
USACE / NAVFAC / AFCEA / NASA UFGS-03 30 04 (April 2006)

Preparing Activity: USACE (CW) Replacing without change
UFGS-03307 (January 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2007

Latest change indicated by CHG tags

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SECTION 03 30 04

CONCRETE FOR MINOR STRUCTURES

04/06

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SECTION 03 30 04

CONCRETE FOR MINOR STRUCTURES 04/06

NOTE: This guide specification covers the requirements for projects involving amounts of concrete less than 500 cubic yards.

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

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

PART 1 GENERAL

NOTE: This specification requires furnishing all material and equipment, and performing all labor for the manufacturing, transporting, placing, finishing, and curing of concrete for recreation sites, road relocations, or other structures such as culvert headwalls, comfort stations, residences, or low head gate structures. Consideration should be given to using Section 03 31 01.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE when the quantity of concrete is 500 cubic yards or greater per structure.

1.1 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.

ACI INTERNATIONAL (ACI)

- | | |
|--------------|---|
| ACI 308R | (2001) Guide to Curing Concrete |
| ACI 318/318R | (2005; Errata 2005) Building Code Requirements for Structural Concrete and Commentary |
| ACI 318M | (2005) Metric Building Code Requirements for Structural Concrete and Commentary |
| ACI 347 | (2004) Guide to Formwork for Concrete |

ASTM INTERNATIONAL (ASTM)

- | | |
|-------------------|---|
| ASTM A 185/A 185M | (2006; E 2006) Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete |
| ASTM A 615/A 615M | (2007) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement |
| ASTM C 1260 | (2007) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method) |
| ASTM C 143/C 143M | (2005a) Standard Test Method for Slump of Hydraulic-Cement Concrete |
| ASTM C 150 | (2007) Standard Specification for Portland Cement |

ASTM C 1567	(2004) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C 171	(2003) Standard Specification for Sheet Materials for Curing Concrete
ASTM C 172	(2004) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C 231	(2004) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 260	(2006) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C 309	(2007) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 31/C 31M	(2006) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C 33	(2003) Standard Specification for Concrete Aggregates
ASTM C 39/C 39M	(2005e1) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C 494/C 494M	(2005a) Standard Specification for Chemical Admixtures for Concrete
ASTM C 595	(2007) Standard Specification for Blended Hydraulic Cements
ASTM C 618	(2005) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C 685/C 685M	(2007) Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C 920	(2005) Standard Specification for Elastomeric Joint Sealants
ASTM C 94/C 94M	(2007) Standard Specification for Ready-Mixed Concrete
ASTM D 1752	(2004a) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D 75	(2003) Standard Practice for Sampling Aggregates

ASTM D 98	(2005) Calcium Chloride
ASTM E 96/E 96M	(2005) Standard Test Methods for Water Vapor Transmission of Materials
U.S. ARMY CORPS OF ENGINEERS (USACE)	
COE CRD-C 400	(1963) Requirements for Water for Use in Mixing or Curing Concrete
COE CRD-C 572	(1974) Specifications for Polyvinylchloride Waterstops

1.2 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. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, 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.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Air-Entraining Admixture

[Accelerating Admixture]
Water-Reducing or Retarding Admixture
Curing Materials
[Reinforcing Steel]
[Expansion Joint Filler Strips, Premolded]
[Joint Sealants - Field Molded Sealants]
[Waterstops]

Manufacturer's literature is available from suppliers which demonstrates compliance with applicable specifications for the above materials.

Batching and Mixing Equipment

Batching and mixing equipment will be accepted on the basis of manufacturer's data which demonstrates compliance with the applicable specifications.

Conveying and Placing Concrete

The methods and equipment for transporting, handling, depositing, and consolidating the concrete shall be submitted prior to the first concrete placement.

[Formwork]

Formwork design shall be submitted prior to the first concrete placement.

SD-06 Test Reports

Aggregates

Aggregates will be accepted on the basis of certificates of compliance and test reports that show the material(s) meets the quality and grading requirements of the specifications under which it is furnished.

Concrete Mixture Proportions

Ten days prior to placement of concrete, the contractor shall submit the mixture proportions that will produce concrete of the quality required. Applicable test reports shall be submitted to verify that the concrete mixture proportions selected will produce concrete of the quality specified.

SD-07 Certificates

Cementitious Materials

Certificates of compliance attesting that the concrete materials meet the requirements of the specifications shall be submitted in accordance with the Special Clause "CERTIFICATES OF COMPLIANCE". Cementitious material will be accepted on the basis of a manufacturer's certificate of compliance, accompanied by mill test reports that the material(s) meet the requirements of the specification under which it is furnished.

Aggregates

Aggregates will be accepted on the basis of certificates of compliance and tests reports that show the material(s) meet the quality and grading requirements of the specifications under which it is furnished.

1.3 UNIT PRICES

NOTE: If Section 01 22 00.00 10 MEASUREMENT AND PAYMENT is included in the project specifications, this paragraph title (UNIT PRICES) should be deleted from this section and the remaining appropriately edited subparagraphs below should be inserted into Section 01 22 00.00 10.

1.3.1 Concrete

1.3.1.1 Payment

All costs associated with [manufacturing,] furnishing, delivering, placing, finishing, and curing of concrete for the various items of the schedule, which price shall include the cost of all formwork. Payment for concrete for which payment is made as a lump sum is [not] to be included in this unit price payment item. Payment for grout, preformed expansion joints, field-molded sealants, waterstops, reinforcing steel bars or wire reinforcement is [not] to be included in this unit price payment item.

1.3.1.2 Measurement

Concrete will be measured for payment on the basis of the actual volume of concrete within the pay lines of the structures as indicated. Measurement of concrete placed against the sides of any excavation without the use of intervening forms will be made only within the pay lines of the structure. No deductions will be made for rounded or beveled edge, for space occupied by meal work, for electrical conduits or timber, or for voids or embedded items that are either less than 0.14 cubic meter 5 cubic feet in volume or 0.1 square meter 1 square foot in cross section.

1.3.1.3 Unit of Measure

Unit of measure: cubic meter yard.

1.4 DESIGN AND PERFORMANCE REQUIREMENTS

The Government will maintain the option to sample and test [joint sealer, joint filler material, waterstop,] aggregates and concrete to determine compliance with the specifications. The Contractor shall provide facilities and labor as may be necessary to assist the Government in procurement of representative test samples. Samples of aggregates will be obtained at the point of batching in accordance with ASTM D 75. Concrete will be sampled in accordance with ASTM C 172. Slump and air content will be determined in accordance with ASTM C 143/C 143M and ASTM C 231, respectively, when cylinders are molded. Compression test specimens will be made, cured, and transported in accordance with ASTM C 31/C 31M. Compression test specimens will be tested in accordance with ASTM C 39/C 39M. Samples for strength tests will be taken not less than once each shift in which concrete is produced [from each class of concrete required]. A

minimum of three specimens will be made from each sample; two will be tested at 28 days (90 days if pozzolan is used) for acceptance, and one will be tested at 7 days for information.

1.4.1 Strength

Acceptance test results will be the average strengths of two specimens tested at 28 days (90 days if pozzolan is used). The strength of the concrete will be considered satisfactory so long as the average of three consecutive acceptance test results equal or exceed the specified compressive strength, f'c, and no individual acceptance test result falls below f'c by more than 3.4 MPa 500 psi.

1.4.2 Construction Tolerances

A Class "C" finish shall apply to all surfaces except those specified to receive a Class "D" finish. A Class "D" finish shall apply to all surfaces which will be permanently concealed after construction. The surface requirements for the classes of finish required shall be as specified in ACI 347.

1.4.3 Concrete Mixture Proportions

NOTE: The nominal maximum size of the coarse aggregate shall be specified in accordance with guidance given in ACI 318/318R, paragraph 3.3.2 and ACI 318M.

Concrete mixture proportions shall be the responsibility of the Contractor. Mixture proportions shall include the dry weights of cementitious material(s); the nominal maximum size of the coarse aggregate; the specific gravities, absorptions, and saturated surface-dry weights of fine and coarse aggregates; the quantities, types, and names of admixtures; and quantity of water per cubic yard of concrete. All materials included in the mixture proportions shall be of the same type and from the same source as will be used on the project. Specified compressive strength f'c shall be [20.7] [_____] MPa [3,000] [_____] psi at 28 days (90 days if pozzolan is used). The maximum nominal size coarse aggregate shall be [19] [25] [37.5] mm [3/4] [1] [1-1/2] inch, in accordance with ACI 318M ACI 318/318R. The air content shall be between 4.5 and 7.5 percent. The slump shall be between 50 and 125 mm 2 and 5 inches. The maximum water cement ratio shall be [0.50] [_____].

1.5 REGULATORY REQUIREMENTS

NOTE: Include the applicable state highway department document title in which an acceptable gradation for the concrete aggregate is presented.

The [state statutory and regulatory requirements] [_____] listed below form a part of this specification to the extent referenced.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

Cementitious materials shall conform to the appropriate specifications listed:

2.1.1.1 Portland Cement

NOTES: Use of air-entraining cement should be limited to concrete placements where separate batching of air-entraining admixture is not practical.

The limiting of the tricalcium aluminate for sulfate resistance is limited to Type III cement. If high early strength is not required, Type II should be specified rather than Type I when moderate sulfate resistance is required, or Type V should be specified when high sulfate resistance is required.

Low-alkali cement should be specified when the aggregate is either silica or carbonate reactive.

ASTM C 150, Type [I, IA, II, IIA, III, IIIA or V], [low alkali] [, except that the tricalcium aluminate of the Type III or IIIA cement shall be limited to [5] [8] percent].

2.1.1.2 [Blended Hydraulic Cement

NOTES: Use of air-entraining cement should be limited to concrete placements where separate batching of air-entraining admixture is not practical.

Low-alkali cement should be specified when reactive aggregates are to be used.

Use the MS suffix when moderate sulfate resistance is needed and the material is available.

Use the MH suffix when the concrete sections are relative massive and heat of hydration may be a problem.

ASTM C 595, Type IS[MS] [MH] [-A], IP[MS] [MH] [-A], P[MS] [LH] [-A], I[PM] [MS] [MH], I[SM] [MS] [MH] [-A] or [_____] [with Table 2 mortar expansion limits].]

2.1.1.3 Pozzolan

Pozzolan shall conform to ASTM C 618, Class C or F, including requirements of Tables 1A and 2A.

2.1.1.2 Aggregates

NOTE: 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).

UFGS 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 UFGS 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 UFGS 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 "[]".

Fine and coarse aggregates shall [meet the quality and grading requirements of [ASTM C 33 Class Designations 4M or better] [or] [state highway department specification in accordance with paragraph REGULATORY REQUIREMENTS]] "[be tested and evaluated for alkali-aggregate reactivity in accordance with ASTM C 1260. 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 C 1260 and ASTM C 1567 shall be performed. The additional testing using ASTM C 1260 and ASTM C 1567 shall be performed using the low alkali portland cement in combination with ground granulated blast furnace (GGBF) slag, or Class F fly ash. GGBF slag

shall be used in the range of 40 to 50 percent of the total cementitious material by mass. Class F fly ash shall be used in the range of 25 to 40 percent of the total cementitious material by mass]".

2.1.1.3 Admixtures

Admixtures to be used, when required or approved, shall comply with the appropriate specification listed. Chemical admixtures that have been in storage at the project site for longer than 6 months or that have been subjected to freezing shall be retested at the expense of the contractor at the request of the Contracting Officer and shall be rejected if test results are not satisfactory.

2.1.1.3.1 Air-Entraining Admixture

Air-entraining admixture shall meet the requirements of **ASTM C 260**.

2.1.1.3.2 [Accelerating Admixture

Calcium chloride shall meet the requirements of **ASTM D 98**. Other accelerators shall meet the requirements of **ASTM C 494/C 494M**, Type C or E.]

2.1.1.3.3 Water-Reducing or Retarding Admixture

Water-reducing or retarding admixture shall meet the requirements of **ASTM C 494/C 494M**, Type A, B, or D. [High-range water reducing admixture Type F [or G] may be used only when approved, approval being contingent upon particular placement requirements as described in the Contractor's Quality Control Plan.]

2.1.1.4 Water

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

2.1.1.5 [Reinforcing Steel

**NOTE: Delete this paragraph if Section 03 20 02
STEEL BARS AND WELDED WIRE FABRIC FOR CONCRETE
REINFORCEMENT is to be used.**

Reinforcing steel bar shall conform to the requirements of **ASTM A 615/A 615M**, Grade 60. Welded steel wire fabric shall conform to the requirements of **ASTM A 185/A 185M**. Details of reinforcement not shown shall be in accordance with **ACI 318M ACI 318/318R**, Chapters 7 and 12.]

2.1.1.6 [Expansion Joint Filler Strips, Premolded

**NOTE: Delete this paragraph if Section 03 15 14.00
10 EXPANSION, CONTRACTION AND CONSTRUCTION JOINTS IN
CONCRETE is used.**

Expansion joint filler strips, premolded shall be sponge rubber conforming to **ASTM D 1752**, Type I.]

2.1.7 [Joint Sealants - Field Molded Sealants]

NOTES: Use ASTM C 920 for field-molded sealants in
small hydraulic structures.

Delete this paragraph if Section 03 15 14.00 10
EXPANSION, CONTRACTION AND CONSTRUCTION JOINTS IN
CONCRETE is used.

Joint sealants - field molded sealants shall conform to ASTM C 920, Type M, Grade NS, Class 25, use NT for vertical joints and Type M, Grade P, Class 25, use T for horizontal joints. Bond-breaker material shall be polyethylene tape, coated paper, metal foil, or similar type materials. The backup material shall be compressible, nonshrink, nonreactive with the sealant, and a nonabsorptive material such as extruded butyl or polychloroprene foam rubber. Immediately prior to installation of field-molded sealants, the joint shall be cleaned of all debris and further cleaned using water, chemical solvents, or other means as recommended by the sealant manufacturer or directed.]

2.1.8 [Waterstops]

NOTE: Delete this paragraph if Section 03 15 14.00
10 EXPANSION, CONTRACTION AND CONSTRUCTION JOINTS IN
CONCRETE is used.

[Waterstops shall conform to COE CRD-C 572.]

2.1.9 [Formwork]

NOTE: Delete this paragraph if Section 03 11 14.00
10 FORMWORK FOR CONCRETE is used.

The design and engineering of the formwork as well as its construction, shall be the responsibility of the Contractor.]

2.1.10 [Form Coatings]

NOTE: Delete this paragraph if Section 03 11 14.00
10 FORMWORK FOR CONCRETE is used.

Forms for exposed surfaces shall be coated with a nonstaining form oil, which shall be applied shortly before concrete is placed.]

2.1.11 [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 second square meter 0.5 perms as determined in accordance with ASTM E 96/E 96M.]

2.1.12 Curing Materials

Curing materials shall conform to the following requirements.

2.1.12.1 Impervious Sheet Materials

Impervious sheet materials, **ASTM C 171**, type optional, except polyethylene film, if used, shall be white opaque.

2.1.12.2 Membrane-Forming Curing Compound

ASTM C 309, Type 1-D or 2, Class [A] [B].

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 General

Construction joints shall be prepared to expose coarse aggregate, and the surface shall be clean, damp, and free of laitance. Ramps and walkways, as necessary, shall be constructed to allow safe and expeditious access for concrete and workmen. Snow, ice, standing or flowing water, loose particles, debris, and foreign matter shall have been removed. Earth foundations shall be satisfactorily compacted. Spare vibrators shall be available. The entire preparation shall be accepted by the Government prior to placing.

3.1.2 Embedded Items

Reinforcement shall be secured in place; joints, anchors, and other embedded items shall have been positioned. Internal ties shall be arranged so that when the forms are removed the metal part of the tie will be not less than **50 mm 2 inches** from concrete surfaces permanently exposed to view or exposed to water on the finished structures. Embedded items shall be free of oil and other foreign matters such as loose coatings or rust, paint, and scale. The embedding of wood in concrete will be permitted only when specifically authorized or directed. All equipment needed to place, consolidate, protect, and cure the concrete shall be at the placement site and in good operating condition.

3.1.3 Formwork Installation

Forms shall be properly aligned, adequately supported, and mortar-tight. The form surfaces shall be smooth and free from irregularities, dents, sags, or holes when used for permanently exposed faces. All exposed joints and edges shall be chamfered, unless otherwise indicated.

3.1.4 [Vapor Barrier Installation

**NOTE: Use a vapor barrier only when it is desirable
to prevent migration of moisture through slabs of
buildings.**

Vapor barriers shall be applied over gravel fill. Edges shall be lapped not less than **150 mm 6 inches**. All joints shall be sealed with

pressure-sensitive adhesive not less than 50 mm 2 inches wide. The vapor barrier shall be protected at all times to prevent injury or displacement prior to and during concrete placement.]

3.1.5 Production of Concrete

3.1.5.1 Ready-Mixed Concrete

Ready-mixed concrete shall conform to ASTM C 94/C 94M except as otherwise specified.

3.1.5.2 Concrete Made by Volumetric Batching and Continuous Mixing

Concrete made by volumetric batching and continuous mixing shall conform to ASTM C 685/C 685M.

3.1.5.3 Batching and Mixing Equipment

The contractor shall have the option of using an on-site batching and mixing facility. The facility shall provide sufficient batching and mixing equipment capacity to prevent cold joints. The method of measuring materials, batching operation, and mixer shall be submitted for review. [On-site plant shall conform to the requirements of either ASTM C 94/C 94M or ASTM C 685/C 685M.]

3.1.6 [Waterstops

NOTE: Delete this paragraph if Section 03 15 14.00
10 EXPANSION, CONTRACTION AND CONSTRUCTION JOINTS IN
CONCRETE is to be used.

Waterstops shall be installed and spliced as directed by the manufacturer.]

3.2 CONVEYING AND PLACING CONCRETE

Conveying and placing concrete shall conform to the following requirements.

3.2.1 General

Concrete placement shall not be permitted when weather conditions prevent proper placement and consolidation without approval. When concrete is mixed and/or transported by a truck mixer, the concrete shall be delivered to the site of the work and discharge shall be completed within 1-1/2 hours [or 45 minutes when the placing temperature is 30 degrees C 85 degrees F or greater unless a retarding admixture is used]. Concrete shall be conveyed from the mixer to the forms as rapidly as practicable by methods which prevent segregation or loss of ingredients. Concrete shall be in place and consolidated within 15 minutes after discharge from the mixer. Concrete shall be deposited as close as possible to its final position in the forms and be so regulated that it may be effectively consolidated in horizontal layers 450 mm 18 inches or less in thickness with a minimum of lateral movement. The placement shall be carried on at such a rate that the formation of cold joints will be prevented.

3.2.2 Consolidation

Each layer of concrete shall be consolidated by [rodding, spading, or]

internal vibrating equipment. [External vibrating equipment may be used when authorized.] Internal vibration shall be systematically accomplished by inserting the vibrator through the fresh concrete in the layer below at a uniform spacing over the entire area of placement. The distance between insertions shall be approximately 1.5 times the radius of action of the vibrator and overlay the adjacent, just-vibrated area by approximately 100 mm a few inches. The vibrator shall penetrate rapidly to the bottom of the layer and at least 150 mm 6 inches into the layer below, if such a layer exists. It shall be held stationary until the concrete is consolidated and then withdrawn slowly at the rate of about 75 mm 3 inches per second.

3.2.3 Cold-Weather Requirements

No concrete placement shall be made when the ambient temperature is below 2 degrees C 35 degrees F or if the ambient temperature is below 5 degrees C 40 degrees F and falling. Suitable covering and other means as approved shall be provided for maintaining the concrete at a temperature of at least 10 degrees C 50 degrees F for not less than 72 hours after placing and at a temperature above freezing for the remainder of the curing period. Salt, chemicals, or other foreign materials shall not be mixed with the concrete to prevent freezing. Any concrete damaged by freezing shall be removed and replaced at the expense of the contractor.

3.2.4 Hot-Weather Requirements

When the rate of evaporation of surface moisture, as determined by use of Figure 1 of ACI 308R, is expected to exceed 1 kg/square meter 0.2 psf per hour, provisions for windbreaks, shading, fog spraying, or covering with a light-colored material shall be made in advance of placement, and such protective measures shall be taken as quickly as finishing operations will allow.

3.3 [FORM REMOVAL

NOTE: Delete this paragraph if Section 03 11 14.00
10 FORMWORK FOR CONCRETE is used.

Forms shall not be removed before the expiration of 24 hours after concrete placement except where otherwise specifically authorized. Supporting forms and shoring shall not be removed until the concrete has cured for at least 5 days. When conditions on the work are such as to justify the requirement, forms will be required to remain in place for longer periods.]

3.4 FINISHING

3.4.1 General

No finishing or repair will be done when either the concrete or the ambient temperature is below 10 degrees C 50 degrees F.

3.4.2 Finishing Formed Surfaces

All fins and loose materials shall be removed, and surface defects including tie holes shall be filled. All honeycomb areas and other defects shall be repaired. All unsound concrete shall be removed from areas to be repaired. Surface defects greater than 13 mm 1/2 inch in diameter and holes left by removal of tie rods in all surfaces not to receive additional

concrete shall be reamed or chipped and filled with dry-pack mortar. The prepared area shall be brush-coated with an approved epoxy resin or latex bonding compound or with a neat cement grout after dampening and filled with mortar or concrete. The cement used in mortar or concrete for repairs to all surfaces permanently exposed to view shall be a blend of portland cement and white cement so that the final color when cured will be the same as adjacent concrete.

3.4.3 Finishing Unformed Surfaces

All unformed surfaces that are not to be covered by additional concrete or backfill shall be float finished to elevations shown, unless otherwise specified. Surfaces to receive additional concrete or backfill shall be brought to the elevations shown and left as a true and regular surface. Exterior surfaces shall be sloped for drainage unless otherwise shown. Joints shall be carefully made with a jointing tool. Unformed surfaces shall be finished to a tolerance of 10 mm 3/8 inch for a float finish [and 8 mm 5/16 inch for a trowel finish] as determined by a 3 m 10 foot straightedge placed on surfaces shown on the plans to be level or having a constant slope. Finishing shall not be performed while there is excess moisture or bleeding water on the surface. No water or cement shall be added to the surface during finishing.

3.4.3.1 Float Finish

Surfaces to be float finished shall be screeded and darbied or bullfloated to eliminate the ridges and to fill in the voids left by the screed. In addition, the darby or bullfloat shall fill all surface voids and only slightly embed the coarse aggregate below the surface of the fresh concrete. When the water sheen disappears and the concrete will support a person's weight without deep imprint, floating should be completed. Floating should embed large aggregates just beneath the surface, remove slight imperfections, humps, and voids to produce a plane surface, compact the concrete, and consolidate mortar at the surface.

3.4.3.2 [Trowel Finish

NOTE: A trowel finish should be required only on building slabs to be left exposed or covered with tile. A trowel finish will not prevent dusting. All other horizontal surfaces should be given a float finish, except when a nonskid finish is necessary, in which case it should be given a broom finish.

A trowel finish shall be applied to [_____]. Trowelling shall be done immediately following floating to provide a smooth, even, dense finish free from blemishes including trowel marks. Finished surfaces shall be protected from damage during the construction period.]

3.4.3.3 [Broom Finish

A broom finish shall be applied to [_____]. The concrete shall be screeded and floated to required finish plane with no coarse aggregate visible. After surface moisture disappears, the surface shall be broomed or brushed with a broom or fiber bristle brush in a direction transverse to that of the main traffic or as directed.]

3.4.3.4 [Expansion and Contraction Joints]

NOTES: Refer to ACI 332R for guidance on expansion joints.

The depth of contraction joints shall be 1/4 to 1/3 of the thickness of the slab.

The maximum spacing (in millimeters) (in feet) between adjacent joints shall be 30 times the concrete thickness (in millimeters) (in feet) for slabs exposed to the environment.

Delete this paragraph if Section 03 15 14.00 10 EXPANSION, CONTRACTION AND CONSTRUCTION JOINTS IN CONCRETE is used.

Expansion and contraction joints shall be made in accordance with the details shown or as otherwise specified. Provide 13 mm 1/2 inch thick transverse expansion joints where new work abuts an existing concrete. Expansion joints shall be provided at a maximum spacing of 10 m 30 feet on center in sidewalks [and at a maximum spacing of [] meters feet in slabs], unless otherwise indicated. Contraction joints shall be provided at a maximum spacing of [2] [] linear meters [6] [] linear feet in sidewalks [and at a maximum spacing of [] meters feet in slabs], unless otherwise indicated. Contraction joints shall be cut at a minimum of [25] [] mm [1] [] inch(es) deep with a jointing tool after the surface has been finished.]

3.5 CURING AND PROTECTION

Beginning immediately after placement and continuing for at least 7 days, [except for concrete made with Type III cement, at least 3 days,] all concrete shall be cured and protected from premature drying, extremes in temperature, rapid temperature change, freezing, mechanical damage, and exposure to rain or flowing water. All materials and equipment needed for adequate curing and protection shall be available and at the site of the placement prior to the start of concrete placement. Preservation of moisture for concrete surfaces not in contact with forms shall be accomplished by one of the following methods:

- a. Continuous sprinkling or ponding.
- b. Application of absorptive mats or fabrics kept continuously wet.
- c. Application of sand kept continuously wet.
- d. Application of impervious sheet material conforming to ASTM C 171.
- e. Application of membrane-forming curing compound conforming to ASTM C 309, Type 1-D, on surfaces permanently exposed to view and Type 2 on other surfaces shall be accomplished in accordance with manufacturer's instructions.

The preservation of moisture for concrete surfaces placed against wooden forms shall be accomplished by keeping the forms continuously wet for 7

days [, except for concrete made with Type III cement, 3 days]. If forms are removed prior to end of the required curing period, other curing methods shall be used for the balance of the curing period. During the period of protection removal, the temperature of the air in contact with the concrete shall not be allowed to drop more than 15 degrees C 25 degrees F within a 24 hour period.

3.6 TESTS AND INSPECTIONS

3.6.1 General

The individuals who sample and test concrete as required in this specification shall have demonstrated a knowledge and ability to perform the necessary test procedures equivalent to the ACI minimum guidelines for certification of Concrete Field Testing Technicians, Grade I.

3.6.2 Inspection Details and Frequency of Testing

3.6.2.1 Preparations for Placing

Foundation or construction joints, forms, and embedded items shall be inspected in sufficient time prior to each concrete placement by the Contractor to certify that it is ready to receive concrete.

3.6.2.2 Air Content

Air content shall be checked at least [once] [twice] during each shift that concrete is placed [for each class of concrete required]. Samples shall be obtained in accordance with ASTM C 172 and tested in accordance with ASTM C 231.

3.6.2.3 Slump

Slump shall be checked [once] [twice] during each shift that concrete is produced [for each class of concrete required]. Samples shall be obtained in accordance with ASTM C 172 and tested in accordance with ASTM C 143/C 143M.

3.6.2.4 Consolidation and Protection

The Contractor shall ensure that the concrete is properly consolidated, finished, protected, and cured.

3.6.3 Action Required

3.6.3.1 Placing

The placing foreman shall not permit placing to begin until he has verified that an adequate number of acceptable vibrators, which are in working order and have competent operators, are available. Placing shall not be continued if any pile is inadequately consolidated.

3.6.3.2 Air Content

Whenever a test result is outside the specification limits, the concrete shall not be delivered to the forms and an adjustment shall be made to the dosage of the air-entrainment admixture.

3.6.3.3 Slump

Whenever a test result is outside the specification limits, the concrete shall not be delivered to the forms and an adjustment should be made in the batch weights of water and fine aggregate. The adjustments are to be made so that the water-cement ratio does not exceed that specified in the submitted concrete mixture proportion.

3.6.4 Reports

The results of all tests and inspections conducted at the project site shall be reported informally at the end of each shift and in writing weekly and shall be delivered within 3 days after the end of each weekly reporting period. See Section 01 45 04.00 10 CONTRACTOR QUALITY CONTROL.

-- End of Section --