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SECTION 03101

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SECTION 03101

FORMWORK FOR CONCRETE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 347R	(1994; R 1999) Guide to Formwork for Concrete

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 31/C 31M	(2000) Making and Curing Concrete Test Specimens in the Field
ASTM C 39/C 39M	(1999) Compressive Strength of Cylindrical Concrete Specimens
ASTM C 1077	(1998) Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation

DEPARTMENT OF COMMERCE (DOC)

DOC PS 1	(1996) Voluntary Product Standard - Construction and Industrial Plywood

1.2 DESIGN REQUIREMENTS

The design, engineering, and construction of the formwork shall be the responsibility of the Contractor. The formwork shall be designed for anticipated live and dead loads and shall comply with the tolerances specified in Section 03301 CAST-IN-PLACE STRUCTURAL CONCRETE, paragraph CONSTRUCTION TOLERANCES. However, for surfaces with an ACI Class A surface designation, the allowable deflection for facing material between studs, for studs between walers and walers between bracing shall be limited to 0.0025 times the span. The formwork shall be designed as a complete system with consideration given to the effects of cementitious materials and mixture additives such as fly ash, cement type, plasticizers, accelerators, retarders, air entrainment, and others. The adequacy of formwork design and construction shall be monitored prior to and during concrete placement as part of the Contractor's approved Quality Control Plan.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The "RE" designates that the Resident Office will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Shop Drawings; G, RE.

Drawings and design computations for all formwork required shall be submitted at least 30 days either before fabrication on site or before delivery of prefabricated forms. If reshoring is permitted, the method, including location, order, and time of erection and removal shall also be submitted for review.

SD-03 Product Data

Materials.

Manufacturer's literature shall be submitted for plywood, concrete form hard board, form accessories, prefabricated forms, and form coating, and form-lining materials.

SD-06 Test Reports

Inspection.

The Contractor shall submit field inspection reports for concrete forms and embedded items.

Formwork Not Supporting Weight of Concrete; G, RE..

If forms are to be removed in less than 24 hours on formwork not supporting the weight of concrete, the evaluation and results of the control cylinder tests shall be submitted to and approved before the forms are removed.

1.4 SHOP DRAWINGS

The shop drawings and data submitted shall include the type, size, quantity, and strength of all materials of which the forms are made, the plan for jointing of facing panels, details affecting the appearance, and the assumed design values and loading conditions.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Forms and Form Liners

Forms and form liners shall be fabricated with facing materials that will produce a finish meeting the specified irregularities in formed surface requirements as defined in ACI 347R. Forms and form liners shall be fabricated with facing materials as specified below.

2.1.1.1 Class "A" Finish

This class of finish shall apply to exposed concrete surfaces of channel walls and inside box culverts. The form facing material shall be composed of new, well-matched tongue-and-groove lumber or new plywood panels conforming to DOC PS 1, Grade B-B concrete form, Class I.

2.1.1.2 Class "D" Finish

This class of finish shall apply to concrete faces against which earthfill will be placed. The form facing may be of wood or steel.

2.1.2 Form Coating

Form coating shall be commercial formulation that will not bond with, stain, cause deterioration, or any other damage to concrete surfaces. The coating shall not impair subsequent treatment of concrete surfaces depending upon bond or adhesion nor impede the wetting of surfaces to be cured with water or curing compounds. If special form liners are to be used, the Contractor shall follow the recommendation of the form coating manufacturer.

2.2 ACCESSORIES

Ties and other similar form accessories to be partially or wholly embedded in the concrete shall be of a commercially manufactured type. After the ends or end fasteners have been removed, the embedded portion of metal ties shall terminate not less than 50 mm from any concrete surface either exposed to view or exposed to water. Plastic snap ties may be used in locations where the surface will not be exposed to view. Form ties shall be constructed so that the ends or end fasteners can be removed without spalling the concrete.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Form Construction

Forms shall be constructed true to the structural design and required alignment. The form surface and joints shall be mortar tight and supported to achieve safe performance during construction, concrete placement, and form removal. The Contractor shall continuously monitor the alignment and stability of the forms during all phases to assure the finished product will meet the required surface class specified in paragraph FORMS AND FORM LINERS and tolerances specified in paragraph DESIGN REQUIREMENTS. Failure of any supporting surface either due to surface texture, deflection or form collapse shall be the responsibility of the Contractor as will the replacement or correction of unsatisfactory surfaces. When forms for

continuous surfaces are placed in successive units, care shall be taken to fit the forms over the completed surface to obtain accurate alignment of the surface and to prevent leakage of mortar. Forms shall not be re-used if there is any evidence of defects which would impair the quality of the resulting concrete surface. All surfaces of used forms shall be cleaned of mortar and any other foreign material before reuse.

3.1.2 Chamfering

All exposed joints, edges and external corners shall be chamfered by molding placed in the forms unless the drawings specifically state that chamfering is to be omitted or as otherwise specified. Chamfered joints shall not be permitted where earth or rockfill is placed in contact with concrete surfaces. Chamfered joints shall be terminated 300 mm outside the limit of the earth or rockfill so that the end of the chamfers will be clearly visible.

3.1.3 Coating

Forms for exposed or painted surfaces shall be coated with form oil or a form-release agent before the form or reinforcement is placed in final position. The coating shall be used as recommended in the manufacturer's instructions. Forms for unexposed surfaces may be wet with water in lieu of coating immediately before placing concrete, except that, in cold weather when freezing temperatures are anticipated, coating shall be mandatory. Surplus coating on form surfaces and coating on reinforcing steel and construction joints shall be removed before placing concrete.

3.2 FORM REMOVAL

Forms shall not be removed without approval. The minimal time required for concrete to reach a strength adequate for removal of formwork without risking the safety of workers or the quality of the concrete depends on a number of factors including, but not limited to, ambient temperature, concrete lift heights, type and amount of concrete admixture, and type and amount of cementitious material in the concrete. It is the responsibility of the Contractor to consider all applicable factors and leave the forms in place until it is safe to remove them. In any case forms shall not be removed unless the minimum time or minimum compressive strength requirements below are met, except as otherwise directed or specifically authorized. When conditions are such as to justify the requirement, forms will be required to remain in place for a longer period. All removal shall be accomplished in a manner which will prevent damage to the concrete and ensure the complete safety of the structure. Where forms support more than one element, the forms shall not be removed until the form removal criteria are met by all supported elements. Form removal shall be scheduled so that all necessary repairs can be performed as specified in Section 03301 CAST-IN-PLACE STRUCTURAL CONCRETE, paragraph FORMED SERVICES. Evidence that concrete has gained sufficient strength to permit removal of forms shall be determined by tests on control cylinders. All control cylinders shall be stored in the structure or as near the structure as possible so they receive the same curing conditions and protection methods as given those portions of the structure they represent. Control cylinders shall be removed from the molds at an age of no more than 24 hours. All control

cylinders shall be prepared and tested in accordance with ASTM C 31/C 31M and ASTM C 39/C 39M at the expense of the Contractor by an independent laboratory that complies with ASTM C 1077 and shall be tested within 4 hours after removal from the site.

3.2.1 Formwork Not Supporting Weight of Concrete

Formwork for walls, columns, sides of beams, gravity structures, and other vertical type formwork not supporting the weight of concrete shall not be removed in less than 24 hours after concrete placement is completed.

3.2.2 Formwork Supporting Weight of Concrete

Formwork supporting weight of concrete and shoring shall not be removed until structural members have acquired sufficient strength to safely support their own weight and any construction or other superimposed loads to which the supported concrete may be subjected. As a minimum, forms shall be left in place until control concrete test cylinders indicate evidence the concrete has attained at least 70 percent of the compressive strength required for the structure in accordance with the quality and location requirements of Section 03301 CAST-IN-PLACE STRUCTURAL CONCRETE FOR CIVIL WORKS, paragraph REQUIRED AVERAGE COMPRESSIVE STRENGTH

3.3 INSPECTION

Forms and embedded items shall be inspected in sufficient time prior to each concrete placement by the Contractor in order to certify to the Contracting Officer that they are ready to receive concrete. The results of each inspection shall be reported in writing.

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SECTION 03151

EXPANSION, CONTRACTION AND CONSTRUCTION JOINTS IN CONCRETE FOR CIVIL WORKS

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SECTION 03151

EXPANSION, CONTRACTION AND CONSTRUCTION JOINTS IN CONCRETE FOR CIVIL WORKS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 920	(1998) Elastomeric Joint Sealants
ASTM D 1751	(1999) Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D 1752	(1984; R 1996el) Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D 2628	(1991; R 1998) Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
ASTM D 2835	(1989; R 1998) Lubricant for Installation of Preformed Compression Seals in Concrete Pavements

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The "RE" designates that the Resident Office will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-04 Samples

Field Molded Sealants and Primer; G, RE.

Four liters of field-molded sealant and 1 L of primer (when primer is recommended by the sealant manufacturer) shall be provided for testing.

SD-06 Test Reports

Premolded Expansion Joint Filler Strips.

Field Molded Sealants and Primer test.

Compression Seals and Lubricant.

Certified manufacturer's test reports shall be provided for premolded expansion joint filler strips, compression seals and lubricant, to verify compliance with applicable specification.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Premolded Expansion Joint Filler Strips

Premolded expansion joint filler strips shall conform to ASTM D 1751 or ASTM D 1752, Type I, or resin impregnated fiberboard conforming to the physical requirements of ASTM D 1752.

2.1.2 Joint Seals and Sealants

2.1.2.1 Field Molded Sealants and Primer

Field molded sealants and primer shall conform to ASTM C 920, Type M, Grade NS, Class 25, use NT for vertical joints and Type M, Grade P, Class 25, use T for horizontal joints. Bond breaker material shall be polyethylene tape, coated paper, metal foil or similar type materials. The back-up material shall be compressible, nonshrink, nonreactive with sealant, and nonabsorptive material type such as extruded butyl or polychloroprene foam rubber.

2.1.2.2 Compression Seals and Lubricant

Compression seals shall conform to ASTM D 2628; lubricant for installation shall conform to ASTM D 2835.

2.2 TESTS, INSPECTIONS, AND VERIFICATIONS

2.2.1 Materials Tests

2.2.1.1 Field Molded Sealants

Samples of field molded sealants and primer, when use of primer is recommended by the manufacturer, as required in paragraph FIELD MOLDED SEALANTS AND PRIMER, shall be tested by and at the expense of the Contractor for compliance with paragraph FIELD MOLDED SEALANTS AND PRIMER. The field molded sealants and primer test report shall be submitted to the Government prior to use of the field molded sealants and primer in the project.

PART 3 EXECUTION

3.1 INSTALLATION

Joint locations and details, including materials and methods of installation of joint fillers and waterstops, shall be as specified, as shown, and as directed. In no case shall any fixed metal be continuous through an expansion or contraction joint.

3.1.1 Expansion Joints

Premolded filler strips shall have oiled wood strips secured to the top thereof and shall be accurately positioned and secured against displacement to clean, smooth concrete surfaces. The wood strips shall be slightly tapered, dressed and of the size required to install filler strips at the desired level below the finished concrete surface and to form the groove for the joint sealant or seals to the size shown. Material used to secure premolded fillers and wood strips to concrete shall not harm the concrete and shall be compatible with the joint sealant or seals. The wood strips shall not be removed until after the concrete curing period. The groove shall be thoroughly cleaned of all laitance, curing compound, foreign materials, protrusions of hardened concrete and any dust which shall be blown out of the groove with oil-free compressed air.

3.1.1.1 Joints With Field-Molded Sealant

Joints shall not be sealed when the sealant, air or concrete temperature is less than 4 degrees C. Immediately prior to installation of field molded sealants, the joint shall be cleaned of all debris and further cleaned using water, chemical solvents or other means as recommended by the sealant manufacturer. The joints shall be dry prior to filling with sealant. Bond breaker and back-up material shall be installed where required. Joints shall be primed and filled flush with joint sealant in accordance with the manufacturer's recommendations.

3.1.1.2 Joints With Preformed Compression Seals

The joint seals shall be installed with equipment which shall be capable of installing joint seals to the prescribed depth without cutting, nicking, twisting, or otherwise distorting or damaging the seal and with no more than five percent stretching of the seal. The sides of the joint and, if necessary, the sides of the compression seal shall be covered with a coating of lubricant, and the seal shall be installed to the depth indicated with joint installation equipment. Butt joints shall be coated with liberal applications of lubricant.

3.1.2 Contraction Joints

Joints requiring a bond breaker shall be coated with curing compound or with bituminous paint.

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SECTION 03200

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SECTION 03200

CONCRETE REINFORCEMENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 318M	(1995) Metric Building Code Requirements for Structural Concrete and Commentary

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 53	(1999b) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 615/A 615M	(2000) Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A 675/A 675M	(1990a; R 1995el) Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties

CONCRETE REINFORCING STEEL INSTITUTE (CRSI)

CRSI MSP-1	(1996) Manual of Standard Practice

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The "RE" designates that the Resident Office will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Reinforcement; G, RE.

Detail drawings showing reinforcing steel placement, schedules, sizes, grades, and splicing and bending details. Drawings shall show support details including types, sizes and spacing.

SD-07 Certificates

Reinforcing Steel.

Certified copies of mill reports attesting that the reinforcing steel furnished contains no less than 25 percent recycled scrap steel and meets the requirements specified herein, prior to the installation of reinforcing steel.

1.3 DELIVERY AND STORAGE

Reinforcement and accessories shall be stored off the ground on platforms, skids, or other supports.

PART 2 PRODUCTS

2.1 DOWELS

Dowels shall conform to ASTM A 675/A 675M, Grade 80. Steel pipe conforming to ASTM A 53, Schedule 80, may be used as dowels provided the ends are closed with metal or plastic inserts or with mortar.

2.2 REINFORCING STEEL

Reinforcing steel shall be deformed bars conforming to ASTM A 615/A 615M grades and sizes as indicated.

2.3 WIRE TIES

Wire ties shall be 16 gauge or heavier black annealed steel wire.

2.4 SUPPORTS

Bar supports for formed surfaces shall be designed and fabricated in accordance with CRSI MSP-1 and shall be steel or precast concrete blocks. Precast concrete blocks shall have wire ties and shall be not less than 100 by 100 mm when supporting reinforcement on ground. Precast concrete block shall have compressive strength equal to that of the surrounding concrete. Where concrete formed surfaces will be exposed to weather or where surfaces are to be painted, steel supports within 13 mm of concrete surface shall be galvanized, plastic protected or of stainless steel. Concrete supports used in concrete exposed to view shall have the same color and texture as the finish surface. For slabs on grade, supports shall be precast concrete blocks, plastic coated steel fabricated with bearing plates, or specifically designed wire-fabric supports fabricated of plastic.

PART 3 EXECUTION

3.1 REINFORCEMENT

Reinforcement shall be fabricated to shapes and dimensions shown and shall conform to the requirements of ACI 318M. Reinforcement shall be cold bent unless otherwise authorized. Bending may be accomplished in the field or at the mill. Bars shall not be bent after embedment in concrete. Safety

caps shall be placed on all exposed ends of vertical concrete reinforcement bars that pose a danger to life safety. Wire tie ends shall face away from the forms.

3.1.1 Placement

Reinforcement shall be free from loose rust and scale, dirt, oil, or other deleterious coating that could reduce bond with the concrete. Reinforcement shall be placed in accordance with ACI 318M at locations shown plus or minus one bar diameter. Reinforcement shall not be continuous through expansion joints and shall be as indicated through construction or contraction joints. Concrete coverage shall be as indicated or as required by ACI 318M. If bars are moved more than one bar diameter to avoid interference with other reinforcement, conduits or embedded items, the resulting arrangement of bars, including additional bars required to meet structural requirements, shall be approved before concrete is placed.

3.1.2 Splicing

Splices of reinforcement shall conform to ACI 318M and shall be made only as required or indicated. Splicing shall be by lapping or by mechanical or welded butt connection. Lapped bars shall be placed in contact and securely tied or spaced transversely apart to permit the embedment of the entire surface of each bar in concrete. Lapped bars shall not be spaced farther apart than one-fifth the required length of lap or 150 mm.

3.2 DOWEL INSTALLATION

Dowels shall be installed in slabs on grade at locations indicated and at right angles to joint being doweled. Dowels shall be accurately positioned and aligned parallel to the finished concrete surface before concrete placement. Dowels shall be rigidly supported during concrete placement. One end of dowels shall be coated with a bond breaker.

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SECTION 03301

CAST-IN-PLACE STRUCTURAL CONCRETE FOR CIVIL WORKS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 117/117R	(1990; Errata) Standard Tolerances for Concrete Construction and Materials
ACI 211.1	(1991) Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 214	(1977; R 1997) Recommended Practice for Evaluation of Strength Test Results of Concrete
ACI 305R	(1999) Hot Weather Concreting
ACI 318M	(1995) Metric Building Code Requirements for Structural Concrete and Commentary

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 31/C 31M	(2000) Making and Curing Concrete Test Specimens in the Field
ASTM C 33	(1999ae1) Concrete Aggregates
ASTM C 39/C 39M	(1999) Compressive Strength of Cylindrical Concrete Specimens
ASTM C 40	(1999) Organic Impurities in Fine Aggregates for Concrete
ASTM C 42/C 42M	(1999) Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C 87	(1983; R 1995el) Effect of Organic Impurities in Fine Aggregate on Strength of Mortar
ASTM C 94/C 94M	(2000) Ready-Mixed Concrete

ASTM C 127	(1988; R 1993el) Specific Gravity and Absorption of Coarse Aggregate
ASTM C 128	(1997) Specific Gravity and Absorption of Fine Aggregate
ASTM C 136	(1996a) Sieve Analysis of Fine and Coarse Aggregates
ASTM C 143/C 143M	(2000) Slump of Hydraulic Cement Concrete
ASTM C 150	(1999a) Portland Cement
ASTM C 172	(1999) Sampling Freshly Mixed Concrete
ASTM C 192/C 192M	(2000) Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 231	(1997e1) Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 260	(2000) Air-Entraining Admixtures for Concrete
ASTM C 309	(1998a) Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 494/C 494M	(1999a) Chemical Admixtures for Concrete
ASTM C 566	(1997) Total Evaporable Moisture Content of Aggregate by Drying
ASTM C 597	(1983; R 1997) Pulse Velocity Through Concrete
ASTM C 618	(2000) Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
ASTM C 803/C 803M	(1997el) Penetration Resistance of Hardened Concrete
ASTM C 805	(1997) Rebound Number of Hardened Concrete
ASTM C 881	(1999) Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 1059	(1999) Latex Agents for Bonding Fresh to Hardened Concrete
ASTM C 1064/C 1064M	(1999) Temperature of Freshly Mixed Portland Cement Concrete

ASTM C 1077	(1998) Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C 1107	(1999) Packaged Dry, Hydraulic-Cement Grout(Nonshrink)
ASTM D 75	(1987; R 1997) Sampling Aggregates

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 94	(1995) Surface Retarders
COE CRD-C 100	(1975) Method of Sampling Concrete Aggregate and Aggregate Sources, and Selection of Material for Testing
COE CRD-C 104	(1980) Method of Calculation of the Fineness Modulus of Aggregate
COE CRD-C 143	(1962) Specifications for Meters for Automatic Indication of Moisture in Fine Aggregate
COE CRD-C 318	(1979) Cloth, Burlap, Jute (or Kenaf)
COE CRD-C 400	(1963) Requirements for Water for Use in Mixing or Curing Concrete
COE CRD-C 521	(1981) Standard Test Method for Frequency and Amplitude of Vibrators for Concrete

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 44	(1997) NIST Handbook 44: Specifications, Tolerances, and other Technical Requirements for Weighing and Measuring Devices

NATIONAL READY-MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA CPMB 100	(1996) Concrete Plant Standards

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The "RE" designates that the Resident Office will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Concrete Mixture Proportioning.

Concrete mixture proportions shall be determined by the Contractor and submitted for review. The concrete mixture quantities of all ingredients per cubic meter and nominal maximum coarse aggregate size that will be used in the manufacture of each quality of concrete shall be stated. Proportions shall indicate the mass of cement, pozzolan and ground granulated blast-furnace (GGBF) slag when used, and water; the mass of aggregates in a saturated surface-dry condition; and the quantities of admixtures. The submission shall be accompanied by test reports from a laboratory complying with ASTM C 1077 which show that proportions thus selected will produce concrete of the qualities indicated. No substitution shall be made in the source or type of materials used in the work without additional tests to show that the quality of the new materials and concrete are satisfactory.

Batch Plant.

Capacity.

The Contractor shall submit batch plant data to the Contracting Officer for review for conformance with applicable specifications.

Concrete Mixers.

Conveying Equipment.

Placing Equipment.

All concrete mixers, conveying equipment, and placing equipment and methods shall be submitted for review by the Contracting Officer for conformance with paragraph CAPACITY.

Tests and Inspections.

Testing Technicians.

Concrete Transportation Construction Inspector (CTCI).

The Contractor shall submit statements that the concrete testing technicians and the concrete inspectors meet the specified requirements. The individuals who perform the inspection of concrete construction shall have demonstrated a knowledge and ability equivalent to the ACI minimum guidelines for certification of Concrete Transportation Construction Inspector (CTCI).

Construction Joint Treatment; G, RE.

The method and equipment proposed for joint cleanup and waste disposal shall be submitted for review and approval.

Curing and Protection; G, RE.

The curing medium and methods to be used shall be submitted for review and approval.

Cold-Weather Placing; G, RE.

If concrete is to be placed under cold-weather conditions, the proposed materials, methods, and protection shall be submitted for approval.

Hot-Weather Placing; G, RE.

If concrete is to be placed under hot-weather conditions, the proposed materials and methods shall be submitted for review and approval.

Finishing; G, RE.

The proposed materials and methods to be used for finishing concrete shall be submitted for review and approval.

SD-04 Samples

Aggregates; G, RE.

Cementitious Materials, Admixtures, and Curing Compound; G, RE.

Samples of materials for government testing and approval shall be submitted as required in paragraph PRECONSTRUCTION SAMPLING AND TESTING.

SD-06 Test Reports

Quality of Aggregates; G, RE.

Aggregate quality tests shall be submitted at least 30 days prior to start of concrete placement.

Mixer Uniformity.

The results of the initial mixer uniformity tests shall be submitted at least 5 days prior to the initiation of placing.

Test Results and Inspection Reports.

Test results and inspection reports shall be submitted daily and weekly as required in paragraph REPORTS.

SD-07 Certificates

Cementitious Materials.

Cementitious Materials, including Cement and Pozzolan, will be accepted on the basis of the manufacturer's certification of compliance, accompanied by mill test reports that materials meet the requirements of the specification under which they are furnished. Certification and mill test reports shall be from samples taken from the particular lot furnished. No cementitious

materials shall be used until notice of acceptance has been given by the Contracting Officer. Cementitious materials will be subject to check testing from samples obtained at the source, at transfer points, or at the project site, as scheduled by the Contracting Officer, and such sampling will be by or under the supervision of the Government at its expense. Material not meeting specifications shall be promptly removed from the site of work.

Chemical Admixtures.

Chemical Admixtures (air-entraining, accelerating, water reducing or retarding admixtures) shall be certified for compliance with all specification requirements.

Membrane-Forming Curing Compound.

Membrane-Forming Curing Compound shall be certified for compliance with all specification requirements.

Epoxy Resin.

Latex Bonding Compound.

Epoxy Resin and Latex Bonding Compound shall be certified for compliance with all specification requirements.

Nonshrink Grout.

Descriptive literature of the Nonshrink Grout proposed for use shall be furnished together with a certificate from the manufacturer stating that it is suitable for the application or exposure for which it is being considered.

1.3 GOVERNMENT TESTING AND SAMPLING

The Government will sample and test aggregates and concrete to determine compliance with the specifications. The Contractor shall provide facilities and labor as may be necessary for procurement of representative test samples. Samples of aggregates will be obtained at the point of batching in accordance with ASTM D 75. Concrete will be sampled in accordance with ASTM C 172.

1.3.1 Preconstruction Sampling and Testing

1.3.1.1 Aggregates

The aggregate sources listed in Section 2.1.2 for aggregates have been tested and at the time testing was performed were capable of producing materials of a quality required for this project provided suitable processing is performed. The Contractor may furnish materials from a listed source or from a source not listed. Samples from any source of coarse aggregate and any source of fine aggregate selected by the Contractor, consisting of not less than 70 kg of each size coarse aggregate and 35 kg of fine aggregate taken under the supervision of the Contracting

Officer in accordance with COE CRD-C 100 shall be delivered to a local materials testing laboratory within 15 days after notice to proceed. Sampling and shipment of samples shall be at the Contractor's expense. Sixty days will be required to complete evaluation of the aggregates. Testing will be performed by and at the expense of the Government in accordance with the applicable COE CRD-C or ASTM test methods. The cost of testing one source for each size of aggregate will be borne by the Government. If the Contractor selects more than one source for each aggregate size or selects a substitute source for any size aggregate after the original source was tested, the cost of that additional testing will be borne by the Contractor. Tests to which aggregate may be subjected are listed in paragraph QUALITY. The material from the proposed source shall meet the quality requirements of this paragraph. The Government's test data and other information on aggregate quality of those sources listed at the end of this section are included in the Design Memorandum and are available for review in the district office. Testing of aggregates by the Government does not relieve the Contractor of the requirements outlined in paragraph TESTS AND INSPECTIONS.

1.3.1.2 Cementitious Materials, Admixtures, and Curing Compound

At least 60 days in advance of concrete placement, the Contractor shall notify the Contracting Officer of the sources for cementitious materials, admixtures, and curing compound, along with sampling location, brand name, type, and quantity to be used in the manufacture and/or curing of the concrete.

1.3.2 Construction Testing by the Government

Sampling and testing will be performed by and at the expense of the Government except as otherwise specified. No material shall be used until notice has been given by the Contracting Officer that test results are satisfactory.

1.3.2.1 Chemical Admixtures Storage

Chemical admixtures that have been in storage at the project site for longer than 6 months or that have been subjected to freezing shall be retested at the expense of the Contractor when directed by the Contracting Officer and shall be rejected if test results are not satisfactory. Chemical admixtures will be accepted based on compliance with the requirements of paragraph CHEMICAL ADMIXTURES.

1.3.2.2 Cement and Pozzolan

If cement or pozzolan is to be obtained from more than one source, the initial notification shall state the estimated amount to be obtained from each source and the proposed schedule of shipments.

a. Prequalified Cement Sources - Cement shall be delivered and used directly from a mill of a producer designated as a qualified source. Samples of cement for check testing will be taken at the project site or concrete-producing plant by a representative of the Contracting Officer for testing at the expense of the Government. A list of

prequalified cement sources is available from Director, U.S. Army Corps of Engineers, Engineer Research and Development Center - Structures Laboratory, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, ATTN: CEERD-SC.

b. Prequalified Pozzolan Sources - Pozzolan shall be delivered and used directly from a producer designated as a qualified source. Samples of pozzolan for check testing will be taken at the project site by a representative of the Contracting Officer for testing at the expense of the Government. A list of prequalified pozzolan sources is available from the Director, U.S. Army Corps of Engineers, Engineer Research and Development Center - Structures Laboratory, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, ATTN: CEERD-SC.

1.3.2.3 Concrete Strength

Compressive strength test specimens will be made by the Government and cured in accordance with ASTM C 31/C 31M and tested in accordance with ASTM C 39/C 39M. The strength of the concrete will be considered satisfactory so long as the average of all sets of three consecutive test results equals or exceeds the specified compressive strength f'c and no individual test result falls below the specified strength f'c by more than 3.5 MPa. A "test" is defined as the average of two companion cylinders, or if only one cylinder is tested, the results of the single cylinder test. Additional analysis or testing, including nondestructive testing, taking cores and/or load tests may be required at the Contractor's expense when the strength of the concrete in the structure is considered potentially deficient.

a. Investigation of Low-Strength Test Results - When any strength test of standard-cured test cylinders falls below the specified strength requirement by more than 3.5 MPa or if tests of field-cured cylinders indicate deficiencies in protection and curing, steps shall be taken to assure that the load-carrying capacity of the structure is not jeopardized. Nondestructive testing in accordance with ASTM C 597, ASTM C 803/C 803M, or ASTM C 805 may be permitted by the Contracting Officer to estimate the relative strengths at various locations in the structure as an aid in evaluating concrete strength in place or for selecting areas to be cored. Such tests shall not be used as a basis for acceptance or rejection.

b. Testing of Cores - When the strength of concrete in place is considered potentially deficient, cores shall be obtained and tested in accordance with ASTM C 42/C 42M. At least three representative cores shall be taken from each member or area of concrete in place that is considered potentially deficient. The location of cores will be determined by the Contracting Officer to least impair the performance of the structure. Concrete in the area represented by the core testing will be considered adequate if the average strength of the cores is equal to at least 85 percent of the specified strength requirement and if no single core is less than 75 percent of the specified strength requirement.

c. Load Tests - If the core tests are inconclusive or impractical to obtain or if structural analysis does not confirm the safety of the

structure, load tests may be directed by the Contracting Officer in accordance with the requirements of ACI 318M. Concrete work evaluated by structural analysis or by results of a load test shall be corrected in a manner satisfactory to the Contacting Officer. All investigations, testing, load tests, and correction of deficiencies will be performed and approved by the Contracting Officer at the expense of the Contractor, except that if all concrete is in compliance with the plans and specifications, the cost of investigations, testing, and load tests will be at the expense of the Government.

1.4 DESIGN REQUIREMENTS

1.4.1 Concrete Strength

Specified compressive strength f'c shall be 30 MPa at 28 days for all concrete structures.

1.4.2 Maximum Water-Cement (W/C) Ratio

Maximum W/C shall be 0.45 for all concrete structures.

1.5 CONSTRUCTION TOLERANCES

1.5.1 General

The definitions of the terms used in the following tables shall be as defined in ACI 117/117R. Level and grade tolerance measurements of slabs shall be made as soon as possible after finishing. When forms or shoring are used, the measurements shall be made prior to removal. Tolerances are not cumulative. The most restrictive tolerance controls. Tolerances shall not extend the structure beyond legal boundaries. Except as specified otherwise, plus tolerance increases the amount or dimension to which it applies, or raises a level alignment, and minus tolerance decreases the amount or dimension to which it applied, or lowers a level alignment. A tolerance without sign means plus or minus. Where only one signed tolerance is specified, there is no limit in the other direction.

TOLERANCE FOR FINISHED FORMED CONCRETE SURFACES

(1) Vertical alignment

Formed surfaces slope with respect to the specified plane

All conditions ..... 10 mm in 3000 mm

(2) Abrupt variation
The offset between concrete surfaces for the following classes of surface:

Class A ..... 3 mm
Class B ..... 6 mm
Class C ..... 6 mm

TOLERANCE FOR FINISHED FORMED CONCRETE SURFACES

Class D ..... 25 mm

(3) Gradual variation

Surface finish tolerances as measured by placing a freestanding (unleveled), 1.5 m straightedge for plane surface or curved template for curved surface anywhere on the surface and allowing it to rest upon two high spots within 72 hr after concrete placement. The gap at any point between the straightedge or template and the surface shall not exceed:

Class A ..... 3 mm
Class B ..... 6 mm
Class C ..... 13 mm
Class D ..... 25 mm

TOLERANCES FOR CHANNEL LINING

(1) Lateral alignment

Alignment of tangents ..... 50 mm
Alignment of curves ..... 100 mm
Width of section at any height ..... 0.0025W + 25 mm

(2) Level alignment

Profile grade ..... 25 mm
Surface of invert ..... 6 mm
Height of lining ..... 0.005H + 25 mm

(3) Cross-sectional dimensions

Thickness of lining cross section: 10 percent specified thickness provided average thickness is maintained as determined by daily batch volumes.

1.5.2 Appearance

Permanently exposed surfaces shall be cleaned, if stained or otherwise discolored, by a method that does not harm the concrete and that is approved by the Contracting Officer.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

Cementitious materials shall be portland cement, or portland-pozzolan cement, and shall conform to appropriate specifications listed below.

2.1.1.1 Portland Cement

ASTM C 150, Type V low alkali.

2.1.1.2 High-Early-Strength Portland Cement

ASTM C 150, Type III, with C_3A limited to 8 percent low alkali, used only when specifically approved in writing.

2.1.1.3 Pozzolan, Other than Silica Fume

Pozzolan shall conform to ASTM C 618, Class F, with the optional requirements for multiple factor, drying shrinkage, and uniformity of Table 2A.

2.1.2 Aggregates

2.1.2.1 General

Concrete aggregates may be furnished from any source capable of meeting the quality requirements of ASTM C 33. No guarantee is given or implied that any of the listed sources are currently capable of producing aggregates that meet the requirements of ASTM C 33. Fine and coarse aggregates shall conform to the grading requirements of ASTM C 33. The nominal maximum size shall be as listed in paragraph NOMINAL MAXIMUM-SIZE COARSE AGGREGATE. Where the use of highway department gradations are permitted, proposed gradations shall be submitted for approval.

2.1.2.2 Concrete Aggregate Sources

a. List of Sources - The concrete aggregates sources may be selected from the following list:

Nevada Ready Mix	Lone Mountain Pit
CSR Materials	Buffalo Road Pit
Hanson Aggregates	Henderson

b. Selection of Source - After the award of the contract, the Contractor shall designate in writing only one source or combination of sources from which he proposes to furnish aggregates. If the Contractor proposes to furnish aggregates from a source or from sources not listed at the end of this section, he may designate only a single source or single combination of sources for aggregates. Regardless of the source, selected samples for acceptance testing shall be provided as required by paragraph GOVERNMENT TESTING AND SAMPLING. If a source for coarse or fine aggregates so designated by the Contractor does not meet the quality requirements stated in paragraph QUALITY, the Contractor may not submit for approval other non-listed sources but shall furnish the coarse or fine aggregate, as the case may be, from

sources listed above at no additional cost to the Government.

2.1.3 Chemical Admixtures

Chemical admixtures to be used, when required or permitted, shall conform to the appropriate specification listed.

2.1.3.1 Air-Entraining Admixture

The air-entraining admixture shall conform to ASTM C 260 and shall consistently cause the concrete to have an air content in the specified ranges under field conditions.

2.1.3.2 Accelerating Admixture

Accelerators shall meet the requirements of ASTM C 494/C 494M, Type C or E, except that calcium chloride or admixtures containing calcium chloride shall not be used.

2.1.3.3 Water-Reducing or Retarding Admixture

a. Water-Reducing or Retarding Admixtures: ASTM C 494/C 494M, Type A, B, or D, except that the 6-month and 1-year compressive strength tests are waived.

b. High-Range Water Reducing Admixture: ASTM C 494/C 494M, Type F or G except that the 6-month and 1-year strength requirements shall be waived. The admixture may be used only when approved by the Contracting Officer, such approval being contingent upon particular mixture control as described in the Contractor's Quality Control Plan.

2.1.4 Curing Materials

2.1.4.1 Membrane-Forming Curing Compound

The membrane-forming curing compound shall conform to ASTM C 309, Type 2, except a styrene acrylate or chlorinated rubber compound meeting Class B requirements shall be used for surfaces that are to be painted or are to receive bituminous roofing, or waterproofing, or floors that are to receive adhesive applications of resilient flooring. The curing compound selected shall be compatible with any subsequent paint, roofing, coating, or flooring specified. Nonpigmented compound shall contain a fugitive dye and shall have the reflective requirements in ASTM C 309 waived.

2.1.4.2 Burlap

Burlap used for curing shall conform to COE CRD-C 318.

2.1.5 Water

Water for mixing and curing shall be fresh, clean, potable, and free of injurious amounts of oil, acid, salt, or alkali, except that nonpotable water may be used if it meets the requirements of COE CRD-C 400.

2.1.6 Nonshrink Grout

Nonshrink grout shall conform to ASTM C 1107 and shall be a commercial formulation suitable for the application proposed.

2.1.7 Latex Bonding Compound

Latex bonding compound agents for bonding fresh to hardened concrete shall conform to ASTM C 1059.

2.1.8 Epoxy Resin

Epoxy resin for use in repairs shall conform to ASTM C 881, Type III, Grade I or II.

2.2 CONCRETE MIXTURE PROPORTIONING

2.2.1 Quality of Mixture

For each portion of the structure, mixture proportions shall be selected so that the strength and W/C requirements listed in paragraph DESIGN REQUIREMENTS are met.

2.2.2 Nominal Maximum-Size Coarse Aggregate

Nominal maximum-size coarse aggregate shall be 37.5 mm except 19.0 mm nominal maximum-size coarse aggregate shall be used when any of the following conditions exist: the narrowest dimension between sides of forms is less than 190 mm, the depth of the slab is less than 100 mm, or the minimum clear spacing between reinforcing is less than 55 mm.

2.2.3 Air Content

Air content as delivered to the forms and as determined by ASTM C 231 shall be between 4 and 7 percent except that when the nominal maximum-size coarse aggregate is 19.0 mm, it shall be between 4-1/2 and 7-1/2 percent.

2.2.4 Slump

The slump shall be determined in accordance with ASTM C 143/C 143M and shall be within the range of 25 mm to 100 mm. Where placement by pump is approved, the slump shall not exceed 150 mm.

2.2.5 Concrete Proportioning

Trial batches and testing requirements for various qualities of concrete specified shall be the responsibility of the Contractor. Samples of aggregates shall be obtained in accordance with the requirements of ASTM D 75. Samples of materials other than aggregate shall be representative of those proposed for the project and shall be accompanied by the manufacturer's test reports indicating compliance with applicable specified requirements. Trial mixtures having proportions, consistencies, and air content suitable for the work shall be made based on methodology described in ACI 211.1, using at least three different water-cement ratios, which

will produce a range of strength encompassing those required for the work. The maximum water-cement ratios required in paragraph MAXIMUM WATER-CEMENT RATIO will be converted to a weight ratio of water to cement plus pozzolan by mass, as described in ACI 211.1. If pozzolan is used in the concrete mixture, the minimum pozzolan content shall be 15 percent of the total cementitious material. Trial mixtures shall be proportioned for maximum permitted slump and air content with due consideration to the approved conveying and placement method. The temperature of concrete in each trial batch shall be reported. For each water-cement ratio, at least three test cylinders for each test age shall be made and cured in accordance with ASTM C 192/C 192M. They shall be tested at 7 days and at the design age specified in paragraph DESIGN REQUIREMENTS in accordance with ASTM C 39/C 39M. From these test results, a curve will be plotted showing the relationship between water-cement ratio and strength.

2.2.6 Required Average Compressive Strength

In meeting the strength requirements specified in paragraph CONCRETE STRENGTH, the selected mixture proportion shall produce a required average compressive strength f'cr exceeding the specified strength f'c by the amount indicated below.

2.2.6.1 Average Compressive Strength from Test Records

Where a concrete production facility has test records, a standard deviation shall be established in accordance with the applicable provisions of ACI 214. Test records from which a standard deviation is calculated shall represent materials, quality control procedures, and conditions similar to those expected, shall represent concrete produced to meet a specified strength or strengths (f'c) within 6.89 MPa of that specified for proposed work, and shall consist of at least 30 consecutive tests. A strength test shall be the average of the strengths of two cylinders made from the same sample of concrete and tested at 28 days or at another test age designated for determination of f'c.

Required average compressive strength f'cr used as the basis for selection of concrete proportions shall be the larger of the equations that follow using the standard deviation as determined above:

$$f'cr = f'c + 1.34S$$
$$f'cr = f'c + 2.33S - 3.45 \text{ MPa}$$

Where S = standard deviation

Where a concrete production facility does not have test records meeting the requirements above but does have a record based on 15 to 29 consecutive tests, a standard deviation shall be established as the product of the calculated standard deviation and a modification factor from the following table:

NUMBER OF TESTS*	MODIFICATION FACTOR FOR STANDARD DEVIATION Use tabulation in paragraph DETERMINING REQUIRED AVERAGE STRENGTH
less than 15	
15	1.16
20	1.08
25	1.03
30 or more	1.00

*Interpolate for intermediate numbers of tests.

2.2.6.2 Average Compressive Strength without Previous Test Records

When a concrete production facility does not have sufficient field strength test records for calculation of the standard deviation, the required average strength fcr shall be determined as follows:

If the specified compressive strength f'c is less than 20.7 MPa,

f'cr = f'c + 6.89 MPa

If the specified compressive strength f'c is 20.7 to 34.5 MPa,

f'cr = f'c + 8.27 MPa

If the specified compressive strength f'c is over 34.5 MPa,

f'cr = f'c + 9.65 MPa

PART 3 EXECUTION

3.1 EQUIPMENT

3.1.1 Capacity

The batching, mixing, conveying, and placing equipment shall have a capacity of at least 100 cubic meters per hour.

3.1.2 Batch Plant

Batch plant shall conform to the requirements of NRMCA CPMB 100 and as specified; however, rating plates attached to batch plant equipment are not required.

3.1.2.1 Batching Equipment

The batching controls shall be, semiautomatic. The semiautomatic batching system shall be provided with interlocks such that the discharge device cannot be actuated until the indicated material is within the applicable tolerance. The batching system shall be equipped with an accurate recorder or recorders that meet the requirements of NRMCA CPMB 100. Separate bins or compartments shall be provided for each size group of aggregate and cement, and pozzolan. Aggregates shall be weighed either in separate weigh

batchers with individual scales or cumulatively in one weigh batcher on one scale. Aggregate shall not be weighed in the same batcher with cement or pozzolan. If both cement and pozzolan are used, they may be batched cumulatively provided that the portland cement is batched first. If measured by mass, the mass of the water shall not be weighed cumulatively with another ingredient. Water batcher filling and discharging valves shall be so interlocked that the discharge valve cannot be opened before the filling valve is fully closed. An accurate mechanical device for measuring and dispensing each admixture shall be provided. Each dispenser shall be interlocked with the batching and discharging operation of the water so that each admixture is separately batched and discharged automatically in a manner to obtain uniform distribution throughout the batch in the specified mixing period. Admixtures shall not be combined prior to introduction in water. The plant shall be arranged so as to facilitate the inspection of all operations at all times. Suitable facilities shall be provided for obtaining representative samples of aggregates from each bin or compartment. All filling ports for cementitious materials bins or silos shall be clearly marked with a permanent sign stating the contents.

3.1.2.2 Scales

The equipment for batching by mass shall conform to the applicable requirements of NIST HB 44, except that the accuracy shall be plus or minus 0.2 percent of scale capacity. The Contractor shall provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring devices. Tests shall be made at the frequency required in paragraph TESTS AND INSPECTIONS, and in the presence of a government inspector.

3.1.2.3 Batching Tolerances

a. Weighing Tolerances

MATERIAL	PERCENT OF REQUIRED MASS
Cementitious materials	0 to plus 2
Aggregate	plus or minus 2
Water	plus or minus 1
Chemical admixture	0 to plus 6

b. Volumetric Tolerances - For volumetric batching equipment, the following tolerances shall apply to the required volume of material being batched:

Water: ..... Plus or minus 1 percent.
Chemical admixtures: ..... Zero to plus 6 percent.

3.1.2.4 Moisture Control

The plant shall be capable of ready adjustment to compensate for the varying moisture content of the aggregates and to change the masses of the materials being batched. An electric moisture meter complying with the provisions of COE CRD-C 143 shall be provided for measuring moisture in the

fine aggregate. The sensing element shall be arranged so that the measurement is made near the batcher charging gate of the sand bin or in the sand batcher.

3.1.3 Concrete Mixers

The concrete mixers shall not be charged in excess of the capacity recommended by the manufacturer. The mixers shall be operated at the drum or mixing blade speed designated by the manufacturer. The mixers shall be maintained in satisfactory operating condition, and the mixer drums shall be kept free of hardened concrete. Should any mixer at any time produce unsatisfactory results, its use shall be promptly discontinued until it is repaired.

3.1.3.1 Stationary Mixers

Concrete plant mixers shall be tilting, nontilting, horizontal-shaft, vertical-shaft, or pugmill and shall be provided with an acceptable device to lock the discharge mechanism until the required mixing time has elapsed. The mixing time and uniformity shall conform to all the requirements in ASTM C 94/C 94M applicable to central-mixed concrete.

3.1.3.2 Truck Mixers

Truck mixers, the mixing of concrete therein, and concrete uniformity shall conform to the requirements of ASTM C 94/C 94M. A truck mixer may be used either for complete mixing (transit-mixed) or to finish the partial mixing done in a stationary mixer (shrink-mixed). Each truck shall be equipped with two counters from which it will be possible to determine the number of revolutions at mixing speed and the number of revolutions at agitating speed.

3.1.4 Conveying Equipment

The conveying equipment shall conform to the following requirements.

3.1.4.1 Buckets

The interior hopper slope shall be not less than 58 degrees from the horizontal, the minimum dimension of the clear gate opening shall be at least five times the nominal maximum-size aggregate, and the area of the gate opening shall not be less than 0.2 square meter. The maximum dimension of the gate opening shall not be greater than twice the minimum dimension. The bucket gates shall be essentially grout tight when closed and may be manually, pneumatically, or hydraulically operated except that buckets larger than 1.5 cubic meters shall not be manually operated. The design of the bucket shall provide means for positive regulation of the amount and rate of deposit of concrete in each dumping position.

3.1.4.2 Transfer Hoppers

Concrete may be charged into nonagitating hoppers for transfer to other conveying devices. Transfer hoppers shall be capable of receiving concrete directly from delivery vehicles and have conical-shaped discharge features.

The transfer hopper shall be equipped with a hydraulically operated gate and with a means of external vibration to effect complete discharge. Concrete shall not be held in nonagitating transfer hoppers more than 30 minutes.

3.1.4.3 Trucks

Truck mixers operating at agitating speed or truck agitators used for transporting plant-mixed concrete shall conform to the requirements of ASTM C 94/C 94M. Nonagitating equipment may be used for transporting plant-mixed concrete over a smooth road when the hauling time is less than 15 minutes. Bodies of nonagitating equipment shall be smooth, watertight, metal containers specifically designed to transport concrete, shaped with rounded corners to minimize segregation, and equipped with gates that will permit positive control of the discharge of the concrete.

3.1.4.4 Chutes

When concrete can be placed directly from a truck mixer, agitator, or nonagitating equipment, the chutes attached to this equipment by the manufacturer may be used. A discharge deflector shall be used when required by the Contracting Officer. Separate chutes and other similar equipment will not be permitted for conveying concrete.

3.1.4.5 Belt Conveyors

Belt conveyors shall be designed and operated to assure a uniform flow of concrete from mixer to final place of deposit without segregation of ingredients or loss of mortar and shall be provided with positive means for preventing segregation of the concrete at the transfer points and the point of placing. Belt conveyors shall be constructed such that the idler spacing shall not exceed 900 mm. The belt speed shall be a minimum of 90 m per minute and a maximum of 230 m per minute. If concrete is to be placed through installed horizontal or sloping reinforcing bars, the conveyor shall discharge concrete into a pipe or elephant trunk that is long enough to extend through the reinforcing bars.

3.1.4.6 Concrete Pumps

Concrete may be conveyed by positive displacement pump when approved. The pumping equipment shall be piston or squeeze pressure. The pipeline shall be rigid steel pipe or heavy-duty flexible hose. The inside diameter of the pipe shall be at least three times the nominal maximum-size coarse aggregate in the concrete mixture to be pumped but not less than 100 mm. Aluminum pipe shall not be used.

3.1.5 Vibrators

Vibrators of the proper size, frequency, and amplitude shall be used for the type of work being performed in conformance with the following requirements:

APPLICATION	HEAD DIAMETER mm	FREQUENCY VPM	AMPLITUDE mm
Thin walls, beams, etc.	32 to 64	9,000 to 13,500	0.5 to 1.0
General construction	50 to 88	8,000 to 12,000	0.6 to 1.2

The frequency and amplitude shall be determined in accordance with COE CRD-C 521.

3.2 PREPARATION FOR PLACING

3.2.1 Embedded Items

Before placement of concrete, care shall be taken to determine that all embedded items are firmly and securely fastened in place as indicated on the drawings, or required. Embedded items shall be free of oil and other foreign matter such as loose coatings or rust, paint, and scale. The embedding of wood in concrete will be permitted only when specifically authorized or directed. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable materials to prevent the entry of concrete into voids. Welding, including tack welding, will not be permitted on embedded metals within 600 mm of the surface of the concrete.

3.2.2 Concrete on Earth Foundations

Earth surfaces upon which concrete is to be placed shall be clean, damp, and free from debris, frost, ice, and standing or running water. Prior to placement of concrete, the earth foundation shall have been satisfactorily compacted in accordance with Section 02300 EARTHWORK.

3.2.3 Concrete on Rock Foundations

Rock surfaces upon which concrete is to be placed shall be clean, free from oil, standing or running water, ice, mud, drummy rock, coating, debris, and loose, semidetached, or unsound fragments. Joints in rock shall be cleaned to a satisfactory depth, as determined by the Contracting Officer, and to firm rock on the sides. Immediately before the concrete is placed, all rock surfaces shall be cleaned thoroughly by the use of air-water jets or sandblasting as described in paragraph CONSTRUCTION JOINT TREATMENT. All rock surfaces shall be kept continuously wet for at least 24 hours immediately prior to placing concrete thereon. All approximately horizontal surfaces shall be covered, immediately before the concrete is placed, with a layer of mortar proportioned similar to that in the concrete mixture. The mortar shall be covered with concrete before the time of initial setting of the mortar.

3.2.4 Construction Joint Treatment

Construction joint treatment shall conform to the following requirements.

3.2.4.1 Joint Preparation

Concrete surfaces to which additional concrete is to be bonded shall be

prepared for receiving the next lift or adjacent concrete by cleaning with either air-water cutting, sandblasting, high-pressure water jet, or other approved method. Air-water cutting will not be permitted on formed surfaces or surfaces congested with reinforcing steel. Regardless of the method used, the resulting surfaces shall be free from all laitance and inferior concrete so that clean, well bonded coarse aggregate is exposed uniformly throughout the lift surface. The edges of the coarse aggregate shall not be undercut. The surface shall be washed clean again as the last operation prior to placing the next lift. There shall be no standing water on the surface upon which concrete is placed.

3.2.4.2 Air-Water Cutting

Air-water cutting of a construction joint shall be performed at the proper time and only on horizontal construction joints. The air pressure used in the jet shall be 620 to 760 kPa, and the water pressure shall be just sufficient to bring the water into effective influence of the air pressure. When approved by the Contracting Officer, a retarder complying with the requirements of COE CRD-C 94 may be applied to the surface of the lift to prolong the period of time during which air-water cutting is effective. Prior to receiving approval, the Contractor shall furnish samples of the material to be used and shall demonstrate the method to be used in applications. After cutting, the surface shall be washed and rinsed as long as there is any trace of cloudiness of the wash water. Where necessary to remove accumulated laitance, coatings, stains, debris, and other foreign material, high-pressure water jet or sandblasting will be required as the last operation before placing the next lift.

3.2.4.3 High-Pressure Water Jet

A stream of water under a pressure of not less than 20.7 MPa may be used for cleaning. Its use shall be delayed until the concrete is sufficiently hard so that only the surface skin or mortar is removed and there is no undercutting of coarse-aggregate particles. If the water jet is incapable of a satisfactory cleaning, the surface shall be cleaned by sandblasting.

3.2.4.4 Wet Sandblasting

This method may be used when the concrete has reached sufficient strength to prevent undercutting of the coarse aggregate particles. The surface of the concrete shall then be washed thoroughly to remove all loose materials.

3.2.4.5 Waste Disposal

The method used in disposing of waste water employed in cutting, washing, and rinsing of concrete surfaces shall be such that the waste water does not stain, discolor, or affect exposed surfaces of the structures, or damage the environment of the project area. The method of disposal shall be subject to approval.

3.3 PLACING

3.3.1 Placing Procedures

The surfaces of horizontal construction joints shall be kept continuously wet for the first 12 hours during the 24-hour period prior to placing concrete. Surfaces may be dampened immediately before placement if necessary. Concrete placement will not be permitted when, in the opinion of the Contracting Officer, weather conditions prevent proper placement and consolidation. Concrete shall be deposited as close as possible to its final position in the forms and, in so depositing, there shall be no vertical drop greater than 1.5 m except where suitable equipment is provided to prevent segregation and where specifically authorized. Depositing of the concrete shall be so regulated that it may be effectively consolidated in horizontal layers 600 mm or less in thickness with a minimum of lateral movement. The amount deposited in each location shall be that which can be readily and thoroughly consolidated. Sufficient placing capacity shall be provided so that concrete placement can be kept plastic and free of cold joints while concrete is being placed. Concrete shall be placed by methods that will prevent segregation or loss of ingredients. Any concrete transferred from one conveying device to another shall be passed through a hopper that is conical in shape. The concrete shall not be dropped vertically more than 1.5 m, except where a properly designed and sized elephant truck with rigid drop chute bottom section is provided to prevent segregation and where specifically authorized. In no case will concrete be discharged to free-fall through reinforcing bars.

3.3.2 Placement by Pump

When concrete is to be placed by pump, the nominal maximum-size coarse aggregate shall not be reduced to accommodate the pumps. The distance to be pumped shall not exceed limits recommended by the pump manufacturer. The concrete shall be supplied to the concrete pump continuously. When pumping is completed, concrete remaining in the pipeline shall be ejected without contamination of concrete in place. After each operation, equipment shall be thoroughly cleaned, and flushing water shall be wasted outside of the forms. Grout used to lubricate the pumping equipment at the beginning of the placement will not be incorporated into the placement.

3.3.3 Time Interval Between Mixing and Placing

Concrete shall be placed within 30 minutes after discharge into nonagitating equipment. When concrete is truck-mixed or when a truck mixer or agitator is used for transporting concrete mixed by a concrete plant mixer, the concrete shall be delivered to the site of the work, and discharge shall be completed within 1-1/2 hours or before the drum has revolved 300 revolutions, whichever comes first after the introduction of the mixing water to the cement and aggregates or the introduction of the cement to the aggregates. When the length of haul makes it impossible to deliver truck-mixed concrete within these time limits, batching of cement and a portion of the mixing water shall be delayed until the truck mixer is at or near the construction site.

3.3.4 Cold-Weather Placing

When cold-weather placing of concrete is likely to be subjected to freezing temperatures before the expiration of the curing period, it shall be placed in accordance with procedures previously submitted in accordance with

paragraph SUBMITTALS. The ambient temperature of the space adjacent to the concrete placement and surfaces to receive concrete shall be above 0 degrees C. The placing temperature of the concrete having a minimum dimension less than 300 mm shall be between 12 and 24 degrees C when measured in accordance with ASTM C 1064/C 1064M. The placing temperature of the concrete having a minimum dimension greater than 300 mm shall be between 10 and 20 degrees C. Heating of the mixing water or aggregates will be required to regulate the concrete-placing temperatures. Materials entering the mixer shall be free from ice, snow, or frozen lumps. Salt, chemicals, or other materials shall not be mixed with the concrete to prevent freezing.

3.3.5 Hot-Weather Placing

Concrete shall be properly placed and finished with procedures previously submitted in accordance with paragraph SUBMITTALS. The concrete-placing temperature shall not exceed 30 degrees C when measured in accordance with ASTM C 1064/C 1064M. Cooling of the mixing water and aggregates, or both, may be required to obtain an adequate placing temperature. A retarder meeting the requirements of paragraph WATER-REDUCING OR RETARDING ADMIXTURE may be used to facilitate placing and finishing. Steel forms and reinforcement shall be cooled prior to concrete placement when steel temperatures are greater than 50 degrees C. Conveying and placing equipment shall be cooled if necessary to maintain proper concrete-placing temperature.

3.3.6 Consolidation

Immediately after placement, each layer of concrete, including flowing concrete, shall be consolidated by internal vibrating equipment. Vibrators shall not be used to transport concrete within the forms. Hand spading may be required, if necessary, with internal vibrating along formed surfaces permanently exposed to view. Form or surface vibrators shall not be used unless specifically approved. The vibrator shall be inserted vertically at uniform spacing over the entire area of placement. The distance between insertions shall be approximately 1-1/2 times the radius of action of the vibrator. The vibrator shall penetrate rapidly to the bottom of the layer and at least 150 mm into the preceding unhardened layer if such exists. It shall be held stationary until the concrete is consolidated and then withdrawn slowly.

3.4 FINISHING

The ambient temperature of spaces adjacent to surfaces being finished shall be not less than 5 degrees C. In hot weather when the rate of evaporation of surface moisture, as determined by use of Figure 2.1.5 of ACI 305R, may reasonably be expected to exceed 1.0 kilogram per square meter per hour. Provisions for windbreaks, shading, fog spraying, or wet covering with a light-colored material shall be made in advance of placement, and such protective measures shall be taken as quickly as finishing operations will allow. All unformed surfaces that are not to be covered by additional concrete or backfill shall have a float finish. Additional finishing shall be as specified below and shall be true to the elevation shown in the drawings. Surfaces to receive additional concrete or backfill shall be

brought to the elevation shown on the drawings and left true and regular. Exterior surfaces shall be sloped for drainage unless otherwise shown in the drawing or as directed. Joints shall be carefully made with a jointing or edging tool. The finished surfaces shall be protected from stains or abrasions. Grate tampers or jitterbugs shall not be used.

3.4.1 Unformed Surfaces

3.4.1.1 Float Finish

Surfaces shall be screeded and darbied or bullfloated to bring the surface to the required finish level with no coarse aggregate visible. No water, cement, or mortar shall be added to the surface during the finishing operation. The concrete, while still green but sufficiently hardened to bear a man's weight without deep imprint, shall be floated to a true and even plane. Floating may be performed by use of suitable hand floats or power-driven equipment. Hand floats shall be made of magnesium or aluminum.

3.4.1.2 Trowel Finish

A trowel finish shall be applied to the top of channel walls. Concrete surfaces shall be finished with a float finish, and after surface moisture has disappeared, the surface shall be troweled to a smooth, even, dense finish free from blemishes including trowel marks.

3.4.1.3 Broom Finish

A broom finish shall be applied to the face and surfaces of concrete channel inverts, and sidewalls. The concrete surface shall be screeded and floated finish plane with no coarse aggregate visible. After surface moisture disappears, the surface shall be broomed or brushed screeded and fine hair-broom or fiber bristle brushed in a direction transverse to that of the channel centerline for all invert side slope areas, or as directed.

3.4.2 Formed Surfaces

Unless another finish is specified, surfaces shall be left with the texture imparted by the forms except that defective surfaces shall be repaired as described in paragraph FORMED SURFACE REPAIR.

Uniform color of the concrete shall be maintained by use of only one mixture without changes in materials or proportions for any structure or portion of structure that is exposed to view or on which a special finish is required. The form panels used to produce the finish shall be orderly in arrangement. Forms shall not be reused if there is any evidence of surface wear or defects that would impair the quality of the surface.

3.4.3 Formed Surface Repair

After removal of forms, all ridges, lips, and bulges on surfaces permanently exposed shall be removed. All repairs shall be completed within 48 hours after form removal.

3.4.3.1 Class A Finishes

Surfaces listed in Section 03101 FORMWORK FOR CONCRETE and as shown to have class A finishes shall have surface defects repaired as follows: defective areas, voids, and honeycombs smaller than 10,000 square millimeters in area and less than 13 mm deep and bug holes exceeding 13 mm in diameter shall be chipped and filled with dry-packed mortar. Holes left by removal of tie rods shall be reamed and filled with dry-packed mortar as specified in paragraph MATERIAL AND PROCEDURE FOR REPAIRS. Defective and unsound concrete areas larger than described shall be defined by 13 mm deep dovetailed saw cuts in a rectangular pattern with lines parallel to the formwork, the defective concrete removed by chipping, and the void repaired with replacement concrete. The prepared area shall be brush-coated with an epoxy resin meeting the requirements of paragraph EPOXY RESIN, a latex bonding agent meeting the requirements of paragraph LATEX BONDING COMPOUND, or a neat cement grout after dampening the area with water. The void shall be filled with replacement concrete in accordance with paragraph MATERIAL AND PROCEDURE FOR REPAIRS.

3.4.3.2 Class D Finish

Surfaces listed in Section 03101 FORMWORK FOR CONCRETE and as shown to have class D finish shall have surface defects repaired as follows: defective areas, voids, and honeycombs greater than 30,000 square millimeters in area or more than 50 mm deep shall be defined by 13 mm deep dovetailed saw cuts in a rectangular pattern, the defective concrete removed by chipping and the void repaired with replacement concrete. The prepared area shall be brush-coated with an epoxy resin meeting the requirements of paragraph EPOXY RESIN, a latex bonding agent meeting the requirements of paragraph LATEX BONDING COMPOUND, or a neat cement grout after dampening the area with water. The void shall be filled with replacement concrete in accordance with paragraph MATERIAL AND PROCEDURE FOR REPAIRS.

3.4.3.3 Material and Procedure for Repairs

The cement used in the dry-packed mortar or replacement concrete shall be a blend of the cement used for production of project concrete and white portland cement properly proportioned so that the final color of the mortar or concrete will match adjacent concrete. Trial batches shall be used to determine the proportions required to match colors. Dry-packed mortar shall consist of one part cement to two and one-half parts fine aggregate. The fine aggregate shall be that used for production of project concrete. The mortar shall be remixed over a period of at least 30 minutes without addition of water until it obtains the stiffest consistency that will permit placing. Mortar shall be thoroughly compacted into the prepared void by tamping, rodding, ramming, etc. and struck off to match adjacent concrete. Replacement concrete shall be produced using project materials and shall be proportioned by the Contracting Officer. It shall be thoroughly compacted into the prepared void by internal vibration, tamping, rodding, ramming, etc. and shall be struck off and finished to match adjacent concrete. Forms shall be used to confine the concrete. If an expanding agent is used in the repair concrete, the repair shall be thoroughly confined on all sides including the top surface. Metal tools shall not be used to finish permanently exposed surfaces. The repaired areas shall be cured for 7 days. The temperature of the in situ concrete,

adjacent air, and replacement mortar or concrete shall be above 5 degrees C during placement, finishing, and curing. Other methods and materials for repair may be used only when approved in writing by the Contracting Officer. Repairs of the so called "plaster-type" will not be permitted.

3.5 CURING AND PROTECTION

3.5.1 Duration

Concrete shall be cured by an approved method for a period of 7 days.

Immediately after placement, concrete shall be protected from premature drying, extremes in temperatures, rapid temperature change, and mechanical damage. All materials and equipment needed for adequate curing and protection shall be available and at the placement site prior to the start of concrete placement. Concrete shall be protected from the damaging effects of rain for 12 hours and from flowing water for 14 days. No fire or excessive heat including welding shall be permitted near or in direct contact with concrete or concrete embedments at any time.
Text

3.5.2 Moist Curing

Moist-cured concrete shall be maintained continuously, not periodically, wet for the entire curing period. If water or curing materials stain or discolor concrete surfaces that are to be permanently exposed, they shall be cleaned as required in paragraph APPEARANCE. Where wooden form sheathing is left in place during curing, the sheathing shall be kept wet at all times. Where steel forms are left in place during curing, the forms shall be carefully broken loose from the hardened concrete and curing water continuously applied into the void so as to continuously saturate the entire concrete surface. Horizontal surfaces may be moist cured by ponding, by covering with a minimum uniform thickness of 50 mm of continuously saturated sand, or by covering with saturated nonstaining burlap or cotton mats. Horizontal construction joints may be allowed to dry for 12 hours immediately prior to the placing of the following lift.

3.5.3 Membrane-Forming Curing Compound

Concrete may be cured with an approved membrane-forming curing compound in lieu of moist curing except that membrane curing will not be permitted on any surface containing protruding steel reinforcement.

3.5.3.1 Pigmented Curing Compound

A pigmented curing compound meeting the requirements of the above paragraph MEMBRANE-FORMING CURING COMPOUND may be used on surfaces that will not be exposed to view when the project is completed.

3.5.3.2 Nonpigmented Curing Compound

A nonpigmented curing compound containing a fugitive dye may be used on surfaces that will be exposed to view when the project is completed. Concrete cured with nonpigmented curing compound must be shaded from the

sun for the first 3 days when the ambient temperature is 32 degrees C or higher.

3.5.3.3 Application

The curing compound shall be applied to formed surfaces immediately after the forms are removed and prior to any patching or other surface treatment except the cleaning of loose sand, mortar, and debris from the surface. The surfaces shall be thoroughly moistened with water, and the curing compound applied as soon as free water disappears. The curing compound shall be applied to unformed surfaces as soon as free water has disappeared and bleeding has stopped. The curing compound shall be applied in a two-coat continuous operation by approved motorized power-spraying equipment operating at a minimum pressure of 500 kPa, at a uniform coverage of not more than 10 square meters per liter for each coat, and the second coat shall be applied perpendicular to the first coat. Concrete surfaces that have been subjected to rainfall within 3 hours after curing compound has been applied shall be resprayed by the method and at the coverage specified. All concrete surfaces on which the curing compound has been applied shall be adequately protected for the duration of the entire curing period from pedestrian and vehicular traffic and from any other cause that will disrupt the continuity of the curing membrane.

3.5.4 Evaporation Retardant

Sheet curing shall not be used on vertical or near-vertical surfaces. All surfaces shall be thoroughly wetted and be completely covered with waterproof paper or polyethylene-coated burlap having the burlap thoroughly water-saturated before placing. Covering shall be laid with light-colored side up. Covering shall be lapped not less than 300 mm and securely weighted down or shall be lapped not less than 100 mm and taped to form a continuous cover with completely closed joints. The sheet shall be weighted to prevent displacement so that it remains in contact with the concrete during the specified length of curing. Coverings shall be folded down over exposed edges of slabs and secured by approved means. Sheets shall be immediately repaired or replaced if tears or holes appear during the curing period.

3.5.5 Cold-Weather Curing and Protection

When the daily outdoor low temperature is less than 0 degrees C, the temperature of the concrete shall be maintained above 5 degrees C for the first 7 days after placing. In addition, during the period of protection removal, the air temperature adjacent to the concrete surfaces shall be controlled so that concrete near the surface will not be subjected to a temperature differential of more than 15 degrees C as determined by observation of ambient and concrete temperatures indicated by suitable temperatures measuring devices furnished by the Government as required and installed adjacent to the concrete surface and 50 mm inside the surface of the concrete. The installation of the thermometers shall be made by the Contractor at such locations as may be directed.

3.6 SETTING OF POSTS, BASE PLATES, AND BEARING PLATES

3.6.1 Setting of Posts and Plates

After being plumbed and properly positioned, posts, column base plates, bearing plates for beams and similar structural members, and machinery and equipment base plates shall be provided with full bearing with nonshrink grout. The space between the top of concrete or masonry-bearing surface and the bottom of the plate shall be approximately 1/24 of the width of the plate, but not less than 13 mm for plates less than 300 mm wide. Concrete surfaces shall be rough, clean, and free of oil, grease, and laitance, and they shall be damp. Metal surfaces shall be clean and free of oil, grease, and rust.

3.6.2 Nonshrink Grout Application

Nonshrink grout shall conform to the requirements of paragraph NONSHRINK GROUT. Water content shall be the minimum that will provide a flowable mixture and fill the space to be grouted without segregation, bleeding, or reduction of strength.

3.6.2.1 Mixing and Placing of Nonshrink Grout

Mixing and placing shall be in conformance with the material manufacturer's instructions and as specified. Ingredients shall be thoroughly dry-mixed before adding water. After adding water, the batch shall be mixed for 3 minutes. Batches shall be of size to allow continuous placement of freshly mixed grout. Grout not used within 30 minutes after mixing shall be discarded. The space between the top of the concrete or masonry-bearing surface and the plate shall be filled solid with the grout. Forms shall be of wood or other equally suitable material for retaining the grout and shall be removed after the grout has set. If grade "A" grout as specified in ASTM C 1107 is used, all surfaces shall be formed to provide restraint. The placed grout shall be worked to eliminate voids; however, overworking and breakdown of the initial set shall be avoided. Grout shall not be retempered or subjected to vibration from any source. Where clearances are unusually small, placement shall be under pressure with a grout pump. Temperature of the grout, and of surfaces receiving the grout, shall be maintained at 20 to 30 degrees C until after setting.

3.6.2.2 Treatment of Exposed Surfaces

After the grout has set, those types containing metallic aggregate shall have the exposed surfaces cut back 25 mm and immediately covered with a parge coat of mortar proportioned by mass of one part portland cement, two parts sand, and sufficient water to make the mixture placeable. The parge coat shall have a smooth, dense finish. The exposed surface of other types of nonshrink grout shall have a smooth, dense finish.

3.6.2.3 Curing

Grout and parge coats shall be cured in conformance with paragraph CURING AND PROTECTION.

3.7 TESTS AND INSPECTIONS

Tests and inspections shall conform to the following requirements. Test Results and Inspection Reports are to be submitted to the Government as required.

3.7.1 General

The Contractor shall perform the inspections and tests described below, and, based upon the results of these inspections and tests, he shall take the action required and submit reports as required. When, in the opinion of the Contracting Officer, the concreting operation is out of control, concrete placement shall cease. The laboratory performing the tests shall be on site and shall conform with ASTM C 1077. The individuals who sample and test concrete or the constituents of concrete as required in this specification shall have demonstrated a knowledge and ability to perform the necessary test procedures equivalent to the ACI minimum guidelines for certification of Concrete Field Testing Technicians, Grade I. The individuals who perform the inspection of concrete construction shall have demonstrated a knowledge and ability equivalent to the ACI minimum guidelines for certification of Concrete Transportation Construction Inspector (CTCI). The Government will inspect the laboratory, equipment, and test procedures prior to start of concreting operations and at least once per year thereafter for conformance with ASTM C 1077.

3.7.2 Testing and Inspection Requirements

3.7.2.1 Fine Aggregate

a. Grading - At least once during each shift when the concrete plant is operating, there shall be one sieve analysis and fineness modulus determination in accordance with ASTM C 136 and COE CRD-C 104 for the fine aggregate or for each size range of fine aggregate if it is batched in more than one size or classification. The location at which samples are taken may be selected by the Contractor as the most advantageous for control. However, the Contractor is responsible for delivering fine aggregate to the mixer within specification limits.

b. Corrective Action for Fine Aggregate Grading - When the amount passing on any sieve is outside the specification limits, the fine aggregate shall be immediately resampled and retested. If there is another failure on any sieve, the fact shall immediately be reported to the Contracting Officer.

c. Moisture Content Testing - When in the opinion of the Contracting Officer the electric moisture meter is not operating satisfactorily, there shall be at least four tests for moisture content in accordance with ASTM C 566 during each 8-hour period of mixing plant operation. The times for the tests shall be selected randomly within the 8-hour period. An additional test shall be made whenever the slump is shown to be out of control or excessive variation in workability is reported by the placing foreman. When the electric moisture meter is operating satisfactorily, at least two direct measurements of moisture content shall be made per week to check the calibration of the meter. The results of tests for moisture content shall be used to adjust the added water in the control of the batch plant.

d. Moisture Content Corrective Action - Whenever the moisture content of the fine aggregate changes by 0.5 percent or more, the scale settings for the fine-aggregate batcher and water batcher shall be adjusted (directly or by means of a moisture compensation device) if necessary to maintain the specified slump.

3.7.2.2 Coarse Aggregate

a. Grading - At least once during each shift in which the concrete plant is operating, there shall be a sieve analysis in accordance with ASTM C 136 for each size of coarse aggregate. The location at which samples are taken may be selected by the Contractor as the most advantageous for production control. However, the Contractor shall be responsible for delivering the aggregate to the mixer within specification limits. A test record of samples of aggregate taken at the same locations shall show the results of the current test as well as the average results of the five most recent tests including the current test. The Contractor may adopt limits for control which are coarser than the specification limits for samples taken at locations other than as delivered to the mixer to allow for degradation during handling.

b. Corrective Action for Grading - When the amount passing any sieve is outside the specification limits, the coarse aggregate shall be immediately resampled and retested. If the second sample fails on any sieve, that fact shall be reported to the Contracting Officer. Where two consecutive averages of five tests are outside specification limits, the operation shall be considered out of control and shall be reported to the Contracting Officer. Concreting shall be stopped and immediate steps shall be taken to correct the grading.

c. Coarse Aggregate Moisture Content - A test for moisture content of each size group of coarse aggregate shall be made at least twice per week. When two consecutive readings for smallest size coarse aggregate differ by more than 1.0 percent, frequency of testing shall be increased to that specified above for fine aggregate, until the difference falls below 1.0 percent.

d. Coarse Aggregate Moisture Corrective Action - Whenever the moisture content of any size of coarse aggregate changes by 0.5 percent or more, the scale setting for the coarse aggregate batcher and the water batcher shall be adjusted if necessary to maintain the specified slump.

3.7.2.3 Quality of Aggregates

a. Frequency of Quality Tests - Thirty days prior to the start of concrete placement the Contractor shall perform all tests for aggregate quality listed below. In addition, after the start of concrete placement, the Contractor shall perform tests for aggregate quality in accordance with the frequency schedule shown below. Samples tested after the start of concrete placement shall be taken immediately prior to entering the concrete mixer.

PROPERTY	FREQUENCY FINE AGGREGATE	FREQUENCY COARSE AGGREGATE	TEST
Specific Gravity	Every 3 months	Every 3 months	ASTM C 127 ASTM C 128
Absorption	Every 3 months	Every 3 months	ASTM C 127 ASTM C 128
Impurities	Every 3 months	Not applicable	ASTM C 40 ASTM C 87

b. Corrective Action for Aggregate Quality - If the result of a quality test fails to meet the requirements for quality immediately prior to start of concrete placement, production procedures or materials shall be changed and additional tests shall be performed until the material meets the quality requirements prior to proceeding with either mixture proportioning studies or starting concrete placement. After concrete placement commences, whenever the result of a test for quality fails the requirements, the test shall be rerun immediately. If the second test fails the quality requirement, the fact shall be reported to the Contracting Officer and immediate steps taken to rectify the situation.

3.7.2.4 Scales

a. Weighing Accuracy - The accuracy of the scales shall be checked by test weights prior to start of concrete operations and at least once every 3 months for conformance with the applicable requirements of paragraph BATCHING EQUIPMENT. Such tests shall also be made as directed whenever there are variations in properties of the fresh concrete that could result from batching errors.

b. Batching and Recording Accuracy - Once a week the accuracy of each batching and recording device shall be checked during a weighing operation by noting and recording the required weight, recorded weight, and the actual weight batched. The Contractor shall confirm that the calibration devices described in paragraph BATCH PLANT for checking the accuracy of dispensed admixtures are operating properly.

c. Scales Corrective Action - When either the weighing accuracy or batching accuracy does not comply with specification requirements, the plant shall not be operated until necessary adjustments or repairs have been made. Discrepancies in recording accuracies shall be corrected immediately.

3.7.2.5 Batch-Plant Control

The measurement of all constituent materials including cementitious materials, each size of aggregate, water, and admixtures shall be continuously controlled. The aggregate weights and amount of added water shall be adjusted as necessary to compensate for free moisture in the aggregates. The amount of air-entraining agent shall be adjusted to

control air content within specified limits. A report shall be prepared indicating type and source of cement used, type and source of pozzolan or slag used, amount and source of admixtures used, aggregate source, the required aggregate and water weights per cubic meter, amount of water as free moisture in each size of aggregate, and the batch aggregate and water weights per cubic meter for each class of concrete batched during plant operation.

3.7.2.6 Concrete Mixture

a. Air Content Testing - Air content tests shall be made when test specimens are fabricated. In addition, at least two tests for air content shall be made on randomly selected batches of each separate concrete mixture produced during each 8-hour period of concrete production. Additional tests shall be made when excessive variation in workability is reported by the placing foreman or Government quality assurance representative. Tests shall be made in accordance with ASTM C 231. Test results shall be plotted on control charts which shall at all times be readily available to the Government. Copies of the current control charts shall be kept in the field by the Contractor's quality control representatives and results plotted as tests are made. When a single test result reaches either the upper or lower action limit a second test shall immediately be made. The results of the two tests shall be averaged and this average used as the air content of the batch to plot on both the control chart for air content and the control chart for range, and for determining the need for any remedial action. The result of each test, or average as noted in the previous sentence, shall be plotted on a separate chart for each mixture on which an "average line" is set at the midpoint of the specified air content range from paragraph AIR CONTENT. An upper warning limit and a lower warning limit line shall be set 1.0 percentage point above and below the average line. An upper action limit and a lower action limit line shall be set 1.5 percentage points above and below the average line, respectively. The range between each two consecutive tests shall be plotted on a control chart for range where an upper warning limit is set at 2.0 percentage points and up upper action limit is set at 3.0 percentage points. Samples for air content may be taken at the mixer, however, the Contractor is responsible for delivering the concrete to the placement site at the stipulated air content. If the Contractor's materials or transportation methods cause air content loss between the mixer and the placement, correlation samples shall be taken at the placement site as required by the Contracting Officer and the air content at the mixer controlled as directed.

b. Air Content Corrective Action - Whenever points on the control chart for percent air reach either warning limit, an adjustment shall immediately be made in the amount of air-entraining admixture batched. As soon as is practical after each adjustment, another test shall be made to verify the result of the adjustment. Whenever a point on the control chart range reaches the warning limit, the admixture dispenser shall be recalibrated to ensure that it is operating accurately and with good reproducibility. Whenever a point on either control chart reaches an action limit line, the air content shall be considered out of control and the concreting operation shall immediately be halted

until the air content is under control. Additional air content tests shall be made when concreting is restarted. All this shall be at no extra cost to the Government.

c. Slump Testing - In addition to slump tests which shall be made when test specimens are fabricated, at least four slump tests shall be made on randomly selected batches in accordance with ASTM C 143/C 143M for each separate concrete mixture produced during each 8-hour or less period of concrete production each day. Also, additional tests shall be made when excessive variation in workability is reported by the placing foreman or Government's quality assurance representative. Test results shall be plotted on control charts which shall at all times be readily available to the Government. Copies of the current control charts shall be kept in the field by the Contractor's quality control representatives and results plotted as tests are made. When a single slump test reaches or goes beyond either the upper or lower action limit, a second test shall immediately be made on the same batch of concrete. The results of the two tests shall be averaged and this average used as the slump of the batch to plot on both the control chart for percent air and the chart for range, and for determining the need for any remedial action. An upper warning limit shall be set at 13 mm below the maximum allowable slump on separate control charts for percent air used for each type of mixture as specified in paragraph SLUMP, and an upper action limit line and lower action limit line shall be set at the maximum and minimum allowable slumps, respectively, as specified in the same paragraph. The range between each consecutive slump test for each type of mixture shall be plotted on a single control chart for range on which an upper action limit is set at 50 mm. Samples for slump shall be taken at the mixer, however, the Contractor is responsible for delivering the concrete to the placement site at the stipulated slump. If the Contractor's materials or transportation methods cause slump loss between mixer and the placement, correlation samples shall be taken at the placement site as required by the Contracting Officer and the slump at the mixer controlled as directed.

d. Slump Corrective Action - Whenever points on the control chart for slump reach the upper warning limit, an adjustment shall be immediately made in the batch weights of water and fine aggregate. The adjustments are to be made so that the total water content does not exceed that amount allowed by the maximum W/C specified, based upon aggregates which are in a saturated surface-dry condition. When a single slump reaches the upper or lower action limit, no further concrete shall be delivered to the placing site until proper adjustments have been made. Immediately after each adjustment, another test shall be made to verify the correctness of the adjustment. Whenever two consecutive slump tests, made during a period when there was no adjustment of batch weights, produce a point on the control chart for range at or above the upper action limit, the concreting operation shall immediately be halted and the Contractor shall take appropriate steps to bring the slump under control. Also, additional slump tests shall be made as directed. All this shall be at no additional cost to the Government.

e. Temperature - The temperature of the concrete shall be measured when compressive strength specimens are fabricated. Measurement shall

be in accordance with ASTM C 1064/C 1064M. The temperature shall be reported along with the compressive strength data.

f. Compressive-Strength Specimens - At least one set of test specimens shall be made each day on each different concrete mixture placed during the day. Additional sets of test cylinders shall be made, as directed by the Contracting Officer, when the mixture proportions are changed or when low strengths have been detected. A random sampling plan shall be developed by the Contractor and approved by the Contracting Officer prior to the start of construction. The plan shall assure that sampling is done in a completely random and unbiased manner. A set of test specimens for concrete with a 28-day specified strength per paragraph DESIGN REQUIREMENTS shall consist of four cylinders, two to be tested at 7 days and two at 28 days. A set of test specimens for concrete with a 90-day strength per specified paragraph DESIGN REQUIREMENTS shall consist of six cylinders, two tested at 7 days, two at 28 days, and two at 90 days. Test specimens shall be molded and cured in accordance with ASTM C 31/C 31M and tested in accordance with ASTM C 39/C 39M. All compressive-strength tests shall be reported immediately to the Contracting Officer. Quality control charts shall be kept for individual strength tests, moving average for strength, and moving average for range for each mixture. The charts shall be similar to those found in ACI 214.

3.7.2.7 Inspection Before Placing

Foundation or construction joints, forms, and embedded items shall be inspected for quality by the Contractor in sufficient time prior to each concrete placement to certify to the Contracting Officer that they are ready to receive concrete. The results of each inspection shall be reported in writing.

3.7.2.8 Placing

a. Placing Inspection - The placing foreman shall supervise all placing operations, shall determine that the correct quality of concrete or grout is placed in each location as directed and shall be responsible for measuring and recording concrete temperatures and ambient temperature hourly during placing operations, weather conditions, time of placement, yardage placed, and method of placement.

b. Placing Corrective Action - The placing foreman shall not permit batching and placing to begin until he has verified that an adequate number of vibrators in working order and with competent operators are available. Placing shall not be continued if any pile of concrete is inadequately consolidated. If any batch of concrete fails to meet the temperature requirements, immediate steps shall be taken to improve temperature controls.

3.7.2.9 Vibrators

a. Vibrator Testing and Use - The frequency and amplitude of each vibrator shall be determined in accordance with COE CRD-C 521 prior to initial use and at least once a month when concrete is being placed.

Additional tests shall be made as directed when a vibrator does not appear to be adequately consolidating the concrete. The frequency shall be determined at the same time the vibrator is operating in concrete with the tachometer held against the upper end of the vibrator head while almost submerged and just before the vibrator is withdrawn from the concrete. The amplitude shall be determined with the head vibrating in air. Two measurements shall be taken, one near the tip and another near the upper end of the vibrator head and these results averaged. The make, model, type, and size of the vibrator and frequency and amplitude results shall be reported in writing.

b. Vibrator Corrective Action - Any vibrator not meeting the requirements of paragraph VIBRATORS shall be immediately removed from service and repaired or replaced.

3.7.2.10 Curing

a. Moist-Curing Inspections - At least once each shift, and once per day on nonwork days an inspection shall be made of all areas subject to moist curing. The surface moisture condition shall be noted and recorded.

b. Moist-Curing Corrective Action - When a daily inspection report lists an area of inadequate curing, immediate corrective action shall be taken, and the required curing period for such areas shall be extended by one (1) day.

c. Membrane-Curing Inspection - No curing compound shall be applied until the Contractor's authorized representative has verified that the compound is properly mixed and ready for spraying. At the end of each operation, he shall estimate the quantity of compound used by measurement of the container and the area of concrete surface covered and compute the rate of coverage in square meters per liter. He shall note whether or not coverage is uniform.

d. Membrane-Curing Corrective Action - When the coverage rate of the curing compound is less than that specified or when the coverage is not uniform, the entire surface shall be sprayed again.

e. Sheet-Curing Inspection - At least once each shift and once per day on nonwork days, an inspection shall be made of all areas being cured using material sheets. The condition of the covering and the tightness of the laps and tapes shall be noted and recorded.

f. Sheet-Curing Corrective Action - When a daily inspection report lists any tears, holes, or laps or joints that are not completely closed, the tears and holes shall promptly be repaired or the sheets replaced, the joints closed, and the required curing period for those areas shall be extended by one (1) day.

3.7.2.11 Cold-Weather Protection and Sealed Insulation Curing

At least once each shift and once per day on nonwork days, an inspection shall be made of all areas subject to cold-weather protection. The

protection system shall be inspected for holes, tears, unsealed joints, or other deficiencies that could result in damage to the concrete. Special attention shall be taken at edges, corners, and thin sections. Any deficiencies shall be noted, corrected, and reported.

3.7.2.12 Cold-Weather Protection Corrective Action

When a daily inspection report lists any holes, tears, unsealed joints, or other deficiencies, the deficiency shall be corrected immediately and the period of protection extended 1 day.

3.7.2.13 Mixer Uniformity

a. Stationary Mixers - Prior to the start of concrete placing and once every 6 months when concrete is being placed, or once for every 57,000 cubic meters of concrete placed, whichever results in the longest time interval, uniformity of concrete mixing shall be determined in accordance with ASTM C 94/C 94M.

b. Truck Mixers - Prior to the start of concrete placing and at least once every 6 months when concrete is being placed, uniformity of concrete shall be determined in accordance with ASTM C 94/C 94M. The truck mixers shall be selected randomly for testing. When satisfactory performance is found in one truck mixer, the performance of mixers of substantially the same design and condition of the blades may be regarded as satisfactory.

3.7.2.14 Mixer Uniformity Corrective Action

When a mixer fails to meet mixer uniformity requirements, either the mixer shall be removed from service on the work, the mixing time shall be increased, batching sequence changed, batch size reduced, or adjustments shall be made to the mixer until compliance is achieved.

3.7.3 Reports

All results of tests or inspections conducted shall be reported informally as they are completed and in writing daily. A weekly report shall be prepared for the updating of control charts covering the entire period from the start of the construction season through the current week. During periods of cold-weather protection, reports of pertinent temperatures shall be made daily. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in preceding paragraphs. Such reports of failures and the action taken shall be confirmed in writing in the routine reports. The Contracting Officer has the right to examine all test and inspection records.

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SECTION 03360

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SECTION 03360

ROLLER-COMPACTED CONCRETE (RCC)

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 305R	(1999) Hot Weather Concreting
ACI 347R	(1994; R 1999) Guide to Formwork for Concrete

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 33	(1999ae1) Concrete Aggregates
ASTM C 70	(1994) Surface Moisture in Fine Aggregate
ASTM C 117	(1995) Materials Finer Than 75 micrometer (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 131	(1996) Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	(1996a) Sieve Analysis of Fine and Coarse Aggregates
ASTM C 150	(1999a) Portland Cement
ASTM C 171	(1997a) Sheet Materials for Curing Concrete
ASTM C 172	(1999) Sampling Freshly Mixed Concrete
ASTM C 174/C 174M	(1997) Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C 494/C 494M	(1999a) Chemical Admixtures for Concrete
ASTM C 566	(1997) Total Evaporable Moisture Content of Aggregate by Drying
ASTM C 618	(2000) Coal Fly Ash and Raw or Calcined

	Natural Pozzolan for Use as a Mineral Admixture in Concrete
ASTM C 881	(1999) Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 1040	(1993; R 2000) Density of Unhardened and Hardened Concrete in Place by Nuclear Methods
ASTM C 1064/C 1064M	(1999) Temperature of Freshly Mixed Portland Cement Concrete
ASTM D 1557	(2000) Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cu. ft. (2,700 kN-m/cu.m.))
ASTM D 4318	(2000) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D 4791	(1999) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM E 329	(2000b) Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 53	Ref(1996) Standard Method for Consistency and Density of Roller-Compacted Concrete Using a Vibrating Tables
COE CRD-C 55	(1992) Test Method for Within-Batch Uniformity of Freshly Mixed Concrete
COE CRD-C 100	(1975) Method of Sampling Concrete Aggregate and Aggregate Sources, and Selection of Material for Testing
COE CRD-C 143	(1962) Specifications for Meters for Automatic Indication of Moisture in Fine Aggregate
COE CRD-C 318	(1979) Cloth, Burlap, Jute (or Kenaf)
COE CRD-C 400	(1963) Requirements for Water for Use in Mixing or Curing Concrete

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 44	(1997) NIST Handbook 44: Specifications,

	Tolerances, and other Technical Requirements for Weighing and Measuring Devices

NATIONAL READY-MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA CPMB 100	(1996) Concrete Plant Standards

STATE OF NEVADA DEPARTMENT OF TRANSPORTATION (NDOT) MATERIALS TESTING DIVISION

NDOT T230C	(Rev C) Method of Test For Determining the Percent of Fractured Faces

1.2 GOVERNMENT TESTING AND STUDIES

1.2.1 Preconstruction Testing and Mixture-Proportioning Studies

1.2.1.1 Aggregate Sampling and Testing

Materials to be used for production of aggregates may be obtained from on-site or off-site sources. The CONTRACTOR is responsible for selecting the source of materials such that all specified physical properties are met by the selected source(s).

Samples from any source selected, whether off-site or on-site, consisting of not less than 150 kilograms (300 pounds) of aggregate, and taken under the supervision of the Contracting Officer in accordance with COE CRD-C 100, shall be delivered to a Government-selected materials testing laboratory (locally) within 90 days after Notice to Proceed. Sampling, shipment, and testing of samples shall be at the Contractor's expense. At least 10 days will be required to complete evaluation of the aggregates. All quality assurance testing will be performed by the Government in accordance with the applicable COE CRD-C or ASTM test methods. Aggregates shall meet all specified physical properties as described in paragraph AGGREGATES. Additional test and analyses of aggregates may be made by the Government at the discretion of the Contracting Officer. Quality assurance testing of aggregates by the Government does not relieve the Contractor of quality control requirements.

1.2.1.2 Cementitious Materials

At least 45 days in advance of submitting samples for mixture proportioning studies, the Contractor shall notify the Contracting Officer of the source, brand name, type, and quantity of all materials (other than aggregates) to be used in the manufacture of RCC. The Contractor shall assist the Contracting Officer in obtaining samples of each material. Sampling and testing as determined appropriate will be performed by and at the expense of the Government. Samples of representative materials will be delivered to the address listed in paragraph MATERIALS FOR RCC MIXTURE-PROPORTIONING STUDIES at the Contractor's expense. If cement or fly ash is to be obtained from more than one source, the notification shall state the estimated amount of cement or fly ash to be obtained from each source and the proposed schedule of shipments. When pozzolan other than fly ash is

used, it shall be from one source.

1.2.1.3 MATERIALS FOR RCC MIXTURE-PROPORTIONING STUDIES

At least 60 days in advance of the time when placing of RCC is expected to begin, samples of representative materials proposed for this project and meeting all the requirements of this specification shall be delivered to the laboratory listed below by the Contractor at his expense.

US Army Engineer Waterways Experiment Station
Concrete and Materials Branch, Building 6000
Geotechnical and Structures Laboratory
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Samples of aggregates shall be taken under the supervision of the Contracting Officer in accordance with COE CRD-C 100, accompanied by test reports indicating conformance with grading and quality requirements specified. Samples of materials other than aggregates shall be representative of those proposed for the project and shall be submitted accompanied by manufacturer's test reports indicating compliance with applicable specified requirements. Quantities of materials required shall be as follows:

MATERIAL	QUANTITY
Composite Aggregate	4,500 kgs
Cement	900 kgs
Pozzolan	550 kgs
Washed Concrete Sand	750 kgs

Mixture-proportioning studies will be made by the Government at its expense.

1.2.2 TESTING DURING CONSTRUCTION BY THE GOVERNMENT

1.2.2.1 General

The Government will sample and test cementitious materials, aggregates, and RCC during construction as considered appropriate to determine compliance with the specifications. The Contractor shall provide equipment and labor as may be necessary for procurement of representative test samples. Samples of aggregates will be obtained at the point of batching in accordance with COE CRD-C 100. Consistency of the RCC will be determined by the Government using the modified Vebe apparatus in accordance with paragraph CONSISTENCY OF RCC. Compression test specimens of batch RCC mix will be made and tested by the Government. Density of the compacted RCC will be checked by the Government as considered appropriate.

1.2.2.2 Aggregates Sampling and Testing

Testing performed by the Government will not relieve the Contractor of his responsibility for testing under paragraph CONTRACTOR QUALITY CONTROL. During construction, aggregates will be sampled for acceptance testing as delivered to the mixer to determine compliance with specification

provisions. The Contractor shall provide necessary equipment and labor for the ready procurement of representative samples under Government supervision. The Government will test such samples at its expense using the specified COE CRD-C and ASTM methods.

1.2.2.3 Cementitious Materials

Cement or pozzolan will be sampled at the mill, shipping point, or site of the work by the Government. Sampling and testing, as determined appropriate will be performed by and at the expense of the Government. If tests prove that a material which has been delivered is unsatisfactory, it shall be promptly removed from the site of the work. Cementitious materials that have not been used within 6 months after being tested will be retested by the Government at the expense of the Contractor when directed by the Contracting Officer.

1.2.2.4 Cement Sources

Samples of cement will be taken at the project site or cement-producing plant by the Contracting Officer for testing at the expense of the Government. A copy of the mill tests from the cement manufacturer shall be furnished for each lot. No cement shall be used until notice has been given by the Contracting Officer that test results are satisfactory. In the event of failure, the cement may be resampled and tested at the request of the Contractor and at the Contractor's expense. The fill gate or gates of the sampled bin will be sealed and kept sealed until shipment from the bin has been completed. Sealing of the fill gate or gates and of conveyances used in shipment will be done by or under the supervision of the Government. Conveyances will not be accepted at the site of the work unless received with all seals intact. If tested cement is rehandled at transfer points, the extra cost of inspection will be at the Contractor's expense. The cost of testing cement will be at the Contractor's expense and will be deducted from payments due the Contractor at a rate of $1,750 per test.

1.2.2.5 Pozzolan Sources

Samples of pozzolan will be taken at the project site by the Contracting Officer for testing at the expense of the Government. A copy of the test results from the pozzolan manufacturer shall be furnished for each lot. All sampling and testing will be performed by and at the expense of the Government. Release for shipment and approval for use will be based on compliance with 7-day lime-pozzolan strength requirements and other physical, chemical, and uniformity requirements for which tests can be completed by the time the 7-day lime-pozzolan strength test is completed. Release for shipment and approval for use on this basis will be contingent on continuing compliance with the other requirements of the specifications. If test results of a bin fail, the contents may be resampled and tested at the Contractor's expense. The Government will supervise or perform the unsealing and resealing of bins and shipping conveyances. If tested pozzolan is rehandled at transfer points, the extra cost of inspection will be at the Contractor's expense. The cost of testing pozzolan will be at the Contractor's expense at a rate of $1,650 per test. The amount will be deducted from payment to the Contractor.

1.3 CONSTRUCTION TOLERANCES

1.3.1 General

The RCC shall be constructed to the lines and grades indicated on the drawings. Level and grade tolerance measurements of RCC shall be made as soon as possible after finishing. When forms are used, the measurements shall be made prior to removal.

1.3.2 Tolerance for Spillway Structure

a. The thickness of compacted lifts of RCC shall be within plus or minus 25 mm of that specified.

b. The allowable variation of the elevation of the surfaces of RCC lifts upon which subsequent RCC is placed shall be minus zero (0) and plus 25 mm (in any direction) from the design elevation.

c. The variation from a straight line for RCC formed faces shall not exceed 75 mm in 30 meters or 25 mm in 10 meters.

1.3.3 Tolerance for Upstream Slope Protection

a. Surface Smoothness - After the completion of the final rolling of RCC, the compacted surface shall be tested with a 3.05 m straightedge. Measurements will be made transverse and longitudinal to the RCC compacted surface at equal distances not to exceed 10 meters. The compacted surfaces from both transverse and longitudinal directions shall show no deviation in excess of 25 mm.

b. Thickness - The thickness of compacted lifts of RCC shall be within plus or minus 25 mm of that specified. Deficiency in the thickness will be evaluated as described in paragraph THICKNESS EVALUATION.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The "RE" designates that the Resident Office will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Batch Plant; G, RE.

Details and data on the concrete plant shall be submitted 60 days prior to plant assembly for review by the Contracting Officer for conformance with the requirements of paragraph BATCH PLANT. Final acceptance of any piece of plant is subject to satisfactory performance during operations.

Mixers; G, RE.

Details and data on the mixing plant including manufacturer's literature on the cementitious material and aggregate feed equipment, water controls, pug mill mixers (plant type and capacity), and layout plan showing that the equipment meets all specified requirements, shall be submitted 30 days prior to plant assembly for review and approval by the Contracting Officer for conformance with the requirements of paragraph MIXERS.

Transporting and Conveying Equipment.

Spreading Equipment.

Compaction Equipment; G, RE.

A listing of the equipment proposed for transporting, handling, depositing, spreading, and compacting the RCC shall be submitted for review by the Contracting Officer 30 days before concrete placement begins. The data submitted shall include site drawings or sketches with locations of equipment and placement site.

Nuclear Density Gauge.

A description of the nuclear density gauge apparatus proposed for use including manufacturer's literature and the latest manufacturer's calibration results of the nuclear density gauge shall be submitted for review by the Contracting Officer 30 days prior to use.

SD-07 Certificates

Aggregate and RCC Production; G, RE.

Descriptions and details for all methods and operations proposed for aggregate and RCC operations including daily and weekly production rates, shall be submitted for review and approval for conformance with specifications.

Joint Cleanup and Waste Disposal.

The method and equipment proposed for joint cleanup and waste disposal shall be submitted for review by the Contracting Officer before concrete placement begins for conformance with paragraph JOINTS.

Curing; G, RE.

The curing media and methods to be used shall be submitted for review to the Contracting Officer before concrete placement begins for conformance with paragraph CURING AND PROTECTION.

Cold-Weather Placement.

When concrete is to be placed under cold-weather conditions, a description of the materials and methods proposed for protection of the concrete meeting the requirements of paragraph COLD-WEATHER PROTECTION, shall be

furnished to the Contracting Officer for review 5 days in advance of anticipated need date.

Hot-Weather Placement.

When concrete is to be placed under hot-weather conditions, a description of the materials and methods proposed for protection of the concrete meeting the requirements of paragraph HOT-WEATHER PROTECTION, shall be furnished to the Contracting Officer for review 5 days in advance of anticipated need date.

Vertical Facings.

Details of the Contractors construction methods and equipment shall be submitted for review within 60 days after Notice to Proceed.

Nuclear Density Gauge Operator; G, RE.

Copies of permits and licenses for gauge operation; copies of certification of training for all operators shall be submitted for review and approval by the Contracting Officer.

Cementitious Materials; G, RE.

Cementitious materials including cement and pozzolan, will be accepted on the basis of the manufacturer's certification of compliance, accompanied by mill test reports that materials meet the requirements of the specification under which they are furnished. No cementitious materials shall be used until notice of acceptance has been given by the Contracting Officer. Cementitious materials will be subject to check testing from samples obtained at the source, at transfer points, or at the project site, as scheduled by the Contracting Officer, and such sampling will be by or under the supervision of the Government at its expense.

SD-11 Closeout Submittals

Waybills and Delivery Tickets; G, RE.

Copies of waybills or delivery tickets for cementitious material during the progress of the work shall be submitted for review and approval. Before the final payment is allowed, waybills and certified delivery tickets shall be furnished for all cementitious material used in the construction.

1.5 MATERIAL DELIVERY, STORAGE, AND HANDLING

1.5.1 Cementitious Materials

1.5.1.1 Transportation

When bulk cement or pozzolan is not unloaded from primary carriers directly into weather-tight hoppers at the batching plant, transportation from the railhead, mill, or intermediate storage to the batching plant shall be accomplished in adequately designed weather-tight trucks, conveyors, or other means that will protect the material from exposure to moisture.

1.5.1.2 Storage

Cementitious materials shall be furnished in bulk. Immediately upon receipt at the site of the work, all cementitious materials shall be stored in a dry, weather-tight, and properly ventilated structure. All storage facilities shall permit easy access for inspection and identification. Sufficient materials shall be in storage for at least two operating days to sustain continuous operation of the mixing plant while the RCC is being placed. In order that cement may not become unduly aged after delivery, the Contractor shall use any cement that has been stored at the site for 60 days or more before using cement of lesser age.

1.5.2 Aggregate Storage

Aggregate shall be stored, in free-draining stockpiles, adjacent to the batch plant and in such a manner as to prevent the inclusion of foreign materials in the aggregate. Aggregate shall remain in free-draining storage for at least 24 hours immediately prior to use. Sufficient aggregate shall be maintained at the site at all times to permit continuous uninterrupted RCC placement.

PART 2 PRODUCTS

2.1 CEMENTITIOUS MATERIALS

2.1.1 Portland Cement

Portland cement shall conform to ASTM C 150, Type V, low alkali.

2.1.2 Pozzolan

Pozzolan shall conform to ASTM C 618, Class F, with loss on ignition limited to 6 percent.

2.1.3 Temperature of Cementitious Materials

The temperature of the cementitious materials as delivered to the site shall not exceed 65 degrees C.

2.2 ADMIXTURES

All chemical admixtures furnished as liquids shall be in a solution of suitable viscosity and dilution for field use as determined by the Contracting Officer.

2.2.1 Water-Reducing Admixture (WRA)

A WRA shall meet the requirements of ASTM C 494/C 494M, Type B or D. The admixture may be added to the concrete mixture only when its use is approved or directed and after mixture proportioning studies.

2.3 CURING MATERIALS

2.3.1 Burlap

Burlap shall conform to COE CRD-C 318.

2.3.2 Sheeting

Waterproof sheeting shall be white waterproof paper or white opaque polyethylene film conforming to ASTM C 171.

2.4 WATER

Water for washing aggregates and for mixing and curing RCC shall be free from injurious amounts of oil, acid, salt, alkali, organic matter, or other deleterious substances and shall comply with COE CRD-C 400.

2.5 EPOXY RESIN

Epoxy resins for use in repairs shall conform to ASTM C 881, Type III, Grade I or II.

2.6 AGGREGATES

2.6.1 Source of Materials for Aggregate and RCC Production

Borrow materials for production of RCC aggregates may be obtained from the required excavation or from off-site sources. The contractor shall make all arrangements, and secure all necessary permits for the procurement, furnishing and transporting aggregates from off-site sources.

2.6.2 Particle Shape

The shape of the particles of the fine aggregate and of the coarse aggregate shall be generally spherical or cubical. The quantity of flat and elongated particles at a length-to-width or width-to-thickness ratio greater than 3 in the separated size groups of coarse aggregate, as defined and determined by ASTM D 4791, shall not exceed 25 percent in any size group.

2.6.3 Deleterious Substances

The maximum plasticity index for RCC aggregate materials shall be limited to 3 when determined in accordance with ASTM D 4318.

2.6.4 Resistance to Abrasion

Coarse aggregate, used in production of RCC, shall not show more than 45 percent loss after 500 revolutions when tested in accordance with ASTM C 131.

2.6.5 Fractured Faces

Coarse aggregate, used in production of RCC, will have a minimum 50 percent fractured faces when tested in accordance with NDOT T230C.

2.6.6 Aggregate Gradation

Aggregate samples will be prepared for RCC mix design studies. The Government will use the specified gradations for use in preparation of mixture proportioning studies.

2.6.6.1 RCC Gradation

The aggregate to be used for RCC construction, when tested in accordance with ASTM C 117 and ASTM C 136, shall conform to the gradation indicated below:

Standard Sieve Size	Percent Passing by Weight
25 mm	100
19 mm	90 - 100
4.75 mm	35 - 65
1.18 mm	20 - 40
0.075 mm	5 - 12

2.7 MIXTURE PROPORTIONING

2.7.1 Composition

RCC mixture will be proportioned by the Contracting Officer. RCC shall be composed of cementitious materials, water, and aggregates and possibly admixtures. The cementitious material shall be portland cement, or portland cement in combination with pozzolan. Admixtures shall not be used unless demonstrated by the Contractor to be beneficial, approved in writing, and used in the mixture proportioning studies.

2.7.2 Proportions

The proportions of all materials entering the RCC, as determined from the mixture proportioning studies, will be furnished to the Contractor by the Contracting Officer. The mixture proportions will be changed as necessary by the Government. Adjustments will be made to the batch weights including cement, pozzolan, and water to maintain the necessary consistency to prevent segregation within the RCC and allow full compaction as determined. Frequent changes to the batch weights shall be considered usual and can be expected to occur frequently during the course of each day's placement depending on such variables as humidity, wind velocity, temperature, and cloud cover. Such changes will be as directed. The Contractor will be responsible for adjusting the aggregate weights to compensate for changes in aggregate moisture contents.

2.7.3 Cementitious Material Content

The total cementitious material content of the RCC will range from an approximate minimum of 180 to an approximate maximum of 250 kilograms per cubic meter, expressed as equivalent portland cement content (by absolute volume). Pozzolan, if used, will be proportioned to approximately thirty percent by absolute volume of the total cementitious material.

2.7.4 Consistency of RCC

The Contracting Officer will determine at the placement site on a continuing basis the proper consistency necessary for adequate hauling, spreading, and compacting and will direct all necessary changes to achieve the proper RCC consistency. Changes will be directed based on visual examination of the RCC during the spreading and compaction process and on the Vebe time when it varies outside the range considered ideal for compaction, as determined by the Government using the modified Vebe apparatus, in accordance with COE CRD-C 53.

2.8 STOCKPILING OF MATERIAL

Whether obtained from the required excavation or off-site commercial sources, aggregates shall not be transported directly to the mixing plant. The aggregates shall be stockpiled on firm ground drained and leveled, free of debris, trash, organic materials, and other objectionable or deleterious material. Stockpiles shall be constructed in layers not exceeding 1 meter in thickness. Ramps formed for the construction of stockpiles shall be made of the same material as that being stockpiled, and will be considered a part of the stockpile. Aggregates taken from the stockpile for RCC production shall be removed from the stockpile in such a manner that material from several layers of the stockpile are combined in each sample and the gradation of the aggregate obtained is representative of that used in the mix design tests.

2.9 BEDDING MORTAR

2.9.1 General

Bedding mortar is to be used for achieving bond between RCC lifts as indicated in paragraph JOINTS. No surfaces to receive a bedding mortar shall be covered with RCC until the prepared surface has been inspected and approved by the Contracting Officer's Representative. In no case will the bedding mortar be allowed to dry from the sun and wind.

2.9.2 Bedding Mortar Mix

The bedding mortar mix design will be developed by the Government and will conform to the following general requirements. Aggregate for bedding mortar shall conform to the requirements of ASTM C 33, for washed concrete sand.

Parameter	
Slump	200-250 mm
Cement Content	250-500 kg/m^3
Minimum Compressive Strength	20 MPa (28 days)

PART 3 EXECUTION

3.1 EQUIPMENT

3.1.1 Capacity

The concrete plant, conveying, placing, compaction, and cleanup systems shall have a capacity of at least 100 cubic meters per hour.

3.1.2 Concrete Plant

The concrete plant shall be a batch or a continuous mixing plant.

3.1.2.1 Location

The concrete plant shall be located at the site of the work, subject to the approval of the Contracting Officer. Approval of the location of the concrete plant does not relieve the Contractor of the responsibility for placement of the concrete plant if location interferes with construction work, including production of material sources, or other necessary earthwork.

3.1.2.2 Bins and Silos

Separate bins, compartments, or silos shall be provided for each classification of aggregate and for each of the cementitious materials. The compartments shall be of ample size and so constructed that the various materials will be maintained separately under all working conditions. All compartments containing bulk cement or pozzolan shall be separated from each other by a free-draining air space. The cement and pozzolan bins shall be equipped with filters which allow air passage but preclude the venting of cement or pozzolan into the atmosphere. All filling ports shall be clearly marked with a permanent sign stating the contents.

3.1.2.3 Batch Plant

The batch plant requirements should meet the following requirements.

a. Batchers - Aggregate shall be weighed in separate weigh batchers with individual scales or may be batched cumulatively. Bulk cement and other cementitious materials shall each be weighed on a separate scale in a separate weigh batcher. Water shall be measured by weight or by volume. It shall not be weighed or measured cumulatively with another ingredient. Ice shall be measured separately by weight. Admixtures shall be batched separately and shall be batched by weight or by volume in accordance with the manufacturer's recommendations.

b. Water Batcher - A suitable water-measuring and batching device shall be provided that will be capable of measuring and batching the mixing water within the specified tolerances for each batch. The mechanism for delivering water to the mixers shall be free from leakage when the valves are closed. The filling and discharge valves for the water batcher shall be so interlocked that the discharge valve cannot be opened before the filling valve is fully closed. When a water meter is used, a suitable strainer shall be provided ahead of the metering device.

c. Admixture Dispensers - A separate batcher or dispenser shall be

provided for the admixture. The plant shall be equipped with the necessary calibration devices that will permit convenient checking of the accuracy of the dispensed volume of the particular admixture. The batching or dispensing devices shall be capable of repetitively controlling the batching of the admixtures to the accuracy specified. Piping for liquid admixtures shall be free from leaks and properly valved to prevent backflow or siphoning. The dispensing system shall include a device or devices that shall detect and indicate the presence or absence of the admixture or provide a convenient means of visually observing the admixture in the process of being batched or discharged. The system shall be capable of ready adjustment to permit varying the quantity of admixture to be batched. The dispenser shall be interlocked with the batching and discharge operations so that each admixture is added separately to the batch in solution in a separate portion of the mixing water in a manner to ensure uniform distribution of the admixtures throughout the batch during the required mixing period. Storage and handling of admixtures shall be in accordance with the manufacturer's recommendations.

c. Moisture Control - The plant shall be capable of ready adjustment to compensate for the varying moisture content of the aggregates and to change the masses of the materials being batched. A moisture meter complying with the provisions of COE CRD-C 143 shall be provided for measurement of moisture in the fine aggregate. The sensing element shall be arranged so that the measurement is made near the batcher charging gate of the fine aggregate bin.

d. Scales - Adequate facilities shall be provided for the accurate measurement and control of each of the materials entering each batch of RCC. The weighing equipment and controls shall conform to the applicable requirements of NIST HB 44, except that the accuracy shall be within 0.2 percent of the scale capacity. The Contractor shall provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring device. Each weighing unit shall include a visible indicator that shall indicate the scale load at all stages of the weighing operation and shall show the scale in balance at zero load. The weighing equipment shall be arranged so that the concrete plant operator can conveniently observe the indicators.

e. Operation and Accuracy - The weighing operation of each material shall conform to requirements of NRMCA CPMB 100. The weigh batchers shall be so constructed and arranged that the sequence and timing of batcher discharge gates can be controlled to produce a ribboning and mixing of the aggregates, water, admixtures, and cementitious materials as the materials pass through the charging hopper into the mixer. The plant shall include provisions to facilitate the inspection of all operations at all times. Delivery of materials from the batching equipment shall be within the following limits of accuracy:

MATERIAL	PERCENT OF REQUIRED MASS
Cementitious materials	0 to +2

MATERIAL	PERCENT OF REQUIRED MASS
Water	1
Each individual aggregate size group	2
Chemical admixtures	0 to +6

When water and chemical admixtures are measured by volume, they shall meet the same tolerance percent as stated in the chart.

f. Interlocks - Batchers and mixers shall be interlocked so that:

(1) The charging device of each batcher cannot be actuated until all scales have returned to zero balance within plus or minus 0.2 percent of the scale capacity and each volumetric device has reset to start or has signaled empty.

(2) The charging device of each batcher cannot be actuated if the discharge device is open.

(3) The discharge device of each batcher cannot be actuated if the charging device is open.

(4) The discharge device of each batcher cannot be actuated until the indicated material is within the allowable tolerances.

(5) Admixtures are batched automatically and separately with the water.

(6) The mixers cannot be discharged until the required mixing time has elapsed.

g. Recorder - An accurate recorder or recorders shall be provided and shall conform to the following detailed requirements:

(1) The recorder shall produce a graphical or digital record on a single visible chart or tape of the weight or volume of each material in the batchers at the conclusion of the batching cycle. The record shall be produced prior to delivery of the materials to the mixer. After the batchers have been discharged, the recorder shall show the return to empty condition.

(2) A graphical recording or digital printout unit shall be completely housed in a single cabinet that shall be capable of being locked.

(3) The chart or tape shall be so marked that each batch may be permanently identified and so that variations in batch weights of each type of batch can be readily observed. The chart or tape shall be easily interpreted in increments not exceeding 0.5 percent of each batch weight.

(4) The chart or tape shall show time of day at intervals of not more than 15 minutes.

(5) The recorder chart or tape shall become the property of the Government.

(6) The recorder shall be placed in a position convenient for observation by the concrete plant operator and the Government inspector.

(7) The recorded weights or volumes when compared to the weights or volumes actually batched shall be accurate within plus or minus 2 percent.

h. Batch Counters - The plant shall include devices for automatically counting the total number of batches of all concrete batched and the number of batches of each preset mixture.

i. Batch Plant Trial Operation - Not less than 7 days prior to commencement of placing the test sections, a test of the batching and mixing plant shall be made in the presence of a representative of the Contracting Officer to check operational adequacy. The number of full-scale concrete batches required to be produced in trial runs shall be as directed, will not exceed 20, and shall be proportioned as directed by the Contracting Officer. All RCC produced in these tests shall be wasted or used for purposes other than inclusion in structures covered by this specification. All deficiencies found in plant operation shall be corrected to the satisfaction of the Contracting Officer prior to the start of RCC placing operations. No separate payment will be made to the Contractor for labor or materials required by provisions of this paragraph. Mixer uniformity testing, in accordance with paragraph CONTRACTOR QUALITY CONTROL, will be performed by the government near the end of this trial operation period. The Contractor shall notify the Contracting Officer of the trial operation not less than 7 days prior to the start of the trial operation.

j. Protection - The weighing, indicating, recording, and control equipment shall be protected against exposure to dust, moisture, and vibration so that there is no interference with proper operation of the equipment.

3.1.2.4 Continuous Mixing Plant

A continuous mixing plant(s) shall be capable of producing RCC of the same quality and uniformity as would be produced in a conventional batch plant and shall be capable of producing a uniform continuous product (at both maximum and minimum production rates) that is mixed so that complete intermingling of all ingredients occurs without balling, segregation, and wet or dry portions.

a. Operation and Accuracy - An electronic control system shall be provided. The control system shall have the capability of changing mixtures instantaneously, measuring the moisture in the combined aggregate entering the mixer, producing any of the mixtures at a variable rate, and tracking a mixture change to a hopper or a conveyor system. The control panel shall display for each ingredient the designed formula values and the instantaneous percentage values and

shall record the instantaneous values at a preset time interval or on demand with a multiple copy printer/recorder. The recorder shall note formula changes and shall print total quantities of each ingredient and total amounts produced on command. There shall be weighing devices (belt scale or other) for continuous weighing of individual ingredients and total ingredients. The plant control shall not require manual devices to adjust the material flow. The plant shall be capable of total manual control operation for a single product at a limited production for short-time durations in the event of loss of electronic control. The electronic control system shall incorporate modular replaceable components to reduce down time in the event of control system malfunction. An inventory shall be maintained of such replaceable components. The bin for the combined aggregate shall have a device that monitors its moisture content immediately prior to dispensing into the mixing plant dispensing system. The accuracy of the plant dispensing systems shall be within the following limits:

Cementitious Materials	0 to +2 percent
Water	1 percent
Aggregate	2 percent
Admixtures	0 to +6 percent

The continuous feeders for each of the ingredients shall be calibrated as per the manufacturer's specifications. Devices and tools shall be maintained at the plant location to check the feeder's calibration at the Contracting Officer's request. A technician shall be provided that is skilled in calibration of the feed devices and the maintenance and repair of the plant control system. The technician shall be available within 30 minutes notice during all scheduled plant operations. The technician could be one or more of the Contractor's personnel.

b. Cement, Pozzolan, and Aggregate Feed - Cement, pozzolan, and aggregates shall be uniformly, continuously, and simultaneously fed (at the proper ratios and quantity for the mixture required) into the mixer by belt, auger, vane feeder, or other acceptable method. The feed bins or silos for each ingredient shall be kept sufficiently full and shall be of sufficient size to ensure a uniform flow at a constant rate for a specific mixture. The feed bins shall have a low-level indicator that both warns the operator and can shut the plant down if insufficient material is available for a uniform and continuous flow.

c. Water and Admixture Dispensers - The liquid-dispensing devices shall be capable of metering and dispensing within the specified requirements. The liquid valves shall be free from leakage in the closed position. The dispensers shall have attachments and/or be installed in such a manner that will permit convenient checking of their accuracy. Plumbing shall be leak-free and properly valved to prevent backflow and siphoning. The dispenser shall be interlocked with the electronic plant control and shall warn the operator and shut down the plant if insufficient liquid is available. Separate nozzles for each liquid shall be properly located at the mixer to assure uniform distribution of each liquid to the materials entering the mixer.

d. Continuous Mixer(s) - The continuous mixer(s) shall have proper

introduction of ingredients as specified by the manufacturer and shall not be charged in excess of the manufacturer's recommended capacity. Mixer(s) shall be capable of combining the materials into a uniform homogeneous mixture and of discharging this mixture without segregation. The mixer(s) shall operate at the blade speed designated by the manufacturer and shall be capable of changing retention time of the ingredients in the mixer. This should be accomplished by manually resetting the mixer(s) blade angles. Mixing time (ingredient retention time in the mixer) shall be predicated upon the uniformity, homogeneity, and consistency of the resultant mixture. Samples for uniformity testing shall be taken at 2-minute intervals and tested as per COE CRD-C 55 and paragraph MIXER UNIFORMITY REQUIREMENTS. The mixer(s) shall be maintained in satisfactory operating condition and mixer blades shall be kept free of hardened RCC. Should mixer(s) at any time produce unsatisfactory results, its use shall be promptly discontinued until it is repaired. Suitable facilities shall be provided for obtaining representative samples of concrete for testing. All necessary platforms, shelters, tools, labor, and equipment shall be provided for obtaining samples.

e. Segregation - A means shall be used to reduce and minimize segregation and waste which would otherwise result from the continuous stream of RCC being fed into the batch haul devices (dump trucks, etc.). The equipment shall retain the RCC between tracks or other means of transport to prevent the need for stopping the mixer. These devices could include, but not be limited to, a discharge hopper having a capacity of at least 20 metric ton. The hopper shall be equipped with dump gates to assure rapid and complete discharge without segregation.

f. Trial operation - Not less than 7 days prior to commencement of concrete placing, a test of the plant shall be made in the presence of a representative of the Contracting Officer to check operational adequacy. The number of cubic meters required to be produced in trial runs shall be as directed, but will not exceed 100 cubic meters. All RCC produced in these tests shall be wasted or used for purposes other than inclusion in structures covered by this specification. All deficiencies found in plant operation shall be corrected to the satisfaction of the Contracting Officer prior to the start of RCC placing operations. Mixer uniformity tests will be performed by the Government near the end of this trial period. No separate payment will be made to the Contractor for labor or materials required by provisions of this paragraph. The Contractor shall notify the Contracting Officer of the trial operation not less than 7 days prior to the start of the trial operation.

g. Protection - The weighing, indicating, recording, and control equipment shall be protected against exposure to dust, moisture, and vibration so that there is no interference with proper operation of the equipment.

3.1.3 Mixers

Mixers shall be stationary mixers or pugmill mixers. Mixers may be batch

or continuous mixing. Each mixer shall combine the materials into a uniform mixture and discharge this mixture without segregation. Mixers shall not be charged in excess of the capacity recommended by the manufacturer on the nameplate. Excessive overmixing requiring additions of water will not be permitted. The mixers shall be maintained in satisfactory operating condition, and mixer drums shall be kept free of hardened RCC. Mixer blades or paddles shall be replaced when worn down more than 10 percent of their depth when compared with the manufacturer's dimension for new blades. Should any mixer at any time produce unsatisfactory results, its use shall be promptly discontinued until it is repaired or replaced.

3.1.3.1 Pugmill Mixers

A batch or continuous mixing twin-shaft pugmill mixer shall be capable of producing RCC of the same quality and uniformity as would be produced in a conventional plant that meets all the requirements of these specification. All pugmill mixers shall meet the requirements of paragraph CONTINUOUS MIXING PLANT.

3.1.3.2 Mixer Uniformity Requirements

All mixers shall be tested by the Government in accordance with this paragraph and in accordance with COE CRD-C 55. When regular testing is performed, the RCC shall meet the limits of any three of the four applicable uniformity requirements. When abbreviated testing is performed, the RCC shall meet only those requirements listed for abbreviated testing. The initial mixer evaluation test shall be a regular test and shall be performed prior to the start of RCC placement. Regular testing shall consist of performing all tests on three batches of RCC. The range for regular testing shall be the average of the ranges of the three batches. Abbreviated testing shall consist of performing the required tests on a single batch of RCC. The range for abbreviated testing shall be the range for one batch. Mixer evaluations shall be performed by the Government. The Contractor shall provide labor and equipment as directed by the Contracting Officer to assist the Government in performing the tests.

PARAMETER	REGULAR TESTS ALLOWABLE MAXIMUM RANGE FOR AVERAGE OF 3 BATCHES	ABBREVIATED TESTS ALLOWABLE MAXIMUM RANGE FOR 1 BATCH
Coarse aggregate, percent	6.0	6.0
Compressive strength at 7 days	10.0	10.0
Water content, percent	1.5	1.5
Consistency, modified Vebe, second	7.0	--

A regular test will be performed before RCC production begins and when the Contractor requests a reduced mixing time. An abbreviated test shall be performed every 3 months when RCC is being placed. If a mixer fails the abbreviated test, a regular test will be performed. Cost of testing when the Contractor requests a reduced mixing time will be paid by the

Contractor.

3.1.4 Sampling RCC

The Contractor shall provide equipment and labor for obtaining representative samples of RCC in accordance with ASTM C 172 for Contractor quality control and Government quality assurance testing.

3.1.5 Sampling Aggregates

Suitable facilities shall be provided for readily obtaining representative samples of aggregates for test purposes immediately prior to the material entering the mixer.

3.1.6 Transporting and Conveying Equipment

The transporting and conveying equipment shall conform to the following requirements.

The concrete mixtures (RCC, bedding mortar, and any other concrete that will interface with the RCC) shall be conveyed from the plant mixer(s) to placement as rapidly and as continuously as practical by methods which limit segregation, contamination, and surface drying. The RCC shall be conveyed from the mixing plant to the structure by means of main-line conveyor, end-dump truck, or a combination thereof.

3.1.6.1 Belt Conveyors

Belt conveyors shall be designed and operated to assure a uniform flow of RCC from mixer to final place pf deposit without segregation of ingredients and shall be provided with positive means for preventing segregation of the RCC at transfer points and the point of placing. The NMSA required in mixture proportions furnished by the Government will not be changed to accommodate the belt width.

3.1.6.2 Waybills and Delivery Tickets

Copies of waybills or delivery tickets for cementitious material during the progress of the work shall be submitted for review and approval. Before the final payment is allowed, waybills and certified delivery tickets shall be furnished for all cementitious material used in the construction.

3.1.7 Spreading Equipment

The spreading equipment shall conform to the following requirements:

The primary spreading procedure shall be accomplished by track dozer. A front-end loader with operator shall be available to assist with deposition of RCC as needed in confined areas. The equipment shall be maintained in good operating condition. The equipment shall not leak or drip oil, grease, or other visible contaminants onto the RCC surface. All equipment used for spreading that leaves the surface of the structure for maintenance or repairs or, for any other reason, must be cleaned of all contaminants by an approved method before returning

to the structure surface. Under no conditions shall a dozer or other tracked vehicle be operated on other than fresh uncompacted RCC except to facilitate startup operations for each lift and by approved procedures.

3.1.8 Compaction Equipment

The compaction equipment shall conform to the following requirements.

3.1.8.1 Primary Rollers

Self-propelled vibratory rollers shall be used for primary rolling and shall be double-drum. They shall transmit a dynamic impact to the surface through a smooth steel drum by means of revolving weights, eccentric shafts, or other equivalent methods. The compactor shall have a minimum gross mass of 9,000 kg and shall produce a minimum dynamic force of 60,000 N/m of drum width. The operating frequency shall be variable in the approximate range of 1,700 to 3,000 cycles per minute. The amplitude shall be adjustable between 0.4 and 1.0 mm. The roller shall be capable of full compaction in both forward and reverse directions. The roller shall be operated at speeds not exceeding 0.7 m/s. Within the range of the operating capability of the equipment, the Contracting Officer may direct or approve variations to the frequency, amplitude, and speed of operation which result in the specified density at the fastest production rate.

3.1.8.2 Small Vibratory Rollers

Small vibratory rollers shall be used to compact the RCC where the larger vibratory rollers specified above cannot maneuver. The rollers shall compact the RCC to the required density and shall be so demonstrated during construction of the test sections. Small vibratory rollers cannot compact the RCC to the same density and thickness as the primary rollers; therefore, when small rollers are used, total lift thickness of the RCC layer or lift shall be reduced to not over 150 mm uncompacted thickness to permit adequate compaction. Rollers shall have independent speed and vibration controls and shall be capable of a wide range of speed adjustments.

3.1.8.3 Tampers (Rammers)

The tampers shall compact the RCC to the required density and shall be so demonstrated during construction of the test sections. Tampers cannot compact the RCC to the same density and thickness as the primary rollers; therefore, when tampers are used, thickness of each RCC layer that is to be compacted shall be reduced to not more than 150 mm uncompacted thickness to assure adequate compaction.

3.1.8.4 Other Motorized Equipment

All other equipment necessary for the successful completion of RCC production, but not previously discussed within these specfications (or determined to be necessary during the course of the work), shall be approved prior to actual use. Such equipment shall not result in any damage to the RCC, shall be maintained in good operating condition, and

shall be operated by skilled contractor-provided personnel.

3.1.9 Nuclear Density Gauge

Tests to determine the density of the compacted RCC shall be made by the Contractor using a single-probe nuclear density gauge supplied by the Contractor. The nuclear density gauge shall meet the applicable requirements of ASTM C 1040. The gauge shall be capable of taking readings along a horizontal path between the probes at 50-mm increments from 50 mm from the surface to 250 mm below the surface. The gauge and nuclear density gauge operator shall be made available to the Government until completion of all RCC production at no additional cost. The Contractor shall obtain all permits and certifications for the equipment and the operators.

3.1.10 Calibration

Nuclear gauge shall have been factory calibrated within 6 months of RCC placement. The Contractor shall construct, at no additional costs to the Government, one (1) calibration test block using RCC materials and proportions representative of those to be used during construction. The block shall be fabricated before the test sections construction begins. The block size shall be a minimum of 450 mm by 450 mm by the maximum thickness of one lift, plus 25 mm. The block shall be compacted between 98 and 100 percent of the maximum wet density, which will be determined by the Contractor in accordance with ASTM D 1557. The moisture content of the RCC used to fabricate the block may be increased just enough to facilitate compaction of the mixture, as long as the proportions of the dry materials remain constant and the required density is achieved. The block shall be measured and weighed to determine the actual density (unit weight) and shall be used to check the calibration of the nuclear density gauge. After drilling a hole in the block to accommodate the nuclear density gauge probe, three full depth nuclear density gauge tests shall be performed in the direct transmission mode and the results averaged. This average nuclear density gauge reading shall be compared with the measured unit weight of the block and the difference used as a correction factor for all readings taken that day. All measuring and weighing of the test block and all calibration checking of the density gauge shall be performed in the presence of a representative of the Contracting Officer. Calibration checks of the density gauge shall be made at the beginning of construction every day. Gauge calibration constants shall be adjusted for performance on the block at least 7 days prior to the evaluation of test sections. The Contractor shall remedy any inconsistencies in gauge performance prior to the start of RCC placement. The block shall be used each day before placing begins to calibrate the full-depth readings of the nuclear density gauges used by the Contractor and the Government. The calibration block shall be available for use by the Government as needed.

3.2 SUBGRADE PREPARATION

Previously constructed underlying material shall be conditioned as specified in Section 02300 EARTHWORK. The existing subgrade, other than specified fills, shall be scarified, conditioned to optimum moisture content, and compacted to at least 90 percent of maximum density in

accordance with ASTM D 1557 for a depth of least 300 mm. In all cases prior to placing RCC, deficiencies in the underlying material shall be corrected, and the surface shall be cleaned and moistened, as directed. The surface of the underlying material will be approved by the Contracting Officer.

3.3 PREPARATION FOR PLACING

3.3.1 Placing Schedule

Before starting RCC production, a detailed schedule shall be submitted indicating intended daily and weekly production rates that, when followed, will meet the beginning and ending specified RCC production dates. After initiation of RCC production, the Contractor's schedule shall be updated and adjusted on a weekly basis for the duration of the RCC placement. If it becomes apparent for any reason that the Contractor is not pursuing a schedule that will meet the specified RCC production dates, actions necessary to increase the production rate shall be taken so that production is once again on schedule. Also, if not back on schedule, the Government reserves the right at this time to direct the Contractor, at no additional cost to the Government, to increase the amount and size of crews and equipment.

3.3.2 Aggregate Production Schedule

Aggregate production and initial stockpiling shall begin and shall be producing acceptable material by not later than 60 days in advance of the time when placement of the RCC test sections is expected to begin. At least 25 percent of the RCC aggregates necessary for the completed RCC construction shall be manufactured and stockpiled prior to start of placement of RCC.

3.3.3 RCC Test Sections

3.3.3.1 General

Prior to placement of any RCC, the Contractor shall construct a test section for the spillway structure horizontal lifts and a test section for the upstream slope protection at the job site. The purpose of the two test sections is to demonstrate the suitability of the Contractor's equipment, methods, and personnel. The two test sections shall each consist of not less than two adjacent lanes, at least 30 meters in length. The test section for the spillway horizontal structure shall be constructed to at least the depth of 6 lifts. The test section for the upstream slope protection shall be constructed to at least the depth of two lifts. In each of the test sections the lane width shall be 3.5 meters. Each of the test sections shall contain at least one fresh longitudinal construction joint, one cold transverse joint, one longitudinal cold construction joint which has stood overnight before completion, and one surface to be treated with bedding mortar. The sites of the test sections shall be approved by the Contracting Officer, and the Contractor shall remain responsible for ensuring that work and schedules are not affected by the selection of the test sites. After evaluation and assessment of the test sections by the Contracting Officer, the Contractor shall dispose of the test sections in

an approved manner. Under no circumstances shall the test sections be incorporated into or become a part of the permanent RCC structures. The date of the test sections construction shall be provided at least 7 days in advance.

3.3.3.2 Test Sections Requirements

The test sections shall demonstrate sustained plant production rates, and batching, mixing, transporting, spreading, compaction procedures, curing and preparation of construction joints. It shall also demonstrate the vertical face construction method along one side (formed), the sloped face construction method along another side (unformed), procedures for foundation preparation, procedures for placement of bedding mortar, rolling pattern, joint preparation, rolling method for both fresh and cold construction joints, start-up and finishing procedures, testing methods, and plant operations. Variable amplitudes of the roller shall be used as approved in different areas to identify the optimum amplitude. Rolling pattern of the vibratory roller may be varied as approved to determine the best pattern. Variations in mixture proportions other than water shall be made if directed. The test sections shall be placed in portions as directed by the Government. Additionally, at least three (3) nuclear gauge readings at the last lift of each of the test sections shall be provided from points selected by the Government. The Contractor shall vary the water content, as necessary, to arrive at the appropriate content, subject to the approval of the Contracting Officer's Representative. The mixing plant shall be operated and calibrated prior to placing the test sections. The Contractor shall use the same equipment, materials, and construction techniques on the test sections as will be used in all subsequent work.

3.3.3.3 Evaluation of Test Sections

The Contractor shall not begin RCC operations for the main structure until testing and evaluations by the Government have been completed, and it has been demonstrated to the satisfaction of the Contracting Officer that all specification requirements were met. Following completion of test sections construction, ten (10) calendar days shall be allowed for testing and evaluation. If the Contractor does not meet requirements as specified, an additional test sections or sections shall be constructed at no additional cost to the Government. Test sections unacceptable to the Contracting Officer shall be removed at the Contractor's expense. The Contractor shall provide six (6) 152.4 mm diameter cores by full depth of the lift thickness to the Government from points selected in the test sections by the Government 7 days after completion of the test sections. Six (6) additional cores shall be provided by the Contractor 28 days after completion of the test sections.

3.3.4 Weather

If unusual adverse weather, such as heavy rain, severe cold, high winds, heavy snow, etc., occurs or is forecast to occur during placement, the placement operation shall be suspended until conditions improve.

3.3.4.1 Placing During Cold Weather

Cold-Weather Placement - Placement shall be discontinued when the air temperature reaches 5 degrees C and is falling and shall not be resumed until the air temperature reaches 2 degrees C and is rising. No RCC shall be placed on any surface containing frost or frozen material. Provision shall be made to protect the RCC from freezing during the specified curing period. Mixing water and/or aggregates shall be heated, as necessary, to produce RCC having a temperature between 10 degrees C and 30 degrees C as placed. Methods and equipment for heating shall be as approved. The aggregates shall be free of ice, snow, and frozen lumps before entering the mixer. Covering and other means shall be provided for maintaining the RCC at a temperature of at least 10 degrees C for not less than 72 hours after placing and at a temperature above freezing for the remainder of the curing period. RCC damaged by freezing shall be removed and replaced as directed.

3.3.4.2 Placing During Rain

RCC shall not be placed during rainfall of 5 mm/hr or more. During periods of lesser rainfall, placement of RCC may continue if, in the opinion of the Contracting Officer, no damage to the RCC is occurring. Work shall commence only after excess free surface water and contaminated paste or RCC have been removed and the surface has gained sufficient strength (no less than 4 hours after the RCC placement was suspended) to prevent rutting, pumping, intermixing of rainwater with the RCC, or other damage to the RCC. When the RCC surface has been contaminated or damaged in any manner, the RCC surface shall be washed to break up and remove laitance and/or mud-like coatings from the surface. Any undercut coarse aggregate shall be removed. All waste shall be removed and disposed of in an approved manner.

3.3.4.3 Placing During Hot Weather

Hot-Weather Placement - During periods of hot weather when the maximum daily air temperature is likely to exceed 30 degrees C; or when the combination of ambient conditions will produce evaporation rates of 1.0 kg/sq m/hr or more, when calculated in accordance with Figure 2.1.5 of ACI 305R; the following precautions shall be taken. The underlying material shall be sprinkled with water immediately before placing the RCC. The RCC shall be placed at the coolest temperature practicable, and in no case shall the temperature of the RCC when placed exceed 32 degrees C. The aggregates and/or mixing water shall be cooled as necessary. The finished surfaces of the newly laid RCC shall be kept damp by applying a waterfog or mist, not streams of water, with approved spraying equipment until the RCC is covered by the curing medium. When heat or wind is determined excessive by the Contracting Officer, the Contractor shall immediately take such additional measures as necessary to protect the RCC surface. Such measures shall consist of wind screens, more effective fog sprays, and similar measures commencing immediately after placement. If these measures are not effective, placement shall be immediately stopped until satisfactory conditions exist.

3.3.5 Surface Preparation

3.3.5.1 Cleaning

All lift surfaces including RCC or bedding mortar shall be cleaned prior to

placing any additional concrete thereon. After cleaning, bedding mortar is to be used specifically for achieving bond between different types of concrete eliminating and preventing segregation or voids along margins or RCC placements. No surfaces to receive bedding mortar shall be covered with RCC until the prepared surfaces have been approved by a Contracting Officer's Representative. All surfaces upon which RCC or any bedding mortar is placed shall be moist (but contain no visible free water). Prior to placing RCC, the surface shall be clean and free of loose, or unkeyed rock; all mud and silt accumulations; laitance; puddles or ponds of free surface water; coatings; and any other detrimental materials. High-pressure water jetting, and/or wet sandblasting, followed by mild high-volume, low-pressure washing, shall be used on all hardened RCC surface (cold joints) as necessary for the removal of laitance, coatings, stains, or other difficult-to-remove contaminants. High-volume low-pressure water washing and/or water jetting may be used for removal of loose materials.

3.3.5.2 High-Volume Low-Pressure Washing

Washing of loose materials can be accomplished with high-volume low-pressure water washing and/or air water jetting using equipment of similar design to that used in large-scale foundation cleanups. The air-water jets shall have 40-mm nozzles, a water supply of at least 2 L/s, and compressed air at the jet of 550 to 850 kPa. The low-pressure water jets shall have 25-mm nozzles available and a capacity of at least 13 L/s for truck-mounted devices.

3.3.5.3 High-Pressure Water Jet

A stream of water under a pressure of not less than 10.3 MPa for RCC shall be used for cleaning all cold joint surfaces, or surfaces with laitance, mortar coatings, stains, or other difficult-to-remove contaminants. There shall be no undercutting of coarse-size aggregates. Aggregate particles that are undercut shall be removed.

3.3.5.4 Wet Sandblasting

This method may be used when the RCC has reached sufficient strength to prevent undercutting of coarse aggregate particles. Wet sandblasting shall be continued until all accumulated laitance, coatings, stain, or other difficult-to-remove contaminants are removed. Wet sandblasting may be used in lieu of or in combination with the high-pressure water jet.

3.3.5.5 Waste Disposal

Any waste water employed in cutting, washing, and rinsing of RCC surfaces, and any other surface water shall not stain, or affect exposed surfaces of the structure(s) or damage the environment of the project area.

3.4 PLACING

3.4.1 Procedures

Placement of RCC shall be of such depth that when compacted, the surface

will conform with cross section, grade, and contour indicated. Each lift shall be completed in its entirety across the full surface of the mass. Placing of mixture shall be as nearly continuous as possible, with an absolute minimum of stops and starts; speed of placing shall be controlled, to permit proper rolling. The timing of placement shall be controlled so that RCC mixtures shall be placed and rolled within the time limit specified in paragraph COMPACTION. Placing shall be discontinued during rain except for light mists which do not cause intermixing of cement and water slurry on the surface. Placing shall be done in a pattern so that curing water from previous placements will not pose a runoff problem on the fresh surface. The contractor shall use care to minimize the production of cold joints.

3.4.2 Lift Placement

RCC shall be placed in successive horizontal lifts for the spillway structure. RCC for the upstream slope protection shall be placed in an up and down fashion along the slope face.

3.4.3 Lift Thickness

The lift thickness after final compaction by the vibratory roller shall not exceed 300 mm for the spillway structure and 150 mm for the upstream slope.

3.4.4 Bedding Mortar

3.4.4.1 General

The bedding mortar shall be applied to the existing surface following any required cleanup. The bedding mortar shall be applied not more than 15 minutes ahead of RCC placement, unless otherwise approved. The bedding mortar shall be used between different RCC placements where cold joints occur, and at other locations as directed or as shown in the drawings. The bedding mortar shall have an average thickness after application of between 6 and 12 mm and shall cover 100 percent of the lift area. Consolidation of the bedding mortar will not be required. Serrated rakes creating small windrows of mortar or other approved devices shall be used for mortar application. Placing temperature of the mortar shall not exceed 30 degrees C when measured in accordance with ASTM C 1064/C 1064M.

3.4.4.2 Time Interval Between Mixing and Placing

Bedding mortar shall be placed within 30 minutes after discharge into nonagitating equipment. When mortar is truck-mixed or when a truck mixer or agitator is used for transporting mortar mixed by a concrete plant mixer, the mortar shall be delivered to the site, and discharge shall be completed within 1.5 hours after batching.

3.4.5 Depositing, Spreading, and Remixing

After the RCC has been deposited, the RCC shall be spread by dozers into horizontal layers, approximately 150 mm thick, that will, after final compaction of the several layers by the vibratory roller, result in the specified lift thickness. During the spreading process, the dozer

operators shall continuously work the RCC surfaces with the dozer blade in a manner to remix any RCC that may contain pockets of segregated material and to compact the material. A front-end loader with operator shall be available to assist with depositing and spreading RCC as needed in confined areas, and at other locations approved or directed. In no case shall the RCC, or bedding mortar be allowed to dry. Under no conditions shall a dozer or other tracked vehicle be operated on other than fresh uncompacted RCC except at the start of each lift placement to facilitate startup operations, and then only by an approved procedure. No RCC shall be placed on a previous lift which has not met specification. Unacceptable material shall be removed.

3.5 COMPACTION

After spreading and working with the dozers, the top surface of each lift shall be compacted with a self-propelled double-drum vibratory roller operating in the vibratory mode as are required to obtain the minimum compaction specified. A round trip over the same material shall count as two passes (i.e., from point A to point B and return to point A by the same route is two passes). Rolling shall begin within 10 minutes of spreading and, except for fresh joints, rolling shall be completed within 45 minutes of start of mixing, except during hot or dry weather conditions, as described in paragraph Placing During Hot Weather. In hot or dry weather, rolling shall begin within 5 minutes of spreading, and except for joints, rolling shall be completed within 30 minutes of start of mixing. Delays in rolling freshly laid mixture will not be permitted. Rollers shall not be operated in the vibratory mode when not moving. The frequency and amplitude of vibration shall be varied, as needed or directed, within the range specified in paragraph EQUIPMENT. Surfaces of roller drums shall be kept clean at all times. At no time shall water be added during compaction operations to the uncompacted RCC mixture. If in the opinion of the Contracting Officer, the surface of a layer of RCC has been rutted or compacted unduly by hauling equipment so as to reduce the effectiveness of compaction by the specified rollers, the Contractor will be required to scarify such surfaces as directed prior to compacting with the specified rollers. At the start of compaction, the mixture shall be in a uniform, loose condition throughout its full depth. Compaction of each layer shall be done in such a manner as to produce a dense surface.

3.5.1 Optimum Compaction Density (OCD) Determination

3.5.1.1 General

The Optimum Compaction Density (OCD) will be determined during placement of demonstration sections using the supplied mix design and Contractor supplied aggregates, materials, and equipment. The OCD method will be used to determine the requirement for achieving minimum density. All OCD determinations shall be performed by the Contractor in the presence of the Contracting Officer. The OCD will be invalid if material proportions, including water, are outside the designated ranges. OCD demonstration strip compaction will commence no later than 10 minutes after mixing of the RCC. Upon completion of the OCD demonstration section the Government shall provide the Contractor with procedural placement requirements and the Contractor shall proceed with RCC production placement.

3.5.1.2 Determination of OCD

The OCD value will be determined during placement of RCC demonstration section. The density of the RCC shall be determined for every one (1) or two (2) passes of compaction equipment, concurrently on the same demonstration section in 2 locations. Compaction shall continue until the change in density decreases significantly. The OCD shall be the average maximum recorded density. A variation in OCD from the two locations of more than 32 kgs/m^3 shall invalidate the test and require that another test set be performed. The number of roller passes to achieve OCD shall be a guide to the equipment operators of the required compaction necessary to achieve OCD.

3.5.2 Required Compaction Density

RCC layers shall be compacted to at least 98 percent of the Optimum Compaction Density (OCD).

3.5.3 Density Determination of Compacted RCC

Density shall be measured using a nuclear density meter in accordance with ASTM C 1040. RCC density value determinations shall be made throughout the course of RCC placement to assure that the RCC is compacted to a minimum 98 percent of the OCD and detect segregation and/or voids throughout the RCC. Compacted RCC which indicates soft or yielding materials shall be tested immediately with the nuclear meter for moisture and density. If test results confirm that the RCC moisture content exceeds that specified, the soft or yielding area(s) will be removed and replaced by the Contractor at no additional cost to the Government.

3.5.4 Operation of Rollers and Tampers

Speed of rollers shall be slow enough at all times to avoid displacement of the RCC but in no case more than 2.5 km/hr. Displacement of RCC resulting from reversing direction of roller or from any other cause shall be immediately corrected. Alternate passes of the roller shall be varied slightly in length and shall overlap sufficiently to provide full coverage over the surface. Additional rollers shall be furnished if RCC density specified is not attained and/or if placing operations are getting ahead of rolling. In no case shall the Contractor allow placing operations be altered without approval of the Contracting Officer's Representative. Places inaccessible to large vibratory rollers shall be thoroughly compacted with walk-behind rollers and hand-tampers to the required density, using multiple thin lifts, as necessary. Additional field density tests shall be made for those areas by the Contractor and may also be made by the Government.

3.5.5 Rolling Pattern

Rolling shall commence at the outer edge of the lane or lift abutting either a bulkhead, previously compacted RCC, or a construction joint. On subsequent adjacent lane or lift, rolling shall begin at the outer edge. The first pass along each edge shall extend to within approximately 450 mm

of the edge except as otherwise approved or directed. If there will be a subsequent lane placed along an edge and the joint will be constructed as a "fresh" joint, the roller shall go no closer to the outer edge until the subsequent lane is placed. If there will be a subsequent lane and the joint will be treated as a "cold" construction joint, or if the edge will be the final edge of the RCC, the outer 450 mm shall be rolled after rolling of the center of the lane. If the edge abuts a previously placed strip, either as a "fresh" joint or as a "cold" joint, the uncompacted joint area shall be rolled after the center of the lane. This joint area shall be given additional passes of the vibratory roller, as necessary, to produce the specified compaction in the joint area. Approved hand-finishing operations shall be used as necessary to produce a tight surface at the joint. The rolling pattern shall be used consistently throughout production.

3.6 JOINTS

Joints shall be perpendicular to the finished grade of the RCC. Joints shall be straight and continuous from edge to edge. Construction joints shall be made to ensure continuity in smoothness and grade between old and new sections of RCC, as specified hereinafter. All joints shall have the same texture, full-depth density, and smoothness as specified for other sections. Regardless of age, contact surfaces of previously constructed strips that have become coated with dust, sand, or other objectionable material shall be cleaned by brushing or cut back with approved power saw, as directed. Joints of the successive lift shall be staggered not less than 450 mm away from the joints of the preceding lift, nor shall the joint be repetitive in position in every other lift.

3.6.1 Lift Joints

The entire RCC shall be placed with sufficient continuity so that it hardens and acts as one monolithic structure without discontinuous joints or potential planes of separation. All lift joints shall be kept clean, uncontaminated, free from ponded water, and continuously moist until placement of the succeeding RCC.

3.6.1.1 Lift Placed Within 4 Hours

Regular lift-joint treatment and maintenance applies to subsequent lifts placed within 4 hours of the previous lift and shall include:

a. Maintaining 100 percent of each compacted lift-joint surface continuously moist by application of water.

b. If necessary, removing all loose contaminants or deteriorated RCC by low pressure washing and vacuuming, air-jetting, or by the methods and procedures in paragraph SURFACE PREPARATION.

c. During periods of hot weather as defined in paragraph PLACING DURING HOT WEATHER, the time period for regular lift joint treatment shall be reduced to 2 hours. After 2 hours, the requirements of paragraph Lift Placed Within 4-8 Hours shall apply.

3.6.1.2 Lift Placed Within 4-8 Hours

When placement of the overlying lift does not occur within 4 hours the surface prior to RCC placement shall be treated by air-water cutting.

a. The air pressure used in the jet shall be 620 to 760 kPa (90 to 110 psi), and the water pressure shall be just sufficient to bring the water into effective influence of the air pressure. After cutting, the surface shall be washed and rinsed until the wash water is no longer cloudy. Surfaces shall be inspected and approved by the Contracting Officer.

b. During periods of hot weather as defined in paragraph Placing During Hot Weather, the time period shall be reduced to 4 hours. After 4 hours the requirements of paragraph Lift Placed More Than 8 Hours shall apply.

3.6.1.3 Lift Placed More Than 8 Hours

When placement of the overlying lift does not occur within 8 hours the surface prior to placement shall be treated by air-water cutting as indicated in paragraph Lift Placed Within 4-8 Hours and/or by the methods and procedures in paragraph SURFACE PREPARATION. Following this initial preparation the cold-joint surface shall be kept continuously moist until the application of a bedding mortar. During periods of hot weather as defined in paragraph Placing During Hot Weather, the time period shall be reduced to 4-hours.

3.6.2 Longitudinal Construction Joints

Any construction joints in which the edge of the initial strip has exceeded the time requirements given in paragraph JOINTS shall be considered "cold joints" and shall be trimmed by cutting back into the complete lift to form a full-depth vertical face and the excess material removed. This vertical face shall be dampened before the placement of the fresh lane begins.

3.6.3 Transverse Construction Joints

When a transverse construction joint is required, the roller shall pass over the end of the freshly placed RCC. In these cases, the previously placed materials shall be cut to full depth of the lift, and the excess material removed. Transverse joints may also be formed by using bulkheads and forms to provide a full-depth vertical face. This vertical face shall be dampened before the placement of the fresh lift begins. When necessary, the fresh mixture shall be hand finished at the joints. Additional rolling shall be used to assure that specified full-depth density and surface finish is attained.

3.6.4 Joint Cleanup and Waste Disposal

The method and equipment proposed for joint cleanup and waste disposal shall be submitted for review by the Contracting Officer before concrete placement begins.

3.7 CURING AND PROTECTION

3.7.1 General

Temporarily exposed surfaces of RCC that will be in contact with succeeding layers of RCC shall be kept continuously moist by moist curing method described hereinafter until placement of the subsequent layer. Curing of permanently exposed surfaces shall begin immediately after compaction and shall continue for at least 14 days. When wood or metal forms are left in place during curing, the forms shall be kept continuously wet. RCC shall be cured and protected from premature drying, extremes in temperature, rapid temperature change, freezing, mechanical damage and exposure to rain or flowing water. The Contractor shall have all equipment needed for adequate curing and protection on hand and ready to install before actual placement begins. The curing method used shall be approved by the Contracting Officer. The RCC shall be protected from the damaging effects of rain for 12 hours and flowing water for 14 days.

3.7.2 Moist Curing

RCC will be moist cured by maintaining all surfaces continuously, not periodically, wet for the duration of the entire curing period. Water for curing shall comply with the requirements of paragraph: WATER. If water is used which stains or discolors RCC surfaces which are to be permanently exposed, the surfaces shall be cleaned to the satisfaction of the Contracting Officer. Horizontal surfaces may be cured by covering with a minimum uniform thickness of 150 mm of continuously saturated sand. Temporarily exposed surfaces shall not be cured by saturated sand.

3.7.3 Truck Applications

Water trucks shall be used, as necessary, to keep surfaces moist at all times until a sprinkler system, wet burlap covering, or final curing method is implemented. The water truck shall be supplemented, as necessary, by mists from hand-held hoses. The truck operator shall be positioned so he is capable of seeing the spray at all times. The spray shall be capable of easy direction, either by attachment to the front of the truck so it can be directed by steering the truck or by other approved means. All spray nozzles both on the trucks and the hand held hoses shall be of a type that produces a true fog spray without any concentrated streams of water. The mist shall not be applied in a channelized or pressurized manner that in any way erodes the surface of the RCC. It shall also be applied at a rate which does not cause ponding at the surface. Trucks shall not be allowed to drop visible oil or other contaminants on the surface. If trucks must leave the surface, the tires shall be washed free of dirt or other foreign material before returning to the surface. Water truck wheel loads shall not exceed 2,000 kg and shall be such that no cracking or other damage to the RCC is caused.

3.7.4 Sprinkler System

An approved sprinkler system consisting of pipe lines and rotating or other approved type of sprinklers may be used. Sprinklers shall deliver a fine mist of water and shall not cause any erosion to the surface of the RCC.

The sprinkler system shall cover all portions of the RCC surface, and keep the surface wet at all times.

3.7.5 Burlap

Burlap covers shall consist of two or more layers of burlap having a combined weight of 4,736 gm per square meter in a dry condition. Burlap shall be either new or shall have been used only for curing RCC or conventional portland cement concrete. Burlap strips shall have a length after shrinkage of at least 300 mm greater than necessary to cover the entire width and edges of the RCC. Mats shall overlap each other at least 150 mm. Mats shall be thoroughly wetted before placing and shall be kept continuously wet and in intimate contact with the surface and edges of the area for the entire specified curing period.

3.7.6 Cure Water Runoff Control

Any water applied to the surface of the RCC or burlap during curing that is in excess of the amount needed to keep the surface of the RCC continuously wet shall be controlled from running onto the subgrade or underlying material and causing ponding on the subgrade or saturation of the subgrade or underlying material.

3.7.7 Protection of RCC

After final rolling of the RCC, no vehicular traffic, except for pneumatic-tired water spray trucks or other curing equipment having wheel loads not exceeding 2,000 kg shall be permitted on the RCC until the end of the curing period. No traffic or equipment shall be allowed on the surface that will cause any damage to the surface. Plastic sheeting meeting the requirements of ASTM C 171 shall be provided and kept readily available to cover RCC less than 12 hours old if rainfall occurs.

3.8 VERTICAL FACINGS FOR RCC CONSTRUCTION

The vertical faces of the RCC structure are to be constructed using a form similar to conventional concrete forms as shown and specified in the drawings. The vertical facings system shall be demonstrated on (one side of) each of the RCC test sections.

3.8.1 Forms for Vertical Facing

Vertical facings shall be as shown in the drawings. The contract drawings are based on designs whereby all vertical and near-vertical faces are constructed at the same time and placement rate of each RCC lift. The design and engineering of the formwork, as well as its construction, shall be the responsibility of the Contractor. The formwork shall be designed for loads, lateral pressure, and allowable stresses in accordance with ACI 347R. Forms shall have sufficient strength to withstand the pressure resulting from placement and vibration of the RCC and shall have sufficient rigidity to maintain specified tolerances. Vertical formwork shall be constructed such that forms are full wall height and shall be left in place (minimum time to be demonstrated during test sections) for all vertical layers/lift of RCC. The required sequence of construction operations after

all forms and surface preparations have been approved is: place the uncompacted RCC (at the specified lift thickness) at full width against the forms; using dozer action, spread each thin RCC layer abutting against the forms, compact the RCC using the vibratory roller except the step edge shall be compacted with a hand-held tamper. Extreme care shall be taken to assure all time restrictions are met and to prevent the occurrence of any openwork, honeycombing, or voids at the formed RCC surface. The Contractor's construction techniques and equipment used including form anchor capability, and elapsed time for form stripping shall be satisfactorily demonstrated during construction of the test sections.

3.9 FINISHING SURFACE

After compaction to the required lines and grades as shown in the drawings, RCC final surfaces shall be smooth and uniform and shall be free of surface pitting, voids or indentations, pockmarks, check cracking, segregation or rock pockets, aggregate drag marks, areas loosened by construction operations, and areas where fines have been washed away during curing process that are greater than 12.5 mm in depth. All holes left in the RCC as a result of nuclear density testing in the upstream slope face and in the last lift of the spillway shall be filled by the Contractor with a cement grout, as directed. Additionally, all holes from the removal of formstakes shall be filled with grout.

3.10 DEFECTIVE AREAS AND SURFACES

Mixtures that become contaminated or are defective shall be removed. Skin patching of an area that has been rolled will not be permitted. Defective surfaces including spalls, excessive rock pockets, voids in the RCC surfaces (both horizontal and vertical surfaces), or in such areas describe in paragaph FINISHING SURFACE shall be repaired in accordance with paragraph SURFACE REPAIR. No additional payment will be made to the Contractor for the repair or for the removal of the defective areas and surfaces.

3.10.1 Surface Repair

Horizontal surface and vertical (formed) surface shall have surface defects repaired as follows: defective areas, spalls, and voids shall be chipped, cleaned, epoxy-coated, and filled with dry-packed mortar. Spalled areas shall be prepared by dovetailed saw cut (in a rectangular pattern) to a minimum depth of 25 mm or to such depth to expose a sound RCC surface at a minimum distance of 25 mm outside the farthest edge of the spall. The prepared areas shall be brush-coated with an epoxy resin meeting the requirements of paragraph EPOXY RESIN. All holes or voids left in the RCC as a result of form stakes removal shall be filled immediately with a cement grout, as directed.

3.10.2 Material and Procedure for Repair

The cement used in the dry-packed mortar shall be a blend of the cement used for production of RCC and white portland cement properly proportioned so that the final color of the mortar will match adjacent RCC. Trial batches shall be used to determine the proportions required to match

colors. Dry-packed mortar shall consist of one part cement to two and one-half parts fine aggregate. The fine aggregate shall meet the grading and quality requirements of ASTM C 33. The mortar shall be remixed over a period of at least 30 minutes without addition of water until it obtains the stiffest consistency that will permit placing. Mortar shall be thoroughly compacted into the prepared areas by tamping, rodding, etc. and struck off to match adjacent RCC. The repaired areas shall be cured for 7 days. Other methods and materials for repair may be used only when approved in writing by the Contracting Officer.

3.11 CONTRACTOR QUALITY CONTROL

3.11.1 General

The Contractor shall perform the inspection and tests as described below, and based upon the results of these inspections and tests, he shall take the action required and submit reports as required. When, in the opinion of the Contracting Officer, the RCC operation is out of control, RCC placement shall cease. The laboratory performing the tests shall conform to ASTM E 329. Any test results requested by the Government for review shall be provided to the Government immediately, and all results of every test by the Contractor shall be furnished to the Government on a daily basis, not later than the day after the test or inspection is made. Verification tests of materials and RCC, if made by the Government, shall in no way relieve the Contractor from the testing requirements specified herein.

3.11.2 Testing and Inspection Requirements

3.11.2.1 Calibration of Mixing Plant

a. Batch-Mixing Plants: Accuracy of the batching equipment shall be checked for each type of cementitious material and aggregate at the beginning of operations and at least once for every 10 shifts in the presence of the Contracting Officer. Such checks shall also be made whenever there are variations in properties of the fresh RCC which could be the result of batching errors. Standard test weights accurate to plus or minus 0.1 percent shall be provided for checking plant scales.

b. Continuous-Mixing Plants: Accuracy of proportioning of the continuous-mixing plant shall be checked for each cementitious material every day at the beginning of operations and for aggregate at the beginning of construction and after every 10 shifts. The accuracy of proportioning shall be checked by simultaneously securing timed samples of the cementitious materials and the aggregate as they are fed to the mixer and weighing each as appropriate.

c. Mixing Time: Mixing time of the pug mill shall be checked at the direction of the Government. Unless otherwise required, determination of mixing time shall be by weight method using the following formula:

Mixing time in seconds = pug mill dead capacity in kg/pug mill output in kg per second

3.11.2.2 Quality of Aggregates

a. Frequency of Quality Tests - Prior to submitting samples for mixture proportioning studies, the Contractor shall perform the tests for specific gravity, friable particles, soft particles, and other tests as specified in paragraph AGGREGATES. In addition, after the start of RCC placement, the Contractor shall perform tests for aggregate quality during RCC construction or aggregate production. Tests for quality shall be performed at least once for each 4,000 cubic meters of placed RCC or produced aggregate and otherwise when there may be a visual change in the aggregate.

b. Corrective Action for Aggregate Quality - If the result of a quality tests fail to meet the requirements during submittal of samples for mixture-proportioning studies, production procedures or materials shall be changed and additional tests shall be performed until the material meets the specified requirements prior to proceeding with the mixture-proportioning studies. If the aggregates still fail the tests, the fact shall be reported to the Contracting Officer and immediate steps shall be taken to rectify the situation.

3.11.2.3 Aggregate Moisture Tests

a. Frequency of Tests - There shall be at least two tests for moisture content tests in accordance with ASTM C 566 or ASTM C 70 during each shift of mixing plant operation. The times for the tests shall be selected randomly within each shift. Additional tests shall be made whenever excessive variation in workability is reported by the placing foreman.

b. Corrective Action for Moisture Tests - When moisture content determinations indicate a change in water entering the mix with the aggregates, the placement foreman shall be notified to check if a corresponding adjustment in water added at the mixer is necessary to obtain adequate compaction and meet consistency requirements at the placement site.

3.11.2.4 Sieve Analysis

a. Grading - Before starting work, at least one sample of aggregate shall be tested in accordance with ASTM C 136 and ASTM C 117. The aggregate shall not be used unless results verify that the aggregate complies with the specified gradation and tolerances. After the initial test, a minimum of one analysis shall be performed for each 400 cubic meters or portion thereof of RCC material placed each shift. The location at which samples are taken may be selected by the Contractor as the most advantageous for production control. However, the Contractor shall be responsible for delivering the aggregate to the mixer within specification limits.

b. Corrective Action for Grading - When deficiences in grading are found, the rate of testing shall be increased as directed. When two consecutive tests show the aggregate to be deficient in grading, the mixing operation shall be stopped until acceptable material is

furnished for delivery to the mixer.

3.11.2.5 Scales

a. Weighing Accuracy - The accuracy of the scales shall be checked by test weights at least once a month for conformance with the applicable requirements of paragraphs BATCH PLANT and CONTINUOUS MIXING PLANT. Such tests shall also be made as directed whenever there are variations in properties of the fresh RCC that could result from batching errors.

b. Batching and Recording Accuracy - Once a week the accuracy of each batching and recording device shall be checked during a weighing operation by noting and recording the required weight, recorded weight, and the actual weight batched. The Contractor shall confirm that the calibration devices described in paragraph BATCH PLANT are operating properly. If a continuous mixing plant is provided, the accuracy and operation of all feeding and dispensing units shall be checked before the start of operation each day.

c. Scales Corrective Action - When the weighing accuracy or batching accuracy does not comply with specification requirements, the plant shall not be operated until necessary adjustments or repairs have been made. Discrepancies in recording accuracies shall be corrected immediately.

3.11.2.6 Mixing Plant Control

The measurement of all constituent materials including cementitious materials, aggregate, and water shall be continuously controlled. The aggregate weight and amount of added water shall be adjusted as necessary to compensate for free moisture in the aggregates. A report shall be prepared indicating type and source of cement used, type and source of pozzolan used, and aggregate source, during plant operation.

3.11.2.7 Field Density

a. Testing and Checking - Density shall be determined for each 150 square meters of completed lift, with a calibrated nuclear density gauge in accordance with ASTM C 1040. Additional tests shall be made, as directed, particularly during start-up and when problems with attaining the required density occur. Field density tests shall be performed as soon as possible, but within 30 minutes, after the completion of vibratory rolling. Each test performed in the spillway structure shall include readings taken at incremental depths of 50 mm to depth of 250 mm. In the upstream slope, density tests shall include readings taken at incremental depths of 50 mm to depth of 100 mm. Only the deepest reading shall be used to evaluate the density. Both wet and dry densities shall be reported, and all individual readings shall be reported; however, only the wet density shall be used for evaluation.

b. Action Required - Whenever the nuclear gauge indicates density less than the specified density, a retest shall be made. If the retest indicates unacceptable density, the Contracting Officer's

Representative shall be notified, additional rolling shall be immediately provided, and a determination shall be made as to whether the lower density resulted from insufficient passes of the roller or a change in the mix properties. If the mix properties have changed, adjustments such as increasing or decreasing the moisture content shall be made at the batch plant. If the problem persists, the Contracting Officer may adjust the proportions of aggregates, cement, and/or pozzolan. If the lower density is the result of incomplete rolling, the operator shall be notified and the Contracting Officer may require removal of the incompletely compacted material at no cost to the Government.

3.11.2.8 Moisture Tests of RCC Mix

a. Testing and Checking - Moisture content of the RCC mix shall be determined each time a density reading is taken with a calibrated nuclear gauge. The nuclear gauge shall be set to backscatter mode when determining moisture content. The calibration of the nuclear gauge shall be verified to oven dry materials at least once per five (5) shifts.

b. Corrective Action - The placing foreman shall continuously monitor the apparent effectiveness of compaction equipment from a visual standpoint, and shall notify the mixing plant whenever the mix becomes too dry or too wet. Whenever moisture content tests indicate a change from what has been established as the optimum batching and placing moisture for maximum density and efficiency of compaction equipment, an adjustment shall be made in the mix water added at the mixing plant and the adjustment shall be noted.

3.11.2.9 Coring Specimens

All cores shall become the property of the Government and may be tested for strength determination or other properties as considered appropriate. Refilling of core holes shall be performed with portland cement mortar, using materials and procedures directed.

a. Upstream Slope - Cores shall be drilled by the Contractor from points in the RCC to determine thickness within 7 days after placement. A minimum of two cores per days placement will be taken from locations selected in a random fashion by the Contracting Officer. Cores shall be 150 mm diameter and shall be obtained for the full depth of RCC placement.

b. Spillway Structure - Cores shall be drilled by the Contractor at locations selected by the Contracting Officer. A minimum of one core per days placement will be taken or as specified by the Contracting Officer. Cores shall be 150 mm diameter and shall be obtained for the full depth of RCC placement.

3.11.2.10 Thickness Evaluation

The thickness of the RCC will be determined by the Government on the basis of measurements made on cores drilled by the Contractor from locations

outlined in paragraph CONTRACTOR QUALITY CONTROL. Measurements of individual cores will be performed in accordance with ASTM C 174/C 174M. When the measurement of any core indicates that the RCC is deficient in thickness by 25 mm or more, additional cores shall be drilled by the Contractor at 8 m intervals, on all sides of the deficient core until the cores indicate that the deficiency in thickness is less than 25 mm. If after the measurement of the additional cores still indicate a deficiency in thickness of 25 mm or more, the areas represented by those cores shall be removed and replaced with RCC of the specified thickness at no additional cost to the Government. If the Contractor believes that the cores and measurement taken are not sufficient to indicate fairly the actual thickness of the RCC, additional cores shall be taken and will be measured provided the Contractor shall bear the extra cost of drilling the cores.

3.11.2.11 Inspection Before Placing

Construction joints and other horizontal surfaces shall be inspected by the Contractor in sufficient time prior to the next lift placement to certify to the Contracting Officer that they are ready to receive RCC. The results of each inspection shall be reported in writing. The inspection of the lift surfaces of the RCC will be a continuing activity and shall be accomplished in accordance with paragraphs SURFACE PREPARATION and JOINTS.

3.11.2.12 Inspection During Placing

a. Inspection - The Contractor shall provide full time supervision of all placing operations to insure that the correct quality of RCC or bedding mortar are performed in accordance with the contract. During placing operations, the quality control staff shall measure and record RCC temperatures in accordance with ASTM C 1064/C 1064M, ambient temperature hourly, record weather conditions, time of placement, volume placed, and method of placement.

b. Cold-Weather Placing - At least once during each shift, an inspection shall be made of all areas subject to cold-weather protection. Deficiencies shall be noted. During removal of protection, the RCC temperature and ambient temperature shall be measured at least hourly.

c. Hot-Weather Placing - When the maximum daily air is likely to exceed 30 degrees C, the Contractor shall take and record the temperature of the mixture at 30-minute intervals during hot-weather placement. The surface of the subgrade or RCC shall be inspected to assure that it is sprinkled with water immediately before the next layer of RCC is placed and any deficiencies noted.

d. Corrective Action - The placing foreman shall not permit RCC placing to begin until he has verified that necessary equipment are all in working order and with competent operators. Placing shall not be continued if any lift of RCC is not fully compacted.

e. Temperature Protection - The Contracting Officer shall be notified whenever the RCC temperature during the period of protection or

protection removal fails to comply with the specifications, and immediate steps shall be taken to correct the situation. Regardless of the ambient temperature, when the temperature of the RCC mixture exceeds 32 degrees C, mixing and placing shall be stopped and the Contracting Officer notified.

3.11.2.13 Curing Inspection

a. Moist Curing Inspections - At least twice each shift, and twice per day on nonwork days an inspection shall be made of all areas subject to moist curing. The surface moisture condition shall be noted and recorded.

b. Moist Curing Corrective Action - When a daily inspection report lists an area of inadequate curing, immediate corrective action shall be taken, and the required curing period for those areas shall be extended by one day.

3.11.2.14 Cold-Weather and Hot-Weather Protection

At least once each shift and once per day on nonwork days an inspection shall be made of all areas subject to cold-weather or hot-weather protection. Any deficiencies shall be noted, corrected, and reported.

3.11.2.15 Cold-Weather and Hot-Weather Protection Corrective Action

When a daily inspection report lists deficiencies, the deficiency shall be corrected immediately and the period of protection extended for one day.

3.11.3 Reports

All results of tests conducted at the project site shall be reported daily and shall be delivered to a designated representative of the Contracting Officer. During periods of cold weather protection, reports of pertinent temperatures shall be made daily. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in preceding paragraphs. Such reports of failure and the action taken shall be confirmed in writing in the routine reports. The Contracting Officer has the right to examine all Contractor quality control records at any time.

-- End of Section --