**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

**References are in agreement with UMRL dated January 2021**
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DIVISION 03 - CONCRETE

SECTION 03 70 00

MASS CONCRETE

**02/10, CHG 2: 08/20**

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**USACE / NAVFAC / AFCEC / NASA** | **UFGS-03 70 00 (February 2010)**
**Change 2 - 08/20**

**Preparing Activity: USACE** | **Superseding**
**UFGS-03 70 00 (April 2006)**

**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

**References are in agreement with UMRL dated January 2021**
**********

SECTION 03 70 00

MASS CONCRETE
**02/10, CHG 2: 08/20**

**********
**NOTE: This guide specification covers the requirements for large projects containing mass concrete or mass and structural concrete, and major projects where the government retains the responsibility for concrete mixture proportioning. 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

**********
**NOTE: The content of this specification is such that guidance given in EM 1110-2-2000, "Standard Practice for Concrete" is applicable.**
**********

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.**

**Consult the concrete materials design memorandum to choose the appropriate cementitious materials and admixtures for measurement and payment.**

**When silica fume is used in the project, the Specifier should include both bid items, "Silica Fume, Dry" and "Silica Fume, Slurry", to give the Contractor the option of supplying the material in dry form or in slurry form.**
**********

1.1.1 Concrete for [_____]

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

1.1.1.1 Payment

Payment will be made for costs associated with completing the concrete work for concrete placed in the [_____]. However, these costs will not include the cost of the cement, pozzolan, [slag,] reinforcement, [water-reducing admixture,] [high range water reducer,] [silica fume,] and embedded parts that are specified to be paid for separately. 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

Concrete will be measurement for payment based upon the actual volume of concrete within the pay lines of the structures as indicated on the drawings. Measurement of concrete placed against the sides of any excavation without the use of intervening forms shall be made only within the pay lines of the structure. No deductions shall 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 meters 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 meters yards.

[1.1.2 Concrete in Blockouts

[1.1.2.1 Payment

Payment will be made for costs associated with concrete placed in the blockouts.

][1.1.2.2 Measurement

Concrete will be measurement for payment based upon the actual volume of concrete placed in the blockouts as indicated on the drawings.

][1.1.2.3 Unit of Measure

Unit of measure: cubic meters yards.

]]1.1.3 Portland Cement

**********
**NOTE: All other cementitious materials (except pozzolan), such as portland-pozzolan cement, slag cement, or portland blast-furnace cement, shall be listed separately similar to this bid item, and the bid items renumbered appropriately.**
**********

1.1.3.1 Payment

Payment will be made for costs associated with Portland cement, which includes the cost of required unloading, hauling, handling, and storage at the site, of all portland cement used in the work.

1.1.3.2 Measurement

Portland cement will be measured for payment based upon the number of tons of portland cement 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 weight in kg/cubic meter pounds/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.

1.1.3.3 Unit of Measure

Unit of measure: tons (metric) (2000 lb).

1.1.4 Pozzolan (Except Silica Fume)

1.1.4.1 Payment

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

1.1.4.2 Measurement

Pozzolan, except silica fume, 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 weight in kg/cubic meter pounds/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 pounds/cubic foot. The average specific gravity shall be the average of the test results for all material accepted during the period covered by the payment.

1.1.4.3 Unit of Measure

Unit of measure: cubic meters feet solid volume.

1.1.5 Ground Granulated Blast-Furnace Slag

1.1.5.1 Payment

Payment will be made for costs associated with ground granulated blast-furnace slag, which includes the cost of required unloading, hauling, handling, and storage at the site, of all ground granulated blast-furnace slag used in the concrete bid items.

1.1.5.2 Measurement

Ground granulated blast-furnace slag will be measured for payment based upon the number of tons of ground granulated blast-furnace slag used excluding the 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 weight in kg/cubic meter pounds/cubic yard of ground granulated blast-furnace slag 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.

1.1.5.3 Unit of Measure

Unit of measure: tons (metric) (2000 lb).

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 meter 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 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 meters yards.

1.1.7 High-Range Water-Reducing Admixture (HRWR)

1.1.7.1 Payment

[Payment will be made for costs associated with high-range water-reducing admixture (HRWR) at the applicable contract unit price per cubic meter yard of concrete containing water-reducing admixture.] [Payment will be made for costs associated with high-range water-reducing admixture (HRWR) 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."]

1.1.7.2 Measurement

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

1.1.7.3 Unit of Measure

Unit of measure: cubic meters yards.

[1.1.8 Silica Fume, Dry

[1.1.8.1 Payment

Payment will be made for costs associated with silica fume, dry, which includes price batching and recording equipment for dry silica fume used in the concrete bid items. Payment will be made at the contract price per kilogram hundredweight of dry silica fume for:

a. "Bid Item [_____]a., first [_____] kilograms hundredweight."

b. "Bid Item [_____]b., all over [_____] kilograms hundredweight."

][1.1.8.2 Measurement

Silica fume, dry, will be measured for payment based upon the number of kilograms hundredweight of silica fume used in the concrete, excluding the amount wasted or used for the convenience of the Contractor. The quantity to be paid for will be determined by multiplying the weight in kilograms pounds of silica fume per cubic meter yard by the number of cubic meters yards of silica fume concrete placed within the pay lines of the structure as determined in accordance with the concrete bid items., divided by 100.

][1.1.8.3 Unit of Measure

Unit of measure: kilograms hundredweight (100 pounds).

]][1.1.9 Silica Fume, Slurry

[1.1.9.1 Payment

Payment will be made for costs associated with silica fume, slurry, which includes the cost of silica fume, slurry; providing admixtures such as

HRWR admixtures that are a component of the slurry; and furnishing storage, batching, and recording equipment for silica fume, slurry, used in the concrete bid items. Payment for silica fume, slurry, will be made at the contract price per hundredweight of dry silica fume for:

a. "Bid Item [_____]a., first [_____] kilograms hundredweight."

b. "Bid Item [_____]b., all over [_____] kilograms hundredweight.

][1.1.9.2 Measurement

Silica fume, slurry, will be measured for payment based upon the number of kilograms hundredweight of silica fume used in the concrete, excluding the amount wasted or used for the convenience of the Contractor. The quantity to be paid for will be determined by multiplying the weight in kilograms pounds of silica fume per cubic meter yard by the number of cubic meters yards of silica fume concrete placed within the pay lines of the structure as determined in accordance with the concrete bid items , divided by 100. The dry weight will be determined by supplier's certificate.

][1.1.9.3 Unit of Measure

Unit of measure: kilograms hundredweight (100 pounds).

]]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 ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

| | |
|---|---|
| AASHTO M 182 | (2005; R 2017) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats |

AMERICAN CONCRETE INSTITUTE (ACI)

| | |
|---|---|
| ACI 117 | (2010; Errata 2011) Specifications for Tolerances for Concrete Construction and Materials and Commentary |
| ACI 214R | (2011) Evaluation of Strength Test Results of Concrete |
| ACI 305R | (2010) Guide to Hot Weather Concreting |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM C31/C31M | (2019a) Standard Practice for Making and Curing Concrete Test Specimens in the Field |
| ASTM C39/C39M | (2020) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens |
| ASTM C40/C40M | (2020) Standard Test Method for Organic Impurities in Fine Aggregates for Concrete |
| ASTM C87/C87M | (2017) Standard Test Method for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar |
| ASTM C94/C94M | (2020) Standard Specification for Ready-Mixed Concrete |
| ASTM C117 | (2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing |
| ASTM C123/C123M | (2014) 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 | (2015) 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 C142/C142M | (2017) 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 | (2020) Standard Specification for Portland Cement |
| ASTM C171 | (2020) Standard Specification for Sheet Materials for Curing Concrete |
| ASTM C172/C172M | (2017) Standard Practice for Sampling Freshly Mixed Concrete |
| ASTM C231/C231M | (2017a) 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 C309 | (2011) Standard Specification for Liquid Membrane-Forming Compounds for Curing 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) 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 | (2019) 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 C881/C881M | (2020a) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete |
| ASTM C928/C928M | (2020a) Standard Specification for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repairs |
| ASTM C937 | (2016) Grout Fluidifier for Preplaced-Aggregate Concrete |

| | |
|---|---|
| ASTM C989/C989M | (2018a) Standard Specification for Slag Cement for Use in Concrete and Mortars |
| ASTM C1059/C1059M | (2013) Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete |
| ASTM C1064/C1064M | (2017) Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete |
| ASTM C1077 | (2017) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation |
| ASTM C1107/C1107M | (2020) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink) |
| ASTM C1240 | (2020) Standard Specification for Silica Fume Used in Cementitious Mixtures |
| ASTM C1260 | (2014) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method) |
| ASTM C1567 | (2013) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method) |
| ASTM D4791 | (2019) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate |
| ASTM E11 | (2020) Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves |

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 55 | (1992) Test Method for Within-Batch Uniformity of Freshly Mixed Concrete |
| COE CRD-C 94 | (1995) Corps of Engineers Specification for Surface Retarders |
| COE CRD-C 100 | (1975) Method of Sampling Concrete Aggregate and Aggregate Sources, and Selection of Material for Testing |

| | |
|---|---|
| COE CRD-C 104 | (1980) Method of Calculation of the Fineness Modulus of Aggregate |
| COE CRD-C 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 144 | (1992) Standard Test Method for Resistance of Rock to Freezing and Thawing |
| 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 |

## 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, Air Force, and NASA 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, Air Force and NASA 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-02 Shop Drawings

Concrete Lifts; G[, [_____]]
Equipment; G[, [_____]]

SD-03 Product Data

Batch Plant; G[, [_____]]
Mixers
Construction Joint Treatment; G[, [_____]]
Curing and Protection; G[, [_____]]
Cold-Weather Protection; G[, [_____]]
Hot-weather Placing; G[, [_____]]
Special Temperature-Controlled Concrete; G[, [_____]]

SD-07 Certificates

Sheet Curing
Nonshrink Grout; G[, [_____]]
Bonding Agents
Expansive Admixture

## 1.4 QUALITY ASSURANCE

### 1.4.1 Government Preconstruction Testing

**********
**NOTE: Contact the Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199, ATTN: CEERD-SC for guidance in filling in the blanks.**
**********

#### 1.4.1.1 Aggregate Sources

The aggregate sources listed in paragraph MATERIAL SPECIFICATION, have been tested, and at the time testing was performed, these sources were capable of producing materials of the quality and quantity required for this project provided suitable processing is performed. Samples from any source selected consisting of not less than [_____] kg pounds of each size of coarse aggregate and [_____] kg pounds of fine aggregate, taken under the supervision of the Contracting Officer in accordance with COE CRD-C 100, shall be delivered to [_____] within 15 days after notice to proceed. Sampling and shipment of samples shall be at the Contractor's expense. [_____] days will be required to complete evaluation of the aggregates. Testing will be performed by the Government in accordance with the applicable COE CRD-C or ASTM test methods. Tests to which aggregate may

be subjected are listed in paragraph MATERIAL SPECIFICATION. The material from the proposed source shall meet the quality requirements of this paragraph to be used for the project. The Government test data and other information on aggregate quality of those sources listed in paragraph MATERIAL SPECIFICATION, 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.

1.4.1.2 Cementitious Materials, Admixtures, and Curing Materials

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 at least 60 days in advance of submitting samples for mixture proportioning studies. 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 pozzolan are to be obtained from more than one source, the notification shall state the estimated amount of cement or pozzolan to be obtained from each source and the proposed schedule of shipments. When pozzolan other than fly ash is used, it shall be from one source.

1.4.1.3 Materials for Mixture-Proportioning Studies

**********

**NOTE: Contact the Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199, ATTN: CEERD-SC to fill in the blanks. At the end of the following table, insert other cementitious materials, including silica fume, as appropriate.**

**********

At least [_____] days in advance of the time when placing of concrete is expected to begin, samples of representative materials proposed for this project and meeting all the requirements of this specification shall be delivered to [_____] by the Contractor at its expense. Samples of aggregates shall be taken under the supervision of the Contracting Officer in accordance with COE CRD-C 100, accompanied by test reports indicating conformance with grading and quality requirements hereinafter specified. Samples of materials other than aggregates shall be representative of those proposed for the project and shall be submitted accompanied by manufacturer's test reports indicating compliance with applicable specified requirements. Quantities of materials required shall be as follows:

| MATERIAL | QUANTITY |
|---|---|
| 150 mm 6 inch nominal maximum-size coarse aggregate | [_____] kg pounds |
| 75 mm 3 inch nominal maximum-size coarse aggregate | [_____] kg pounds |
| 37.5 mm 1-1/2 inch nominal maximum-size coarse aggregate | [_____] kg pounds |

| MATERIAL | QUANTITY |
|---|---|
| 19 mm 3/4 inch nominal maximum-size coarse aggregate | [_____] kg pounds |
| Fine aggregate | [_____] kg pounds |
| Cement | [_____] kg pounds |
| Pozzolans | [_____] cubic m feet |
| Air-entraining admixture | [_____] L quarts |
| Other admixtures (each) | [_____] L gallons |

Mixture-proportioning studies will be made by the Government.

1.4.2 Construction Testing by the Government

1.4.2.1 General

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 will be determined in accordance with ASTM C143/C143M and ASTM C231/C231M, respectively, except the point of sampling will be as directed. Compression test specimens will be made and laboratory cured in accordance with ASTM C31/C31M and will be tested in accordance with ASTM C39/C39M.

1.4.2.2 Testing Aggregates

Testing performed by the Government will not relieve the Contractor of its responsibility for testing as appropriate for quality control. 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 Contracting Officer supervision. The Government will test such samples at its expense using appropriate COE CRD-C and ASTM methods.

1.4.2.3 Cementitious Materials

Furnish cement or pozzolan or both from a prequalified source or, if not, it (they) will be sampled at the mill, shipping point, or site of the work by the Contracting Office. A list of prequalified cement sources and prequalified pozzolan sources is available from the Director, U.S. Army Corps of Engineers, Engineer Research and Development Center - Structures Laboratory, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, ATTN: CEERD-SC. If tests prove that a material which has been delivered is unsatisfactory, it shall be promptly removed from the site of the work. Cementitious materials that have not been used within 6 months after being tested will be retested by the Government at the expense of the Contractor when directed.

1.4.2.4 Cement from Prequalified Sources

Cement shall be delivered and used 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. A copy of the mill tests from the cement manufacturer shall be furnished to the Contracting Officer for each lot.

1.4.2.5 Pozzolan from Prequalified Sources

Pozzolan shall be delivered and used 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. A copy of the test results from the pozzolan manufacturer shall be furnished to the Contracting Officer for each lot.

1.4.2.6 Cement from Nonprequalified 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 Contracting Officer and at Government expense. No cement shall be used until notice has been given by the Contracting Officer that test results are satisfactory. In the event of failure, the cement may be resampled and tested at the request of the Contractor and at the Contractor's expense. When the point of sampling is other than at the site of the work, the fill gate or gates of the sampled bin will be sealed and kept sealed until shipment from the bin has been completed. The fill gate or gates of conveyances used in shipment will be sealed by or under the supervision of the Contracting Officer. 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.

1.4.2.7 Pozzolan from Nonprequalified 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 seven day lime-pozzolan strength requirements and other physical, chemical, and uniformity requirements for which tests can be completed by the time the seven 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.

1.4.2.8 [Ground Granulated Blast-Furnace Slag

**********
**NOTE: If any other cementitious materials, including silica fume, are to be allowed, an additional paragraph should be added similar to this paragraph, with the name of the cementitious material substituted for "Ground Granulated Blast-Furnace Slag".**
**********

Ground granulated blast-furnace slag will be sampled and tests at the mill or shipping point by and at the expense of the Government to determine that the material meets the requirements of the specification under which it is furnished. No ground granulated blast-furnace slag shall be used until notice of acceptance has been given by the Contracting Officer. Ground granulated blast-furnace slag will be subject to check testing from samples obtained at the project site, as scheduled, and such sampling will be by or under the supervision of the Contracting Officer and at Government expense. Material not meeting specifications shall be promptly removed from the site of work.]

1.4.2.9 Chemical Admixtures

Provide satisfactory facilities for ready procurement of test samples. All sampling and testing of a chemical admixture will be by and at the expense of the Government. Tests will be conducted using samples of materials proposed for the project.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Cementitious Materials

1.5.1.1 Transportation

When bulk cement, pozzolan, dry silica fume, or ground granulated blast-furnace slag is not unloaded from primary carriers directly into weather-tight hoppers at the batching plant, transportation from the railhead, mill, or intermediate storage to the batching plant shall be accomplished in weather-tight trucks, conveyors, or other means that will protect the material from exposure to moisture. Transportation facilities for dry bulk silica fume shall be approved in advance.

1.5.1.2 Storage

Cementitious materials shall be furnished in bulk except that cement used for finishing and patching may be packaged, and silica fume may be packaged or in slurry form. Immediately upon receipt at the site of the work, all cementitious materials, shall be stored in separate dry, weather-tight, and properly ventilated structures. All storage facilities shall permit easy access for inspection and identification. Sufficient

materials shall be in storage to complete any lift of concrete started. 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. Silica fume in slurry form that has been in storage at the project site for longer than recommended by the manufacturer or that has been subjected to freezing shall not be used in the work and shall be removed from the site.

1.5.1.3 Separation of Materials

Separate facilities shall be provided for unloading, transporting, and handling each cementitious material. Separate appropriate storage facilities shall be provided for each type of cement and each source of pozzolan, dry bulk silica fume, or slag. The contents of each storage facility shall be plainly marked with a large permanent sign posted near the loading port.

1.5.2 Aggregates Storage

Fine aggregate and each size of coarse aggregate shall be stored 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 concrete. Sufficient fine and coarse aggregate shall be maintained at the site at all times to permit continuous placement and completion of any lift of concrete started.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Concrete shall be composed of cementitious materials, water, fine and coarse aggregates, and admixtures. The cementitious materials shall be [portland cement], [portland cement in combination with pozzolan], [portland cement in combination with [_____]], [portland blast-furnace slag cement] [portland cement in combination with ground granulated blast-furnace slag] [portland cement in combination with silica fume] [portland-pozzolan cement]. The admixture shall be an air-entraining admixture [or an air-entraining admixture plus] [a retarding admixture], [a WRA], [a HRWRA], [or an accelerating admixture]. A retarding admixture may be used at the request of the Contractor when approved. No other chemical admixtures than those listed above shall be used.

2.1.1 Proportioning Responsibility

**********
**NOTE: The last optional sentence should be used if slow strength gain cementitious materials are to be used.**
**********

The concrete mixtures will be proportioned by the Contracting Officer. [Preliminary mixture-proportioning studies or thermal studies which include mixture proportions are available for review in the District Office.] [Some mixtures, especially those containing higher amounts of pozzolans, may have slow strength gain which may impact form design and form removal time.]

2.1.2 Design Requirements

**********
**NOTE: See the concrete materials design memorandum to select the optional cementitious materials.**
**********

The proportions of all material entering into each concrete mixture will be furnished to the Contractor. The proportions will be changed by the Contracting Officer as necessary. Adjustments shall be made by the Contractor to the batch weights of aggregates and water as necessary to compensate for free moisture in the aggregates. The quantity of air-entrainment admixture shall be adjusted by the Contractor to maintain the specified air content.

2.1.3 Air Content

The air content by volume shall be determined by ASTM C231/C231M. When the nominal maximum size of coarse aggregate is 37.5 mm 1-1/2 inches or larger, the air content of the sample measured in accordance with ASTM C231/C231M shall be 5-1/2 ± 1-1/2 percent. When the nominal maximum-size coarse aggregate is 19 mm 3/4 inch, the air content shall be 6 ± 1 percent. The specified air content shall be present in the concrete when the concrete has been placed in the forms.

2.1.4 Slump

The slump shall be determined in accordance with ASTM C143/C143M and shall be 50 mm 2 inches ± 25 mm 1 inch for massive features and between 25 and 100 mm 1 and 4 inches for all others except where placement by pump is approved, in which case the slump shall be 114 mm 4-1/2 ± 38 mm 1-1/2 inches. In addition, the range of each set of two consecutive tests for each mixture shall be not more than 50 mm 2 inches. The above specified slump is that required at the forms.

2.1.5 Construction Tolerances

Level and grade tolerance measurements of slabs shall be made as soon as possible after finishing. When forms or shoring are used, the measurements shall be made prior to removal. Tolerances are not cumulative. The most restrictive tolerance controls. Tolerances shall not extend the structure beyond legal boundaries. Except as specified otherwise, plus tolerance increases the amount or dimension to which it applies, or raises a level alignment and minus tolerance decreases the amount or dimension to which it applied, or lowers a level alignment. A tolerance without sign means plus or minus. Where only one signed tolerance is specified, there is no limit in the other direction. The unformed finished surfaces subject to high-velocity flow (12 m/s) (40 fps) shall be finished to meet the tolerances for A-HV surfaces specified in Table, "TOLERANCES FOR FINISHED FORMED CONCRETE SURFACES".

2.1.6 Tabulations and Definitions

**********
**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 tabulations are used as defined and used in ACI 117. Level and grade tolerance measurements of slabs shall be made as soon as possible after finishing.

| TOLERANCES FOR FOUNDATIONS | | |
|---|---|---|
| (1) | Lateral alignment | |
| | As cast to the center of gravity as specified; 0.02 times width of footing in direction of misplacement but not more than | 50 mm2 inches |
| | Supporting masonry construction | 13 mm1/2 inch |
| (2) | Level alignment | |
| | Top of footings supporting masonry | 13 mm1/2 inch |
| | Top of other footings | +13 mm, -50 mm +1/2 inch, -2 inch |
| (3) | Cross-sectional dimensions | |
| | Horizontal dimensions of formed members | +50 mm, -13 mm +2 in.,-1/2 in. |
| | Horizontal dimensions of unformed members cast against soil | |
| | 600 mm 2 feet or less | +75 mm, -13 mm +3 in., -1/2 in. |
| | Greater than 600 mm 2 feet but less than 1800 mm 6 feet | +150 mm, -13 mm +6 in., -1/2 in. |
| | Over 1800 mm 6 feet | +300 mm, -13 mm +12 in., -1/2 in. |
| | Vertical dimension (thickness) | -5 percent |
| (4) | Relative alignment | |
| | Slope of footing side and top surfaces with respect to the specified plan | 25 mm/3000 mm1 in./10 ft |

| TOLERANCES FOR CAST-IN-PLACE REINFORCED CONCRETE FOR BUILDINGS | | | |
|---|---|---|---|
| (1) | Vertical alignment | | |
| | For heights30 m 100 feet | | |
| | | Lines, surfaces, and arrises | 25 mm1 inch |
| | | Outside corner of exposed corner columns and control joint grooves in concrete exposed to view | 13 mm1/2 inch |
| | For heights greater than 30 m 100 ft | | |
| | | Lines, surfaces, and arrises, 1/1,000 times the height at any point but not more than | 150 mm6 inches |
| | | Outside corner of exposed corner columns and control joint grooves in concrete, 1/2,000 times the height at any point but not more than | 75 mm3 inches |
| (2) | Lateral alignment | | |
| | Members | | 25 mm1 inch |
| | In slabs, centerline location of openings 12 in. or smaller and edge location of larger openings | | 13 mm1/2 inch |
| | Sawcuts, joints, and weakened plane embedment in slabs | | 19 mm3/4 inch |
| (3) | Level alignment | | |
| | Top of slabs | | |
| | | Elevation of slabs-on-grade | 19 mm3/4 inch |
| | | Elevation of top surfaces of formed slabs before removal of supporting shores | 19 mm3/4 inch |
| | Elevation of formed surfaces before removal of shores | | 19 mm3/4 inch |
| | Lintels, sills, parapets, horizontal grooves, and other lines exposed to view | | 13 mm1/2 inch |
| (4) | Cross-sectional dimensions | | |
| | Members, such as columns, beams, piers, walls (thickness only) and slabs (thickness only) | | |
| | | 300 mm 12 inches dimension or less | +10, -6 mm<br>+3/8, -1/4 inch |
| | | More than 300 mm 12 inches but not over 900 mm 3 feet dimension | +13, -10 mm<br>+1/2, -3/8 inch |
| | | Over 900 mm 3 feet dimension | +25, -19 mm<br>+1, -3/4 inch |

| TOLERANCES FOR CAST-IN-PLACE REINFORCED CONCRETE FOR BUILDINGS | | | |
|---|---|---|---|
| (5) | Relative alignment | | |
| | Stairs | | |
| | | Different in height between adjacent risers | 3 mm1/8 inch |
| | | Different in width between adjacent treads | 6 mm1/4 inch |
| | Grooves | | |
| | | Specified width 50 mm 2 inches or less | 3 mm1/8 inch |
| | | Specified width more than 50 mm 2 inches but not more than 300 mm 12 inches | 6 mm1/4 inch |
| | Sawcuts, joints, and weakened plane on slab | | |
| | | Lateral, gradual | 19 mm in 3000 mm3/4 inch in 10 feet |
| | | Lateral, abrupt | 0 mm inch |
| (6) | Openings through members | | |
| | Cross-sectional size of opening | | +25 mm, -6 mm +1, -1/4 inch |
| | Location of centerline of opening | | 13 mm1/2 inch |

| TOLERANCE FOR FINISHED FORMED CONCRETE SURFACES | | |
|---|---|---|
| (1) | Vertical alignment: Formed surfaces slope with respect to the specified plane | |
| | Vertical alignment of outside corner of exposed corner columns and control joint grooves in concrete exposed to view | 7 mm in 3000 mm 1/4 in. in 10 ft |
| | All other conditions | 10 mm in 3000 mm3/8 in. in 10 ft |

| TOLERANCE FOR FINISHED FORMED CONCRETE SURFACES | | |
|---|---|---|
| (2) | Abrupt variation: The offset between concrete surfaces under adjacent pieces of formwork for the following classes of surface: (For Class A-HV, positive means raise of elevation in the direction of waterflow, negative means drop of elevation in the direction of waterflow) | |
| | Class A-HV, in the direction of waterflow | +0, -3 mm -1/8 inch |
| | *Class A-HV, perpendicular to the direction of waterflow | 3 mm1/8 inch |
| | Class A | 3 mm1/8 inch |
| | Class B | 6 mm1/4 inch |
| | Class C | 6 mm1/4 inch |
| | Class D | 25 mm1 inch |
| (3) | Gradual variation: Surface finish tolerances as measured by placing a freestanding (unleveled), 1.5 m 5 foot straightedge for plane surface or curved template for curved surface anywhere on the surface and allowing it to rest upon two high spots within 72 hr after concrete placement. The gap at any point between the straightedge or template and the surface shall not exceed: | |
| | *Class A (including Class A-HV) | 3 mm1/8 inch |
| | Class B | 6 mm1/4 inch |
| | Class C | 13 mm1/2 inch |
| | Class D | 25 mm1 inch |
| *Includes any high-velocity flow surface. | | |

| TOLERANCES FOR CAST-IN-PLACE, VERTICALLY SLIPFORMED BUILDING ELEMENTS | | |
|---|---|---|
| (1) | Translation and rotation from a fixed point at the base of the structure: | |
| | For heights 30 m 100 feet or less | 50 mm2 inches |
| | For heights greater than 30 m 100 feet, 1/600 times the height but not more than | 205 mm8 inches |
| (2) | Lateral alignment | |
| | Between adjacent elements | 50 mm2 inches |
| (3) | Cross-sectional dimensions | |
| | Wall thickness | +19 mm, -10 mm +3/4 inch, -3/8 inch |

| TOLERANCES FOR CAST-IN-PLACE, VERTICALLY SLIPFORMED BUILDING ELEMENTS | | |
|---|---|---|
| (4) | Relative alignment | |
| | Formed surface slope with respect to the specified plane | 19 mm in 3000 mm<br>3/4 in. in 10 ft |

| TOLERANCES FOR MASS CONCRETE STRUCTURES OTHER THAN BUILDINGS | | |
|---|---|---|
| (1) | Vertical alignment | |
| | Visible surfaces | 30 mm1-1/4 inch |
| | Concealed surfaces | 65 mm2-1/2 inches |
| | Side walls for radial gates and similar watertight joints | 5 mm3/16 inch |
| (2) | Lateral alignment | |
| | Visible surfaces | 30 mm1-1/4 inch |
| | Concealed surfaces | 65 mm2-1/2 inches |
| (3) | Level alignment | |
| | Visible flatwork and formed surfaces | 13 mm1/2 inch |
| | Concealed flatwork and formed surfaces | 25 mm1 inch |
| | Sills for radial gates and similar watertight joints | 5 mm3/16 inch |
| (4) | Relative alignment: Formed surface slope with respect to the specified plane | |
| | Slopes in lateral and level alignments | |
| | Visible surfaces | 7 mm in 3000 mm<br>1/4 in. in 10 ft |
| | Concealed surfaces | 13 mm in 3000 mm<br>1/2 in. in 10 ft |
| | Slopes in vertical alignment | |
| | Visible surfaces | 13 mm in 3000 mm<br>1/2 in. in 10 ft |
| | Concealed surfaces | 25 mm in 3000 mm<br>1 in. in 10 ft |

| TOLERANCES FOR CANAL LINING | | |
|---|---|---|
| (1) | Lateral alignment | |
| | Alignment of tangents | 50 mm2 inches |
| | Alignment of curves | 100 mm4 inches |
| | Width of section at any height | 0.0025W + 25 mm 1 inch |
| (2) | Level alignment | |
| | Profile grade | 25 mm1 inch |
| | Surface of invert | 6 mm1/4 inch |
| | Surface of side slope | 13 mm1/2 inch |
| | Height of lining | 0.005H + 25 mm 1 inch |
| (3) | Cross-sectional dimensions | |
| | Thickness of lining cross section: percent of specified thickness provided average thickness is maintained as determined by daily batch volumes | 10 |

| TOLERANCES FOR BRIDGES, EROSION-PROTECTION STRUCTURES, AND SMALL HYDRAULIC STRUCTURES | | |
|---|---|---|
| (1) | Vertical alignmnet | |
| | Exposed surfaces | 19 mm3/4 inch |
| | Concealed surfaces | 40 mm1-1/2 inch |
| (2) | Lateral alignment | |
| | Centerline alignment | 25 mm1 inch |

| TOLERANCES FOR BRIDGES, EROSION-PROTECTION STRUCTURES, AND SMALL HYDRAULIC STRUCTURES | | | |
|---|---|---|---|
| (3) | Level alignment | | |
| | Profile grade | | 25 mm1 inch |
| | Top of other concrete surfaces and horizontal grooves | | |
| | | Exposed | 19 mm3/4 inch |
| | | Concealed | 40 mm1-1/2 inch |
| | Mainline pavements in longitudinal direction, the gap below 3 m 10 feet unleveled straightedge resting on highspots shall not exceed | | 3 mm1/8 inch |
| | Mainline pavements in transverse direction, the gap below 3 m 10 feet unleveled straightedge resting on highspots shall not exceed | | 6 mm1/4 inch |
| | Ramps, sidewalks, and intersections, in any direction, the gap below a 3 m 10 feet unleveled straightedge resting on highspots shall not exceed | | 6 mm1/4 inch |
| (4) | Cross-sectional dimensions | | |
| | Bridge slab thickness | | +6 mm, -3 mm+1/4 inch, -1/8 inch |
| | Members such as columns, beams, piers, walls, and others (slabs--thickness only) | | +13 mm, -6 mm+1/2 inch, -1/4 inch |
| | Openings through concrete members | | 13 mm1/2 inch |
| (5) | Relative alignment | | |
| | Location of openings through concrete members | | 13 mm1/2 inch |
| | Formed surface slope with respect to the specified plane | | |
| | | Watertight joints | 3 mm in 3000 mm1/8 in. in 10 ft |
| | | Other exposed surfaces | 13 mm in 3000 mm1/2 in. in 10 ft |
| | | Concealed surfaces | 25 mm in 3000 mm1 in. in 10 ft |
| | Unformed exposed surfaces slopes with respect to the specified plane | | 7 mm in 3000 mm1/4 in. in 10 ft |
| | | | 10 mm in 6000 mm3/8 in. in 20 ft |
| TOLERANCES FOR TUNNEL LININGS, CONDUITS, AND FILLING AND EMPTYING CULVERTS | | | |

| | | | |
|---|---|---|---|
| (1) | Lateral alignment | | |
| | Centerline alignment | | |
| | | Water conveying tunnels, conduits, and culverts | 13 mm1/2 inch |
| | | Other | 25 mm1 inch |
| | Inside dimensions | | 0.005 times inside dimension |
| (2) | Level alignment | | |
| | Profile grade | | |
| | | Water conveying tunnels, conduits, and culverts | 13 mm1/2 inch |
| | | Other | 25 mm1 inch |
| | Surface of invert | | 6 mm1/4 inch |
| | Surface of side slope | | 13 mm1/2 inch |
| (3) | Cross-sectional dimension | | |
| | Thickness at any point | | |
| | | Tunnel and culvert lining | -0 mm inch |
| | | Conduits | +5 percent thickness but not less than 13 mm1/2 inch |
| | | | -2.5 percent thickness but not less than 6 mm 1/4 inch |

## 2.2 MATERIALS

### 2.2.1 Cementitious Materials

**********

**NOTE: See the appropriate concrete aggregates design memorandum or thermal study to select the proper requirements for cementitious materials options, pozzolan, and silica fume.**

**********

#### 2.2.1.1 Portland Cement

Portland cement shall conform to ASTM C150/C150M, Type [_____], [low-alkali when used with aggregates listed to require it in paragraph COMMERCIAL CONCRETE AGGREGATE SOURCES below, or when directed if a nonlisted source is permitted.] [including the heat of hydration requirement at 7 days] [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 pozzolan or slag provided the following requirement is met. The expansion of the proposed combination shall be equal to or less than the expansion of a low-alkali cement meeting the requirements of this paragraph when tested in general conformance with ASTM C441/C441M. The expansion tests shall be run

concurrently at an independent laboratory that is nationally recognized to perform such tests. The Government reserves the right to confirm the test results and to adjust the percentage of pozzolan or slag in the combination to suit other requirements.] [White portland cement shall meet these requirements except that it may be Type I, Type II, or Type III [low alkali].] [Type III may be used only in specific areas of the structure, when approved in writing.]

2.2.1.2 [Pozzolan Other than Silica Fume

Pozzolan other than silica fume shall conform 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 entrained air) shall apply to all fly ash. [Table 1A., Supplementary Optional Chemical Requirement for Maximum Alkalis, shall apply when used with aggregates listed to require low-alkali cement].]

2.2.1.3 [Ground Granulated Blast-Furnace Slag

Ground granulated blast-furnace slag shall conform to ASTM C989/C989M, Grade [_____].]

2.2.1.4 [Silica Fume

**********
**NOTE: Optional Table 2 in ASTM C1240 shall be included when used with aggregates listed to require low-alkali cement. Other requirements in Table 4 may be specified if necessary. Refer EM 1110-2-2000 for guidance.**
**********

Silica fume may be furnished as a dry, densified material or as a slurry. Silica fume, unprocessed, or before processing into a slurry or a densified material, shall conform to ASTM C1240 with [Table 2 and] the Specific Surface Area and Uniformity Requirements in Table 4 invoked. Provide the services of a manufacturer's technical representative, experienced in mixture proportioning, placement procedures, and curing of concrete containing silica fume. The manufacturer's representative shall be available for consultation by both the Contractor and the Contracting officer during mixture proportioning, planning, and production of silica-fume concrete and shall be onsite immediately prior to and during at least the first placement of concrete containing silica fume, and at other times if directed.]

2.2.1.5 Temperature of Cementitious Materials

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

2.2.2 Admixtures

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

2.2.2.1 Air-Entraining Admixtures

The air-entraining admixture shall conform to ASTM C260/C260M and shall

consistently entrain air in the specified ranges under field conditions.

2.2.2.2 [Accelerating Admixture

Calcium chloride shall not be used. Accelerators shall meet the requirements of ASTM C494/C494M, Type C [(or Type E)].]

2.2.2.3 [Retarding Admixture

**********

**NOTE: A retarding admixture should not be used where high early strength is desirable so that form stripping may proceed expeditiously. Before listing items consult the concrete materials design memorandum to determine areas where retarders may be necessary.**

**********

A retarding admixture shall meet the requirements of ASTM C494/C494M, Type B, or 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 approved[, except for the following structural items where a retarding admixture shall not be used: [_____]]. Use of Type D shall not be the reason to reduce the cementitious material content unless used in mixture proportioning studies.]

2.2.2.4 [Water-Reducing Admixture

A water-reducing admixture shall meet the requirements of ASTM C494/C494M, Type A [or 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.]

2.2.2.5 [High-Range Water-Reducing Admixture (HRWRA)

High-range water-reducing admixture shall meet the requirements of ASTM C494/C494M, Type F [or G], except the 6-month and 1-year strength requirements shall be waived. The admixture may be used only after mixture proportioning studies and when approved.] [Provide the services of a manufacturer's technical representative experienced in mixture proportioning and placement procedures of concrete containing HRWRA. The technical representative shall be available for consultation during mixture proportioning and shall be on-site for the first placement of concrete containing HRWRA.]

2.2.2.6 [Expansive Admixture

**********

**NOTE: Delete this paragraph and paragraph BLOCK-OUT CONCRETE in Part 3 if block-out concrete is not used.**

**********

Submit manufacturer's descriptive literature and certification for fluidifier to be used as expansive admixture in block-out concrete, 60 days prior to its use. Expansive admixture used in block-out concrete shall conform to ASTM C937.]

2.2.3 Curing Materials

2.2.3.1 [Sheet Materials

Sheet curing materials shall conform to ASTM C171, type optional, except polyethylene sheet shall not be used.] Submit a manufacturer's certificate certifying that the materials comply with the requirements of ASTM C171, if sheet curing is used.

2.2.3.2 Membrane-Forming Curing Compound

Membrane-forming curing compound shall conform to ASTM C309, Type 1D or 2, except a styrene acrylate or chlorinated rubber compound meeting ASTM C309, Class B, requirements may be used for surfaces that are to be painted or are to receive subsequent coatings, or floors that are to receive adhesive applications of resilient flooring. The curing compound selected shall be compatible with any subsequent paint, roofing, coating, or flooring specified.

2.2.3.3 Burlap

Burlap for curing purposes shall conform to AASHTO M 182.

2.2.4 Water

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

2.2.5 Aggregates

**********

**NOTE: See the concrete materials design memorandum 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 2.1.1.1 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.**

**Section 32 13 14.13 CONCRETE PAVING FOR AIRFIELDS AND OTHER HEAVY DUTY PAVEMENTS, paragraph 2.3.1.2 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 shall 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 UFGS 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 "[.]".**

**********

2.2.5.1 Aggregate Composition

[Fine aggregate shall consist of natural sand, manufactured sand, or a combination of natural and manufactured sands. Coarse aggregate shall consist of gravel, crushed gravel, crushed stone, air-cooled blast-furnace slag, or a combination thereof.] "[Fine and coarse aggregates proposed for use in concrete shall be tested and evaluated for alkali-aggregate reactivity in accordance with ASTM C1260. The fine and coarse aggregates shall be evaluated separately and in combination, which matches the Contractor's proposed mix design proportioning. All results of the separate and combination testing shall 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, the aggregate(s) shall be rejected or additional testing using ASTM C1260 and ASTM C1567 shall be performed. The additional testing using ASTM C1260 and ASTM C1567 shall be performed using the low alkali portland cement in combination with ground granulated blast furnace (GGBF) slag, or Class F fly ash. GGBF slag shall be used in the range of 40 to 50 percent of the total cementitious material by mass. Class F fly ash shall be used in the range of 25 to 40 percent of the total cementitious material by mass.]"

2.2.5.2 Quality of Aggregates

**********

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

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

**The petrographic examination shall be used to identify deleterious substances in aggregates. Deleterious substances shall be listed individually with respective limits.**

**********

Aggregates delivered to the mixer shall meet the following requirements:

| TEST LIMITS | | | |
|---|---|---|---|
| PROPERTY | FINE AGGREGATE | COARSE AGGREGATE | TESTS |
| Specific Gravity | [_____] | [_____] | ASTM C127<br>ASTM C128 |
| Absorption | [_____] | [_____] | ASTM C127<br>ASTM C128 |
| Durability Factor using Procedure A | [_____] | [_____] | COE CRD-C 114<br>ASTM C666/C666M |
| Clay Lumps and Friable Particles | [_____] | [_____] | ASTM C142/C142M |
| Material Finer than 75 µ No. 200 Sieve | [_____] | [_____] | ASTM C117 |
| Organic Impurities | Not Darker than No. 3, Not less than 95 percent | | ASTM C40/C40M<br>ASTM C87/C87M |
| L.A. Abrasion | [_____] | [_____] | ASTM C131/C131M<br>ASTM C535 |
| Soft Particles | [_____] | [_____] | COE CRD-C 130 |
| Petrographic Examination | List unwanted deleterious materials and their limits | [_____] | ASTM C295/C295M |
| Chert, less than 2.40 specific gravity | [_____] | [_____] | ASTM C123/C123M |
| [Coal and Lignite, less than 2.00 specific gravity] | [_____] | [_____] | ASTM C123/C123M |

2.2.5.3 Grading

**********

**NOTES: The Designer should invoke the optional requirement limiting the amount of material passing the 75-µm No. 200 sieve when manufactured sand is specified and may invoke the option when natural sand is specified. If the limitation is invoked here, it must be listed for fine aggregate in paragraph AGGREGATES above.**

**See the concrete materials design memorandum for the approved gradings. Delete gradings not required.**
**********

2.2.5.3.1 Fine Aggregate

The grading of the fine aggregate as delivered to the mixers shall be such that the individual percent retained on any sieve shall not vary more than 3 percent from the percent retained on that sieve in a fixed grading selected by the Contractor with the approval of the Contracting Officer. The fixed grading may be selected at the start of concrete placement and based upon 30 days fine aggregate production or selected after the first 30 days of concrete placement. The minimum individual percent retained on the 2.36 mm (No. 8) sieve shall be 5 percent and on all smaller sieves[, except the 75 µm (No. 200),] shall be 10 percent. In addition to the grading limits, the fine aggregate, as delivered to the mixer, shall have a fineness modulus of not less than 2.25 nor more than 2.85. The grading of the fine aggregate shall also be controlled so that the fineness moduli groups (average of the current test and the previous two tests) of the fine aggregate as delivered to the mixer shall not vary more than 0.10 from the target fineness modulus of the fixed grading selected by the Contractor and approved by the Contracting Officer. The range of each group shall not exceed 0.20. The fineness modulus shall be determined 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 the uniformity of grading of the separate sizes shall be controlled so that they may be combined throughout the job in fixed proportions established during the first 30 days of concrete placement. The selected fixed grading shall be within the following limits, except any individual test result may be outside these limits if within the allowable 3 percent variation from the selected grading.

| SIEVE DESIGNATION U.S. STANDARD SQUARE MESH | PERMISSIBLE LIMITS PERCENT BY MASS, PASSING |
|---|---|
| 9.5 mm3/8 inch | 100 |
| 4.75 mmNo. 4 | 95 - 100 |
| 2.36 mmNo. 8 | 80 - 95 |
| 1.18 mmNo. 16 | 60 - 80 |
| 600 µmNo. 30 | 35 - 60 |
| 300 µmNo. 50 | 15 - 30 |
| 150 µmNo. 100 | 5 - 10 |
| 75 µmNo. 200 | 0 - 5 |

2.2.5.3.2 Coarse Aggregate

The coarse aggregate shall be rescreened just prior to delivery to the

concrete batch plant bins. The grading of the coarse aggregate within the separate size groups shall 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 | 75 mm 3 inch to150 mm 6 inch |
| 175 mm7 inch | | | | 100 |
| 150 mm6 inch | | | | 90 - 100 |
| 100 mm4 inch | | | 100 | 20 - 55 |
| 75 mm3 inch | | | 90 - 100 | 0 - 15 |
| 50 mm2 inch | | 100 | 20 - 55 | 0 - 5 |
| 37.5 mm1-1/2 inch | | 90 - 100 | 0 - 10 | |
| 25 mm1 inch | 100 | 20 - 45 | 0 - 5 | |
| 19.0 mm3/4 inch | 90 - 100 | 0 - 10 | | |
| 9.5 mm3/8 inch | 20 - 55 | 0 - 5 | | |
| 4.75 mmNo. 4 | 0 - 10 | | | |
| 2.36 mmNo. 8 | 0 - 5 | | | |

2.2.5.4 Particle Shape

The quantity of flat and elongated particles in the separate size groups of coarse aggregate, as determined by ASTM D4791, using a value of 3 for width-thickness ratio and length-width ratio shall not exceed 25 percent in any size group.

2.2.5.5 Nominal Maximum-Size of Aggregate

The nominal maximum-size of coarse aggregate to be used in the various parts of the work shall be in accordance with the following tabulation except as directed. The NMSA may be changed for sections requiring a special quality of concrete as directed.

| FEATURES | NOMINAL MAXIMUM-SIZE AGGREGATE |
|---|---|
| Sections 190 mm 7-1/2 inches or less in width or slabs 100 mm 4 inches or less in thickness or any section with a clear distance between reinforcement less than 55 mm 2-1/4 inches | 19 mm3/4 inch |

| FEATURES | NOMINAL MAXIMUM-SIZE AGGREGATE |
|---|---|
| Sections over 190 mm 7-1/2 inches or slabs at least 100 mm 4 inch in thickness. However, this size shall not be used in any section in which the clear distance between reinforcement is less than 55 mm 2-1/4 inch | 40 mm1-1/2 inch |
| Unreinforced sections over 300 mm 12 inches in width and reinforced sections over 450 mm 18 inches in width or slabs 255 mm 10 inches or greater in thickness. However, this size shall not be used in any section in which the clear distance between reinforcing bars is less than 115 mm 4-1/2 inches | 75 mm3 inches |
| Massive sections exceeding 1.8 m 6 feet in width and slabs 600 mm 24 inches in thickness, in which the clear distance between reinforcing bars is at least 225 mm 9 inches | 150 mm6 inches |

2.2.5.6 Moisture Content

The fine aggregate shall not be placed in bins at the batch plant until it is in a stable state of moisture content. A stable moisture content shall be 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 1 hour of the 2 hours prior to placing the material in the batch plant bins and the variation in moisture content when sampled at the same location shall not be more than 2.0 percent during the last 8 hour period that the aggregate remains in the stockpile. The coarse aggregate shall be delivered to the mixers with the least amount of free moisture and the least variation in free moisture practicable under the job conditions. Under no conditions shall the coarse aggregate be delivered to the mixer "dripping wet".

2.2.5.7 [Commercial Concrete Aggregate Sources

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

Concrete aggregates may be furnished from any source capable of meeting the quality requirements stated in paragraph AGGREGATES 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 Design Memorandum 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 memorandum. The test results and conclusions shall be considered valid only for the sample

tested and shall not be taken as an indication of the quality of all material from a source nor for the amount of processing required.

a. List of Sources

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

**********

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

**********

b. Selection of Source - After the award of the contract, designate in writing only one source or combination of sources from which the Contractor proposes to furnish aggregates. If the Contractor proposes to furnish aggregates from a source or sources not listed in subparagraph "a.", LIST OF SOURCES, above, designate only a single source or single combination of sources for aggregates. Regardless of the source selected, samples for quality-assurance testing shall be provided as required by paragraphs GOVERNMENT PRECONSTRUCTION TESTING and MATERIALS FOR MIXTURE-PROPORTIONING STUDIES IN part 1. If a source for coarse or fine aggregate so designated by the Contractor does not meet the quality requirements stated above, do not submit for approval other sources but furnish the coarse or fine aggregate, as the case may be, from one or a combination of the sources listed at no additional cost to the Government].

2.2.5.8 Government Furnished Concrete Aggregate Source

**********

**NOTE: The Specification Writer should ascertain that restoration of the pit or quarry site is specified under other sections.**

**********

2.2.5.8.1 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, a 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 shall be the responsibility of the Contractor, and the Government shall not be held liable for costs resulting from such work or waste. Produce the concrete aggregate from the following sites as shown:

| | QUARRY SITE | BAR | TERRACE | COORDINATES | DIST. AND DIRECTION |
|---|---|---|---|---|---|
| G1 | [_____] | [_____] | [_____] | [_____] | [_____] |
| G2 | [_____] | [_____] | [_____] | [_____] | [_____] |
| G3 | [_____] | [_____] | [_____] | [_____] | [_____] |

[2.2.5.8.2 Explorations

The deposits listed 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.

]2.2.6 Nonshrink Grout

**********

**NOTE: Grade of nonshrink grout will be specified based on the application, exposure conditions, and manufacturer's recommendation.**

**********

Nonshrink grout for use in setting base plates and machinery shall conform to ASTM C1107/C1107M, Grade [_____], and shall be a commercial formulation suitable for the application proposed. Submit descriptive literature of the grout proposed for use containing certified laboratory test results showing that it meets ASTM C1107/C1107M 60 days prior to its use together with a certificate from the manufacturer stating that the grout is suitable for the application or exposure for which it is being considered. In addition, a detailed plan for review, showing equipment and procedures for use in mixing and placing the grout.

2.2.7 Packaged Dry Repair Materials

Packaged dry rapid-hardening cementitious materials for concrete repairs shall be a commercial formulation conforming to ASTM C928/C928M requiring only the addition of water.

2.2.8 Bonding Agents

Submit descriptive literature and certification in advance of their use. Bonding agents shall meet the following requirements:

2.2.8.1 Latex Bonding Agent

Latex agents for bonding fresh to hardened concrete shall conform to ASTM C1059/C1059M, Type II.

2.2.8.2 Epoxy Resin

Epoxy resins for use in repairs shall conform to ASTM C881/C881M, Type V, Grade I or II.

2.2.9 Surface Retarder

Surface retarder shall conform to COE CRD-C 94.

2.3 PLANT AND EQUIPMENT

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

The batching, mixing, conveying, and placing systems shall have a capacity of at least [_____] cubic meters yards per hour. Submit the methods and description of the equipment proposed for transporting, handling, and depositing the concrete for review, 60 days before concrete placement begins. The data submitted shall include site drawings or sketches with locations of equipment and placement site.

2.3.1 Batch Plant

**********
**NOTE: See EM 1110-2-2000, and the concrete materials design memorandum for selection of automatic or semiautomatic plant.**
**********

Submit details and data on the concrete plant, within 60 days prior to assembly, to the Contracting Officer for conformance review with the requirements of paragraph PLANT AND EQUIPMENT. Batch plant shall meet the following requirements:

2.3.2 Location

The concrete plant [shall] [may] be located at the site of the work in the general area indicated on the drawings, [or may be located offsite].

2.3.3 Bins and Silos

Separate bins, compartments, or silos shall be provided for each size or classification of aggregate and for each of the cementitious materials. The compartments shall be of ample size and so constructed that the various materials will be maintained separately under all working conditions. All compartments containing bulk cement, pozzolan, ground granulated blast-furnace slag, or silica fume shall be separated from each other by a free-draining air space. All filling ports shall be clearly marked with a permanent sign stating the contents.

### 2.3.4 Batching Equipment

#### 2.3.4.1 Batchers

Weigh aggregate in separate weigh batchers with individual scales. Weigh each bulk cement and/or other cementitious materials on a separate scale in a separate weigh batcher. Measure water by weight or by volume. If measured by weight, do not weigh cumulatively with another ingredient. Measure ice separately by weight. Batch admixtures separately and batch by weight or by volume in accordance with the manufacturer's recommendations.

#### 2.3.4.2 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. The mechanism for delivering water to the mixers shall be free from leakage when the valves are closed. The filling and discharge valves for the water batcher shall be so interlocked that the discharge valve cannot be opened before the filling valve is fully closed. When a water meter is used, a suitable strainer shall be provided ahead of the metering device.

#### 2.3.4.3 Admixture Dispensers

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

#### 2.3.4.4 Moisture Control

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

#### 2.3.4.5 Scales

Provide facilities for the accurate measurement and control of each of the materials entering each batch of concrete. The weighing equipment and controls shall conform to the applicable requirements of NIST HB 44,

except that the accuracy shall be within 0.2 percent of the scale capacity. Provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring device. Tests shall be made at the frequency required in paragraph TESTS AND INSPECTIONS in PART 3, and in the presence of a Government quality assurance representative. Each weighing unit shall include a visible indicator that shall indicate the scale load at all stages of the weighing operation and shall show the scale in balance at zero load. The weighing equipment shall be arranged so that the concrete plant operator can observe the indicators.

2.3.4.6 Operation and Accuracy

[The weighing operation of each material shall start automatically when actuated by a single starter switch and shall 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 NRMCA CPMB 100.] [The weighing operation of each material shall start automatically when actuated by one or more starter switches and shall 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 NRMCA CPMB 100.] There shall be equipment to permit the selection of [_____] preset mixes each by the movement of not more than two switches or other control devices. Cumulative weighing will not be permitted. The weigh batchers shall be so constructed and arranged that the sequence and timing of batcher discharge gates can be controlled to produce a ribboning and mixing of the aggregates, water, admixtures, and cementitious materials as the materials pass through the charging hopper into the mixer. The plant shall include provisions to facilitate the inspection of all operations at all times. Delivery of materials from the batching equipment shall be within the following limits of accuracy:

| MATERIAL | PERCENT |
|---|---|
| Cementitious materials | ± 1 |
| 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 | ± 3 |

2.3.4.7 Interlocks

Batchers and mixers shall be interlocked so that:

a. The charging device of each batcher cannot be actuated until all scales have returned to zero balance within ± 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. One admixture is batched automatically with the water.

f. Each additional admixture is batched automatically with a separate portion of the water or with the fine aggregate.

g. The mixers cannot be discharged until the required mixing time has elapsed.

2.3.4.8 Recorder

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

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

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

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

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

e. The recorder chart or tape shall become the property of the Government.

f. The recorder shall be placed 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 shall be accurate within ± 2 percent.

2.3.4.9 Batch Counters

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

2.3.4.10 Rescreening Plant

A rescreening plant shall be located, arranged, and operated 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 excessive variation and conforming to the size groups and grading of paragraph AGGREGATES above and with moisture content conforming

to the provisions of paragraph MOISTURE CONTENT above. 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 shall be wasted.

2.3.4.11 Washing Plant

All coarse aggregates shall be washed immediately prior to entering the rescreening plant. The rewashing plant shall contain water nozzles and vibrating screens to remove foreign materials and coatings from aggregate particles. Water used for washing shall meet the requirements of paragraph WATER above.

2.3.4.12 Trial Operation

Not less than 7 days prior to commencement of concrete placing, a test of the batching and mixing plant shall be made in the presence of the Contracting Officer to check operational adequacy. The number of full-scale concrete batches required to be produced in trial runs shall be as directed, will not exceed 20, and shall be proportioned as directed. All concrete produced in these tests shall be wasted or used for purposes other than inclusion in structures covered by this specification. All deficiencies found in plant operation shall be corrected 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. Notify the Contracting Officer of the trial operation not less than 7 days prior to the start of the trial operation.

2.3.4.13 Protection

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

2.3.5 Laboratory Areas

**********

**NOTE: The editor should use the alternate sentence and fill in the correct Section number unless a laboratory building is to be government furnished.**

**********

A room shall be provided in the plant to house the moisture and grading testing equipment for aggregate and to provide working space. Another room shall be provided for testing fresh concrete and for fabricating and initial curing of concrete test specimens in accordance with ASTM C31/C31M. The size, arrangement, and location of these rooms will be subject to approval. Provide electricity, air conditioning, heat, and water as required for use in these laboratory areas.

[2.3.6 Plant Layout Drawings

**********

**NOTE: The paragraph should be included in projects for which "onsite" plant is a requirement. The wording should be modified as necessary to suit the particular requirements of each project. Drawings**

**submitted in compliance with this paragraph will enable the Contracting Officer to determine in advance of erection whether or not the plant meets the requirements of these specifications.**
**********

Drawings, in triplicate, showing the layout of the plant the Contractor proposes to use on the work shall be submitted for review. The drawings shall show the locations of the principal components of the construction plant; offices; shop and storage building; housing facilities, if any; and storage areas and yards which the Contractor proposes to construct at the site of the work and elsewhere. Also furnish for review drawings, in triplicate, showing the general features of his aggregate processing plant; aggregate transporting; storage and reclaiming facilities; aggregate rinsing and dewatering plant, if required; coarse aggregate rescreening plant, if required; concrete batching and mixing plant; concrete conveying and placing plant; and when precooling of concrete is required, the cooling plant. The drawing shall appropriately show the capacity of each major feature of the plant including the rated capacity of the aggregate production plant in tons (metric) (2000 lb) per hour of fine and coarse aggregates; rated capacity of the aggregate transporting, storage and reclaiming facilities; volume of aggregate storage; capacity of cement and pozzolan storage; rated capacity of the concrete batching and mixing plant in cubic meters yards per hour; rated capacity of the concrete transporting and placing plant in cubic meters yards per hour; and when used rated capacity of plant for precooling of concrete. Drawings in triplicate showing any changes in plant made during design and erection or after the plant is in operation shall be submitted for review. Two sets of the drawings will be retained and one set will be returned to the Contractor with comments.

]2.3.7 Mixers

**********
**NOTE: See the concrete materials design memorandum for information on mixer selection and concrete mixers. Truck mixers shall not be allowed for mixing or transporting concrete with less than 50 mm 2 in. slump or greater than 37 mm 1-1/2 in. nominal maximum size aggregate (NMSA).**
**********

Mixers shall be stationary mixers [or truck mixers]. Each mixer shall combine the materials into a uniform mixture and discharge this mixture without segregation. Mixers shall not be charged in excess of the capacity recommended by the manufacturer on the nameplate. Excessive over-mixing requiring introduction of additional water will not be permitted. The mixers shall be maintained in satisfactory operating condition, and mixer drums shall be kept free of hardened concrete. Mixer blades or paddles shall be replaced when worn down more than 10 percent of their depth when compared with the manufacturer's dimension for new blades. Should any mixer at any time produce unsatisfactory results, its use shall be promptly discontinued until it is repaired or replaced. Submit the make, type, capacity, and number of the concrete mixers proposed for use, 60 days prior to installation for review by the Contracting Officer for conformance with the requirements of paragraph PLANT AND EQUIPMENT.

2.3.7.1 Stationary Mixer Uniformity Requirements

**********
**NOTE: The option for the government to perform the initial mixer evaluation may be invoked.**
**********

Adjust the size of the batch, the mixing time, the charging sequence, and other factors to provide concrete that meets the uniformity limits specified herein and in paragraph MIXER UNIFORMITY IN PART 3. All testing shall be performed in accordance with COE CRD-C 55. When regular testing is performed, the concrete shall meet the limits of any five of the six uniformity requirements. When abbreviated testing is performed, the concrete shall meet only those requirements listed for abbreviated testing. The initial mixer evaluation test shall be a regular test and shall be performed prior to the start of concrete placement. The concrete proportions used for the evaluation shall contain the largest size aggregate on the project and shall be as directed. Regular testing shall consist of performing all six tests on three batches of concrete. The range for regular testing shall be the average of the ranges of the three batches. Abbreviated testing shall consist of performing the three required tests on a single batch of concrete. The range for abbreviated testing shall be 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 shall apply to the others, subject to approval. Perform mixer evaluations as specified herein. [However, the initial evaluation will be performed by the Government. Provide labor and equipment as directed to assist the Government in performing any evaluation made by the Government.]

| | ABBREVIATED | |
|---|---|---|
| PARAMETER | REGULAR TESTS ALLOWABLE MAXIMUM RANGE FOR AVERAGE OF 3 BATCHES | TESTS ALLOWABLE MAXIMUM RANGE FOR 1 BATCH |
| Unit weight of air-free mortar, kg/m$^3$ lb/cu ft | 322.0 | 322.0 |
| Air content, percent | 1.0 | --- |
| Slump, mm inches | 251.0 | --- |
| Coarse aggregate, percent | 6.0 | 6.0 |
| Compressive strength at 7 days, percent | 10.0 | 10.0 |
| Water content, percent | 1.5 | --- |

[2.3.7.2 Truck Mixers

Truck mixers and the mixing of concrete therein shall conform to the requirements of ASTM C94/C94M. A truck mixer may be used for complete mixing (transit-mixed) or to finish the partial mixing done in a stationary mixer (shrink-mixed). Each truck shall be equipped with two counters from which it shall be possible to determine the number of revolutions at mixing speed and the number of revolutions at agitating speed. Truck mixers shall not be used to mix or agitate concrete with

greater than 37.5 mm 1-1/2 inch nominal maximum-size aggregate or concrete with a slump of 50 mm 2 inches or less. The acceptability of truck mixers shall be determined by uniformity tests in accordance with ASTM C94/C94M.

]2.3.8 Sampling Facilities

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

2.3.9 Coarse Aggregate

**********

**NOTE: The automatic sampling plant should be required for aggregates in concrete containing larger than 75 mm 3 inch NMSA. For aggregates in concrete containing 75 mm 3 inch NMSA, a cost analysis should be made before specifying the automatic sampling plant. The automatic sampling plant should not be specified for aggregates in concrete containing 75 or 150 mm 3 or 6 inch NMSA. Note that the quarry sloping screens on the automatic plant will require slightly larger screens than those used for tests by ASTM C136/C136M for comparable results.**

**********

Suitable facilities shall be provided for readily obtaining representative samples of coarse aggregate for test purposes immediately prior to the material entering the mixer. [The facilities shall include automatic equipment capable of obtaining, sieving, and weighing samples of the coarse aggregate as follows:

| AGGREGATE SIZE (mm) (inch) | APPROXIMATE SIZE OF SAMPLE (kg) (lb) |
|---|---|
| 4.75 to 19.0No. 4 to 3/4 | 250500 |
| 19.0 to 37.53/4 to 1-1/2 | 250500 |
| 37.5 to 751-1/2 to 3 | 5001000 |
| 75 to 1503 to 6 | 10002000 |

The equipment shall be capable of running a complete sieving, of any required sample, without the necessity of intermittent loading. The assembly shall be designed to permit selection, screening, and weighing of any individual sample in 10 minutes or less. The equipment shall be designed by a company engaged in the design and manufacture of aggregate sieving devices. Provide equipment that will accomplish the desired

purpose. Sieves shall meet the applicable requirements of ASTM E11, except for the frame size requirements. The equipment shall be arranged so that all controls will be enclosed and operable from a single position commanding a view of the screen device and the scale or scales. Communication shall be provided from the batch plant operation to this control area. The Contractor is responsible for charging of the assembly as directed, disposal of waste material, and proper service and maintenance of the assembly. Each sieve shall be provided with individual controls for frequency and angle. Run correlation tests with equipment as used for ASTM C136/C136M before concrete placement begins and at least every 60 days while concrete is being placed. The correlation test will determine the optimum angle, volume of feed, and the frequency for each sieve.]

2.3.10 Transporting Equipment

Transporting equipment shall be designed, operated, and maintained so that it does not cause or permit segregation or loss of material. The concrete shall not be dropped vertically more than 1.5 m 5 feet except where suitable equipment is provided to prevent segregation and where specifically authorized.

2.3.10.1 Buckets

Bottom-dump buckets shall conform to the following requirements: the interior hopper slope shall be not less than 70 degrees from the horizontal; the minimum dimension of the clear gate opening shall be at least five times the nominal maximum size of the aggregate, and the area of the gate opening shall not be less than 0.2 square meters 2 square feet; the bucket gates shall be grout-tight when closed, shall be of the double clamshell type, and shall be manually, pneumatically, or hydraulically operated; and the gate-opening mechanism shall be designed to close the gates automatically when the control is released or when the air or hydraulic line is broken. If gate actuation is dependent on integral air or hydraulic reservoirs, the capacity of the reservoirs shall be sufficient to open and close the gates three times without recharging the reservoir.

2.3.10.2 Trucks

Truck mixers or agitators used for transporting central-mixed concrete shall conform to the applicable requirements of ASTM C94/C94M. Truck mixers shall not be used to transport concrete with larger than 37.5 mm 1-1/2 inch nominal maximum-size aggregate or 50 mm 2 inch or lower slump. Nonagitating trucks may be used for transporting 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 nonagitating trucks shall be smooth, watertight, metal containers specifically designed to transport concrete, shaped with rounded corners to minimize segregation, and equipped with gates that will permit positive control of the discharge of the concrete.

2.3.10.3 Chutes

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

specifically approved and in no case shall slump be increased to accommodate their use.

2.3.10.4 Belt Conveyors

Belt conveyors shall be designed and operated 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 shall be provided with positive means for preventing segregation of the concrete or loss of mortar at the transfer point(s) and the point of placing. The idler spacing shall not exceed 900 mm 36 inches. Belt speed shall be a minimum of 90 m 300 feet per minute and a maximum of 230 m 750 feet per minute. Belt width shall be a minimum of 600 mm 24 inches if the NMSA is 150 mm 6 inches and shall be a minimum of 400 mm 16 inches if the NMSA is 75 mm 3 inches or less. The NMSA required in mixture proportions furnished by the Government will not be changed to accommodate the belt width.

2.3.10.5 Pump Placement

Concrete may be conveyed by positive-displacement pump when approved. Pump placement will be approved only for areas where placement by bucket or conveyor is difficult or impractical. The pumping equipment shall be piston or squeeze-pressure type. The pipeline shall be rigid-steel pipe or heavy-duty flexible hose. Aluminum pipe shall not be used. The inside diameter of the pipe shall be at least 3 times the nominal maximum size of the coarse aggregate in the concrete to be pumped but not less than 100 mm 4 inches.

PART 3 EXECUTION

3.1 PREPARATION FOR PLACING

3.1.1 Vibrators

An adequate number of vibrators shall be on hand to meet placing requirements, and spare vibrators shall be available to maintain production in the event of breakdown. There shall be adequate air pressure available for air vibrators and adequate voltage for electric vibrators. Vibrators of the proper size, frequency, and amplitude shall be used for the type of work being performed in conformance with the following requirements:

| APPLICATION | HEAD DIAMETER (mm) (inch) | FREQUENCY VPM | AMPLITUDE (mm) (inch) |
|---|---|---|---|
| Thin walls, beams, etc. | 32 - 641-1/4 - 2-1/2 | 9,000 - 13,500 | 0.5 - 1.00.020 - 0.04 |
| General construction | 50 - 882 - 3-1/2 | 8,000 - 12,000 | 0.6 - 1.20.025 - 0.05 |
| Heavy sections | 75 - 1503 - 6 | 7,000 - 10,500 | 0.75 - 1.50.030 - 0.06 |
| Mass concrete | 125 - 1755 - 7 | 5,500 - 8,500 | 1.0 - 2.00.04 - 0.08 |

The frequency and amplitude shall be within the range indicated in the tabulation as determined in accordance with paragraph TESTS AND INSPECTIONS below.

### 3.1.2 Embedded Items

Before placing concrete, take care to determine that all embedded items are securely fastened in place as indicated in the drawings or required. Embedded items shall be free of oil and other foreign matter such as loose coatings of rust, paint, and scale. The embedding of wood in concrete will be permitted only when specifically authorized or directed. Any air or water lines or other materials embedded in structures, as authorized construction expedients, shall conform to the above requirements and upon completion of their use shall be backfilled with concrete or mortar as directed. Welding will not be permitted on embedded or otherwise exposed metals which are in contact with concrete surfaces. Tack welding of or to embedded items will not be permitted.

### 3.1.3 Concrete on Earth Foundations

Earth foundations upon which concrete is to be placed shall be clean, damp, and free from frost, ice, and standing or running water. Prior to placement of concrete, the earth foundation shall have been satisfactorily compacted in accordance with the provisions of Section 31 00 00 EARTHWORK.

### 3.1.4 Concrete on Rock Foundations

Rock surfaces upon which concrete is to be placed shall be clean and free from oil, standing or running water, ice, mud, drummy rock, coatings, debris, and loose, semidetached, overhanging, or unsound fragments. Faults or joints shall be cleaned to a satisfactory depth and to firm rock on the sides as directed by the Contracting Officer. Immediately before concrete is placed, all rock surfaces shall be cleaned thoroughly by the use of air-water jet, high-pressure water jet, or sandblasting as described in the paragraph below. All rock surfaces shall be kept continuously wet for at least 24 hours immediately prior to placing concrete thereon. All approximately horizontal surfaces shall be covered immediately before the concrete is placed with a 13 mm 1/2 inch layer of mortar composed of the same sand and cementitious materials used in the concrete. The sand-cementitious materials ratio and the water-cementitious material ratio of the mortar shall be approximately the same as those used in the concrete mixture. The mortar shall be covered with concrete before the mortar has reached its initial time of setting.

### 3.1.5 Construction Joint Treatment

Submit the method and equipment proposed for joint cleanup and waste disposal, for review 30 days before concrete placement begins.

#### 3.1.5.1 Joint Preparation

Concrete surfaces to which other concrete is to be bonded shall be prepared for receiving the next lift or adjacent concrete by cleaning by sandblasting, high-pressure water jet, or air-water cutting. Surface cutting by air-water jets will not be permitted for concrete surfaces congested with reinforcing steel or if they are relatively inaccessible. If, for any other reason, it is considered undesirable to disturb the surface of a lift before it has hardened, the use of sandblasting or high-pressure water jet after hardening will be required. Regardless of the method used, the resulting surface shall be free from all laitance and inferior concrete so that clean, well-bonded coarse aggregate particles are exposed uniformly over the lift surface. Application of the joint treatment method shall be such that the edges of the larger particles of

aggregate are not undercut. Where joint preparation occurs more than 2 days prior to placing the next lift or where the work in the area subsequent to the joint preparation causes dirt or debris to be deposited on the surface, the surface shall be cleaned as the last operation prior to placing the next lift. The surface of the construction joint shall be kept continuously wet for the first 12 hours of the 24 hours prior to placing concrete, except that the surface shall be damp with no free water at the time of placement.

3.1.5.2 Air-Water Cutting

Air-water cutting of a construction joint shall be performed at the proper time, generally between 4 and 12 hours after placement and only on horizontal construction joints. This period may be modified if a retarder is used to prolong the setting of the cement at surface of the concrete. The air pressure used in the jet shall be 620 to 760 kPa 90 to 110 psi, and the water pressure shall be just sufficient to bring the water into effective influence of the air pressure. When approved a surface retarder complying with the requirements of COE CRD-C 94 may be applied to the surface of the lift to prolong the period of time during which air-water cutting is effective. Prior to receiving approval, furnish samples of the material to be used and shall demonstrate the method to be used in its application. After cutting, the surface shall be washed and rinsed until the wash water is no longer cloudy. If air-water cutting does not produce acceptable results, the surface shall be prepared by high-pressure water jet or sandblasting.

3.1.5.3 High-Pressure Water Jet

A stream of water under a pressure of not less than 21 MPa 3,000 psi may be used for cleaning. Its use shall be delayed until the concrete is sufficiently hard so that only the surface skin or mortar is removed and there is no undercutting of coarse-aggregate particles. If the high-pressure water jet is incapable of a satisfactory cleaning, the surface shall be cleaned by sandblasting.

3.1.5.4 Wet Sandblasting

This method of joint preparation may be used when the concrete has reached sufficient strength to prevent undercutting of coarse aggregate particles. The operation shall be continued until all accumulated laitance, coatings, stains, debris, and foreign materials are removed. The surface of the concrete shall then be washed thoroughly to remove all loose material. This method may be used on both horizontal and vertical surfaces.

3.1.5.5 Waste Water Disposal

**********

**NOTE: Specification Writer will fill in the section number for the Environment Protection Plan.**

**********

The method used in disposing of waste water employed in cutting, washing, and rinsing of concrete surfaces shall be such that the waste water does not stain, discolor, or affect exposed surfaces of the structures, or damage the environment of the project area. The method of disposal shall meet all requirements of Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS.

## 3.2 TRANSPORTING AND PLACING

### 3.2.1 Transporting

Methods and equipment for conveying and depositing the concrete into the form shall be subject to approval. The capacity of the transporting system shall be sufficient to supply concrete at a rate to prevent cold joints forming during placement. A properly designed and sized elephant trunk and rigid drop chute bottom section which will prevent free-fall within the elephant trunk and rigid drop chute will be used if concrete is to drop more than 1.5 m 5 feet. If concrete is to be placed through installed horizontal or sloping reinforcing bars, the concrete shall discharge into a pipe or elephant trunk that is long enough to extend through the reinforcing bars to within 1.5 m 5 feet of the placing surface. In no case will concrete be discharged to free fall through the reinforcing bars.

#### 3.2.1.1 Transporting by Bucket

Provide indicating and signaling devices to control the identification of types or classes of concrete as they are mixed and discharged into buckets for transfer to the forms. Each type or class of concrete shall be visually identified by placing a colored tag or marker on a bucket as it leaves the mixing plant so that the concrete may be positively identified in the forms and placed in the structure in the desired position.

#### 3.2.1.2 Transporting by Pump

The nominal maximum-size coarse aggregate will not be reduced or mixture proportions changed to accommodate a pump except as specifically determined appropriate. The distance and height to be pumped shall not exceed limits recommended by the pump manufacturer. The concrete shall be supplied to the pump continuously. When pumping is completed, concrete remaining in the pipeline shall be ejected without contamination of concrete in place. After each operation the equipment shall be thoroughly cleaned and flushing water shall be wasted outside the forms.

#### 3.2.1.3 Transporting by Belt Conveyor

Methods and equipment for transporting the concrete by belt conveyor into the form are subject to approval.

### 3.2.2 Placing

The capacity of the placing system shall be sufficient to supply concrete at a rate which will prevent cold joints in any placement. Concrete shall be worked into the corners and angles of the forms and around all reinforcement and embedded items without permitting the material to segregate. Concrete shall be deposited as close as possible to its final position in the forms, and in so depositing, there shall be no vertical drop greater than 1.5 m 5 feet except where suitable equipment is provided to prevent segregation and where specifically authorized. Depositing of the concrete shall be so regulated that it will be effectively placed and consolidated in horizontal layers not exceeding 1.5 m 5 feet in thickness with a minimum of lateral movement. The amount of concrete deposited shall be such that it can be readily and thoroughly consolidated and shall not exceed 3 cubic meters 4 cubic yards in one pile. All concrete-placing equipment and methods shall be subject to approval. Concrete placement will not be permitted when, in the opinion of the Contracting Officer,

weather conditions prevent proper placement and consolidation.

3.2.2.1 Time Interval Between Mixing and Placing

Concrete mixed in stationary mixers and transported by nonagitating equipment shall be placed within 30 minutes after it has been mixed, unless otherwise authorized. When concrete is truck mixed or when a truck mixer or agitator is used for transporting concrete mixed by stationary mixers, the concrete shall be delivered to the site of the work, and discharge shall be completed within 1 hour after introduction of the cement to either the water or aggregate.

3.2.2.2 Hot-Weather Placing

**********
**NOTE: See EM 1110-2-2000 for the proper placing temperature.**
**********

The temperature of the concrete when deposited in the forms during hot weather shall not exceed [_____] degrees C F except as further required above. An approved retarding admixture may be used in accordance with paragraph MATERIAL SPECIFICATION to facilitate placing and finishing. Steel forms and reinforcement and conveying and placing equipment shall be cooled if necessary to assist in maintaining specified concrete-placing temperature. The temperature of the fresh concrete shall be measured in accordance with ASTM C1064/C1064M. Submit a description of the materials and methods proposed for protection of the concrete 60 days in advance of anticipated need date for review, when concrete is to be placed under hot-weather conditions.

3.2.2.3 Cold Weather Placing

The temperature of the concrete when deposited in the forms shall not be less than 5 degrees C 40 degrees F. The ambient temperature of the placement area and all surfaces to receive concrete shall be above 0 degrees C 32 degrees F. Materials entering the mixer shall be free from ice, snow, and frozen lumps. The heating of mixing water or aggregates necessary to keep the concrete temperature above 5 degrees C 40 degrees F shall be closely regulated so that the concrete temperature does not exceed 15 degrees C 60 degrees F. An accelerator may be used when approved in advance.

[3.2.2.4 Special Temperature-Controlled Concrete

**********
**NOTE: See the appropriate concrete materials design memorandum or thermal study to fill in blanks**
**********

Special temperature control is applicable to concrete in the following structures: [_____]; [_____]; [_____]. Regardless of requirements specified above, the concrete shall have a temperature of not more than [_____] degrees C F and not less than 5 degrees C 40 degrees F when measured at least 20 minutes after mixing. Heating of the mixing water or aggregates will not be permitted until the temperature of the concrete has decreased to 7 degrees C 45 degrees F. The materials shall be heated in such a manner that they will be free from ice, snow, and frozen lumps before entering the mixer. Submit methods and equipment for review and

comment 60 days in advance of anticipated date required for use, when special temperature controls are required.

]3.2.2.5 Concrete Lifts

**********
**NOTE: The required construction joints should be shown in the drawings.**
**********

The depth of concrete placed in each lift will be as shown in the drawings. All concrete shall be deposited in approximately horizontal layers about 0.5 m 1-1/2 feet in thickness in stepped progression at such a rate that the formation of cold joints will be prevented. Slabs shall be placed in one lift, unless 0.8 m 2.5 foot or more deep. Where 2.3 m 7.5 foot or greater lift depths are permitted, furnish approved cantilever forms that are jointed or hinged approximately midheight to facilitate placement against surfaces sloping more than 10 degrees from vertical. At the beginning of the placing of a lift, the top half of a hinged or jointed form shall be retracted to such a position that it does not interfere with the operation of buckets placing concrete adjacent to the form. A minimum of five successive horizontal layers in stepped progression shall be used for 2.3 m 7.5 foot lifts. Where 1.5 m 5 foot lifts are required, a minimum of three successive horizontal layers in stepped progression shall be used. Each new layer of concrete shall be placed on the oldest exposed layer. The maximum exposed bulkhead face of concrete between adjacent monoliths shall not exceed 12 m 40 feet except as otherwise approved. Submit a lift drawing and bill of materials for each lift of concrete. (Only one lift shall be shown on a drawing). These drawings shall be to scale and shall show all embedded items in sufficient detail for the proper installation and prosecution of the work. All embedded electrical and/or mechanical items shall be identified. The drawings shall not be less than 594 by 841 mm 22 by 34 inches in size and the scale used shall be sufficiently large to clearly show all details of the structure covered by these drawings. A note shall be included on each lift drawing indicating all contract drawings from which the lift drawing was prepared. Submit [_____] copies of each drawing for review at least 60 days prior to scheduling the lift for placement.

3.2.2.6 Consolidation

Immediately after placing, each layer of concrete shall be consolidated by internal vibrating equipment. Vibrators shall not be used to cause concrete to flow for significant distances within the forms. Hand spading may be used if necessary together with internal vibration along formed surfaces permanently exposed to view. Form vibrators shall not be used unless forms are specifically designed for this use and unless specifically approved. The vibrator shall be inserted vertically at uniform spacing over the entire area of placement. The distance between insertions shall be approximately 1.5 times the radius of action of the vibrator. The vibrator shall penetrate rapidly to the bottom of the layer and at least 150 mm 6 inches into the preceding unhardened layer if such exists. It shall be held stationary until the concrete is consolidated and then withdrawn slowly. Slabs 200 mm 8 inches or less in depth shall be consolidated by approved methods.

[3.2.2.7 Placing Concrete in Unformed Curved Sections

The unformed portion of the ogee crest, spillway bucket, and similar features shall be finished by placing concrete slightly above grade, consolidating and striking off to grade by accurate screeding. Screeding may be accomplished by semimechanical devices or by a mechanical screed that consolidates and screeds the surface in one operation. Ribs embedded in the fresh concrete as guides for screeds will not be permitted.

][3.2.2.8 Placing Concrete Underwater

Concrete, described in Bid Item [_____], shall be deposited through water by a tremie or concrete pump. The methods and equipment used shall be submitted in advance of placement for review. Concrete buckets may be used only to charge the hopper on top of the tremie. Concrete buckets shall not be lowered under water and the concrete discharged subaqueously. The tremie shall be watertight and sufficiently large to permit a free flow of concrete. The discharge end of the pump line or tremie pipe shall be kept submerged continuously in the concrete after placement starts. The underwater seal shall be effected in a manner that will not produce undue contamination of the concrete or turbulence in the water. Placement shall proceed without interruption until the concrete has been brought to the required height. The tremie or pump lines shall not be moved horizontally during a placing operation, unless removed, moved, and properly restarted, and a sufficient number of tremies or pump lines shall be provided so that the maximum horizontal flow will be limited to 4.5 m 15 feet.

]3.3 FINISHING

3.3.1 Unformed Surfaces

The ambient temperature of spaces adjacent to surfaces being finished shall be not less than 5 degrees C 40 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 1.0 kg/square meter 0.2 psf per hour, provisions for windbreaks, shading, fog spraying, or evaporation retarding film shall be made in advance of placement to prevent plastic shrinkage cracks, and such protective measures shall be taken before, during, and immediately after finishing as operations require. All unformed surfaces of concrete that are not to be covered by additional concrete or backfill shall have a float finish, unless a trowel finish is specified, and shall be true to elevation as shown on the drawings. Surfaces to receive additional concrete or backfill shall be brought to the elevation shown and left true and regular. Exterior surfaces shall be sloped for drainage unless otherwise shown in the drawing or directed. Joints shall be carefully made with a jointing or edging tool. The finished surfaces shall be protected from stains or abrasions. The concrete shall be thoroughly consolidated before finishing operations commence or before leaving it for future concrete or backfill placement.

3.3.1.1 Float Finish

Surfaces to receive a float finish shall be screeded and darbied or bullfloated to bring the surface to the required finish level with no coarse aggregate visible. No water, cement, or mortar shall be added to the surface during the finishing operation. Floating may be performed by use of suitable hand floats or power-driven equipment. Hand floats shall

be of aluminum or magnesium. After the water sheen has disappeared, the concrete, while still green but sufficiently hardened to bear a man's weight without deep imprint, shall be floated to a true even plane.

3.3.1.2 Trowel Finish

**********

**NOTE: Refer to the appropriate design memorandum for surfaces to be trowel finished. Be sure these are shown in the drawings.**

**********

A trowel finish shall be applied to the following surfaces [_____]; [_____]; [_____]. Concrete surfaces shall first be given a float finish. After surface moisture has disappeared, the surface shall be troweled to a smooth, even, dense finish, free from blemishes, including trowel marks. In lieu of hand finishing, an approved power finishing machine may be used in accordance with the directions of the machine manufacturer. A final hard steel troweling shall be done by hand. Joints shall be carefully made with a jointing or edging tool. The finished surfaces shall be protected from stains or abrasions. Surfaces or edges likely to be injured during the construction period shall be protected from damage.

[3.3.1.3 Broom Finish

**********

**NOTE: Refer to the appropriate design memorandum for surfaces to be broom finished. Be sure these are shown in the drawings.**

**********

A broom finish shall be applied to the following surfaces: [_____]; [_____]; [_____]. The concrete surface to be broom finished shall first be given a float finish. The surface shall then be broomed with a [stiff fiber-bristle broom] [hair broom in a direction transverse to that of the traffic].

][3.3.1.4 Abrasive Aggregate Finish

**********

**NOTE: Refer to the appropriate design memorandum for surfaces to receive the abrasive aggregate finish. Be sure this is shown in the drawings.**

**********

An abrasive aggregate finish shall be applied to the following surfaces: [_____]; [_____]; [_____]. The concrete surface shall first be given a float finish. Abrasive aggregate shall be uniformly sprinkled over the surface immediately after floating, at a rate of not less than 1.22 kg/square meter 1/4 psf. The surface shall be refloated and then be troweled to a smooth even finish that is uniform in texture and appearance including trowel marks. Immediately after curing, cement coating or laitance covering the abrasive aggregate shall be removed by wire brushing, rubbing with abrasive stone, or sandblasting to expose the abrasive particles.

][3.3.1.5 High Velocity Finishes

**********

**NOTE: Refer to the appropriate design memorandum for surfaces to receive high velocity finishes. Be sure these are shown in the drawings.**
**********

Unformed surfaces subjected to high velocity flow (12 m/s) (40 fps) shall receive a trowel finish.

]3.3.2 Formed Surface Repair

**********
**NOTE: Refer to EM 1110-2-2000 for direction on class of finish. Please note that definitions for class of finish have been changed recently. Class of finish shall also be shown in the drawings. Paragraph CONSTRUCTION TOLERANCES, in PART 1, presents surface tolerances. Section 03 30 00 CAST-IN-PLACE CONCRETE presents materials for each class.**
**********

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

3.3.2.1 Classes A, A-HV, & B Finishes

Surfaces listed in Section 03 30 00 CAST-IN-PLACE CONCRETE, paragraph [_____], and as shown in the drawings to have classes A, A-HV, and B finishes, shall have surface defects repaired as follows: defective areas, voids, and honeycombs smaller than 10 000 square mm 16 square inches in area and less than 13 mm 1/2 inches deep; bug holes exceeding 13 mm 1/2 inch in diameter shall be chipped and filled with dry-packed mortar; holes left by removal of tie rods shall be reamed and filled with the below specified material; defective and unsound concrete areas larger than described shall be defined by 13 mm 1/2 inch deep dovetailed saw cuts in a rectangular pattern with lines parallel to the formwork, the defective concrete removed by chipping and the void repaired with replacement concrete. The prepared area shall be brush-coated with an epoxy resin meeting the requirements of ASTM C881/C881M, Type V; a latex bonding agent meeting the requirements of ASTM C1059/C1059M, Type II; or a neat cement grout after dampening the area with water. The void shall be filled with replacement concrete in accordance with the paragraph MATERIAL AND PROCEDURE FOR REPAIRS below.

3.3.2.2 Class C Finish

Surfaces listed in Section 03 30 00 CAST-IN-PLACE CONCRETE, paragraph [_____], and as shown in the drawings, shall have defects repaired as follows: defective areas, voids, and honeycombs smaller than 15 000 square mm 24 square inches and less than 50 mm 2 inches deep; bug holes exceeding 38 mm 1-1/2 inches in diameter shall be chipped and filled with dry-packed mortar; and holes left by removal of the tie rods shall be reamed and filled with dry-packed mortar. Defective and unsound concrete areas larger than 15,000 square mm 24 square inches and deeper than 38 mm 1-1/2 inches shall be defined by 13 mm 1/2 inch deep dovetailed saw cuts in a rectangular pattern, the defective concrete removed by chipping, and the void repaired with replacement concrete. The prepared area shall be brush-coated with an epoxy resin meeting the requirements of

ASTM C881/C881M, Type V; a latex bonding agent meeting the requirements of ASTM C1059/C1059M, Type II; or a neat cement grout after dampening the area with water. The void shall be filled with replacement concrete in accordance with the paragraph below.

3.3.2.3 Class D Finish

Surfaces listed in Section 03 30 00 CAST-IN-PLACE CONCRETE, paragraph [_____], and as shown in the drawings to have class D finish, shall have surface defects repaired as follows: defective areas, voids, and honeycombs greater than 30,000 square mm 48 square inches in area or more than 50 mm 2 inches deep shall be defined by 13 mm 1/2 inch deep dovetailed saw cuts in a rectangular pattern, the defective concrete removed by chipping and the void repaired with replacement concrete. The prepared area shall be brush-coated with an epoxy resin meeting the requirements of ASTM C881/C881M, Type V; a latex bonding agent meeting the requirements of ASTM C1059/C1059M, Type II; or a neat cement grout after dampening the area with water. The void shall be filled with replacement concrete in accordance with the following paragraph.

3.3.2.4 Material and Procedure for Repairs

The cement used in the dry-packed mortar or replacement concrete shall be a blend of the cement used for production of project concrete and white portland cement properly proportioned so that the final color of the mortar or concrete will match adjacent concrete. Trial batches shall be used to determine the proportions required to match colors. Dry-packed mortar shall consist of one part cement to two and one-half parts fine aggregate. The fine aggregate shall be that used for production of project concrete. The mortar shall be remixed over a period of at least 30 minutes without addition of water until it obtains the stiffest consistency that will permit placing. Mortar shall be thoroughly compacted into the prepared void by tamping, rodding, ramming, etc. and struck off to match adjacent concrete. Replacement concrete shall be produced using project materials and shall be proportioned by the Contracting Officer. It shall be thoroughly compacted into the prepared void by internal vibration, tamping, rodding, ramming, etc. and shall be struck off and finished to match adjacent concrete. Forms shall be used to confine the concrete. If an expanding agent is used in the repair concrete, the repair shall be thoroughly confined on all sides including the top surface. Metal tools shall not be used to finish permanently exposed surfaces. The repaired areas shall be cured for 7 days. The temperature of the in situ concrete, adjacent air, and replacement mortar or concrete shall be above 5 degrees C 40 degrees F during placement, finishing, and curing. Packaged materials meeting the requirements of ASTM C928/C928M may be used in lieu of dry-packed mortar when approved. Other methods and materials for repair may be used only when approved in writing. Repairs of the so called "plaster-type" will not be permitted.

3.3.3 Grout-Cleaned Finish

**********

**NOTE: See the appropriate design memorandum and EM 1110-2-2000 for surfaces to receive a grout cleaned finish. Be sure this is shown in the drawings.**

**********

The surfaces of [_____] shall be given a grout-cleaned finish as hereinafter described, as approved by the Contracting Officer and after

all required curing, cleaning, and repairs have been completed. Surfaces to be grout-cleaned shall be moist cured for the required period of time before application of the grout-cleaned finish. Grout-cleaning shall be delayed until near the end of construction on all surfaces not to be painted to achieve uniformity of appearance and reduce the chance of discoloring caused by subsequent construction operations. The temperature of the air adjacent to the surface shall be not less than 5 degrees C 40 degrees F for 24 hours prior to and 72 hours following the application of the finish. The finish for any area shall be completed in the same day, and the limits of a finished area shall be made at natural breaks in the finished surface. The surface to receive grout-cleaned finish shall be thoroughly wetted to prevent absorption of water from the grout but shall have no free water present. The surface shall then be coated with grout. The grout shall be applied as soon as the surface of the concrete approaches surface dryness and shall be vigorously and thoroughly rubbed over the area with clean burlap pads, cork floats, or stones to fill all voids. The grout shall be composed of one part portland cement as used on the project, to two parts by volume of well-graded sand passing a 600-µm (No. 30) sieve mixed with water to the consistency of thick paint. White cement shall be used for all or part of the cement as approved to give the desired finish color. The applied coating shall be uniform, completely filling all pits, air bubbles, and surface voids. While the grout is still plastic, remove all excess grout by working the surface with a rubber float, burlap pad, or other means. Then, after the surface whitens from drying (about 30 minutes at normal temperature), rub vigorously with clean burlap pads. Immediately after rubbing is completed the finished surface shall be continuously moist cured for 72 hours. Burlap pads used for this operation shall be burlap stretched tightly around a board to prevent dishing the mortar in the voids.

## 3.4 CURING AND PROTECTION

Submit the curing media and methods to be used for review 30 days before concrete placement begins.

### 3.4.1 Curing Time

**********

**NOTE: Curing time may be extended if required by the thermal study. See the concrete materials design memorandum for the approved types of cementitious materials.**

**********

All concrete shall be cured by one of the following methods or combination of methods for the period of time given below corresponding to the cementing materials used in the concrete:

| | |
|---|---|
| Type III portland cement | 3 days |
| Type I portland cement | 7 days |
| Portland cement in combination with silica fume | 7 days |
| Type II portland cement | 14 days |

| | |
|---|---|
| Type III portland cement | 3 days |
| Portland cement blended with 25 percent or less fly-ash or GGBF slag | 14 days |
| Portland cement blended with more than 25 percent fly-ash or GGBF slag | 21 days |

Curing shall begin immediately after placing. Provide all equipment needed for curing and protection of the concrete on hand and ready to install before actual concrete placement begins. The curing medium and method, or the combination of media and methods used, shall be as approved in accordance with paragraph SUBMITTALS, SD-03 Product Data, submittal item "Curing".

3.4.2 Moist Curing

**********

**NOTE: This requirement is for hot weather curing only and has to be used under certain conditions only. Thermal cracking can occur when the difference in temperature between the interior concrete is more than 11 degrees C 20 degrees F higher than the surface temperature of a concrete placement. Tepid water is water at a temperature no more than 11 degrees C 20 degrees F cooler than the surface of the concrete placement. For massive placements, thermal insulation should be provided to reduce the temperature gradient between the interior and exterior of the placement.**

**********

[Concrete containing silica fume shall be moist cured.] Horizontal and nearly horizontal surfaces shall be moist cured by ponding, by covering with a minimum uniform thickness of 50 mm 2 inches of continuously saturated sand, or by covering with saturated nonstaining burlap or cotton mats. Burlap and cotton mats shall be rinsed to remove soluble substances before using. Other surfaces shall be moist cured when approved or directed. Concrete that is moist cured shall be maintained continuously, not periodically, wet for the duration of the entire curing period. Water for curing shall comply with the requirements of the paragraph WATER in PART 2. If the water, sand, mats, etc. cause staining or discoloration of permanently exposed concrete surfaces, the surfaces shall be cleaned by a method approved. When wood forms are left in place during curing, the forms shall be kept continuously wet except for sealed insulation curing in cold weather. When steel forms are left in place on vertical surfaces during curing of concrete, [when using high-strength concrete] [when concrete being cured has a water-cement ratio less than 0.40] [placements with a minimum dimension greater than 600 mm 2 feet] the forms shall be carefully broken loose from the hardened concrete and curing water continuously introduced into the void. The temperature of the water should be tepid. Horizontal construction joints shall be allowed to dry sufficiently to remove free water immediately prior to placing the next lift.

### 3.4.3 Membrane Curing

Membrane curing may be used on surfaces that are not specified or directed to receive moist curing and that are not to receive a grout-cleaned finish. Membrane-forming curing compound shall not be used on surfaces that contain protruding steel reinforcing, that are heated by free steam, that will have additional concrete bonded to them, or that are to be grout-cleaned.

#### 3.4.3.1 Pigmented Curing Compound

Pigmented compound conforming to ASTM C309, Type 2, Class A, may be used on surfaces that will not be exposed to view when the project is completed. Only pigmented compound of the styrene acrylate or chlorinated rubber formulation conforming to ASTM C309, Class B, requirements may be used on surfaces that are to be painted or to receive bituminous roofing or water proofing or floors that are to receive adhesive applications of resilient flooring. The curing compound selected by the Contractor for such use shall be compatible with any subsequent paint, roofing, coating, or flooring specified elsewhere in the contract.

#### 3.4.3.2 Nonpigmented Curing Compound

**********
**NOTE: See the concrete materials design memorandum for guidance on the optional sentence.**
**********

Nonpigmented compound conforming to ASTM C309, Type ID, containing a fugitive dye may be used on surfaces that will be exposed to view when the project is completed. The reflective requirements of ASTM C309 are waived. [Surfaces cured with nonpigmented compound shall be shielded from direct rays of the sun for 3 days.]

#### 3.4.3.3 Application

The curing compound shall be applied to formed surfaces immediately after the forms are removed. The surfaces shall be thoroughly moistened with water, and the curing compound applied as soon as free water disappears. The curing compound shall be applied to unformed surfaces as soon as free water has disappeared provided steps have been taken when necessary to prevent premature loss of free water due to excessive evaporation as described in paragraph UNFORMED SURFACES above. The curing compound shall be applied in a two-coat continuous operation by motorized power-spraying equipment or pressure-tank equipment operating at a minimum pressure of 520 kPa 75 psi with provisions for continuous agitation. The application equipment shall be approved in advance. Hand-operated pressure applicators ("garden sprayers") shall not be used except in small, isolated areas as approved. The compound shall be applied at a uniform coverage of not more than 10 square meters/L 400 square feet/gallon for each coat. The second coat shall be applied perpendicular to the first coat. Concrete surfaces that have been subjected to rainfall within 3 hours after the curing compound has been applied shall be resprayed by the method and at the coverage specified. All concrete surfaces on which the curing compound has been applied shall be protected for the duration of the entire curing period from pedestrian and vehicular traffic and from any other influence that will disrupt the continuity of the curing membrane.

[3.4.4 Sheet Curing

**********
**NOTE: The only concrete that may be cured using sheet should be horizontal or nearly horizontal finished surfaces such as roof slabs, uncolored floors or the first course of two-course floors, or floors that are to be covered with tile or resilient flooring.**
**********

The following concrete surfaces may be cured using sheets: [_____]; [_____]; [_____]. Sheets shall be used only on horizontal or near horizontal surfaces. The sheets shall comply with the requirements of ASTM C171, except that polyethylene sheet shall not be used. All surfaces shall be thoroughly wetted and completely covered with waterproof paper, or polyethylene-coated burlap. Covering shall be laid with light-colored side up. Covering shall be lapped not less than 100 mm 4 inches and taped to form a continuous cover with completely closed joints. The sheet shall be weighted to prevent displacement so that it remains in contact with the concrete during the specified length of curing. Coverings shall be folded down over exposed edges of slabs and secured by approved means. Sheets shall be immediately repaired or replaced if tears or holes appear during the curing period.

]3.4.5 Sealed Insulation Curing

Between dates listed in paragraph COLD WEATHER PROTECTION below where cold weather protection is provided entirely by insulation, all joints in the insulation shall be sealed to retard moisture loss and maintain a seal throughout the curing period.

3.4.6 Protection

**********
**NOTE: Add more sophisticated requirements for vibration control where appropriate.**
**********

No fire or excessive heat shall be permitted near or in direct contact with concrete at any time. No vibratory earth compaction equipment or pile-driving equipment shall be operated within 30 m 100 feet horizontally of concrete less than 5 days old. Blasting shall not be permitted within 30 m 100 feet horizontally of concrete less than 90 days old. Blasting plans shall be approved by the Contracting Officer. All galleries, conduits, and other openings through the concrete shall be kept closed or sealed during the entire construction period. The surface of the concrete shall be protected from rain or snow during placing.

3.4.7 Cold Weather-Protection

**********
**NOTE: The editor must insert the insulating value and the calendar dates in the appropriate blanks. The values will be taken from the thermal study that was performed during design of the structure. The paragraph may be revised or expanded to provide varying insulating values and dates for various concrete features of the project in accordance with**

**the thermal study.**
**********

Between [_____] of each year and [_____] of the following year, all concrete [less than 30 days old] [immediately after placing] shall be covered for a period of [_____] days with insulation that provides an R value not less than [_____] square meter degree Celsius per watt hour square foot degree Fahrenheit per BTU. Submit a description of the materials and methods proposed for protection of the concrete, 60 days in advance of anticipated need date for review, when concrete is to be placed under cold-weather conditions.

a. The insulation shall be maintained in such a condition that the R value does not diminish during the period of protection. Edges and corners of the placement shall be protected with a double layer of the insulation specified above for a minimum distance of 0.6 m 2 feet in all directions.

b. Concrete placed prior to the starting date shall be insulated from the starting date until it reaches an age of [_____] days. Concrete placed after the starting date shall be continuously insulated during and subsequent to placement [until it reaches an age of [_____] days or] until the end of the protection period [, whichever comes first].

c. Forms shall be insulated in such a manner that the combined form-insulation system shall have a thermal resistance (R value) not less than that specified. Insulation and the combined form-insulation system shall remain in place for at least 5 days after placement of the concrete. After 5 days, forms and insulation on vertical surfaces may be removed for periods not to exceed 4 hours in a 24 hour period to allow forms to be moved, and insulation on horizontal surfaces may be removed for periods not to exceed 8 hours in a 24 hour period to allow reinforcement to be installed, insulation to be installed, lift joints to be prepared, etc. provided that suitable precautions are taken to prevent the concrete from being subjected at any time to ambient temperatures of minus 7 degrees C 20 degrees F or below.

d. The first 1.8 m 6 feet of all steel protruding from insulated concrete shall be insulated with material having an R value as stated. All form bolts and metal ribs on the forms shall be insulated in a like manner. During the period of protection there shall be no holes or openings in the insulation or between the insulation and concrete which permit ambient air to penetrate the insulation except as noted for construction purposes. Special attention shall be given to seams, corners, and edges to prevent holes or openings in the insulation.

## 3.5 BASE PLATES AND BEARING PLATES

### 3.5.1 Setting of Plates

After being plumbed and properly positioned, column base plates, bearing plates for beams and similar structural members, and machinery and equipment base plates shall be provided full bearing using nonshrink grout. The space between the top of the concrete bearing surface and the bottom of the plate shall not be less than 1/24 of the width of the plate or 13 mm 1/2 inch, whichever is greater. Concrete surfaces shall be clean, free of oil, grease, and laitance, and shall be damp. Metal surfaces shall be clean and free of oil, grease, and rust.

### 3.5.2 Nonshrink Grout

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

#### 3.5.2.1 Mixing and Placing

Mixing and placing shall be in conformance with the material manufacturer's instructions and as specified. Ingredients shall be thoroughly dry-mixed before adding water. After adding water, the batch shall be mixed for 3 minutes. Batches shall be sized to allow continuous placement of freshly mixed grout. Grout not used within 30 minutes after mixing shall be discarded. The space between the top of the concrete or masonry bearing surface and the plate shall be filled with the grout. Forms shall be of wood or other suitable material for retaining the grout and shall be removed after the grout has hardened. If Grade "A" grout is used, all surfaces, including top surfaces, shall be formed to provide restraint. The placed grout shall be worked to eliminate voids; however, overworking and breakdown of the initial set shall be avoided. Grout shall not be retempered or subjected to vibration from any source. Where clearances are unusually small, placement shall be made under pressure with a grout pump. Temperature of the grout, and of surfaces receiving the grout, shall be maintained at 20 to 30 degrees C 65 to 85 degrees F until after setting.

#### 3.5.2.2 Treatment of Exposed Surfaces

Those types of grout containing metallic aggregate, Grade B or C grout, shall, after setting, have exposed surfaces under cut back 1 inch from the edge of the base plate and immediately covered with a thick coat of mortar proportioned by weight of one part portland cement, two parts sand, and sufficient water to make the mixture placeable. The parge coat shall have a smooth, dense finish. The exposed surface of other types of nonshrink grout shall have a smooth, dense finish.

#### 3.5.2.3 Curing

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

## [3.6 BLOCK-OUT CONCRETE

### [3.6.1 Composition and Proportions

Block-out concrete shall be composed of portland cement, water, fine and coarse aggregate, and admixtures. The concrete mixture proportions, including admixture, will be provided by the Contracting Officer. An expansive admixture shall be used to cause the blockout concrete to expand to fit snugly in the space that confines it. The expansive admixture shall conform to the requirements of ASTM C937 for grout fluidifier. Any block-out concrete not placed within 30 minutes after contact of the cement and admixture shall be wasted. The block-out shall be confined on all sides to provide restraint.

### ][3.6.2 Placing Block-out Concrete

Blockouts shall be provided as shown on the plans for the embedment of

gate seal seats, gate guides, bulkhead guides, beams embedded for bulkhead seals, crane rails, and other embedded metalwork as appropriate. Prior to installation of embedded items, the block-outs or recesses shall be cleaned in accordance with applicable requirements of the paragraph on construction joint treatment. After installation of embedded items and prior to placing any forms, all surfaces of the block-outs or recesses and surfaces of items to be embedded shall be thoroughly cleaned of all loose material, oil, grease, and other contaminants which might reduce the bond between the surfaces of the blockouts or recesses and new concrete. Extreme caution shall be exercised in placing block-out concrete to avoid distortion or displacement of the embedded items.

]]3.7 TESTS AND INSPECTIONS

3.7.1 General

Perform the following inspection and tests as described, 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, concrete placement shall cease. The laboratory performing the tests shall be onsite and shall conform with the requirements given in ASTM C1077. The individuals who sample and test concrete or the constituents of concrete as required in this specification shall have demonstrated a knowledge and ability to perform the necessary test procedures equivalent to the ACI minimum guidelines for certification of Concrete Field Testing Technicians, Grade I. The 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. The individual who performs the inspection shall have demonstrated a knowledge and ability equivalent to the ACI minimum guidelines for certification of [Concrete Transportation Construction Inspector (CTCI)] [Concrete Construction Inspector (CCI)].

3.7.2 Testing and Inspection Requirements

3.7.2.1 Fine Aggregate

**********
**NOTE: If the optional requirement to limit the amount of material passing the 75 µm No. 200 sieve was invoked in paragraph AGGREGATES in PART 2, the requirement to perform ASTM C117 must be invoked in subparagraph a.**
**********

3.7.2.1.1 Grading

At least once during each shift when the concrete plant is operating, there shall be one sieve analysis and fineness modulus determination in accordance with ASTM 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. The results shall be recorded on a sheet on which are also shown the specification limits applicable to the project.

3.7.2.1.2 Fineness Modulus Control Chart

Results for fineness modulus shall be grouped in sets of three consecutive tests, and the average and range of each group shall be plotted on a control chart. The upper and lower control limits for average shall be drawn 0.10 units above and below the target fineness modulus, and the upper control limit for range shall be 0.20 units above the target fineness modulus.

3.7.2.1.3 Corrective Action for Fine Aggregate Grading

When the amount passing any sieve is outside the specification limits, the fine aggregate shall be immediately resampled and retested. If there is another failure for any sieve, the fact shall immediately be reported. Whenever a point on the fineness modulus control chart, either for average or range, is beyond one of the control limits, the frequency of testing shall be doubled. If two consecutive points are beyond the control limits, the process shall be considered out of control and concreting shall be stopped. 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.

3.7.2.1.4 Moisture Content Testing

When in the opinion of the Contracting Officer the electric moisture meter is not operating satisfactorily, there shall be at least four tests for moisture content in accordance with ASTM C566 during each 8-hour period of mixing plant operation. The times for the tests shall be selected randomly within the 8-hour period. An additional test shall be made whenever the slump is shown to be out of control or excessive variation in workability is reported by the placing foreman. When an electric moisture meter is operating satisfactorily, at least two direct measurements of moisture content shall be made per week to check the calibration of the meter. The results of tests for moisture content shall be used to adjust the added water in the control of the batch plant.

3.7.2.1.5 Moisture Content Corrective Action

Whenever the moisture content of the fine aggregate changes by 0.5 percent or more, the scale settings for the fine-aggregate batcher and water batcher shall be adjusted (directly or by means of a moisture compensation device).

3.7.2.2 Coarse Aggregate

3.7.2.2.1 Grading

At least once during each shift in which the concrete plant is operating, there shall be 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. However, the Contractor is responsible for delivering the aggregate to the mixer within specification limits. A test record of samples of aggregate taken at the same locations shall show the results of the current test as well as the average results of the five most recent tests including the current test. The Contractor may adopt limits for control 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 shall be done.

3.7.2.2.2 Corrective Action for Grading

When the amount passing any sieve is outside the specification limits, the coarse aggregate shall be immediately resampled and retested. If the second sample fails on any sieve, that fact shall be reported. Where two consecutive averages of five tests (or two consecutive tests where large samples are used) are outside specification limits, the operation shall be considered out of control, and that fact shall be reported, concreting shall be stopped, and immediate steps shall be taken to correct the grading.

3.7.2.2.3 Coarse Aggregate Moisture Content

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

3.7.2.2.4 Coarse Aggregate Moisture Corrective Action

Whenever the moisture content of any size of coarse aggregate changes by 0.5 percent or more, the scale setting for the coarse aggregate batcher and the water batcher shall be adjusted to compensate for this.

3.7.2.2.5 Particle Shape Testing

When directed, a problem exists in connection with aggregate particle shape, tests shall be made in accordance with ASTM D4791. Testing frequency shall be not less than one per day, when directed.

3.7.2.2.6 Particle Shape Corrective Action

When testing for particle shape is required, two consecutive failures in the same sieve size shall be immediately reported, who shall determine what corrective action is needed.

3.7.2.2.7 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 aggregate, tests shall be made in accordance with ASTM C117. Testing frequency shall be as directed.

3.7.2.2.8 Corrective Action for Material Finer than the 75-µm No. 200 Sieve

When material finer than the 75-µm No. 200 sieve exceeds 1.0 percent of the weight of the aggregate finer than 37.5 mm 1-1/2 inches or 0.5 percent of the weight of the aggregate coarser than 37.5 mm 1-1/2 inches, the Contracting Officer shall be notified and steps, such as washing or other corrective action, shall be initiated immediately.

3.7.2.3 Quality of Aggregates

**********

**NOTES: Tests should be those listed in paragraph MATERIAL SPECIFICATION.**

**The petrographic examination shall be used to**

**identify deleterious substances in aggregates. Deleterious substances shall be listed individually with respective limits.**
**********

3.7.2.3.1 Frequency of Quality Tests

Prior to submitting samples for mixture proportioning studies and 30 days prior to the start of concrete placement, perform the tests for aggregate quality in the following list. In addition, after the start of concrete placement, perform tests for aggregate quality in accordance with the following frequency schedule. Samples tested after the start of concrete placement shall be taken immediately prior to entering the concrete mixer.

| PROPERTY | FINE AGGREGATE | FREQUENCY COARSE AGGREGATE | TEST |
|---|---|---|---|
| Specific Gravity | Every 3 months | Every 3 months | ASTM C127<br>ASTM C128 |
| Absorption | Every 3 months | Every 3 months | ASTM C127<br>ASTM C128 |
| Durability (Procedure A) | Factor using Every 12 months | Every 12 months | COE CRD-C 144<br>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 | Every 3 months | Every 3 months | ASTM C117 |
| Organic Impurities | Every 3 months | Not applicable | ASTM C40/C40M |
| L.A. Abrasion | Not applicable | Every 6 months | ASTM C131/C131M<br>ASTM C535 |
| Soft and Friable (Scratch Hardness) | Not applicable | Every 6 months | COE CRD-C 130 |
| Petrographic Examination | Every 6 months | Every 6 months | ASTM C295/C295M |
| 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 |

3.7.2.3.2 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, production procedures or

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

3.7.2.4 Scales

3.7.2.4.1 Weighing Accuracy

The accuracy of the scales shall be checked by test weights at least once a month for conformance with the applicable requirements of paragraph PLANT AND EQUIPMENT. Such tests shall also be made as directed whenever there are variations in properties of the fresh concrete that could result from batching errors.

3.7.2.4.2 Batching and Recording Accuracy

Once a week the accuracy of each batching and recording device shall be checked during a weighing operation by noting and recording the required weight, recorded weight, and the actual weight batched. Confirm that the calibration devices described in paragraph PLANT AND EQUIPMENT in PART 2, for checking the accuracy of dispensed admixtures, are operating properly.

3.7.2.4.3 Scales Corrective Action

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

3.7.2.5 Batch-Plant Control

The measurement of all constituent materials including cementitious materials, each size of aggregate, water, and admixtures shall be continuously controlled. The aggregate weights and amount of added water shall be adjusted as necessary to compensate for free moisture in the aggregates. The amount of air-entraining agent shall be adjusted to control air content within specified limits. A report shall be prepared indicating type and source of cement used, type and source of pozzolan or slag used, amount and source of admixtures used, aggregate source, the required aggregate and water weights per cubic meter yard, amount of water as free moisture in each size of aggregate, and the batch aggregate and water weights per cubic meter yard for each class of concrete batched during plant operation.

3.7.2.6 Concrete

3.7.2.6.1 Air Content

At least two tests for air content shall be made on randomly selected batches of each concrete mixture produced during each 8 hour period of concrete production. Additional tests shall be made when excessive variation in workability is reported. Tests shall be made in accordance with ASTM C231/C231M. The average of each set of two tests for each mixture shall be plotted on control charts on which the average percent and upper and lower limits are set in accordance with paragraph MATERIALS

FOR MIXTURE PROPORTIONING STUDIES, in PART 1, for each NMSA. The range between two consecutive tests for each mixture shall be plotted on a control chart on which the upper control limit is 3.0 percent. Samples for air content shall normally be taken at the mixer, however the Contractor is responsible for delivering the concrete to the forms at the proper air content. Samples shall be taken at the placement site as often as required, depending on the Contractor's delivery method, to determine any air loss.

3.7.2.6.2 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, another test shall be made to verify the correction of the adjustment. Whenever a point falls above the upper control for range, the dispenser shall be calibrated 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, the Contracting Officer shall be notified.

3.7.2.6.3 Slump Testing

At least two slump tests shall be made in accordance with ASTM C143/C143M on each concrete mixture produced during each 8-hour period or less of concrete production each day. Additional tests shall be made when excessive variation in workability is reported. The result of each test for each mixture shall be plotted on a control chart on which the upper and lower limits are set as specified in paragraph MIXTURE PROPORTIONING. The range shall be plotted on a control chart on which the upper control limit is 50 mm 2 inches. Samples for slump shall be taken at the mixer, however the Contractor is responsible for delivering the concrete to the placement site at the stipulated slump. If the Contractor's materials or transportation methods cause slump loss between the mixer and the placement, samples shall be taken at the placement site as often as required by the Contracting Officer.

3.7.2.6.4 Slump Corrective Action

Whenever points on the control chart approach the upper or lower control limits, an adjustment shall be made in the batch weights of water and fine aggregate. The adjustments are to be made so that the total water content does not exceed that amount specified in the mixture proportions provided 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 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, another test shall be made 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, the slump shall be considered to be out of control, the concreting operation halted, and the additional testing for aggregate moisture content required shall be undertaken, and action taken immediately to correct the problem.

3.7.2.6.5 Compression Test Cylinders

At least one set of test cylinders shall be made each shift on each different concrete mixture placed during the shift. Additional sets of test cylinders shall be made, as directed, when the mixture proportions are changed or when low strengths have been detected. A random sampling plan shall be developed by the Contractor and approved by the Contracting Officer prior to start of construction. The plan shall assure that sampling is done in a completely random and unbiased, not just haphazard, manner. A set of test cylinders for structural concrete containing Type I or Type II portland cement only shall consist of four cylinders, two to be tested at 7 days and two at 28 days. A set of test cylinders for all other concrete shall consist of six cylinders, two to be tested at 7 days, two at 28 days, and two at 90 days. In addition, for all concrete except that containing Type I or Type II portland cement only, every 2 months four additional cylinders shall be made and two tested at 6 months of age and two tested at 12 months of age. All test specimens shall be molded and cured in accordance with ASTM C31/C31M and tested in accordance with ASTM C39/C39M. All compressive strength tests shall be reported immediately. Quality control charts shall be kept for individual strength tests, moving average for strength and moving average for range for each mixture. The charts shall be similar to those found in ACI 214R.

3.7.2.7 Inspection Before Placing

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

3.7.2.8 Concrete Placement

3.7.2.8.1 Placing Inspection

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

3.7.2.8.2 Placing Corrective Action

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

3.7.2.9 Vibrators

3.7.2.9.1 Vibrator Testing and Use

The frequency and amplitude of each vibrator shall be determined in accordance with COE CRD-C 521prior to initial use and at least once a month when concrete is being placed. Additional tests shall be made as directed when a vibrator does not appear to be adequately consolidating the concrete. The frequency shall be determined 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. The amplitude shall be determined with the head vibrating in air. Two measurements shall be taken, one near the tip and another near the upper end of the vibrator head, and these results averaged. The make, model, type, and size of the vibrator and frequency and amplitude results shall be reported in writing.

3.7.2.9.2 Vibrator Corrective Action

Any vibrator not meeting the requirements of paragraph PREPARATION FOR PLACING above shall be immediately removed from service and repaired or replaced.

3.7.2.10 Curing

3.7.2.10.1 Moist Curing Inspections

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

3.7.2.10.2 Moist Curing Corrective Action

When a daily inspection report lists an area of inadequate moistness, immediate corrective action shall be taken, and the required curing period for those areas shall be extended by one (1) day.

3.7.2.10.3 Membrane Curing Inspection

No curing compound shall be applied until the Contractor's authorized representative has verified that the compound is properly mixed and ready for spraying. At the end of each operation, estimate the quantity of compound used by measurement of the container and the area of concrete surface covered and compute the rate of coverage in square meters/L square feet per gallon. Note whether or not coverage is uniform.

3.7.2.10.4 Membrane Curing Corrective Action

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

3.7.2.10.5 Sheet Curing Inspection

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

3.7.2.10.6 Sheet Curing Corrective Action

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

3.7.2.11 Cold Weather Protection and Sealed Insulation Curing

At least once each shift and once per day on nonwork days an inspection shall be made of all areas subject to cold weather protection. The protection system shall be inspected for holes, tears, unsealed joints, or other incongruities which could result in damage to the concrete. Special attention shall be taken at edges, corners, and thin sections. Any deficiencies shall be noted, corrected, and reported.

3.7.2.12 Cold Weather Protection Corrective Action

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

3.7.2.13 Mixer Uniformity

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**NOTE: The optional phrases should be used if the Contractor is to perform the initial test. Correlate with paragraph PLANT AND EQUIPMENT in PART 2.**
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3.7.2.13.1 Stationary Mixers

[Prior to the start of concrete placing and] once every 3 months when concrete is being placed, or once for every 57,000 cubic meters 75,000 cubic yards of concrete placed, whichever results in the longest time, interval uniformity of concrete mixing shall be determined in accordance with paragraph PLANT AND EQUIPMENT in PART 2. [The initial and] every fourth set of tests shall be regular tests performed on three batches of concrete. Intermediate uniformity tests shall be abbreviated tests performed on a single batch of concrete. If the mixer fails the abbreviated test, a regular test shall be immediately performed. Whenever adjustments in a mixer or increased mixing time are required because of failure of a uniformity test, the mixer shall be reevaluated by a regular test after the adjustments have been completed. If the Contractor proposes to reduce a mixing time, a regular test shall be performed to evaluate the proposed time. Additional testing shall be performed when directed when there is visible evidence of possible improper mixer performance. Results of all uniformity tests shall be reported in writing.

3.7.2.13.2 Truck Mixers

Prior to the start of concrete placing and at least once every 6 months when concrete is being placed, uniformity of concrete shall be determined in accordance with ASTM C94/C94M. The truck mixers shall be selected randomly for testing. When satisfactory performance is found in one truck mixer, the performance of mixers of substantially the same design and condition of the blades may be regarded as satisfactory. Results of tests shall be reported in writing.

3.7.2.14 Mixer Uniformity Corrective Action

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

3.7.3 Reports

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

-- End of Section --