
USACE / NAVFAC / AFCEC / NASA UFGS-03 31 01.00 10 (November 2010)

Preparing Activity: USACE Superseding
UFGS-03 31 01 00 10 (November 2009)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2013

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11/10

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SECTION 03 31 01.00 10

CAST-IN-PLACE STRUCTURAL CONCRETE FOR CIVIL WORKS 11/10

NOTE: This guide specification covers the requirements for furnishing, hauling, and placing the cast-in-place structural concrete complete, as specified herein and shown on the contract drawings. 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 items(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 characteristics that distinguish this specification from Section 03 70 00 MASS CONCRETE, are:

1. Concrete strengths and maximum permitted water-cement ratios are specified.
2. The proportioning of concrete mixtures is the responsibility of the Contractor.
3. Measurement of concrete is on the basis of the actual volume of concrete within pay lines of the

structure as indicated on the drawings. Payment is made at contract prices per cubic meter (yard) for various items on the schedule. As an option payment may be by lump sum for various items on the schedule.

4. For large complex projects, this specification may be used in conjunction with Section 03 70 00 MASS CONCRETE. If so used, the portions of the project to be constructed under the respective specifications must be clearly called out in the contract documents.

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 22 00.00 10 MEASUREMENT AND PAYMENT 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 22 00.00 10.

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

1.1.1 Structure [_____]

NOTE: Repeat this lump sum bid item and its respective subparagraphs for each structure to be paid for by lump sum, renumbering the bid items appropriately. Lump sum bid items should be inserted in paragraph LUMP SUM BID ITEMS of Section 01 22 00.00 10 MEASUREMENT AND PAYMENT.

1.1.1.1 Payment

Payment will be made for costs associated with operations necessary for construction of the structure at Station [_____].

1.1.1.2 Unit of Measure

Unit of measure: lump sum.

1.1.2 Concrete for [_____]

NOTE: Repeat this bid item and its respective subparagraphs for each bid item of concrete, renumbering the bid items appropriately. Unit price bid items should be inserted in paragraph UNIT PRICE

BID ITEMS of Section 01 22 00.00 10 MEASUREMENT AND
PAYMENT.

1.1.2.1 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 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.

1.1.2.2 Measurement

Concrete will be measured 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, or 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.

1.1.2.3 Unit of Measure

Unit of measure: cubic meters yards.

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 RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

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

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

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 117

(2010; Errata 2011) Specifications for
Tolerances for Concrete Construction and

Materials and Commentary

ACI 211.1	(1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 214R	(2011) Evaluation of Strength Test Results of Concrete
ACI 318	(2011; Errata 1 2011; Errata 2 2012; Errata 3-4 2013) Building Code Requirements for Structural Concrete and Commentary
ACI 318M	(2011; Errata 2013) Building Code Requirements for Structural Concrete & Commentary

ASTM INTERNATIONAL (ASTM)

ASTM C1017/C1017M	(2007) Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C1059/C1059M	(1999; R 2008) Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete
ASTM C1064/C1064M	(2011) Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
ASTM C1077	(2013b) Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C1107/C1107M	(2013) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM C117	(2013) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C123/C123M	(2012) Standard Test Method for Lightweight Particles in Aggregate
ASTM C1240	(2012) Standard Specification for Silica Fume Used in Cementitious Mixtures
ASTM C1260	(2007) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C127	(2012) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C128	(2012) Standard Test Method for Density,

	Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C142/C142M	(2010) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C143/C143M	(2012) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C1567	(2013) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C172/C172M	(2010) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C192/C192M	(2013) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231/C231M	(2010) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C295/C295M	(2012) Petrographic Examination of Aggregates for Concrete
ASTM C31/C31M	(2012) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2013) Standard Specification for Concrete Aggregates
ASTM C39/C39M	(2012) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C40/C40M	(2011) Standard Test Method for Organic Impurities in Fine Aggregates for Concrete
ASTM C42/C42M	(2013) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

ASTM C441	(2011) Effectiveness of Pozzolans or Ground Blast-Furnace Slag in Preventing Excessive Expansion of Concrete Due to the Alkali-Silica Reaction
ASTM C494/C494M	(2013) Standard Specification for Chemical Admixtures for Concrete
ASTM C535	(2012) 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 C595/C595M	(2013) Standard Specification for Blended Hydraulic Cements
ASTM C597	(2009) Pulse Velocity Through Concrete
ASTM C618	(2012a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C666/C666M	(2003; R 2008) Resistance of Concrete to Rapid Freezing and Thawing
ASTM C803/C803M	(2003; R 2010) Penetration Resistance of Hardened Concrete
ASTM C805/C805M	(2013) Rebound Number of Hardened Concrete
ASTM C87/C87M	(2010) Effect of Organic Impurities in Fine Aggregate on Strength of Mortar
ASTM C881/C881M	(2010) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C94/C94M	(2013a) Standard Specification for Ready-Mixed Concrete
ASTM C989/C989M	(2012a) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM D75/D75M	(2009) Standard Practice for Sampling Aggregates
ASTM E1155	(1996; R 2008) Standard Test Method for Determining Floor Flatness and Floor Levelness Numbers
ASTM E1155M	(1996; R 2008) Standard Test Method for Determining Floor Flatness and Floor Levelness Numbers (Metric)

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 44 (2013) 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 100 (1975) Method of Sampling Concrete Aggregate and Aggregate Sources, and Selection of Material for Testing

COE CRD-C 104 (1980) Method of Calculation of the Fineness Modulus of Aggregate

COE CRD-C 114 (1997) Test Method for Soundness of Aggregates by Freezing and Thawing of Concrete Specimens

COE CRD-C 130 (2001) Standard Recommended Practice for Estimating Scratch Hardness of Coarse Aggregate Particles

COE CRD-C 143 (1962) Specifications for Meters for Automatic Indication of Moisture in Fine Aggregate

COE CRD-C 400 (1963) Requirements for Water for Use in Mixing or Curing Concrete

COE CRD-C 521 (1981) Standard Test Method for Frequency and Amplitude of Vibrators for Concrete

COE CRD-C 94 (1995) Corps of Engineers Specification for Surface Retarders

1.3 DESIGN REQUIREMENTS

NOTE: Consult the appropriate DM for the nominal maximum-size aggregate.

For each portion of the structure, select [concrete mixture proportions](#) so that the strength and W/C requirements are met. Submit concrete mixture proportions as determined by the Contractor and submitted for review. The submission shall be accompanied by test reports from a laboratory complying with [ASTM C1077](#) showing that proportions thus selected will produce concrete of the qualities indicated. No substitution shall be made in the source or type of materials used in the work without additional tests to show that the quality of the new materials and concrete are satisfactory. The concrete mixture quantities of all ingredients per cubic [meter yard](#) and nominal maximum coarse aggregate size that will be used in the manufacture of each quality of concrete shall be stated. Proportions shall indicate the mass of cement, pozzolan and ground granulated blast-furnace (GGBF)

slag when used, and water; the mass of aggregates in a saturated surface-dry condition; and the quantities of admixtures. Nominal maximum-size coarse aggregate shall be [37.5 mm 1-1/2 inch] [25.0 mm 1 inch] except 19.0 mm 3/4 inch nominal maximum-size coarse aggregate shall be used when any of the following conditions exist: the narrowest dimension between sides of forms is less than 190 mm 7-1/2 inches, the depth of the slab is less than 100 mm 4 inches, or the minimum clear spacing between reinforcing is less than 55 mm 2-1/4 inches.

1.3.1 Air Content

**NOTE: For a specified compressive strength (f'c) of
34.5 MPa (5,000 psi) or greater the air content may
be reduced by 1.0 percent.**

Air content as delivered to the forms and as determined by ASTM C231/C231M shall be between 4 and 7 percent except that when the nominal maximum-size coarse aggregate is 19.0 mm 3/4 inch, it shall be between 4.5 and 7.5 percent.

1.3.2 Slump

**NOTE: Consult the appropriate DM and or the
Materials Engineer to fill in the blank and to use
the optional sentence.**

The slump shall be determined in accordance with ASTM C143/C143M and shall be within the range of 25 to 100 mm 1 to 4 inches. Where placement by pump is approved, the slump shall not exceed 150 mm 6 inches. [Concrete to be placed in [_____] may contain a chemical admixture for use in producing flowing concrete in accordance with ASTM C1017/C1017M, and the slump of the concrete shall not exceed 200 mm 8 inches].

1.3.3 Concrete Proportioning

Trial batches and testing requirements for various qualities of concrete specified are the responsibility of the Contractor. Obtain samples of aggregates in accordance with the requirements of ASTM D75/D75M. Samples of materials other than aggregate shall be representative of those proposed for the project and shall be accompanied by the manufacturer's test reports indicating compliance with applicable specified requirements. Make trial mixtures having proportions, consistencies, and air content suitable for the work based on methodology described in ACI 211.1, using at least three different water-cement ratios, which will produce a range of strength encompassing those required for the work. The maximum water-cement ratios required in paragraph MAXIMUM WATER-CEMENT (W/C) RATIO below, will be converted to a weight ratio of water to cement plus pozzolan by mass, silica fume, or GGBF slag by mass equivalency as described in ACI 211.1. In the case where GGBF slag is used, include the weight of the slag in the equations for the term P, which is used to denote the mass of pozzolan. If pozzolan is used in the concrete mixture, the minimum pozzolan content shall be 15 percent of the total cementitious material. Proportion trial mixtures for maximum permitted slump and air content with due consideration to the approved conveying and placement method. The temperature of concrete in each trial batch shall be reported. For each water-cement

ratio, at least three test cylinders for each test age shall be made and cured in accordance with [ASTM C192/C192M](#); they shall be tested at 7 days and at the design age specified in accordance with [ASTM C39/C39M](#). From these test results, a curve will be plotted showing the relationship between water-cement ratio and strength.

1.3.4 Required Average Compressive Strength

In meeting the strength requirements specified below, the selected mixture proportion shall produce a required average compressive strength f'_{cr} exceeding the specified strength f'_c by the amount indicated below.

1.3.4.1 Average Compressive Strength from Test Records

Where a concrete production facility has test records, establish a standard deviation in accordance with the applicable provisions of [ACI 214R](#). Test records from which a standard deviation is calculated shall represent materials, quality control procedures, and conditions similar to those expected, shall represent concrete produced to meet a specified strength or strengths (f'_c) within [6.89 MPa 1,000 psi](#) of that specified for proposed work, and shall consist of at least 30 consecutive tests. A strength test shall be the average of the strengths of two cylinders made from the same sample of concrete and tested at 28 days or at another test age designated for determination of f'_c . Required average compressive strength f'_{cr} used as the basis for selection of concrete proportions shall be the larger of the equations that follow using the standard deviation as determined above:

$$f'_{cr} = f'_c + 1.34S$$

$$f'_{cr} = f'_c + 2.33S - \text{3.45 500}$$

Where S = standard deviation

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

NUMBER OF TESTS*	MODIFICATION FACTOR FOR STANDARD DEVIATION
less than 15	Use tabulation in paragraph REQUIRED AVERAGE COMPRESSIVE STRENGTH
15	1.16
20	1.08
25	1.03
30 or more	1.00
*Interpolate for intermediate numbers of tests.	

1.3.4.2 Average Compressive Strength without Previous Test Records

When a concrete production facility does not have sufficient field strength test records for calculation of the standard deviation, determine the required average strength f_{cr} as follows:

If the specified compressive strength f'_c is less than [20.7 MPa 3,000 psi](#),

$$f'_{cr} = f'_c + 6.89 \sqrt{f'_c}$$

If the specified compressive strength f'_c is 20.7 to 34.5 MPa 3,000 to 5,000 psi,

$$f'_{cr} = f'_c + 8.27 \sqrt{f'_c}$$

If the specified compressive strength f'_c is over 34.5 MPa 5,000 psi,

$$f'_{cr} = f'_c + 9.65 \sqrt{f'_c}$$

1.3.5 Concrete Strength

NOTE: Consult the Structural Design Engineer and the appropriate DM to fill in the blanks.

Specified compressive strength f'_c shall be as follows:

COMPRESSIVE STRENGTH (MPa) (PSI)	STRUCTURE OR PORTION OF STRUCTURE
34.5 @ [_____] days 5,000 @ [_____] days	[_____]
27.6 @ [_____] days 4,000 @ [_____] days	[_____]
20.7 @ [_____] days 3,000 @ [_____] days	[_____]
17.2 @ [_____] days 2,500 @ [_____] days	[_____]
[_____] @ [_____] days	[_____]

1.3.6 Maximum Water-Cement (W/C) Ratio

NOTE: Consult EM 1110-2-2000 and the appropriate DM to fill in the blanks and to select the appropriate W/C. When cementitious materials other than portland cement are used, see paragraph CONCRETE PROPORTIONING above, for definitions of W/C.

Maximum W/C shall be as follows:

WATER-CEMENT RATIO, BY MASS	STRUCTURE OR PORTION OF STRUCTURE
0.40	[_____]
0.45	[_____]
0.50	[_____]
0.55	[_____]
0.60	[_____]

WATER-CEMENT RATIO, BY MASS	STRUCTURE OR PORTION OF STRUCTURE
0.65	[_____]

These W/C's may cause higher strengths than that required by paragraph CONCRETE STRENGTH.

1.3.7 Construction Tolerances

NOTE: Finished or formed surfaces subject to high-velocity flow (12 m/s (40 fps) and greater) will meet the tolerances for Class A-HV surfaces specified in paragraph FORMED CONCRETE SURFACES below.

Except as specified otherwise, a plus tolerance increases and a minus tolerance decreases the dimension to which it applies. A tolerance without sign means plus or minus. Where only one sign is specified, there is no limit in the other direction. Tolerances are not cumulative. The most restrictive tolerance will control. Tolerances shall not extend the structure beyond legal boundaries.

- a. 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.
- b. Construction tolerances shall meet the requirements of [ACI 117](#) and any of the following requirements that are applicable.

1.3.7.1 Formed Concrete Surfaces

For High Velocity flow, Class A-HV-Abrupt variation, a positive offset between concrete surfaces is a raise of elevation in the direction of water flow and a negative offset is a drop of elevation in the direction of the water flow.

Direction of water flow	+0 mm 0 inches
	-3 mm 1/8 inch
Perpendicular to the direction of water flow	3 mm 1/8 inch

1.3.7.2 Floor Finish by the F-Number System

NOTE: Delete this paragraph if floor finish tolerances are not applicable. If surface is subjected to high-velocity flow (12 m/s (40 fps) or greater), the tolerances for Class A-HV surfaces specified above, apply. Be aware that the "very flat surface" is difficult to obtain and may require special finishing techniques.

Refer to EM-1110-2-2000 for guidance on the F-Number System. Refer to the appropriate DM for a list of floor locations and F-Numbers to insert in the

blanks.

The flatness and levelness of the floors in the following listed areas shall be carefully controlled and the tolerances shall be measured by the F-Number system:

[_____]
[_____]

Furnish a floor profilograph or other equipment capable of measuring the floor flatness (FF) number and the floor levelness (FL) number, in accordance with ASTM E1155M ASTM E1155. Perform the tolerance measurements while being observed by the Contracting Officer. The tolerance requirement will be FF[_____] / FL[_____]. Special finishing procedures and special care will be required to meet these tolerances.

1.3.7.3 Tunnel Linings, Conduits, Filling & Emptying Culverts

Water Conveying:

Lateral alignment	
Centerline alignment	13 mm 1/2 inch
Inside dimensions	0.005 times inside dimension
Level alignment	
Profile grade	13 mm 1/2 inch
Cross-Sectional dimension	
Tunnel and culvert lining	-0 mm 0 inch

1.3.7.4 Appearance

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

1.4 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated 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 submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation 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.

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

SD-03 Product Data

Concrete Mixture Proportions[; G][; G, [____]]
Batch Plant[; G][; G, [____]]
Concrete Mixers
Conveying Equipment
Placing Equipment
Construction Joint Treatment[; G][; G, [____]]
Cold-Weather Placing[; G][; G, [____]]
Hot-Weather Placing[; G][; G, [____]]

SD-04 Samples

Aggregates[; G][; G, [____]]
Cementitious Materials, Admixtures, and Curing Compound[; G][; G, [____]]

SD-06 Test Reports

Quality of Aggregates[; G][; G, [____]]
Mixer Uniformity.
Tests and Inspections

SD-07 Certificates

Testing Technicians
Concrete Construction Inspector (CCI)
[Cementitious Materials[; G][; G, [____]]]
[Air-Entraining Admixture]
[Other Chemical Admixtures]
Epoxy Resin
Latex Bonding Compound

Nonshrink Grout

1.5 QUALITY ASSURANCE

The Government will sample and test aggregates and concrete 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 **ASTM D75/D75M**. Concrete will be sampled in accordance with **ASTM C172/C172M**. No material shall be used until notice has been given by the Contracting Officer that test results are satisfactory. [The Government will sample and test chemical admixtures, curing compounds, and cementitious materials.] The individuals who sample and test concrete or the constituents of concrete as required in this specification shall have demonstrated a knowledge and ability to perform the necessary test procedures equivalent to the ACI minimum guidelines for certification of Concrete Field **Testing Technicians**, Grade I. The individuals who perform the inspection of concrete construction shall have demonstrated a knowledge and ability equivalent to the ACI minimum guidelines for certification of **Concrete Construction Inspector (CCI)**. Submit statements that the concrete testing technicians and the concrete inspectors meet the specified requirements.

1.5.1 Cement and Pozzolan

NOTE: Delete this paragraph if materials are to be accepted on the basis of a manufacture's certification of compliance and mill test reports, and the optional sentence in paragraph SUBMITTALS, SD-07 Certificates will be used. See the appropriate DM or consult the Materials Engineer to select prequalified sources, (1) and (2), sealed bins, (3) and (4), or both options, (1), (2), (3) and (4). Selection of the sealed bin method, subparagraphs (3) and (4), must be fully justified in the appropriate DM.

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

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

Development Center - Structures Laboratory, 3909 Halls Ferry Road,
Vicksburg, MS 39180-6199, ATTN: CEERD-SC.]

- [c. Nonprequalified Cement Sources - Cement, if not from a prequalified source, will be sampled at the source and stored in sealed bins pending completion of testing. Sampling, testing, and the shipping inspection from the point of sampling, when the point is other than at the site of the work, will be made by or under the supervision of the Government and at its 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 and expense of the Contractor. When the point of sampling is other than at the site of the work, the fill gates of the sampled bin and conveyances used in shipment will be sealed under Government supervision and kept sealed until shipment from the bin has been completed. If tested cement is rehandled at transfer points, the extra cost of inspection shall be at the Contractor's expense. The cost of testing cement excess to project requirements shall also be at the expense of the Contractor. The charges for testing cement at the expense of the Contractor will be deducted from the payments due the Contractor at a rate of [_____] dollars per ton (metric) (2000 lb) of cement represented by the tests.]

**NOTE: To fill in the blank for cost of testing
excess cement contact the Structures Laboratory,
Concrete Division at WES.**

- [d. Nonprequalified Pozzolan Sources - Pozzolan, if not from a prequalified source, will be sampled at the source and stored in sealed bins pending completion of certain tests. Pozzolan will also be sampled at the site when determined necessary. All sampling and testing will be by and at the expense of the Government. Release for shipment and approval for use will be based on compliance with 7-day lime-pozzolan strength requirements and other physical and chemical and uniformity requirements for which tests can be completed by the time the 7-day lime-pozzolan strength test is completed. Release for shipment and approval for use on the above basis will be contingent on continuing compliance with the other requirements of the specifications. If a bin fails, the contents may be resampled and tested at the Contractor's expense. In this event the pozzolan may be sampled as it is loaded into cars, trucks, or barges provided they are kept at the source until released for shipment. Unsealing and resealing of bins and sealing of shipping conveyances will be done by or under the supervision of the Government. Shipping conveyances will not be accepted at the site of the work unless received with all seals intact. If pozzolan is damaged in shipment, handling, or storage, it shall be promptly removed from the site of the work. Pozzolan that has not been used within 6 months after testing shall be retested at the expense of the Contractor when directed by the Contracting Officer and shall be rejected if the test results are not satisfactory. If tested pozzolan is rehandled at transfer points, the extra cost of inspection shall be at the Contractor's expense. The cost of testing excess pozzolan shall be at the Contractor's expense at a rate of [_____] cents per ton (metric) (2000 lb). The amount will be deducted from payment to the Contractor.]

1.5.2 Concrete Strength

Compressive strength test specimens will be made by the Government and cured in accordance with [ASTM C31/C31M](#) and tested in accordance with [ASTM C39/C39M](#). The strength of the concrete will be considered satisfactory so long as the average of all sets of three consecutive test results equals or exceeds the specified compressive strength f'_c and no individual test result falls below the specified strength f'_c by more than [3.5 MPa 500 psi](#). A "test" is defined as the average of two companion cylinders, or if only one cylinder is tested, the results of the single cylinder test. Additional analysis or testing, including nondestructive testing, taking cores and/or load tests may be required at the Contractor's expense when the strength of the concrete in the structure is considered potentially deficient.

- a. Investigation of Low-Strength Test Results - When any strength test of standard-cured test cylinders falls below the specified strength requirement by more than [3.5 MPa 500 psi](#) or if tests of field-cured cylinders indicate deficiencies in protection and curing, take steps to ensure that the load-carrying capacity of the structure is not jeopardized. Nondestructive testing in accordance with [ASTM C597](#), [ASTM C803/C803M](#), or [ASTM C805/C805M](#) may be permitted by the Contracting Officer to estimate the relative strengths at various locations in the structure as an aid in evaluating concrete strength in place or for selecting areas to be cored. Such tests shall not be used as a basis for acceptance or rejection.
- b. Testing of Cores - When the strength of concrete in place is considered potentially deficient, obtain cores and test them in accordance with [ASTM C42/C42M](#). At least three representative cores shall be taken from each member or area of concrete in place that is considered potentially deficient. The location of cores will be determined by the Contracting Officer to least impair the performance of the structure. Concrete in the area represented by the core testing will be considered adequate if the average strength of the cores is equal to at least 85 percent of the specified strength requirement and if no single core is less than 75 percent of the specified strength requirement.
- c. Load Tests - If the core tests are inconclusive or impractical to obtain or if structural analysis does not confirm the safety of the structure, load tests may be directed by the Contracting Officer in accordance with the requirements of [ACI 318M ACI 318](#). Concrete work evaluated by structural analysis or by results of a load test shall be corrected in a manner satisfactory to the Contracting Officer. All investigations, testing, load tests, and correction of deficiencies will be performed and approved by the Contracting Officer at the expense of the Contractor, except that if all concrete is in compliance with the plans and specifications, the cost of investigations, testing, and load tests will be at the expense of the Government.

1.5.3 Aggregates

NOTE: The Designer should consult the appropriate DM, identify the sources for aggregates, and attach them to the end of this section. A Format Template for Aggregate Sources is located in the Template Menu of UFGS. Contact the Director, U.S. Army Corps of Engineers, Engineer Research and Development

Center - Structures Laboratory, 3909 Halls Ferry
Road, Vicksburg, Mississippi 39180-6199, ATTN:
CEERD-SC for information to fill in the blanks below.

The aggregate sources listed at the end of this section for aggregates have been tested and at the time testing was performed were capable of producing materials of a quality required for this project provided suitable processing is performed. The Contractor may furnish materials from a listed source or from a source not listed. Samples from any source of coarse aggregate and any source of fine aggregate selected by the Contractor, consisting of not less than [70] [_____] kg [150] [_____] pounds of each size coarse aggregate and [35] [_____] kg [75] [_____] 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 and at the expense of the Government in accordance with the applicable COE CRD-C or ASTM test methods. The cost of testing one source for each size of aggregate will be borne by the Government. If the Contractor selects more than one source for each aggregate size or selects a substitute source for any size aggregate after the original source was tested, the cost of that additional testing will be borne by the Contractor. Tests to which aggregate may be subjected are listed in paragraph QUALITY ASSURANCE. The material from the proposed source shall meet the quality requirements of this paragraph. The Government's test data and other information on aggregate quality of those sources listed at the end of this section are included in the Design Memorandum and are available for review in the district office. Testing of aggregates by the Government does not relieve the Contractor of the requirements outlined in paragraph TESTS AND INSPECTIONS.

1.5.4 Cementitious Materials, Admixtures, and Curing Compound

NOTE: When the optional sentence below is deleted,
the corresponding manufacturer's certification
described in paragraph SUBMITTALS should be used.
EM 1110-2-2000, "Standard Practice for Concrete,"
provides guidance in selecting the options for
Government or for Contractor testing."

At least 60 days in advance of concrete placement, notify the Contracting Officer of the sources for cementitious materials, admixtures, and curing compound, along with sampling location, brand name, type, and quantity to be used in the manufacture and/or curing of the concrete. Cementitious Materials, including Cement and Pozzolan, [and Ground Granulated Blast-Furnace Slag] will be accepted on the basis of the manufacturer's certification of compliance. No cementitious materials shall be used until notice of acceptance has been given by the Contracting Officer. Cementitious materials will be subject to check testing from samples obtained at the source, at transfer points, or at the project site, as scheduled by the Contracting Officer, and such sampling will be by or under the supervision of the Government at its expense. Material not meeting specifications shall be promptly removed from the site of work. Submit samples of materials for Government testing and approval.

1.6 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.1 MATERIALS

NOTE: Delete the requirements for Certificates for
air entrainment admixtures, other chemical
admixtures, curing compounds, portland cement and
pozzolan if the optional parts of paragraph
CEMENTITIOUS MATERIALS, ADMIXTURES, AND CURING
COMPOUND above, is used.

Submit mill test reports attesting that materials meet the requirements of the specification under which they are furnished. Certification and mill test reports shall be from samples taken from the particular lot furnished. The following shall be certified for compliance with all specification requirements: Impervious-Sheet Curing Materials, Air-Entraining Admixture, Other Chemical Admixtures, Membrane-Forming Curing Compound, Epoxy Resin and Latex Bonding Compound. Submit descriptive literature of the Nonshrink Grout proposed for use together with a certificate from the manufacturer stating that it is suitable for the application or exposure for which it is being considered.

2.1.1 Cementitious Materials

NOTE: See the appropriate DM to select the proper
requirements for the Cementitious Materials Options.
Other cementitious materials may be added if
specifically recommended and approved in the
concrete materials DM.

Cementitious materials shall be portland cement, portland-pozzolan cement, portland blast-furnace slag cement, portland cement in combination with pozzolan or GGBF slag [or [____]] [or portland cement in combination with silica fume] conforming to appropriate specifications listed below. Use of cementitious materials in architectural concrete shall be restricted to one color, one source, and one type.

2.1.1.1 Portland Cement

ASTM C150/C150M, Type I or II, except that the maximum amount of C3A in Type I cement shall be 15 percent [including the heat of hydration at 7 days] [including false set requirements] [low alkali when used with aggregates listed at the end of this section which require it.] [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 GGBF slag provided the following requirement is met. The expansion of the

proposed combination when tested in accordance with ASTM C441 shall be equal to or less than the expansion of a low-alkali cement meeting the requirements of ASTM C150/C150M when tested in general conformance with ASTM C441. 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 the above requirements except that it may be Type I, Type II, or Type III [low alkali]. White Type III may be used only in specific areas of the structure, when approved in writing by the Contracting Officer.]

2.1.1.2 High-Early-Strength Portland Cement

ASTM C150/C150M, Type III, [with C3A limited to [5] [8] percent] [low alkali when used with aggregates listed at the end of this section which require it] [used only when specifically approved in writing].

2.1.1.3 Pozzolan, Other than Silica Fume

Pozzolan shall conform to ASTM C618, Class [C] [F], with the optional requirements for multiple factor, drying shrinkage, and uniformity of Table 2A. Table 1A requirement for maximum alkalies shall apply when used with aggregates listed at the end of this section to require low-alkali cement.

2.1.1.4 [Ground Granulated Blast-Furnace Slag

Ground Granulated Blast-Furnace Slag shall conform to ASTM C989/C989M, Grade [____].]

2.1.1.5 [Silica Fume

NOTE: Optional Table 2 in ASTM C1240 should be included when used with aggregates listed to require low-alkali cement. Other requirements in Table 4 may be specified if necessary. Refer to 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 Government 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.]

2.1.1.6 Blended Hydraulic Cement

[Portland blast-furnace slag cement shall conform to ASTM C595/C595M, Type IS.] [Portland-pozzolan cement shall conform to ASTM C595/C595M, Type IP.]

2.1.2 Aggregates

2.1.2.1 General

NOTE: The list of sources and required tests and test limits will be taken from the concrete materials DM; however, if the materials DM will be more than five (5) years old at time of the proposed issuance of the solicitation, then the Designer must update the materials information prior to the issuance of the solicitation.

Concrete aggregates may be furnished from any source capable of meeting the quality requirements below. The sources listed at the end of this section were evaluated during the design phase of the project in [20__] 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 listed sources are currently capable of producing aggregates that meet the required quality stated in paragraph QUALITY ASSURANCE. 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. Fine and coarse aggregates shall conform to the grading requirements of ASTM C33/C33M. Where the use of highway department gradations are permitted, proposed gradations shall be submitted for approval.

2.1.2.2 Concrete Aggregate Sources

NOTE: If an aggregate source is provided by the Government, the appropriate paragraphs from Section 03 70 00 MASS CONCRETE should be used.

2.1.2.2.1 List of Sources

The concrete aggregates sources may be selected from sources listed at the end of this section.

2.1.2.2.2 Selection of Source

After the award of the contract, designate in writing only one source or combination of sources from which to furnish aggregates. If the Contractor proposes to furnish aggregates from a source or from sources not listed at the end of this section, designate only a single source or single combination of sources for aggregates. Regardless of the source, selected samples for acceptance testing shall be provided as required by paragraph QUALITY ASSURANCE. If a source for coarse or fine aggregates, so designated by the Contractor, does not meet the quality requirements specified below, the Contractor may not submit for approval other non-listed sources but shall furnish the coarse or fine aggregate, as the case may be, from sources listed at the end of this section at no additional cost to the Government.

2.1.2.3 Quality

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.

Depending upon the quality of aggregates available, some tests may not be required. Refer to EM 1110-2-2000 for the purpose of each test.

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

Section 32 13 11 CONCRETE PAVEMENT FOR AIRFIELDS AND OTHER HEAVY-DUTY PAVEMENTS, paragraph Alkali-Silica Reactivity, provides a specification method for the Contractor to evaluate and mitigate ASR in concrete mixtures. The expansion limits specified in Section 32 13 11 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 Section 32 13 11 CONCRETE PAVEMENT FOR AIRFIELDS AND OTHER HEAVY-DUTY PAVEMENTS 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 "[.]".

Fine and coarse aggregates delivered to the mixer 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]". [meet the following requirements:

TEST LIMITS			
PROPERTY	FINE AGGREGATE	COARSE AGGREGATE	TEST
Specific Gravity	[_____]	[_____]	ASTM C127 ASTM C128
Absorption	[_____]	[_____]	ASTM C127 ASTM C128
Durability Factor using (Procedure A)	[_____]	[_____]	COE CRD-C 114 ASTM C666/C666M
Clay Lumps and Friable Particles	[_____]	[_____]	ASTM C142/C142M
Material Finer than 75-m No. 200 Sieve	[_____]	[_____]	ASTM C117
Organic Impurities	Not darker than No. 3 Not less than 95 percent		ASTM C40/C40M ASTM C87/C87M
L.A. Abrasion	[_____]	[_____]	ASTM C131 ASTM C535
Soft Particles	[_____]	[_____]	COE CRD-C 130
Chert, less than 2.40 specific gravity	[_____]	[_____]	ASTM C123/C123M
Coal and Lignite, less than less than 2.00 specific gravity	[_____]	[_____]	ASTM C123/C123M

TEST LIMITS			
PROPERTY	FINE AGGREGATE	COARSE AGGREGATE	TEST
Petrographic Examination	[List unwanted deleterious materials and their limits]		ASTM C295/C295M

]

2.1.3 Chemical Admixtures

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

2.1.3.1 Air-Entraining Admixture

The air-entraining admixture shall conform to ASTM C260/C260M and shall consistently cause the concrete to have an air content in the specified ranges under field conditions.

2.1.3.2 Accelerating Admixture

Accelerators shall meet the requirements of ASTM C494/C494M, Type C or E, except that calcium chloride or admixtures containing calcium chloride shall not be used.

2.1.3.3 Water-Reducing or Retarding Admixture

2.1.3.3.1 Water-Reducing or Retarding Admixtures

ASTM C494/C494M, Type A, B, or D, except that the 6-month and 1-year compressive strength tests are waived.

2.1.3.3.2 High-Range Water Reducing Admixture

ASTM C494/C494M, Type F or G except that the 6-month and 1-year strength requirements shall be waived. The admixture may be used only when approved by the Contracting Officer, such approval being contingent upon particular mixture control as described in the Contractor's Quality Control Plan.

[2.1.3.4 Other Chemical Admixtures

NOTE: Use this paragraph when the optional sentences in paragraph SLUMP is used.

Other chemical admixtures for use in producing flowing concrete shall comply with ASTM C1017/C1017M, Type 1 or 2. These admixture shall be used only for concrete listed in paragraph SLUMP.

]2.1.4 Water

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

2.1.5 Nonshrink Grout

Nonshrink grout shall conform to [ASTM C1107/C1107M](#) and shall be a commercial formulation suitable for the application proposed.

2.1.6 Abrasive Aggregates

Fifty-five percent, minimum, aluminum oxide or silicon-dioxide abrasive ceramically bonded together to form a homogeneous material sufficiently porous to provide a good bond with portland paste; or factory-graded emery aggregate consisting of not less than 45 percent aluminum oxide and 25 percent ferric oxide. The aggregate shall be well graded from particles retained on the 600- μ m (No. 30) sieve to particles passing the 2.36-mm (No. 8) sieve.

2.1.7 Latex Bonding Compound

Latex bonding compound agents for bonding fresh to hardened concrete shall conform to [ASTM C1059/C1059M](#).

2.1.8 Epoxy Resin

Epoxy resin for use in repairs shall conform to [ASTM C881/C881M](#), Type III, Grade I or II.

2.2 EQUIPMENT

NOTE: Refer to the appropriate DM for the capacity. Guidance is also found in EM 1110-2-2000.

Submit data on [placing equipment](#) and methods. The batching, mixing, conveying, and placing equipment shall have a capacity of at least [_____] cubic [meters yards](#) per hour. [Batch plant](#) shall conform to the requirements of [NRMCA CPMB 100](#) and as specified; however, rating plates attached to batch plant equipment are not required. Submit batch plant data to the Contracting Officer for review and conformance with applicable specifications.

2.2.1 Batching Equipment

NOTE: Refer to the appropriate DM to choose the appropriate alternates.

The batching controls shall be [partially automatic], [semiautomatic], [or] [automatic]. [Provide the semiautomatic batching system with interlocks such that the discharge device cannot be actuated until the indicated material is within the applicable tolerance.] Equip the batching system with an accurate recorder or recorders that meet the requirements of [NRMCA CPMB 100](#). Provide separate bins or compartments for each size group of aggregate and cement, pozzolan, and GGBF slag. Aggregates shall be weighed either in separate weigh batchers with individual scales or cumulatively in one weigh batcher on one scale. Aggregate shall not be weighed in the same batcher with cement, pozzolan, or GGBF slag. If both cement and pozzolan or GGBF slag are used, they may be batched cumulatively

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

2.2.2 Scales

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

2.2.3 Batching Tolerances

a. Weighing Tolerances

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

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

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

2.2.4 Moisture Control

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

2.2.5 Concrete Mixers

The concrete mixers shall not be charged in excess of the capacity recommended by the manufacturer. The mixers shall be operated at the drum or mixing blade speed designated by the manufacturer. Maintain the mixers in satisfactory operating condition, and keep the mixer drums free of hardened concrete. Should any mixer at any time produce unsatisfactory results, promptly discontinue its use until it is repaired. Submit concrete mixer data including the make, type, and capacity of concrete mixers proposed for mixing concrete.

2.2.5.1 Stationary Mixers

Concrete plant mixers shall be tilting, nontilting, horizontal-shaft, vertical-shaft, or pugmill and provided with an acceptable device to lock the discharge mechanism until the required mixing time has elapsed. The mixing time and uniformity shall conform to all the requirements in [ASTM C94/C94M](#) applicable to central-mixed concrete.

2.2.5.2 Truck Mixers

Truck mixers, the mixing of concrete therein, and concrete uniformity shall conform to the requirements of [ASTM C94/C94M](#). A truck mixer may be used either for complete mixing (transit-mixed) or to finish the partial mixing done in a stationary mixer (shrink-mixed). Equip each truck with two counters from which it will be possible to determine the number of revolutions at mixing speed and the number of revolutions at agitating speed.

2.2.6 Conveying Equipment

Submit data on the conveying equipment and methods for transporting, handling, and depositing the concrete. The conveying equipment shall conform to the following requirements:

2.2.6.1 Buckets

The interior hopper slope shall be not less than 58 degrees from the horizontal, the minimum dimension of the clear gate opening shall be at least five times the nominal maximum-size aggregate, and the area of the gate opening shall not be less than [0.2 square meters](#) [2 square feet](#). The maximum dimension of the gate opening shall not be greater than twice the minimum dimension. The bucket gates shall be essentially grout tight when closed and may be manually, pneumatically, or hydraulically operated except that buckets larger than [1.5 cubic meters](#) [2 cubic yards](#) shall not be manually operated. The design of the bucket shall provide means for positive regulation of the amount and rate of deposit of concrete in each dumping position.

2.2.6.2 Transfer Hoppers

Concrete may be charged into nonagitating hoppers for transfer to other conveying devices. Transfer hoppers shall be capable of receiving concrete directly from delivery vehicles and have conical-shaped discharge features. The transfer hopper shall be equipped with a hydraulically operated gate and with a means of external vibration to effect complete discharge. Concrete shall not be held in nonagitating transfer hoppers more than 30 minutes.

2.2.6.3 Trucks

Truck mixers operating at agitating speed or truck agitators used for transporting plant-mixed concrete shall conform to the requirements of **ASTM C94/C94M**. Nonagitating equipment may be used for transporting plant-mixed concrete over a smooth road when the hauling time is less than 15 minutes. Bodies of nonagitating equipment shall be smooth, watertight, metal containers specifically designed to transport concrete, shaped with rounded corners to minimize segregation, and equipped with gates that will permit positive control of the discharge of the concrete.

2.2.6.4 Chutes

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

2.2.6.5 Belt Conveyors

Belt conveyors shall be designed and operated to assure a uniform flow of concrete from mixer to final place of deposit without segregation of ingredients or loss of mortar and shall be provided with positive means for preventing segregation of the concrete at the transfer points and the point of placing. Belt conveyors shall be constructed such that the idler spacing shall not exceed **900 mm 36 inches**. The belt speed shall be a minimum of **90 m 300 feet** per minute and a maximum of **230 m 750 feet** per minute. If concrete is to be placed through installed horizontal or sloping reinforcing bars, the conveyor shall discharge concrete into a pipe or elephant trunk that is long enough to extend through the reinforcing bars.

2.2.6.6 Concrete Pumps

Concrete may be conveyed by positive displacement pump when approved. The pumping equipment shall be piston or squeeze pressure. The pipeline shall be rigid steel pipe or heavy-duty flexible hose. The inside diameter of the pipe shall be at least three times the nominal maximum-size coarse aggregate in the concrete mixture to be pumped but not less than **100 mm 4 inches**. Aluminum pipe shall not be used.

2.2.7 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 Inches	FREQUENCY (VPM)	AMPLITUDE mm Inches
Thin walls, beams, etc.	32 to 64 1-1/4 to 2-1/2	9,000 to 13,500	0.5 to 1.0 0.02 to 0.04
General construction	50 to 88 2 to 3-1/2	8,000 to 12,000	0.6 to 1.2 0.025 to 0.05

Determine the frequency and amplitude in accordance with **COE CRD-C 521**.

PART 3 EXECUTION

3.1 PREPARATION FOR PLACING

3.1.1 Embedded Items

Before placement of concrete, take care to determine that all embedded items are firmly and securely fastened in place as indicated on the drawings, or required. Embedded items shall be free of oil and other foreign matter such as loose coatings or rust, paint, and scale. The embedding of wood in concrete will be permitted only when specifically authorized or directed. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable materials to prevent the entry of concrete into voids. Welding, including tack welding, will not be permitted on embedded metals within 600 mm 2 feet of the surface of the concrete.

3.1.2 Concrete on Earth Foundations

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

3.1.3 Concrete on Rock Foundations

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

3.1.4 Construction Joint Treatment

Submit the method and equipment proposed for joint cleanup and waste disposal, for review and approval. Construction joint treatment shall conform to the following requirements:

3.1.4.1 Joint Preparation

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

3.1.4.2 Air-Water Cutting

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

3.1.4.3 High-Pressure Water Jet

A stream of water under a pressure of not less than 20.7 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 water jet is incapable of a satisfactory cleaning, the surface shall be cleaned by sandblasting.

3.1.4.4 Wet Sandblasting

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

3.1.4.5 Waste Disposal

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

3.2 PLACING

3.2.1 Placing Procedures

The surfaces of horizontal construction joints shall be kept continuously wet for the first 12 hours during the 24-hour period prior to placing concrete. Surfaces may be dampened immediately before placement if necessary. Concrete placement will not be permitted when, in the opinion of the Contracting Officer, weather conditions prevent proper placement and consolidation. Deposit concrete 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 may be effectively consolidated in horizontal layers 600 mm 2.0 feet or less in thickness with a minimum of lateral movement. The amount deposited in each location shall be that which can be readily and thoroughly consolidated. Sufficient placing capacity shall be provided so that concrete placement can be kept plastic and free of cold

joints while concrete is being placed. Concrete shall be placed by methods that will prevent segregation or loss of ingredients. Any concrete transferred from one conveying device to another shall be passed through a hopper that is conical in shape. The concrete shall not be dropped vertically more than 1.5 m 5 feet, except where a properly designed and sized elephant truck with rigid drop chute bottom section is provided to prevent segregation and where specifically authorized. In no case will concrete be discharged to free-fall through reinforcing bars.

3.2.2 Placement by Pump

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

3.2.3 Time Interval Between Mixing and Placing

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

3.2.4 Cold-Weather Placing

When cold-weather placing of concrete is likely to be subjected to freezing temperatures before the expiration of the curing period, concrete shall be placed in accordance with procedures previously submitted. The ambient temperature of the space adjacent to the concrete placement and surfaces to receive concrete shall be above 0 degrees C 32 degrees F. The placing temperature of the concrete having a minimum dimension less than 300 mm 12 inches shall be between 12 and 24 degrees C 55 and 75 degrees F when measured in accordance with ASTM C1064/C1064M. The placing temperature of the concrete having a minimum dimension greater than 300 mm 12 inches shall be between 10 and 20 degrees C 50 and 70 degrees F. Heating of the mixing water or aggregates will be required to regulate the concrete-placing temperatures. Materials entering the mixer shall be free from ice, snow, or frozen lumps. Salt, chemicals, or other materials shall not be mixed with the concrete to prevent freezing. Submit the proposed materials, methods, and protection for approval, if concrete is to be placed under cold-weather conditions.

3.2.5 Hot-Weather Placing

NOTE: See the appropriate DM for the proper placing
temperature.

Concrete shall be properly placed and finished with procedures previously submitted. The concrete-placing temperature shall not exceed [_____] degrees C F when measured in accordance with ASTM C1064/C1064M. Cooling of the mixing water and aggregates, or both, may be required to obtain an adequate placing temperature. A retarder meeting the requirements of paragraph WATER-REDUCING OR RETARDING ADMIXTURES may be used to facilitate placing and finishing. Steel forms and reinforcement shall be cooled prior to concrete placement when steel temperatures are greater than 50 degrees C 120 degrees F. Conveying and placing equipment shall be cooled if necessary to maintain proper concrete-placing temperature. Submit the proposed materials and methods for review and approval, if concrete is to be placed under hot-weather conditions.

3.2.6 Consolidation

Immediately after placement, each layer of concrete, including flowing concrete, shall be consolidated by internal vibrating equipment. Vibrators shall not be used to transport concrete within the forms. Hand spading may be required, if necessary, with internal vibrating along formed surfaces permanently exposed to view. Form or surface vibrators shall not be used unless specifically approved. The vibrator shall be inserted vertically at uniform spacing over the entire area of placement. The distance between insertions shall be approximately 1-1/2 times the radius of action of the vibrator. The vibrator shall penetrate rapidly to the bottom of the layer and at least 150 mm 6 inches into the preceding unhardened layer if such exists. It shall be held stationary until the concrete is consolidated and then withdrawn slowly.

3.2.7 [Placing Concrete in Ogee Section

The unformed portion of the ogee section shall be finished by placing concrete slightly above grade 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.]

3.2.8 [Placing Concrete Underwater

Concrete, described in Bid Item [_____] , shall be deposited in water by a tremie or concrete pump. The methods and equipment used will be subject to approval. Concrete buckets will not be permitted for underwater placement of concrete except to deliver concrete to the tremie. The tremie shall be watertight and sufficiently large to permit a free flow of concrete. Keep the discharge end of the pump line or tremie shaft continuously submerged in the concrete. The underwater seal shall be effected in a manner that will not produce undue turbulence in the water. The tremie shaft shall be kept full of concrete to a point well above the water surface. Placement shall proceed without interruption until the concrete has been brought to the required height. The tremie shall not be moved horizontally during a placing operation, and a sufficient number of tremies shall be provided so that the maximum horizontal flow will be limited to 5 m 15 feet.]

3.3 SETTING OF BASE PLATES AND BEARING PLATES

3.3.1 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 with full bearing with nonshrink grout. The space between the top of concrete or masonry-bearing surface and the bottom of the plate shall be approximately 1/24 of the width of the plate, but not less than 13 mm 1/2 inch for plates less than 300 mm 12 inches wide. Concrete surfaces shall be rough, clean, and free of oil, grease, and laitance, and they shall be damp. Metal surfaces shall be clean and free of oil, grease, and rust.

3.3.2 Nonshrink Grout Application

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

3.3.2.1 Mixing and Placing of Nonshrink Grout

Mixing and placing shall be in conformance with the material manufacturer's instructions and as specified. Ingredients shall be thoroughly dry-mixed before adding water. After adding water, the batch shall be mixed for 3 minutes. Batches shall be of size to allow continuous placement of freshly mixed grout. Grout not used within 30 minutes after mixing shall be discarded. The space between the top of the concrete or masonry-bearing surface and the plate shall be filled solid with the grout. Forms shall be of wood or other equally suitable material for retaining the grout and shall be removed after the grout has set. If grade "A" grout as specified in ASTM C1107/C1107M is used, all surfaces shall be formed to provide restraint. The placed grout shall be worked to eliminate voids; however, overworking and breakdown of the initial set shall be avoided. Grout shall not be retempered or subjected to vibration from any source. Where clearances are unusually small, placement shall be under pressure with a grout pump. Temperature of the grout, and of surfaces receiving the grout, shall be maintained at 20 to 30 degrees C 65 to 85 degrees F until after setting.

3.3.2.2 Treatment of Exposed Surfaces

After the grout has set, those types containing metallic aggregate shall have the exposed surfaces cut back 25 mm 1 inch and immediately covered with a parge coat of mortar proportioned by mass of one part portland cement, two parts sand, and sufficient water to make the mixture placeable. The parge coat shall have a smooth, dense finish. The exposed surface of other types of nonshrink grout shall have a smooth, dense finish.

3.3.2.3 Curing

Grout and parge coats shall be cured in conformance with Section 03 39 00.00 10.

3.4 TESTS AND INSPECTIONS

Submit test results and inspection reports, daily and weekly. Tests and inspections shall conform to the following requirements:

3.4.1 General

Perform the inspections and tests described below, and, based upon the results of these inspections and tests, he shall take the action required and submit reports as required. When, in the opinion of the Contracting

Officer, the concreting operation is out of control, concrete placement shall cease. The laboratory performing the tests shall be on site and shall conform with [ASTM C1077](#). The Government will inspect the laboratory, equipment, and test procedures prior to start of concreting operations and at least once per year thereafter for conformance with [ASTM C1077](#).

3.4.2 Testing and Inspection Requirements

3.4.2.1 Fine Aggregate

3.4.2.1.1 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](#) and [COE CRD-C 104](#) for the fine aggregate or for each size range of fine aggregate if it is batched in more than one size or classification. The location at which samples are taken may be selected by the Contractor as the most advantageous for control. However, the Contractor is responsible for delivering fine aggregate to the mixer within specification limits.

3.4.2.1.2 Corrective Action for Fine Aggregate Grading

When the amount passing on any sieve is outside the specification limits, the fine aggregate shall be immediately resampled and retested. If there is another failure on any sieve, the fact shall immediately be reported to the Contracting Officer.

3.4.2.1.3 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 the electric moisture meter is operating satisfactorily, at least two direct measurements of moisture content shall be made per week to check the calibration of the meter. The results of tests for moisture content shall be used to adjust the added water in the control of the batch plant.

3.4.2.1.4 Moisture Content Corrective Action

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

3.4.2.2 Coarse Aggregate

3.4.2.2.1 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](#) for each size of coarse aggregate. The location at which samples are taken may be selected by the Contractor as the most advantageous for production control. A test record of samples of aggregate taken at the same locations shall show the results of the current test as well as the average results

of the five most recent tests including the current test. The Contractor may adopt limits for control which are coarser than the specification limits for samples taken at locations other than as delivered to the mixer to allow for degradation during handling.

3.4.2.2.2 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 to the Contracting Officer. Where two consecutive averages of five tests are outside specification limits, the operation shall be considered out of control and shall be reported to the Contracting Officer. Concreting shall be stopped and immediate steps shall be taken to correct the grading.

3.4.2.2.3 Coarse Aggregate Moisture Content

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

3.4.2.2.4 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 if necessary to maintain the specified slump.

3.4.2.3 [Quality of Aggregates](#)

NOTES: Tests should be those listed in paragraph
QUALITY ASSURANCE.

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

Depending upon the quality pf aggregates available,
some tests may not be required. Refer to EM
1110-2-2000 for the purpose of each test.

Submit aggregate quality tests at least 30 days prior to start of concrete placement.

3.4.2.3.1 Frequency of Quality Tests

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

FREQUENCY			
PROPERTY	FINE AGGREGATE	COARSE AGGREGATE	TEST
Specific Gravity	Every 3 months	Every 3 months	ASTM C127 ASTM C128
Absorption	Every 3 months	Every 3 months	ASTM C127 ASTM C128
Durability Factor (using Procedure A)	Every 12 months	Every 12 months	COE CRD-C 114 ASTM C666/C666M
Clay Lumps and Friable Particles	Every 3 months	Every 3 months	ASTM C142/C142M
Material Finer than 75- μ No. 200 Sieve	Not applicable	Every 3 months	ASTM C117
Impurities	Every 3 months	Not applicable	ASTM C40/C40M ASTM C87/C87M
L.A. Abrasion	Not applicable	Every 6 months	ASTM C131 ASTM C535
Soft and Friable (Scratch)	Not applicable	Every 6 months	COE CRD-C 130
Chert, less than 2.40 specific gravity	Every 6 months	Every 6 months	ASTM C123/C123M
Coal and Lignite, less than less than 2.00 specific gravity	Every 6 months	Every 6 months	ASTM C123/C123M
Petrographic Examination	Every 6 months	Every 6 months	ASTM C295/C295M

3.4.2.3.2 Corrective Action for Aggregate Quality

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

3.4.2.4 Scales

3.4.2.4.1 Weighing Accuracy

The accuracy of the scales shall be checked by test weights prior to start

of concrete operations and at least once every 3 months for conformance with the applicable requirements of paragraph BATCHING EQUIPMENT. Such tests shall also be made as directed whenever there are variations in properties of the fresh concrete that could result from batching errors.

3.4.2.4.2 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 EQUIPMENT, for checking the accuracy of dispensed admixtures, are operating properly.

3.4.2.4.3 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.

3.4.2.5 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.

3.4.2.6 Concrete Mixture

3.4.2.6.1 Air Content Testing

Air content tests shall be made when test specimens are fabricated. In addition, at least two tests for air content shall be made on randomly selected batches of each separate concrete mixture produced during each 8-hour period of concrete production. Additional tests shall be made when excessive variation in workability is reported by the placing foreman or Government quality assurance representative. Tests shall be made in accordance with ASTM C231/C231M. Test results shall be plotted on control charts which shall at all times be readily available to the Government. Copies of the current control charts shall be kept in the field by the Contractor's quality control representatives and results plotted as tests are made. When a single test result reaches either the upper or lower action limit a second test shall immediately be made. The results of the two tests shall be averaged and this average used as the air content of the batch to plot on both the control chart for air content and the control chart for range, and for determining the need for any remedial action. The result of each test, or average as noted in the previous sentence, shall be plotted on a separate chart for each mixture on which an "average line" is set at the midpoint of the specified air content range from paragraph AIR CONTENT. An upper warning limit and a lower warning limit line shall be set 1.0 percentage point above and below the average line. An upper action

limit and a lower action limit line shall be set 1.5 percentage points above and below the average line, respectively. The range between each two consecutive tests shall be plotted on a control chart for range where an upper warning limit is set at 2.0 percentage points and up upper action limit is set at 3.0 percentage points. Samples for air content may be taken at the mixer, however, the Contractor is responsible for delivering the concrete to the placement site at the stipulated air content. If the Contractor's materials or transportation methods cause air content loss between the mixer and the placement, correlation samples shall be taken at the placement site as required by the Contracting Officer and the air content at the mixer controlled as directed.

3.4.2.6.2 Air Content Corrective Action

Whenever points on the control chart for percent air reach either warning limit, an adjustment shall immediately be made in the amount of air-entraining admixture batched. As soon as is practical after each adjustment, another test shall be made to verify the result of the adjustment. Whenever a point on the control chart range reaches the warning limit, the admixture dispenser shall be recalibrated to ensure that it is operating accurately and with good reproducibility. Whenever a point on either control chart reaches an action limit line, the air content shall be considered out of control and the concreting operation shall immediately be halted until the air content is under control. Additional air content tests shall be made when concreting is restarted. All this shall be at no extra cost to the Government.

3.4.2.6.3 Slump Testing

In addition to slump tests which shall be made when test specimens are fabricated, at least four slump tests shall be made on randomly selected batches in accordance with [ASTM C143/C143M](#) for each separate concrete mixture produced during each 8-hour or less period of concrete production each day. Also, additional tests shall be made when excessive variation in workability is reported by the placing foreman or Government's quality assurance representative. Test results shall be plotted on control charts which shall at all times be readily available to the Government. Copies of the current control charts shall be kept in the field by the Contractor's quality control representatives and results plotted as tests are made. When a single slump test reaches or goes beyond either the upper or lower action limit, a second test shall immediately be made on the same batch of concrete. The results of the two tests shall be averaged and this average used as the slump of the batch to plot on both the control chart for percent air and the chart for range, and for determining the need for any remedial action. An upper warning limit shall be set at [13 mm 1/2 inch](#) below the maximum allowable slump on separate control charts for percent air used for each type of mixture as specified in paragraph SLUMP, and an upper action limit line and lower action limit line shall be set at the maximum and minimum allowable slumps, respectively, as specified in the same paragraph. The range between each consecutive slump test for each type of mixture shall be plotted on a single control chart for range on which an upper action limit is set at [50 mm 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 mixer and the placement, correlation samples shall be taken at the placement site as required by the Contracting Officer and the slump at the mixer controlled as directed.

3.4.2.6.4 Slump Corrective Action

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

3.4.2.6.5 Temperature

The temperature of the concrete shall be measured when compressive strength specimens are fabricated. Measurement shall be in accordance with [ASTM C1064/C1064M](#). The temperature shall be reported along with the compressive strength data.

3.4.2.6.6 Compressive-Strength Specimens

At least one set of test specimens shall be made each day on each different concrete mixture placed during the day. Additional sets of test cylinders shall be made, as directed by the Contracting Officer, when the mixture proportions are changed or when low strengths have been detected. A random sampling plan shall be developed and approved by the Contracting Officer prior to the start of construction. The plan shall assure that sampling is done in a completely random and unbiased manner. A set of test specimens for concrete with a 28-day specified strength in accordance with paragraph DESIGN REQUIREMENTS shall consist of four cylinders, two to be tested at 7 days and two at 28 days. A set of test specimens for concrete with a 90-day strength shall consist of six cylinders, two tested at 7 days, two at 28 days, and two at 90 days. Test specimens shall be molded and cured in accordance with [ASTM C31/C31M](#) and tested in accordance with [ASTM C39/C39M](#). All compressive-strength tests shall be reported immediately to the Contracting Officer. Quality control charts shall be kept for individual strength tests, moving average for strength, and moving average for range for each mixture. The charts shall be similar to those found in [ACI 214R](#).

3.4.2.7 Inspection Before Placing

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

3.4.2.8 Placing

3.4.2.8.1 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, yardage placed, and method of placement.

3.4.2.8.2 Placing Corrective Action

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

3.4.2.9 Vibrators

3.4.2.9.1 Vibrator Testing and Use

The frequency and amplitude of each vibrator shall be determined in accordance with [COE CRD-C 521](#) prior to initial use and at least once a month when concrete is being placed. Additional tests shall be made as directed when a vibrator does not appear to be adequately consolidating the concrete. The frequency shall be determined at the same time the vibrator is operating in concrete with the tachometer held against the upper end of the vibrator head while almost submerged and just before the vibrator is withdrawn from the concrete. The amplitude shall be determined with the head vibrating in air. Two measurements shall be taken, one near the tip and another near the upper end of the vibrator head and these results averaged. The make, model, type, and size of the vibrator and frequency and amplitude results shall be reported in writing.

3.4.2.9.2 Vibrator Corrective Action

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

3.4.2.10 [Mixer Uniformity](#)

Submit the results of the initial mixer uniformity tests, at least 5 days prior to the initiation of placing.

3.4.2.10.1 Stationary Mixers

Prior to the start of concrete placing and once every 6 months when concrete is being placed, or once for every [57,000 cubic meters](#) [75,000 cubic yards](#) of concrete placed, whichever results in the longest time interval, uniformity of concrete mixing shall be determined in accordance with [ASTM C94/C94M](#).

3.4.2.10.2 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.

3.4.2.11 Mixer Uniformity Corrective Action

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

3.4.3 Reports

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

_____, 20__

LIST OF FINE AND COARSE AGGREGATE SOURCES

LAT/LONG	PIT LOCATION, ADDRESS AND TELEPHONE NUMBER	MAIN OFFICE, ADDRESS AND TELEPHONE NUMBER
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FINE AGGREGATE

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COARSE AGGREGATE

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