with the specified quality and is being placed in accordance with the drawings and specifications with proper documentation. The Inspector shall check to determine that it is adequately secured to prevent its displacement during concrete placement and that it has not been displaced during concrete placement. These inspections shall also take place immediately before and during placement of the concrete.

(g) Roller Compacted Concrete (RCC) – Quality control shall consist of continuous inspection during the installation of the RCC. The Inspector shall ensure that the cement and pozzolan meet temperature and storage requirements. The Inspector shall ensure that the mix produced meets the job mix and proper documentation is furnished. The Inspector shall perform the uniformity tests as specified in Construction Specification 36 and measure and record temperature of RCC. The Inspector shall determine the average maximum density on the test fills and check density on the fill. The Inspector shall also ensure the RCC is cured according to specifications.

(h) Reinforced Concrete Pressure Pipe Spillway Conduits - Quality control shall consist of continuous inspection while the pipe is being installed. The Inspector shall also determine and document that the pipe meets the specified requirements, that the pipe has not been damaged in shipment and delivery, that the pipe is properly bedded and laid at specified grade and alignment and that all joints are fully closed and properly sealed.

(i) PVC Plastic Pipe - Quality control shall consist of continuous inspection during the installation of the PVC plastic pipe. The Inspector shall determine and document that the PVC plastic pipe and fittings comply with the specifications, that the perforations are to the size and orientation specified, that the pipe is installed at the lines and grades shown on the drawings and as specified and that the pipe is properly bedded and carefully backfilled.

(j) Rock Riprap - Quality control shall consist of full-time inspection during the placement of the rock riprap. The Inspector shall also determine that the rock riprap complies with the specified quality and gradation limits; that proper certifications are provided; that the rock is placed as shown on the drawings and as specified and that segregation of particle sizes has not occurred during delivery or placement. At least one onsite gradation test will be made by the Contractor.

(k) Metal Fabrication - Quality control shall consist of periodic inspection during installation of metalwork. The Inspector shall determine and document the fabricated metal work meets material specifications and dimensions, coatings are applied according to specifications and the erected work is to the lines and grades specified.

(l) Geotextile - Quality control shall consist of continuous inspection during the installation of the geotextile. The Inspector shall determine and document that the geotextile complies with the specifications, that the

subgrade has been excavated and smoothed to grade, that the geotextile is installed in accordance with the plans and specifications and that the geotextile is not punctured, damaged or caked with mud during installation.

(m) Conduit Abandonment - Quality control shall consist of continuous inspection during the placement of grout inside the conduit. In addition, the Inspector shall assure that the grout design mix meets contract requirements, that conduit is properly prepared, and that the grout is properly placed to prevent voids or air pockets.

(9) The skills, knowledge, abilities and experience needed by the Contractor's quality control personnel to perform the quality control shall be as follows:

(a) Must have the ability to maintain communications with the landowners, the Contracting Officer and the Contractor.

(b) Knowledge of cut and grade staking and earthwork installations.

(c) Knowledge of soils, including foundation conditions, density and classifications.

(d) Knowledge of sampling of soils and determination of density of in-place soils.

(e) When applicable, must have knowledge of acceptable moisture-density test methods and the ability to satisfactorily perform the tests.

(f) Have the ability to interpret survey notes and to prepare quantity computations.

(g) Have the ability to maintain adequate files and records of construction inspection work.

(h) Have the ability to interpret construction drawings and specifications.

(i) Must have knowledge of tests required for placement of acceptable concrete and the procedures required for satisfactory placement.

(j) Must have knowledge and ability to perform concrete tests that include slump tests, air contents and temperature measurements, and preparation of compressive strength cylinders.

(k) Must have knowledge of steel placement details and the ability to interpret steel requirements from construction drawings.

(l) Must have knowledge of form construction and bracing for construction of concrete structures.

(m) Must have knowledge of the United Soil Classification System and the ability to interpret soil classification requirements from the construction drawings.

(n) Must have knowledge of tests required for placement of acceptable RCC and the procedures required for satisfactory placement.

(o) Concrete Laboratory Testing Technicians – Must have certification from the American Concrete Institute (ACI) for Concrete Laboratory Testing Technician.

(10) Quality control personnel shall also be responsible for maintaining a record of progress with photographs. Construction activities shall be documented with 3 megapixels or greater digital photography in a JPEG file format. Photographs of daily construction work, problems encountered, and unique construction practices shall be taken to insure full coverage of all work performed. The photographs shall be numbered, date and time imprinted and indexed with documentation explaining construction activities shown, and must be submitted with the request for final payment.

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Construction Specification 95—Geotextile

1. Scope
This work consists of furnishing all material, equipment, and labor necessary for the installation of geotextiles.

2. Quality
Geotextiles shall conform to the requirements of Material Specification 592 and this specification.

3. Storage
Before use, the geotextile shall be stored in a clean, dry location out of direct sunlight, not subject to extremes of either hot or cold temperatures, and with the manufacturer's protective cover undisturbed. Receiving, storage, and handling at the job site shall be in accordance with the requirements listed in ASTM D 4873.

4. Surface preparation
The surface on which the geotextile is to be placed shall be graded to the neat lines and grades as shown on the drawings. It shall be reasonably smooth and free of loose rock and clods, holes, depressions, projections, muddy conditions, and standing or flowing water (unless otherwise specified in section 7 of this specification).

5. Placement
Before the geotextile is placed, the soil surface will be reviewed for quality assurance of the design and construction. The geotextile shall be placed on the approved prepared surface at the locations and in accordance with the details shown on the drawings and specified in section 7 of this specification. It shall be unrolled along the placement area and loosely laid, without stretching, in such a manner that it conforms to the surface irregularities when material or gabions are placed on or against it. The geotextile may be folded and overlapped to permit proper placement in designated area(s).

Method 1—The geotextile shall be joined by machine sewing using thread material meeting the chemical requirements for the geotextile fibers or yarn. Thread shall be polypropylene, polyester, or Kevlar™ aramid thread, unless a specific thread type is specified. The thread shall be consist of two parallel stitched rows at a spacing of about 1 inch and shall not cross (except for any required re-stitching). The stitching shall be a lock-type stitch. Each row of stitching shall be located a minimum of 2 inches from the geotextile edge. Unless otherwise specified, the seam tensile strength as measured according to ASTM D4884 shall be a minimum of 90 percent of the geotextile tensile strength in the weakest principal direction as measured according to ASTM D4632.

The geotextile shall be temporarily secured during placement of overlying material to prevent slippage, folding, wrinkling, or other displacement of the geotextile. Unless otherwise specified, methods of securing shall not cause punctures, tears, or other openings to be formed in the geotextile.

Method 2—The geotextile shall be joined by overlapping a minimum of 18 inches (unless otherwise specified) and secured against the underlying foundation material. Securing pins, approved and provided by the geotextile manufacturer, shall be placed along the edge of the panel or roll material to adequately hold it in place during installation. Pins shall be steel or fiberglass formed as a **U**, **L**, or **T** shape or contain "ears" to prevent total penetration through the geotextile. Steel washers shall be provided on all but the U-shaped pins. The upstream or upslope geotextile shall overlap the abutting downslope geotextile. At vertical laps, securing pins shall be inserted through the bottom layers along a line through approximately the mid-point of the overlap. At horizontal laps and across slope labs, securing shall be inserted through the bottom layer only. Securing pins shall be placed along a line about 2 inches in from the edge of the placed geotextile at intervals not to exceed 12 feet unless otherwise specified. Additional pins shall be installed as necessary and where appropriate to prevent any undue slippage or movement of the geotextile. The use of securing pins will be held to the minimum necessary. Pins are to remain in place unless otherwise specified.

Should the geotextile be torn or punctured, or the overlaps or sewn joint disturbed, as evidenced by visible geotextile damage, subgrade pumping, intrusion, or grade distortion, the backfill around the damaged or displaced area shall be

removed and restored to the original approved condition. The repair shall consist of a patch of the same type of geotextile being used and overlaying the existing geotextile. When the geotextile seams are required to be sewn, the overlay patch shall extend a minimum of 1 foot beyond the edge of any damaged area and joined by sewing as required for the original geotextile except that the sewing shall be a minimum of 6 inches from the edge of the damaged geotextile. Geotextile panels joined by overlap shall have the patch extend a minimum of 2 feet from the edge of any damaged area.

Geotextile shall be placed in accordance with the following applicable specification according to the use indicated in section 7:

Slope protection—The geotextile shall not be placed until it can be anchored and protected with the specified covering within 48 hours or protected from exposure to ultraviolet light. In no case shall material be dropped on uncovered geotextile from a height of more than 3 feet.

Subsurface drains—The geotextile shall not be placed until drainfill or other material can be used to provide cover within the same working day. Drainfill material shall be placed in a manner that prevents damage to the geotextile. In no case shall material be dropped on uncovered geotextile from a height of more than 5 feet.

Road stabilization—The geotextile shall be unrolled in a direction parallel to the roadway centerline in a loose manner permitting conformation to the surface irregularities when the roadway fill material is placed on its surface. In no case shall material be dropped on uncovered geotextile from a height of more than 5 feet. Unless otherwise specified, the minimum overlap of geotextile panels joined without sewing shall be 24 inches. The geotextile may be temporarily secured with pins recommended or provided by the manufacturer, but they shall be removed before the permanent covering material is placed.

6. Measurement and payment

Method 1—For items of work for which specific unit prices are established in the contract, the quantity of geotextile for each type placed within the specified limits is determined to the nearest specified unit by measurements of the covered surfaces only, disregarding that required for anchorage, seams, and overlaps. Payment is made at the contract unit price. Such payment constitutes full compensation for the completion of the work.

Method 2—For items of work for which specific unit prices are established in the contract, the quantity of geotextile for each type placed with the specified limits is determined to the nearest specified unit by computing the area of the actual roll size or partial roll size installed. The computed area will include the amount required for overlap, seams, and anchorage as specified. Payment is made at the contract unit price. Such payment constitutes full compensation for the completion of the work.

Method 3—For items of work for which specific lump sum prices are established in the contract, the quantity of geotextile is not measured for payment. Payment for geotextiles is made at the contract lump sum price and constitutes full compensation for the completion of the work.

All methods—The following provisions apply to all methods of measurement and payment. Compensation for any item of work described in the contract, but not listed in the bid schedule, is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 7 of this specification.

7. Items of work and construction details

7. Items of work and construction details

In Section 5, Placement, Method 2 shall apply.

In Section 6, Measurement and payment, Method 1 shall apply. Geotextile shall be measured by the square yard.

Items of work to be performed in conformance with this specification and the construction details therefore are:

a. Bid Item 32, Geotextile

(1) This item shall consist of furnishing and placing the geotextile for the rock riprap located along the upstream wave berm; impact basin; downstream rock lined outlet; rock scour pads; and the RCC chute spillway drainage system as shown on the drawings.

(2) Placing the geotextile for the rock riprap includes all excavation, fill and backfill required for keying geotextile into the slope, as shown on the drawings. The minimum anchorage shall be 18 inches unless otherwise indicated by the manufacturer.

(3) Geotextiles shall be non-woven Class I and meet Material Specification 592.

(4) The geotextile shall be placed and approved by the Engineer immediately prior to the placement of the rock riprap or drainfill.

b. Subsidiary Item, Riser and RCC Sidewall Bearing Pad Geotextile

(1) This item shall consist of furnishing and placing the geotextile below the coarse drainfill required to complete the inlet riser and RCC sidewall foundations as shown in the drawings.

(2) This item shall include the geotextile required to separate the select RCC sidewall select gravel backfill from the fine drainfill of the RCC drainage system.

(3) Separate payment will not be made for this item of work. Compensation for this item will be included in the payment for the bid item for Drainfill.

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Construction Specification 99—Conduit Abandonment

1. Scope

The work consists of furnishing and installing cellular concrete to fill a conduit.

2. Material

Admixtures must conform to the requirements of Material Specification 533, Chemical Admixtures for Concrete. If air-entraining cement is used, any additional air-entraining admixture must be of the same type as that in the cement.

Fly ash must conform to the requirements of Material Specification 532, Supplementary Cementitious Materials, for the specified class.

Foaming agents must conform to the requirements of ASTM C869.

Portland cement must conform to the requirements of Material Specification 531, Portland Cement, for the specified type.

Water reducing and/or retarding admixtures must conform to the requirements of Material Specification 533, Chemical Admixtures for Concrete.

Water used for the job mix must be clean and free from injurious amounts of oil, salt, acid, alkali, organic matter or other deleterious substances. Potable water may be used without testing. Nonpotable water must conform to the requirements of ASTM C1602.

3. Terminology

For the purpose of this specification the following definitions and terms apply:

bulkhead—A form, seal, or other apparatus installed to contain cellular concrete in the abandoned conduit.

cellular concrete—A lightweight concrete having a homogeneous void or cell structure made with a foaming agent, which may contain typical concrete admixtures or supplementary cementitious materials, such as fly ash; synonymous with grout.

cold weather—The condition that exists when the average daily ambient temperature is less than 40 degrees Fahrenheit for 3 consecutive days and the temperature is less than 50 degrees Fahrenheit for more than one-half of any 24-hour period.

engineer—The person responsible to the contracting officer or owner for verifying the technical adequacy of the work.

gauge saver—A device installed between a grout line and a pressure gauge to prevent grout from entering the pressure gauge.

grout line—Equipment through which the cellular concrete is pumped to the point of deployment.

hot weather—Any combination of high temperatures, low relative humidity, high winds, and solar radiation that impairs the quality of freshly mixed or hardened concrete or grout by accelerating the rate of moisture loss and rate of cement hydration, or otherwise causes detrimental results.

inline rotor-stator mixer—A type of high-shear mixer that can be installed in a grout line and used to combine foam or a foaming additive with neat-cement grout.

job mix—A cellular concrete mix that has been designed to comply with this specification and has the engineer's concurrence for its specified use.

neat-cement grout—A mixture of Portland cement and water that may contain admixtures or a supplementary cementitious material such as fly ash.

prefoamed grout—A mixture of Portland cement, water, and a foaming agent that may contain additives or a supplementary cementitious material such as fly ash.

pumped cellular concrete—Cellular concrete sampled at or beyond the point of grout line discharge.

prepumped cellular concrete—Cellular concrete sampled at the mixer before it is pumped through the grout line.

slick line—Tubing that is used to deliver cellular concrete to a point within the abandoned conduit.

4. Submittals

At least 14 days before filling the conduit, furnish the engineer a written plan for the operation. Include evidence satisfactory to the engineer that the cellular concrete will be installed by a contractor having completed a minimum of 10 cellular concrete installations that are similar in nature to that specified.

Include a cellular concrete mix design report with a statement of all materials to be incorporated into the mix, the mix proportions, and evidence that the materials and the mix meet specification requirements. Provide results of ASTM C232 for bleeding, ASTM C495 for compressive strength, and wet density as specified in section 9. Include a detailed description of the mechanisms that will be used for producing and conveying the job mix into the conduit. Address the installation of bulkheads, vents, grout nipples, slick lines, and any other materials and equipment necessary to maintain pressure and flow of the mix. Once approved by the engineer, the statement of materials and proportions will constitute the job mix. Any change to the job mix must be approved by the engineer.

Include any materials and methods proposed to seal holes and separated joints. A description of bonding surface preparation and adhesives must be included.

When applicable, include a plan for confined space entry or permit-required confined space entry, as applicable, as defined in OSHA 1910.

After approval of the plan, it must not change without prior written notice and the engineer's concurrence with the change.

During the grouting operation, the contractor must furnish the engineer a record of the mix ingredients and proportions. Any materials batched offsite shall must include the time of batching and the time the load was discharged.

Report the results of onsite testing to determine that cellular concrete density and temperature comply with specification requirements at the time of determination.

Submit a final written report to the engineer including all test results. Include location, date, and time of sampling and testing with all density values. Described corrective actions including, but not limited to, mix proportion adjustments, adjustments in foam generation, and pumping pressure adjustments. Include the results of oven-dry density and 28-day compressive strength tests made and reported in accordance with ASTM C495.

5. Design of job mix

Proportion the mix according to recommendations of the manufacturer of the foaming admixture.

Use Portland cement and a pozzolan such as fly ash with the amount of pozzolan ranging from 25 to 50 percent of the volume of cementitious materials.

Control the water/cementitious materials ratio so that bleeding does not occur.

The job mix must have a wet density ranging from 40 to 70 pounds per cubic foot.

The job mix 28-day compressive strength must equal or exceed 200 pounds per square inch.

6. Preparing the conduit

Remove all sediment and debris from the conduit, and flush it with water prior to installing the carrier pipe. The quality of the water must be such that no residue remains in the conduit after flushing. Remove all standing water from within the conduit prior to filling with cellular concrete.

Holes in the conduit or separated joints must be sealed unless otherwise specified in section 11.

7. Mixers and mixing

Cellular concrete production must comply with requirements set forth by the manufacturer of the foaming admixture and this specification.

Neat-cement grout to be used in the production of the job mix may be batched and mixed on site or batched and mixed elsewhere and transported to the site. Use a high-speed paddle or high-shear mixer to mix the foaming agent or prefoamed grout with the neat-cement grout. A concrete drum mixer must not be used for adding foam or a foaming agent to the job mix.

If an inline rotor-stator mixer is used for incorporating prefoamed grout into the neat-cement grout, install a point of discharge with a valve just beyond the inline mixer for the purpose of sampling and measuring the prepumped wet density of the job mix.

The prepumped wet density of the job mix must not vary more than 2 pounds per cubic foot throughout the grouting operation.

8. Grouting

Convey and pump the job mix into the conduit within 90 minutes after the introduction of the cement to the mix. The mix shall must be conveyed and pumped as rapidly as practical at pressures at or below the specified maximum.

Pump the job mix with progressive cavity pumps, positive displacement pumps, eccentric screw pumps, eccentric cavity pumps, peristaltic pumps, or other nonpulsing pumps. Piston pumps and other pumps which subject the mix to pulsing pressures shall must not be used.

The pumped wet density must not vary more than 5 pounds per cubic foot and must be maintained, throughout the grouting operation, within 5 pounds per cubic foot of the prepumped density.

Pumping—Pumping pressure must be controlled and provisions made to guard against sudden failure of pump lines, and bulkheads, or and pressure-induced separation of the conduit.

With both vents open, pump the job mix into a grout nipple in the downstream bulkhead. Close the downstream vent when cellular concrete begins flowing from the vent.

Cellular concrete may be conveyed the entire length of the pipe from the bulkhead provided the whole conduit is filled and the pressure at the point of discharge does not exceed the maximum pressure specified in section 11.

Discharge the job mix at multiple points in the abandoned conduit if the job mix cannot be deployed throughout the conduit without exceeding the specified maximum pressure or damaging the bulkheads or conduit. When discharging at multiple points is necessary, begin pumping into the shortest slick line and proceeding to the next shortest slick line, repeating the process to completely fill the abandoned conduit.

Hold period—With all vents, slick lines, and all unconnected grout nipples closed, maintain 2 to 4 pounds per square inch pressure on the closed system for a minimum of 5 minutes. After the hold period, close the connected grout nipple and disconnect the grout line. Leave the bulkheads in place for a minimum period of 24 hours after the hold period or until the job mix is set as determined.

Determining if the job mix has set—Fill a container having a minimum volume of 0.2 cubic foot with cellular concrete discharged from the grout line. Seal the container to prevent drying or evaporation and store it away from sunlight. The mix will have set when it will not flow from the open container.

Cold weather—The job mix must not be conveyed and pumped into the conduit during cold weather unless it is insulated or otherwise prevented from freezing for a period of 24 hours after setting. The temperature of the mix must equal or exceed 40 degrees Fahrenheit at the time of pumping into the conduit.

Hot weather—In hot weather or under conditions contributing to quick stiffening of the mix, the time between the introduction of the water into the mix and pumping must not exceed 45 minutes. The engineer may allow a longer time, provided the setting time of the mix is increased a corresponding amount by the addition of an approved set-retarding admixture. The temperature of mix must not exceed 90 degrees Fahrenheit at the time of pumping into the annular space.

9. Monitoring and testing

Monitor wet density of prepumped and pumped cellular concrete throughout the grouting operation and make adjustments to comply with this specification.

Use a cylindrical container of known weight and volume to monitor the wet density of prepumped and pumped cellular concrete. The container must be at least 0.2 cubic foot in volume and made of nonabsorbent material. Tap the sides of the container by hand or rubber mallet while collecting a representative sample of cellular concrete. Overfill the container and screed excess concrete with a sawing motion using a glass, acrylic, or metal strike-off plate. Clean excess concrete from the container exterior and weigh the sample with a scale accurate to 0.1 pounds. Compute and record the wet density to the nearest 0.5 pound per cubic foot.

Test prepumped wet density at the beginning of cellular concrete production and test pumped wet density prior to connecting the grout line to the grout nipple entering the conduit. Test prepumped and pumped wet density at least every 30 minutes during the grouting operation, when there are visually noticeable changes in the cellular concrete, and after corrective actions to adjust the density.

Test the mix for bleeding according to ASTM C232.

Prepare strength test specimens according to ASTM C495. Obtain six initial strength specimens from the grout line discharge immediately prior to making the first grout nipple connection. Obtain six final strength test specimens immediately prior to making the last grout nipple connection. Test specimens for 28-day compressive strength and oven-dry density according to ASTM C495.

10. Measurement and payment

Payment for conduit abandonment will be made at the contract lump sum price and will constitute full compensation for all labor, equipment, materials, and all other items necessary and incidental to the completion of the work.

Compensation for any item of work described in the contract, but not listed in the bid schedule, is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 11 of this specification.

11. Items of work and construction details

11. Items of work and construction details

In Section 8, Grouting, the maximum grout pressure shall not exceed 4 psi.

Items of work to be performed in conformance with this specification and the construction details are:

a. Bid Item 33, Conduit Abandonment

This item consists of filling the existing principal spillway conduit designated to be abandoned with the job mix as specified in Section 5.

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Part 642 – Specifications

Chapter 3 – National Standard Material Specifications

Material Specification 521—Aggregates for Drainfill and Filters

A. Scope

This specification covers the quality of mineral aggregates for the construction of drainfill and filters.

B. Quality

(1) Drainfill and filter aggregates shall be sand, gravel, or crushed stone or mixtures thereof. Aggregates shall be composed of clean, hard, durable, mineral particles free from organic matter, clay balls, soft particles, or other substances that would interfere with the free-draining properties of the aggregates.
(2) Coarse aggregate may be crushed limestone or other material that has limestone particles included. Aggregates from crushed limestone shall be thoroughly washed and screened to remove limestone dust, limestone fines, and fine soil particles. Limestone shall not be used for fine aggregates except in combination with other material, such that not more than 5 percent of the portion finer than the No. 4 sieve shall be limestone.
(3) Aggregates shall be tested for soundness according to ASTM C88 and shall have a weighted average loss in 5 cycles of not more than 12 percent when sodium sulfate is used or 18 percent when magnesium sulfate is used.

C. Grading

Drainfill and filter aggregates shall conform to the specified grading limits after being placed or after being compacted when compaction is specified. Grading shall be determined by ASTM C136. The percentage of material finer than the No. 200 sieve shall be determined by the method in ASTM C117.

D. Storing and Handling

Drainfill and filter aggregates shall be stored and handled by methods that prevent segregation of particle sizes or contamination by mixing with other material.

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Part 642 – Specifications

Chapter 3 – National Standard Material Specifications

Material Specification 522—Aggregates for Portland Cement Concrete

A. Scope

This specification covers the quality of fine aggregate and coarse aggregate for use in the manufacture of Portland cement concrete.

B. Quality

Aggregate shall conform to the requirements of ASTM C33 for the specified sizes. Aggregates that fail to meet any requirement may be accepted only when either:

(i) The specified alternate conditions of acceptance can be proven before the aggregates are used on the job and within a period such that no work under the contract will be delayed by the requirements of such proof or,

(ii) The specification for concrete expressly contains a provision of special mix requirements to compensate for the effects of the deficiencies.

C. Reactivity with alkalies

(1) The potential reactivity of aggregates with the alkalies in cement shall be evaluated by petrographic examination as per ASTM C295, or by the results of previous tests or service records of concrete made from similar aggregates from the same source. The standards for evaluating potential reactivity shall be as described in ASTM C1778

(2) Aggregates indicated by any of the above to be potentially reactive shall not be used except under one of the following conditions:

(i) Applicable test results of mortar bar tests made according to ASTM Method C 1567 are available which indicate an expansion of less than 0.10 percent at 16 days.

(ii) The concrete mixture complies with the appropriate testing procedures and mitigations measures established in ASTM C1778.

(iii) Concrete made from similar aggregates from the same source has been demonstrated to be sound after 3 years or more of service under conditions of exposure to moisture and weather similar to those anticipated for the concrete under these specifications.

(3) Aggregates indicated to be potentially reactive, but within acceptable limits as determined by mortar bar test results or service records, shall be used only with low alkali cement, containing less than 0.60 percent alkalies expressed as sodium oxide.

D. Sulfur in Aggregate

(1) There is currently not an ASTM standard on the acceptable level of sulfur in concrete aggregate.

(2) To prevent concrete cracking from iron sulfide expansion, perform petrographic testing per ASTM C295 and use the following limits for sulfur (S) in aggregate based on the American Concrete Institute Technical Paper 113-M31 and the Concrete Society BS EN 12620:

(i) When S is less than 0.1 percent, the aggregate is acceptable.

(ii) When S is between 0.1 and 1.0 percent, perform further testing to determine if iron sulfide minerals such as pyrrhotite, gypsum, pyrite, or marcasite are present:

- If the additional testing shows pyrrhotite, gypsum, pyrite, or marcasite are present, reject the aggregate and use an acceptable aggregate.

- If the additional testing shows pyrrhotite, gypsum, pyrite, or marcasite are not present, the aggregate is acceptable.

(iii) Aggregate with S greater than 1 percent is not acceptable.

E. Storing and Handling

Aggregates of each class and size shall be stored and handled by methods that prevent segregation of particles sizes or contamination by intermixing with other material.

Part 642 – Specifications

Chapter 3 – National Standard Material Specifications

Material Specification 523—Rock for Riprap

A. Scope

This specification covers the quality of rock to be used in the construction of rock riprap.

B. Quality

(1) Individual rock fragments must be dense, sound, and free from cracks, seams, and other defects conducive to accelerated weathering. Except as otherwise specified, the rock fragments must be angular to subrounded. The least dimension of an individual rock fragment must be not less than one-third the greatest dimension of the fragment. ASTM D4992 provides guidance on selecting rock from a source.

(2) Except as otherwise provided, the rock must be tested and must have the following properties:

(i) Rock type 1

- Bulk specific gravity (saturated surface-dry basis)—Not less than 2.5 when tested in accordance with ASTM D6473 on samples prepared as described for soundness testing.
- Absorption—Not more than 2 percent when tested in accordance with ASTM D6473 on samples prepared as described for soundness testing.
- Soundness—The weight loss in 5 cycles must not be more than 10 percent when sodium sulfate is used or more than 15 percent when magnesium sulfate is used.

(ii) Rock type 2

- Bulk specific gravity (saturated surface-dry basis)—Not less than 2.5 when tested in accordance with ASTM D6473 on samples prepared as described for soundness testing.
- Absorption—Not more than 2 percent when tested in accordance with ASTM D6473 on samples prepared as described for soundness testing.
- Soundness—The weight loss in 5 cycles must be not more than 20 percent when sodium sulfate is used or more than 25 percent when magnesium sulfate is used.

(iii) Rock type 3

- Bulk specific gravity (saturated surface-dry basis)—Not less than 2.3 when tested in accordance with ASTM D6473 on samples prepared as described for soundness testing.
- Absorption—Not more than 4 percent when tested in accordance with ASTM D6473 on samples prepared as described for soundness testing.
- Soundness—The weight loss in 5 cycles must be not more than 20 percent when sodium sulfate is used or more than 25 percent when magnesium sulfate is used.

C. Methods of Soundness Testing

(1) Rock cube soundness—

(i) The sodium or magnesium sulfate soundness test for all rock types (1, 2, or 3) must be performed on a test sample of 5,000 ± 300 grams of rock fragments, reasonably uniform in size and cubical in shape, and weighing, after sampling, about 100 grams each. They must be obtained from rock samples that are representative of the total rock mass, as noted in ASTM D4992, and that have been sawed into slabs as described in ASTM

D5121. The samples must further be reduced in size by sawing the slabs into cubical blocks. The thickness of the slabs and the size of the sawed fragments must be determined by the size of the available test apparatus and as necessary to provide, after sawing, the approximate 100-gram samples. The cubes must undergo five cycles of soundness testing in accordance with ASTM C88.

(ii) Internal defects may cause some of the cubes to break during the sawing process or during the initial soaking period. Do not test any of the cubes that break during this preparatory process. Such breakage, including an approximation of the percentage of cubes that break, must be noted in the test report.

(iii) After the sample has been dried following completion of the final test cycle and washed to remove the sodium sulfate or magnesium sulfate, the loss of weight must be determined by subtracting from the original weight of the sample the final weight of all fragments that have not broken into three or more fragments.

(iv) The test report must show the percentage loss of the weight and the results of the qualitative examination.

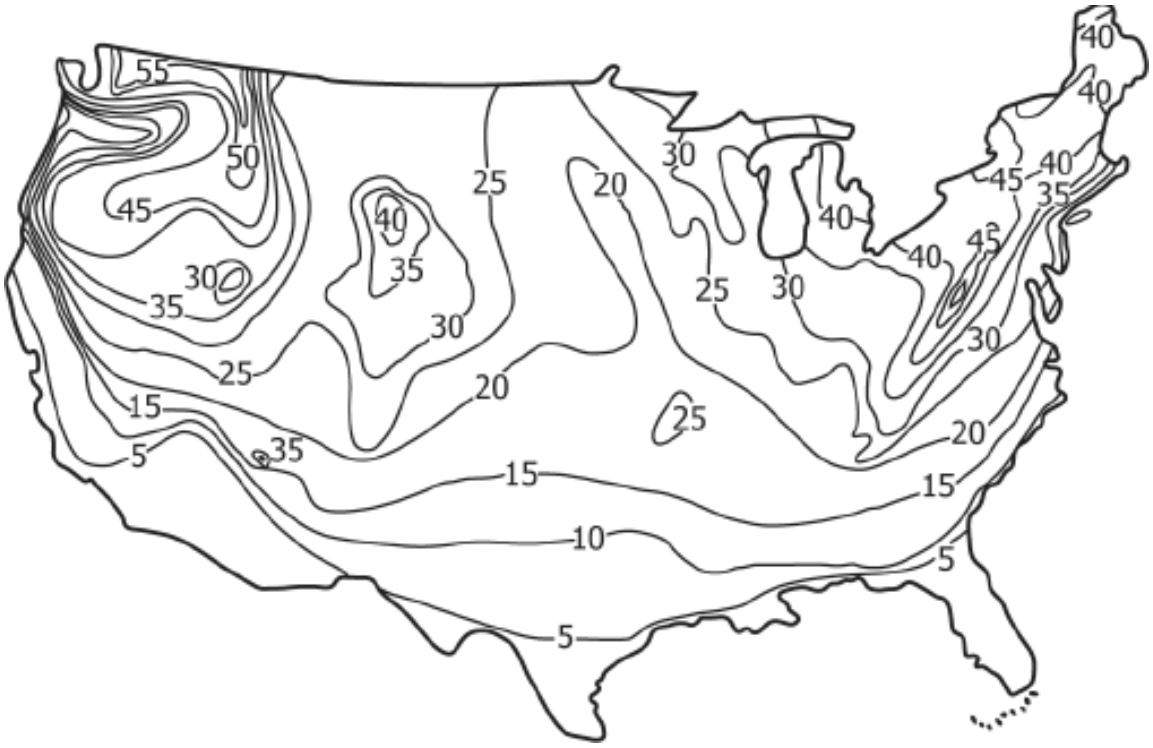
(2) Rock slab soundness—

(i) When specified, the rock must also be tested in accordance with ASTM D5240. Deterioration of more than 25 percent of the number of blocks must be cause for rejection of rock from this source. Rock must also meet the requirements for average percent weight loss stated below.

(ii) For projects located north of the Number 20 Freeze-Thaw Severity Index Isoline (fig. 523–1 below), unless otherwise specified, the average percent weight loss for Rock Type 1 must not exceed 20 percent when sodium sulfate is used or 25 percent when magnesium sulfate is used. For Rock Types 2 and 3, the average percent weight loss must not exceed 25 percent for sodium sulfate soundness or 30 percent for magnesium sulfate soundness.

(iii) For projects located south of the Number 20 Freeze-Thaw Severity Index Isoline, unless otherwise specified, the average percent weight loss for Rock Type 1 must not exceed 30 percent when sodium sulfate is used or 38 percent when magnesium sulfate is used. For Rock Types 2 and 3, the average percent weight loss must not exceed 38 percent for sodium sulfate soundness or 45 percent for magnesium sulfate soundness.

Figure 523–1 Isoline Map of the Freeze-Thaw Severity Index for Contiguous 48 United States (map is from ASTM D5312)



D. Field Durability Inspection

(1) Rock that fails to meet the material requirements stated above (if specified), may be accepted only if similar rock from the same source has been demonstrated to be sound after 5 years or more of service under conditions of weather, wetting and drying, and erosive forces similar to those anticipated for the rock to be installed under this specification.

(2) A rock source may be rejected if the rock from that source deteriorates in less than 5 years under similar use and exposure conditions expected for the rock to be installed under this specification, even though it meets the testing requirements stated above.

(3) Deterioration is defined as the loss of more than one-quarter of the original rock volume, or severe cracking that would cause a block to split. Measurements of deterioration are taken from linear or surface area particle counts to determine the percentage of deteriorated blocks. Deterioration of more than 25 percent of the pieces must be cause for rejection of rock from the source.

E. Grading

The rock must conform to the specified grading limits after it has been placed within the matrix of the rock riprap. Grading tests must be performed, as necessary, according to ASTM D5519, Method A, B, or C, as applicable.

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Part 642 – Specifications

Chapter 3 – National Standard Material Specifications

Material Specification 524—Aggregates for Roller Compacted Concrete

A. Scope

This specification covers the quality of aggregate for use in the manufacture of roller compacted concrete (RCC).

B. Quality

Aggregate shall conform to the quality requirements of ASTM C33.

C. Gradation

(1) Aggregate gradation shall be within the limits provided below for the total aggregate weight in a unit volume of RCC. For the sieve sizes shown below that are larger than #4, no more than 20 percent of the total aggregate shall be retained on an individual sieve. For sieve sizes smaller than 3/8 inch, at least 3 percent of the total aggregate shall be retained on each sieve.

Sieve size	Percent passing
2"	100
1-1/2"	85-100
1"	70-100
3/4"	60-84
1/2"	50-70
3/8"	40-60
#4	32-50
#8	26-42
#16	20-35
#30	14-28
#50	8-22
#100	4-15
#200	0-7

(2) Unless otherwise specified, the fines (material passing the #200 sieve) shall have a plasticity index less than four.

(3) Particle shape—The amount of flat and elongated particles with a length-to-width or width-to-thickness ratio greater than 3:1, as determined by ASTM D4791, shall not exceed 25 percent on any individual sieve size group nor a weighted average of 20 percent for all of the sieve sizes in the total gradation.

D. Reactivity with Alkalies

(1) The potential reactivity of aggregates with the alkalies in cement shall be evaluated by petrographic examination as per ASTM C295, or by the results of previous tests or service records of concrete made from similar aggregates from the same source. The standards for evaluating potential reactivity shall be as described in ASTM C1778

(2) Aggregates indicated by any of the above to be potentially reactive shall not be used except under one of the following conditions:
   (i) Applicable test results of mortar bar tests made according to ASTM Method C 1567 are available which indicate an expansion of less than 0.10 percent at 16 days.
   (ii) The concrete mixture complies with the appropriate testing procedures and mitigations measures established in ASTM C1778.
   (iii) Concrete made from similar aggregates from the same source has been demonstrated to be sound after 3 years or more of service under conditions of exposure to moisture and weather similar to those anticipated for the concrete under these specifications.

(3) Aggregates indicated to be potentially reactive, but within acceptable limits as determined by mortar bar test results or service records, shall be used only with low alkali cement, containing less than 0.60 percent alkalies expressed as sodium oxide.

E. Sulfur in Aggregate

(1) There is currently not an ASTM standard on the acceptable level of sulfur in concrete aggregate.

(2) To prevent concrete cracking from iron sulfide expansion, perform petrographic testing perASTM C295 and use the following limits for sulfur (S) in aggregate based on the American Concrete Institute Technical Paper 113-M31 and the Concrete Society BS EN 12620:
   (i) When S is less than 0.1 percent, the aggregate is acceptable.
   (ii) When S is between 0.1 and 1.0 percent, perform further testing to determine if iron sulfide minerals such as pyrrhotite, gypsum, pyrite, or marcasite are present:
      - If the additional testing shows pyrrhotite, gypsum, pyrite, or marcasite are present, reject the aggregate and use an acceptable aggregate.
      - If the additional testing shows pyrrhotite, gypsum, pyrite, or marcasite are not present, the aggregate is acceptable.
   (iii) Aggregate with S greater than 1 percent is not acceptable.

F. Acceptance

Aggregates that fail to meet any requirement may be accepted only when the specification for RCC expressly contains either:
   (i) special provisions for acceptance that can be proven before the aggregates are used on the job and within a period such that no work under the contract will be delayed by the requirements of such proof; or
   (ii) special provisions for specific mix requirements to compensate for the effects of the deficiencies.

G. Storing and Handling

Aggregates shall be stored in stockpiles at specified storage areas. Separators, such as timbers, boards, or pre-cast concrete panels, shall be used between adjacent stockpiles to prevent the contamination and intermixing of dissimilar materials. The contractor shall be responsible for providing a system that reliably and consistently stockpiles the aggregates and allows the withdrawal of the aggregates from the stockpiles without contamination or segregation. Segregated or contaminated aggregates will not be allowed in production of RCC.

Part 642 – Specifications

Chapter 3 – National Standard Material Specifications

Material Specification 531—Portland Cement

A. Scope

This specification covers the quality of Portland cement.

B. Quality

(1) Portland cement shall conform to the requirements of ASTM C150 for the specific types of cement such as Type I, IA, II, IIA, II(MH), II(MH)A, III, IIIA, IV, and V Portland cement.
(2) Type IS Portland blast-furnace slag cement, Type IP Portland-pozzolan cement, or Type IL Portland-limestone cement shall conform to the requirements of ASTM C595 and may be used unless prohibited by the specifications.
(3) When air-entraining cement is required, the contractor shall furnish the manufacturer's written statement providing the source, amount, and brand name of the air-entraining component.

C. Storage at the Construction Site

Cement shall be stored and always protected from weather, dampness, or other destructive elements. Cement that is partly hydrated or otherwise damaged will not be accepted.

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Part 642 – Specifications

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Material Specification 532—Supplementary Cementitious Materials

A. Scope

This specification covers the quality of supplementary cementitious materials for concrete.

B. Quality

(1) Fly ash used as a partial substitution of Portland cement shall conform to the requirements of ASTM C618, Class C or F except the loss on ignition shall not exceed 3 percent, unless otherwise specified. Lot-to-lot variation in the loss on ignition shall not exceed 1 percent. When specified, fly ash shall conform to one or more of the supplementary optional physical requirements listed in ASTM C618.

(2) Natural pozzolan used as a partial substitution of Portland cement shall conform to the requirements of ASTM C618, Class N including the optional requirements for uniformity and effectiveness in controlling ASR. Class N pozzolan for the use in mitigating Alkali-Silica Reactivity shall have a Calcium Oxide (CaO) content of less than 13 percent and total equivalent alkali content less than 3 percent.

(3) Blast-furnace slag used as a partial substitution of Portland cement shall conform to ASTM C989 for ground granulated blast-furnace slag.

(4) Silica fume used as a partial substitution of Portland Cement shall conform to ASTM C1240.

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Part 642 – Specifications

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Material Specification 533—Chemical Admixtures for Concrete

A. Scope

This specification covers the quality of chemical ad-mixtures for manufacturer of Portland cement concrete.

B. Quality

(1) Air-entraining admixtures shall conform to the requirements of ASTM C260.
(2) Water-reducing and/or retarding admixtures shall conform to the requirements of ASTM C494, Types A, B, D, F, or G.
(3) Plasticizing or plasticizing and retarding admixtures shall conform to ASTM C494, Types F or G.
(4) Accelerating or water-reducing and accelerating ad-mixtures shall be noncorrosive and conform to the requirements of ASTM C494, Types C and E. The manufacturer shall provide long-term test data results from an independent laboratory verifying that the product is noncorrosive when used in concrete exposed to continuously moist conditions.

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Material Specification 534—Concrete Curing Compound

A. Scope

This specification covers the quality of liquid membrane-forming compounds suitable for spraying on concrete surfaces to retard the loss of water during the concrete curing process.

B. Quality

The curing compound must meet the requirements of either ASTM Specification C309 or C1315. If Type 1 is specified, a fugitive dye must be used.

C. Delivery and Storage

All curing compounds must be delivered to the site of the work in the original container bearing the name of the manufacturer and the brand name. The compound must be stored in a manner that prevents damage to the container and protects water-emulsion types from freezing.

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Material Specification 535—Preformed Expansion Joint Filler

A. Scope

This specification covers the quality of preformed expansion joint fillers for concrete.

B. Quality

Preformed expansion joint filler shall conform to the requirements of ASTM D1752, Type I, Type II, Type III, or Type IV unless bituminous type is specified. Bituminous type preformed expansion joint filler shall conform to the requirements of ASTM D994, or ASTM D1751.

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Material Specification 536—Sealing Compound for Joints for Concrete and Concrete Pipe

A. Scope

This specification covers the quality of sealing compound for filling joints in concrete pipe and concrete structures.

B. Type

The compound must be a cold-application material unless otherwise specified.

C. Quality

The sealing compound must conform to the requirements of one of the following specifications:

(i) ASTM C990—Joints for concrete pipe, manholes, and precast box sections using preformed flexible joint sealants.
(ii) ASTM C877—External sealing bands for concrete pipe, manholes, and precast box sections.
(iii) ASTM D6690—Standard specification for joint and crack sealants, hot applied, for concrete and asphalt pavements.
(iv) ASTM C920—Elastomeric joint sealants for cold applied sealing and caulking of joints on mortar and concrete structures not subject to fuel spills. Use Type S or M, or Grade NS for vertical joints; Type S or M, Grade P or NS for horizontal joints. For Class 25, use Type M.
(v) The sealing compound if used with other joint material, such as fillers or gaskets, must be compatible.

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Part 642 – Specifications

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Material Specification 539—Steel Reinforcement (for concrete)

A. Scope

This specification covers the quality of steel reinforcement for reinforced concrete.

B. Quality

(1) All reinforcement shall be free from loose or flaky rust, soil, oil, grease, paint, or other deleterious matter.
(2) Steel bars for concrete reinforcement shall be grade 40, 50, or 60 deformed bars conforming to one of the following specifications:
(i) Deformed and plain billet-steel bars for concrete reinforcement—ASTM A615.
(ii) Rail-steel deformed bars for concrete reinforcement—ASTM A996.
(iii) Axle-steel deformed bars for concrete reinforcement—ASTM A996.
(3) Dowels shall be plain round bars conforming to the same specifications listed above for steel bars.
(4) Fabricated deformed steel bar mats for concrete reinforcement shall conform to the requirements of ASTM A184.
(5) Deformed and plain steel welded wire reinforcement shall conform to the requirements of ASTM A1064.
(6) Epoxy-coated steel bars for concrete reinforcement shall conform to the requirements of ASTM A775.

C. Dimensions of Welded Wire Reinforcement

Gauges, diameters, spacing, and arrangement of wires for welded steel wire fabric shall be as defined for the specified style designations.

D. Storage

Steel reinforcement inventories at the site of the work shall be stored above the ground surface on platforms, skids, or other supports and shall be kept clean and protected from mechanical injury and corrosion.

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Material Specification 541—Reinforced Concrete Pressure Pipe

A. Scope

This specification covers the quality of reinforced concrete pressure pipe and fittings.

B. Manufacture and Fabrication

(1) The pipe, the material used in its manufacture, and the methods of fabrication shall conform to the requirements of the following specifications applicable to the specified type of pipe.
(2) Steel cylinder type, pre-stressed—AWWA Standard C301for Pre-stressed Concrete Pressure Pipe, Steel Cylinder Type, for Water and Other Liquids.
(3) Steel cylinder type, not pre-stressed—AWWA Standard C300 for Reinforced Concrete Pressure Pipe, Steel Cylinder Type, for Water and Other Liquids.
(4) Noncylinder type, not pre-stressed—AWWA Standard C302 for Reinforced Concrete Pressure Pipe, Non-Cylinder Type, for Water and Other Liquids.
(5) Steel cylinder type, pre-tensioned—AWWA Standard C303 for Concrete Pressure Pipe, Bar-Wrapped, Steel Cylinder Type for Water and Other Liquids.
(6) Low head pressure pipe—ASTM C361.
The following specification sections shall not apply:
AWWA C302 and C303, sections 4.2 and 4.3.

C. Design

The actual pipe and fittings shall be designed by the manufacturer to withstand the specified external loads and internal pressures. Designs shall be by Indirect design, Direct design, or Standard design as applicable to the type of pipe specified:

(i) Indirect design—ASTM C497 for Standard Test Method for Concrete Pipe, Manhole Sections, or Tile. Pipe design shall be based on the results of external crushing strength tests on a minimum 2-foot length of pipe or a specimen of equivalent size, design, and material. The test shall demonstrate the following bearing loads:
- For pipe manufactured according to ASTM C361, AWWA C300, or AWWA C302, the load required to produce a 0.01-inch crack 1 foot long.
- For pipe manufactured according to AWWA C301, the load required to produce a 0.001-inch crack 1 foot long or the load 10 percent greater than the specified three-edge bearing strength, whichever occurs first.
- In lieu of actual testing for this contract, pipe design may be based on design curve previously approved and published by the Natural Resources Conservation Service.

(ii) Direct design—AWWA C304 for Design of Pre- Stressed Concrete Cylinder Pipe or AWWA Manual M9 3rd ED for Concrete Pressure Pipe. Pipe design shall be based on structural analysis and design calculations.

(iii) Standard design—ASTM C361 for Reinforced Concrete Low Head Pressure Pipe. Pipe design shall be as published in the standard.

D. Steel Reinforcement

The steel reinforcements shall conform to the requirements of the specifications cited in section B for the specified type of pipe except that elliptical reinforcing cages or other reinforcements that require special orientation of the pipe during placement are not allowed.

E. Joints

(1) The pipe joints shall conform to the requirements of the applicable specification for the pipe. They shall be bell-and-spigot type or double-spigot-and-sleeve type and shall have a positive groove in the spigot to contain the rubber gasket. The size and shape of the groove shall be such that it prevents displacement of the gasket by either internal or external water pressure when the joint is in any position within the required range of movement capability. Joint sleeves, also referred to as collars or coupling bands, shall conform to the requirements for bell rings in the applicable pipe specification.

(2) The joints shall be constructed to permit relative movement of the adjoining pipe sections with no reduction of watertightness. The joint length and the limiting angle defining the required capability of relative movement at each joint shall be no less than specified.

(3) Joint length refers to the permissible axial movement in the joint. It is defined as the maximum distance through which the spigot can move, relative to the bell or sleeve, from the fully engaged to the fully extended condition of the joint when the adjoining pipe sections are in parallel, concentric alignment. The joint is considered to be fully engaged when the spigot is inserted as far as it will go into the bell or sleeve and is fully extended when it is inserted the least amount that will ensure full confinement of the gasket and complete watertightness.

(4) Joint length specified for double-spigot joints refers to the permissible movement in each of the spigot-to-sleeve connections, not the sum of the two.

(5) The limiting angle of the joint is defined as the maximum deflection angle between adjoining pipe sections the joint will permit before the outer surface of the spigot comes into direct contact with inside of the mating bell or sleeve. If both spigot-to-sleeve connections of a double-spigot joint permit angular movement, the limiting angle of the joint is the sum of the two deflection angles permitted by the two connections.

F. Gaskets

The pipe joint gaskets shall conform to the requirements of the specifications cited in section B of this specification. They shall be endless rubber gaskets having circular cross section. The cross-sectional diameter of the gaskets shall conform to the pipe manufacturer's recommendation for the type and size of pipe furnished.

G. Marking

All pipe sections and special fittings shall be marked by the manufacturer with the manufacturer's name or trademark, the date of manufacture, the nominal size, design head, design external load, and the structure site for which it was designed and manufactured.

H. Certification

(1) All component material and actual pipe fabrication shall be tested, inspected, and documented as prescribed in the manufacturing specifications for the type of pipe specified. All documentation as noted in the manufacturing specifications shall be submitted to the engineer. Documentation shall include current test reports on steel

and steel wire reinforcing and compression tests of concrete used in the manufacture of the furnished pipe. Current tests are those that have been conducted within the last year.

(2) For pipe design based on actual external crushing strength tests, the engineer shall witness the actual test.

(3) For pipe design based on published design curves, a copy of the appropriate design curve marked to show the resultant concrete core stress and corresponding three-edge bearing load and a specification sheet showing all data and dimensions necessary to calculate the resultant core stress for the pipe furnished shall be submitted to the engineer.

(4) For pipe design based on structural analysis and calculations, such analysis and calculations shall be submitted to the engineer. Printouts of such calculations by computer programs shall be sufficiently detailed to enable comparison with standardized procedures and methods.

(5) Drawings, details, and descriptions of the pipe joints as necessary to show that the joint conforms to the specified requirements shall also be submitted.

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Material Specification 547—Plastic Pipe

A. Scope

This specification covers the quality of Poly Vinyl Chloride (PVC), Polyethylene (PE), High Density Polyethylene (HDPE), and Acrylonitrile-Butadiene-Styrene (ABS) plastic pipe, fittings, and joint materials.

B. Material

(1) Pipe—The pipe must be as uniform as commercially practicable in color, opaqueness, density, and other specified physical properties. It must be free from visible cracks, holes, foreign inclusions, or other defects. The dimensions of the pipe must be measured as prescribed in ASTM D2122. Unless otherwise specified, the pipe must conform to the requirements listed in this specification and the applicable reference specifications in Figure 547–2, the requirements specified in Construction Specification 45, Plastic Pipe, and the requirements shown on the drawings.

(2) Fittings and joints—Fittings and joints must be of a schedule, SDR or DR, pressure class, external load carrying capacity, or pipe stiffness that equals or exceeds that of the plastic pipe. The dimensions of fittings and joints must be compatible with the pipe and measured in accordance with ASTM D2122. Joint and fitting material must be compatible with the pipe material. The joints and fittings must be as uniform as commercially practicable in color, opaqueness, density, and other specified physical properties. It must be free from visible cracks, holes, foreign inclusions, or other defects. Fittings and joints must conform to the requirements listed in this specification, the requirements of the applicable specification referenced in the ASTM or AWWA specification for the pipe, the requirements specified in Construction Specification 45, and the requirements shown on the drawings.

(3) Solvents—Solvents for solvent-welded pipe joints must be compatible with the plastic pipe used and must conform to the requirements of the applicable specification referenced in the ASTM or AWWA specification for the pipe, fitting, or joint.

(4) Gaskets—Rubber gaskets for pipe joints must conform to the requirements of ASTM F477, Elastomeric Seals (Gaskets) for Jointing Plastic Pipe.

C. Perforations

When perforated pipe is specified, perforations must conform to the following requirements unless otherwise specified in Construction Specification 45 or shown on the drawings:

(1) Perforations must be either circular or slots.

(2) Circular perforations must be 1/4 ± 1/16-inch diameter holes arranged in rows parallel to the axis of the pipe.

(3) Perforations must be evenly spaced along each row such that the center-to-center distance between perforations is not less than eight times the perforation diameter. Perforations may appear at the ends of short and random lengths. The minimum perforation opening per foot of pipe must be as shown in Figure 547–1.

Figure 547-1 Perforations

Nominal pipe size	Minimum number of rows		Minimum opening/foot (in^2)
	circular	slot	
4	2	2	0.22
6	4	2	0.44
8	4	2	0.44
10	4	2	0.44
12	6	2	0.66

(4) Rows must be arranged in two equal groups at equal distance from the bottom on each side of the vertical centerline of the pipe. The lower-most rows of perforations must be separated by an arc of not less than 60 degrees or more than 125 degrees. The uppermost rows of perforations must be separated by an arc not to exceed 166 degrees. The spacing of rows between these limits must be uniform. The minimum number of rows must be as shown in Figure 547–1.

(5) Slot perforations must be symmetrically located in two rows, one on each side of the pipe centerline. Slot perforations must be located within the lower quadrants of the pipe with slots no wider than 1/8 inch and spaced not to exceed 11 times the perforation width. Minimum perforation opening per lineal foot of pipe must be as shown in Figure 547–1.

(6) On both the inside and outside of the pipe, perforations must be free of cuttings or frayed edges and of any material that would reduce the effective opening.

Figure 547-2 Pipe Specifications

Pipe	Specification
Poly vinyl chloride (PVC) pipe	
Plastic pipe - Schedules 40, 80, 120	ASTM D1785 ASTM D2466
Pressure rated pipe - SDR Series	AWWA C900 ASTM D2241
Plastic drain, waste, and vent pipe and fittings	ASTM D2665
Joints for IPS PVC pipe using solvent weld cement	ASTM D2672
Composite sewer pipe	ASTM D2680
Type PSM PVC sewer pipe and fittings	ASTM D3034
Large-diameter gravity sewer pipe and fittings	ASTM F679
Smooth-Wall Underdrain Systems for Highway, Airport, and Similar Drainage	ASTM F758
Profile gravity sewer pipe and fittings based on controlled inside diameter	ASTM F794
Corrugated sewer pipe with a smooth	ASTM F949

Pipe	Specification
interior and fittings	
Pressure pipe, 4-inch through 60-inch for water distribution	AWWA C900
Polyethylene (PE) plastic pipe	
12- to 60-inch annular corrugated profile-wall polyethylene (PE) pipe and fittings	ASTM F2306
SIDR-PR based on controlled inside diameter	ASTM D2239
SDR-PR based on controlled outside diameter	ASTM D3035
High density polyethylene (HDPE) plastic pipe	
Plastic pipe and fittings	ASTM D3350
SDR-PR based on controlled outside diameter	ASTM F714
Heat joining polyolefin pipe and fittings	ASTM D2657
Acrylonitrile-butadiene-styrene (ABS) pipe	
Composite sewer pipe	ASTM D2680

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Material Specification 553—Ductile Iron Pipe

A. Scope

This specification covers the quality of ductile-iron pipe and fittings.

B. Pipe

Ductile-iron pipe shall conform to the requirements of ANSI/AWWA C151/A21.51-02, Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds for Water or Other Liquids, and ANSI/AWWA C115/A21.15-20, Flanged Ductile-Iron Pipe with Threaded Flanges.

C. Fittings

Ductile-iron pipe fittings shall conform to the requirements of ANSI/AWWA C110/A21.10-12, Ductile-Iron and Gray-Iron Fittings, 3-inch through 48-inch, for Water and Other Liquids, and ANSI/AWWA C153/A21.53-19, Ductile-Iron Compact Fittings, 3-inch through 12-inch, for Water and Other Liquids.

D. Joints

Rubber-gasket joints for ductile-iron pipe and fittings where either mechanical or push-on joints are used shall conform to the requirements of ANSI/AWWA C111/A21.11-17, Rubber-Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe and Fittings.

E. Lining

Interior lining for ductile-iron pipe and fittings shall conform to the requirements of ANSI/AWWA C104/A21.4-16, Cement Mortar Lining for Ductile-Iron Pipe and Fittings for Water.

F. Encasement

Encasement for ductile-iron pipe and fittings shall conform to the requirements of ANSI/AWWA C105/A21.5-18, Polyethylene Encasement for Ductile-Iron Pipe for Water and Other Liquids.

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Material Specification 571—Slide Gates

A. Scope

This specification covers the quality of metal slide gates for water control.

B. Class and Type of Gate

The class of gate is expressed as an alpha numerical symbol composed of the seating head (L = Light, M = Moderate, H = Heavy, and unseating head (1,2,3). The two are separated by a hyphen with the seating head listed first. For this purpose, the unseating head must be expressed in terms of feet of water. Gates must be of the specified types as defined:

Light duty	
Type MLS-1	Cast iron with cast iron seat facings.
Type MLS-2	Fabricated metal.
Moderate duty	
Type MMS-1	Cast iron with bronze seat facings, cast iron or galvanized structural steel guides, and galvanized steel, bronze, or stainless steel fasteners.
Type MMS-2	Cast iron with bronze seat facings, cost iron or stainless steel guides, and bronze or stainless steel fasteners. Guides and fasteners are stainless steel, when specified.
Heavy duty	
Type MHS-1	Have gray cast iron slides, frames, guides, and yokes, and are fitted with bronze seat facings, bronze wedges and wedge blocks or wedge seat facings, and bronze stem blocks or thrust nuts; bronze or stainless steel fasteners; and cold rolled steel stems except where stainless steel stems are specified.
Type MHS-2	Have gray cast iron slides, frames, guides, and yokes, and are fitted with stainless steel seat facings, wedges, wedge seat facings, stems and fasteners; and austenitic cast iron stem blocks or thrust nuts.
Type MHS-3	Have austenitic gray cast iron slides, frames, guides, and yokes, and are fitted with nickel-copper alloy seat facings, wedges, wedge seat facings, stems and fasteners; and austenitic cast iron stem blocks or thrust nuts.

C. Quality of Material

(1) Material for slide gates and appurtenances must conform to the requirements of the applicable specifications listed below for the alloy, grade, type, or class of material and the condition and finish appropriate to the structural and operational requirements.

(2) Galvanizing (zinc coating) must conform to the requirements of Material Specification 582.

Material	ASTM specification
Cast iron and gray cast iron	A48 Class 30, A126 Class B
Austenitic cast iron	A436
Structural steel shapes, plates, and bars	A36
Cold rolled steel	A108
Carbon steel bars	A108 or A575
Stainless steel	A240, A276, A269, A582; Type 302, 303, 304, or 304L
Castings, nickel and nickel alloy	A494
Carbon steel sheets and strips	A1011
Zinc-coated carbon steel sheets	A653 or A924
Bronze bar, rods, and shapes	B21 or B98
Naval bronze	B21
Phosphor bronze	B103 or B139
Manganese bronze	B138 or B584
Silicon bronze	B98 or B584
Cast bronze	B584
Nickel-copper alloy plate, sheet, or strip	B127
Nickel-copper alloy rod or bar	B164
Rubber for gaskets and seals	D395, D412, D471, D572, or D2240

D. Fabricated Metal Gates (Light Duty Gates)

Fabricated metal gates must be built to withstand the seating head expressed by the gate class designation. Unless otherwise specified, the gates must be galvanized steel with flat-back frames.

E. Cast Iron Gates (Light Duty Gates)

(1) The frame must be cast iron of the specified type. The front face must be machined to receive the gate guides.

(2) The gate slide must be cast iron and be fabricated to withstand the seating and unseating heads expressed by the gate class designation as defined in section 2 of this specification.

(3) Grooves must be cast on the vertical sides of the slide to match the guide angles.
(4) The gate guides must be galvanized structural steel or stainless steel and be fabricated to withstand the total thrust of the gate slide from water pressure and wedge action under maximum operating conditions.
(5) Wedges and wedge seats must have smooth bearing surfaces. Wedges may be cast as integral parts of the slide. Removable wedges and wedge seats must be fastened to the slide, frame, or guides by means of suitable studs, screws, or bolts and be firmly locked in place after final adjustment. Each interacting set of wedge and wedge seat must be adjustable as needed to ensure accurate and effective contact. Adjusting bolts or screws must be bronze or galvanized steel.
(6) Seat facings must be machined to a smooth finish to ensure proper watertight contact.

F. Frame or Seat (Moderate and Heavy Duty Gates)

The frame must be cast iron and of the specified type. The front face must be machined to receive the gate guides, and the rear face must be machined as required to match the specified attaching means. For heavy duty gates, a dovetailed groove must be machined on the perimeter of the front face to receive the seat facing.

G. Gate Slide (Moderate and Heavy Duty Gates)

(1) The gate slide must be cast iron, rectangular in shape, and have horizontal and vertical stiffening ribs of sufficient section to withstand the seating and unseating heads expressed by the gate class designation as defined in section 2 of this specification. For heavy duty gates, a dovetailed groove must be machined on the perimeter of the slide face to receive the seat facing.
(2) Tongues must be machined on the vertical sides of the slide along its entire height to match the guide grooves and angles with a maximum clearance of 1/16 inch for gates smaller than 54 inches by 54 inches, and 1/8 inch for larger gates.
(3) A nut pocket with reinforcing ribs must be integrally cast on the vertical centerline and above the horizontal centerline of the slide. The pocket must be of a shape adequate to receive a flat-backed thrust nut or stem block and be built to withstand the opening and closing thrust of the stem.

H. Gate Guides (Moderate and Heavy Duty Gates)

(1) The gate guides must be built to withstand the total thrust of the gate slide from water pressure and wedge action. The gate guides must be cast iron for heavy duty gates.
(2) Grooves must be machine-in cast iron guides to receive the tongue on the gate slide throughout the entire length of the guide.
(3) The guides must be of adequate length to retain a minimum of one-half the height of the gate slide when the gate is fully opened.

I. Wedges and Wedge Seats (Moderate and Heavy Duty Gates)

(1) Pads for supporting wedges, wedge seats (or blocks), and wedge loops (or stirrups) must be cast as integral parts of the gate frame, slide, or guides and be accurately machined to receive those parts.
(2) Wedges and wedge seats must have smooth bearing surfaces for moderate duty gates and have machine finish bearing surfaces for heavy duty gates. Removable wedges may be cast as integral part of the slide for moderate duty gates. Wedges must be fastened to the gate slide, frame, or guides with suitable studs, screws, or bolts and be firmly locked in place after final adjustment. Each interacting set of wedge and wedge seat must be adjustable as needed to ensure accurate and effective contact.

J. Seat Facing

(1) Moderate duty gates—Seat facings must be machined to a smooth finish to ensure proper watertight contact. Bronze facings must be securely attached by welding or other approved methods.
(2) Heavy duty gates—Seat facings must be pressed or impacted into the machined dovetailed grooves on the gate slide and frame and machined to a smooth finish to ensure proper watertight contact.

K. Yoke

When a self-contained gate is specified, the yoke must be of such design as to withstand the loads resulting from normal operation of the gate. For moderate and heavy duty gates, cast iron yokes must be provided with machined pads for connecting to the ends of gate guides and to receive the stem thrust cap or handwheel lift.

L. Flush Bottom Seal (Heavy Duty Gate)

When a flush bottom sealing gate is specified, a solid, square-corner type rubber seal must be provided at the bottom of the gate opening. It must be securely attached either to the bottom of the slide or to the frame. Metal surfaces bearing on the rubber seal must be smooth and rounded as necessary to prevent cutting of the seal during gate operation.

M. Gate Stem and Lift (or Hoist)

(1) The gate stem and lift/hoist must be of the specified type, size, and capacity and, if hand operated, must be capable of moving the gate slide under normal conditions, following unseating from the wedging device, with a pull on the handwheel or crank of not more than 25 pounds with the specified seating and/or unseating head of water against the gate.
(2) Unless otherwise specified, the stem must be carbon steel and be furnished in sections as necessary to permit reasonable ease in installation. Couplings must be bolted, pinned, or keyed to the stem. The stem must be furnished with rolled or machine-cut 29 degree Acme threads of sufficient length to completely open the gate. The threads must be smooth and of uniform lead and cross-section, such that the nut can travel the full length without binding or excessive friction. For moderate and heavy duty gates, the stem must be threaded for connection to the stem block or thrust nut on the gate slide.
(3) The lift must be compatible with the type of stem furnished. Unless otherwise specified, the lift nut must be cast bronze for light and moderate duty gates and cast manganese bronze for heavy duty gates and be fitted with ball or roller thrust bearings designed to withstand the normal thrust developed during opening and closing of the gate at the maximum operating heads. All gears, sprockets, and pinions must be machine-cut, with ratios and strength adequate to withstand expected operating loads. Sufficient grease fittings must be provided to allow lubrication of all moving parts. An arrow and the word "open" must be cast on the rim of the handwheel or on the lift housing to indicate the direction of gate opening. Unless otherwise specified, the lift for the nonrising-stem gate must be provided with an indicator capable of showing both when the gate is fully open and when it is fully closed for the moderate and heavy duty gates.
(4) Provisions must be made to prevent stem rotation within the stem block or thrust nut or at the connection of the gate slide.
(5) Stop collars must be provided to prevent overtravel in opening and closing the gate.

N. Stem Guides

Unless otherwise specified, stem guides must be cast iron for light duty gates and cast iron with bronze bushed collars for moderate and heavy duty gates. They must be fully adjustable in two directions.

O. Wall Thimble (Moderate and Heavy Duty Gates)

(1) When a wall thimble is specified, it must be of the same cast iron used in the gate frame and of the section, type, and depth specified. The front flange must be machined to match the gate frame and drilled and tapped to accurately receive the gate attachment studs.
(2) Gaskets or mastic to be installed between the thimble and the gate frame must conform to the recommendations of the gate manufacturer and be furnished with the thimble.

P. Fasteners

Unless otherwise specified, all anchor bolts and other fasteners must be galvanized steel or bronze for light duty gates; galvanized steel or stainless steel or bronze for moderate duty gates; and, of the quality and size as recommended by the gate manufacturer for heavy duty gates. All anchor bolts, assembly bolts, screws, nuts, and other fasteners must be of ample section to withstand the forces created by operation of the gate while subjected to the specified seating and unseating heads. Anchor bolts must be furnished with two nuts to facilitate installation.

Q. Installation Instructions

Before installation, provide the engineer with the manufacturer's complete installation data, instructions for adjustments, and drawings or templates showing the location of all anchor bolts for each gate.

R. Painting

When specified, gates and accessories must be painted by the designated paint system.

S. Certification

The supporting data submitted to the engineer must include the name of the manufacturer, the manufacturer's model number (for standard catalogue items), or the seating and unseating heads for which the gate is designed together with such drawings and specifications as may be necessary to show that the gate conforms to the requirements of this specification.

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Part 642 – Specifications

Chapter 3 – National Standard Material Specifications

Material Specification 581—Metal

A. Scope

This specification covers the quality of steel, stainless steel, and aluminum alloys.

B. Structural Steel

(1) Structural steel must conform to the requirements of ASTM A36.
(2) High-strength low-alloy structural steel must conform to ASTM A242 or A588.
(3) Carbon steel plates of structural quality to be bent, formed, or shaped cold must conform to ASTM A283, Grade C.
(4) Carbon steel sheets of structural quality must conform to ASTM A1011, Grade 40, or A1008, Grade 40.
(5) Carbon steel strip of structural quality must conform to ASTM A1011, Grade 36.
(6) Stainless steel must conform to ASTM A240, A320, A276, A269, A582; Type 302, 303, 304, or 304L.

C. Commercial or Merchant Quality Steel

Commercial or merchant quality steel must conform to the requirements of the applicable ASTM listed below:

Product	ASTM standards
Carbon steel bars	A575, Grade M 1015 to Grade M 1031
Carbon steel sheets	A1011
Carbon steel strips	A1011
Zinc-coated carbon steel sheets	A653 or A924

D. Aluminum Alloy

Aluminum alloy products must conform to the requirements of the applicable ASTM standard listed below. Unless otherwise specified, alloy 6061-T6 must be used.

Product	ASTM standards
Standard structural shape	B308
Extruded structural pipe and tube	B429
Extruded bars, rods, shapes, and tubes	B221
Drawn seamless tubes	B210
Rolled or cold-finished bars, rods, and wire	B211
Sheet and plate	B209

E. Bolts

(1) Steel bolts must conform to the requirements of ASTM A307. If high-strength bolts are specified, they must conform to the requirements of ASTM F3125.
(2) When galvanized or zinc-coated bolts are specified, the zinc coating must conform to the requirements of ASTM A153, except that bolts 0.5 inch or less in diameter may be coated with electro-deposited zinc or cadmium coating conforming to the requirements of ASTM B633, Service Condition SC 3, or ASTM B766, unless otherwise specified.
(3) Stainless steel bolts must conform to ASTM A320.

F. Rivets

Unless otherwise specified, steel rivets must conform to the requirements of ASTM A31, Grade B. Unless otherwise specified, aluminum alloy rivets must be Alloy 6061 conforming to the requirements of ASTM B316.

G. Welding Electrodes

(1) Steel welding electrodes must conform to the requirements of American Welding Society Specification AWS A5.1, "Specification for Mild Steel Covered Arc-Welding Electrodes," except that they must be uniformly and heavily coated (not washed) and must be of such a nature that the coating does not chip or peel while being used with the maximum amperage specified by the manufacturer.
(2) Aluminum welding electrodes must conform to the requirements of American Welding Society Specification AWS A5.10, "Specification for Aluminum and Aluminum-Alloy Welding Rods and Bare Electrodes."
(3) Stainless steel electrodes must conform to the requirements of AWS A5.22/ A5.22M:2012 Specification for Stainless Steel Electrodes for Flux Cored Arc Welding and Stainless Steel Flux Cored Rods for Gas Tungsten Arc Welding.

Part 642 – Specifications

Chapter 3 – National Standard Material Specifications

Material Specification 582—Galvanizing

A. Scope

This specification covers the quality of zinc coatings applied to iron and steel productions.

B. Quality

(1) Zinc coatings shall conform to the requirements of ASTM A123 for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products or as otherwise specified in the items of work and construction details of the Construction Specification.

(2) ASTM A123 covers both fabricated and nonfabricated products; e.g., assembled steel products, structural steel fabrications, large tubes already bent or welded before galvanizing, and wire work fabricated from noncoated steel wire. It also covers steel forgings and iron castings incorporated into pieces fabricated before galvanizing or which are too large to be centrifuged (or otherwise handled to remove excess galvanizing bath metal).

(3) Items to be centrifuged or otherwise handled to remove excess zinc shall meet the requirements of ASTM A153, except bolts, screws, and other fasteners 0.5 inch or less in diameter may be coated with electro-deposited zinc or cadmium coating conforming to the requirements of ASTM B766, coating thickness Class 5, Type III, or ASTM B633, Service Condition SC-3, unless otherwise specified.

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Part 642 – Specifications

Chapter 3 – National Standard Material Specifications

Material Specification 591—Field Fencing Material

A. Scope

This specification provides the minimum quality requirements for the material used in the construction of field fences.

B. Wire Gauge

When the size of steel wire is designated by gage number, the diameter must be as defined for U.S. Steel Wire Gauge.

C. Fencing

Fencing material must conform to the requirements of ASTM A121 for barbed wire, ASTM A116 for woven wire, ASTM A390 for poultry fence or netting, and ASTM A854 for high-tensile wire. Barbed wire and woven wire must be class 3 zinc coated as specified in ASTM A641 unless otherwise specified. High-tensile wire must have type I zinc coating unless otherwise specified.

D. Stays, Fasteners, and Tension Wire

Stays and fasteners must conform to the requirements of the appropriate ASTM for the fencing material specified unless otherwise specified. Tension wires must have a tensile strength not less than 58,000 pounds per square inch. Stays, fasteners, and tension wire must have class 3 zinc coating as specified in ASTM A641 unless otherwise specified.

E. Wood Fence Posts and Braces

(1) Unless otherwise specified, wood posts must be naturally rot resistant, preservative-treated, or other wood of equal life and strength. At least half the diameter or diagonal dimension of naturally rot resistant posts must be in heartwood. Provide new wood posts that are sound, free from decay with all limbs trimmed substantially flush with the body. All posts must be substantially straight throughout their full length.

(2) Make tops convex rounded or inclined. Provide posts free of ring shake, season cracks more than a quarter-inch wide, splits in the end, and unsound knots. Pine must be pressure treated in conformance with Material Specification 585, Wood Preservatives and Treatment. Wood braces must be of wood material equal to or better than construction grade Douglas fir. Wood braces must be pressure treated in conformance with Material Specification 585.

F. Steel Fence Posts and Braces

Steel fence posts must conform to the requirements of ASTM A702. Posts with punched tabs for fastening the wires must not be installed. Bracing pipes must conform to the requirements of ASTM A53 except that the A53 requirements for hydrostatic test will not apply.

G. Concrete Fence Posts

Concrete fence posts must be manufactured to the specified requirements of size, shape, and strength.

H. Panel Gates

Panel gates must be the specified types, sizes, and quality and include the necessary fittings required for installation. Gates must be of rigid construction free from sag or twist. The fittings must consist of not less than two hinges and one latch or galvanized chain for fastening. Latches must be of such design that a padlock may be used for locking. All fittings must not be of lesser quality than the gate manufacturer's standard.

I. Wire Gates

Wire gates must be the type shown on the drawings, constructed in accordance with specifications, at the locations and to the dimensions shown on the drawings. The material must conform to the kinds, grades, and sizes specified for new fence and must include the necessary fittings and stays.

J. Staples

Staples required to secure the fence wire to wood posts must be 9-gauge galvanized wire with a minimum length of 1.5 inches for soft woods and a minimum length of 1 inch for close-grain hardwoods.

K. Galvanizing

All iron and steel fencing material, except as otherwise specified, must be zinc coated by the hot dip process meeting the requirements of Material Specification 582. Clips, bolts, and other small hardware must be protected by hot-dipped galvanizing, electro-deposited zinc, or cadmium coating.

Part 642 – Specifications

Chapter 3 – National Standard Material Specifications

Material Specification 592—Geotextile

A. Scope

This specification covers the quality of geotextile, including geotextile for temporary silt fence.

B. General Requirements

(1) Fibers (threads and yarns) used in the manufacture of geotextile must consist of synthetic polymers composed of a minimum of 85 percent by weight polypropylene, polyester, polyamide, polyethylene, polyolefin, or polyvinylidene-chloride. The fiber must be formed into a stable network of filaments retaining dimensional stability relative to each other. The geotextile must be free of defects, such as holes, tears, and abrasions. The geotextile must be free of any chemical treatment or coating that significantly reduces its porosity. Fibers must contain stabilizers, inhibitors, or both to enhance resistance to ultraviolet light. Geotextile other than for temporary silt fence must conform to the requirements in Figure 592-1 or 592-2, as applicable. Geotextile for temporary silt fence must conform to ASTM D6461.

(2) Thread used for factory or field sewing must be of a color contrasting to the color of the fabric and made of high-strength polypropylene, polyester, or polyamide material. It must be as resistant to ultraviolet light as the geotextile being sewn.

C. Classification

(1) There are two geotextile classifications, woven and nonwoven. Geotextile for temporary silt fence may be either woven or nonwoven. Silt film woven geotextile may not be used except for temporary silt fence.

(2) Woven geotextiles are made from fabric that is formed by the uniform and regular interweaving of the threads or yarns in two directions. Woven fabrics must be manufactured from monofilament yarn formed into a uniform pattern with distinct and measurable openings, retaining their position relative to each other. The fabric must have a selvedge edge or otherwise be finished to prevent unraveling.

(3) Nonwoven geotextiles are made from fabric that is formed by a random placement of threads in a mat and bonded by needle punching, heat bonding, or resin bonding. Nonwoven geotextiles must have distinct but variable small openings, retaining their position relative to each other when bonded. The use of heat- or resin-bonded nonwovens is restricted as specified in note 2 of Figure 592-2.

D. Sampling and Testing

The geotextile must conform to Figure 592-1 or 592-2 or ASTM D6461, as applicable, for the product type shown on the label. Documentation described in either (i) or (ii) below is required to verify the product meets the specified requirements:

(i) Product properties as listed in the latest edition of the "Specifiers Guide," Geosynthetics (Industrial Fabrics Association International, 1801 County Road B, West Roseville, MN 55113-4061 or at http://www.geosindex.com), and that represent average roll values, are acceptable.

(ii) Test data from the geotextile production run for each of the specified tests listed in Figure 592-1 or 592-2 or ASTM D6461, as applicable.

E. Shipping and Storage

Each roll of geotextile must be labeled or tagged to clearly identify the brand, class, and individual production run in accordance with ASTM D4873. The geotextile must be shipped and transported in rolls wrapped with a cover for protection from moisture, dust, dirt, debris, and ultraviolet light. The cover must be maintained undisturbed to the maximum extent possible before placement.

Figure 592-1 Requirements for Woven Geotextiles [1/]

Property	Test method	Class I	Class II	Class III	Class IV
Grab tensile strength (lb)	ASTM D4632	247 minimum	180 minimum	180 minimum	315
Elongation at failure (%)	ASTM D4632	<50	<50	<50	<50
Trapezoidal tear strength (lb)	ASTM D4533	90 minimum	67 minimum	67 minimum	112 minimum
Puncture strength (lb)	ASTM D6241	495 minimum	371 minimum	371 minimum	618 minimum
Ultraviolet stability (% retained strength)	ASTM D4355	50 minimum	50 minimum	50 minimum	70 minimum
Permittivity (sec^{-1})	ASTM D4491	as specified			
Apparent opening size (AOS) [2/]	ASTM D4751	as specified			
Percent open area (POA) (%)	USACE [3/]CWO-02215-86	as specified			

[1/] All values are minimum average roll values (MARV) in the weakest principal direction, unless otherwise noted.

[2/] Maximum average roll value.

[3/] Note: CWO is a USACE reference.

Figure 592-2 Requirements for Non-Woven Geotextiles [1/]

Property	Test method	Class I [2/]	Class II [2/]	Class III [2/]	Class IV [2/]
Grab tensile strength (lb)	ASTM D4632 grab test	202 minimum	157 minimum	112 minimum	202 minimum
Elongation at failure (%)	ASTM D4632	50 minimum	50 minimum	50 minimum	50 minimum
Trapezoidal tear strength (lb)	ASTM D4533	79 minimum	56 minimum	40 minimum	79 minimum
Puncture strength (lb)	ASTM D6241	433 minimum	309 minimum	223 minimum	433 minimum
Ultraviolet light (% retained strength)	ASTM D4355	50 minimum	50 minimum	50 minimum	50 minimum
Permittivity sec^{-1}	ASTM D4491	0.70 minimum or as specified			
Apparent opening size (AOS) (mm) [3/]	ASTM D4751	0.22 maximum or as specified			

[1/] All values are minimum average roll values (MARV) in the weakest principal direction, unless otherwise noted.

[2/] Needle punched geotextiles may be used for all classes. Heat-bonded or resin-bonded geotextiles may be used for class IV only.

[3/] Maximum average roll value.

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