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USACE / NAVFAC / AFCESA **UFGS-03300A (November 2001)**

Preparing Activity: USACE **Superseding UFGS-03300A (May 2001)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 25 June 2004

Latest change indicated by CHG tags
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DIVISION 03 - CONCRETE

SECTION 03300A

CAST-IN-PLACE STRUCTURAL CONCRETE

11/01

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SECTION 03300A

CAST-IN-PLACE STRUCTURAL CONCRETE
11/01

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NOTE: This guide specification covers the requirements for cast-in-place concrete materials, mixing, placement, and finishes.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.
****

PART 1 GENERAL

****
NOTE: This specification covers concrete work primarily for buildings, but may also be used for other applications such as wharves, docks, drainage structures, warehouse type slabs, and driveways. The following guide specifications are relative to this section and will be included to the extent applicable in projects where this section is used:

Section 03100A STRUCTURAL CONCRETE FORMWORK
Section 03200A CONCRETE REINFORCEMENT
Section 03150A EXPANSION JOINTS, CONTRACTION JOINTS, AND WATERSTOPS
Section 07920 JOINT SEALANTS

Specifications on concrete for bridge construction

should be in a separate section and should be essentially in agreement with concrete construction requirements in the American Association of State Highway and Transportation Officials, "Standard Specifications for Highway Bridges." Requirements for deck slabs, curbs, gutters, and sidewalks forming an integral part of the bridge should be included in the section concerning concrete for bridge construction.

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1.1 REFERENCES

****

NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest guide specification. Use of SpecsIntact automated reference checking is recommended for projects based on older guide specifications.

****

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.

ACI INTERNATIONAL (ACI)

ACI 117	(1990) Standard Tolerances for Concrete Construction and Materials & Commentary
ACI 211.1	(1991) Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 211.2	(1998) Standard Practice for Selecting Proportions for Structural Lightweight Concrete
ACI 213R	(1987) Guide for Structural Lightweight Aggregate Concrete
ACI 214.3R	(1988; R 1997) Simplified Version of the Recommended Practice for Evaluation of Strength Test Results of Concrete
ACI 301	(1999) Specifications for Structural Concrete for Buildings
ACI 303R	(1991) Guide to Cast-In-Place Architectural Concrete Practice
ACI 305R	(1999) Hot Weather Concreting
ACI 318/318R	(2002) Building Code Requirements for Structural Concrete and Commentary

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182	(1991; R 2000) Burlap Cloth Made from Jute or Kenaf

ASTM INTERNATIONAL (ASTM)

ASTM C 1017/C 1017M	(1998) Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C 1059	(1999) Latex Agents for Bonding Fresh to Hardened Concrete
ASTM C 1064/C 1064M	(20031) Temperature of Freshly Mixed Portland Cement Concrete
ASTM C 1077	(2003) Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C 1107	(2002) Packaged Dry, Hydraulic-Cement Grout(Nonshrink)
ASTM C 1116	(2003) Fiber-Reinforced Concrete and Shotcrete
ASTM C 1240	(2003a) Silica Fume for Use as a Mineral Admixture in Hydraulic-Cement Concrete, Mortar and Grout
ASTM C 131	(2003) Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	(2001) Sieve Analysis of Fine and Coarse Aggregates
ASTM C 143/C 143M	(2003) Slump of Hydraulic Cement Concrete
ASTM C 150	(2002ae1) Portland Cement
ASTM C 171	(2003) Sheet Materials for Curing Concrete
ASTM C 172	(1999) Sampling Freshly Mixed Concrete
ASTM C 173	(1994ael) Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C 192/C 192M	(2002) Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 231	(2003) Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 260	(2001) Air-Entraining Admixtures for Concrete

ASTM C 309	(2003) Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 31/C 31M	(2003a) Making and Curing Concrete Test Specimens in the Field
ASTM C 33	(2003) Concrete Aggregates
ASTM C 330	(2003) Lightweight Aggregates for Structural Concrete
ASTM C 39/C 39M	(2003) Compressive Strength of Cylindrical Concrete Specimens
ASTM C 42/C 42M	(2003) Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C 494/C 494M	(1999ae1) Chemical Admixtures for Concrete
ASTM C 496	(1996) Splitting Tensile Strength of Cyclindrical Concrete Specimens
ASTM C 552	(2000e1) Cellular Glass Thermal Insulation
ASTM C 567	(2000) Determining Density of Structural Lightweight Concrete
ASTM C 578	(2003a) Rigid, Cellular Polystyrene Thermal Insulation
ASTM C 591	(2001) Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM C 595	(2003) Blended Hydraulic Cements
ASTM C 595M	(1997) Blended Hydraulic Cements (Metric)
ASTM C 618	(2003) Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
ASTM C 685	(2000) Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C 78	(2002) Flexural Strength of Concrete (Using Simple Beam With Third-Point Loading)
ASTM C 881	(1999) Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 937	(1997) Grout Fluidifier for Preplaced-Aggregate Concrete
ASTM C 94/C 94M	(2003a) Ready-Mixed Concrete
ASTM C 940	(1998a) Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory

ASTM C 989	(1999) Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
ASTM D 1751	(1999) Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D 1752	(1984; R 1996e1) Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D 75	(2003) Sampling Aggregates
ASTM E 1155	(1996; R 2001) Determining Floor Flatness and Floor Levelness Numbers
ASTM E 1155M	(1996; R 2001) Determining Floor Flatness and Floor Levelness Numbers (Metric)
ASTM E 96	(2000e1) Water Vapor Transmission of Materials

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 44	(2004) NIST Handbook 44: Specifications, Tolerances, and other Technical Requirements for Weighing and Measuring Devices

NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA CPMB 100	(2000) Concrete Plant Standards
NRMCA QC 3	(2002) Quality Control Manual: Section 3, Plant Certifications Checklist: Certification of Ready Mixed Concrete Production Facilities
NRMCA TMMB 100	(2001) Truck Mixer, Agitator and Front Discharge Concrete Carrier Standards

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 104	(1980) Method of Calculation of the Fineness Modulus of 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 540	(2001) Standard Specification for Nonbituminous Inserts for Contraction Joints in Portland Cement Concrete Airfield Pavements, Sawable Type

COE CRD-C 572	(1974) Specifications for Polyvinylchloride Waterstops
COE CRD-C 94	(1966) Specification for Surface Retarders

1.2 UNIT PRICE CONTRACT

****
NOTE: Remove these paragraphs when lump sum contract is required.
****

1.2.1 Measurement

Measurement of concrete for payment will be made on the basis of the actual volume within the pay lines of the structure as indicated on the contract drawings. Measurement for payment of concrete placed against the sides of any excavation without intervening forms will be made only within the pay lines of the structure as shown on the contract drawings. No deductions will be made for rounded or beveled edges, for space occupied by metal work, for conduits, for voids, or for embedded items which are less than 0.15 cubic meters 5 cubic feet in volume or 0.09 square meters 1 square foot in cross section.

1.2.2 Payment

Unless otherwise specified, payment for concrete will be made at the respective unit prices per cubic meter yard for the various items of the schedule, measured as specified above, which price shall include the cost of all labor, materials, and the use of equipment and tools required to complete the concrete work, except for any reinforcement and embedded parts specified to be paid separately. Unit price payment will not be made for concrete placed in structures for which payment is made as a lump sum.

1.3 LUMP SUM CONTRACT

****
NOTE: Remove this paragraph when unit price contract is required.
****

Under this type of contract concrete items will be paid for by lump sum and will not be measured. The work covered by these items consists of furnishing all concrete materials, reinforcement, miscellaneous embedded materials, and equipment, and performing all labor for the forming, manufacture, transporting, placing, finishing, curing, and protection of concrete in these structures.

1.4 SUBMITTALS

****
NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

A "G" following a submittal item indicates that the submittal requires Government approval. Some

submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" 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 projects.

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.

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

SD-03 Product Data

Mixture Proportions[; G][; G, [_____]]

The results of trial mixture design studies along with a statement giving the maximum nominal coarse aggregate size and the proportions of ingredients that will be used in the manufacture of each strength or class of concrete, at least 14 days prior to commencing concrete placing operations. Aggregate weights shall be based on the saturated surface dry condition. The statement shall be accompanied by test results from an approved independent commercial testing laboratory, showing that mixture design studies have been made with materials proposed for the project and that the proportions selected will produce concrete of the qualities indicated. No substitutions shall be made in the materials used in the mixture design studies without additional tests to show that the quality of the concrete is satisfactory.

Lightweight Aggregate Concrete

Written recommendations from lightweight aggregate supplier on batching and mixing cycles.

Dry Shake Finish

Manufacturer's written instructions on application of dry shake

material 15 days prior to start of construction.

SD-04 Samples

Surface Retarder

Sample of surface retarder material with manufacturer's instructions for application in conjunction with air-water cutting.

SD-06 Test Reports

Testing and Inspection for Contractor Quality Control[; G][; G, [_____]]

Certified copies of laboratory test reports, including mill tests and all other test data, for portland cement, blended cement, pozzolan, ground granulated blast furnace slag, silica fume, aggregate, admixtures, and curing compound proposed for use on this project.

SD-07 Certificates

Qualifications

Written documentation for Contractor Quality Control personnel.

1.5 QUALIFICATIONS

Contractor Quality Control personnel assigned to concrete construction shall be American Concrete Institute (ACI) Certified Workmen in one of the following grades or shall have written evidence of having completed similar qualification programs:

Concrete Field Testing Technician, Grade I
Concrete Laboratory Testing Technician, Grade I or II
Concrete Construction Inspector, Level II

Concrete Transportation Construction Inspector or
Reinforced Concrete Special Inspector, Jointly certified by American Concrete Institute (ACI), Building Official and Code Administrators International (BOCA), International Conference of Building Officials (ICBO), and Southern Building Code Congress International (SBCCI).

The foreman or lead journeyman of the flatwork finishing crew shall have similar qualification for ACI Concrete Flatwork Technician/Finisher or equal, with written documentation.

1.6 FIELD TEST PANELS

****
NOTE: Edit these paragraphs as appropriate. Specify location for all field test panels. Add requirements for mock-ups if applicable. Add requirements for slab panels if exposed aggregate slab finish is required or if superflat slab finish is required.
****

Field test panels shall be constructed prior to beginning of work using the materials and procedures proposed for use on the job, to demonstrate the results to be attained. The quality and appearance of each panel shall be subject to the approval of the Contracting Officer, and, if not judged satisfactory, additional panels shall be constructed until approval is attained. Formed or finished surfaces in the completed structure shall match the quality and appearance of the approved field example.

1.6.1 Sample Wall Panels

One sample panel at least 1220 mm 4 feet by 1525 mm 5 feetand 150 mm 6 inches thick shall be constructed to demonstrate Class A formed finish and a similar one for Class B formed finish. Panels shall be located [_____]. Each panel shall include a full length and full width joint line and shall have at least two voids each at least 300 mm 12 inches by 300 mm 12 inches by 75 mm 3 inches deep either impressed in the concrete as placed or chipped in the hardened concrete. After the concrete is 7 days old, the voids shall be patched to demonstrate the effectiveness and the appearance of the Contractor's repair procedures.

1.6.2 Slab Panels

A slab panel at least 1220 mm 4 feet by 1525 mm 5 feet and 100 mm 4 inches thick shall be constructed to demonstrate exposed aggregate slab finish and a similar panel for extra high class slab finish. Panels shall be located [_____]. Each panel shall have a full length joint line.

1.7 SPECIAL REQUIREMENTS

****

NOTE: When the construction includes special items such as very high strength concrete; non-sparking, conductive flooring; acid-resistant concrete; slipforming; super-flat floors; etc., a pre-installation meeting will be required. In which case this paragraph will be retained with appropriate editing and identification.

****

A pre-installation meeting with the Contracting Officer will be required at least 10 days prior to start of construction on [_____]. The Contractor shall be responsible for calling the meeting; the Project Superintendent and active installation personnel shall be present.

1.8 GENERAL REQUIREMENTS

****

NOTE: In addition to specified requirements the following information will be shown on project drawings:

1. Assumed temperature range when temperature stresses are a factor in design.

2. Details of concrete sections showing dimensions, reinforcement cover, and required camber.

3. Joint details showing locations and dimensions, including critical construction joints, indicating

waterstop locations and splices, keys, and dowels when required.

4. Locations where structural lightweight concrete will be used.

5. Details which require a depressed structural slab for tile, terrazzo, or other floor finishes in order to provide finished surfaces at the same elevations.

6. When exposed concrete surfaces are specified, the locations in the finished structure shall be indicated. If other than cast finish is required, the type and location shall be indicated.

7. Loading assumptions

8. Material strengths used in design, and f'c.

****

1.8.1 Tolerances

****

NOTE: Insert any special tolerance requirements of the project. Select the method desired for floor finish tolerance and delete the other. Do not use both as a Contractor's option. An effort should be made to begin to convert to the F-system for floor slabs. The F-system should always be used where very flat floors are required, particularly warehouse aisles where high-lift forklift units or other similar stackers will operate.

****

Except as otherwise specified herein, tolerances for concrete batching, mixture properties, and construction as well as definition of terms and application practices shall be in accordance with ACI 117. 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.

1.8.1.1 Floors

For the purpose of this Section the following terminology correlation between ACI 117 and this Section shall apply:

Floor Profile Quality Classification From ACI 117	This Section
Conventional Bullfloated	Same
Conventional Straightedged	Same
Flat	Float Finish or Trowel Finish
Very Flat	Same. Use only with F-system

Levelness tolerance shall not apply where design requires floors to be sloped to drains or sloped for other reasons.

1.8.1.2 Floors by the F-Number System

The flatness and levelness of floors shall be carefully controlled and the tolerances shall be measured by the F-Number system of Paragraph 4.5.6 and 4.5.6.1 of ACI 117. The Contractor shall furnish an approved floor profilograph or other equipment capable of measuring the floor flatness (FF) number and the floor levelness (FL) number in accordance with ASTM E 1155M ASTM E 1155. The Contractor shall perform the tolerance measurements within 72 hours after floor slab construction while being observed by the Contracting Officer. The tolerances of surfaces beyond the limits of ASTM E 1155M ASTM E 1155 (the areas within 600 mm 24 inches of embedments and construction joints) shall be acceptable to the Contracting Officer. Tolerances of the following areas shall meet the requirements for the listed surfaces as specified in paragraphs 4.5.6 and 4.5.6.1 of ACI 117.

Bullfloated-	Areas	[_____]
Straightedged-	Areas	[_____]
Float Finish-	Areas	[_____]
Trowel Finish-	Areas	[_____]
Very Flat-	Areas	[_____]

1.8.1.3 Floors by the Straightedge System

The flatness of the floors shall be carefully controlled and the tolerances shall be measured by the straightedge system as specified in paragraph 4.5.7 of ACI 117, using a 3 m 10 foot straightedge, within 72 hours after floor slab installation and before shores and/or forms are removed. The listed tolerances shall be met at any and every location at which the straightedge can be placed.

Bullfloated	[_____]
Straightedged	[_____]
Float Finish	[_____]
Trowel Finish	[_____]

1.8.2 Strength Requirements and w/c Ratio

1.8.2.1 Strength Requirements

****

NOTE: The designer will list the strengths of concrete for the job and the uses for each. A 28-day compressive strength of 20 MPa (3000 psi) will be required for most building work. Concrete of 27.5 MPa (4000 psi) should be used in containers for liquids, and in other structures where loading, durability, or wear requirements dictate. Higher compressive strengths will be used if required by structural design. A 28-day flexural strength of 4.5 MPa (650 psi) will normally be specified for slabs on grade subject to vehicular traffic; however, since cylinders are easier to cast and test than beams, 27.5 MPa (4000 psi) compressive strength concrete may be specified if past experience has shown this to be appropriate. Concrete for hangar floors will be designed according to airfield pavement criteria and will be specified in Section 02513 CONCRETE PAVEMENT FOR AIRFIELDS AND OTHER HEAVY-DUTY PAVEMENTS.

When the designer considers it appropriate, 90-day compressive or flexural strength may be specified in lieu of 28-day, but not both.

****

Specified compressive strength (f'c) shall be as follows:

COMPRESSIVE STRENGTH	STRUCTURE OR PORTION OF STRUCTURE
[35 MPa 5000 psi at 28 days	[_____]]
[27.5 MPa 4000 psi at 28 days	[_____]]
[20 MPa 3000 psi at 28 days	[_____]]
[[_____] MPa [_____] psi at [_____] days	[_____]]

Concrete slabs on-grade shall have a 28-day flexural strength of [4.5] [_____] MPa.[650] [_____] psi. Concrete made with high-early strength cement shall have a 7-day strength equal to the specified 28-day strength for concrete made with Type I or II portland cement. Compressive strength shall be determined in accordance with ASTM C 39/C 39M. Flexural strength shall be determined in accordance with ASTM C 78.

a. Evaluation of Concrete Compressive Strength. Compressive strength specimens (152 by 305 mm 6 by 12 inch cylinders) shall be fabricated by the Contractor and laboratory cured in accordance with ASTM C 31/C 31M and tested in accordance with ASTM C 39/C 39M. The strength of the concrete will be considered satisfactory so long as the average of all sets of three consecutive test results equals or exceeds the specified compressive strength f'c and no individual test result falls below the specified strength f'c by more than 3.5 MPa.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 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.

b. Investigation of Low-Strength Compressive 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, steps shall be taken to assure that the load-carrying capacity of the structure is not jeopardized. When the strength of concrete in place is considered potentially deficient, cores shall be obtained and tested in accordance with ASTM C 42/C 42M. At least three representative cores shall be taken from each member or area of concrete in place that is considered potentially deficient. The location of cores will be determined by the Contracting Officer to least impair the strength 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. Non-destructive tests (tests other than test cylinders or cores) shall not be used as a basis for acceptance or rejection. The Contractor shall perform the coring and repair the holes. Cores will be tested by the Government.

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 318/318R. Concrete work evaluated by structural analysis or by results of a load test as being understrength shall be corrected in a manner satisfactory to the Contracting Officer. All investigations, testing, load tests, and correction of deficiencies shall be performed by and at the expense of the Contractor and must be approved by the Contracting Officer, except that if all concrete is found to be in compliance with the drawings and specifications, the cost of investigations, testing, and load tests will be at the expense of the Government.

d. Evaluation of Concrete Flexural Strength. Flexural strength specimens (beams) shall be fabricated by the Contractor and laboratory cured in accordance with ASTM C 31/C 31M and tested in accordance with ASTM C 78. 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 flexural strength and no individual test result falls below the specified flexural strength by more than 350 kPa.50 psi.A "test" is defined as the average of two companion beams. Additional analysis or testing, including taking cores and/or load tests may be required at the Contractor's expense when the strength of the concrete in the slab is considered potentially deficient.

1.8.2.2 Water-Cement Ratio

****
NOTE: Where durability or other factors are a major consideration, retain this paragraph limiting w/c; coordinate this subparagraph with paragraph MIXTURE PROPORTIONS and its subparagraphs before deleting any of the contents, otherwise delete. When cementitious materials other than portland cement are used, retain the last two sentences. Consult EM 1110-2-2000 to fill in the blanks and to select the appropriate w/c.
****

Maximum water-cement ratio (w/c) for normal weight concrete shall be as follows:

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

These w/c's may cause higher strengths than that required above for compressive or flexural strength. The maximum w/c required will be the equivalent w/c as determined by conversion from the weight ratio of water to cement plus pozzolan, silica fume, and ground granulated blast furnace slag (GGBF slag) by the weight equivalency method as described in ACI 211.1. In the case where silica fume or GGBF slag is used, the weight of the silica fume and GGBF slag shall be included in the equations of ACI 211.1 for the term P which is used to denote the weight of pozzolan.

1.8.3 Air Entrainment

****
NOTE: Remove last two sentences when lightweight concrete is not required.
****

Except as otherwise specified for lightweight concrete, all normal weight concrete shall be air entrained to contain between 4 and 7 percent total air, except that when the nominal maximum size coarse aggregate is 19 mm 3/4 inch or smaller it shall be between 4.5 and 7.5 percent. Concrete with specified strength over 35 MPa 5000 psi may have 1.0 percent less air than specified above. Specified air content shall be attained at point of placement into the forms. Air content for normal weight concrete shall be determined in accordance with ASTM C 231. Lightweight concrete in the [_____] parts of the structure shall be air-entrained with a total air content of 4.5 to 7.5 percent, except that if the nominal maximum size coarse aggregate is 9.5 mm 3/8 inch or less, the air content shall be 5.5 to 8.5 percent. Air content for lightweight concrete shall be determined in accordance with ASTM C 173.

1.8.4 Slump

****
NOTE: Use the sentence in the first set of brackets when those admixtures are permitted by the specifications. Add special slump requirements for Class 8 and 9 floor slabs from ACI 302, when such floors are to be constructed. Edit for lightweight concrete as required.
****

Slump of the concrete, as delivered to the point of placement into the forms, shall be within the following limits. Slump shall be determined in accordance with ASTM C 143/C 143M.

Structural Element	Slump Minimum	Slump Maximum
Walls, columns and beams	50 mm 2 in.	100 mm 4 in.
Foundation walls, substructure walls, footings, slabs	25 mm 1 in.	75 mm 3 in.
Any structural concrete approved for placement by pumping:		
At pump	50 mm 2 in.	150 mm 6 in.
At discharge of line	25 mm 1 in.	100 mm 4 in.

[When use of a plasticizing admixture conforming to ASTM C 1017/C 1017M or when a Type F or G high range water reducing admixture conforming to ASTM C 494/C 494M is permitted to increase the slump of concrete, concrete shall have a slump of 50 to 100 mm 2 to 4 inches before the admixture is added and a maximum slump of 200 mm 8 inches at the point of delivery after the admixture is added.] [For troweled floors, slump of structural lightweight concrete with normal weight sand placed by pump shall not exceed 125 mm 5

inches at the point of placement. For other slabs, slump of lightweight concrete shall not exceed 100 mm 4 inches at point of placement.]

1.8.5 Concrete Temperature

The temperature of the concrete as delivered shall not exceed 32 degrees C. 90 degrees F. When the ambient temperature during placing is 5 degrees C 40 degrees F or less, or is expected to be at any time within 6 hours after placing, the temperature of the concrete as delivered shall be between 12 and 25 degrees C.55 and 75 degrees F.

1.8.6 Size of Coarse Aggregate

The largest feasible nominal maximum size aggregate (NMSA) specified in paragraph AGGREGATES shall be used in each placement. However, nominal maximum size of aggregate shall not exceed any of the following: three-fourths of the minimum cover for reinforcing bars, three-fourths of the minimum clear spacing between reinforcing bars, one-fifth of the narrowest dimension between sides of forms, or one-third of the thickness of slabs or toppings.

1.8.7 Special Properties and Products

****

NOTE: If the use of a particular type of admixture is required for certain parts of the structure, this paragraph should be revised accordingly.

****

Concrete may contain admixtures other than air entraining agents, such as water reducers, superplasticizers, or set retarding agents to provide special properties to the concrete, if specified or approved. Any of these materials to be used on the project shall be used in the mix design studies.

1.8.8 Lightweight Aggregate Structural Concrete

****

NOTE: Retain this paragraph when lightweight aggregate structural concrete is required. Use bracketed alternate strength inserts (compressive or splitting tensile strength) as appropriate. Correlate strength versus unit weight requirements as determined from table in ASTM C 330, and as determined by consultation with local producers. Remove last sentence when floor fill is not required.

****

Lightweight aggregate structural concrete shall conform to the requirements specified for normal weight concrete except as specified herein. [Specified compressive strength shall be at least [_____] at 28 days,] [Specified splitting tensile strength determined in accordance with ASTM C 496 shall be at least [_____] at 28 days,] as determined by test specimens that have been air dried at 50 percent relative humidity for the last 21 days. Air-dry unit weight shall be not over [_____] at 28 days as determined by ASTM C 567. However, fresh unit weight shall be used for acceptance during concreting, using a correlation factor between the two types of unit weight as determined during mixture design studies. Lightweight aggregate structural concrete floor fill shall have a 28-day compressive strength of at least 17.3 MPa 2500 psi and an air-dry unit

weight not exceeding 1850 kg/cubic meter.115 pcf.

1.8.9 Technical Service for Specialized Concrete

****
NOTE: Use this paragraph when lightweight aggregate structural concrete is specified or for other specialized concretes like those containing silica fume.
****

The services of a factory trained technical representative shall be obtained to oversee proportioning, batching, mixing, placing, consolidating, and finishing of specialized structural concrete, such as [_____]. The technical representative shall be on the job full time until the Contracting Officer is satisfied that field controls indicate concrete of specified quality is furnished and that the Contractor's crews are capable of continued satisfactory work. The technical representative shall be available for consultation with, and advice to, Government forces.

1.9 MIXTURE PROPORTIONS

****
NOTE: This paragraph places the responsibility for mixture proportioning on the Contractor. Where Government mix design is required, the entire paragraph will be revised accordingly. Do not delete 15 percent minimum for pozzolan, unless pozzolan is prohibited.
****

Concrete shall be composed of portland cement, other cementitious and pozzolanic materials as specified, aggregates, water and admixtures as specified.

1.9.1 Proportioning Studies for Normal Weight Concrete

Trial design batches, mixture proportioning studies, and testing requirements for various classes and types of concrete specified shall be the responsibility of the Contractor. Except as specified for flexural strength concrete, mixture proportions shall be based on compressive strength as determined by test specimens fabricated in accordance with ASTM C 192/C 192M and tested in accordance with ASTM C 39/C 39M. Samples of all materials used in mixture proportioning studies shall be representative of those proposed for use in the project and shall be accompanied by the manufacturer's or producer's test reports indicating compliance with these specifications. Trial mixtures having proportions, consistencies, and air content suitable for the work shall be made based on methodology described in ACI 211.1, using at least three different water-cement ratios for each type of mixture, which will produce a range of strength encompassing those required for each class and type of concrete required on the project. The maximum water-cement ratios required in subparagraph Water-Cement Ratio will be the equivalent water-cement ratio as determined by conversion from the weight ratio of water to cement plus pozzolan, silica fume, and ground granulated blast furnace slag (GGBF slag) by the weight equivalency method as described in ACI 211.1. In the case where silica fume or GGBF slag is used, the weight of the silica fume and GGBF slag shall be included in the equations in ACI 211.1 for the term P, which is used to denote the weight of pozzolan. If pozzolan is used in the concrete mixture, the minimum

pozzolan content shall be 15 percent by weight of the total cementitious material, and the maximum shall be 35 percent. Laboratory trial mixtures shall be designed for maximum permitted slump and air content. Separate sets of trial mixture studies shall be made for each combination of cementitious materials and each combination of admixtures proposed for use. No combination of either shall be used until proven by such studies, except that, if approved in writing and otherwise permitted by these specifications, an accelerator or a retarder may be used without separate trial mixture study. Separate trial mixture studies shall also be made for concrete for any conveying or placing method proposed which requires special properties and for concrete to be placed in unusually difficult placing locations. 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 withASTM C 192/C 192M. They shall be tested at 7 and 28 days in accordance with ASTM C 39/C 39M. From these test results, a curve shall be plotted showing the relationship between water-cement ratio and strength for each set of trial mix studies. In addition, a curve shall be plotted showing the relationship between 7 day and 28 day strengths. Each mixture shall be designed to promote easy and suitable concrete placement, consolidation and finishing, and to prevent segregation and excessive bleeding.

1.9.2 Proportioning Studies for Flexural Strength Concrete

****

NOTE: Retain this paragraph only when the design requires flexural strength concrete.

****

Trial design batches, mixture proportioning studies, and testing requirements shall conform to the requirements specified in paragraph Proportioning Studies for Normal Weight Concrete, except that proportions shall be based on flexural strength as determined by test specimens (beams) fabricated in accordance with ASTM C 192/C 192M and tested in accordance with ASTM C 78. Procedures given in ACI 211.1 shall be modified as necessary to accommodate flexural strength.

1.9.3 Proportioning Studies for Lightweight Aggregate Structural Concrete

Trial design batches, mixture proportioning studies, and testing requirements shall conform to the requirements specified in paragraph Proportioning Studies for Normal Weight Concrete, except as follows. Trial mixtures having proportions, consistencies and air content suitable for the work shall be made based on methodology described in ACI 211.2, using at least three different cement contents. Trial mixes shall be proportioned to produce air dry unit weight and concrete strengths specified in paragraph GENERAL REQUIREMENTS. Trial mixtures shall be proportioned for maximum permitted slump and air content. Test specimens and testing shall be as specified for normal weight concrete except that [28-day compressive strength] [splitting tensile strength in accordance with ASTM C 496] shall be determined from test cylinders that have been air dried at 50 percent relative humidity for the last 21 days. Air dry unit weight shall be determined in accordance with ASTM C 567 and shall be designed to be at least 32 kg per cubic meter 2.0 pcf less than the maximum specified air dry unit weight in paragraph GENERAL REQUIREMENTS. Curves shall be plotted using these results showing the relationship between cement factor and strength and air dry unit weight. Normal weight fine aggregate may be substituted for part or all of the lightweight fine aggregate, provided the concrete meets the strength and unit weight. A correlation shall also be

developed showing the ratio between air dry unit weight and fresh concrete unit weight for each mix.

1.9.4 Average Compressive Strength Required for Mixtures

The mixture proportions selected during mixture design studies shall produce a required average compressive strength (f'cr) exceeding the specified compressive strength (f'c) by the amount indicated below. This required average compressive strength, f'cr, will not be a required acceptance criteria during concrete production. However, whenever the daily average compressive strength at 28 days drops below f'cr during concrete production, or daily average 7-day strength drops below a strength correlated with the 28-day f'cr, the mixture shall be adjusted, as approved, to bring the daily average back up to f'cr. During production, the required f'cr shall be adjusted, as appropriate, based on the standard deviation being attained on the job.

1.9.4.1 Computations from Test Records

Where a concrete production facility has test records, a standard deviation shall be established in accordance with the applicable provisions of ACI 214.3R. 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 7 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. 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 where units are in MPaf'cr = f'c + 1.34S where units are in psi

f'cr = f'c + 2.33S - 3.45 where units are in MPaf'cr = f'c + 2.33S - 500 where units are in psi

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
15	1.16
20	1.08
25	1.03
30 or more	1.00

1.9.4.2 Computations without Previous Test Records

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

a. If the specified compressive strength f'c is less than 20 MPa, 3,000 psi,

f'cr = f'c + 6.9 MPa f'cr = f'c + 1000 psi

b. If the specified compressive strength f'c is 20 to 35 MPa, 3,000 to 5,000 psi,

f'cr = f'c + 8.3 MPa f'cr = f'c + 1,200 psi

c. If the specified compressive strength f'c is over 35 MPa, 5,000 psi,

f'cr = f'c + 9.7 MPa f'cr = f'c + 1,400 psi

1.9.5 Average Flexural Strength Required for Mixtures

****
NOTE: Retain this paragraph when flexural strength mixtures are used.
****

The mixture proportions selected during mixture design studies for flexural strength mixtures and the mixture used during concrete production shall be designed and adjusted during concrete production as approved, except that the overdesign for average flexural strength shall simply be 15 percent greater than the specified flexural strength at all times.

1.9.6 Mix Design for Bonded Topping for Heavy Duty Floors

****
NOTE: Retain this paragraph when design requires heavy duty floors.
****

The concrete mix design for bonded topping for heavy duty floors shall contain the greatest practical proportion of coarse aggregate within the specified proportion limits. The mix shall be designed to produce concrete having a 28-day strength of at least 34.5 MPa.5000 psi. Concrete for the topping shall consist of the following proportions, by weight:

1.00 part portland cement
1.15 to 1.25 parts fine aggregate
1.80 to 2.00 parts coarse aggregate

Maximum w/c shall be 0.33. The topping concrete shall not be air-entrained. The concrete shall be mixed so as to produce a mixture of the driest consistency possible to work with a sawing motion of the strike-off and which can be floated and compacted as specified without producing water or excess cement at the surface. In no case shall slump exceed 25 mm 1 inch as determined by ASTM C 143/C 143M.

1.10 STORAGE OF MATERIALS

Cement and other cementitious materials shall be stored in weathertight buildings, bins, or silos which will exclude moisture and contaminants and keep each material completely separated. Aggregate stockpiles shall be arranged and used in a manner to avoid excessive segregation and to prevent

contamination with other materials or with other sizes of aggregates. Aggregate shall not be stored directly on ground unless a sacrificial layer is left undisturbed. Reinforcing bars and accessories shall be stored above the ground on platforms, skids or other supports. Other materials shall be stored in such a manner as to avoid contamination and deterioration. Admixtures which have been in storage at the project site for longer than 6 months or which have been subjected to freezing shall not be used unless retested and proven to meet the specified requirements. Materials shall be capable of being accurately identified after bundles or containers are opened.

1.11 GOVERNMENT ASSURANCE INSPECTION AND TESTING

Day-to day inspection and testing shall be the responsibility of the Contractor Quality Control (CQC) staff. However, representatives of the Contracting Officer can and will inspect construction as considered appropriate and will monitor operations of the Contractor's CQC staff. Government inspection or testing will not relieve the Contractor of any of his CQC responsibilities.

1.11.1 Materials

The Government will sample and test aggregates, cementitious materials, other materials, and concrete to determine compliance with the specifications as considered appropriate. The Contractor shall provide facilities and labor as may be necessary for procurement of representative test samples. Samples of aggregates will be obtained at the point of batching in accordance with ASTM D 75. Other materials will be sampled from storage at the jobsite or from other locations as considered appropriate. Samples may be placed in storage for later testing when appropriate.

1.11.2 Fresh Concrete

Fresh concrete will be sampled as delivered in accordance with ASTM C 172 and tested in accordance with these specifications, as considered necessary.

1.11.3 Hardened Concrete

Tests on hardened concrete will be performed by the Government when such tests are considered necessary.

1.11.4 Inspection

Concrete operations may be tested and inspected by the Government as the project progresses. Failure to detect defective work or material will not prevent rejection later when a defect is discovered nor will it obligate the Government for final acceptance.

PART 2 PRODUCTS

****
NOTE: Edit this PART to include only those products which are locally available, are required by the project, and are acceptable to the designer.
****

2.1 CEMENTITIOUS MATERIALS

****

NOTE: EPA recommends that procuring agencies use flowable fill containing coal fly ash (pozzolan) and/or ferrous foundry sands for backfill and other fill applications. EPA further recommends that procuring agencies include provisions in all construction contracts involving backfill or other fill applications, to allow for the use of flowable fill containing coal fly ash and/or ferrous foundry sands, where appropriate.

Include the limits on soluble alkalies for portland cement and for pozzolan whenever there is a possibility of alkali-aggregate reactive aggregates being furnished.

Where alkali-bearing soil or groundwater is encountered, or where the concrete will be exposed to seawater, brackish water, or sewage, see ACI 201.2 R for guidance on selecting cementitious material. See EM 1110-2-2000 for guidance when proposing to use any type of portland-pozzolan or portland-furnace-slag cement.

Edit bracketed items as required.

****

Cementitious Materials shall be portland cement, [portland-pozzolan cement,] [portland blast-furnace slag cement,] or portland cement in combination with [pozzolan] [or ground granulated blast furnace slag] [or silica fume] and shall conform to appropriate specifications listed below. Use of cementitious materials in concrete which will have surfaces exposed in the completed structure shall be restricted so there is no change in color, source, or type of cementitious material.

2.1.1 Portland Cement

ASTM C 150, Type I [low alkali] with a maximum 15 percent amount of tricalcium aluminate, or Type II [low alkali] [including false set requirements] or [Type V]. 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 shall be used only in specific areas of the structure, when approved in writing.

2.1.2 High-Early-Strength Portland Cement

ASTM C 150, Type III with tricalcium aluminate limited to [5] [8] percent, [low alkali]. Type III cement shall be used only in isolated instances and only when approved in writing.

2.1.3 Blended Cements

****

NOTE: Never specify I(PM) or I(SM) cement.

****

ASTM C 595M ASTM C 595, Type [IP] [IP (MS)] [IP (MH)] [IS] [IS (MS)] [IS

(MH)].

2.1.4 Pozzolan (Fly Ash)

ASTM C 618, Class [C] [F] with the optional requirements for multiple factor, drying shrinkage, and uniformity from Table 2A of ASTM C 618. [Requirement for maximum alkalies from Table 1A of ASTM C 618 shall apply]. If pozzolan is used, it shall never be less than 15 percent nor more than 35 percent by weight of the total cementitious material. The Contractor shall comply with EPA requirements in accordance with Section 01670 RECYCLED / RECOVERED MATERIALS.

2.1.5 Ground Granulated Blast-Furnace (GGBF) Slag

ASTM C 989, Grade 120.

2.1.6 Silica Fume

****

NOTE: Silica Fume Concrete should be used where low permeability and enhanced durability are necessary and justified by additional cost, such as marine structures, other places where low permeability is needed, and severe abrasion resistance. Finishing is more difficult than conventional concrete. Proper curing is essential because there is a strong tendency for severe plastic shrinkage cracking.

Supervision by manufacturer's representative should be required during batching, finishing, and curing at start-up of the job. A HRWR recommended by the manufacturer of the silica fume should be used.

****

Silica fume shall conform to ASTM C 1240. Available alkalies shall conform to the optimal limit given in Table 2 of ASTM C 1240. Silica fume may be furnished as a dry, densified material or as a slurry. In accordance with paragraph Technical Service for Specialized Concrete, the Contractor shall provide at no cost to the Government the services of a manufacturer's technical representative experienced in mixing, proportioning, placement procedures, and curing of concrete containing silica fume.

2.2 AGGREGATES

****

NOTE: Edit and fill in the blanks as appropriate. Consideration should always be given to the local aggregate supply situation, quality, and availability.

****

Aggregates shall conform to the following.

2.2.1 Fine Aggregate

Fine aggregate shall conform to the quality and gradation requirements of ASTM C 33.

2.2.2 Coarse Aggregate

Coarse aggregate shall conform to ASTM C 33, Class 5S, size designation [_____].

2.2.3 Lightweight Aggregate

Lightweight fine and coarse aggregate shall conform to the quality and gradation requirements of ASTM C 330, size [_____] for coarse aggregate. Lightweight aggregate shall be prewetted in accordance with the Manufacturer's instructions unless otherwise specified. For pumped concrete, prewetting shall be sufficient to ensure that slump loss through the pump line does not exceed 100 mm. \4 inches.

2.2.4 Materials for Bonded Topping for Heavy Duty Floors

In addition to the requirements specified above, coarse aggregate used for this purpose shall be a well graded, hard, sound diabase, trap rock, emery, granite or other natural or manufactured aggregate having equivalent hardness and wearing qualities and shall have a percentage of loss not to exceed 30 after 500 revolutions when tested in accordance with ASTM C 131. Gradation of the aggregates when tested in accordance with ASTM C 136 shall be as follows:

Coarse Aggregate

Sieve Size	Cumulative Percent By Weight Passing
19 mm 3/4 in.	100
12.5 mm 1/2 in.	50-100
9.5 mm 3/8 in.	25-50
4.75 mm No. 4	0-15
2.36 mm No. 8	0-8

Fine Aggregate

Sieve Size	Cumulative Percent By Weight Passing
9.5 mm 3/8 in.	100
4.75 mm No. 4	95-100
2.36 mm No. 8	65-80
1.18 mm No. 16	45-65
0.600 mm No. 30	25-45
0.300 mm No. 50	5-15
0.150 mm No. 100	0-5

2.3 CHEMICAL ADMIXTURES

****
NOTE: Edit as appropriate for the project. Do not permit the use of calcium chloride.
****

Chemical admixtures, when required or permitted, shall conform to the appropriate specification listed. Admixtures shall be furnished in liquid

form and of suitable concentration for easy, accurate control of dispensing.

2.3.1 Air-Entraining Admixture

ASTM C 260 and shall consistently entrain the air content in the specified ranges under field conditions.

2.3.2 Accelerating Admixture

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

2.3.3 Water-Reducing or Retarding Admixture

ASTM C 494/C 494M, Type A, B, or D, except that the 6-month and 1-year compressive and flexural strength tests are waived.

2.3.4 High-Range Water Reducer

****
NOTE: Use this paragraph only when high-range water reducing admixture is allowed in paragraph SLUMP in PART 1.
****

ASTM C 494/C 494M, Type F or G, except that the 6-month and 1-year strength requirements are waived. The admixture shall be used only when approved in writing, such approval being contingent upon particular mixture control as described in the Contractor's Quality Control Plan and upon performance of separate mixture design studies.

2.3.5 Surface Retarder

COE CRD-C 94.

2.3.6 Expanding Admixture

Aluminum powder type expanding admixture conforming to ASTM C 937.

2.3.7 Other Chemical Admixtures

****
NOTE: Use this paragraph only when a plasticizing admixture is allowed in paragraph SLUMP in PART 1.
****

Chemical admixtures for use in producing flowing concrete shall comply with ASTM C 1017/C 1017M, Type I or II. These admixtures shall be used only when approved in writing, such approval being contingent upon particular mixture control as described in the Contractor's Quality Control Plan and upon performance of separate mixture design studies.

2.4 CURING MATERIALS

2.4.1 Impervious-Sheet

Impervious-sheet materials shall conform to ASTM C 171, type optional, except, that polyethylene sheet shall not be used.

2.4.2 Membrane-Forming Compound

Membrane-Forming curing compound shall conform to ASTM C 309, Type 1-D or 2, except that only a styrene acrylate or chlorinated rubber compound meeting Class B requirements shall be used for surfaces that are to be painted or are to receive bituminous roofing, or waterproofing, or floors that are to receive adhesive applications of resilient flooring. The curing compound selected shall be compatible with any subsequent paint, roofing, waterproofing, or flooring specified. Nonpigmented compound shall contain a fugitive dye, and shall have the reflective requirements in ASTM C 309 waived.

2.4.3 Burlap and Cotton Mat

Burlap and cotton mat used for curing shall conform to AASHTO M 182.

2.5 WATER

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

2.6 NONSHRINK GROUT

Nonshrink grout shall conform to ASTM C 1107, Grade [A] [B] [C], and shall be a commercial formulation suitable for the proposed application.

2.7 NONSLIP SURFACING MATERIAL

Nonslip surfacing material shall consist of 55 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 cement 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 0.6 mm No. 30 sieve to particles passing the 2.36 mm No. 8 sieve.

2.8 LATEX BONDING AGENT

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

2.9 EPOXY RESIN

Epoxy resins for use in repairs shall conform to ASTM C 881, Type V, Grade 2. Class as appropriate to the existing ambient and surface temperatures.

2.10 EMBEDDED ITEMS

Embedded items shall be of the size and type indicated or as needed for the application. Dovetail slots shall be galvanized steel. Hangers for suspended ceilings shall be as specified in Section 09510 ACOUSTICAL CEILINGS. Inserts for shelf angles and bolt hangers shall be of malleable iron or cast or wrought steel.

2.11 FLOOR HARDENER

****

NOTE: Floor hardener should only be specified on

specialized indoor floors where dusting of concrete would present an unusual problem or where specially requested by the Using Service.

****

Floor hardener shall be a colorless aqueous solution containing zinc silicofluoride, magnesium silicofluoride, or sodium silicofluoride. These silicofluorides can be used individually or in combination. Proprietary hardeners may be used if approved in writing by the Contracting Officer.

2.12 PERIMETER INSULATION

****

NOTE: Show required K-value on the drawings.

****

Perimeter insulation shall be polystyrene conforming to ASTM C 578, Type II; polyurethane conforming to ASTM C 591, Type II; or cellular glass conforming to ASTM C 552, Type I or IV. The Contractor shall comply with EPA requirements in accordance with Section 01670 RECYCLED / RECOVERED MATERIALS.

2.13 VAPOR BARRIER

Vapor barrier shall be polyethylene sheeting with a minimum thickness of 0.15 mm (6 mils) 6 mils or other equivalent material having a vapor permeance rating not exceeding 30 nanograms per Pascal per second per square meter (0.5 perms) 0.5 perms as determined in accordance with ASTM E 96.

2.14 JOINT MATERIALS

2.14.1 Joint Fillers, Sealers, and Waterstops

****

NOTE: Do not use bituminous filler with non-bituminous sealer. Designer will edit bracketed items for joint sealing.

****

Expansion joint fillers shall be preformed materials conforming to [ASTM D 1751] [ASTM D 1752]. Materials for waterstops shall be in accordance with Section 03150A EXPANSION JOINTS, CONTRACTION JOINTS, AND WATERSTOPS. Materials for and sealing of joints shall conform to the requirements of Section [07920] JOINT SEALANTS [02760 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS] [02762 COMPRESSION JOINT SEALS FOR CONCRETE PAVEMENTS].

2.14.2 Contraction Joints in Slabs

Sawable type contraction joint inserts shall conform to COE CRD-C 540. Nonsawable joint inserts shall have sufficient stiffness to permit placement in plastic concrete without undue deviation from a straight line and shall conform to the physical requirements of COE CRD-C 540, with the exception of Section 3.4 "Resistance to Sawing". Plastic inserts shall be polyvinyl chloride conforming to the materials requirements of COE CRD-C 572.

2.15 SYNTHETIC FIBERS FOR REINFORCING

****
NOTE: Use fiber reinforcement only when approved by the designer; in that case retain this paragraph. Drawings should indicate where fiber reinforced concrete is located. Fiber reinforcing is used to help control cracking due to drying shrinkage and thermal expansion/contraction; reduce permeability; and increase impact capacity, shatter and abrasion resistance, and toughness. Fiber reinforcing will not: control cracking due to structural stresses, significantly increase strength, control curling or creeping, justify reducing structural members, eliminate control joints, or replace any moment or structural steel reinforcement. Include flexural toughness tests when synthetic reinforcement fibers are used to increase toughness and when justified by size and importance of the job, but not when fibers are used only to control shrinkage cracking. Include technical representative requirement when warranted by size and importance of the job.
****

Synthetic fibers shall conform to ASTM C 1116, Type III, Synthetic Fiber, and as follows. Fibers shall be 100 percent virgin polypropylene fibrillated fibers containing no reprocessed olefin materials. Fibers shall have a specific gravity of 0.9, a minimum tensile strength of 480 MPa 70 ksi graded per manufacturer, and specifically manufactured to an optimum gradation for use as concrete secondary reinforcement.

SHAKE=TOPPING> =REINFORCING> • SHAKE=TOPPING> =REINFORCING> • SHAKE=TOPPING> =REINFORCING> • SHAKE=TOPPING> =REINFORCING> • SHAKE=TOPPING> =REINFORCING> • SHAKE=TOPPING> =REINFORCING> •2.16 DRY SHAKE FLOOR TOPPING MATERIAL

****
NOTE: Edit and supplement this paragraph for light reflective, spark resistant, static disseminating floors as applicable to the project.
****

Dry shake floor topping material shall be a premixed ready-to-use dry shake. It shall be proportioned, mixed and packaged at the factory, and delivered to the jobsite in sealed, moisture resistant bags, ready to apply, finish and cure. The manufacturer of the dry shake material shall have at least 10 years experience in the manufacture of such material. Any material from a manufacturer who makes any disclaimer of the materials performance shall not be used.

PART 3 EXECUTION

3.1 PREPARATION FOR PLACING

Before commencing concrete placement, the following shall be performed. Surfaces to receive concrete shall be clean and free from frost, ice, mud, and water. Forms shall be in place, cleaned, coated, and adequately supported, in accordance with Section 03100A STRUCTURAL CONCRETE FORMWORK. Reinforcing steel shall be in place, cleaned, tied, and adequately supported, in accordance with Section 03200A CONCRETE REINFORCEMENT.

Transporting and conveying equipment shall be in-place, ready for use, clean, and free of hardened concrete and foreign material. Equipment for consolidating concrete shall be at the placing site and in proper working order. Equipment and material for curing and for protecting concrete from weather or mechanical damage shall be at the placing site, in proper working condition and in sufficient amount for the entire placement. When hot, windy conditions during concreting appear probable, equipment and material shall be at the placing site to provide windbreaks, shading, fogging, or other action to prevent plastic shrinkage cracking or other damaging drying of the concrete.

3.1.1 Foundations

3.1.1.1 Concrete on Earth Foundations

Earth (subgrade, base, or subbase courses) 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 foundation shall be well drained and shall be satisfactorily graded and uniformly compacted.

3.1.1.2 Preparation of Rock

Rock surfaces upon which concrete is to be placed shall be 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, rock surfaces shall be cleaned thoroughly by the use of air-water jets or sandblasting as specified below for Previously Placed Concrete. Rock surfaces shall be kept continuously moist for at least 24 hours immediately prior to placing concrete thereon. All horizontal and 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. Concrete shall be placed before the mortar stiffens.

3.1.1.3 Excavated Surfaces in Lieu of Forms

****

NOTE: Delete this paragraph when forms are required.

****

Concrete for [footings] [and] [walls] may be placed directly against the soil provided the earth or rock has been carefully trimmed, is uniform and stable, and meets the compaction requirements of Section 02300 EARTHWORK. The concrete shall be placed without becoming contaminated by loose material, and the outline of the concrete shall be within the specified tolerances.

3.1.2 Previously Placed Concrete

****

NOTE: If structure has few construction joints to be bonded, none of them critical, remove the following requirements except for subparagraph Preparation of Previously Placed Concrete. Otherwise, use the following requirements and remove subparagraph Preparation of Previously Placed Concrete.

****

Concrete surfaces to which additional concrete is to be bonded shall be prepared for receiving the next horizontal lift by cleaning the construction joint surface with either air-water cutting, sandblasting, high-pressure water jet, or other approved method. Concrete at the side of vertical construction joints shall be prepared as approved by the Contracting Officer. Air-water cutting shall not be used 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 surfaces of well bonded coarse aggregate are exposed and make up at least 10-percent of the surface area, distributed uniformly throughout the surface. The edges of the coarse aggregate shall not be undercut. The surface of horizontal construction joints shall be kept continuously wet for the first 12 hours during the 24-hour period prior to placing fresh concrete. The surface shall be washed completely clean as the last operation prior to placing the next lift. For heavy duty floors and two-course floors a thin coat of neat cement grout of about the consistency of thick cream shall be thoroughly scrubbed into the existing surface immediately ahead of the topping placing. The grout shall be a 1:1 mixture of portland cement and sand passing the 2.36 mm No. 8 sieve. The topping concrete shall be deposited before the grout coat has had time to stiffen.

3.1.2.1 Air-Water Cutting

Air-water cutting of a fresh concrete surface shall be performed at the proper time and only on horizontal construction joints. The air pressure used in the jet shall be 700 kPa 100 psi plus or minus, 70 kPa, 10 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 surface retarder complying with the requirements of COE CRD-C 94 may be applied to the surface of the lift in order to prolong the period of time during which air-water cutting is effective. 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 waterjet or sandblasting shall be used as the last operation before placing the next lift.

3.1.2.2 High-Pressure Water Jet

A stream of water under a pressure of not less than 20 MPa 3,000 psi shall be used for cutting and 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 waterjet is incapable of a satisfactory cleaning, the surface shall be cleaned by sandblasting.

3.1.2.3 Wet Sandblasting

Wet sandblasting shall be used after the concrete has reached sufficient strength to prevent undercutting of the coarse aggregate particles. After wet sandblasting, the surface of the concrete shall then be washed thoroughly to remove all loose materials.

3.1.2.4 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.

3.1.2.5 Preparation of Previously Placed Concrete

****
NOTE: When the structure has few construction joints to be bonded, none of them critical, use this subparagraph and delete requirements of above subparagraphs and of paragraph Previously Placed Concrete. Renumber this specification accordingly.
****

Concrete surfaces to which other concrete is to be bonded shall be abraded in an approved manner that will expose sound aggregate uniformly without damaging the concrete. Laitance and loose particles shall be removed. Surfaces shall be thoroughly washed and shall be moist but without free water when concrete is placed.

3.1.3 Vapor Barrier

****
NOTE: When this paragraph is used, coordinate drawings and specifications ensuring that drawings indicate vapor barrier beneath slabs. Retain the penultimate sentence unless experience in the area has shown it to be unnecessary.
****

Vapor barrier shall be provided beneath the interior on-grade concrete floor slabs. The greatest widths and lengths practicable shall be used to eliminate joints wherever possible. Joints shall be lapped a minimum of 300 mm.12 inches. Torn, punctured, or damaged vapor barrier material shall be removed and new vapor barrier shall be provided prior to placing concrete. For minor repairs, patches may be made using laps of at least 300 mm.12 inches. Lapped joints shall be sealed and edges patched with pressure-sensitive adhesive or tape not less than 50 mm 2 inches wide and compatible with the membrane. Vapor barrier shall be placed directly on underlying subgrade, base course, or capillary water barrier, unless it consists of crushed material or large granular material which could puncture the vapor barrier. In this case, the surface shall be choked with a light layer of sand, as approved, before placing the vapor barrier. A 50 mm 2 inch layer of compacted, clean concrete sand (fine aggregate) shall be placed on top of the vapor barrier before placing concrete. Concrete placement shall be controlled so as to prevent damage to the vapor barrier, or any covering sand.

3.1.4 Perimeter Insulation

****
NOTE: When this paragraph is used, ensure that drawings indicate location and extent of perimeter insulation.
****

Perimeter insulation shall be installed at locations indicated. Adhesive shall be used where insulation is applied to the interior surface of

foundation walls and may be used for exterior application.

3.1.5 Embedded Items

Before placement of concrete, care shall be taken to determine that all embedded items are firmly and securely fastened in place as indicated on the drawings, or required. Conduit and other embedded items shall be clean and 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 shall not be performed on embedded metals within 300 mm 1 feet of the surface of the concrete. Tack welding shall not be performed on or to embedded items.

3.2 CONCRETE PRODUCTION

****
NOTE: Use this paragraph and its subparagraphs for all projects except where designer chooses to use the following optional paragraph CONCRETE PRODUCTION, SMALL PROJECTS, provided it meets the criteria described therein, in which case delete these. Do not specify both options.
****

3.2.1 Batching, Mixing, and Transporting Concrete

****
NOTE: The designer must choose one of the two bracketed requirements and delete the other. Do not use the first bracketed requirement if ready-mixed concrete is not wanted.
****

[Concrete shall either be batched and mixed onsite or shall be furnished from a ready-mixed concrete plant. Ready-mixed concrete shall be batched, mixed, and transported in accordance with ASTM C 94/C 94M, except as otherwise specified. Truck mixers, agitators, and nonagitating transporting units shall comply with NRMCA TMMB 100. Ready-mix plant equipment and facilities shall be certified in accordance with NRMCA QC 3. Approved batch tickets shall be furnished for each load of ready-mixed concrete. Site-mixed concrete shall conform to the following subparagraphs.] [Concrete shall be batched and mixed onsite, or close to onsite, and shall conform to the following subparagraphs.]

3.2.1.1 General

****
NOTE: Choose the desired bracketed options for plant locations. Insert desired minimum capacity of plant, it should be sufficient to accommodate the largest placement within a reasonable time.
****

The batching plant shall be located [on site in the general area indicated on the drawings] [or] [off site close to the project]. The batching, mixing and placing system shall have a capacity of at least [_____] cubic meters cubic yards per hour. The batching plant shall conform to the

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

3.2.1.2 Batching Equipment

****
NOTE: Retain the bracketed sentence concerning truck mixers unless it is desired to prohibit truck mixers. Always retain bracketed item about silica fume when its use is allowed, otherwise delete.
****

The batching controls shall be semiautomatic or automatic, as defined in NRMCA CPMB 100. A semiautomatic batching system shall be provided with interlocks such that the discharge device cannot be actuated until the indicated material is within the applicable tolerance. The batching system shall be equipped with accurate recorder or recorders that meet the requirements of NRMCA CPMB 100. The weight of water and admixtures shall be recorded if batched by weight. Separate bins or compartments shall be provided for each size group of aggregate and type of cementitious material, to prevent intermingling at any time. Aggregates shall be weighed either in separate weigh batchers with individual scales or, provided the smallest size is batched first, cumulatively in one weigh batcher on one scale. Aggregate shall not be weighed in the same batcher with cementitious material. If both portland cement and other cementitious material are used, they may be batched cumulatively, provided that the portland cement is batched first, [except that silica fume shall always be batched separately]. Water may be measured by weight or volume. Water shall not be weighed or measured cumulatively with another ingredient. Filling and discharging valves for the water metering or batching system shall be so interlocked that the discharge valve cannot be opened before the filling valve is fully closed. Piping for water and for admixtures shall be free from leaks and shall be properly valved to prevent backflow or siphoning. Admixtures shall be furnished as a liquid of suitable concentration for easy control of dispensing. An adjustable, accurate, mechanical device for measuring and dispensing each admixture shall be provided. Each admixture dispenser shall be interlocked with the batching and discharging operation of the water so that each admixture is separately batched and individually discharged automatically in a manner to obtain uniform distribution throughout the water as it is added to the batch in the specified mixing period. [When use of truck mixers makes this requirement impractical, the admixture dispensers shall be interlocked with the sand batchers]. Different admixtures shall not be combined prior to introduction in water and shall not be allowed to intermingle until in contact with the cement. Admixture dispensers shall have suitable devices to detect and indicate flow during dispensing or have a means for visual observation. 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, and for sampling and calibrating the dispensing of cementitious material, water, and admixtures. Filling ports for cementitious materials bins or silos shall be clearly marked with a permanent sign stating the contents.

3.2.1.3 Scales

The weighing equipment shall conform to the applicable requirements of CPMB Concrete Plant Standard, and of NIST HB 44, except that the accuracy shall be plus or minus 0.2 percent of scale capacity. The Contractor shall

provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring devices. The tests shall be made at the specified frequency in the presence of a Government inspector. The weighing equipment shall be arranged so that the plant operator can conveniently observe all dials or indicators.

3.2.1.4 Batching Tolerances

(A) Tolerances with Weighing Equipment

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

(B) Tolerances with Volumetric Equipment

For volumetric batching equipment used for water and admixtures, the following tolerances shall apply to the required volume of material being batched:

MATERIAL	PERCENT OF REQUIRED MATERIAL
Water:	plus or minus 1 percent
Chemical admixtures:	0 to plus 6 percent

3.2.1.5 Moisture Control

The plant shall be capable of ready adjustment to compensate for the varying moisture content of the aggregates and to change the weights of the materials being batched.

3.2.1.6 Concrete Mixers

****
NOTE: Retain bracketed phrase unless it is desired to prohibit truck mixers, in which case delete.
****

Mixers shall be stationary mixers [or truck mixers]. Mixers shall be capable of combining the materials into a uniform mixture and of discharging this mixture without segregation. The mixers shall not be charged in excess of the capacity recommended by the manufacturer. The mixers shall be operated at the drum or mixing blade speed designated by the manufacturer. The mixers shall be maintained in satisfactory operating condition, and the mixer drums shall be kept free of hardened concrete. Should any mixer at any time produce unsatisfactory results, its use shall be promptly discontinued until it is repaired.

3.2.1.7 Stationary Mixers

Concrete plant mixers shall be drum-type mixers of tilting, nontilting,

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

3.2.1.8 Truck Mixers

****
NOTE: Delete this subparagraph if truck mixers have been previously prohibited, otherwise retain. Use bracketed item only for small jobs.
****

Truck mixers, the mixing of concrete therein, and concrete uniformity shall conform to the requirements of ASTM C 94/C 94M. A truck mixer may be used either for complete mixing (transit-mixed) or to finish the partial mixing done in a stationary mixer (shrink-mixed). Each truck shall be equipped with two counters from which it is possible to determine the number of revolutions at mixing speed and the number of revolutions at agitating speed. [Or, if approved in lieu of this, the number of revolutions shall be marked on the batch tickets.] Water shall not be added at the placing site unless specifically approved; and in no case shall it exceed the specified w/c. Any such water shall be injected at the base of the mixer, not at the discharge end.

3.3 CONCRETE PRODUCTION, SMALL PROJECTS

****
NOTE: Use this paragraph at the designer's option in lieu of the previous paragraph CONCRETE PRODUCTION and its subparagraphs, which must then be deleted, but only when all the following conditions exist:

(a) There are no particularly critical structural items.

(b) There are no items of particularly critical appearance.

(c) No concrete is required with a specified compressive strength greater than 24.2 MPa (3500 psi).

(d) Not over 1150 cubic meters (1500 cubic yards) of concrete are required.

Otherwise, use the above listed previous paragraph and subparagraphs only. Do not specify both options.
****

Batch-type equipment shall be used for producing concrete. Ready-mixed concrete shall be batched, mixed, and transported in accordance with ASTM C 94/C 94M, except as otherwise specified. Truck mixers, agitators, and nonagitating transporting units shall comply with NRMCA TMMB 100. Ready-mix plant equipment and facilities shall be certified in accordance with NRMCA QC 3. Approved batch tickets shall be furnished for each load of ready-mixed concrete. Site-mixed concrete shall be produced in

accordance with ACI 301, and plant shall conform to NRMCA CPMB 100. [In lieu of batch-type equipment, concrete may be produced by volumetric batching and continuous mixing, which shall conform to ASTM C 685.]

3.4 LIGHTWEIGHT AGGREGATE CONCRETE

In addition to the requirements specified for normal weight concrete, lightweight aggregate concrete shall conform to the following. The batching and mixing cycle shall be as directed based on written recommendations from the aggregate supplier which the Contractor shall furnish. Unless otherwise directed, the mixer shall be charged with approximately 2/3 of the total mixing water and all of the aggregate. This shall be mixed for at least 1-1/2 minutes in a stationary mixer or 15 revolutions at mixing speed in a truck mixer. The remaining ingredients shall then be added and mixing continued as specified for normal weight concrete. Lightweight aggregate concrete shall not be vibrated to the extent that large particles of aggregate float to the surface. During finishing, lightweight aggregate concrete shall not be worked to the extent that mortar is driven down and lightweight coarse aggregate appears at the surface. Lightweight aggregate concrete to be pumped shall have a cement content of at least 335 kg per cubic meter.564 lb. per cu. yd. [A field trial run of lightweight aggregate concrete placement and finishing shall be made in accordance with ACI 213R.]

3.5 FIBER REINFORCED CONCRETE

****

NOTE: Only use fiber reinforcing when approved by the structural designer. Drawings should indicate where fiber reinforced concrete is located. Fiber reinforcing is used (1) to help control cracking due to drying shrinkage and thermal expansion and contraction, (2) to reduce permeability, (3) to increase impact capability, shatter resistance, abrasion resistance, and toughness. Fiber reinforcing will not: control cracking due to structural stresses, significantly increase strength, control curling or creeping, justify reducing structural members, eliminate control joints, or replace any moment or structural steel reinforcement. Include flexural toughness tests when synthetic reinforcement fibers are used to increase toughness and when justified by size and importance of job, but not when fibers are used only to control shrinkage cracking. Include technical representative when warranted by size and importance of job.

****

Fiber reinforced concrete shall conform to ASTM C 1116 and as follows, using the fibers specified in PART 2. A minimum of 0.9 kg of fibers per cubic m 1.5 pounds of fibers per cubic yard of concrete shall be used. Fibers shall be added at the batch plant. [Toughness indices shall meet requirements for performance level I of ASTM C 1116.] The services of a qualified technical representative shall be provided to instruct the concrete supplier in proper batching and mixing of materials to be provided.

3.6 TRANSPORTING CONCRETE TO PROJECT SITE

Concrete shall be transported to the placing site in [truck mixers,] [agitators,] [nonagitating transporting equipment conforming to NRMCA TMMB 100] or by approved [pumping equipment] [conveyors]. Nonagitating equipment, other than pumps, shall not be used for transporting lightweight aggregate concrete.

3.7 CONVEYING CONCRETE ON SITE

****
NOTE: Delete conveying equipment not wanted on the project.
****

Concrete shall be conveyed from mixer or transporting unit to forms as rapidly as possible and within the time interval specified by methods which will prevent segregation or loss of ingredients using following equipment. Conveying equipment shall be cleaned before each placement.

3.7.1 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 5 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 yardsshall not be manually operated. The design of the bucket shall provide means for positive regulation of the amount and rate of deposit of concrete in each dumping position.

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

3.7.3 Trucks

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

3.7.4 Chutes

When concrete can be placed directly from a truck mixer, agitator, or nonagitating equipment, the chutes normally attached to this equipment by

the manufacturer may be used. A discharge deflector shall be used when required by the Contracting Officer. Separate chutes and other similar equipment will not be permitted for conveying concrete.

3.7.5 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, such as discharge baffle or hopper , 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 meters 300 feet per minute and a maximum of 225 meters 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 truck that is long enough to extend through the reinforcing bars.

3.7.6 Concrete Pumps

Concrete may be conveyed by positive displacement pump when approved. The pumping equipment shall be piston or squeeze pressure type; pneumatic placing equipment shall not be used. The pipeline shall be rigid steel pipe or heavy-duty flexible hose. The inside diameter of the pipe shall be at least 3 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.

3.8 PLACING CONCRETE

Mixed concrete shall be discharged within 1-1/2 hours or before the mixer drum has revolved 300 revolutions, whichever comes first after the introduction of the mixing water to the cement and aggregates. When the concrete temperature exceeds 30 degrees C, 85 degrees F, the time shall be reduced to 45 minutes. Concrete shall be placed within 15 minutes after it has been discharged from the transporting unit. Concrete shall be handled from mixer or transporting unit to forms in a continuous manner until the approved unit of operation is completed. Adequate scaffolding, ramps and walkways shall be provided so that personnel and equipment are not supported by in-place reinforcement. Placing will not be permitted when the sun, heat, wind, or limitations of facilities furnished by the Contractor prevent proper consolidation, finishing and curing. Sufficient placing capacity shall be provided so that concrete can be kept free of cold joints.

3.8.1 Depositing Concrete

Concrete shall be deposited as close as possible to its final position in the forms, and there shall be no vertical drop greater than 1.5 meters 5 feet except where suitable equipment is provided to prevent segregation and where specifically authorized. Depositing of the concrete shall be so regulated that it will be effectively consolidated in horizontal layers not more than 300 mm 12 inches thick, except that all slabs shall be placed in a single layer. Concrete to receive other construction shall be screeded to the proper level. Concrete shall be deposited continuously in one layer or in layers so that fresh concrete is deposited on in-place concrete that is still plastic. Fresh concrete shall not be deposited on concrete that has hardened sufficiently to cause formation of seams or planes of weakness within the section. Concrete that has surface dried, partially hardened,

or contains foreign material shall not be used. When temporary spreaders are used in the forms, the spreaders shall be removed as their service becomes unnecessary. Concrete shall not be placed in slabs over columns and walls until concrete in columns and walls has been in-place at least two hours or until the concrete begins to lose its plasticity. Concrete for beams, girders, brackets, column capitals, haunches, and drop panels shall be placed at the same time as concrete for adjoining slabs.

3.8.2 Consolidation

****
NOTE: For large jobs, this paragraph may be expanded. Consolidation equipment and procedures are described in detail in ACI 309.
****

Immediately after placing, each layer of concrete shall be consolidated by internal vibrators, except for slabs 100 mm 4 inches thick or less. The vibrators shall at all times be adequate in effectiveness and number to properly consolidate the concrete; a spare vibrator shall be kept at the jobsite during all concrete placing operations. The vibrators shall have a frequency of not less than 10,000 vibrations per minute, an amplitude of at least 0.6 mm, 0.025 inch, and the head diameter shall be appropriate for the structural member and the concrete mixture being placed. Vibrators shall be inserted vertically at uniform spacing over the area of placement. The distance between insertions shall be approximately 1-1/2 times the radius of action of the vibrator so that the area being vibrated will overlap the adjacent just-vibrated area by a reasonable amount. The vibrator shall penetrate rapidly to the bottom of the layer and at least 150 mm 6 inches into the preceding layer if there is such. Vibrator shall be held stationary until the concrete is consolidated and then vertically withdrawn slowly while operating. Form vibrators shall not be used unless specifically approved and unless forms are constructed to withstand their use. Vibrators shall not be used to move concrete within the forms. Slabs 100 mm 4 inches and less in thickness shall be consolidated by properly designed vibrating screeds or other approved technique. Excessive vibration of lightweight concrete resulting in segration or flotation of coarse aggregate shall be prevented. Frequency and amplitude of vibrators shall be determined in accordance with COE CRD-C 521. Grate tampers ("jitterbugs") shall not be used.

3.8.3 Cold Weather Requirements

****
NOTE: When the designer is especially concerned about corrosion of reinforcing steel or embedded items, or possibility of sulfate attack, (particularly to prestressing steel) the percentage of chloride ion in the mixture should be limited. See ACI Committee 201 report "Guide to Durable Concrete" and ACI Committee 222 report "Corrosion of Metals in Concrete" for guidance on control of chloride ion.
****

Special protection measures, approved by the Contracting Officer, shall be used if freezing temperatures are anticipated before the expiration of the specified curing period. The ambient temperature of the air where concrete is to be placed and the temperature of surfaces to receive concrete shall

be not less than 5 degrees C.40 degrees F. The temperature of the concrete when placed shall be not less than 10 degrees C 50 degrees F nor more than 25 degrees C.75 degrees F. Heating of the mixing water or aggregates will be required to regulate the concrete placing temperature. Materials entering the mixer shall be free from ice, snow, or frozen lumps. Salt, chemicals or other materials shall not be incorporated in the concrete to prevent freezing. Upon written approval, an accelerating admixture conforming to ASTM C 494/C 494M, Type C or E may be used, provided it contains no calcium chloride. Calcium chloride shall not be used.

3.8.4 Hot Weather Requirements

****

NOTE: If desired, placement of floor slabs may be specified to be delayed until a roof is in place. Additional information concerning hot weather concreting may be obtained from ACI 305R.

****

When the ambient temperature during concrete placing is expected to exceed 30 degrees C, 85 degrees F, the concrete shall be placed and finished with procedures previously submitted and as specified herein. The concrete temperature at time of delivery to the forms shall not exceed the temperature shown in the table below when measured in accordance with ASTM C 1064/C 1064M. Cooling of the mixing water or aggregates or placing concrete in the cooler part of the day may be required to obtain an adequate placing temperature. A retarder may be used, as approved, to facilitate placing and finishing. Steel forms and reinforcements shall be cooled as approved prior to concrete placement when steel temperatures are greater than 49 degrees C.120 degrees F. Conveying and placing equipment shall be cooled if necessary to maintain proper concrete-placing temperature.

Maximum Allowable Concrete Placing Temperature

Relative Humidity, Percent, During Time of Concrete Placement	Maximum Allowable Concrete Temperature Degrees
Greater than 60	33 C 90 F
40-60	30 C 85 F
Less than 40	27 C 80 F

3.8.5 Prevention of Plastic Shrinkage Cracking

During hot weather with low humidity, and particularly with appreciable wind, as well as interior placements when space heaters produce low humidity, the Contractor shall be alert to the tendency for plastic shrinkage cracks to develop and shall institute measures to prevent this. Particular care shall be taken if plastic shrinkage cracking is potentially imminent and especially if it has developed during a previous placement. Periods of high potential for plastic shrinkage cracking can be anticipated by use of Fig. 2.1.5 of ACI 305R. In addition the concrete placement shall be further protected by erecting shades and windbreaks and by applying fog sprays of water, sprinkling, ponding or wet covering. Plastic shrinkage cracks that occur shall be filled by injection of epoxy resin as directed, after the concrete hardens. Plastic shrinkage cracks shall never be

troweled over or filled with slurry.

3.8.6 Placing Concrete Underwater

****
NOTE: Delete this paragraph when not applicable. If major underwater concrete placement is required, supplement this paragraph using guidance from ACI 304R. If appropriate, add special requirements for underwater concrete to paragraphs Concrete Proportioning Studies, Normal Weight Concrete and General Requirements both in PART 1. If considered necessary, require a special technical representative in paragraph Technical Service for Specialized Concrete in PART 1. Contractor will be required to submit proposed procedures.
****

Concrete shall be deposited in water by a tremie or concrete pump. The methods and equipment used shall be subject to approval. Concrete buckets shall not be used 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. The concrete shall be deposited so that it enters the mass of the previously placed concrete from within, displacing water with a minimum disturbance to the surface of the concrete. The discharge end of the pump line or tremie shaft shall be kept continuously submerged in the concrete. The underwater seal at start of placing shall 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 of concrete will be limited to 5 m.15 feet. Concrete shall not be deposited in running water or in water with a temperature below 2 degrees C.35 degrees F.

3.8.7 Placing Concrete in Congested Areas

****
NOTE: Delete the last sentence when not applicable.
****

Special care shall be used to ensure complete filling of the forms, elimination of all voids, and complete consolidation of the concrete when placing concrete in areas congested with reinforcing bars, embedded items, waterstops and other tight spacing. An appropriate concrete mixture shall be used, and the nominal maximum size of aggregate (NMSA) shall meet the specified criteria when evaluated for the congested area. Vibrators with heads of a size appropriate for the clearances available shall be used, and the consolidation operation shall be closely supervised to ensure complete and thorough consolidation at all points. Where necessary, splices of reinforcing bars shall be alternated to reduce congestion. Where two mats of closely spaced reinforcing are required, the bars in each mat shall be placed in matching alignment to reduce congestion. Reinforcing bars may be temporarily crowded to one side during concrete placement provided they are returned to exact required location before concrete placement and consolidation are completed.

3.8.8 Placing Flowable Concrete

****
NOTE: Delete this paragraph when flowable concrete is not permitted.
****

If a plasticizing admixture conforming to ASTM C 1017/C 1017M is used or if a Type F or G high range water reducing admixture is permitted to increase the slump, the concrete shall meet all requirements of paragraph GENERAL REQUIREMENTS in PART 1. Extreme care shall be used in conveying and placing the concrete to avoid segregation. Consolidation and finishing shall meet all requirements of paragraphs Placing Concrete, Finishing Formed Surfaces, and Finishing Unformed Surfaces. No relaxation of requirements to accommodate flowable concrete will be permitted.

3.9 JOINTS

****
NOTE: All joints should be indicated on the drawings. When some of the joints are not shown, the Designer must edit this paragraph for conformance with job requirements.
****

Joints shall be located and constructed as indicated or approved. Joints not indicated on the drawings shall be located and constructed to minimize the impact on the strength of the structure. In general, such joints shall be located near the middle of the spans of supported slabs, beams, and girders unless a beam intersects a girder at this point, in which case the joint in the girder shall be offset a distance equal to twice the width of the beam. Joints in walls and columns shall be at the underside of floors, slabs, beams, or girders and at the tops of footings or floor slabs, unless otherwise approved. Joints shall be perpendicular to the main reinforcement. All reinforcement shall be continued across joints; except that reinforcement or other fixed metal items shall not be continuous through expansion joints, or through construction or contraction joints in slabs on grade. Reinforcement shall be 50 mm 2 inches clear from each joint. Except where otherwise indicated, construction joints between interior slabs on grade and vertical surfaces shall consist of 1.5 kg per square meter 30 pound asphalt-saturated felt, extending for the full depth of the slab. The perimeters of the slabs shall be free of fins, rough edges, spalling, or other unsightly appearance. Reservoir for sealant for construction and contraction joints in slabs shall be formed to the dimensions shown on the drawings by removing snap-out joint-forming inserts, by sawing sawable inserts, or by sawing to widen the top portion of sawed joints. Joints to be sealed shall be cleaned and sealed as indicated and in accordance with Section 07920 JOINT SEALANTS.

3.9.1 Construction Joints

****
NOTE: Drawings must show details for construction joints, including any required dowels or keyways. Drawings must indicate whether dowels are conventional smooth "paving" dowels or "structural" type deformed dowels (tie-bars).
****

For concrete other than slabs on grade, construction joints shall be located so that the unit of operation does not exceed [_____] meters. [_____] feet. Concrete shall be placed continuously so that each unit is monolithic in construction. Fresh concrete shall not be placed against adjacent hardened concrete until it is at least 24 hours old. Construction joints shall be located as indicated or approved. Where concrete work is interrupted by weather, end of work shift or other similar type of delay, location and type of construction joint shall be subject to approval of the Contracting Officer. Unless otherwise indicated and except for slabs on grade, reinforcing steel shall extend through construction joints. Construction joints in slabs on grade shall be keyed or doweled as shown. Concrete columns, walls, or piers shall be in place at least 2 hours, or until the concrete begins to lose its plasticity, before placing concrete for beams, girders, or slabs thereon. In walls having door or window openings, lifts shall terminate at the top and bottom of the opening. Other lifts shall terminate at such levels as to conform to structural requirements or architectural details. Where horizontal construction joints in walls or columns are required, a strip of 25 mm 1 inchsquare-edge lumber, bevelled and oiled to facilitate removal, shall be tacked to the inside of the forms at the construction joint. Concrete shall be placed to a point 25 mm 1 inch above the underside of the strip. The strip shall be removed 1 hour after the concrete has been placed, and any irregularities in the joint line shall be leveled off with a wood float, and all laitance shall be removed. Prior to placing additional concrete, horizontal construction joints shall be prepared as specified in paragraph Previously Placed Concrete.

3.9.2 Contraction Joints in Slabs on Grade

****
NOTE: Drawings must indicate desired location and detail for contraction joints.
****

Contraction joints shall be located and detailed as shown on the drawings. Contraction Joints shall be produced by forming a weakened plane in the concrete slab by [use of rigid inserts impressed in the concrete during placing operations] [use of snap-out plastic joint forming inserts] [or] [sawing a continuous slot with a concrete saw]. Regardless of method used to produce the weakened plane, it shall be 1/4 the depth of the slab thickness and between 3 and 5 mm 1/8 and 3/16 inch wide. For saw-cut joints, cutting shall be timed properly with the set of the concrete. Cutting shall be started as soon as the concrete has hardened sufficiently to prevent ravelling of the edges of the saw cut. Cutting shall be completed before shrinkage stresses become sufficient to produce cracking. Reservoir for joint sealant shall be formed as previously specified.

3.9.3 Expansion Joints

Installation of expansion joints and sealing of these joints shall conform to the requirements of Section 03150A EXPANSION JOINTS, CONTRACTION JOINTS, AND WATERSTOPS and Section 07920 JOINT SEALANTS.

3.9.4 Waterstops

Waterstops shall be installed in conformance with the locations and details shown on the drawings using materials and procedures specified in Section 03150A EXPANSION JOINTS, CONTRACTION JOINTS, AND WATERSTOPS.

3.9.5 Dowels and Tie Bars

Dowels and tie bars shall be installed at the locations shown on the drawings and to the details shown, using materials and procedures specified in Section 03200A CONCRETE REINFORCEMENT and herein. Conventional smooth "paving" dowels shall be installed in slabs using approved methods to hold the dowel in place during concreting within a maximum alignment tolerance of 1 mm in 100 mm.1/8 inch in 12 inches. "Structural" type deformed bar dowels, or tie bars, shall be installed to meet the specified tolerances. Care shall be taken during placing adjacent to and around dowels and tie bars to ensure there is no displacement of the dowel or tie bar and that the concrete completely embeds the dowel or tie bar and is thoroughly consolidated.

3.10 FINISHING FORMED SURFACES

****

NOTE: Formwork, form materials and form construction are specified in Section 03100A STRUCTURAL CONCRETE FORMWORK. Classes of finish to be used for various formed surfaces of the structure must be indicated on the drawings or clearly specified herein. Criteria to use in choosing class of finish are as follows:

Class A Finish. This finish is for surfaces permanently exposed to public view that require excellent appearance at close range. Examples: Exterior walls of office and residential buildings, of warehouse/industrial type buildings where frequent public access occurs, and of other similar exposed structures; and interior walls, columns or beams of these same structures where no other finish treatment is to be added.

Class B Finish. This finish is for surfaces exposed to public view that do not require the excellent appearance of Class A. Exterior walls of warehouse/ industrial buildings where public access is infrequent, structures on combat training ranges, and other similar exposed structures; interior exposed surfaces of such structures, and interior surfaces of liquid containers.

Class C Finish. This finish is for concealed surfaces not exposed to view and for all surfaces not covered by Class A, B, or D finish. Examples: Interior surfaces that will be covered by dry wall or other applied surfaces, surfaces of mechanical rooms and elevator shafts.

Class D Finish. This finish is for surfaces where roughness and irregularities are not objectionable. Examples: Walls and foundation surfaces against which backfill will be placed, exterior surfaces permanently submerged in water where no coating is to be applied.

When a Class A or B Finish is specified, add to

paragraph FIELD TEST PANELS in PART 1 requirements for the Contractor to construct a sample panel for approval before start of construction. Finishes for surfaces to be exposed to high velocity flow of water (above 40 ft per sec) will be designed and constructed in accordance with Civil Works criteria.

****

Forms, form materials, and form construction are specified in Section 03100A STRUCTURAL CONCRETE FORMWORK. Finishing of formed surfaces shall be as specified herein. Unless another type of architectural or special finish is specified, surfaces shall be left with the texture imparted by the forms except that defective surfaces shall be repaired. Unless painting of surfaces is required, uniform color of the concrete shall be maintained by use of only one mixture without changes in materials or proportions for any structure or portion of structure that requires a Class A or B finish. Except for major defects, as defined hereinafter, surface defects shall be repaired as specified herein within 24 hours after forms are removed. Repairs of the so-called "plaster-type" will not be permitted in any location. Tolerances of formed surfaces shall conform to the requirements of ACI 117. These tolerances apply to the finished concrete surface, not to the forms themselves; forms shall be set true to line and grade. Form tie holes requiring repair and other defects whose depth is at least as great as their surface diameter shall be repaired as specified in paragraph Damp-Pack Mortar Repair. Defects whose surface diameter is greater than their depth shall be repaired as specified in paragraph Repair of Major Defects. Repairs shall be finished flush with adjacent surfaces and with the same surface texture. The cement used for all repairs shall be a blend of job cement with white cement proportioned so that the final color after curing and aging will be the same as the adjacent concrete. Concrete with excessive honeycomb, or other defects which affect the strength of the member, will be rejected. Repairs shall be demonstrated to be acceptable and free from cracks or loose or drummy areas at the completion of the contract and, for Class A and B Finishes, shall be inconspicuous. Repairs not meeting these requirements will be rejected and shall be replaced.

3.10.1 Class A Finish and Class B Finish

Class A finish is required [where indicated on the drawings.] [in the following areas, [_____].] Class B finish is required [where indicated on the drawings] [in the following areas, [_____].] Fins, ravelings, and loose material shall be removed, all surface defects over 12 mm 1/2 inch in diameter or more than 12 mm 1/2 inch deep, shall be repaired and, except as otherwise indicated or as specified in Section 03100A STRUCTURAL CONCRETE FORMWORK, holes left by removal of form ties shall be reamed and filled. Defects more than 12 mm 1/2 inch in diameter shall be cut back to sound concrete, but in all cases at least 25 mm 1 inch deep. The Contractor shall prepare a sample panel for approval (as specified in PART 1) before commencing repair, showing that the surface texture and color match will be attained. Metal tools shall not be used to finish repairs in Class A surfaces.

3.10.2 Class C and Class D Finish

Class C finish is required [where indicated on the drawings.] [in the following areas, [_____].] Class D finish is required [where indicated on the drawings.] [in the following areas, [_____].] Fins, ravelings, and loose material shall be removed, and, except as otherwise indicated or as specified in Section 03100A STRUCTURAL CONCRETE FORMWORK, holes left by

removal of form ties shall be reamed and filled. Honeycomb and other defects more than 12 mm 1/2 inch deep or more than 50 mm 2 inches in diameter shall be repaired. Defects more than 50 mm 2 inches in diameter shall be cut back to sound concrete, but in all cases at least 25 mm 1 inch deep.

3.10.3 Architectural and Special Finishes

****
NOTE: The specification writer must ensure that any areas to receive architectural and special finishes are indicated on the drawings or specified in Section 03330A CAST-IN-PLACE ARCHITECTURAL CONCRETE or herein. Where these paragraphs require a finish to match a sample panel on display during the bidding period, the specification writer must ensure that such panel is fabricated and displayed. When considered appropriate, require a test panel to be fabricated for approval before start of construction.
****

Architectural concrete finishes are specified in Section 03330 CAST-IN-PLACE ARCHITECTURAL CONCRETE. Special finishes shall conform to the requirements specified herein.

3.10.3.1 Smooth Finish

After other concrete construction is complete in each overall separate contiguous area of the structure, smooth finish shall be applied to [the areas indicated on the drawings] [the following areas, [_____]]. A mortar mix consisting of one part portland cement and two parts well-graded sand passing a 0.6 mm No. 30 sieve, with water added to give the consistency of thick paint, shall be used. Where the finished surface will not receive other applied surface, white cement shall be used to replace part of the job cement to produce an approved color, which shall be uniform throughout the surfaces of the structure. After the surface has been thoroughly wetted and allowed to approach surface dryness, the mortar shall be vigorously applied to the area by clean burlap pads or by cork or wood-floating, to completely fill all surface voids. Excess grout shall be scraped off with a trowel. As soon as it can be accomplished without pulling the mortar from the voids, the area shall be rubbed with burlap pads having on their surface the same sand-cement mix specified above but without any mixing water, until all of the visible grout film is removed. The burlap pads used for this operation shall be stretched tightly around a board to prevent dishing the mortar in the voids. The finish of any area shall be completed in the same day, and the limits of a finished area shall be made at natural breaks in the surface. The surface shall be continuously moist cured for 48 hours commencing immediately after finishing operations in each area. The temperature of the air adjacent to the surface shall be not less than 10 degrees C 50 degrees F for 24 hours prior to, and 48 hours after, the application. In hot, dry weather the smooth finish shall be applied in shaded areas or at night, and shall never be applied when there is significant hot, dry wind.

3.10.3.2 Exposed Coarse-Aggregate Finish

Coarse aggregate shall consist of [_____] material, shall meet the specified quality requirements, and shall have a grading as follows: [_____]. Coarse aggregate shall be exposed by an approved method. The

finish shall be similar to and shall closely match the finish on the sample panel put on display during the bidding period, and the finish on the approved preconstruction test panel fabricated by the Contractor.

3.10.3.3 Sandblast Finish

The concrete surface shall be blasted at an approved age with approved wet sandblasting procedures to obtain a [brush] [light] [medium] [heavy] finish which will match the descriptive photographs in ACI 303R. The finish shall be similar to and shall closely match the finish on the approved preconstruction test panel fabricated by the Contractor.

3.10.3.4 Tooled Finish

The thoroughly cured concrete shall be dressed at an approved age with approved electric, air, or hand tools to a uniform texture with a [hand-tooled] [rough] [fine-pointed] [crandalled] [or] [bush-hammered] surface texture. The finish shall be similar to and shall closely match the finish on the approved preconstruction test panel fabricated by the Contractor.

3.11 REPAIRS

3.11.1 Damp-Pack Mortar Repair

Form tie holes requiring repair and other defects whose depth is at least as great as their surface diameter but not over 100 mm 4 inchesshall be repaired by the damp-pack mortar method. Form tie holes shall be reamed and other similar defects shall be cut out to sound concrete. The void shall then be thoroughly cleaned, thoroughly wetted, brush-coated with a thin coat of neat cement grout and filled with mortar. Mortar shall be a stiff mix of 1 part portland cement to 2 parts fine aggregate passing the 1.18 mm No. 16 mesh sieve, and minimum amount of water. Only sufficient water shall be used to produce a mortar which, when used, will stick together on being molded into a ball by a slight pressure of the hands and will not exude water but will leave the hands damp. Mortar shall be mixed and allowed to stand for 30 to 45 minutes before use with remixing performed immediately prior to use. Mortar shall be thoroughly tamped in place in thin layers using a hammer and hardwood block. Holes passing entirely through walls shall be completely filled from the inside face by forcing mortar through to the outside face. All holes shall be packed full. Damp-pack repairs shall be moist cured for at least 48 hours.

3.11.2 Repair of Major Defects

Major defects will be considered to be those more than 12 mm 1/2 inch deep or, for Class A and B finishes, more than 12 mm 1/2 inch in diameter and, for Class C and D finishes, more than 50 mm 2 inches in diameter. Also included are any defects of any kind whose depth is over 100 mm 4 inches or whose surface diameter is greater than their depth. Major defects shall be repaired as specified below.

3.11.2.1 Surface Application of Mortar Repair

Defective concrete shall be removed, and removal shall extend into completely sound concrete. Approved equipment and procedures which will not cause cracking or microcracking of the sound concrete shall be used. If reinforcement is encountered, concrete shall be removed so as to expose the reinforcement for at least 50 mm 2 inches on all sides. All such

defective areas greater than 7800 square mm 12 square inchesshall be outlined by saw cuts at least 25 mm 1 inch deep. Defective areas less than 7800 square mm 12 square inches shall be outlined by a 25 mm 1 inch deep cut with a core drill in lieu of sawing. All saw cuts shall be straight lines in a rectangular pattern in line with the formwork panels. After concrete removal, the surface shall be thoroughly cleaned by high pressure washing to remove all loose material. Surfaces shall be kept continually saturated for the first 12 of the 24 hours immediately before placing mortar and shall be damp but not wet at the time of commencing mortar placement. The Contractor, at his option, may use either hand-placed mortar or mortar placed with a mortar gun. If hand-placed mortar is used, the edges of the cut shall be perpendicular to the surface of the concrete. The prepared area shall be brush-coated with a thin coat of neat cement grout. The repair shall then be made using a stiff mortar, preshrunk by allowing the mixed mortar to stand for 30 to 45 minutes and then remixed, thoroughly tamped into place in thin layers. If hand-placed mortar is used, the Contractor shall test each repair area for drumminess by firm tapping with a hammer and shall inspect for cracks, both in the presence of the Contracting Officer's representative, immediately before completion of the contract, and shall replace any showing drumminess or cracking. If mortar placed with a mortar gun is used, the gun shall be a small compressed air-operated gun to which the mortar is slowly hand fed and which applies the mortar to the surface as a high-pressure stream, as approved. Repairs made using shotcrete equipment will not be accepted. The mortar used shall be the same mortar as specified for damp-pack mortar repair. If gun-placed mortar is used, the edges of the cut shall be beveled toward the center at a slope of 1:1. All surface applied mortar repairs shall be continuously moist cured for at least 7 days. Moist curing shall consist of several layers of saturated burlap applied to the surface immediately after placement is complete and covered with polyethylene sheeting, all held closely in place by a sheet of plywood or similar material rigidly braced against it. Burlap shall be kept continually wet.

3.11.2.2 Repair of Deep and Large Defects

****

NOTE: Use this paragraph only for areas where the designer considers this degree of repair acceptable; otherwise require removal and replacement of concrete containing these types of defects.

****

Deep and large defects will be those that are more than 150 mm 6 inches deep and also have an average diameter at the surface more than 450 mm 18 inches or that are otherwise so identified by the Project Office. Such defects shall be repaired as specified herein or directed, except that defects which affect the strength of the structure shall not be repaired and that portion of the structure shall be completely removed and replaced. Deep and large defects shall be repaired by procedures approved in advance including forming and placing special concrete using applied pressure during hardening. Preparation of the repair area shall be as specified for surface application of mortar. In addition, the top edge (surface) of the repair area shall be sloped at approximately 20 degrees from the horizontal, upward toward the side from which concrete will be placed. The special concrete shall be a concrete mixture with low water content and low slump, and shall be allowed to age 30 to 60 minutes before use. Concrete containing a specified expanding admixture may be used in lieu of the above mixture; the paste portion of such concrete mixture shall be designed to

have an expansion between 2.0 and 4.0 percent when tested in accordance with ASTM C 940. A full width "chimney" shall be provided at the top of the form on the placing side to ensure filling to the top of the opening. A pressure cap shall be used on the concrete in the chimney with simultaneous tightening and revibrating the form during hardening to ensure a tight fit for the repair. The form shall be removed after 24 hours and immediately the chimney shall be carefully chipped away to avoid breaking concrete out of the repair; the surface of the repair concrete shall be dressed as required.

3.11.3 Resinous and Latex Material Repair

****
NOTE: The portland cement type repairs specified above are considered appropriate for usual repairs. The designer should use the materials specified herein only if there is a record of previous successful use or if the use has been discussed in detail with the Waterways Experiment Station (CEWES-SL-EP). Additional requirements for their use must be added. Color match may be a problem with this type of repair.
****

In lieu of the portland cement [bonding coats specified above, an epoxy resin or a latex bonding agent may be used.] [based mortars specified above, an epoxy resin mortar based on epoxy resin or a mortar based on latex bonding agent may be used in the following specific locations [_____].] The following additional requirements shall be met in the use of these materials [_____].

3.12 FINISHING UNFORMED SURFACES

****
NOTE: Type of finish of unformed surfaces should be indicated on the drawings. If not on the drawings, it must be specified here. Correlate this paragraph with paragraph Tolerances in PART 1 and ACI 117.
****

The finish of all unformed surfaces shall meet the requirements of paragraph Tolerances in PART 1, when tested as specified herein.

3.12.1 General

The ambient temperature of spaces adjacent to unformed surfaces being finished and of the base on which concrete will be placed shall be not less than 10 degrees C.50 degrees F. In hot weather all requirements of paragraphs Hot Weather Requirements and Prevention of Plastic Shrinkage Cracking shall be met. Unformed surfaces that are not to be covered by additional concrete or backfill shall have a float finish, with additional finishing as specified below, and shall be true to the elevation shown on the drawings. Surfaces to receive additional concrete or backfill shall be brought to the elevation shown on the drawings, properly consolidated, and left true and regular. Unless otherwise shown on the drawings, exterior surfaces shall be sloped for drainage, as directed. Where drains are provided, interior floors shall be evenly sloped to the drains. Joints shall be carefully made with a jointing or edging tool. The finished surfaces shall be protected from stains or abrasions. Grate tampers or

"jitterbugs" shall not be used for any surfaces. The dusting of surfaces with dry cement or other materials or the addition of any water during finishing shall not be permitted. If bleedwater is present prior to finishing, the excess water shall be carefully dragged off or removed by absorption with porous materials such as burlap. During finishing operations, extreme care shall be taken to prevent over finishing or working water into the surface; this can cause "crazing" (surface shrinkage cracks which appear after hardening) of the surface. Any slabs with surfaces which exhibit significant crazing shall be removed and replaced. During finishing operations, surfaces shall be checked with a 10 foot straightedge, applied in both directions at regular intervals while the concrete is still plastic, to detect high or low areas.

3.12.2 Rough Slab Finish

****
NOTE: Rough-slab finish alone is used when a bonded surface course for heavy use industrial floor is specified, or where roof fill or thick mortar setting bed is used. If the drawings do not indicate the slabs to receive only a rough slab finish, they must be specified here. Rough slab finish must be retained as the first operation for all subsequent finishing.
****

As a first finishing operation for unformed surfaces and as final finish for slabs to receive mortar setting beds, the surface shall receive a rough slab finish prepared as follows. [Areas indicated on the drawings] [The following areas [_____]] shall receive only a rough slab finish. The concrete shall be uniformly placed across the slab area, consolidated as previously specified, and then screeded with straightedge strikeoffs immediately after consolidation to bring the surface to the required finish level with no coarse aggregate visible. Side forms and screed rails shall be provided, rigidly supported, and set to exact line and grade. Allowable tolerances for finished surfaces apply only to the hardened concrete, not to forms or screed rails. Forms and screed rails shall be set true to line and grade. "Wet screeds" shall not be used.

3.12.3 Floated Finish

****
NOTE: If the drawings do not indicate the areas to receive a floated finish, they must be specified here.
****

Slabs to receive more than a rough slab finish shall next be given a wood float finish. [Areas as indicated on the drawings] [The following areas [_____]] shall be given only a float finish. The screeding shall be followed immediately by darbying or bull floating before bleeding water is present, to bring the surface to a true, even plane. Then, after the concrete has stiffened so that it will withstand a man's weight without imprint of more than 6 mm 1/4 inch and the water sheen has disappeared, it shall be floated to a true and even plane free of ridges. Floating shall be performed by use of suitable hand floats or power driven equipment. Sufficient pressure shall be used on the floats to bring a film of moisture to the surface. Hand floats shall be made of wood, magnesium, or aluminum. Lightweight concrete or concrete that exhibits stickiness shall be floated

with a magnesium float. Care shall be taken to prevent over-finishing or incorporating water into the surface.

3.12.4 Troweled Finish

****

NOTE: If the drawings do not indicate the areas to receive a trowel finish, they must be specified here. Edit accordingly. A troweled finish will be specified for most wearing surfaces and where a smooth dense surface finish is required. Edit bracketed items as desired by designer. Delete this paragraph when no troweled finish or subsequent finish is required.

****

[Areas as indicated on the drawings] [The following areas [_____]] shall be given a trowel finish. After floating is complete and after the surface moisture has disappeared, unformed surfaces shall be steel-troweled to a smooth, even, dense finish, free from blemishes including trowel marks. In lieu of hand finishing, an approved power finishing machine may be used in accordance with the directions of the machine manufacturer. Additional trowelings shall be performed, either by hand or machine until the surface has been troweled [2] [3] [4] times, with waiting period between each. Care shall be taken to prevent blistering and if such occurs, troweling shall immediately be stopped and operations and surfaces corrected. A final hard steel troweling shall be done by hand, with the trowel tipped, and using hard pressure, when the surface is at a point that the trowel will produce a ringing sound. The finished surface shall be thoroughly consolidated and shall be essentially free of trowel marks and be uniform in texture and appearance. The concrete mixture used for troweled finished areas shall be adjusted, if necessary, in order to provide sufficient fines (cementitious material and fine sand) to finish properly.

3.12.5 Superflat Finish

****

NOTE: If the drawings do not indicate the areas to receive a superflat surface, they must be specified here. Correlate this paragraph with the "Tolerances" paragraph in PART 1. Primary locations where superflat floors are required are warehouse aisles where very high lift forklifts and other type stackers operate. Delete this paragraph when superflat finish is not required.

****

[Areas as indicated on the drawings] [The following areas [_____]] shall be constructed as superflat floors. Extreme care shall be taken to meet specified tolerances. If necessary, special heavy duty, laser guided machines built especially for this work shall be used and shall have experienced, factory-trained operators. Finishing operations shall include use of long-handled 3 meter 10 foot "highway type" cutting straightedges plus any other tools necessary to meet the surface tolerance requirements. Surface finish shall conform to paragraph [Troweled Finish] [_____].

3.12.6 Non-Slip Finish

****

NOTE: If drawings do not indicate the areas to receive non-slip finish, they must be specified here. Broom finish is usually used for exterior slabs and abrasive aggregate for interior slabs, but such policy is not definite. Edit bracketed items as appropriate. Delete these paragraphs when Non-Slip Finish is not required.

****

Non-slip floors shall be constructed in accordance with the following subparagraphs.

3.12.6.1 Broomed

[Areas as indicated on the drawings] [The following areas [_____]] shall be given a broomed finish. After floating, the surface shall be lightly steel troweled, and then carefully scored by pulling a [hair] [coarse fiber] push-type broom across the surface. Brooming shall be transverse to traffic or at right angles to the slope of the slab. After the end of the curing period, the surface shall be vigorously broomed with a coarse fiber broom to remove all loose or semi-detached particles.

3.12.6.2 Abrasive Aggregate

[Areas as indicated on the drawings] [The following areas [_____]] shall be given an abrasive aggregate finish. The concrete surface shall be given a float finish. Abrasive aggregate shall then immediately be uniformly sprinkled over the floated surface at a total rate of not less than 1.25 kg per square meter 0.25 psf spread in two applications at right angles to each other. The surface shall then be troweled to a smooth, even finish that is uniform in texture and appearance and free from blemishes including trowels marks. Immediately after curing, cement paste and laitance covering the abrasive aggregate shall be removed by steel brushing, rubbing with abrasive stone, or sandblasting to expose the abrasive particles.

3.12.7 Dry Shake Finish

****

NOTE: If the drawings do not indicate the areas to receive a dry shake finish, they must be specified here. When dry shake finish is required, add to paragraph Technical Service for Specialized Concrete a requirement that a manufacturer's representative be present during use of dry shake finish.

****

[Areas as indicated on the drawings] [The following areas [_____]] shall be constructed with a dry shake finish. [Dry shake floor armoring topping] [Dry shake conductive and spark resistant floor topping] [Dry shake non-metallic, light reflective floor topping] shall be used to surface the floor. The base slab shall be constructed and the dry shake material applied in accordance with the manufacturer's written instructions, which shall be furnished by the Contractor. The dry shake material shall be applied in a two-stage application. Total application shall be at the rate recommended by the manufacturer but at a rate not less than 7.5 kg per square meter.1.5 psf. The first application shall be at the rate of two-thirds of the total and shall be applied immediately following floating of total area. The dry shake material shall first be applied to the floated concrete adjacent to forms, entryways, columns, and walls where

moisture will be lost first. Dry shake material shall be distributed evenly using an approved mechanical spreader. The material shall not be hand thrown on the surface. Finishing machines with float shoes shall be used as soon as dry shake has absorbed moisture (indicated by darkening of surface); floating shall be done just sufficiently to bring moisture from base slab through the shake. Immediately following floating of the first shake, the remaining one-third of the total specified shake shall be applied in the same manner and machine floated. Surface shall be further compacted by a third mechanical floating if time and setting characteristics will allow. At no time shall water be added to the surface. As surface further stiffens, indicated by loss of sheen, it shall be hand or mechanically troweled with blades relatively flat. All marks and pinholes shall be removed in the final raised trowel operation. Floors finished with dry shake material shall be cured using a curing compound recommended by the manufacturer of the dry shake material. Membrane curing compound shall be applied immediately after the floor surface has hardened sufficiently so surface will not be marred by the application. Compound shall be applied uniformly over the entire surface at a coverage which will provide moisture retention in excess of the requirements of ASTM C 309. When dry, the coating shall be protected from droppings of plaster, paint, dirt, and other debris by a covering of scuffproof, non-staining building paper. Floor shall remain covered and be kept free of traffic and loads for at least 10 days after completion. Adequate provision shall be made for maintaining the concrete temperature at 10 degrees C 50 degrees F or above during the curing period. The curing compound shall remain in place for not less than 30 days. The curing compound shall be removed by a manufacturer recommended method prior to turning the facility over to the Government.

3.12.8 Heavy Duty Floors

****

NOTE: Heavy duty floors are to be used only for floors that will receive major traffic of tracked vehicles or steel wheeled equipment when the designer is concerned about wear. Moderate amounts of such traffic can be accommodated by ordinary concrete floors. If drawings do not indicate areas to receive heavy duty finish, they must be specified here. Delete this subparagraph if not required. Edit bracketed items. Add to and strengthen this subparagraph as needed but do not delete any of the listed requirements.

****

[Areas as indicated on the drawings] [The following areas [_____]] shall have heavy duty floors constructed as follows:

3.12.8.1 General

Heavy duty floor shall be constructed by placing a heavy duty bonded topping on a base slab which has had a rough slab finish left 50 mm 2 inches below final grade. Concrete in the base slab shall be thoroughly hardened but not more than 30 hours old. The temperature of the fresh concrete topping shall not vary more than 5 degrees C 10 degrees Fplus or minus from the temperature of the base slab. The ambient temperature of the space adjacent to the concrete placement and of the base slab shall be between 10 and 30 degrees C.50 and 90 degrees F.

3.12.8.2 Preparation of Base Slab

The base slab shall be kept continuously damp until topping is placed. The surface of the base slab shall be thoroughly cleaned with an air-water jet immediately before placing the topping. A thin coat of neat cement grout of about the consistency of thick cream shall be thoroughly scrubbed into the existing surface immediately ahead of the overlay placing. At the time the neat cement grout is placed, the existing concrete surface shall be damp but shall have no free water present. The overlay concrete shall be deposited before the grout coat has had time to stiffen.

3.12.8.3 Placing and Finishing

Concrete shall be placed, as nearly as practicable in final position, in a uniform layer. The overlay shall be placed and screeded slightly above the required finished grade, compacted by rolling with rollers weighing not less than 4.5 kg 10 pounds per linear 25 mm 1 inch of roller width or by approved tamping equipment and finish screeded to established grade. Grid type tampers shall not be used. The concrete, while still green but sufficiently hardened to bear a person's weight without deep imprint, shall be floated to a true even plane with no coarse aggregate visible. Floating shall be performed with an approved disc-type mechanical float which has integral impact mechanism. The surface of the overlay shall then be left undisturbed until the concrete has hardened enough to prevent excess fines from being worked to the top. Joints shall be formed to match those in the base slab.

3.12.8.4 Curing and Protection

Concrete shall be maintained in a moist condition and shall be protected against rapid temperature change, mechanical injury, and injury from rain or flowing water, for a curing period of not less than 10 days. Concrete shall be maintained in a moist condition at temperatures above 10 and below 30 degrees C above 50 and below 90 degrees F throughout the specified curing period. Concrete shall be protected from a temperature change greater than 3 degrees C 5 degrees F per hour and from rapid drying for the first 24 hours following the removal of temperature protection. Curing activities shall begin as soon as free water has disappeared from the concrete surface after placing and finishing. Curing shall be moist curing accomplished by the following method. Surfaces shall be covered with a double layer of burlap, wetted before placing, and overlapped at least 150 mm.6 inches. Burlap shall be kept continually wet and in intimate contact with the surface. Burlap shall be kept covered with a polyethylene sheeting at least 0.1 mm 4 milsthick. All traffic shall be kept from the floor during the curing period and heavy traffic shall be kept off till 28-day age.

3.12.9 Two-Course Floor Construction

****

NOTE: Where it is anticipated that the surface of a floor slab may be damaged during construction operations, a two-course floor may be specified with the second course applied late in the contract. If the drawings do not indicate areas to receive two-course floor construction, they must be specified here. Delete this subparagraph when two-course floor is not required. Edit bracketed items.

****

[Areas as indicated on the drawings] [The following areas [_____]] shall have floors constructed with two-course construction. Two-course floor shall be constructed by placing a bonded topping on the thoroughly hardened concrete base slab which has been left with a rough slab finish left 50 mm 2 inches below final grade as shown on the drawings. Topping shall be applied at an approved time late in the contract period. The floor topping mixture shall have a specified compressive strength of 34.5 MPa 5000 psi at 28 days, a 50 mm 2 inch maximum slump, 12.5 mm 1/2 inch maximum size coarse aggregate, and shall be proportioned to obtain required finishability. The surface of the base slab shall be thoroughly cleaned by sandblasting or high-pressure waterjet immediately before placing topping. The temperature of the fresh concrete topping shall not vary more than 5 degrees C 10 degrees F plus or minus from the temperature of the base slab. The ambient temperature of the space adjacent to the concrete placement and of the base slab shall be between 10 and 30 degrees C.50 and 90 degrees F. The base slab shall be kept continuously wet for the first 12 hours during the 24 hour period immediately prior to placing the finished floor. After all free water has evaporated or has been removed from the surface, a grout shall be scrubbed in. The grout shall be a 1:1 mixture of portland cement and sand passing the 2.36 mm No. 8 sieve mixed to a creamlike consistency. The grout shall be scrubbed into the surface just ahead of the concrete topping placing operation. While the grout is still damp, the top course shall be spread and screeded and darbied or bull floated. When the surface moisture has disappeared, the surface shall then be floated with disc-type power float with integral impact mechanism followed by a minimum of two power trowelings. Trowel marks left by the machine shall be removed by a final, hard steel troweling by hand. Joints shall be formed to match those in the base slab. Concrete shall be maintained in a moist condition and shall be protected against rapid temperature change, mechanical injury, and injury from rain or water, for a curing period of not less than 10 days. Concrete shall be maintained in a moist condition at temperatures above 10 and below 30 degrees F 50 and below 90 degrees F throughout the specified curing period. Concrete shall be protected from a temperature change greater than 3 degrees C 5 degrees F per hour and from rapid drying for the first 24 hours following the removal of temperature protection. Curing activities shall be started immediately as soon as free water has disappeared from the surface of the concrete after placing and finishing. Curing shall be moist curing accomplished by the following method. Surfaces shall be covered with a double layer of burlap, wetted before placing, and overlapped at least 150 mm.6 inches. Burlap shall be kept continually wet and in intimate contact with the surface. Burlap shall be kept covered with a polyethylene sheeting at least 0.1 mm 4 mils thick. All traffic shall be kept from the topping during the curing period.

3.13 FLOOR HARDENER

****

NOTE: If the drawings do not indicate the areas to receive floor hardener, they must be specified here. Normally, floor hardener is not needed. Use only where extreme dust-free area is required or where requested by using service.

****

[Areas as indicated on the drawings] [The following areas [_____]] shall be treated with floor hardener. Floor hardener shall be applied after the concrete has been cured and then air dried for [14] [28] days. Three coats

shall be applied, each the day after the preceding coat was applied. For the first application, 0.5 kg one pound of the silocofluoride shall be dissolved in 4 liters one gallon of water. For subsequent applications, the solution shall be 1.0 kg two pounds of silicofluoride to each 4 liters gallon of water. Floor should be mopped with clear water shortly after the preceding application has dried to remove encrusted salts. Proprietary hardeners shall be applied in accordance with the manufacturer's instructions. During application, area should be well ventilated. Precautions shall be taken when applying silicofluorides due to the toxicity of the salts. Any compound that contacts glass or aluminum should be immediately removed with clear water.

3.14 EXTERIOR SLAB AND RELATED ITEMS

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NOTE: Edit bracketed statements and use these paragraphs only when minor amounts of specified items are required in the project. Remove affected paragraph when pertinent Section (Ex: 02513 CONCRETE PAVEMENT FOR AIRFIELDS AND OTHER HEAVY-DUTY PAVEMENTS, 02511 CONCRETE SIDEWALKS AND CURBS AND GUTTERS) is included in the contract.

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3.14.1 Pavements

Pavements shall be constructed where shown on the drawings. After forms are set and underlying material prepared as specified, the concrete shall be placed uniformly throughout the area and thoroughly vibrated. As soon as placed and vibrated, the concrete shall be struck off and screeded to the crown and cross section and to such elevation above grade that when consolidated and finished, the surface of the pavement will be at the required elevation. The entire surface shall be tamped with the strike off, or consolidated with a vibrating screed, and this operation continued until the required compaction and reduction of internal and surface voids are accomplished. Care shall be taken to prevent bringing excess paste to the surface. Immediately following the final consolidation of the surface, the pavement shall be floated longitudinally from bridges resting on the side forms and spanning but not touching the concrete. If necessary, additional concrete shall be placed and screeded, and the float operated until a satisfactory surface has been produced. The floating operation shall be advanced not more than half the length of the float and then continued over the new and previously floated surfaces. After finishing is completed but while the concrete is still plastic, minor irregularities and score marks in the pavement surface shall be eliminated by means of long-handled cutting straightedges. Straightedges shall be 3.75 m 12 feet in length and shall be operated from the sides of the pavement and from bridges. A straightedge operated from the side of the pavement shall be equipped with a handle 1 m 3 feet longer than one-half the width of the pavement. The surface shall then be tested for trueness with a 3.75 12 foot straightedge held in successive positions parallel and at right angles to the center line of the pavement, and the whole area covered as necessary to detect variations. The straightedge shall be advanced along the pavement in successive stages of not more than one-half the length of the straightedge. Depressions shall be immediately filled with freshly mixed concrete, struck off, consolidated, and refinished. Projections above the required elevation shall also be struck off and refinished. The straightedge testing and finishing shall continue until the entire surface of the concrete is true. Before the surface sheen has disappeared and well

before the concrete becomes nonplastic, the surface of the pavement shall be given a nonslip sandy surface texture by [belting with approved "belt" and procedures] [use of a burlap drag. A strip of clean, wet burlap from 1.0 to 1.5 m 3 to 5 feet wide and 0.7 m 2 feet longer than the pavement width shall be carefully pulled across the surface]. Edges and joints shall be rounded with an edger having a radius of 3 mm.1/8 inch. Curing shall be as specified.

3.14.2 Sidewalks

Concrete shall be 100 mm 4 inches minimum thickness. Contraction joints shall be provided at 1.75 m 5 feet spaces unless otherwise indicated. Contraction joints shall be cut 25 mm 1 inch deep with a jointing tool after the surface has been finished. Transverse expansion joints 12 mm 1/2 inch thick shall be provided at changes in direction and where sidewalk abuts curbs, steps, rigid pavement, or other similar structures. Sidewalks shall be given a lightly broomed finish. A transverse slope of 1 mm per 50 mm 1/4 inch per foot shall be provided, unless otherwise indicated. Variations in cross section shall be limited to 1 mm per 250 mm.1/4 inch in 5 feet.

3.14.3 Curbs and Gutters

Concrete shall be formed, placed, and finished by hand using a properly shaped "mule" or constructed using a slipform machine specially designed for this work. Contraction joints shall be cut 75 mm 3 inches deep with a jointing tool after the surface has been finished. Expansion joints (12 mm 1/2 inch wide) shall be provided at 35 m 100 feetmaximum spacing unless otherwise indicated. Exposed surfaces shall be finished using a stiff bristled brush.

3.14.4 Pits and Trenches

Pits and trenches shall be constructed as indicated on the drawings. Bottoms and walls shall be placed monolithically or waterstops and keys, shall be provided as approved.

3.15 CURING AND PROTECTION

3.15.1 General

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NOTE: Do not allow membrane curing compound on surfaces where appearance is critical or that are maintained at curing temperature with free steam. Moist curing should almost always be permitted.
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Concrete shall be cured by an approved method for the period of time given below:

Concrete with Type III cement	3 days
All other concrete	7 days

Immediately after placement, concrete shall be protected from premature drying, extremes in temperatures, rapid temperature change, mechanical injury and damage from rain and flowing water for the duration of the curing period. Air and forms in contact with concrete shall be maintained at a temperature above 10 degrees C 50 degrees F for the first 3 days and

at a temperature above 0 degrees C 32 degrees F for the remainder of the specified curing period. Exhaust fumes from combustion heating units shall be vented to the outside of the enclosure, and heaters and ducts shall be placed and directed so as not to cause areas of overheating and drying of concrete surfaces or to create fire hazards. Materials and equipment needed for adequate curing and protection shall be available and at the site prior to placing concrete. No fire or excessive heat, including welding, shall be permitted near or in direct contact with the concrete at any time. Except as otherwise permitted by paragraph Membrane Forming Curing Compounds, moist curing shall be provided for any areas to receive floor hardener, any paint or other applied coating, or to which other concrete is to be bonded. Concrete containing silica fume shall be initially cured by fog misting during finishing, followed immediately by continuous moist curing. Except for plastic coated burlap, impervious sheeting alone shall not be used for curing.

3.15.2 Moist Curing

Concrete to be moist-cured shall be maintained continuously wet for the entire curing period, commencing immediately after finishing. If water or curing materials used stain or discolor concrete surfaces which are to be permanently exposed, the concrete surfaces shall be cleaned as approved. When wooden forms are left in place during curing, they shall be kept wet at all times. If steel forms are used in hot weather, nonsupporting vertical forms shall be broken loose from the concrete soon after the concrete hardens and curing water continually applied in this void. If the forms are removed before the end of the curing period, curing shall be carried out as on unformed surfaces, using suitable materials. Surfaces shall be cured by ponding, by continuous sprinkling, by continuously saturated burlap or cotton mats, or by continuously saturated plastic coated burlap. Burlap and mats shall be clean and free from any contamination and shall be completely saturated before being placed on the concrete. The Contractor shall have an approved work system to ensure that moist curing is continuous 24 hours per day.

3.15.3 Membrane Forming Curing Compounds

Membrane forming curing compounds shall be used only on surfaces in the following areas, [_____]. Concrete in the following areas [may be cured with a pigmented curing compound in lieu of moist curing.] [may be cured with a nonpigmented curing compound containing a fugitive dye in lieu of moist curing.] Membrane curing shall not be used on surfaces that are to receive any subsequent treatment depending on adhesion or bonding to the concrete, including surfaces to which a smooth finish is to be applied or other concrete to be bonded. However, a styrene acrylate or chlorinated rubber compound meeting ASTM C 309, Class B requirements, may be used for surfaces which are to be painted or are to receive bituminous roofing or waterproofing, or floors that are to receive adhesive applications of resilient flooring. The curing compound selected shall be compatible with any subsequent paint, roofing, waterproofing or flooring specified. Membrane curing compound shall not be used on surfaces that are maintained at curing temperatures with free steam. Curing compound shall be applied to formed surfaces immediately after the forms are removed and prior to any patching or other surface treatment except the cleaning of loose sand, mortar, and debris from the surface. All surfaces shall be thoroughly moistened with water. Curing compound shall be applied to slab surfaces as soon as the bleeding water has disappeared, with the tops of joints being temporarily sealed to prevent entry of the compound and to prevent moisture loss during the curing period. The curing compound shall be applied in a

two-coat continuous operation by approved motorized power-spraying equipment operating at a minimum pressure of 500 kPa, 75 psi, at a uniform coverage of not more than 10 cubic meters per L 400 square feet per gallon for each coat, and the second coat shall be applied perpendicular to the first coat. Concrete surfaces which have been subjected to rainfall within 3 hours after curing compound has been applied shall be resprayed by the method and at the coverage specified. Surfaces on which clear compound is used shall be shaded from direct rays of the sun for the first 3 days. Surfaces coated with curing compound shall be kept free of foot and vehicular traffic, and from other sources of abrasion and contamination during the curing period.

3.15.4 Impervious Sheeting

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NOTE: Use impervious sheeting only for surfaces that are horizontal or near horizontal. Do not use on slab surfaces where appearance is critical.
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The following concrete surfaces may be cured using impervious sheets: [_____]. However, except for plastic coated burlap, impervious sheeting alone shall not be used for curing. Impervious-sheet curing shall only be used on horizontal or nearly horizontal surfaces. Surfaces shall be thoroughly wetted and be completely covered with the sheeting. Sheeting shall be at least 450 mm 18 inches wider than the concrete surface to be covered. Covering shall be laid with light-colored side up. Covering shall be lapped not less than 300 mm 12 inches and securely weighted down or shall be lapped not less than 100 mm 4 inches and taped to form a continuous cover with completely closed joints. The sheet shall be weighted to prevent displacement so that it remains in contact with the concrete during the specified length of curing. Coverings shall be folded down over exposed edges of slabs and secured by approved means. Sheets shall be immediately repaired or replaced if tears or holes appear during the curing period.

3.15.5 Ponding or Immersion

Concrete shall be continually immersed throughout the curing period. Water shall not be more than 10 degrees C 20 degrees F less than the temperature of the concrete.

3.15.6 Cold Weather Curing and Protection

When the daily ambient low temperature is less than 0 degrees C 32 degrees F the temperature of the concrete shall be maintained above 5 degrees C 40 degrees F for the first seven days after placing. During the period of protection removal, the air temperature adjacent to the concrete surfaces shall be controlled so that concrete near the surface will not be subjected to a temperature differential of more than 13 degrees C 25 degrees F as determined by suitable temperature measuring devices furnished by [the Government][the Contractor], as required, and installed adjacent to the concrete surface and 50 mm 2 inches inside the surface of the concrete. The installation of the thermometers shall be made by the Contractor as directed.

3.16 SETTING BASE PLATES AND BEARING PLATES

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NOTE: Damp-pack bedding mortar will be specified for setting base and bearing plates, except that nonshrink grout will be specified for heavy machinery bases or where design requires precision setting of plates or requires that bedding material have high resistance to shear, impact, or vibration, and where good damp packing is difficult or impossible. When using nonshrink grout on important structures, such as large machinery bases, the grout should be required to meet ASTM C 1107, Grade A, B, or C, grade or grades as selected by the designer. This nonshrink grout must not be used for embedding post-tensioned tendons or rock bolts. Edit bracketed item as appropriate, and delete entire paragraph if not needed.

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After being properly positioned, column base plates, bearing plates for beams and similar structural members, and machinery and equipment base plates shall be set to the proper line and elevation with damp-pack bedding mortar, except where nonshrink grout is indicated. The thickness of the mortar or grout shall be approximately 1/24 the width of the plate, but not less than 20 mm.3/4 inch. Concrete and metal surfaces in contact with grout shall be clean and free of oil and grease, and concrete surfaces in contact with grout shall be damp and free of laitance when grout is placed. Nonshrink grout shall be used for [_____].

3.16.1 Damp-Pack Bedding Mortar

Damp-pack bedding mortar shall consist of 1 part cement and 2-1/2 parts fine aggregate having water content such that a mass of mortar tightly squeezed in the hand will retain its shape but will crumble when disturbed. The space between the top of the concrete and bottom of the bearing plate or base shall be packed with the bedding mortar by tamping or ramming with a bar or rod until it is completely filled.

3.16.2 Nonshrink Grout

Nonshrink grout shall be a ready-mixed material requiring only the addition of water. Water content shall be the minimum that will provide a flowable mixture and completely fill the space to be grouted without segregation, bleeding, or reduction of strength.

3.16.2.1 Mixing and Placing of Nonshrink Grout

Mixing and placing shall be in conformance with the material manufacturer's instructions and as specified therein. 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 machinery-bearing surface and the plate shall be filled solid with the grout. Forms shall be of wood or other equally suitable material for completely retaining the grout on all sides and on top and shall be removed after the grout has set. The placed grout shall be carefully worked by rodding or other means 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 18 to 30 degrees C 65 to 85 degrees F until after setting.

3.16.2.2 Treatment of Exposed Surfaces

For metal-oxidizing nonshrink grout, exposed surfaces shall be cut back 25 mm 1 inch and immediately covered with a parge coat of mortar consisting of 1 part portland cement and 2-1/2 parts fine aggregate by weight, with sufficient water to make a plastic mixture. The parge coat shall have a smooth finish. For other mortars or grouts, exposed surfaces shall have a smooth-dense finish and be left untreated. Curing shall comply with paragraph CURING AND PROTECTION.

3.17 TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL

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NOTE: For non-critical small projects, less than 1200 cubic meters (1500 cu. yd.) of concrete, the designer may reduce, but not eliminate, the requirements of this paragraph, and edit it appropriately for the project specifications. Otherwise, retain complete.

****

The Contractor shall perform the inspection and tests described below and, based upon the results of these inspections and tests, shall take the action required and shall submit specified reports. When, in the opinion of the Contracting Officer, the concreting operation is out of control, concrete placement shall cease and the operation shall be corrected. The laboratory performing the tests shall be onsite and shall conform with ASTM C 1077. Materials may be subjected to check testing by the Government from samples obtained at the manufacturer, at transfer points, or at the project site. The Government will inspect the laboratory, equipment, and test procedures prior to start of concreting operations and at least once per [_____] thereafter for conformance with ASTM C 1077.

3.17.1 Grading and Corrective Action

3.17.1.1 Fine Aggregate

At least once during each shift when the concrete plant is operating, there shall be one sieve analysis and fineness modulus determination in accordance with ASTM C 136 and COE CRD-C 104 for the fine aggregate or for each 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. 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 reported to the Contracting Officer, concreting shall be stopped, and immediate steps taken to correct the grading.

3.17.1.2 Coarse Aggregate

At least once during each shift in which the concrete plant is operating, there shall be a sieve analysis in accordance with ASTM C 136 for each size of coarse aggregate. The location at which samples are taken may be selected by the Contractor as the most advantageous for production control.

However, the Contractor shall be responsible for delivering the aggregate to the mixer within specification limits. A test record of samples of aggregate taken at the same locations shall show the results of the current test as well as the average results of the five most recent tests including the current test. The Contractor may adopt limits for control coarser than the specification limits for samples taken other than as delivered to the mixer to allow for degradation during handling. 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 5 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.

3.17.2 Quality of Aggregates

Thirty days prior to the start of concrete placement, the Contractor shall perform all tests for aggregate quality required by ASTM C 33. In addition, after the start of concrete placement, the Contractor shall perform tests for aggregate quality at least every three months, and when the source of aggregate or aggregate quality changes. Samples tested after the start of concrete placement shall be taken immediately prior to entering the concrete mixer.

3.17.3 Scales, Batching and Recording

The accuracy of the scales shall be checked by test weights prior to start of concrete operations and at least once every three months. Such tests shall also be made as directed whenever there are variations in properties of the fresh concrete that could result from batching errors. 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. At the same time, the Contractor shall test and ensure that the devices for dispensing admixtures are operating properly and accurately. 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.

3.17.4 Batch-Plant Control

The measurement of concrete 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, cubic yard, amount of water as free moisture in each size of aggregate, and the batch aggregate and water weights per cubic meter cubic yard for each class of concrete batched during each day's plant operation.

3.17.5 Concrete Mixture

a. Air Content Testing. Air content tests shall be made when test

specimens are fabricated. In addition, at least two tests for air content shall be made on randomly selected batches of each separate concrete mixture produced during each 8-hour period of concrete production. Additional tests shall be made when excessive variation in workability is reported by the placing foreman or Government inspector. Tests shall be made in accordance with ASTM C 231 for normal weight concrete and ASTM C 173 for lightweight concrete. Test results shall be plotted on control charts which shall at all times be readily available to the Government and shall be submitted weekly. Copies of the current control charts shall be kept in the field by testing crews 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 air content and the control chart for range, and for determining need for any remedial action. The result of each test, or average as noted in the previous sentence, shall be plotted on a separate control chart for each mixture on which an "average line" is set at the midpoint of the specified air content range from paragraph Air Entrainment. An upper warning limit and a lower warning limit line shall be set 1.0 percentage point above and below the average line, respectively. 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 secondary control chart for range where an upper warning limit is set at 2.0 percentage points and an upper action limit is set at 3.0 percentage points. Samples for air content may be taken at the mixer, however, the Contractor is responsible for delivering the concrete to the placement site at the stipulated air content. If the Contractor's materials or transportation methods cause air content loss between the mixer and the placement, correlation samples shall be taken at the placement site as required by the Contracting Officer, and the air content at the mixer controlled as directed.

b. Air Content Corrective Action. Whenever points on the control chart for percent air reach either warning limit, an adjustment shall immediately be made in the amount of air-entraining admixture batched. As soon as practical after each adjustment, another test shall be made to verify the result of the adjustment. Whenever a point on the secondary control chart for 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.

c. Slump Testing. In addition to slump tests which shall be made when test specimens are fabricated, at least four slump tests shall be made on randomly selected batches in accordance with ASTM C 143/C 143M for each separate concrete mixture produced during each 8-hour or less period of concrete production each day. Also, additional tests shall be made when excessive variation in workability is reported by the placing foreman or Government inspector. Test results shall be plotted on control charts which

shall at all times be readily available to the Government and shall be submitted weekly. Copies of the current control charts shall be kept in the field by testing crews 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. 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 charts for slump and the chart for range, and for determining need for any remedial action. Limits shall be set on separate control charts for slump for each type of mixture. The upper warning limit shall be set at 12.5 mm 1/2 inch below the maximum allowable slump specified in paragraph Slump in PART 1 for each type of concrete 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 the mixer and the placement, correlation samples shall be taken at the placement site as required by the Contracting Officer, and the slump at the mixer controlled as directed.

d. Slump Corrective Action. Whenever points on the control charts for slump reach the upper warning limit, an adjustment shall immediately be made in the batch weights of water and fine aggregate. The adjustments are to be made so that the total water content does not exceed that amount allowed by the maximum w/c ratio specified, based on 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 individual slump tests, made during a period when there was no adjustment of batch weights, produce a point on the control chart for range at or above the upper action limit, the concreting operation shall immediately be halted, and the Contractor shall take appropriate steps to bring the slump under control. Additional slump tests shall be made as directed.

e. Temperature. The temperature of the concrete shall be measured when compressive strength specimens are fabricated. Measurement shall be in accordance with ASTM C 1064/C 1064M. The temperature shall be reported along with the compressive strength data.

f. Strength Specimens. At least one set of test specimens shall be made, for compressive or flexural strength as appropriate, on each different concrete mixture placed during the day for each 380 cubic meters 500 cubic yards or portion thereof of that concrete mixture placed each day. Additional sets of test specimens shall be made, as directed by the Contracting Officer, when the mixture proportions are changed or when low strengths have been detected. A truly random (not haphazard) sampling plan shall be developed by the Contractor and approved by the Contracting Officer prior to the start of construction. The plan shall assure that sampling is

done in a completely random and unbiased manner. A set of test specimens for concrete with a 28-day specified strength per paragraph Strength Requirements in PART 1 shall consist of four specimens, two to be tested at 7 days and two at 28 days. [A set of test specimens for concrete with a 90-day strength per the same paragraph shall consist of six specimens, two tested at 7 days, two at 28 days, and two at 90 days.] Test specimens shall be molded and cured in accordance with ASTM C 31/C 31M and tested in accordance with ASTM C 39/C 39M for test cylinders and ASTM C 78 for test beams. Results of all strength tests shall be reported immediately to the Contracting Officer. Quality control charts shall be kept for individual strength "tests", ("test" as defined in paragraph Strength Requirements in PART 1) moving average of last 3 "tests" for strength, and moving average for range for the last 3 "tests" for each mixture. The charts shall be similar to those found in ACI 214.3R.

3.17.6 Inspection Before Placing

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

3.17.7 Placing

The placing foreman shall supervise placing operations, shall determine that the correct quality of concrete or grout is placed in each location as specified and as directed by the Contracting Officer, and shall be responsible for measuring and recording concrete temperatures and ambient temperature hourly during placing operations, weather conditions, time of placement, volume placed, and method of placement. The placing foreman shall not permit batching and placing to begin until it has been 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.

3.17.8 Vibrators

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 while the vibrator is operating in concrete with the tachometer being held against the upper end of the vibrator head while almost submerged and just before the vibrator is withdrawn from the concrete. The amplitude shall be determined with the head vibrating in air. Two measurements shall be taken, one near the tip and another near the upper end of the vibrator head, and these results averaged. The make, model, type, and size of the vibrator and frequency and amplitude results shall be reported in writing. Any vibrator not meeting the requirements of paragraph Consolidation, shall be immediately removed from service and repaired or replaced.

3.17.9 Curing Inspection

a. Moist Curing Inspections. At least once each shift, and not less than twice per day on both work and non-work days, an inspection shall be made of all areas subject to moist curing. The surface moisture condition shall be noted and recorded.

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

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

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

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

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

3.17.10 Cold-Weather Protection

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

3.17.11 Mixer Uniformity

a. Stationary Mixers. Prior to the start of concrete placing and once every 6 months when concrete is being placed, or once for every 60,000 cubic meters 75,000 cubic yards of concrete placed, whichever results in the shortest time interval, uniformity of concrete mixing shall be determined in accordance with ASTM C 94/C 94M.

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

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

3.17.12 Reports

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

-- End of Section --