

Preparing Activity: USACE

Superseding
UFGS-03 37 23 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2024

SECTION TABLE OF CONTENTS

DIVISION 03 - CONCRETE

SECTION 03 37 23

ROLLER-COMPACTED CONCRETE FOR MASS CONCRETE CONSTRUCTION

11/09

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Roller-Compacted Concrete (RCC) in [_____]

- 1.1.1.1 Payment
- 1.1.1.2 Measurement
- 1.1.1.3 Unit of Measure

1.1.2 Dental Concrete

- 1.1.2.1 Payment
- 1.1.2.2 Measurement
- 1.1.2.3 Unit of Measure

1.1.3 Bedding Concrete

- 1.1.3.1 Payment
- 1.1.3.2 Measurement
- 1.1.3.3 Unit of Measure

1.1.4 Portland Cement

- 1.1.4.1 Payment
- 1.1.4.2 Measurement
- 1.1.4.3 Unit of Measure

1.1.5 Pozzolan

- 1.1.5.1 Payment
- 1.1.5.2 Measurement
- 1.1.5.3 Unit of Measure

1.1.6 Water-Reducing Admixture (WRA)

- 1.1.6.1 Payment
- 1.1.6.2 Measurement
- 1.1.6.3 Unit of Measure

1.1.7 RCC Test Section

- 1.1.7.1 Payment
- 1.1.7.2 Measurement
- 1.1.7.3 Unit of Measure

1.2 REFERENCES

1.3 SUBMITTALS

1.4 QUALITY ASSURANCE

- 1.4.1 Preconstruction Government Testing
- 1.4.2 Cementitious Materials and Admixtures
- 1.4.3 Government Testing During Construction
 - 1.4.3.1 Aggregates Testing
 - 1.4.3.2 Cementitious Materials
 - 1.4.3.3 Prequalified Cement Sources
 - 1.4.3.4 Prequalified Pozzolan Sources
 - 1.4.3.5 Nonprequalified Cement Sources
 - 1.4.3.6 Nonprequalified Pozzolan Sources
 - 1.4.3.7 Admixtures
- 1.5 DELIVERY, STORAGE, AND HANDLING
 - 1.5.1 Cementitious Materials
 - 1.5.1.1 Transportation
 - 1.5.1.2 Storage
 - 1.5.2 Aggregate Storage
 - 1.5.3 Chemical Admixtures
- 1.6 ENVIRONMENTAL REQUIREMENTS
 - 1.6.1 Cold-Weather Placement
 - 1.6.2 Placing During Rain
 - 1.6.3 Hot-Weather Placement

PART 2 PRODUCTS

- 2.1 RCC SYSTEM
 - 2.1.1 General Requirements
 - 2.1.2 Mixture Proportions and Studies
 - 2.1.3 Proportioning Responsibility
 - 2.1.4 Nominal Maximum Size of Aggregate
 - 2.1.5 Consistency of RCC
 - 2.1.6 Materials for Mixture-Proportioning Studies
- 2.2 MATERIALS
 - 2.2.1 Cementitious Materials
 - 2.2.1.1 Portland Cement
 - 2.2.1.2 Pozzolan
 - 2.2.1.3 Ground Granulated Blast-Furnace (GGBF) Slag
 - 2.2.1.4 Temperature of Cementitious Materials
 - 2.2.2 Admixtures
 - 2.2.2.1 Water-Reducing Admixture (WRA)
 - 2.2.2.2 Air-Entraining Admixture
 - 2.2.3 Water
 - 2.2.4 Aggregates
 - 2.2.4.1 Composition
 - 2.2.4.2 Quality
 - 2.2.4.3 Grading
 - 2.2.4.4 Particle Shape
 - 2.2.4.5 Moisture Content
 - 2.2.4.6 Commercial Concrete Aggregate Sources
 - 2.2.4.7 Government-Furnished Concrete Aggregate Source
- 2.3 PLANT AND EQUIPMENT
 - 2.3.1 Concrete Plant
 - 2.3.2 Location
 - 2.3.3 Bins and Silos
 - 2.3.4 Bulk Cement or Pozzolan
 - 2.3.5 Batch Plant
 - 2.3.5.1 Batchers
 - 2.3.5.2 Water Batchers
 - 2.3.5.3 Admixture Dispensers
 - 2.3.5.4 Moisture Control
 - 2.3.5.5 Scales

- 2.3.5.6 Operation and Accuracy
- 2.3.5.7 Interlocks
- 2.3.5.8 Recorder
- 2.3.5.9 Batch Counters
- 2.3.5.10 Rescreening Plant
- 2.3.5.11 Washing Plant
- 2.3.5.12 Batch Plant Trial Operation
- 2.3.5.13 Protection
- 2.3.6 Continuous Mixing Plant(s)
 - 2.3.6.1 Operation and Accuracy
 - 2.3.6.2 Cement, Pozzolan, and Aggregate Feed
 - 2.3.6.3 Water and Admixture Dispensers
 - 2.3.6.4 Continuous Mixer(s)
 - 2.3.6.5 Segregation
 - 2.3.6.6 Trial Operation
 - 2.3.6.7 Protection
- 2.3.7 Laboratory Areas
- 2.3.8 Mixers
- 2.3.9 Truck Mixers
- 2.3.10 Pugmill Mixers
- 2.3.11 Mixer Uniformity Requirements
- 2.3.12 Sampling Facilities
 - 2.3.12.1 Sampling Concrete
 - 2.3.12.2 Sampling Aggregates
- 2.3.13 Transporting and Conveying Equipment
 - 2.3.13.1 Trucks
 - 2.3.13.2 Belt Conveyors
- 2.3.14 Spreading and Remixing Equipment
- 2.3.15 Compaction Equipment
 - 2.3.15.1 Primary Rollers
 - 2.3.15.2 Small Vibratory Rollers
 - 2.3.15.3 Tampers (Rammers)
 - 2.3.15.4 Other Requirements
- 2.3.16 Truck-Mounted Vacuum Pickup System
- 2.3.17 Other Motorized Equipment
- 2.3.18 Nuclear Density Gauge
- 2.3.19 Calibration
- 2.3.20 Vibrators
- 2.3.21 Slipforming Equipment

PART 3 EXECUTION

- 3.1 PREPARATION FOR PLACING
 - 3.1.1 Placing Schedule
 - 3.1.2 RCC Orientation Session
 - 3.1.3 Aggregate Production Schedule
 - 3.1.4 RCC Test Section
 - 3.1.5 Surface Preparation
 - 3.1.5.1 Cleaning
 - 3.1.5.2 High-Volume Low-Pressure Washing
 - 3.1.5.3 High-Pressure Water Jet
 - 3.1.5.4 Wet Sandblasting
 - 3.1.5.5 Waste Disposal
- 3.2 PLACING
 - 3.2.1 Procedures
 - 3.2.2 Bedding Mortar
 - 3.2.3 Bedding Concrete
 - 3.2.4 Lift Thickness
 - 3.2.5 Depositing, Spreading, and Remixing

- 3.2.6 Compaction/Consolidation
 - 3.2.6.1 Theoretical Density (TD) Determination
 - 3.2.6.2 Required Compaction Density
 - 3.2.6.3 Density Determination of Compacted RCC
 - 3.2.6.4 Additional Compaction
 - 3.2.6.5 Consolidation of Bedding and Other Conventional Concrete
- 3.2.7 Lift Joints
 - 3.2.7.1 Regular Lift-Joint Treatment
 - 3.2.7.2 Cold Joints
 - 3.2.7.3 Vertical Joints
- 3.2.8 Downstream Face
 - 3.2.8.1 Using Sacrificial Concrete
 - 3.2.8.2 Using Conventional Concrete
- 3.3 CURING AND PROTECTION
 - 3.3.1 Curing
 - 3.3.2 Cold-Weather Protection
 - 3.3.3 Special Cold-Weather Insulation Protection
 - 3.3.4 Hot-Weather Protection
- 3.4 VERTICAL FACINGS FOR RCC CONSTRUCTION
 - 3.4.1 Form and Cast-in-Place Conventional Concrete
 - 3.4.2 Slipformed Facing Elements
 - 3.4.2.1 Prequalification of Equipment
 - 3.4.2.2 Slipform Operations
 - 3.4.2.3 Slipforming - Preparation for Placing
 - 3.4.2.4 Slipforming - Placing
 - 3.4.2.5 Slipforming - Finishing
 - 3.4.3 Precast Reinforced Panels
 - 3.4.3.1 Leveling Pad
 - 3.4.3.2 Alignment
- 3.5 CONTRACTION JOINTS
- 3.6 GALLERY
 - 3.6.1 Precast Gallery Segments
 - 3.6.2 Temporary Forms
 - 3.6.3 Noncementing Fill Method
- 3.7 SPILLWAY CONSTRUCTION
 - 3.7.1 Spillway Chute and Ogee Section
 - 3.7.2 Training Walls
 - 3.7.3 Finishing
 - 3.7.3.1 General
 - 3.7.3.2 Float Finish
- 3.8 CONSTRUCTION TOLERANCES
 - 3.8.1 Conventional Concrete Surfaces
 - 3.8.2 RCC Surfaces
- 3.9 TESTS AND INSPECTIONS
 - 3.9.1 General
 - 3.9.2 Testing and Inspection Requirements
 - 3.9.2.1 Fine Aggregate
 - 3.9.2.1.1 Grading
 - 3.9.2.1.2 Fineness-Modulus Control Chart
 - 3.9.2.1.3 Corrective Action for Fine Aggregate Grading
 - 3.9.2.1.4 Moisture Content Testing
 - 3.9.2.1.5 Moisture Content Corrective Action
 - 3.9.2.2 Coarse Aggregate
 - 3.9.2.2.1 Grading
 - 3.9.2.2.2 Corrective Action for Grading
 - 3.9.2.2.3 Coarse Aggregate Moisture Content
 - 3.9.2.2.4 Coarse Aggregate Moisture Corrective Action
 - 3.9.2.2.5 Material Finer than the 75 μm No. 200 Sieve
 - 3.9.2.2.6 Corrective Action for material finer than the 75 μm

- No. 200 Sieve
- 3.9.2.3 Quality of Aggregates
 - 3.9.2.3.1 Frequency of Quality Tests
 - 3.9.2.3.2 Corrective Action for Aggregate Quality
- 3.9.2.4 Scales
 - 3.9.2.4.1 Weighing Accuracy
 - 3.9.2.4.2 Batching and Recording Accuracy
 - 3.9.2.4.3 Scales Corrective Action
- 3.9.2.5 Concrete Plant Control
- 3.9.2.6 Concrete
 - 3.9.2.6.1 Conventional Concrete Slump Testing
 - 3.9.2.6.2 Slump Corrective Action
 - 3.9.2.6.3 Air Content
 - 3.9.2.6.4 Air Content Corrective Action
- 3.9.2.7 Field Density
 - 3.9.2.7.1 Testing and Checking
 - 3.9.2.7.2 Action Required
- 3.9.2.8 Inspection Before Placing
- 3.9.2.9 Placing Inspection
 - 3.9.2.9.1 Inspection
 - 3.9.2.9.2 Corrective Action
- 3.9.2.10 Vibrator Tests
 - 3.9.2.10.1 Vibrator Testing and Use
 - 3.9.2.10.2 Vibrator Corrective Action
- 3.9.2.11 Curing Inspection
 - 3.9.2.11.1 Moist Curing Inspections
 - 3.9.2.11.2 Moist Curing Corrective Action
- 3.9.2.12 Cold-Weather and Hot-Weather Protection
- 3.9.2.13 Cold-Weather and Hot-Weather Protection Corrective Action
- 3.9.3 Reports

-- End of Section Table of Contents --

Preparing Activity: USACE

Superseding
UFGS-03 37 23 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2024

SECTION 03 37 23

ROLLER-COMPACTED CONCRETE FOR MASS CONCRETE CONSTRUCTION
11/09

NOTE: This guide specification covers the requirements for furnishing, hauling, placing, and roller-compacting concrete for mass concrete construction. This section was originally developed for USACE Civil Works projects.

Adhere to [UFC 1-300-02](#) Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a [Criteria Change Request \(CCR\)](#).

PART 1 GENERAL

1.1 UNIT PRICES

NOTE: If Section 01 20 00 PRICE AND PAYMENT PROCEDURES is included in the project specifications, this paragraph title (UNIT PRICES) should be deleted from this section and the remaining appropriately edited subparagraphs below should be inserted into Section 01 20 00.

See appropriate Design Memorandum (DM) for concrete items that are to be measured by the neat line, batch or lump sum.

1.1.1 Roller-Compacted Concrete (RCC) in [_____]

NOTE: Repeat this bid item and its respective subparagraphs for each bid item of concrete, renumbering the bid items appropriately.

See the Design Memorandum on the use of the optional item on air entrainment.

If bedding concrete is to be paid for as a separate bid item, delete the optional words, "Bedding concrete and", below.

1.1.1.1 Payment

Payment will be made for costs associated with completing the concrete work for roller-compacted concrete placed in the [_____], including all aggregate [, air-entraining admixture,] and the use of all equipment and tools to complete the concrete work. However, these costs will not include the cost of the cement, pozzolan, [water-reducing admixture,] and embedded parts that are specified to be paid for separately. [Bedding concrete and] bedding mortar [is] [are] incidental to the RCC and will be paid for as part of the RCC within the neat lines. [Joint materials, waterstops, sealants, and bond breakers are incidental to the concrete and will be paid for as part of the RCC.] No payment will be made for concrete, as such, that is placed in structures of which payment is made as a lump sum.

1.1.1.2 Measurement

Roller-compacted concrete will be measured for payment on the basis of the actual volume of RCC within the pay lines of the structures as indicated on the drawings. Measure RCC placed against the sides of any excavation without the use of intervening forms only within the pay lines of the structure. No deductions will be made for rounded or beveled edges, space occupied by metal work, electrical conduits or reinforcing steel, nor for voids or embedded items that are either less than 0.14 cubic meter 5 cubic feet in volume or 0.09 square meter 1 square foot in cross section.

1.1.1.3 Unit of Measure

Unit of measure: cubic meter yard.

[1.1.2 Dental Concrete

1.1.2.1 Payment

Payment will be made for costs associated with placing dental concrete.

1.1.2.2 Measurement

Dental concrete will be measured for payment based upon the actual volume of dental concrete placed. The dental concrete volume in cubic meters yards will be computed from the mass weight of the material batched at the batch plant using the theoretical mass per meter weight per yard as

determined from the design mixture. Any concrete which is wasted or placed in violation of the specifications will not be measured for payment.

1.1.2.3 Unit of Measure

Unit of measure: cubic meter yard.

]1.1.3 Bedding Concrete

NOTE: If bedding concrete is to be paid for as a separate bid item, delete the optional wording "Bedding concrete and" in Bid Item "(1) Roller-Compacted Concrete (RCC) in [_____]"; above.

1.1.3.1 Payment

Payment will be made for costs associated with placing bedding concrete.

1.1.3.2 Measurement

Bedding concrete will be measurement for payment based upon the actual volume of bedding concrete placed. The bedding concrete volume in cubic meters yards will be computed from the mass weight of the material batched at the batch plant using the theoretical mass/meter weight/yard as determined from the design mixture. Any concrete which is wasted or placed in violation of the specifications will not be measured for payment.

1.1.3.3 Unit of Measure

Unit of measure: cubic meter yard.

]1.1.4 Portland Cement

1.1.4.1 Payment

Payment will be made for costs associated with portland cement, including the cost of required unloading, hauling, handling, and storage at the site, of all portland cement used in the work for all of the concrete bid items.

1.1.4.2 Measurement

Portland cement will be measured for payment based upon the number of tons (metric) (2,000 pounds) of portland cement used, excluding amount specifically excepted, wasted, or used for the convenience of the Contractor. The quantity to be paid for will be determined by multiplying the approved batch mass in kg/cubic meter weight in pounds per cubic yard of portland cement in each type of concrete used by the number of cubic meters yards of concrete types placed within the pay lines of the structure, as determined in accordance with the concrete bid items, and dividing by 1000 2,000.

1.1.4.3 Unit of Measure

Unit of measure: tons (metric) (2,000 pounds).

1.1.5 Pozzolan

1.1.5.1 Payment

Payment will be made for costs associated with pozzolan, including the cost of required unloading, hauling, handling, and storage at the site, of all pozzolan used in the concrete bid items.

1.1.5.2 Measurement

Pozzolan will be measured for payment based upon the number of cubic meters feet solid volume of pozzolan used unless specifically excepted, wasted, or used for the convenience of the Contractor. The quantity to be paid for will be determined by multiplying the approved batch mass in kg/cubic meter weight in pounds per cubic yard of pozzolan in each type of concrete used by the number of cubic meters yards of concrete of the types placed within the pay lines of the structure, as determined in accordance with the concrete bid items, and dividing by the product of the average specific gravity of the pozzolan multiplied by 1000 kg/cubic meter 62.4 pcf. The average specific gravity is the average of the test results for all material accepted during the period covered by the payment.

1.1.5.3 Unit of Measure

Unit of measure: cubic meter foot solid volume.

1.1.6 Water-Reducing Admixture (WRA)

1.1.6.1 Payment

[Payment will be made for costs associated with water-reducing admixture (WRA) at the applicable contract unit price per cubic yard of concrete containing water-reducing admixture.][Payment will be made for costs associated with water-reducing admixture (WRA) at the applicable contract unit cost of concrete containing water-reducing admixture for:

- a. "Bid Item [____]a., first [____] cubic meters yards".
- b. "Bid Item [____]b., all over [____] cubic meters yards".]

1.1.6.2 Measurement

Water-reducing admixture (WRA) will be measured for payment based upon the actual volume of roller-compacted concrete containing the admixture and within the pay lines of the structures, as determined in accordance with the concrete bid items.

1.1.6.3 Unit of Measure

Unit of measure: cubic meter yard.

1.1.7 RCC Test Section

NOTE: The Test Section may be paid for as a lump sum pay item provided test section requirement are clearly specified.

1.1.7.1 Payment

Payment will be made for costs associated with completing the roller-compacted test section, including equipment and tools needed to complete the test section.

1.1.7.2 Measurement

Roller-compacted concrete test section will be measurement for payment based upon the actual number of test sections taken.

1.1.7.3 Unit of Measure

Unit of measure: each.

1.2 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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

AMERICAN CONCRETE INSTITUTE (ACI)

- ACI 117 (2010; R 2015) Specifications for Tolerances for Concrete Construction and Materials and Commentary
- ACI 305R (2020) Guide to Hot Weather Concreting
- ACI 347R (2014; Errata 1 2017) Guide to Formwork for Concrete

ASTM INTERNATIONAL (ASTM)

- ASTM C31/C31M (2024) Standard Practice for Making and Curing Concrete Test Specimens in the Field
- ASTM C33/C33M (2023) Standard Specification for Concrete

Aggregates

ASTM C39/C39M	(2023) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C40	(2011) Standard Test Method for Organic Impurities in Fine Aggregates for Concrete
ASTM C40/C40M	(2020) Standard Test Method for Organic Impurities in Fine Aggregates for Concrete
ASTM C87/C87M	(2023) Standard Test Method for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar
ASTM C94/C94M	(2023) Standard Specification for Ready-Mixed Concrete
ASTM C117	(2023) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C123/C123M	(2023) Standard Test Method for Lightweight Particles in Aggregate
ASTM C127	(2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C128	(2022) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C138/C138M	(2023) Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
ASTM C142/C142M	(2017; R 2023) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C143/C143M	(2020) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2022) Standard Specification for Portland Cement
ASTM C172/C172M	(2017) Standard Practice for Sampling Freshly Mixed Concrete

ASTM C231/C231M	(2024) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C295/C295M	(2019) Standard Guide for Petrographic Examination of Aggregates for Concrete
ASTM C441/C441M	(2017) Standard Test Method for Effectiveness of Pozzolans or Ground Blast-Furnace Slag in Preventing Excessive Expansion of Concrete Due to the Alkali-Silica Reaction
ASTM C494/C494M	(2019; E 2022) Standard Specification for Chemical Admixtures for Concrete
ASTM C535	(2016) Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C566	(2013) Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying
ASTM C618	(2023; E 2023) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C666/C666M	(2015) Resistance of Concrete to Rapid Freezing and Thawing
ASTM C989/C989M	(2024) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C1040/C1040M	(2016) Standard Test Methods for In-Place Density of Unhardened and Hardened Concrete, Including Roller Compacted Concrete, by Nuclear Methods
ASTM C1064/C1064M	(2023) Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
ASTM C1077	(2024) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1260	(2023) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1567	(2023) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate

(Accelerated Mortar-Bar Method)

ASTM D4318

(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

ASTM D4791

(2019) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 44

(2018) Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices

NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA CPMB 100

(2000; R 2006) Concrete Plant Standards

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 53

(2001) Test Method for Consistency of No-Slump Concrete Using the Modified Vebe Apparatus

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 104

(1980) Method of Calculation of the Fineness Modulus of Aggregate

COE CRD-C 114

(1997) Test Method for Soundness of Aggregates by Freezing and Thawing of Concrete Specimens

COE CRD-C 130

(2001) Standard Recommended Practice for Estimating Scratch Hardness of Coarse Aggregate Particles

COE CRD-C 143

(1962) Specifications for Meters for Automatic Indication of Moisture in Fine Aggregate

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

EM 385-1-1

(2024) Safety -- Safety and Health Requirements Manual

1.3 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy and Air Force projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy and Air Force projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

- Batch Plant; G[, [_____]]
- Compaction Equipment; G[, [_____]]
- Aggregate Production Schedule; G[, [_____]]
- Regular Lift-Joint Treatment; G[, [_____]]
- Curing and Protection; G[, [_____]]
- Cold-Weather Protection; G[, [_____]]

Hot-Weather Protection; G[, [_____]]

Contraction Joints

Gallery

Vertical Facings for RCC Construction; G[, [_____]]

1.4 QUALITY ASSURANCE

1.4.1 Preconstruction Government Testing

**NOTE: Contact the division laboratory for guidance
in filling in the blanks.**

The aggregate sources listed in paragraph COMMERCIAL CONCRETE AGGREGATE SOURCES in PART 2, have been tested and, at the time testing was performed, were capable of producing materials of the quality required for this project, provided suitable processing is performed. Deliver samples from any source selected, whether listed or not listed, consisting of not less than [_____] kg pounds of each size coarse aggregate and [_____] kg pounds of fine aggregate, and taken under the supervision of the Contracting Officer in accordance with COE CRD-C 100, to [_____] within 15 days after Notice to Proceed. Sampling, shipment, and testing of samples is at the Contractor's expense. [_____] 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. Use material from the proposed source that meet the quality requirements of this paragraph for this project. The Government test data and other information on aggregate quality of those sources listed in PART 2 are included in the Design Memorandum and are available for review in the district office. Quality assurance testing of aggregates by the Government does not relieve the Contractor of quality control requirements.

1.4.2 Cementitious Materials and Admixtures

[At least [_____] days in advance of submitting samples for mixture proportioning studies,] [Not later than [_____] days after Notice to Proceed] notify the Contracting Officer of the source, brand name, type, and quantity of all materials (other than aggregates) to be used in the manufacture and curing of the concrete. 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. If cement or fly ash are to be obtained from more than one source, state the estimated amount of cement or fly ash to be obtained from each source and the proposed schedule of shipments in the notification. When pozzolan other than fly ash is used, it must be from one source.

1.4.3 Government Testing During Construction

The Government will sample and test cementitious materials, admixtures, aggregates, and concrete during construction as considered appropriate to determine compliance with the specifications. 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 COE CRD-C 100. Slump and air content of conventional concrete will be determined in accordance with ASTM C143/C143M and ASTM C231/C231M, respectively, except the point of sampling will be as specified in paragraph TESTS AND INSPECTIONS in PART 3. Compression test specimens of conventional concrete will be made and laboratory cured in accordance with ASTM C31/C31M and will be tested in accordance with ASTM C39/C39M. Consistency of the RCC will be determined by the Government using the modified Vebe apparatus in accordance with paragraph CONSISTENCY OF RCC above. Compression test specimens of RCC will be made and tested by the Government. Density of the compacted RCC will be checked by the Government as considered appropriate.

1.4.3.1 Aggregates Testing

Testing performed by the Government will not relieve the Contractor of its responsibility for testing under paragraph TESTS AND INSPECTIONS in PART 3. During construction, aggregates will be sampled for acceptance testing as delivered to the mixer to determine compliance with specification provisions. Provide necessary facilities 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.

1.4.3.2 Cementitious Materials

Cement or pozzolan will be sampled at the mill, shipping point, or site of the work by the Government. A list of prequalified cement sources and prequalified pozzolan sources is available from the Commander and Director, U.S. Army Engineer Waterways Experiment Station (CEWES-SC-MP), 3909 Halls Ferry Road, Vicksburg, MS 39180-6199. If tests prove that a material which has been delivered is unsatisfactory, promptly remove it 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.

1.4.3.3 Prequalified Cement Sources

Deliver and use cement directly from a mill of a producer designated as a prequalified source for the type of cement being used. Samples of cement for quality-assurance testing will be taken at the project site or cement-producing plant by the Contracting Officer for testing at the expense of the Government. Furnish a copy of the mill tests from the cement manufacturer for each lot.

1.4.3.4 Prequalified Pozzolan Sources

Deliver and use pozzolan directly from a producer designated as a prequalified source. Samples of pozzolan for check testing will be taken at the project site by the Contracting Officer for testing at the expense of the Government. Furnish a copy of the test results from the pozzolan manufacturer for each lot.

1.4.3.5 Nonprequalified Cement Sources

NOTE: The Contractor's expense rate for excess testing of cement and Pozzolan by the Government can be obtained from the Structures Laboratory, U.S. Army Engineer Waterways Experiment Station

(CEWES-SC-MP), 3909 Halls Ferry Road, Vicksburg, MS
39180-6199.

Cement, if not from a prequalified source, will be sampled and tested by or under the supervision of the Government and at its expense. Do not use cement 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 excess to project requirements will also be at the Contractor's expense and will be deducted from payments due the Contractor at a rate of [_____] dollars per test.

1.4.3.6 Nonprequalified Pozzolan Sources

Pozzolan, if not from a prequalified source, will be sampled at the source or at the site of the work and will be stored in sealed bins pending completion of acceptance tests. Pozzolan may be resampled at the site when determined necessary. 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 excess pozzolan in excess of project requirements will be at the Contractor's expense at a rate of [_____] dollars per test. The amount will be deducted from payment to the Contractor.

1.4.3.7 Admixtures

Provide satisfactory facilities for ready procurement of adequate test samples. All sampling and testing of an admixture will be by and at the expense of the Government. Tests will be conducted on the same materials which will be shipped to the project.

1.5 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, accomplish transportation from the railhead, mill, or intermediate storage to the batching plant in adequately designed weather-tight trucks, conveyors, or other means that will protect the material from exposure to moisture.

1.5.1.2 Storage

Furnish cementitious materials in bulk. Immediately upon receipt at the site of the work, store all cementitious materials in a dry, weather-tight, and properly ventilated structure. All storage facilities must permit easy access for inspection and identification. Store sufficient materials for at least two operating days of continuous placement. In order that cement may not become unduly aged after delivery, 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

NOTE: Consult the materials engineer to select the appropriate optional phrase and to fill in the blank.

Store fine aggregate and each size of coarse aggregate in separate size groups adjacent to the batch plant and in such a manner as to prevent the intermingling of size groups or the inclusion of foreign materials in the aggregate. Maintain sufficient fine and coarse aggregate at the site for at least [30] [_____] operating days of continuous placement.

1.5.3 Chemical Admixtures

Do not use any admixture that has been in storage at the project site for longer than recommended by the manufacturer or that has been subjected to freezing in the work and remove from the site.

1.6 ENVIRONMENTAL REQUIREMENTS

NOTE: Make sure the climatological data is included if that optional sentence is included.

If unusual adverse weather, such as heavy rain, severe cold, high winds, heavy snow, etc., occurs or is forecast to occur during placement, suspend the placement operation until conditions improve. [A sample of available climatological data for this project based on historical information is contained herein for general information only. However, it is the responsibility of the Contractor to maintain the construction schedule at no additional cost to the Government.]

1.6.1 Cold-Weather Placement

In Cold-weather placement, do not place the RCC when the ambient air temperature drops below 0 degrees C 32 degrees F. If the ambient air temperature does drop below 0 degrees C 32 degrees F, the surface of any recently placed (within the previous 72 hours) and exposed horizontal RCC surface must not remain exposed for more than 4 hours. Protect surfaces that will be exposed for longer times as specified in paragraph COLD-WEATHER PROTECTION in PART 3 as a measure to maintain RCC temperatures above 0 degrees C 32 degrees F until after the ambient air temperature rises to above 0 degrees C 32 degrees F and is expected to remain above 0 degrees C 32 degrees F until the end of the curing and protection period, or until covered by another lift.

1.6.2 Placing During Rain

Do not place RCC during rainfall of 2.5 mm/hr 0.1 inch/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. Commence work 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, wash the RCC to break up and remove laitance and/or mud-like coatings from the surface. Remove any undercut coarse aggregate. Remove and dispose of all waste in an approved manner.

1.6.3 Hot-Weather Placement

NOTE: Refer to the concrete materials DM for use of the optional sentences and the correct placing temperature.

In hot-weather placement control the temperature of the RCC so that it does not exceed [25] [_____] degrees C [75.0] [_____] degrees F when placed. Suspend placement as soon as the RCC temperature exceeds [25] [_____] degrees C [75] [_____] degrees F. Measures that can be taken to prevent temperatures exceeding [25] [_____] degrees C [75] [_____] degrees F include, but are not limited to, chilling mixing water, sprinkling aggregate stockpiles, use of a canopy to shade the RCC placement areas, placing during nighttime and early morning hours, or restricting placements to cloudy days. Do not use any of these systems as reason for extension of completion dates specified in these specifications. [In addition, to prevent potential damage to the RCC due to hot-weather related placement conditions, suspend all RCC operation between [_____] [June 15th] and [October 31st] [_____]].

PART 2 PRODUCTS

2.1 RCC SYSTEM

NOTE: Contact the materials engineer or the concrete materials DM for information on filling in the blanks.

2.1.1 General Requirements

Perform all work in accordance with EM 385-1-1. Provide RCC composed of cementitious materials, water, fine and coarse aggregates, and possibly admixtures. The cementitious material must be portland cement, or portland cement in combination with pozzolan. An admixture, when approved or directed, will be a water-reducing/retarding admixture. Air-entraining admixture will be used in the bedding concrete and other conventional concrete.

2.1.2 Mixture Proportions and Studies

RCC mixtures and all conventional concrete mixtures that interface with the RCC (such as facing concrete and bedding mixtures) will be proportioned by the Contracting Officer [except that slipformed facing concrete mixture will be proportioned by the Contractor]. There will be one primary RCC mixture used for the mass of the dam [, _____,] [and _____]. The primary mixture will contain approximately [_____] to [_____] kg pounds water, [_____] kg pounds portland cement and [_____] kg pounds pozzolan per cubic meter yard. [Secondary RCC mixtures requiring higher portland cement and pozzolan contents (approximately [_____] to [_____] kg pounds per cubic meter yard) will be used for [_____] [, _____,] [and _____].] There also will be a "bedding mortar" and "bedding concrete." The bedding mortar is a broomable mixture containing approximately 280 to 355 kg 475 to 600 pounds of portland cement and 135 to 180 kg 225 to 300 pounds pozzolan per cubic meter yard. The bedding mortar will have 9.5 mm 3/8-inch nominal maximum size aggregate and a slump, when placed, of 175 to 225 mm 7 to 9 inches. The bedding concrete, 75 to 100 mm 3 to 4 inch slump conventional concrete, must contain 19.0 mm 3/4-inch nominal maximum size aggregate and approximately [_____] kg pounds of portland cement and pozzolan per cubic meter yard. The air content of the bedding concrete as delivered to the placement site must be between 4.5 and 7.5 percent. [Preliminary mixture proportioning studies are available for review in the District office.] Use concrete mixtures for [the upstream face] [, and _____,] and other conventional concrete mixtures that contain from [_____] to [_____] kg pounds of cementitious materials and the slump must be between 25 and 100 mm 1 and 4 inches.

2.1.3 Proportioning Responsibility

The proportions of all materials entering the RCC and the conventional concrete will be furnished. The 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 are 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 added water to compensate for changes in aggregate moisture content and to adjust the amount of air-entraining admixture (if used) to keep the percent of air within the specified range.

2.1.4 Nominal Maximum Size of Aggregate

Use nominal maximum size of coarse aggregate in the various parts of the work in accordance with following:

FEATURES	NOMINAL MAXIMUM SIZE AGGREGATE
[RCC used in the main concrete gravity dam]	75 mm 3 inches
[RCC used in construction of the [_____]]	
[Conventional concrete for the upstream face]	

FEATURES	NOMINAL MAXIMUM SIZE AGGREGATE
[Conventional concrete for the [_____]]	
[RCC used in the [_____]]	37.5 mm 1-1/2 inch
[RCC used in the [_____]]	
[Conventional concrete for [_____]]	
[Conventional concrete bedding mixture]	19.0 mm 3/4 inch
[Bedding mortar]	4.75 mm No. 4
Note: The nominal maximum size aggregate may be changed for applications requiring a special quality of concrete as directed.	

2.1.5 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.

2.1.6 Materials for Mixture-Proportioning Studies

NOTE: Contact the Division Lab to fill in the blanks.

At least [_____] days in advance of the time when placing of concrete is expected to begin, deliver samples of representative materials proposed for this project and meeting all the requirements of this specification to [_____] by the Contractor at its expense. Take samples of aggregates 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 hereinafter specified. Use samples of materials other than aggregates that are representative of those proposed for the project and submit accompanied by manufacturer's test reports indicating compliance with applicable specified requirements. Quantities of materials required are as follows:

MATERIAL	QUANTITY
75 mm 3 inches nominal maximum size coarse aggregate	[_____] kg/pounds

MATERIAL	QUANTITY
37.5 mm 1-1/2 inch nominal maximum size coarse aggregate	[_____] kgpounds
19 mm 3/4 inch nominal maximum size coarse aggregate	[_____] kgpounds
Fine aggregate	[_____] kgpounds
Cement	[_____] kgpounds
Pozzolans	[_____] cu meters feet
Admixtures (each)	[_____] L gallons

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

2.2 MATERIALS

2.2.1 Cementitious Materials

NOTE: See the appropriate concrete aggregates DM or thermal study to select the proper requirements for cementitious materials options.

2.2.1.1 Portland Cement

Provide portland cement conforming to **ASTM C150/C150M**, Type [____], [low alkali when it is to be used with aggregates listed to require it in the paragraph COMMERCIAL CONCRETE AGGREGATE SOURCES below or when directed if a nonlisted source is permitted.] [the heat of hydration requirement at 7 days must be no greater than [____] calories per gram] [including false-set requirement]. [In lieu of low-alkali cement, the Contractor may use a combination of portland cement that does not meet the low-alkali requirement with a suitable pozzolan or ground granulated blast-furnace slag (GGBFS) provided the following requirement is met. The expansion of the proposed combination must be equal to or less than the expansion of a low-alkali cement meeting the requirements of **ASTM C150/C150M** when tested in conformance with **ASTM C441/C441M**. Perform these two tests concurrently at an independent certified laboratory at the Contractor's expense. The Government reserves the right to confirm the test results and to adjust the percentage of pozzolan or GGBFS in the combination to suit other requirements at no additional cost to the Government.] Furnish portland cement in bulk.

2.2.1.2 Pozzolan

Provide pozzolan conforming to **ASTM C618**, Class C or F, including low alkali [multiple factor,] [drying shrinkage,] [uniformity,] [and

] [moderate] [severe] sulfate resistance requirements of Table 2A. Uniformity Requirements (for air content) applies to all fly ash. [Table 1A, Supplementary Optional Chemical Requirement for Maximum Alkalies, applies when it is to be used with aggregates listed to require low-alkali cement]. Furnish pozzolan in bulk.

2.2.1.3 Ground Granulated Blast-Furnace (GGBF) Slag

Provide ground granulated blast-furnace slag conforming to **ASTM C989/C989M**, Grade 100 or Grade 120.

2.2.1.4 Temperature of Cementitious Materials

The temperature of the cementitious materials as delivered to the site must not exceed **65 degrees C 150 degrees F**.

2.2.2 Admixtures

Furnish all liquid chemical admixtures in a solution of suitable viscosity and dilution for field use as determined by the Contracting Officer.

[2.2.2.1 Water-Reducing Admixture (WRA)

Provide WRA meeting the requirements of **ASTM C494/C494M**, Type D, except that the 6-month and 1-year compressive strength tests are waived. The admixture may be added to the concrete mixture only when its use is approved or directed and after mixture proportioning studies.

]2.2.2.2 Air-Entraining Admixture

Provide air-entraining admixture conforming to **ASTM C260/C260M**.

2.2.3 Water

Use water for washing aggregates and for mixing and curing concrete that is free from injurious amounts of oil, acid, salt, alkali, organic matter, or other deleterious substances and complies with **COE CRD-C 400**.

2.2.4 Aggregates

NOTE: See the concrete materials DM to select the aggregate composition options.

This note may be disregarded for regions where Alkali-Silica Reactivity (ASR) is not a concern. Some aggregate sources may exhibit an ASR potential. ASR is a potentially deleterious reaction between alkalis present in concrete and some siliceous aggregates, reference EM 1110-2-2000 paragraph 2-3b(6) and appendix D. Use of cementitious materials meeting the low alkali requirement may be effective in some applications, and insufficient in others. In regions where imposing the low alkali requirement has not been effective in controlling ASR, additional effort for evaluation and mitigation may be required. In which case, the alternate procedures to proportion cementitious materials to meet the low alkali

requirement in paragraph PORTLAND CEMENT should not be used with the following requirements. Where ASR is known or suspected to pose a concern for concrete durability, it is recommended that aggregates proposed for use in concrete be evaluated to determine ASR potential and an effective mitigation. EM 1110-2-2000, provides recommendations for evaluating and mitigating ASR in concrete mixtures. Aggregate evaluations may not be practical for projects requiring small quantities of concrete (less than 200 cubic meters 250 cubic yards).

Section 32 13 14.13 CONCRETE PAVING FOR AIRFIELDS AND OTHER HEAVY DUTY PAVEMENTS, paragraph ALKALI-SILICA REACTIVITY, provides a specification method for the Contractor to evaluate and mitigate ASR in concrete mixtures. The expansion limits specified in Section 32 13 14.13 are requirements for pavements and exterior slab construction. For structural concrete applications the measured expansion must be less than 0.10 percent. It may not be economical or practical to specify different test limit requirements for use on the same project. In which case the lower limit required by the application should be used.

The designer may use the specification method in Section 32 13 14.13 by incorporating the relevant paragraphs into this specification, or may use the following requirements (retain either the 0.10 or the 0.08 percent expansion limits as appropriate).included in the set of brackets highlighted thus "[]".

2.2.4.1 Composition

[Use fine aggregate consisting of natural sand, manufactured sand, or a combination of natural and manufactured sands. Use coarse aggregate consisting of [gravel], [crushed gravel], [crushed stone], [air-cooled blast-furnace slag], or a combination thereof.] "[Test and evaluate fine and coarse aggregates proposed for use in concrete for alkali-aggregate reactivity in accordance with ASTM C1260. Evaluate the fine and coarse aggregates separately and in combination, which matches the Contractor's proposed mix design proportioning. All results of the separate and combination testing must have a measured expansion less than 0.10 (0.08) percent at 16 days after casting. Should the test data indicate an expansion of 0.10 (0.08) percent or greater, reject the aggregate(s) or perform additional testing using ASTM C1260 and ASTM C1567. Perform additional testing using ASTM C1260 and ASTM C1567 using the low alkali portland cement in combination with ground granulated blast furnace (GGBF) slag, or Class F fly ash. Use GGBF slag in the range of 40 to 50 percent of the total cementitious material by mass. Use Class F fly ash in the range of 25 to 40 percent of the total cementitious material by mass.]"

2.2.4.2 Quality

NOTE: The tests selected should be those which are applicable to the concrete to be used in the project. These tests may include those listed below in addition to others not listed. See EM 1110-2-2000 for schedule of tests.

Only a limited number of laboratories are now running ASTM C123/C123M due to the toxic chemicals required. Recommend that ASTM C295/C295M/C295M be specified.

A list of properties and test values are unique to each project and should be taken from the concrete materials DM. Delete the quality tests not required in the DM.

Use the petrographic examination to identify deleterious substances in aggregates. List deleterious substances individually with respective limits.

Deliver aggregates to the mixer that meet the following requirements:

TEST LIMITS			
PROPERTY	FINE AGGREGATE	COARSE AGGREGATE	TESTS
Specific Gravity	[_____]	[_____]	ASTM C127 ASTM C128
Absorption	[_____]	[_____]	ASTM C127 ASTM C128
Flat and Elongate	[_____]	25 percent max.	ASTM D4791
Durability Factor using Procedure A	[_____]	[_____]	COE CRD-C 114 ASTM C666/C666M
Clay Lumps and Friable Particles	[_____]	[_____]	ASTM C142/C142M
Material Finer than 75 µm No. 200 Sieve	[_____]	[_____]	ASTM C117
Liquid Limit and Plastic Limit on material passing the 75 µm No. 200 sieve size	LL 30 max., PI 10 max.	[_____]	ASTM D4318

TEST LIMITS			
PROPERTY	FINE AGGREGATE	COARSE AGGREGATE	TESTS
Organic Impurities	Not Darker than No. 3, Not less than 95 percent	[_____]	ASTM C40/C40M ASTM C87/C87M
L.A. Abrasion	[_____]	[_____]	ASTM C131/C131M ASTM C535
Soft Particles	[_____]	[_____]	COE CRD-C 130
Petrographic Examination	List unwanted deleterious materials and their limits	[_____]	ASTM C295/C295M
Percent coarse aggregate with 2 or more fractured faces	[_____]	20 percent min.	[_____]
Chert, less than 2.40 specific gravity	[_____]	[_____]	ASTM C123/C123M ASTM C295/C295M
[Coal and Lignite, less than 2.00 specific gravity]	[_____]	[_____]	ASTM C123/C123M or ASTM C295/C295M

2.2.4.3 Grading

NOTE: See DM for appropriate fine aggregate options.

- a. Fine Aggregate - The grading of the fine aggregate as delivered to the mixer for the RCC must be such that the individual percent retained on any sieve does not vary more than 3 percent from the percent retained on that sieve in a fixed grading selected by the Contractor after the first 30 days of concrete placement. The minimum percent retained on each of the 2.36 mm No. 8 through 75 µm No. 200 sieve sizes must be 5 percent. In addition to the grading limits, the fine aggregate, as delivered to the mixer, must have a fineness modulus of no less than 2.10 nor more than 2.75. Also control the grading of the fine aggregate so that the fineness moduli for at least four of five consecutive test samples of the fine aggregate as delivered to the mixer does not vary more than 0.10 from the fineness modulus of the fixed grading selected by the Contractor, and approved. Determine the fineness modulus in accordance with COE CRD-C 104. At the option of the Contractor, fine aggregate may be separated into two or more sizes or classifications, but control the uniformity of the grading of the separate sizes so that they may be combined throughout the job in

fixed proportions established during the first 30 days of RCC placement. The grading of the fine aggregate for the bedding concrete and all other conventional concrete must conform to the requirements of [ASTM C33/C33M]. [Section 03 30 00 CAST-IN-PLACE CONCRETE] The fixed grading and the results of individual tests during the first 30 days must fall within the following limits:

SIEVE DESIGNATION U.S. STANDARD SQUARE MESH	PERMISSIBLE LIMITS PERCENT BY MASS, PASSING
9.5 mm 3/8 inch	100
4.75 mm No. 4	95 - 100
2.36 mm No. 8	75 - 95
1.18 mm No. 16	55 - 80
600 µm No. 30	35 - 60
300 µm No. 50	24 - 40
150 µm No. 100	12 - 28
75 µm No. 200	*8 - 18
* The required fines smaller than the 75 µm No. 200 sieve size may substituted with Class F fly ash, at no additional cost to the Government.	

- b. Coarse Aggregate - The grading of the coarse aggregate within the separate size groups must conform to the following requirements as delivered to the mixer.

PERCENT BY MASS PASSING INDIVIDUAL SIEVES			
U.S. STANDARD SIEVE SIZE	4.75 mm No. 4 to 19.0 mm 3/4 inch	19.0 mm 3/4 inch to 37.5 mm 1-1/2 inch	37.5 mm 1-1/2 inch to 75 mm 3 inch
100 mm 4 inch			100
75 mm 3 inch			90 - 100
50 mm 2 inch		100	20 - 55
37.5 mm 1-1/2 inch		90 - 100	0 - 10
25 mm 1 inch	100	20 - 45	0 - 5
19.0 mm 3/4 inch	90 - 100	0 - 10	
9.5 mm 3/8 inch	20 - 55	0 - 5	

PERCENT BY MASS PASSING INDIVIDUAL SIEVES			
U.S. STANDARD SIEVE SIZE	4.75 mm No. 4 to 19.0 mm 3/4 inch	19.0 mm 3/4 inch to 37.5 mm 1-1/2 inch	37.5 mm 1-1/2 inch to 75 mm 3 inch
4.75 mm No. 4	0 - 10		
2.36 mm No. 8	0 - 5		

2.2.4.4 Particle Shape

Use particles of the fine aggregate and of the coarse aggregate that are generally spherical or cubical in shape. 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 D4791, must not exceed 25 percent in any size group.

2.2.4.5 Moisture Content

Do not place fine aggregate in bins at the batch plant until it is in a stable state of moisture content. A stable moisture content is reached when the variation in the percent of total moisture tested in accordance with ASTM C566 and when sampled at the same location will not be more than 0.5 percent during one (1) hour of the two (2) hours prior to placing the material in the batch plant bins and the variation in moisture content when sampled at the same location must not be more than 2.0 percent during the last 8-hour period that the aggregate remains in the stockpile. Deliver coarse aggregate to the mixers with the least amount of free moisture and the least variation in free moisture practicable under the job conditions. Do not deliver the coarse aggregate to the mixer "dripping wet" under no conditions.

[2.2.4.6 Commercial Concrete Aggregate Sources

NOTE: The list of sources and required tests will be taken from the concrete materials DM.

Concrete aggregates may be furnished from any source capable of meeting the quality requirements stated in paragraph QUALITY above. The following sources were evaluated during the design phase of the project in [_____] and were found at that time capable of meeting the quality requirements when suitably processed. No guarantee is given or implied that any of the following listed sources are currently capable of producing aggregates that meet the required quality stated above. A DM containing the results of the Government investigation and test results is available for review in the [_____] District Office. Contact [_____] at [_____] to arrange for review of the DM. Consider test results and conclusions valid only for the sample tested and do not take as an indication of the quality of all material from a source nor for the amount of processing required.

a. List of Sources

NOTE: The concrete materials DM will list those sources requiring low-alkali cement, which must be noted herein.

FINE AGGREGATE	COARSE AGGREGATE
F1: [_____] [1/]	C1: [_____] [1/]
F2: [_____] [1/]	C2: [_____] [1/]
F3: [_____] [1/]	C3: [_____] [1/]
[1/ Low-alkali cement must be used with these sources.]	

- b. Selection of Source - After the award of the contract, designate in writing only one source or combination of sources from which to furnish aggregates. If the Contractor proposes to furnish aggregates from a source or sources not listed above, he may designate only a single source or single combination of sources for aggregates. Regardless of the source selected, provide samples for quality-assurance testing as required by paragraphs PRECONSTRUCTION GOVERNMENT TESTING and MIXTURE PROPORTIONS AND STUDIES. If a source for coarse or fine aggregate so designated by the Contractor does not meet the quality requirements stated in paragraph QUALITY above, the Contractor may not submit for approval any other unlisted sources but must furnish the coarse or fine aggregate, as the case may be, from sources listed, provided it meets the requirements of the same paragraph, at no additional cost to the Government.

][2.2.4.7 Government-Furnished Concrete Aggregate Source

NOTE: The specification writer should ascertain that restoration of the pit or quarry site is specified under other sections.

- a. Location - The deposits are [owned] [controlled] by the Government and are made available to the Contractor free of charge for production of aggregate required under this contract. Within the designated area, an adequate supply of material is available from which concrete aggregate meeting the requirement of these specifications can be produced with suitable processing. The Government guarantees that a sufficient amount of material of suitable quality for production of all of the concrete aggregate required is available within the deposit and that concrete aggregates of suitable quality can be produced with a properly designed and operated plant [without hand-picking or similar operations]. However, the amount of work involved or the amount of unsatisfactory materials required to be wasted to produce a sufficient quantity of suitable concrete aggregate is the responsibility of the Contractor, and the Government will not be held liable for costs resulting from such work or waste. Produce the concrete aggregate from the following sites as shown in the drawings:

	QUARRY SITE	BAR	TERRACE	COORDINATES	DIST. and DIRECTION
G1					
G2					
G3					

b. Explorations - The deposits listed above have been explored by the Government to determine the character and extent of the materials available. The locations of the explorations are shown in the contract drawings. The logs of the exploratory holes are also shown in the drawings. Samples of materials secured are available for inspection at [_____]. The results of explorations are furnished for information only. These data are the result of limited explorations and tests conducted by and for the Government and are accurate to the extent of the scope of the investigations conducted. The Government will not be responsible for any deduction, interpretation, or conclusion drawn therefrom by the Contractor.

]2.3 PLANT AND EQUIPMENT

2.3.1 Concrete Plant

**NOTE: See the concrete materials DM or EM
1110-2-2000 for the plant size requirements.**

**See EM 1110-2-2000 and the concrete materials DM for
selection of automatic or semiautomatic plant and
for use of the rescreening and washing plant.**

Use concrete plant, conveying, placing, compaction, and cleanup systems with a capacity of at least [_____] cubic meters yards per hour. Use a batch or a continuous mixing concrete plant.

2.3.2 Location

Locate the concrete plant at the site of the work in the general area indicated in the drawings[, or locate offsite].

2.3.3 Bins and Silos

Provide separate bins, compartments, or silos for each size or classification of aggregate and for each of the cementitious materials. Provide compartments of ample size and constructed so that the various materials will be maintained separately under all working conditions.

2.3.4 Bulk Cement or Pozzolan

Separate all compartments containing bulk cement or pozzolan from each other by a free-draining air space. Equip cement and pozzolan bins with filters which allow air passage but preclude the venting of cement or pozzolan into the atmosphere. Clearly mark all filling ports with a permanent sign stating the contents.

2.3.5 Batch Plant

Submit details and data on the concrete plant [[_____] days prior to assembly] [not later than 30 days after Notice to Proceed] for review by the Contracting Officer. Final acceptance of any piece of plant is subject to satisfactory performance during operations. The batch plant should meet the following requirements.

2.3.5.1 Batchers

Weigh aggregate in separate weigh batchers with individual scales [or may be batched cumulatively]. Weigh bulk cement and other cementitious materials on a separate scale in a separate weigh batcher. Measure water by weight or by volume, but do not weigh or measure it cumulatively with another ingredient. Measure ice separately by weight. Batch admixtures separately and batch by weight or by volume in accordance with the manufacturers recommendations.

2.3.5.2 Water Batcher

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

2.3.5.3 Admixture Dispensers

Provide a separate batcher or dispenser for each admixture. Equip each plant with the necessary calibration devices that will permit convenient checking of the accuracy of the dispensed volume of the particular admixture. Provide batching or dispensing devices capable of repetitively controlling the batching of the admixtures to the accuracy specified. Provide piping for liquid admixtures that is free from leaks and properly valved to prevent backflow or siphoning. Provide dispensing system which includes a device or devices that 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. Ensure each system is capable of ready adjustment to permit varying the quantity of admixture to be batched. Interlock each dispenser 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. Store and handle admixtures in accordance with the manufacturer's recommendations.

2.3.5.4 Moisture Control

Provide plant that is capable of ready adjustment to compensate for the varying moisture content of the aggregates and to change the masses of the materials being batched. Provide a moisture meter complying with the provisions of [COE CRD-C 143](#) for measurement of moisture in the fine aggregate. Arrange sensing element so that the measurement is made near the batcher charging gate of the sand bin or in the sand batcher.

2.3.5.5 Scales

Provide adequate facilities for the accurate measurement and control of each of the materials entering each batch of concrete. Provide weighing equipment and controls conforming to the applicable requirements of NIST HB 44, except that the accuracy must be within 0.2 percent of the scale capacity. Provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring device. Make tests at the frequency required in paragraph TESTS AND INSPECTIONS in PART 3 and in the presence of a Government inspector. Include a visible indicator that indicates the scale load at all stages of the weighing operation and shows the scale in balance at zero load with each weighing unit. Arrange weighing equipment so that the concrete plant operator can conveniently observe the indicators.

2.3.5.6 Operation and Accuracy

[The weighing operation of each material must start automatically when actuated by a single starter switch and end automatically when the designated amount of each material has been reached. These requirements can be met by providing an automatic batching system as defined in the NRMCA CPMB 100.] [The weighing operation of each material must begin automatically when actuated by one or more starter switches and end when the designated amount of each material has been reached. These requirements can be met by providing a semiautomatic or automatic batching system as defined by the NRMCA CPMB 100.] There must be equipment to permit the selection of [_____] preset mixtures each by the movement of not more than two switches or other control devices. Construct and arrange weigh batchers so 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. Include provisions to facilitate the inspection of all operations at all times. Deliver materials from the batching equipment within the following limits of accuracy:

MATERIAL	PERCENT OF REQUIRED MASS
Cementitious materials	0 to +2
Water	±1
Aggregate smaller than 37.5 mm 1-1/2 inch size	±2
Aggregate larger than 37.5 mm 1-1/2 inch size	±3
Chemical admixtures	0 to +6
Note: When water or chemical admixtures are measured by volume, they must meet the same tolerance percent as stated in the chart.	

2.3.5.7 Interlocks

Interlock batchers and mixers so that:

- a. 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.

- b. The charging device of each batcher cannot be actuated if the discharge device is open.
- c. The discharge device of each batcher cannot be actuated if the charging device is open.
- d. The discharge device of each batcher cannot be actuated until the indicated material is within the allowable tolerances.
- e. Admixtures are batched automatically and separately with the water.
- f. The mixers cannot be discharged until the required mixing time has elapsed.

2.3.5.8 Recorder

Provide an accurate recorder or recorders conforming to the following detailed requirements:

- a. 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. Produce the record prior to delivery of the materials to the mixer. After the batchers have been discharged, show the return to empty condition.
- b. Completely house graphical recording or digital printout unit in a single cabinet that is capable of being locked.
- c. Mark the chart or tape so that each batch may be permanently identified and so that variations in batch weights of each type of batch can be readily observed. Use chart or tape that is easily interpreted in increments not exceeding 0.5 percent of each batch weight.
- d. Show time of day at intervals of no more than 15 minutes.
- e. The recorder chart or tape will become the property of the Government.
- f. Place the recorder in a position convenient for observation by the concrete plant operator and the Government inspector.
- g. The recorded weights or volumes when compared to the weights or volumes actually batched must be accurate within plus or minus 2 percent.

2.3.5.9 Batch Counters

Include devices for automatically counting the total number of batches of all concrete batched and the number of batches of each preset mixture.

[2.3.5.10 Rescreening Plant

Locate, arrange, and operate a rescreening plant in a manner that all coarse aggregate will be routed through the plant and that its operation will ensure delivery to the mixers of graded coarse aggregate free from variation and conforming to the size groups and grading of paragraph

AGGREGATES above and with moisture content conforming to the provisions of paragraph TESTS AND INSPECTIONS in PART 3. Coarse aggregate may be rescreened and delivered to the batch plant bins one size group at a time or two or more adjacent size groups at a time. Simultaneous rescreening of nonadjacent size groups is not permitted. All material passing the bottom screen of the smallest size of coarse aggregate being screened must be wasted.

][2.3.5.11 Washing Plant

Wash all coarse aggregates immediately prior to entering the rescreening plant. The washing plant must contain adequate water nozzles and vibrating screens to remove foreign materials and coatings from aggregate particles. Use water for washing that meets the requirements of paragraph WATER above.

]2.3.5.12 Batch Plant Trial Operation

No less than 7 days prior to commencement of placing the test section, make a test of the batching and mixing plant in the presence of a representative of the Contracting Officer to check operational adequacy. Produce the number of full-scale concrete batches required in trial runs as directed, do not exceed 20, and proportion as directed by the Contracting Officer. Waste or use all concrete produced in these tests for purposes other than inclusion in structures covered by this specification. Correct all deficiencies found in plant operation to the satisfaction of the Contracting Officer prior to the start of concrete 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 TESTS AND INSPECTIONS in Part 3, will be performed by the government near the end of this trial operation period. Notify the Contracting Officer of the trial operation not less than 7 days prior to the start of the trial operation.

2.3.5.13 Protection

Protect weighing, indicating, recording, and control equipment against exposure to dust, moisture, and vibration so that there is no interference with proper operation of the equipment.

2.3.6 Continuous Mixing Plant(s)

NOTE: See the concrete materials DM or consult the materials engineer to fill in the blanks.

Provide a continuous mixing plant(s) that is capable of producing RCC of the same quality and uniformity as would be produced in a conventional batch plant and 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.

2.3.6.1 Operation and Accuracy

Provide an electronic control system. Provide control system with the capability of changing mixtures instantaneously, producing at least [_____] different mixtures, producing any of the mixtures at a variable

rate, and tracking a mixture change to a hopper or a conveyor system. The control panel must display for each ingredient the designed formula values and the instantaneous percentage values and record the instantaneous values at a preset time interval or on demand with a multiple copy printer/recorder. The recorder must note formula changes and print total quantities of each ingredient and total amounts produced on command. Provide weighing devices (belt scale or other) for continuous weighing of individual ingredients and total ingredients. The plant control must not require manual devices to adjust the material flow. The plant must 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. Incorporate modular replaceable components to reduce down time in the event of control system malfunction. Maintain an inventory of such replaceable components. Provide a device to monitor the fine aggregate content immediately prior to dispensing into the mixing plant dispensing system. The accuracy of the plant dispensing systems must be within the following limits:

MATERIAL	PERCENT OF REQUIRED MASS
Pozzolan	0 to +2 percent
Cement	0 to +2 percent
Water	± 1 percent
Aggregate smaller than 37.5 mm 1-1/2 inch size	± 2 percent
Aggregate larger than 37.5 mm 1-1/2 inch size	± 3 percent
Admixtures	0 to +6 percent
<p>Note: Calibrate the continuous feeders for each of the ingredients in accordance with the manufacturer's specifications. Maintain devices and tools at the plant location to check the feeder's calibration at the Contracting Officer's request. Provide a technician that is skilled in calibration of the feed devices and the maintenance and repair of the plant control system. The technician must be available within 30 minutes notice during all scheduled plant operations. The technician could be one or more of the Contractor's personnel.</p>	

2.3.6.2 Cement, Pozzolan, and Aggregate Feed

Feed cement, pozzolan, and aggregate uniformly, continuously, and simultaneously (at the proper ratios and quantity for the mixture required) into the mixer by belt, auger, vane feeder, or other acceptable method. Keep feed bins or silos for each ingredient sufficiently full and must be of sufficient size to ensure a uniform flow at a constant rate for a specific mixture. The feed bins must 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.

2.3.6.3 Water and Admixture Dispensers

Provide liquid-dispensing devices capable of metering and dispensing within the specified requirements. Provide liquid valves that are free from leakage in the closed position. Use dispensers with attachments and/or install in such a manner that will permit convenient checking of their accuracy. Ensure plumbing is leak-free and properly valved to

prevent backflow and siphoning. Interlock dispenser with the electronic plant control to warn the operator and shut down the plant if insufficient liquid is available. Properly locate separate nozzles for each liquid at the mixer to assure uniform distribution of each liquid to the materials entering the mixer.

2.3.6.4 Continuous Mixer(s)

Provide continuous mixer(s) that have proper introduction of ingredients as specified by the manufacturer and do not charge in excess of the manufacturer's recommended capacity. Provide mixer(s) that are capable of combining the materials into a uniform homogeneous mixture and of discharging this mixture without segregation. Operate mixer(s) at the blade speed designated by the manufacturer and mixer(s) must be capable of changing retention time of the ingredients in the mixer. This should be accomplished by manually resetting the mixer(s) blade angles. Predicate mixing time (ingredient retention time in the mixer) upon the uniformity, homogeneity, and consistency of the resultant mixture. Take samples for uniformity testing at 2-minute intervals and test in accordance with [COE CRD-C 55](#) and paragraph MIXER UNIFORMITY REQUIREMENTS below. Maintain mixer(s) in satisfactory operating condition and keep mixer blades free of hardened concrete. Should mixer(s) at any time produce unsatisfactory results, promptly discontinue its use until it is repaired. Provide suitable facilities for obtaining representative samples of concrete for testing. Provide all necessary platforms, shelters, tools, labor, and equipment for obtaining samples.

2.3.6.5 Segregation

Use a means to reduce and minimize segregation and waste which would otherwise result from the continuous stream of concrete being fed into the batch haul devices (concrete buckets, dump trucks, etc.). Provide equipment which retains the concrete between tracks or other means of transport to prevent the need for stopping the mixer. These devices could include, but not be limited to, small-volume conveyor discharge hopper with a large gate that is automatically opened on a timed interval, thereby dumping a series of small batches into larger batch hoppers, trucks, or truck beds

2.3.6.6 Trial Operation

No less than 7 days prior to commencement of concrete placing, make a test of the plant in the presence of a representative of the Contracting Officer to check operational adequacy. Produce the number of cubic [meters yards](#) required in trial runs directed, but do not exceed [40 cubic meters](#) [50 cubic yards](#) and proportion as directed by the Contracting Officer. Waste or use all concrete produced in these tests for purposes other than inclusion in structures covered by this specification. Correct all deficiencies found in plant operation to the satisfaction of the Contracting Officer prior to the start of concrete placing operations. Mixer uniformity tests by the Government will be performed 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. Notify the Contracting Officer of the trial operation not less than 7 days prior to the start of the trial operation.

2.3.6.7 Protection

Protect weighing, indicating, recording, and control equipment against

exposure to dust, moisture, and vibration so that there is no interference with proper operation of the equipment.

2.3.7 Laboratory Areas

NOTE: The specification writer should use this paragraph unless a laboratory building is to be government furnished.

Provide a [room] [separate building] adjacent to the plant to house the moisture and grading testing equipment for aggregate and to provide working space for the Government representative. Provide another room for testing fresh concrete and for fabricating and initial curing (approximately 72 hours) of concrete test specimens in accordance with **ASTM C31/C31M**. The size, arrangement, and location of these rooms will be subject to approval by the Contracting Officer. Provide electricity, air-conditioning, heat, and water as required for use in these laboratory areas.

2.3.8 Mixers

NOTE: See the concrete materials DM for information on mixer selection and concrete mixers. Truck mixers are allowed for mixing or transporting RCC or conventional concrete with less than 50 mm 2 inch slump or greater than 38 mm 1-1/2 inch nominal maximum size aggregate (NMSA).

Provide stationary mixers or pugmill mixers. [Truck mixers may be used for conventional concrete]. Mixers may be batch or continuous mixing. Combine the materials into a uniform mixture and discharge this mixture without segregation. Do not charge mixers in excess of the capacity recommended by the manufacturer on the nameplate. Excessive overmixing requiring additions of water will not be permitted. Maintain mixers in satisfactory operating condition, and keep mixer drums free of hardened concrete. Replace mixer blades or paddles 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, promptly discontinue its use until it is repaired or replaced.

[2.3.9 Truck Mixers

Provide truck mixers and the mixing of concrete therein conforming to the requirements of **ASTM C94/C94M**. A truck mixer may be used for conventional concrete complete mixing (transit-mixed) or to finish the partial mixing done in a stationary mixer (shrink-mixed). Equip each truck with two counters to determine the number of revolutions at mixing speed and the number of revolutions at agitating speed. Do not use truck mixers to mix or agitate concrete with greater than **37.5 mm 1-1/2 inches** NMSA or concrete with a slump of **50 mm 2 inches** or less. Determine acceptability of truck mixers for uniform mixing by uniformity tests in accordance with **ASTM C94/C94M**.

2.3.10 Pugmill Mixers

Provide a batch or continuous mixing twin-shaft pugmill mixer 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 must meet the requirements of paragraph CONTINUOUS MIXING PLANT(S) above.

2.3.11 Mixer Uniformity Requirements

All mixers, except for truck mixers, will be tested by the Government in accordance with this paragraph and in accordance with COE CRD-C 55. When regular testing is performed, the conventional concrete must meet the limits of any five of the six applicable uniformity requirements, and the RCC must meet the limits of any three of the four applicable uniformity requirements. When abbreviated testing is performed, the concrete must meet only those requirements listed for abbreviated testing. The initial mixer evaluation test must be a regular test and perform prior to the start of concrete placement. Use concrete proportions the evaluation that contain the largest size aggregate on the project as directed by the Contracting Officer. Regular testing consists of performing all tests on three batches of concrete. The range for regular testing is the average of the ranges of the three batches. Abbreviated testing consists of performing the required tests on a single batch of concrete. The range for abbreviated testing is the range for one batch. If more than one mixer is used and all are identical in terms of make, type, capacity, condition, speed of rotation, etc., the results of tests on one of the mixers apply to the others, subject to the approval of the Contracting Officer. Perform mixer evaluations by the Government. 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
Unit weight of air-free mortar, 1)	16 kg/cu m2.0 lb/cu ft	16 kg/cu m2.0 lb/cu ft
Air content	1.0 percent	--
Slump, 1)	25 mm1 inch 1.0	--
Coarse aggregate, 1),2)	6.0 percent	6.0 percent
Compressive strength at 7 days, 1),2)	10.0	10.0
Water content, 1), 2)	1.5 percent	1.5 percent
Consistency, modified Vebe, 2) second	7.0	--

PARAMETER	REGULAR TESTS ALLOWABLE MAXIMUM RANGE FOR AVERAGE OF 3 BATCHES	ABBREVIATED TESTS ALLOWABLE MAXIMUM RANGE FOR 1 BATCH
Note: 1) = Test for conventional concrete mixed in stationary mixer, 2) = Test for RCC		

A regular test will be performed before concrete production begins and when the Contractor requests a reduced mixing time. Perform an abbreviated test every 3 months when concrete 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.

2.3.12 Sampling Facilities

2.3.12.1 Sampling Concrete

Provide suitable facilities and labor for obtaining representative samples of concrete in accordance with [ASTM C172/C172M](#) for Contractor quality control and Government quality assurance testing.

2.3.12.2 Sampling Aggregates

Provide suitable facilities for readily obtaining representative samples of aggregates for test purposes immediately prior to the material entering the mixer.

2.3.13 Transporting and Conveying Equipment

Provide transporting and conveying equipment conforming to the following requirements.

- a. Convey concrete mixtures (RCC, bedding mortar, concrete, and any other concrete that will interface with the RCC) from the plant mixer(s) to placement as rapidly and as continuously as practical by methods which limit segregation, contamination, and surface drying.
- b. Convey RCC from the mixing plant to the structure by means of main-line conveyor, end-dump truck, front-end loader, or a combination thereof.
- c. Conventional concrete may be transported by ready-mix truck, conveyor, or agitator truck, or properly designed nonagitating truck.
- d. Provide indicating and signaling devices for the control and identification of types or classes of concrete as they are mixed and discharged for transfer to the placement site.
- e. Identify each type or class of concrete visually by placing a colored tag or other marker as it leaves the mixing plant so that the concrete may be positively identified and placed in the structure in the desired position.

2.3.13.1 Trucks

Use truck mixers or agitators for transporting central-mixed conventional concrete which conform to the applicable requirements of **ASTM C94/C94M**. Do not use truck mixers to transport concrete with larger than **37.5 mm 1-1/2-inch** nominal maximum size aggregate (NMSA) or **50 mm 2 inch** slump, or less. Nonagitator trucks may be used for transporting conventional central-mixed concrete over a smooth road when the hauling time is less than 15 minutes and the slump is less than **75 mm 3 inches**. Bodies of nonagitator trucks must be smooth, water-tight, metal containers specifically designed to transport concrete, shaped with rounded corners to minimize segregation.

2.3.13.2 Belt Conveyors

Design and operate belt conveyors to assure a uniform flow of concrete from mixer or delivery truck to final place of deposit without segregation of ingredients or loss of mortar and provide with positive means for preventing segregation of the concrete or loss of mortar 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.

2.3.14 Spreading and Remixing Equipment

Use spreading and remixing equipment conforming to the following requirements:

- a. Use dozer to accomplish primary spreading procedure. Graders or other equipment not specified may be used to facilitate the RCC spreading process only when approved.
- b. For open, unrestricted areas, use dozer of a minimum size and weight equivalent to a Caterpillar D-6. For restricted placement areas, such as placement of RCC near the dam crest or next to abutments, use dozer of a minimum size and weight equivalent to a Caterpillar D-4.
- c. A minimum of one operating dozer for each **150 cubic meters 200 cubic yards** of RCC placed each hour. Equip dozers with well maintained grousers. A front-end loader with operator must be available to assist with deposition and spreading of RCC as needed in confined areas.
- d. Maintain equipment in good operating condition. The equipment must not leak or drip oil, grease, or other visible contaminants onto the RCC surface.
- e. Clean all equipment used for spreading and remixing that leaves the surface of the structure for maintenance or repairs or, for any other reason, of all contaminants by an approved method before returning to the structure surface. Do not operate a dozer or other tracked vehicle on other than fresh uncompactd RCC except to facilitate startup operations for each lift and by approved procedures.

2.3.15 Compaction Equipment

Submit a listing of the equipment proposed for transporting, handling, depositing, spreading, and compacting the concrete for review by the Contracting Officer [[_____] days before concrete placement begins.] [not

later than 30 days after Notice to Proceed.] Include site drawings or sketches with locations of equipment and placement site. The compaction equipment must conform to the following requirements.

2.3.15.1 Primary Rollers

Use double-drum self-propelled vibratory rollers for primary rolling. Transmit a dynamic impact to the surface through a smooth steel drum by means of revolving weights, eccentric shafts, or other equivalent methods. Provide compactor with a minimum gross mass of 9000 kg 20,000 pounds and produce a minimum dynamic force of 60 000 N/m 350 pounds/linear inch of drum width. Use a variable operating frequency in the approximate range of 1,700 to 3,000 cycles per minute. Use an adjustable amplitude between 0.4 and 1.0 mm 0.015 and 0.04 inches. Provide roller capable of full compaction in both forward and reverse directions. Operate roller at speeds not exceeding 0.7 m/s 2.2 ft/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.

2.3.15.2 Small Vibratory Rollers

Use small vibratory rollers to compact the RCC where the larger vibratory rollers specified above cannot maneuver. Compact the RCC to the required density and demonstrate during construction of the test section. Small vibratory rollers cannot compact the RCC to the same density and thickness as the primary rollers; therefore, when small rollers are used, reduce total lift thickness of the RCC layer or lift to no more 150 mm 6 inches uncompacted thickness to permit adequate compaction. Provide rollers with independent speed and vibration controls and are capable of a wide range of speed adjustments.

2.3.15.3 Tampers (Rammers)

Compact the RCC to the required density and demonstrate during construction of the test section. Tampers cannot compact the RCC to the same density and thickness as the primary rollers; therefore, when tampers are used, reduce thickness of each RCC layer that is to be compacted to no more than 150 mm 6 inches uncompacted thickness to assure adequate compaction.

2.3.15.4 Other Requirements

NOTE: See the concrete materials DM or the materials engineer to fill in the blanks.

Maintain at least [_____] self-propelled vibratory rollers, at least [_____] small rollers, and at least [_____] tampers meeting these requirements full time at the site and ready for service at all times during production and placement.

2.3.16 Truck-Mounted Vacuum Pickup System

Provide a truck-mounted vacuum pickup system for various cleanup operations from the beginning of foundation cleanup to final placement of job RCC. The unit(s) must be capable of pumping 125 cubic meters 4,500 cubic feet of air per minute through an 200-mm 8-inch diameter opening and

capable of pumping water at a minimum rate of 125 L/s 2,000 gpm. Maintain equipment in good operating condition. The equipment must not leak cleanup water and other debris during equipment operation or transit. The equipment must not leak or drip oil, grease, or other visible contamination onto the RCC.

2.3.17 Other Motorized Equipment

All other equipment (backhoe with vibratory plate, backhoe with immersion vibrators, backhoe with mandrel for inserting contraction joint plates, wash trucks, etc.) necessary for the successful completion of RCC production, but not previously discussed within these specifications (or determined to be necessary during the course of the work), must be approved prior to actual use. Such equipment must not result in any damage to the RCC, must be maintained in good operating condition, and must be operated by skilled contractor-provided personnel.

2.3.18 Nuclear Density Gauge

Make tests to determine the density of both the uncompacted and compacted RCC using a two-probe nuclear density gauge supplied by the Contractor. Use nuclear density gauge meeting the applicable requirements of ASTM C1040/C1040M and capable of taking readings along a horizontal path between the probes at 50-mm 2-inch increments from 50 mm 2 inches from the surface to 600 mm 24 inches below the surface. Make gauge and operator available to the Government until completion of all RCC production at no additional cost. Obtain all permits and certifications for the equipment and the operators.

2.3.19 Calibration

Provide factory calibrated nuclear gauges within 6 months of RCC placement. Construct, at no additional costs to the Government, three conventional concrete test blocks using RCC coarse aggregates and RCC fine aggregate, and with dimensions 300 mm 12 inches larger than the gauge dimensions. Formulate concrete to have densities of approximately 2100, 2300, and 2600 kg/cu m 130, 145, and 160 lb/cu ft using the RCC materials and so far as possible, similar relative proportions. Weigh and measure completed blocks to determine unit weight. Adjust gauge calibration constants for performance on these blocks at least 7 days prior to the evaluation of test strips. Remedy any inconsistencies in gauge performance prior to the start of RCC placement. After the start of RCC placement, field calibrate gauges against cast blocks every 24 hours.

2.3.20 Vibrators

Use internal vibrators of the proper size, frequency, and amplitude for the work being performed as indicated in the chart below to consolidate conventional concrete and the interface between conventional concrete and RCC. Provide vibrators for the conventional concrete/RCC interface consisting of a minimum of four vibrators "gang-mounted" in a line on the boom of a backhoe or similar chassis. Use gang-mounted vibrators that are the large (80 to 150 mm) (3 to 6 inch) models of that listed below:

APPLICATION	HEAD DIAMETER (mm) (inch)	FREQUENCY (VPM)	AMPLITUDE (mm) (inch)
RCC interface	80 to 1503 to 6	7,000 to 10,500	0.75 to 1.50 0.03 to 0.06
General construction	50 to 902 to 3-1/2	8,000 to 12,000	0.65 to 1.25 0.025 to 0.05
Thin walls	32 to 651-1/4 to 2-1/2	9,000 to 13,500	0.50 to 1.00 0.02 to 0.04

Determine the frequency and amplitude in the presence of a Government representative in accordance with COE CRD-C 521.

[2.3.21 Slipforming Equipment

NOTE: Consult the materials engineer or the concrete materials DM for whether slipforming is to be allowed or required.

Use slipforming equipment capable of slipforming facing elements as specified at a minimum rate of 7.5 mm/s 1.5 ft/min. Provide slip-former with an automated guidance system which guides the slip-former within the specified tolerances. Provide slipformer with the capability of turning and guiding the form without damage to the RCC and facing element. Provide slipform mold that is at least 1 m 3 feet long to allow the slipform to track easily and to minimize surface tearing caused by friction between the mold and the concrete. Design mold to be mortar-tight and to contain the concrete so that it can be fully consolidated.

]PART 3 EXECUTION

3.1 PREPARATION FOR PLACING

NOTE: Refer to the appropriate DM and the project coordinator for filling in the correct dates and to choose the optional sentences.

3.1.1 Placing Schedule

Start RCC Placement for the main structure no later than [_____] and no earlier than [_____]. Complete placement of all RCC by [_____]. Before starting RCC production, submit a detailed schedule 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, update and adjust the Contractor's schedule 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, take actions necessary to increase the production rate so that production is once again on schedule, within [_____] calendar days after written notice. Also, if not back on schedule by the end of the [_____] days calendar period, 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.

3.1.2 RCC Orientation Session

Prior to or in conjunction with the construction of the RCC test section, supervisors and all other Contractor personnel which are expected to participate in the production of RCC for this job (including laborers, equipment operators, foremen, and QC and inspection staff) must participate in a 2-hour orientation session organized by the Contracting Officer. Provide a facility suitable for slide and videotape presentation. The intent is to orient all individuals on the goals of the RCC placement process, provide clarification of specification requirements if requested, and be provided orientation as to what constitutes good construction practices. Additional orientation sessions will also be made available to, and must be attended by, all new Contractor personnel who are subsequently hired and that will be involved with the production of the RCC.

3.1.3 Aggregate Production Schedule

NOTE: See the appropriate DM or the materials engineer to fill in the blanks.

Begin aggregate production and initial stockpiling and produce acceptable material by no later than [_____] days in advance of the time when placement of the RCC test section is expected to begin. Manufacture and stockpile at least [_____] percent of all RCC aggregates for each size group necessary for the completed RCC construction prior to start of placement of RCC for the permanent RCC structures. Submit descriptions and details for all methods and operations proposed for aggregate and concrete operations including daily and weekly production rates, [not later than [_____] days after Notice to Proceed] for review and approval for conformance with specifications.

3.1.4 RCC Test Section

NOTE: See the materials engineer for information for filling in the blanks.

Prior to placement of any RCC, construct a test section. The purpose of the test section is to demonstrate the suitability of the Contractor's equipment, methods, and personnel. The test section must be at least [5] [_____] lifts in height and be at least [60] [_____] m [200] [_____] feet long and [12] [_____] m [40] [_____] feet wide at the top. The site of the test section must be approved. After evaluation and assessment of the test section by the Contracting Officer, dispose of the test section in an approved manner. Under no circumstances must the test section be incorporated into or become a part of the permanent RCC structure. Demonstrate sustained plant production rates, and batching, mixing, transporting, spreading, and compaction procedures. Also demonstrate the vertical face construction method along one side, the sloped face construction method along another side, procedures for foundation and concrete surface preparation and cleanup, procedures for placement of bedding concrete, bedding mortar, and other conventional concrete, and the installation of any contraction joints and waterstops. Do 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 section construction, allow [10] [_____] calendar days for testing and evaluations. If the Contractor does not meet requirements as specified, construct an additional test section or sections at no additional cost to the Government. Provide date of the test section construction at least 7 days in advance.

3.1.5 Surface Preparation

3.1.5.1 Cleaning

Clean all lift surfaces including any RCC, dental concrete, bedding concrete, bedding mortar, or other conventional concrete placed adjacent to and at the same time as the RCC prior to placing any additional concrete thereon. After cleaning, bedding concrete and bedding mortar are to be used specifically for achieving bond between different types of concrete and/or foundation and eliminating and preventing segregation or voids along margins or RCC placements. Do not cover surfaces to receive bedding concrete or bedding mortar with RCC until the prepared surfaces have been accepted in writing and that acceptance has been recorded on an approved checkout form. All surfaces upon which RCC or any bedding mortar or bedding mix is placed must be moist (but contain no visible free water). Prior to placing any concrete adjacent to and at the same time as the RCC, ensure all surfaces are clean and free of loose, unkeyed, or deteriorated rock; all mud and silt accumulations; vegetation; laitance; puddles or ponds of free surface water; coatings; and any other detrimental materials. Use high-pressure water jetting, and/or wet sandblasting, followed by mild high-volume, low-pressure washing, on all hardened concrete surfaces (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. Keep adequate equipment with operators on hand at the site to clean all surfaces in conformance with these specifications without disrupting in any way the RCC production as scheduled.

3.1.5.2 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. Provide air-water jets with 40-mm 1-1/2-inch nozzles, a water supply of at least 2 L/s 30 gpm, and compressed air at the jet of 550 to 850 kPa 80 to 120 psi. Provide low-pressure water jets with 25-mm 1-inch nozzles available and a capacity of at least 13 L/s 200 gpm for truck-mounted devices.

3.1.5.3 High-Pressure Water Jet

Use a stream of water under a pressure of no less than 10.3 MPa 1,500 psi for RCC and use 27.6 MPa 4,000 psi for conventional concrete to clean all cold joint surfaces, or surfaces with laitance, mortar coatings, stains, or other difficult-to-remove contaminants. Do not undercut coarse-size aggregates. Remove aggregate particles that are undercut. For cleaning large open areas larger than [_____] square meters feet, use a truck-mounted high-pressure water jet system. For cleaning small or confined areas, use a portable high-pressure water jet system.

3.1.5.4 Wet Sandblasting

This method may be used when the RCC has reached sufficient strength to prevent undercutting of coarse aggregate particles. Continue wet sandblasting 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.

3.1.5.5 Waste Disposal

Any waste water employed in cutting, washing, and rinsing of concrete surfaces, and any other surface water must not stain, or affect exposed surfaces of the structure(s) or damage the environment of the project area. The method of disposal is subject to approval.

3.2 PLACING

NOTE: Consult the concrete materials DM for the use of optional sentences and filling in the blanks.

3.2.1 Procedures

It is the intent of this contract to raise the structure at essentially the same level across the entire horizontal surface area. For a dam, proceed placement from abutment to abutment and from downstream to upstream. Complete each lift in its entirety across the full surface of the mass. As the advancing edge of the lift progresses, keep the exposed leading edges "live" by progressively placing out from the advancing edge in a sloping and uniform fan-like manner. Deposit RCC (from the conveyor, end-dump truck, or front-end loader) on the uncompacted RCC of the advancing edge in a forward direction from the dump pile. Do not place RCC in consecutive or consistent lanes. Vary dump location to avoid "lane" construction. [See Contract Drawing [_____] showing typical depositing, spreading, and remixing operations.] The interval between batch plant mixing and final RCC compaction must be no greater than 45 minutes for 300 mm 12 inch lifts and 75 minutes for 600 mm 24 inch lifts. Final compaction is defined as: Any RCC lift composed of layers that have been worked twice by dozer grousers, receives four passes with the vibratory roller, and meets the density requirements.

3.2.2 Bedding Mortar

Apply bedding mortar to the existing surface following any required cleanup. Apply bedding mortar no more than 15 minutes ahead of RCC placement, unless otherwise approved. Use bedding mortar between hardened conventional concrete and RCC, between different RCC placements where cold joints occur, and other locations as directed or as shown in the drawings. The bedding mortar must have an average thickness after application of between 6 and 13 mm 1/4 and 1/2 inch and cover 100 percent of the lift area.

3.2.3 Bedding Concrete

Use bedding concrete, a conventional concrete mixture, at the abutment-RCC interface, and except for cast-in-place concrete for the upstream face, between the RCC and any formed sloping or vertical surface and other

locations as directed or as shown in the drawings. Place the bedding mixture only after all required surface preparations have been completed.

3.2.4 Lift Thickness

NOTE: See the concrete materials DM for the lift thickness.

The total lift thickness after final compaction by the vibratory roller must be [300] [_____] mm [12] [_____] inches.

3.2.5 Depositing, Spreading, and Remixing

NOTE: See the appropriate Design Memorandum for use of the alternate optional paragraphs below.

After the RCC has been deposited, spread the RCC by dozers into gently sloping layers, approximately 150 mm 6 inches thick, that will, after final compaction of the several layers by the vibratory roller, result in the specified lift thickness. During the spreading process, continuously work the RCC surfaces with the dozer blade and grousers in a manner to remix any RCC that may contain pockets of segregated material and to compact the material. Make at least two passes with the grousers to all surfaces of each layer. Operate dozers continuously during the spreading process, even if this action results in more than two passes. Provide a front-end loader with operator to assist with depositing and spreading RCC as needed in confined areas, at the abutments, and at other locations approved or directed. Do not allow the RCC, bedding mixes, or bedding mortar to dry. Do not operate dozer or other tracked vehicle 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. Do not place RCC or other concrete on a previous lift which has not met specification. Remove unacceptable material.

3.2.6 Compaction/Consolidation

After spreading and working with the dozers, compact the top surface of each lift with a minimum of four, plus as many additional passes with a self-propelled double-drum vibratory roller operating in the vibratory mode as are required to obtain a minimum of 98 percent of the theoretical density. Count a round trip over the same material as two passes (i.e., from point A to point B and return to point A by the same route is two passes). Do not operate rollers in the vibratory mode unless they are moving. Consolidate bedding concrete and any other conventional concrete that interfaces with the RCC with internal vibrators.

3.2.6.1 Theoretical Density (TD) Determination

NOTE: See the appropriate DM to fill in the blanks.

The TD is defined as the theoretical density (unit weight) of the concrete, kg pounds per cubic meter foot, computed to include an air content of [_____] percent. The TD value to be used during construction

will be determined using job mixture proportions and Contractor supplied materials; and, using compaction techniques suitable for RCC, and following the appropriate testing procedures used to determine theoretical unit weight of concrete as described as in [ASTM C138/C138M](#).

3.2.6.2 Required Compaction Density

Compact all RCC to a minimum of 98 percent of the TD value. The anticipated TD, estimated from laboratory test data is approximately [_____] kg pounds per cubic meter foot.

3.2.6.3 Density Determination of Compacted RCC

Measure density using a nuclear density meter in accordance with [ASTM C1040/C1040M](#). Make RCC density value determinations throughout the course of RCC placement to assure that the RCC is compacted to a minimum 98 percent of the TD and detect segregation and/or voids throughout the RCC.

3.2.6.4 Additional Compaction

If more than four passes are required to achieve the required density, make additional passes at no additional cost to the Government.

3.2.6.5 Consolidation of Bedding and Other Conventional Concrete

Do not use vibrators to transport concrete. Insert vibrator vertically at uniform spacing over the entire area of conventional concrete placement area. Make insertions at a distance approximately one and one-half times the radius of action of the vibrator. The vibrator must penetrate rapidly to the bottom of the layer and at least 150 mm 6 inches into any preceding plastic layer if such exists. Hold vibrator stationary until the entrapped air is forced to the surface (up to 6 seconds) and the concrete is consolidated and then withdrawn slowly. Keep an adequate number of vibrators on hand to meet placing requirements and spare vibrators available to maintain production in the event of breakdown.

3.2.7 Lift Joints

PLACE entire RCC mass with sufficient continuity so that it hardens and acts as one monolithic block without discontinuous joints or potential planes of separation. Keep all lift joints clean, uncontaminated, free from ponded water, and continuously moist until placement of the succeeding RCC or other concrete.

3.2.7.1 Regular Lift-Joint Treatment

Give lift joints that have not hardened or dried and are less than 72 hours old the regular lift-joint treatment. Submit the method and equipment proposed for joint cleanup and waste disposal for review by the Contracting Officer [[_____] days before concrete placement begins] [not later than [_____] days after Notice to Proceed] for conformance with specifications. Regular lift-joint treatment and maintenance must include:

- a. Maintaining 100 percent of each compacted lift-joint surface continuously moist,
- b. If necessary, removing all loose contaminants or deteriorated RCC by low-pressure washing and/or vacuuming, and

- c. Application of a 6 to 13 mm 1/4 to 1/2 inch thick bedding mortar over the entire placement surface area immediately before placement of the next lift.

For regular lift-joint treatment, no washing or vacuuming will be necessary provided damage or contamination of the lift surface is prevented.

3.2.7.2 Cold Joints

A cold joint is any vertical or horizontal RCC surface:

- a. That does not receive the next RCC lift within 72 hours,
- b. In which the RCC has been allowed to dry, or
- c. That has been contaminated to the extent that contaminants cannot be removed using low-pressure water.

Prepare cold joints for the next lift by the methods and procedures in paragraph SURFACE PREPARATION above, prior to resumption of RCC placement. Following this initial preparation, keep the cold-joint surface continuously moist until application of the bedding mortar. Whenever a cold joint at any edge or end of any lift occurs, locate it at least 10 m 30 feet from the location of other cold joints that may have previously occurred in the same direction along previous lifts.

3.2.7.3 Vertical Joints

Joints for sloping, near-vertical or vertical RCC surfaces are considered to be vertical joints. A vertical joint most often will occur when an RCC placement is terminated before the entire RCC placement for that lift has been completed. When it does become apparent that placement of RCC will be terminated prior to completion of a lift, adjust the RCC spreading procedure at the leading zone of the placement to provide a gradual tapered slope to complete that lift. The taper must be no steeper than 25 horizontal on 1 vertical. Where the tapered slope meets the underlying hardened lift surface, take care to prevent or remove any segregated or uncompacted material. Compact tapered surface in accordance with paragraph COMPACTION/CONSOLIDATION above. Prior to resumption of RCC placements, prepare tapered surface in accordance with paragraph SURFACE PREPARATION above.

3.2.8 Downstream Face

**NOTE: See the concrete materials DM to select one
of the two optional systems for the downstream face.**

[3.2.8.1 Using Sacrificial Concrete

Construct downstream sloped face of the dam and the exposed slopes of the stilling basin training walls using sacrificial RCC on [[_____] vertical to [_____] horizontal slope] [1 vertical to 0.85 horizontal slope]. Construct slope to the tolerances specified. Overbuild each RCC lift at least 300 mm 12 inches, and subsequently trim to the surface smoothness tolerance. Trim before the RCC is more than 48 hours old. Demonstrate

process during the test section. Trim in such a manner to prevent damage to the surface and interior RCC.

]3.2.8.2 Using Conventional Concrete

Construct downstream face of conventional concrete in accordance with paragraph VERTICAL FACINGS FOR RCC CONSTRUCTION below.

]3.3 CURING AND PROTECTION

Submit the curing media and methods to be used for review to the Contracting Officer [[_____] days before concrete placement begins] for conformance with specifications.

3.3.1 Curing

Keep surface of every RCC lift continuously moist, commencing immediately after compaction, by use of water trucks equipped with fog sprayers for 14 days or until the surface is covered with the next lift. The sloping downstream surface of the Dam, [and the [_____] if constructed of uncompacted sacrificial RCC, need not be cured. Curing and protection for all conventional concrete used in the construction of the vertical faces and any horizontal RCC surfaces that will not receive a subsequent concrete covering must be moist cured. Moist cure conventional concrete made with Type II portland cement, or any type of portland cement with pozzolan, and all RCC for 14 days. Moist cure conventional concrete made with Type I portland cement for 7 days. Moist cure conventional concrete by covering with saturated nonstaining burlap or cotton mats. Rinse new burlap or cotton mats to remove soluble substances before using. Maintain concrete that is moist cured continuously, not periodically, wet for the duration of the entire curing period. Use water for curing in compliance with the requirements of paragraph WATER in PART 2. If the water or mats cause staining or discoloration of permanently exposed concrete surfaces, clean the surfaces by a method approved by the Contracting Officer. When wood or metal forms are left in place during curing, keep the forms continuously wet, except for sealed insulation curing in cold weather. RCC may be cured with saturated cotton or burlap mats in lieu of the approved fog spraying equipment.

3.3.2 Cold-Weather Protection

NOTE: See the concrete materials DM or thermal study for the optional numbers.

Maintain air and forms in contact with the RCC and any conventional concrete at a temperature above 0 degrees C 32 degrees F for [14] [_____] days. In addition, at the time insulation or protection is removed, control the air temperature adjacent to the RCC surfaces so that the concrete near the surface will not be subjected to a temperature differential of more than 15 degrees C 25 degrees F (as determined by observation of ambient air and concrete temperatures). Submit a description of the materials and methods proposed for protection of the concrete, when concrete is to be placed under cold-weather conditions, to the Contracting Officer for review [_____] days in advance of anticipated need date.

3.3.3 Special Cold-Weather Insulation Protection

NOTE: See the appropriate DM for use of this paragraph and to fill in the blanks.

In addition to the requirements specified above, all RCC and any conventional concrete placed at the same time and in direct contact with the RCC must receive special insulation protection as described for the following time periods:

- a. [_____].
- b. [_____].

Provide insulation with an R value no less than [_____] square meter degree Celsius per watt hour square foot degree Fahrenheit per BTU.

3.3.4 Hot-Weather Protection

When ambient air temperatures exceeds 30 degrees C 90 degrees F and as soon as the conventional concrete and RCC is sufficiently hard to withstand washing of surface mortar, apply water by fog spraying in a controlled manner to provide evaporative cooling. Apply water at such a rate that it quickly evaporates and such that the surface remains continuously moist without ponding. In addition, when surface materials begin to dry and while the RCC placement, spreading, and compaction process is still underway and until the concrete has sufficiently hardened to permit the above water spray, apply hand-held fog spraying to the concrete surfaces as directed to prevent drying out of concrete materials and replace moisture lost to evaporation. These hot-weather protection procedures will require additional labor(s) to assure complete coverage of the entire surface areas to prevent unacceptable damage to the RCC and conventional concrete. Submit a description of the materials and methods proposed for protection of the concrete, when concrete is to be placed under hot-weather conditions, to the Contracting Officer for review [_____] days in advance of anticipated need date.

3.4 VERTICAL FACINGS FOR RCC CONSTRUCTION

NOTE: See the concrete materials DM to select the appropriate method or methods specified below. It should be noted that the method used for other vertical conventional concrete work may be different from the method used for construction of the upstream face. See paragraphs GALLERY and SPILLWAY CONSTRUCTION, below.

The vertical faces of the RCC structure are to be constructed using [a form and cast-in-place conventional concrete system] [a slipform facing system] [a precast concrete panel system] as shown and specified. Submit details of the construction methods and equipment for review within [_____] days after Notice to Proceed. Demonstrate vertical facings system on one side of the RCC test section.

[3.4.1 Form and Cast-in-Place Conventional Concrete

Provide vertical and near-vertical facings as shown in the drawings. The contract drawings are based on designs whereby all vertical and near-vertical faces are constructed of conventional slump concrete at the same time and rate as used in placement of each RCC lift. In construction of vertical facings, place a 0.75 to 1.25 meter 2.5 to 4.0 foot wide zone of conventional concrete against the forms or other hard surface. The design and engineering of the formwork, as well as its construction, is the responsibility of the Contractor. Design formwork for loads, lateral pressure, and allowable stresses in accordance with Chapter 1 of ACI 347R. Use forms of sufficient strength to withstand the pressure resulting from placement and vibration of the concrete and sufficient rigidity to maintain specified tolerances. The required sequence of construction operations after all forms and concrete surface preparations have been approved is: place conventional concrete full height of each RCC lift and full width against the forms; using dozer action, spread each thin RCC layer into and abutting against the conventional concrete while at the same time tracking the interface between the two with dozer grousers; after full-lift thickness of the RCC is in place next to the conventional concrete, consolidate 100 percent of the conventional concrete and the interface; and finally, compact the RCC (to include the interface) using the vibratory roller. Consolidate and "knit" together the interface between the RCC and conventional concrete using the gang heavy-duty, machine-mounted, immersion vibrators. Take extreme care to stage activities to assure all time restrictions are met and to prevent the occurrence of any openwork, honeycombing, or voids at the conventional concrete/RCC interface. Thoroughly consolidate and intermix all conventional concrete and bedding concrete placed along the RCC and the interface using immersion vibrators. Demonstrate satisfactorily the Contractor's construction techniques and equipment used during construction of the test section.

] [3.4.2 Slipformed Facing Elements

Construct a slipformed conventional concrete face on the upstream face of the dam [and [_____]]. Provide concrete for the slipformed facing elements conforming to requirements of this section. The configuration for the facing elements are as shown. The concrete mixture for the facing elements must be proportioned by the Contractor to be formed by a slipform curbing machine and to have sufficient early strength to allow compaction for RCC against its surface within 4 hours.

3.4.2.1 Prequalification of Equipment

Prior to placing any slipformed facing elements for incorporation into the dam, perform a demonstration of the slipform equipment and concrete mixture as a part of the test section. Form one side of the test section using his proposed slipforming equipment, in accordance with paragraph RCC TEST SECTION above. If necessary, adjust the concrete mixture and make any adjustments or modifications to the slipforming equipment and concrete supply procedures and equipment as may be required to produce a satisfactory slipformed facing element. Construct a starting block to enable the first facing element to be formed without modification to the slipform.

3.4.2.2 Slipform Operations

Operate equipment in such a manner as to prevent damage to the RCC surface

and facing element. The slipformer must carry a surge hopper of sufficient capacity to enable the slipformer to continue to extrude facing element between concrete deliveries. If the slipformer is stopped, consolidate concrete thoroughly, make a joint, and remove unacceptable concrete from the mold. Use slipformer with an automated guidance system which guides the slipformer within the specified tolerances. Achieve a smooth, mortar-tight joint between successive elements. Keep molds and vibrators available in sufficient quantities to replace worn or damaged ones. Use vibrators that are capable of being adjusted and relocated to achieve complete consolidation.

3.4.2.3 Slipforming - Preparation for Placing

Do not begin placement until after all preparations are complete and the authorized representative of the Contracting Officer has approved in writing completion of all preparations for that placement. Do not place facing element concrete until the surfaces to receive facing element concrete are free of deleterious substances including but not limited to: uncompacted, loose, deteriorated, or improperly cured RCC or facing element concrete, laitance, dirt, ice, curing compounds, and visible free surface water.

3.4.2.4 Slipforming - Placing

All joint surfaces more than 24 hours old, or in any other way damaged or not meeting the specification requirements, must be wet sandblasted, washed with air-water jets, and surface dried prior to placement of adjoining facing elements. Keep molds for the slipform continually full, and concrete vibrated, to prevent voids. Ensure slipformed facing element is uniform, dense, and free of surface blemishes and tears.

3.4.2.5 Slipforming - Finishing

The class of finish and the requirements for finishing of slipformed facing elements must be as specified in this paragraph, paragraph CONSTRUCTION TOLERANCES, and as indicated. The finished surface must be smooth and free from rock pockets and surface voids. Light surface pitting (voids up to 6 mm 1/4 inch diameter) and light slipforming marks are not considered objectionable. Where the surface produced meets specified requirements, no further finishing operations will be required.

][3.4.3 Precast Reinforced Panels

Design the precast panel systems as specified in [Section 03 41 33 PRECAST STRUCTURAL PRETENSIONED CONCRETE] [03 45 00 PRECAST ARCHITECTURAL CONCRETE] [03 45 33 PRECAST [PRESTRESSED] STRUCTURAL CONCRETE] [_____]. Provide typical panel systems consisting of interlocked panels measuring 1 m 4 ft by as much as 5 m 16 ft, 4 inches thick (min.), and anchored at four locations. Provide anchor bars, straps, and connections that are oversized or treated to compensate for deterioration due to exposure to moisture. Brace panels adequately with either external strongbacks or by staggering panel placement and connection to adjacent panels. By design, assure the safety and immobility of the panel system. Include upstream face [, downstream face] [, spillway crest] [, spillway training wall] [, and stilling basin training wall panels]. Match panel joints with pier noses, spillway cap, intake structure, and transverse joints.

3.4.3.1 Leveling Pad

No concrete leveling pad for setting panels is required unless the panel design so requires, however, embed the base of the panels at least 300 mm 1 foot into concrete, RCC, or backfill material. Brace, align, and level initial row of panels adequately.

3.4.3.2 Alignment

Install panels so that horizontal joint lines of the upstream and downstream faces and the spillway crest panel joints align and meet the tolerances in paragraph CONSTRUCTION TOLERANCES.

]3.5 CONTRACTION JOINTS

NOTE: See the appropriate DM to fill in the blanks.

Form contraction joints by inserting plates into non-compacted full lift thickness RCC at locations as shown on the drawings. The plates, when installed adjacent to each other (at the same structure stationing within each lift) must form a bond breaker that serves as a contraction joint. Provide plates that are [900] [_____] mm [36] [_____] inches wide, [300] [_____] mm [12] [_____] inches deep, up to 6 mm 1/4 inch thick, and made out of [_____]. Install plates vertically into the RCC by means of a vibrating plate mounted on a backhoe. Submit the exact details for the design of the contraction joints, as well as installation and methods of maintaining tolerances, alignment, etc., within [_____] days after the Notice to Proceed. Control plate alignment by laser or other approved survey technique. Provide waterstops, drains, and contraction joints within any conventional concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE and as indicated.

[3.6 GALLERY

NOTE: See the concrete materials DM for use of this optional paragraph and to select the optional methods.

Submit details of the construction methods within [_____] days after the Notice to Proceed. Construct gallery using one of the following schemes or combination thereof, the details which are the Contractor's responsibility:

- a. Precast gallery segments,
- b. Removable rigid forms against which conventional concrete, or RCC is placed, and
- c. A noncementing fill as a temporary filler in the gallery area and removing it to form the gallery after the RCC has gained sufficient strength to be self-supporting.

Regardless of which procedure is used, slope the gallery to drain and include a gutter along the downstream gallery wall as shown in the drawings. Do not allow the gallery floor surface to pond more than 25 mm

1 inch of water. The size and shape of the gallery must be as shown in the drawings.

[3.6.1 Precast Gallery Segments

If stay-in-place precast gallery units are used to form the gallery, construct them in accordance with [Section 03 41 33 PRECAST STRUCTURAL PRETENSIONED CONCRETE] [03 45 33 PRECAST [PRESTRESSED] STRUCTURAL CONCRETE] [_____]. Submit design for review and comment. Design the sections to carry the full load of the vibratory roller over the first lift of fresh RCC above the ceiling section with a safety factor of 4 and to carry the vibrating load of subsequent compaction without excessive deflection that could damage the previously placed RCC. For each lift, place a ribbon of bedding concrete, approximately 0.09 cubic meter per linear meter 1 cubic foot per linear foot of precast panel, between the RCC and panels. Vibrate RCC bedding concrete interface thoroughly with immersion vibrators to eliminate any voids or segregation within the RCC. A permanent reinforced precast slab may be used to construct the gallery ceiling section in combination with other gallery construction schemes chosen by the contractor.

][3.6.2 Temporary Forms

The design of any temporary gallery form system and its adequacy is the responsibility of the Contractor. Provide forms in compliance with the requirements of 03 30 00 CAST-IN-PLACE CONCRETE, except that they need not be mortar-tight, and they must meet the tolerances in paragraph CONSTRUCTION TOLERANCES. Design ceiling form such that it can safely carry the load of the vibratory roller with a safety factor of 4 and is stiff enough to prevent damage to the fresh RCC from elastic deflection and rebound while compaction is being accomplished. Do not remove forms until the RCC has gained sufficient strength to be self supporting (estimated to be 90 days) and not until at least 10 m 40 feet of RCC has been placed above the gallery ceiling.

][3.6.3 Noncementing Fill Method

The gallery section may be constructed by placing a noncementitious fill in the cross-sectional area where the gallery is to be located, compacting it at the same time that the adjacent RCC is compacted, and later removing the fill. Submit details of how this procedure will be followed, what the noncementitious will consist of, how the fill will be removed later, and how the gallery doors will be set for review and comment in accordance with paragraph SUBMITTALS. To form the outline of the gallery, place braced partitions (or forms) along the perimeter of the gallery section between the RCC and non-cementitious fill. Install separate partitions (or forms) for each lift, of such size and configuration, and position on the previous lift's partitions (or forms) to ultimately form the gallery section. Removed braced partitions during the excavation process. Alignment of partitions (or forms) must not result in offsets and irregularities that exceed construction tolerances specified in paragraph CONSTRUCTION TOLERANCES. The noncementitious fill material may be one or more of the standard RCC aggregates or any other approved fill material, without portland cement or pozzolan; however, nominal maximum-size aggregate must not exceed 19.0 mm (3/4 inch). Do not start excavation of the gallery fill until the RCC has gained sufficient strength to be self supporting (a minimum of 30 days) and until at least 10 m 35 feet of RCC has been placed above the gallery section. As soon as the strength and cover requirements have been met, begin removal of the gallery. Dispose

excavated fill material in an approved manner.

]]3.7 SPILLWAY CONSTRUCTION

3.7.1 Spillway Chute and Ogee Section

Construct spillway floor as shown. The drawings are based on a design whereby the spillway is constructed at the same time and rate as used in placement of each RCC lift. Use the same technology and construction procedures as used in the construction of the vertical upstream face. The major difference being, instead of placing conventional concrete for the floor against vertical cantilevered forms, conventional concrete will be placed against sloping cantilevered forms to form the spillway chute. The design and engineering of the formwork, as well as its construction and methods of maintaining tolerances, etc., is the responsibility of the Contractor. Design formwork for loads, lateral pressures, and allowable stresses in accordance with Chapter 1 of [ACI 347R](#). Provide forms of sufficient strength to withstand the pressure resulting from placement and vibration of the concrete and sufficient rigidity to maintain specified tolerances. Take extreme care to prevent the occurrence of any permanent openwork, honeycombing, or voids at the conventional concrete/RCC interface, or next to the forms. Demonstrate construction techniques satisfactorily during placement of the test section. The unformed portion of the spillway will be finished by placing concrete slightly above grade and striking off to grade by accurate screeding. Finish surface as specified in paragraph FLOAT FINISH below.

3.7.2 Training Walls

Provide concrete for training walls as shown in the drawings and as specified in paragraph VERTICAL FACINGS FOR RCC CONSTRUCTION above.

3.7.3 Finishing

3.7.3.1 General

The ambient temperature of spaces adjacent to surfaces being finished must be no less than [10 degrees C](#) [50 degrees F](#). 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 kg/sq m](#) [0.2 lb/sq ft](#) per hour, make provisions for windbreaks, shading, fog spraying, or wet covering with a light-colored material in advance of placement, and take such protective measures as quickly as finishing operations will allow. Float finish all unformed surfaces that are not to be covered by additional concrete or backfill, unless a trowel finish is specified, and finish true to the elevation shown. Bring surfaces to receive additional concrete or backfill to the elevation shown in the drawings and leave true and regular. Slope exterior surfaces for drainage unless otherwise shown or as directed. Make joints carefully with a jointing or edging tool. Protect finished surfaces from stains or abrasions.

3.7.3.2 Float Finish

Surfaces must be screeded and darbirded or bullfloated to bring the surface to the required finish level with no coarse aggregate visible. Do not add water, cement, or mortar to the surface during the finishing operation. Float concrete, while still green but sufficiently hardened to bear a man's weight without deep imprint, to a true and even plane. Floating may be performed by use of suitable hand floats or power-driven equipment.

Use magnesium or aluminum hand floats. Tolerance for a floated finish must be true plane within 8 mm in 3000 mm 5/16 inch in 10 feet as determined by a 3-m 10-foot straightedge placed anywhere on the slab in any direction.

13.8 CONSTRUCTION TOLERANCES

NOTE: Delete any of the following tables that are not applicable. Most projects will require several tables to cover all parts of the structure.

The definitions of the terms used in the following tables are as defined in ACI 117. Make level and grade tolerance measurements of slabs as soon as possible after finishing. When forms or shoring are used, make measurements prior to removal. Tolerances are not cumulative. The most restrictive tolerance controls. Tolerances must not extend the structures 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.

3.8.1 Conventional Concrete Surfaces

TOLERANCES FOR CAST-IN-PLACE, VERTICALLY SLIPFORMED BUILDING ELEMENTS	
Vertical alignment Translation and rotation from a fixed point at the base of the structure:	
For heights 30 m or less	50 mm 2 inches
For heights greater than 30 m, 1/600 times the height but not more than	200 mm 8 inches
Lateral alignment Between adjacent elements	50 mm 2 inches
Cross-sectional dimensions Wall thickness	plus 19 mm 3/4 inch minus 10 mm 3/8 inch
Relative alignment Formed surface slope with respect to the plane indicated	18 mm in 3000 mm
TOLERANCES FOR CONCRETE STRUCTURES OTHER THAN BUILDINGS	
Vertical alignment	
Visible surfaces	30 mm 1-1/4 inch
Concealed surfaces	65 mm 2-1/2 inches
Side walls for radial gates and similar water-tight joints	5 mm 3/16 inch
Lateral alignment	

Visible surfaces	30 mm 1/4 inch
Concealed surfaces	65 mm 2-1/2 inches
Level alignment	
Visible flatwork and formed surfaces	13 mm 1/2 inch
Concealed flatwork and formed surfaces	25 mm 1 inch
Sills for radial gates and similar water-tight joints	5 mm 3/16 inch
Relative alignment: Formed surface slope with respect to the specified plane.	
Slopes in lateral and level alignments	
Visible surfaces	6 mm in 3000 mm 1/4 inch in 10 feet
Concealed surfaces	12 mm in 3000 mm 1/2 inch in 10 feet
Slopes in vertical alignment	
Visible surfaces	12 mm in 3000 mm 1/2 inch in 10 feet
Concealed surfaces	25 mm in 3000 mm 1 inch in 10 feet
TOLERANCE FOR FINISHED OR FORMED CONVENTIONAL CONCRETE SURFACES	
Vertical alignment Formed surfaces slope with respect to the specified plane	
Vertical alignment of exposed corner columns and control joint grooves in concrete exposed to view	9 mm in 3000 mm 3/8 inch in 10 feet
All other conditions	12 mm in 3000 mm 1/2 inch in
Abrupt variation in spillway surface: The offset between concrete surfaces under adjacent pieces of formwork	
	3 mm 1/8 inch
Gradual variation: Surface finish tolerances as measured by placing a freestanding (unleveled), 1500-mm or 5-ft 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 must not exceed	
	6 mm 1/4 inch
Offsets of adjacent precast gallery segments must not exceed	
	25 mm 1 inch

3.8.2 RCC Surfaces

- a. Variations from the lines and grades of the gallery walls and ceiling from that shown in the drawings must not exceed plus or minus 75 mm 3 inches except keep tolerances at the gallery entrances within the limits necessary for the bulkheads and doorways to fit and function as designed.

- b. Allowable variation from lines and grades of the downstream face of the dam (measured in any direction) must be minus zero (-0) (no under build allowed) and plus 100 mm 4 inches, [except that the elevation and shape of the spillway stilling basin training walls must be such that the training walls match with the downstream face as shown in the drawings or otherwise provided for]. See additional restrictions in paragraph DOWNSTREAM FACE in Part 3.
- c. The thickness of compacted lifts of RCC must be within plus or minus 50 mm 2 inches of that specified.
- d. The elevation of the surfaces of RCC lifts upon which subsequent RCC or conventional concrete is placed must not vary more than 150 mm 0.5 ft from the design elevation, except that the elevation of the top three lifts of the dam must be within 60 mm 0.2 ft of that shown.
- e. The location of anchor bars, waterstops, contraction joints, and drain holes must be within 150 mm 0.5 ft of the designated locations shown.
- f. The spacing of individual reinforcing steel bars in RCC must be within 50 mm 2 inches of that shown.
- g. Tolerances for exposed surfaces of upstream face concrete [, the face of the spillway chute,] and any other conventional concrete that interfaces with the RCC must be in accordance with paragraph CONVENTIONAL CONCRETE SURFACES above.

3.9 TESTS AND INSPECTIONS

3.9.1 General

Perform the inspection and tests as described below, and based upon the results of these inspections and tests, take the action required and submit reports as required. When, in the opinion of the Contracting Officer, the concreting operation is out of control, cease concrete placement. The laboratory performing the tests must be on-site and conform with ASTM C1077. The individuals who sample and test concrete or the constituents of concrete as required in this specification will 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 individual who performs the inspection will have demonstrated a knowledge and ability equivalent to the ACI minimum guidelines for certification of [Concrete Transportation Construction Inspector (CTCI)] [Concrete Construction Inspector (CCI)], Level II. 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 C1077.

3.9.2 Testing and Inspection Requirements

3.9.2.1 Fine Aggregate

3.9.2.1.1 Grading

At least once during each shift when the concrete plant is operating, make one sieve analysis and fineness modulus determination in accordance with ASTM C136/C136M, ASTM C117, and COE CRD-C 104 for the fine aggregate or for each 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. Record results on a sheet on which are also shown the specification limits applicable to the project.

3.9.2.1.2 Fineness-Modulus Control Chart

Group results for fineness modulus in sets of three consecutive tests, and plot the average and range of each group on a control chart. Draw the upper and lower control limits for average 0.10 units above and below the target fineness modulus, and the upper control limit for range is 0.20.

3.9.2.1.3 Corrective Action for Fine Aggregate Grading

When the amount passing on any sieve is outside the specification limits, resample and retest the fine aggregate immediately. If there is another failure on any sieve, report the fact immediately to the Contracting Officer. Whenever a point on the fineness modulus control chart, either for average or range, is beyond one of the control limits, double the frequency of testing. If two consecutive points are beyond the control limits, consider the process out of control and stop concreting. Notify the Contracting Officer, and take immediate steps to rectify the situation. After two consecutive points have fallen within the control limits, testing at the normal frequency may be resumed.

3.9.2.1.4 Moisture Content Testing

When in the opinion of the Contracting Officer the electric moisture meter is not operating satisfactorily, perform at least four tests for moisture content in accordance with [ASTM C566](#) during each 8-hour period of mixing plant operation. Randomly select times for the tests within the 8-hour period. Make an additional test whenever the slump is out of control or excessive variation in workability is reported by the placing foreman. When an electric moisture meter is operating satisfactorily, make at least two direct measurements of moisture content per week to check the calibration of the meter. Use results of tests for moisture content to adjust the added water in the control of the batch plant.

3.9.2.1.5 Moisture Content Corrective Action

Whenever the moisture content of the fine aggregate changes by 0.5 percent or more from the previous sample, adjust the scale settings for the fine aggregate batcher and water batcher (directly or by means of a moisture compensation device).

3.9.2.2 Coarse Aggregate

3.9.2.2.1 Grading

At least once during each shift in which the concrete plant is operating, perform a sieve analysis in accordance with [ASTM C136/C136M](#) 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. A test record of samples of aggregate taken at the same locations must 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 coarser than the specification limits for samples taken other than as delivered to the mixer to allow for degradation during handling. When facilities are available to test

samples five times as large as those required in ASTM C136/C136M, no averaging is permitted.

3.9.2.2.2 Corrective Action for Grading

When the amount passing any sieve is outside the specification limits, resample and retest the coarse aggregate immediately. If the second sample fails on any sieve, report that fact to the Contracting Officer. Where two consecutive averages of five tests (or two consecutive tests where large samples are used) are outside specification limits, consider the operation out of control, and report that fact to the Contracting Officer, stop concreting, and take immediate steps to correct the grading.

3.9.2.2.3 Coarse Aggregate Moisture Content

Make a test for moisture content of each size group of coarse aggregate at least once a shift. When two consecutive readings for smallest size coarse aggregate differ by more than 1.0 percent, increase frequency of testing to that specified previously for fine aggregate.

3.9.2.2.4 Coarse Aggregate Moisture Corrective Action

Whenever the moisture content of any size of coarse aggregate changes by 0.5 percent or more from the previous sample, adjust the scale setting for the coarse aggregate batcher and the water batcher to compensate for this.

3.9.2.2.5 Material Finer than the 75 µm No. 200 Sieve

When in the opinion of the Contracting Officer, a problem exists in connection with the cleanliness of the coarse aggregate, make tests in accordance with ASTM C117. Testing frequency must be as directed.

3.9.2.2.6 Corrective Action for material finer than the 75 µm No. 200 Sieve

When material finer than the No. 200 sieve exceeds 1.0 percent of the weight of the coarse aggregate finer than 37.5 mm 1-1/2 inch or 0.5 percent of the weight of the aggregate coarser than 37.5 mm 1-1/2 inch, notify the Contracting Officer, and initiate steps, such as washing or other corrective action, immediately.

3.9.2.3 Quality of Aggregates

NOTES: Tests should be those listed in paragraph QUALITY in PART 2. Use the petrographic examination to identify deleterious substances in aggregates. List deleterious substances individually with respective limits.

Only a limited number of laboratories are now running ASTM C123/C123M due to the toxic chemicals required. Recommend that ASTM C295/C295M/C295M be specified.

3.9.2.3.1 Frequency of Quality Tests

Prior to submitting samples for mixture proportioning studies, perform the tests for aggregate quality in the following list. In addition, after the

start of concrete placement, perform tests for aggregate quality during concrete or aggregate production, in accordance with the following frequency schedule. Samples tested after the start of concrete placement must be taken immediately prior to entering the concrete mixer.

FREQUENCY			
PROPERTY	FINE AGGREGATE	COARSE AGGREGATE	TEST
Specific Gravity	Every 3 months	Every 3 months	ASTM C127 ASTM C128
Absorption	Every 3 months	Every 3 months	ASTM C127 ASTM C128
Flat and Elongate	Not applicable	Every 3 months	ASTM D4791
Durability Factor using Procedure A	Every 12 months	Every 12 months	COE CRD-C 114 ASTM C666/C666M
Clay Lumps and Friable Particles	Every 3 months	Every 3 months	ASTM C142/C142M
Material Finer than the 75 μm No. 200 Sieve	Not applicable	Every 3 months	ASTM C117
Organic Impurities	Every 3 months	Not applicable	ASTM C40 ASTM C87/C87M
L.A. Abrasion	Not applicable	Every 6 months	ASTM C131/C131M ASTM C535
Liquid Limit and Plasticity Limits of -75 m No. 200 Sieve Size	Every 3 months	Not applicable	[_____]
Soft and Friable (Scratch Hardness)	Not applicable	Every 6 months	COE CRD-C 130
Petrographic Examination	Every 6 months	Every 6 months	[_____]
[Chert, less than 2.40 specific gravity]	Every 6 months	Every 6 months	ASTM C123/C123M
[Coal and Lignite, less than 2.00 specific gravity]	Every 6 months	Every 6 months	ASTM C123/C123M or ASTM C295/C295M

3.9.2.3.2 Corrective Action for Aggregate Quality

If the result of a quality test fails to meet the requirements for quality during submittal of samples for mixture-proportioning studies or immediately prior to start of concrete placement, change production procedures or materials and perform additional tests 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, rerun the test immediately. If the second test fails the quality requirement, report the fact to the Contracting Officer and immediate steps taken to rectify the situation.

3.9.2.4 Scales

3.9.2.4.1 Weighing Accuracy

Check the accuracy of the scales by test weights at least once a month for conformance with the applicable requirements of paragraphs BATCH PLANT and CONTINUOUS MIXING PLANT both in PART 2. Also make such tests as directed whenever there are variations in properties of the fresh concrete that could result from batching errors.

3.9.2.4.2 Batching and Recording Accuracy

Check the accuracy of each batching and recording device once a week during a weighing operation by noting and recording the required weight, recorded weight, and the actual weight batched. Confirm that the calibration devices described in paragraph BATCH PLANT in PART 2 for checking the accuracy of dispensed admixtures are operating properly. If a continuous mixing plant is provided, check the accuracy and operation of all feeding and dispensing units before the start of operation each day.

3.9.2.4.3 Scales Corrective Action

When the weighing accuracy or batching accuracy does not comply with specification requirements, do not operate the plant until necessary adjustments or repairs have been made. Correct discrepancies in recording accuracies immediately.

3.9.2.5 Concrete Plant Control

Continuously control the measurement of all constituent materials including cementitious materials, each size of aggregate, water, and admixtures. Adjust aggregate weights and amount of added water as necessary to compensate for free moisture in the aggregates. Prepare a report 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 yard, amount of water as free moisture in each size of aggregate, and the as-mixed aggregate and water weights per cubic meter yard for each class of concrete placed during plant operation.

3.9.2.6 Concrete

3.9.2.6.1 Conventional Concrete Slump Testing

Make at least two slump tests in accordance with ASTM C143/C143M on each conventional concrete mixture, including bedding mortar produced during each 8-hour period or less of concrete production each day. Make additional tests when excessive variation in workability is reported by the placing foreman or Government inspector. Plot the result of each test for each mixture on a control chart on which the upper and lower limits are set as specified in paragraph MIXTURE PROPORTIONS AND STUDIES in PART 1. Plot the range on a control chart on which the upper control limit is

50 mm 2.0 inches. Take samples for slump 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 the mixer and the placement, take samples at the placement site as often as required by the Contracting Officer.

3.9.2.6.2 Slump Corrective Action

Whenever points on the control chart approach the upper or lower control limits, make an adjustment 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 specified in the mixture proportions provided by the Contracting Officer based on the free water available with the aggregates and that amount of water batched. If the adjustments to the batch weights of water and aggregates do not satisfactorily produce the required slump, the Contracting Officer may adjust the mixture proportions if the fine-aggregate moisture content is found to be stable and within the required limits. When a single slump is outside the control limits, such adjustment is mandatory. As soon as practical after each adjustment, make another test to verify the correctness of the adjustment. Whenever two consecutive individual slump tests, made during a period when there was no adjustment of batch weights, produce a point on the control chart for range above the upper control limits, consider the slump to be out of control, halt concreting operation, and undertake additional testing for required aggregate moisture content, and take action immediately to correct the problem.

3.9.2.6.3 Air Content

Make at least one test for air content of conventional concrete on a randomly selected batch of each concrete mixture produced during each 8-hour period of concrete production. Make additional tests when excessive variation in workability is reported by the placing foreman or Government inspector. Make tests in accordance with ASTM C231/C231M. Plot the average of each test for each mixture on control charts on which the average percent and upper and lower limits are set in accordance with paragraph MIXTURE PROPORTIONS AND STUDIES. Plot the range between two consecutive tests for each mixture on a control chart on which the upper control limits is 3.0 percent.

3.9.2.6.4 Air Content Corrective Action

Whenever points on the control chart approach the upper or lower control limits, an adjustment should be made in the amount of air-entraining admixture batched. If a single test result is outside the specification limit, immediate adjustment is mandatory. As soon as practical after each adjustment, make another test to verify the correction of the adjustment. Whenever a point falls above the upper control for range, calibrate the dispenser to ensure that it is operating correctly and with good reproducibility. Whenever two consecutive points either for average or range are outside the control limits, notify the Contracting Officer.

3.9.2.7 Field Density

3.9.2.7.1 Testing and Checking

Determine density for [each 450 square meters 5,000 square feet of completed lift] [at least eight locations per RCC lift] with a calibrated

nuclear density gauge in accordance with [ASTM C1040/C1040M](#). Take densities at depths of [100 and 200 mm 4 and 8 inches](#). If the densities at [100 and 200 mm 4 and 8 inches](#) conflict, acceptance must be at the [200 mm 8 inch](#) depth.

3.9.2.7.2 Action Required

Whenever the nuclear gauge indicates density less than the specified density, make a retest. If the retest indicates unacceptable density, notify the Contracting Officer's Representative, provide additional rolling immediately, and make a determination 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, make adjustments such as increasing or decreasing the moisture content 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, notify the operator and the Contracting Officer may require removal of the incompletely compacted material at no cost to the Government.

3.9.2.8 Inspection Before Placing

Inspect foundation or construction joints, forms, and embedded items in sufficient time prior to each concrete placement to certify to the Contracting Officer that they are ready to receive concrete. Report results of each inspection in writing. The inspection of the lift surfaces of the RCC will be a continuing activity and will be accomplished in accordance with paragraph REGULAR LIFT-JOINT TREATMENT above.

3.9.2.9 Placing Inspection

3.9.2.9.1 Inspection

Provide full time supervision of all placing operations to insure that the correct quality of RCC, conventional concrete, or grout is placed in each location and that all other aspects of the placing operation are performed in accordance with the contract. During placing operations, the quality control staff must measure and record concrete temperatures in accordance with [ASTM C1064/C1064M](#), ambient temperature hourly, record weather conditions, time of placement, yardage placed, and method of placement.

3.9.2.9.2 Corrective Action

Do not permit placing to begin until verification of an adequate number of vibrators, spreaders, and compactors in working order and with competent operators are available. Do not continue placing if any conventional concrete is inadequately consolidated or if any lift of RCC is not fully compacted. Perform additional compaction, if necessary, in accordance with paragraph ADDITIONAL COMPACTION above. If any batch of conventional concrete fails to meet the temperature requirements, take immediate steps to improve temperature controls.

3.9.2.10 Vibrator Tests

3.9.2.10.1 Vibrator Testing and Use

Determine the frequency and amplitude of each vibrator in accordance with [COE CRD-C 521](#) prior to initial use and at least once a month when concrete is being placed. Make additional tests as directed when a vibrator does

not appear to be adequately consolidating the concrete. Determine the frequency while the vibrator is operating in concrete with the tachometer being held against the upper end of the vibrator head while almost submerged and just before the vibrator is withdrawn from the concrete. Determine the amplitude with the head vibrating in air. Take two measurements, one near the tip and another near the upper end of the vibrator head, and average these results. Report the make, model, type, and size of the vibrator and frequency and amplitude results in writing. In addition, check the self-propelled vibratory rollers, as specified in PART 2, paragraph PRIMARY ROLLERS, for frequency and amplitude prior to use and once every 3 months when RCC is being placed.

3.9.2.10.2 Vibrator Corrective Action

Remove any vibrator not meeting the requirements of paragraph VIBRATORS immediately from service and repair or replace.

3.9.2.11 Curing Inspection

3.9.2.11.1 Moist Curing Inspections

At least twice each shift, and twice per day on nonwork days inspect all areas subject to moist curing. Note and record the surface moisture condition.

3.9.2.11.2 Moist Curing Corrective Action

When a daily inspection report lists an area of inadequate curing, take immediate corrective action, and extend the required curing period for those areas by one day.

3.9.2.12 Cold-Weather and Hot-Weather Protection

At least once each shift and once per day on nonwork days inspect all areas subject to cold-weather or hot-weather protection. Note, correct, and report any deficiencies.

3.9.2.13 Cold-Weather and Hot-Weather Protection Corrective Action

When a daily inspection report lists deficiencies, correct the deficiency immediately and extend the period of protection for one day.

3.9.3 Reports

Report all results of tests or inspections conducted informally as they are completed and in writing daily. Prepare a weekly report 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, make reports of pertinent temperatures daily. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in preceding paragraphs. Confirm such reports of failures and the action taken in writing in the routine reports. The Contracting Officer has the right to examine all contractor quality control records.

-- End of Section --