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USACE / NAVFAC / AFCEC / NASA **UFGS-03 30 00.00 10 (November 2010)**

Preparing Activity: USACE **Superseding UFGS-03 31 00.00 10 (April 2006)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2013
****

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DIVISION 03 - CONCRETE

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CAST-IN-PLACE CONCRETE

11/10

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SECTION 03 30 00.00 10

CAST-IN-PLACE CONCRETE
11/10

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

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

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

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

PART 1 GENERAL

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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 03 11 13.00 10 CONCRETE FORMING
Section 03 20 00.00 10 CONCRETE REINFORCEMENT
Section 03 15 00.00 10 CONCRETE ACCESSORIES
Section 07 92 00 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.

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 should be indicated. If other than cast finish is required, the type and location must be indicated.

7. Loading assumptions

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

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1.1 UNIT PRICES

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

1.1.1 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.

1.1.2 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 includes 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.

1.2 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.

1.3 REFERENCES

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

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

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

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

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 117	(2010; Errata 2011) Specifications for Tolerances for Concrete Construction and Materials and Commentary
ACI 211.1	(1991; R 2009) Standard Practice for

	Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 211.2	(1998; R 2004) Standard Practice for Selecting Proportions for Structural Lightweight Concrete
ACI 213R	(2003) Guide for Structural Lightweight-Aggregate Concrete
ACI 214R	(2011) Evaluation of Strength Test Results of Concrete
ACI 301	(2010; Errata 2011) Specifications for Structural Concrete
ACI 301M	(2010) Metric Specifications for Structural Concrete
ACI 305.1	(2006) Specification for Hot Weather Concreting
ACI 318	(2011; Errata 1 2011; Errata 2 2012; Errata 3-4 2013) Building Code Requirements for Structural Concrete and Commentary
ACI 318M	(2011; Errata 2013) Building Code Requirements for Structural Concrete & Commentary

ASTM INTERNATIONAL (ASTM)

ASTM C1017/C1017M	(2007) Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C1059/C1059M	(1999; R 2008) Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete
ASTM C1064/C1064M	(2011) Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
ASTM C1077	(2013b) Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C1107/C1107M	(2013) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM C1116/C1116M	(2010a) Standard Specification for Fiber-Reinforced Concrete
ASTM C1240	(2012) Standard Specification for Silica Fume Used in Cementitious Mixtures

ASTM C1260	(2007) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C143/C143M	(2012) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C1567	(2013) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C172/C172M	(2010) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C173/C173M	(2012) Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C192/C192M	(2013) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231/C231M	(2010) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C31/C31M	(2012) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2013) Standard Specification for Concrete Aggregates
ASTM C330/C330M	(2009) Standard Specification for Lightweight Aggregates for Structural Concrete
ASTM C39/C39M	(2012) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C42/C42M	(2013) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

ASTM C494/C494M	(2013) Standard Specification for Chemical Admixtures for Concrete
ASTM C496/C496M	(2011) Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
ASTM C552	(2012b) Standard Specification for Cellular Glass Thermal Insulation
ASTM C567/C567M	(2011) Determining Density of Structural Lightweight Concrete
ASTM C578	(2012b) Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation
ASTM C591	(2012a) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM C595/C595M	(2013) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2012a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C685/C685M	(2011) Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C78/C78M	(2012; E 2013) Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C881/C881M	(2010) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C937	(2010) Grout Fluidifier for Preplaced-Aggregate Concrete
ASTM C94/C94M	(2013a) Standard Specification for Ready-Mixed Concrete
ASTM C989/C989M	(2012a) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM D75/D75M	(2009) Standard Practice for Sampling Aggregates
ASTM E1155	(1996; R 2008) Standard Test Method for Determining Floor Flatness and Floor Levelness Numbers
ASTM E1155M	(1996; R 2008) Standard Test Method for Determining Floor Flatness and Floor Levelness Numbers (Metric)
ASTM E96/E96M	(2012) Standard Test Methods for Water

Vapor Transmission of Materials

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 44	(2013) Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices

NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA CPMB 100	(2000; R 2006) Concrete Plant Standards
NRMCA QC 3	(2011) Quality Control Manual: Section 3, Plant Certifications Checklist: Certification of Ready Mixed Concrete Production Facilities
NRMCA TMMB 100	(2001; R 2007) 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 94	(1995) Corps of Engineers Specification for Surface Retarders

1.4 SYSTEM DESCRIPTION

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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.

****

Provide concrete composed of portland cement, other cementitious and pozzolanic materials as specified, aggregates, water and admixtures as specified.

1.4.1 Proportioning Studies-Normal Weight Conc

Trial design batches, mixture proportions studies, and testing requirements for various classes and types of concrete specified are 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 C192/C192M and tested in accordance with ASTM C39/C39M.

a. Samples of all materials used in mixture proportioning studies shall be

representative of those proposed for use in the project and be accompanied by the manufacturer's or producer's test reports indicating compliance with these specifications.

b. Make trial mixtures having proportions, consistencies, and air content suitable for the work based on methodology described in ACI 211.1, using at least three different water-cement ratios 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.

c. The maximum water-cement ratios required in subparagraph Water-Cement Ratio below 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.

d. Design laboratory trial mixtures for maximum permitted slump and air content. Make separate sets of trial mixture studies 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.

e. Report the temperature of concrete in each trial batch. For each water-cement ratio, at least three test cylinders for each test age shall be made, cured in accordance with ASTM C192/C192M and tested at 7 and 28 days in accordance with ASTM C39/C39M. From these test results, plot a curve 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. Design each mixture to promote easy and suitable concrete placement, consolidation and finishing, and to prevent segregation and excessive bleeding.

f. Submit 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. Accompany the statement with 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.

1.4.2 Proportioning Studies-Flexural Strength Conc

****
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 above, except that proportions shall be based on flexural strength as determined by test specimens (beams) fabricated in accordance with ASTM C192/C192M and tested in accordance with ASTM C78/C78M. Modify procedures given in ACI 211.1 as necessary to accommodate flexural strength.

1.4.3 Proportioning Studies-Lightweight Aggregate Structural Conc

Trial design batches, mixture proportioning studies, and testing requirements shall conform to the requirements specified in paragraph Proportioning Studies for Normal Weight Concrete above, 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. Proportion trial mixes to produce air dry unit weight, concrete strengths, 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 C496/C496M] shall be determined from test cylinders that have been air dried at 50 percent relative humidity for the last 21 days. Determine air dry unit weight in accordance with ASTM C567/C567M, designed to be at least 32 kg/cubic meter 2.0 pcf less than the maximum specified air dry unit weight. Plot curves 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.

1.4.4 Average Compressive Strength

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, adjust the mixture, 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.

1.4.5 Computations from Test Records

Where a concrete production facility has test records, establish a standard deviation in accordance with the applicable provisions of ACI 214R. Test records from which a standard deviation is calculated shall represent materials, quality control procedures, and conditions similar to those expected; shall represent concrete produced to meet a specified strength or

strengths (f'c) within 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 MPa f'cr = f'c + 1.34S where units are in psi

f'cr = f'c + 2.33S - 3.45 where units are in MPa f'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

1.4.6 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

1.4.7 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.

1.4.8 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. Design the mix 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. Do not air-entrain the topping concrete. Mix the concrete 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 C143/C143M.

1.4.9 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. Take level and grade tolerance measurements of slabs as soon as possible after finishing; when forms or shoring are used, the measurements shall be made prior to removal.

1.4.10 Floor Finish

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 does not apply where design requires floors to be sloped to drains or sloped for other reasons.

1.4.10.1 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 4.8.5 and 4.8.5.1 of ACI 117. 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 E1155M ASTM E1155. 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 E1155M ASTM E1155 (the areas within 600 mm 24 inches of embedments and construction joints) will be acceptable to the Contracting Officer. Tolerances of the following areas shall meet the requirements for the listed surfaces as specified in paragraphs 4.8.5 and 4.8.5.1 of ACI 117.

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

1.4.10.2 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	[_____]

1.4.11 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 32 13 11 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 C39/C39M. Flexural strength shall be determined in accordance with ASTM C78/C78M.

1.4.11.1 Evaluation of Concrete Compressive Strength

Fabricate compressive strength specimens (152 by 305 mm6 by 12 inch cylinders), laboratory cure them in accordance with ASTM C31/C31M and test them in accordance with ASTM C39/C39M. The strength of the concrete will be considered satisfactory so long as the average of all sets of three consecutive test results equals or exceeds the specified compressive strength f'c and no individual test result falls below the specified strength f'c by more than 3.5 MPa 500 psi. A "test" is defined as the average of two companion cylinders, or if only one cylinder is tested, the results of the single cylinder test. Additional analysis or testing, including 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.

1.4.11.2 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, take steps 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 C42/C42M. At least three representative cores shall be taken from each member or area of concrete in place that is considered potentially deficient. The location of cores will be determined by the Contracting Officer to least impair the 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. Perform the coring and repair the holes; cores will be tested by the Government.

1.4.11.3 Load Tests

If the core tests are inconclusive or impractical to obtain or if structural analysis does not confirm the safety of the structure, load tests may be directed by the Contracting Officer in accordance with the requirements of ACI 318M ACI 318. Concrete work evaluated by structural analysis or by results of a load test 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 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.

1.4.11.4 Evaluation of Concrete Flexural Strength

Fabricate flexural strength specimens (beams) laboratory cure them in accordance with ASTM C31/C31M and test them in accordance with ASTM C78/C78M. 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.

1.4.12 Water-Cement Ratio

****
NOTE: Where durability or other factors are a major consideration, retain this paragraph limiting w/c; coordinate this subparagraph with paragraph SYSTEM DESCRIPTION above 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.

1.4.13 Air Entrainment

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

Entrained air should not be used for concrete to be given a smooth, dense, hard-troweled finish because blistering and delamination may occur. Refer to ACI 302.1R for a detailed discussion on how to produce high-quality concrete slabs-on-ground and suspended floors for various classes of service.

****

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 C231/C231M. 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 C173/C173M.

1.4.14 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 C143/C143M.

Structural Element	Slump (mminches)	
	Minimum	Maximum
Walls, columns and beams	502	1004
Foundation walls, substructure walls, footings, slabs	251	753
Any structural concrete approved for placement by pumping:		
At pump	502	1506
At discharge of line	251	1004

[When use of a plasticizing admixture conforming to ASTM C1017/C1017M or when a Type F or G high range water reducing admixture conforming to ASTM C494/C494M 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.]

1.4.15 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.

1.4.16 Size of Coarse Aggregate

Use the largest feasible nominal maximum size aggregate (NMSA), specified in PART 2 paragraph AGGREGATES, 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.

1.4.17 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 C330/C330M, 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 C496/C496M 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 not be over [_____] at equilibrium as determined by ASTM C567/C567M. 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 at equilibrium.

1.5 SUBMITTALS

****

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

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal

is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

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

****

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

SD-03 Product Data

Recycled Content Products; (LEED)
Portland Cement
Ready-Mixed Concrete
Vapor Barrier
Latex Bonding Agent
Floor Finish
Floor Hardener
Chemical Admixtures
Epoxy Resin

SD-04 Samples

Surface Retarder

SD-05 Design Data

Mixture Proportions[; G][; G, [_____]]
Lightweight Aggregate Concrete

SD-06 Test Reports

Testing and Inspection for CQC[; G][; G, [_____]]

SD-07 Certificates

Qualifications

1.6 QUALITY ASSURANCE

Submit qualifications for Contractor Quality Control personnel assigned to concrete construction as American Concrete Institute (ACI) Certified Workmen in one of the following grades or show 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 Code Council (ICC), and Southern Building Code Congress International (SBCCI)
Foreman or Lead Journeyman of the flatwork finishing crew	Similar qualification for ACI Concrete Flatwork Technician/Finisher or equal, with written documentation

1.6.1 Pre-installation Meeting

****
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 is responsible for calling the meeting; the Project Superintendent and active installation personnel shall be present.

1.6.2 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.

1.6.3 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.
****

Obtain the services of a factory trained technical representative 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.

1.6.4 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 CQC responsibilities.

1.6.4.1 Materials

The Government will sample and test aggregates, cementitious materials, other materials, and concrete to determine compliance with the specifications as considered appropriate. Provide facilities and labor as may be necessary for procurement of representative test samples. Samples of aggregates will be obtained at the point of batching in accordance with ASTM D75/D75M. 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.

1.6.4.2 Fresh Concrete

Fresh concrete will be sampled as delivered in accordance with ASTM C172/C172M and tested in accordance with these specifications, as considered necessary.

1.6.4.3 Hardened Concrete

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

1.6.4.4 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.

1.7 DELIVERY, STORAGE, AND HANDLING

Store cement and other cementitious materials 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. Store reinforcing bars and accessories 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.

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.
****

In accordance with Section 01 62 35 RECYCLED/RECOVERED/BIOBASED MATERIALS submit documentation indicating: distance between manufacturing facility and the project site, distance of raw material origin from the project site, percentage of post-industrial and post-consumer recycled content per unit of product and relative dollar value of recycled content products to total dollar value of products included in project. Submittals shall be as specified in the subject Section.

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 alkalis 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] conforming to appropriate specifications listed below. Restrict usage of cementitious materials in concrete that will have surfaces exposed in the completed structure so there is no change in color, source, or type of cementitious material.

2.1.1 Portland Cement

ASTM C150/C150M, 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 C150/C150M, Type III with tricalcium aluminate limited to [5] [8] percent, [low alkali]. Use Type III cement 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 C595/C595M, Type [IP] [IP (MS)] [IP (MH)] [IS] [IS (MS)] [IS (MH)].

2.1.4 Pozzolan (Fly Ash)

Pozzolan shall conform to ASTM C618, Class C or F, including low alkali [multiple factor,] [drying shrinkage,] [uniformity,] [and [moderate] [severe] sulfate resistance] requirements in Table 3 of ASTM C618. If pozzolan is used, it shall never be less than 15 percent nor more than 35 percent by weight of the total cementitious material. Comply with EPA requirements in accordance with Section 01 62 35 RECYCLED/RECOVERED/BIOBASED MATERIALS.

2.1.5 Ground Granulated Blast-Furnace (GGBF) Slag

ASTM C989/C989M, 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 C1240. Available alkalis shall conform to the optimal limit given in Table 2 of ASTM C1240. Silica fume may be furnished as a dry, densified material or as a slurry. In accordance with paragraph Technical Service for Specialized Concrete in PART 1, 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.

This note may be disregarded for regions where Alkali-Silica Reactivity (ASR) is not a concern. Some aggregate sources may exhibit an ASR potential. ASR is a potentially deleterious reaction between alkalis present in concrete and some siliceous aggregates, reference EM 1110-2-2000 paragraph 2-3b(6) and appendix D. Where ASR is known or suspected to pose a concern for concrete durability, it is recommended that aggregates proposed for use in concrete be evaluated to determine ASR potential and an effective mitigation. EM 1110-2-2000, provides recommendations for evaluating and mitigating ASR in concrete mixtures. Aggregate evaluations may not be practical for projects requiring small quantities of concrete (less than 250 cubic yards).

Section 32 13 11 CONCRETE PAVEMENT FOR AIRFIELDS AND OTHER HEAVY-DUTY PAVEMENTS MORE THAN 10,000 CUBIC YARDS, paragraph 2.2.1.2 Alkali-Silica Reactivity, provides a specification method for the Contractor to evaluate and mitigate ASR in concrete mixtures. The expansion limits specified in Section 32 13 11 are requirements for pavements and exterior slab construction. For structural concrete applications the measured expansion shall be less than 0.10 percent. It may not be economical or practical to specify different test limit requirements for use on the same project. In which case the lower limit required by the application should be used.

The designer may use the specification method in Section 32 13 11 by incorporating the relevant paragraphs into this specification, or may use the following requirements (retain either the 0.10 or the 0.08 percent expansion limits as appropriate) included in the set of brackets highlighted thus ["."]. Remove quotation marks if this option is selected.

****

Fine and coarse aggregates shall ["be tested and evaluated for alkali-aggregate reactivity in accordance with ASTM C1260. The fine and coarse aggregates shall be evaluated separately and in combination, which matches the Contractor's proposed mix design proportioning. All results of the separate and combination testing shall have a measured expansion less than 0.10 (0.08) percent at 16 days after casting. Should the test data indicate an expansion of 0.10 (0.08) percent or greater, the aggregate(s) shall be rejected or additional testing using ASTM C1260 and ASTM C1567 shall be performed. The additional testing using ASTM C1260 and ASTM C1567 shall be performed using the low alkali portland cement in combination with ground granulated blast furnace (GGBF) slag, or Class F fly ash. GGBF slag shall be used in the range of 40 to 50 percent of the total cementitious material by mass. Class F fly ash shall be used in the range of 25 to 40 percent of the total cementitious material by mass."] [conform to the following.]

2.2.1 Fine Aggregate

Fine aggregate shall conform to the quality and gradation requirements of ASTM C33/C33M.

2.2.2 Coarse Aggregate

Coarse aggregate shall conform to ASTM C33/C33M, Class 5S, size designation [_____].

2.2.3 Lightweight Aggregate

Lightweight fine and coarse aggregate shall conform to the quality and gradation requirements of ASTM C330/C330M, size [_____] for coarse aggregate. Prewet and vacuum saturate lightweight aggregate in accordance with the Manufacturer's instructions unless otherwise specified. For pumped concrete, prewet sufficiently 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 C131. Gradation of the aggregates when tested in accordance with ASTM C136 shall be as follows:

Coarse Aggregate	
Sieve Size	Cumulative Percent Cumulative Percent
19 mm 3/4 inch	100
12.5 mm 1/2 inch	50-100
9.5 mm 3/8 inch	25-50

Coarse Aggregate	
Sieve Size	Cumulative Percent Cumulative Percent
4.75 mm No. 4	0-15
2.36 mm No. 8	0-8

Fine Aggregate	
Sieve Size	Cumulative Percent
9.5 mm 3/8 inch	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 C260/C260M and shall consistently entrain the air content in the specified ranges under field conditions.

2.3.2 Accelerating Admixture

ASTM C494/C494M, 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 C494/C494M, 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 C494/C494M, 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. Submit sample of surface retarder material with manufacturer's instructions for application in conjunction with air-water cutting.

2.3.6 Expanding Admixture

Aluminum powder type expanding admixture conforming to ASTM C937.

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 C1017/C1017M, 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 WATER

Water for mixing 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.

2.5 NONSHRINK GROUT

Nonshrink grout shall conform to ASTM C1107/C1107M, and shall be a commercial formulation suitable for the proposed application.

2.6 NONSLIP SURFACING MATERIAL

Provide nonslip surfacing material consisting 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.

2.7 LATEX BONDING AGENT

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

2.8 EPOXY RESIN

Epoxy resins for use in repairs shall conform to ASTM C881/C881M, Type V, Grade 2. Class as appropriate to the existing ambient and surface temperatures. Submit manufacturer's product data, indicating VOC content. Manufacturer's catalog data for the items above, including printed instructions.

2.9 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 09 51 00 ACOUSTICAL CEILINGS. Inserts for shelf angles and bolt hangers shall be of malleable iron or cast or wrought steel.

2.10 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.

2.11 PERIMETER INSULATION

****
NOTE: Show required K-value on the drawings.
****

Perimeter insulation shall be polystyrene conforming to ASTM C578, Type II; polyurethane conforming to ASTM C591, Type II; or cellular glass conforming to ASTM C552, Type I or IV. Comply with EPA requirements in accordance with Section 01 62 35 RECYCLED/RECOVERED/BIOBASED MATERIALS.

2.12 VAPOR BARRIER

Vapor barrier shall be polyethylene sheeting with a minimum thickness of 0.15 mm 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 as determined in accordance with ASTM E96/E96M.

2.13 JOINT MATERIALS

2.13.1 Joint Fillers, Sealers, and Waterstops

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

Materials for expansion joint fillers and waterstops shall be in accordance with Section 03 15 00.00 10 CONCRETE ACCESSORIES. Materials for and sealing of joints shall conform to the requirements of Section [07 92 00 JOINT SEALANTS] [32 01 19 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS] [32 13 73 COMPRESSION JOINT SEALS FOR CONCRETE PAVEMENTS].

2.13.2 Contraction Joints in Slabs

Materials for contraction joint inserts shall be in accordance with Section 03 15 00.00 10 CONCRETE ACCESSORIES.

PART 3 EXECUTION

3.1 PREPARATION FOR PLACING

Before commencing concrete placement, perform the following: 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 03 11 13.00 10 STRUCTURAL CONCRETE FORMWORK. Reinforcing steel shall be in place, cleaned, tied, and adequately supported, in accordance with Section 03 20 00.00 10 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. Keep rock surfaces 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. Place concrete 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 31 00 00 EARTHWORK. Place the concrete without becoming contaminated by loose material, and outlined 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. Prepare concrete at the side of vertical construction joints 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. Keep the surface of horizontal construction joints 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

Use a stream of water under a pressure of not less than 20 MPa 3,000 psi 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

Use wet sandblasting 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. Remove laitance and loose particles. 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.
****

Provide vapor barrier beneath the interior on-grade concrete floor slabs. Use the greatest widths and lengths practicable 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. Place vapor barrier 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, a thin layer of approximately 13 mm 1/2 inch of fine graded material should be rolled or compacted over the fill before installation of the vapor barrier to reduce the possibility of puncture. Control concrete

placement so as to prevent damage to the vapor barrier.

3.1.4 Perimeter Insulation

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

Install perimeter insulation 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, 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 12 inches 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 General Requirements

****
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 C94/C94M, 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.]

3.2.2 Batching Plant

****
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.
****

Locate the batching plant [onsite in the general area indicated on the drawings] [or] [offsite close to the project]. The batching, mixing and placing system shall have a capacity of at least [_____] cubic meters 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.

3.2.3 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. Provide a semiautomatic batching system with interlocks such that the discharge device cannot be actuated until the indicated material is within the applicable tolerance. Equip the batching system with accurate recorder or recorders that meet the requirements of NRMCA CPMB 100. Record the weight of water and admixtures if batched by weight. Provide separate bins or compartments 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. Furnish admixtures as a liquid of suitable concentration for easy control of dispensing. Provide an adjustable, accurate, mechanical device for measuring and dispensing each admixture. 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. Arrange the plant so as to facilitate the inspection of all

operations at all times. Provide suitable facilities 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.

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

3.2.5 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
Chemical admixture	0 to plus 6

3.2.6 Moisture Control

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

3.2.7 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] 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. Operate the mixers 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.

3.2.8 Stationary Mixers

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

3.2.9 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 C94/C94M. A truck mixer may be used either for complete mixing (transit-mixed) or to finish the partial mixing done in a stationary mixer (shrink-mixed). 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.

****

Use batch-type equipment for producing concrete. Ready-mixed concrete shall be batched, mixed, and transported in accordance with ASTM C94/C94M, 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. Furnish approved batch tickets for each load of ready-mixed concrete. Produce site-mixed concrete in accordance with ACI 301M ACI 301, with plant conforming 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 C685/C685M.]

3.4 LIGHTWEIGHT AGGREGATE CONCRETE

In addition to the requirements specified for normal weight concrete, conform lightweight aggregate concrete to the following. The batching and mixing cycle shall be based on written recommendations from the aggregate supplier furnished by the Contractor, submitted for approval. Unless otherwise directed, charge the mixer with approximately 2/3 of the total mixing water and all of the aggregate. This shall be mixed for at least 1.5 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/cubic meter 564 lb/cu. yd.[Perform a field trial run of lightweight aggregate concrete placement and finishing 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 C1116/C1116M and as follows, using the fibers specified in Section 03 20 00.00 10 CONCRETE REINFORCING. Use a minimum of 0.9 kg of fibers per cubic m 1.5 pounds of fibers per cubic yard of concrete. Add fibers at the batch plant. [Toughness indices shall meet requirements for performance level I of ASTM C1116/C1116M.] Provide the services of a qualified technical representative to instruct the concrete supplier in proper batching and mixing of materials.

3.6 TRANSPORTING CONCRETE TO PROJECT SITE

Transport concrete 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 ONSITE

****

NOTE: Delete conveying equipment not wanted on the project.

****

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

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. Equip the transfer hopper 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 C94/C94M. Use nonagitating equipment 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. Use a discharge deflector when required by the Contracting Officer. Separate chutes and other similar equipment will not be permitted for conveying concrete.

3.7.5 Belt Conveyors

Design and operate belt conveyors to assure a uniform flow of concrete from mixer to final place of deposit without segregation of ingredients or loss of mortar and 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. Construct belt conveyors such that the idler spacing does 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

Discharge mixed concrete within 1.5 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, reduce the time to 45 minutes. Place concrete 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. Provide adequate scaffolding, ramps and walkways 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 prevent proper consolidation, finishing and curing. Provide sufficient placing capacity so that concrete can be kept free of cold joints.

3.8.1 Depositing Concrete

Deposit concrete as close as possible to its final position in the forms, and with 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 lift. 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. Place concrete for beams, girders, brackets, column capitals, haunches, and drop panels 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, consolidate each layer of concrete 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; keep a spare vibrator 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. Insert vibrators vertically at uniform spacing over the area of placement. The distance between insertions shall be approximately 1.5 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 segregation or flotation of coarse aggregate shall be prevented. Frequency and amplitude of vibrators shall be determined in accordance with COE CRD-C 521. Do not use grate tampers (jitterbugs).

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.

****

Use special protection measures, approved by the Contracting Officer, 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 C494/C494M, Type C or E may be used, provided it contains no calcium chloride. Do not use calcium chloride.

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 job-site conditions are present or anticipated that accelerate the rate of moisture loss or rate of cement hydration of freshly mixed concrete, including an ambient temperature of 27 degrees C 80 degrees F or higher, and an evaporation rate that exceeds 1 kg/m^2/h 0.2 lb/ft^2/h, concrete work shall conform to all requirements of ACI 305.1.

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. Take particular care if plastic shrinkage cracking is potentially imminent and especially if it has developed during a previous placement. Conform with the requirement of ACI 305.1. 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 Proportioning Studies-Normal Weight Concrete 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.

****

Deposit concrete 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. Keep the discharge end of the pump line or tremie shaft continuously submerged in the concrete. The underwater seal at start of placing shall not produce undue turbulence in the water. Keep the tremie shaft 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.

****

Use special care 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 C1017/C1017M 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 SYSTEM DESCRIPTION. Use extreme care in conveying and placing the concrete to avoid segregation. 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.
****

Locate and construct joints 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, locate such joints 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 07 92 00 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, locate construction joints 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. Locate construction joints 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, extend reinforcing steel 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, terminate lifts 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 inch square-edge lumber, beveled and oiled to facilitate removal, shall be tacked to the inside of the forms at the construction joint. Place concrete 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 above.

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. Produce contraction joints by forming a weakened plane in the concrete slab using materials and procedures specified in Section 03 15 00.00 10 CONCRETE ACCESSORIES.

3.9.3 Expansion Joints

Installation of expansion joints and sealing of these joints shall conform to the requirements of Section 03 15 00.00 10 EXPANSION JOINTS, CONTRACTION JOINTS, AND WATERSTOPS and Section 07 92 00 JOINT SEALANTS.

3.9.4 Waterstops

Install waterstops in conformance with the locations and details shown on the drawings using materials and procedures specified in Section 03 15 00.00 10 EXPANSION JOINTS, CONTRACTION JOINTS, AND WATERSTOPS.

3.9.5 Dowels and Tie Bars

Install dowels and tie bars at the locations shown on the drawings and to the details shown, using materials and procedures specified in Section 03 20 00.00 10 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 SPECIALTY FLOORS

3.10.1 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:

3.10.1.1 General

Construct heavy duty floor 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 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.

3.10.1.2 Preparation of Base Slab

Keep the base slab 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. Deposit the overlay concrete before the grout coat has had time to stiffen.

3.10.2 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 by placing a bonded topping on the thoroughly hardened concrete base slab which has been left with a rough slab finish 50 mm 2 inches below final grade as shown on the drawings. Apply topping 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. Scrub the grout 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.

3.11 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 applied after the concrete has been cured and then air dried for [14] [28] days. Apply three coats, each the day after the preceding coat was applied. For the first application, 0.5 kg one pound of the silicofluoride 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. Apply proprietary hardeners in accordance with the manufacturer's instructions. During application, area should be well ventilated. Take precautions when applying silicofluorides due to the toxicity of the salts. Any compound that contacts glass or aluminum should be immediately removed with clear water.

3.12 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: 32 13 11 CONCRETE PAVEMENT FOR AIRFIELDS AND OTHER HEAVY-DUTY PAVEMENTS, 32 16 13 CONCRETE SIDEWALKS AND CURBS AND GUTTERS) is included in the contract.
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3.12.1 Pavements

Construct pavements where shown on the drawings. After forms are set and underlying material prepared as specified, place the concrete 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. Take care to prevent bringing excess paste to the surface. Curing shall be as specified.

3.12.2 Sidewalks

Concrete shall be 100 mm 4 inches minimum thickness. Provide contraction joints 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. Provide transverse expansion joints 12 mm 1/2 inch thick at changes in direction and where sidewalk abuts curbs, steps, rigid pavement, or other similar structures. 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.

3.12.3 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 feet maximum spacing unless otherwise indicated.

3.12.4 Pits and Trenches

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

3.13 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 C1107/C1107M, 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 19 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. Use nonshrink grout for [_____].

3.13.1 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.

3.13.2 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.

3.13.2.1 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, mix the batch for 3 minutes. Batches shall be of size to allow continuous placement of freshly mixed grout. Discard grout not used within 30 minutes after mixing. 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.

3.13.2.2 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 Section 03 39 00.00 10 CONCRETE CURING.

3.14 TESTING AND INSPECTION FOR CQC

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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.
****

Perform the inspection and tests described below and, based upon the results of these inspections and tests, take the action required. Submit 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.

a. When, in the opinion of the Contracting Officer, the concreting operation is out of control, cease concrete placement and correct the operation.

b. The laboratory performing the tests shall be onsite and shall conform with ASTM C1077. Materials may be subjected to check testing by the Government from samples obtained at the manufacturer, at transfer points, or at the project site.

c. 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 C1077.

3.14.1 Grading and Corrective Action

3.14.1.1 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 C136 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 be immediately reported to the Contracting Officer, concreting shall be stopped, and immediate steps taken to correct the grading.

3.14.1.2 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 C136 for each size of coarse aggregate. The location at which samples are taken may be selected by the Contractor as the most advantageous for production control. 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 reported to the Contracting Officer. Concreting shall be stopped and immediate steps shall be taken to correct the grading.

3.14.2 Quality of Aggregates

Thirty days prior to the start of concrete placement, perform all tests for aggregate quality required by ASTM C33/C33M. In addition, after the start

of concrete placement, 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.

3.14.3 Scales, Batching and Recording

Check the accuracy of the scales 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, 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.

3.14.4 Batch-Plant Control

Continuously control the measurement of concrete materials, including cementitious materials, each size of aggregate, water, and admixtures. Adjust the aggregate weights and amount of added water 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. Prepare a report indicating type and source of cement used, type and source of pozzolan or slag used, amount and source of admixtures used, aggregate source, the required aggregate and water weights per cubic meter yard amount of water as free moisture in each size of aggregate, and the batch aggregate and water weights per cubic meter yard for each class of concrete batched during each day's plant operation.

3.14.5 Concrete Mixture

3.14.5.1 Air Content Testing

Perform air content tests 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. Perform additional tests when excessive variation in workability is reported by the placing foreman or Government inspector. Tests shall be made in accordance with ASTM C231/C231M for normal weight concrete and ASTM C173/C173M for lightweight concrete. Plot test results on control charts which shall at all times be readily available to the Government and submitted weekly. Keep copies of the current control charts 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, perform a second test immediately. 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 in PART 1. Set an upper warning limit and a lower warning limit line 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.

3.14.5.2 Air Content Corrective Action

Whenever points on the control chart for percent air reach either warning limit, an adjustment shall immediately be made in the amount of air-entraining admixture batched. As soon as 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.

3.14.5.3 Slump Testing

In addition to slump tests which are made when test specimens are fabricated, at least four slump tests shall be made on randomly selected batches in accordance with ASTM C143/C143M for each separate concrete mixture produced during each 8-hour or less period of concrete production each day. Also, additional tests shall be made when excessive variation in workability is reported by the placing foreman or Government inspector. Plot test results on control charts which shall at all times be readily available to the Government and submitted weekly. Keep copies of the current control charts 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, immediately perform a second test. 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. Set limits 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. Take samples for slump at the mixer. However, the Contractor is responsible for delivering the concrete to the placement site at the stipulated slump. If the Contractor's materials or transportation methods cause slump loss between the mixer and the placement, take correlation samples at the placement site as required by the Contracting Officer, and the slump at the mixer controlled as directed.

3.14.5.4 Slump Corrective Action

Whenever points on the control charts for slump reach the upper warning

limit, make an adjustment immediately 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, halt the concreting operation immediately, and take appropriate steps to bring the slump under control. Additional slump tests shall be made as directed.

3.14.5.5 Temperature

Measure the temperature of the concrete when compressive strength specimens are fabricated in accordance with ASTM C1064/C1064M. Report the temperature along with the compressive strength data.

3.14.5.6 Strength Specimens

Perform at least one set of test specimens, 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. Perform additional sets of test specimens, as directed by the Contracting Officer, when the mixture proportions are changed or when low strengths have been detected. Develop a truly random (not haphazard) sampling plan for approval by the Contracting Officer prior to the start of construction. The plan shall ensure that sampling is done in a completely random and unbiased manner. A set of test specimens for concrete with a 28-day specified strength in accordance with paragraph 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 in accordance with 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 C31/C31M and tested in accordance with ASTM C39/C39M for test cylinders and ASTM C78/C78M 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 214R.

3.14.6 Inspection Before Placing

Inspect foundations, construction joints, forms, and embedded items in sufficient time prior to each concrete placement in order to certify to the Contracting Officer that they are ready to receive concrete. Report the results of each inspection in writing.

3.14.7 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.

3.14.8 Vibrators

Determine the frequency and amplitude of each vibrator in accordance with COE CRD-C 521 prior to initial use and at least once a month when concrete is being placed. Perform additional tests 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. Determine the amplitude with the head vibrating in air. Take two measurements, one near the tip and another near the upper end of the vibrator head, and these results averaged. Report the make, model, type, and size of the vibrator and frequency and amplitude results in writing. Any vibrator not meeting the requirements of paragraph Consolidation above, shall be immediately removed from service and repaired or replaced.

3.14.9 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.

3.14.10 Mixer Uniformity

3.14.10.1 Stationary Mixers

Prior to the start of concrete placing and once every 6 months when concrete is being placed, or once for every 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 C94/C94M.

3.14.10.2 Truck Mixers

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

3.14.10.3 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.

3.14.11 Reports

Report all results of tests or inspections conducted, informally as they

are completed and in writing daily. Prepare a weekly report for the updating of control charts covering the entire period from the start of the construction season through the current week. During periods of cold-weather protection, 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 --