
USACE / NAVFAC / AFCEA / NASA UFGS-03 30 00.00 20 (July 2006)

Preparing Activity: NAVFAC Superseding
 UFGS-03 30 00.00 20 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATION

References are in agreement with UMRL dated October 2007

Revised throughout - changes not indicated by CHG tags

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SECTION 03 30 00.00 20

CAST-IN-PLACE CONCRETE

07/06

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CAST-IN-PLACE CONCRETE 07/06

NOTE: This guide specification covers the requirements for cast-in-place concrete.

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).

NOTE: The following information shall be shown on the project drawings:

1. Loading assumptions.
2. Assumed temperature range when temperature stresses are a factor in design.
3. Material strengths used in design, f'c.
4. Details of concrete sections, showing dimensions, reinforcement cover, and required camber.
5. Locations where structural lightweight concrete or lightweight insulation or fill concrete will be used.

6. Details which require a depressed structural slab for static-disseminating and spark-resistant tile, terrazzo, or other floor finishes in order to provide finished surfaces at the same elevations.

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

PART 1 GENERAL

1.1 REFERENCES

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

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

ACI INTERNATIONAL (ACI)

ACI 117	(2006) Standard Specifications for Tolerances for Concrete Construction and Materials
ACI 211.1	(1991; R 2002) 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 301	(2005) Specifications for Structural Concrete
ACI 302.1R	(2004; Errata 2006; Errata 2007) Guide for Concrete Floor and Slab Construction
ACI 304.2R	(1996) Placing Concrete by Pumping Methods
ACI 304R	(2000) Guide for Measuring, Mixing, Transporting, and Placing Concrete
ACI 305R	(1999; Errata 2006) Hot Weather Concreting

ACI 306.1	(1990; R 2002) Standard Specification for Cold Weather Concreting
ACI 318M	(2005) Metric Building Code Requirements for Structural Concrete and Commentary
ACI 347	(2004) Guide to Formwork for Concrete
ACI SP-66	(2004) ACI Detailing Manual
AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)	
AASHTO M 182	(2005) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats
AMERICAN HARDBOARD ASSOCIATION (AHA)	
AHA A135.4	(2004) Basic Hardboard
AMERICAN WELDING SOCIETY (AWS)	
AWS D1.4/D1.4M	(2005; Errata 2005) Structural Welding Code - Reinforcing Steel
APA - THE ENGINEERED WOOD ASSOCIATION (APA)	
APA PS 1	(1995) Voluntary Product Standard for Construction and Industrial Plywood
ASTM INTERNATIONAL (ASTM)	
ASTM A 123/A 123M	(2002) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 185/A 185M	(2006; E 2006) Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM A 496/A 496M	(2005) Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement
ASTM A 497/A 497M	(2006e1) Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete
ASTM A 615/A 615M	(2007) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A 706/A 706M	(2006a) Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A 767/A 767M	(2005) Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement

ASTM A 775/A 775M	(2007) Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A 780	(2001; R 2006) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A 82/A 82M	(2005a) Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
ASTM A 934/A 934M	(2004) Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars
ASTM A 966/A 966M	(2007) Standard Test Method for Magnetic Particle Examination of Steel Forgings Using Alternating Current
ASTM C 1017/C 1017M	(2007) Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C 1107/C 1107M	(2007a) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM C 1116/C 1116M	(2006) Standard Specification for Fiber-Reinforced Concrete and Shotcrete
ASTM C 1240	(2005) Standard Specification for Silica Fume Used in Cementitious Mixtures
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 171	(2003) Standard Specification for Sheet Materials for Curing Concrete
ASTM C 172	(2004) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C 173/C 173M	(2007) Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C 192/C 192M	(2006) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 227	(2003) Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)
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 295	(2003) Petrographic Examination of Aggregates 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 311	(2005) Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland-Cement Concrete
ASTM C 33	(2003) Standard Specification for Concrete Aggregates
ASTM C 330	(2005) Standard Specification for Lightweight Aggregates for Structural Concrete
ASTM C 39/C 39M	(2005e1) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C 42/C 42M	(2004) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C 494/C 494M	(2005a) Standard Specification for Chemical Admixtures for Concrete
ASTM C 567	(2005a) Determining Density of Structural Lightweight 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 881/C 881M	(2002) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 920	(2005) Standard Specification for Elastomeric Joint Sealants
ASTM C 94/C 94M	(2007) Standard Specification for Ready-Mixed Concrete
ASTM C 989	(2006) Standard Specification for Ground Granulated Blast-Furnace Slag for Use in

Concrete and Mortars

ASTM D 1190	(1997) Standard Specification for Concrete Joint Sealer, Hot-Applied Elastic Type
ASTM D 1751	(2004) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D 1752	(2004a) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D 4397	(2002) Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications
ASTM D 5759	(1995; R 2005) Characterization of Coal Fly Ash and Clean Coal Combustion Fly Ash for Potential Uses
ASTM D 7116	(2005) Standard Specification for Joint Sealants, Hot Applied, Jet Fuel Resistant Types, for Portland Cement Concrete
ASTM E 1155	(1996; R 2001) Standard Test Method for Determining Floor Flatness and Floor Levelness Numbers
ASTM E 1155M	(1996; R 2001) Standard Test Method for Determining Floor Flatness and Floor Levelness Numbers (Metric)

FOREST STEWARDSHIP COUNCIL (FSC)

FSC STD 01 001	(2000) Principles and Criteria for Forest Stewardship
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U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 572	(1974) Specifications for Polyvinylchloride Waterstops
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U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS SS-S-1614	(Rev A; Am 1) Sealants, Joint, Jet-Fuel-Resistant, Hot-Applied, for Portland Cement and Tar Concrete Pavements
FS SS-S-200	(Rev E; Am 2) Sealant, Joint, Two-Component, Jet-Blast-Resistant, Cold-Applied, for Portland Cement Concrete Pavement
FS UU-B-790	(Rev A) Building Paper, Vegetable Fiber: (Kraft, Waterproofed, Water Repellent and Fire Resistant)

U.S. GREEN BUILDING COUNCIL (USGBC)

LEED

(2002; R 2005) Leadership in Energy and Environmental Design(tm) Green Building Rating System for New Construction (LEED-NC)

1.2 DEFINITIONS

- a. "Cementitious material" as used herein shall include all portland cement, pozzolan, fly ash, ground iron blast-furnace slag, and [silica fume].
- b. "Exposed to public view" means situated so that it can be seen from eye level from a public location after completion of the building. A public location is accessible to persons not responsible for operation or maintenance of the building.

1.3 SUBMITTALS

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

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

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

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

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.] [for information only. When used, a designation following the

"G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

[Formwork]

Reinforcing steel; G

Reproductions of contract drawings are unacceptable.

SD-03 Product Data

Materials for curing concrete

Joint sealants; (LEED) [

Submit manufacturer's product data, indicating VOC content.]

Joint filler; (LEED)

Plastic Forms

Carton Forms

Recycled Aggregate Materials; (LEED)

Cement; (LEED)

Reinforcement; (LEED)

Submit documentation indicating percentage of post-industrial and post-consumer recycled content per unit of product. Indicate relative dollar value of recycled content products to total dollar value of products included in project.

Vapor retarder[Vapor barrier]

[Epoxy bonding compound]

[Synthetic reinforcing fibers]

Waterstops

[Wood Forms]

[Local/Regional Materials; (LEED)

Submit documentation indicating distance between manufacturing facility and the project site. Indicate distance of raw material origin from the project site. Indicate relative dollar value of local/regional materials to total dollar value of products included in project.]

[Biodegradable Form Release Agent

Submit documentation indicating type of biobased material in product and biobased content. Indicate relative dollar value of biobased content products to total dollar value of products included in project.]

SD-04 Samples

NOTE: Where flat surface finishing is important and the crew inexperienced in this type of concrete, ask for a sample installation to train the crew.

Slab finish sample

SD-05 Design Data

Concrete mix design; G

Thirty days minimum prior to concrete placement, submit a mix design for each strength and type of concrete. Submit a complete list of materials including type; brand; source and amount of cement, fly ash, pozzolans, [silica fume], ground slag [polypropylene fibers], and admixtures; and applicable reference specifications. Provide mix proportion data 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. If source material changes, resubmit mix proportion data using revised source material. No material shall be provided unless proven by trial mix studies to meet the requirements of this specification, unless otherwise approved in writing by the Contracting Officer. The submittal shall clearly indicate where each mix design will be used when more than one mix design is submitted. Submit additional data regarding concrete aggregates if the source of aggregate changes. In addition, copies of the fly ash, [silica fume], [polypropylene fibers] and pozzolan test results shall be submitted. The approval of fly ash, [silica fume], and pozzolan [, and polypropylene fibers] test results shall have been within 6 months of submittal date. Obtain acknowledgement of receipt prior to concrete placement.

[Calculations]

SD-06 Test Reports

Concrete mix design; G

Fly ash

Pozzolan

Ground iron blast-furnace slag

[Aggregates]

[Fiber-reinforced concrete]

[Tolerance report]

Compressive strength tests

[Unit weight of structural lightweight concrete]

[Ion concentration]

NOTE: Require air content test results to be submitted when the air percentage is critical to slab finishes such as shake or hardener finishes and the total air content must NOT EXCEED a certain percentage.

[Air Content]

[SD-07 Certificates

NOTE: Include following paragraphs when job complexity justifies the additional cost associated with these requirements.

[Curing concrete elements]

[Pumping concrete]

[Silica fume manufacturer's representative]

[Finishing plan]

[Form removal schedule]

[Biodegradable Form Release Agent]

[VOC Content for form release agents, curing compounds, and concrete penetrating sealers]

[Material Safety Data Sheets]]

Forest Stewardship Council (FSC) Certification

SD-08 Manufacturer's Instructions

Fly ash

Ground iron blast-furnace slag

1.4 MODIFICATION OF REFERENCES

Accomplish work in accordance with ACI publications except as modified herein. Consider the advisory or recommended provisions to be mandatory, as though the word "shall" had been substituted for the words "should" or "could" or "may," wherever they appear. Interpret reference to the "Building Official," the "Structural Engineer," and the "Architect/Engineer" to mean the Contracting Officer.

1.5 DELIVERY, STORAGE, AND HANDLING

NOTE: Materials which are woven, fibrous, or porous in nature have a high capacity to adsorb VOC emissions; for instance, acoustical ceilings, carpet, textiles, and unprimed gypsum wall board.

Do not deliver concrete until vapor barrier, forms, reinforcement, embedded items, and chamfer strips are in place and ready for concrete placement. **ACI 301** for job site storage of materials. Protect materials from contaminants such as grease, oil, and dirt. Ensure materials can be accurately identified after bundles are broken and tags removed. Do not store concrete curing compounds or sealers with materials that have a high capacity to adsorb volatile organic compound (VOC) emissions, including [_____]. Do not store concrete curing compounds or sealers in occupied spaces.

1.5.1 Reinforcement

Store reinforcement of different sizes and shapes in separate piles or racks raised above the ground [to avoid excessive rusting]. Protect from contaminants such as grease, oil, and dirt. Ensure bar sizes can be accurately identified after bundles are broken and tags removed.

[1.5.1.1 Epoxy Coated Reinforcing Steel

Record coating lot on each shipping notice and carefully identify and re-tag bar bundles from bending plant. Provide systems for handling coated bars which have padded contact areas, nylon slings, etc., all free of dirt and grit. Lift bundled coated bars with strong back, multiple supports, or platform bridge to prevent sagging and abrasion. Bundling bands shall be padded where in contact with bars. Do not drop or drag bars or bundles. Store coated bars both in shop and in field, aboveground, on wooden or padded cribbing. Space the dunnage close enough to prevent excessive sags. Stack large quantities of straight bars with adequate protective blocking between layers. Schedule deliveries of epoxy coated bars to the job site to avoid the need for long term storage. Protect from direct sunlight and weather. Bars to be stored longer than 12 hours at the job site shall be covered with opaque polyethylene sheeting or other suitable equivalent protective material.

]1.6 Quality Assurance

1.6.1 Design Data

[1.6.1.1 Formwork Calculations

ACI 347. Include design calculations indicating arrangement of forms, sizes and grades of supports (lumber), panels, and related components. Furnish drawings and calculations of shoring and reshoring methods proposed for floor and roof slabs, spandrel beams, and other horizontal concrete members.

]1.6.2 Drawings

[1.6.2.1 Formwork

Drawings showing details of formwork including; joints, supports, studding and shoring, and sequence of form and shoring removal. Reproductions of contract drawings are unacceptable.

]1.6.2.2 Reinforcing Steel

ACI SP-66. Indicate bending diagrams, assembly diagrams, splicing and laps of bars, shapes, dimensions, and details of bar reinforcing, accessories,

and concrete cover. Do not scale dimensions from structural drawings to determine lengths of reinforcing bars.

[1.6.3 Control Submittals

[1.6.3.1 Curing Concrete Elements

Submit proposed materials and methods for curing concrete elements.

] [1.6.3.2 Pumping Concrete

Submit proposed materials and methods for pumping concrete. Submittal shall include mix designs, pumping equipment including type of pump and size and material for pipe, and maximum length and height concrete will be pumped.

] [1.6.3.3 Silica Fume Manufacturer's Representative

NOTE: A pre-construction meeting with the concrete supplier, contractor, finisher, admixture supplier, and Contracting Officer should be required for projects which require silica fume, corrosion inhibitors, or high-range water reducers (superplasticizers). An initial sample pour with the proposed concrete mix and methods of placing, finishing and curing may be beneficial to ensure concrete quality.

Provide statement that the manufacturer's representative will be present at mix plant to ensure proper mix, including high range water reducer, and batching methods during the first 3 [_____] days of concrete mix preparation and placement. After which the manufacturer's representative shall designate a representative at the concrete producer's plant to ensure the concrete mix procedures meet the silica fume manufacturer's recommendations. [Representative to attend and advise at finishing of sample slab.]

] [1.6.3.4 Finishing Plan

NOTE: Include when finishing or special flatness are critical.

The contractor shall submit proposed material and procedures to be used in obtaining the finish for the [_____] floors. Include qualification of person to be used for obtaining floor tolerance measurement, description measuring equipment to be used, and sketch showing lines and locations the measuring equipment will follow.

] 1.6.3.5 Form Removal Schedule

Submit schedule for form removal indicating element and minimum length of time for form removal.

] [1.6.3.6 VOC Content for form release agents, curing compounds, and concrete penetrating sealers

Submit certification for the form release agent, curing compounds, and concrete penetrating sealers that indicate the VOC content of each product.

] [1.6.3.7 Material Safety Data Sheets

Submit Material Safety Data Sheets (MSDS) for all materials that are regulated for hazardous health effects. Prominently post the MSDS at the construction site.

] 1.6.4 Test Reports

1.6.4.1 Concrete Mix Design

Submit copies of laboratory test reports showing that the mix has been successfully tested to produce concrete with the properties specified and that mix will be suitable for the job conditions. The laboratory test reports shall include mill test and all other test for cement, [silica fume,] aggregates, and admixtures. Provide maximum nominal aggregate size, gradation analysis, percentage retained and passing sieve, and a graph of percentage retained verses sieve size. Test reports shall be submitted along with the concrete mix design. Obtain approval before concrete placement.

1.6.4.2 Fly Ash and Pozzolan

Submit test results in accordance with ASTM C 618 for fly ash and pozzolan. Submit test results performed within 6 months of submittal date. Submit manufacturer's policy statement on fly ash use in concrete.

1.6.4.3 Ground Iron Blast-Furnace Slag

Submit test results in accordance with ASTM C 989 for ground iron blast-furnace slag. Submit test results performed within 6 months of submittal date. Submit manufacturer's policy statement on slag use in concrete.

[1.6.4.4 Aggregates

NOTE: Require aggregate quality testing on large
concrete projects, where concrete is exposed to
seawater, alkali soils, moist conditions, or the
quality of the aggregates is questionable.

ASTM C 227 for potential alkali-silica reactions, ASTM C 295 for petrographic analysis.

] [1.6.4.5 Fiber-Reinforced Concrete

Test to determine flexural toughness index I5 in accordance with ASTM C 1116/C 1116M.

] 1.6.5 Field Samples

1.6.5.1 Slab Finish Sample

Install minimum of 3000 mm by 3000 mm (10 foot by 10 foot) 10 foot by 10 foot slab. Finish as required by specification. [Silica fume manufacturer's representative will attend and advise.]

1.6.6 Special Finisher Qualifications

NOTE: Finishing of slabs is affected by slower set times and less bleed water.

For 35 percent or more fly ash content as a percentage of cementitious materials, finisher shall have a minimum of 3 years' experience finishing high-volume fly ash concrete.

1.7 ENVIRONMENTAL REQUIREMENTS

NOTE: In some regions, designer shall choose the most appropriate option(s) for ventilation. For instance, high-humidity regions may generate too much condensate when using 100 percent outside air.

Provide space ventilation according to manufacturer recommendations, at a minimum, during and following installation of concrete curing compound and sealer. Maintain one of the following ventilation conditions during the curing compound/sealer curing period or for 72 hours after installation:

- a. Supply 100 percent outside air 24 hours a day.
- b. Supply airflow at a rate of 6 air changes per hour, when outside temperatures are between 13 degrees C 55 degrees F and 29 degrees C 85 degrees F and humidity is between 30 percent and 60 percent.
- c. Supply airflow at a rate of 1.5 air changes per hour, when outside air conditions are not within the range stipulated above.

1.8 SUSTAINABLE DESIGN REQUIREMENTS

1.8.1 Local/Regional Materials

NOTE: Using local materials can help minimize transportation impacts, including fossil fuel consumption, air pollution, and labor. Using materials harvested and manufactured within a 500 mile radius from the project site contributes to the following LEED credit: MR5. Coordinate with Section 01 33 29 LEED(tm) DOCUMENTATION. Use second option if Contractor is choosing local materials in accordance with Section 01 33 29 LEED(tm) DOCUMENTATION. Use second option for USACE projects. Army projects shall include option only if pursuing this LEED credit.

[Use materials or products extracted, harvested, or recovered, as well as manufactured, within a [500][_____] mile [800][_____] kilometer radius from the project site, if available from a minimum of three sources.] [See Section 01 33 29 LEED(tm) DOCUMENTATION for cumulative total local material requirements. Concrete materials may be locally available.]

1.8.2 Forest Stewardship Council (FSC) Certification

Use FSC-certified wood where specified. Provide letter of certification signed by lumber supplier. Indicate compliance with FSC STD 01 001 and identify certifying organization. Submit FSC certification numbers; identify each certified product on a line-item basis. Submit copies of invoices bearing the FSC certification numbers.

PART 2 PRODUCTS

NOTE: Designer must verify that products meeting the indicated minimum recycled content are available, preferably from at least three sources, to ensure adequate competition. If not, write in suitable recycled content values that reflect availability and competition.

2.1 MATERIALS FOR FORMS

Provide wood, plywood, plastic, carton, or steel. Use plywood or steel forms where a smooth form finish is required.

2.1.1 Wood Forms

Use lumber as specified in Section 06 10 00 ROUGH CARPENTRY and as follows. Lumber shall be square edged or tongue-and-groove boards, free of raised grain, knotholes, or other surface defects. Plywood shall comply with APA PS 1, B-B concrete form panels or better or AHA A135.4, hardboard for smooth form lining. [Submit data verifying that composite wood products contain no urea formaldehyde resins.] [Virgin wood used shall be FSC-certified.]

2.1.2 Plastic Forms

Plastic lumber as specified in Section 06 10 00 ROUGH CARPENTRY. Plastic forms shall contain a minimum of [50][100] percent post-consumer recycled content, or a minimum of [50][100] percent post-industrial recycled content.

2.1.3 Carton Forms

Moisture resistant treated paper faces, biodegradable, structurally sufficient to support weight of wet concrete until initial set. Carton forms shall contain a minimum of [5][10][_____] percent post-consumer recycled content, or a minimum of [20][40][_____] percent post-industrial recycled content.

2.1.4 Steel Forms

Steel form surfaces shall not contain irregularities, dents, or sags.

2.2 FORM TIES AND ACCESSORIES

The use of wire alone is prohibited. Form ties and accessories shall not reduce the effective cover of the reinforcement.

2.2.1 Polyvinylchloride Waterstops

COE CRD-C 572.

2.2.2 Dovetail Anchor Slot

Preformed metal slot approximately 25 by 25 mm (1 by 1 inch) 1 by 1 inch of not less than 22 gage galvanized steel cast in concrete. Coordinate actual size and throat opening with dovetail anchors and provide with removable filler material.

2.3 CONCRETE

[2.3.1 Contractor's Option for Material Only

NOTE: Use for SOUTHNAVFACENGCOM projects and elsewhere if approved. Fill in appropriate state and title of referenced specification where work is to be accomplished. If a special class of aggregate and a choice of other materials exists in the state specification, specify that class of aggregate and choice of material. Fill in applicable strength class or other appropriate identification of concrete strength specified in state Department of Transportation specifications. Do not use for LANTNAVFACENGCOM.

At the option of the Contractor, those applicable material sections of [_____] DOT RBS for Class [A] [_____] strength concrete shall govern in lieu of this specification for concrete. Do not change the selected option during the course of the work.

]2.3.2 Contractor-Furnished Mix Design

NOTE: For concrete exposed to weather or special exposure conditions, leave in optional column[s] and select air entrainment and water-cement ratio. When specifying air entrainment give one number and allow variation of 1.5 percent on either side.

AIR ENTRAINMENT AND AGGREGATE SIZE:

Aggregate Nominal Maximum Size (mm)	Size No.	Air Content, Percent Moderate Exposure
10	8	8
13	7	7
20	67	7
25	57	5

Aggregate Nominal Maximum Size (mm)	Size No.	Air Content, Percent Moderate Exposure
35	467	5

Aggregate Nominal Maximum Size (inches)	Size No.	Air Content, Percent Moderate Exposure
3/8	8	8
1/2	7	7
3/4	67	7
1	57	5
1 1/2	467	5

Maximum aggregate size should not exceed:

1. 1/5 the dimension of nonreinforced members.
2. 3/4 the clear spacing between reinforcing bars or between reinforcing bars and forms.
3. 1/3 the depth of nonreinforced slabs on the ground.

CONCRETE FOR FLOORS (From ACI 301): The following criteria applies only when structural or durability requirements do not necessitate higher strengths:

Class	Usual Traffic	Typical Uses	[28 day Max. Str. MPa	Slump mm
1	Light foot	Residential or tile covered	20	100
2	Foot	Offices, churches, schools, hospitals, residences	24	100
3	Light foot & pneumatic wheels	Drives, garage floors, and sidewalks for residence	25	100
4	Foot and pneumatic wheels	Light industrial, commercial	30	75
5	Foot & wheels abrasive wear	Single-course industrial, integral topping	35	75
6	Foot & steel-tire vehicles - severe abrasion]	Two-course heavy industrial topping	See ACI 301	

Class	Usual Traffic	Typical Uses	[28 day Max. Str. psi	Slump in.
1	Light foot	Residential or tile covered	3000	4
2	Foot	Offices, churches, schools, hospitals, residences	3500	4
3	Light foot & pneumatic wheels	Drives, garage floors, and sidewalks for residence	3500	4
4	Foot and pneumatic wheels	Light industrial, commercial	4000	3
5	Foot & wheels abrasive wear	Single-course industrial, integral topping	4500	3
6	Foot & steel-tire vehicles - severe abrasion]	Two-course heavy industrial topping	See ACI 301	

GUIDELINES FOR CONCRETE NOT EXPOSED TO SEVERE CONDITIONS FOR
MAXIMUM WATER-CEMENT RATIO:

Compressive Strength	Without AE	With AE
3000 PSI (20 MPa)	0.58	0.50
3500 PSI (25 MPa)	0.54	0.48
4000 PSI (30 MPa)	0.50	0.45

AE= air-entrainment

REQUIREMENTS FOR SPECIAL EXPOSURE CONDITIONS (From ACI 318M):

Exposure Condition	Max. Water-Cement Ratio (Normal Weight Aggregate)
Concrete intended to be watertight:	
(a) Concrete exposed to fresh water	0.50
(b) Concrete exposed to brackish water or seawater	0.45
Concrete exposed to freezing and thawing in moist conditions:	
(a) Curbs, gutters, guardrails, or thin sections	0.45
(b) Other elements	0.50
(c) In presence of deicing chemicals	0.45

Max. Water-Cement Ratio
(Normal Weight Aggregate)

0.40 (a) Min.

0.45 (b) ACI 318

0.45

ACI 211.1, ACI 301, and ACI 318M [and ACI 211.2] [ACI 304.2R] [and] [ACI 213R] except as otherwise specified. The compressive strength (f'_c) of the concrete for each portion of the structure(s) shall be as indicated [and as specified below].

Location	f'c (Min. 28-Day Comp. Strength) (MPa)	ASTM C 33 Maximum Nominal Aggregate (Size No.)	Range of Slump (mm)	[Maximum Water- Cement Ratio] (by weight)	[Air Entr.] (percent)
[All areas]	[_____]	[_____]	[_____]	[_____]	[_____]
[Concrete exposed to weather	[30]	[57]	[_____]	[0.50]	[6]
All other areas	[_____]	[_____]	[_____]	[_____]	[_____]
[Reinforced foundation walls and footings	[_____]	[_____]	[25-75]	[_____]	[_____]
Plain footings, caissons, and substructure walls	[_____]	[_____]	[25-75]	[_____]	[_____]
Beams and reinforced walls	[_____]	[_____]	[25-100]	[_____]	[_____]
Building columns	[_____]	[_____]	[25-100]		
Pavement and exterior slabs	[_____]	[_____]	[25-75]	[_____]	[_____]
Floor slabs	[_____]	[_____]	[_____]	[_____]	[_____]
Floor slabs	[_____]	[See Combined Aggregate Gradation]	[_____]	[_____]	[_(a)_]

Location	f'c (Min. 28- Day Comp. Strength) (MPa)	ASTM C 33 Maximum Nominal Aggregate (Size No.)	Range of Slump (mm)	[Maximum Water- Cement Ratio] (by weight)	[Air Entr.] (percent)
Floor toppings	[_____]	[_____]	[_____]	[_____]	[_____]
Walks, curbs, and gutters	[_____]	[_____]	[_____]	[_____]	[_____]
Utility structures	[_____]	[_____]	[_____]	[_____]	[_____]
Drainage structures	[_____]	[_____]	[_____]	[_____]	[_____]
[_____]	[_____]	[_____]	[_____]	[_____]	[_____]

Location	f'c (Min. 28- Day Comp. Strength) (psi)	ASTM C 33 Maximum Nominal Aggregate (Size No.)	Range of Slump (inches)	[Maximum Water- Cement Ratio] (by weight)	[Air Entr.] (percent)
[All areas]	[_____]	[_____]	[_____]	[_____]	[_____]
[Concrete exposed to weather	[4000]	[57]	[_____]	[0.50]	[6]
Floor slabs	[_____]	[See Combined Aggregate Gradation]	[_____]	[_____]	[_(a)_]
All other areas	[_____]	[_____]	[_____]	[_____]	[_____]

NOTE: Chlorides can cause corrosion of
reinforcement. Use 0.15 for reinforced concrete
exposed to chlorides in service, 1.00 for reinforced
concrete that is dry or protected from moisture in
service, and 0.30 for other reinforced concrete.

Maximum slump shown above may be increased 25 mm (1 inch) 1 inch for
methods of consolidation other than vibration. Slump may be increased to
200 mm (8 inches) 8 inches when superplasticizers are used. [Provide air
entrainment using air-entraining admixture. Air entrainment shall be
within plus or minus 1.5 percent of the value specified.] [The water
soluble chloride ion concentrations in hardened concrete at ages from 28 to
42 days shall not exceed [0.15] [1.00] [0.30]].

Note (a): Entrapped air shall be 3% or less.]

NOTE: The following allows for lower cement and
water contents and higher fly ash contents.

Proportion concrete mixes for strength at [56] [90] [_____] days.

2.3.2.1 Mix Proportions for Normal Weight Concrete

Trial design batches, mixture proportioning studies, and testing requirements for various classes and types of concrete specified shall be the responsibility of the Contractor. Mixture proportions shall be based on compressive strength as determined by test specimens fabricated in accordance with **ASTM C 192/C 192M** and tested in accordance with **ASTM C 39/C 39M**. Samples of all materials used in mixture proportioning studies shall be representative of those proposed for use in the project and shall be accompanied by the manufacturer's or producer's test report indicating compliance with these specifications. Trial mixtures having proportions, consistencies, and [air content] suitable for the work shall be made based on methodology described in **ACI 211.1**. The trial mixture shall use at least three different water-cement ratios for each type of mixture, which will produce a range of strength encompassing those required for each class and type of concrete required on the project. The maximum water-cement ratio required will be based on equivalent water-cement ratio calculations as determined by the conversion from the weight ratio of water to cement plus pozzolan, [silica fume,] and ground granulated blast-furnace slag by weight equivalency method. Laboratory trial mixture shall be designed for maximum permitted slump and air content. Each combination of material proposed for use shall have separate trial mixture, except for accelerator or retarder use can be provided without separate trial mixture.

The temperature of concrete in each trial batch shall be reported. For each water-cement ratio, at least three test cylinders for each test age shall be made and cured in accordance with **ASTM C 192/C 192M** and tested in accordance with **ASTM C 39/C 39M** for 7 and 28 days. From these results, a curve shall be plotted showing the relationship between water-cement ratio and strength for each set of trial mix studies. In addition a curve shall be plotted showing the relationship between 7 and 28 day strengths.

[2.3.2.2 Lightweight Concrete Proportion

NOTE: Check with structural designer for unit weight of concrete. ACI 213R provides recommendations for lightweight concrete.

ACI 211.2, using weight method. Provide **ASTM C 330** aggregates for concrete; [115] [_____] pcf (dry) for floors with a [_____] MPa psi minimum compressive strength at 28 days. Provide aggregate size No. [_____] . Range of slump shall be between [_____] and [_____] mm inches. [Provide [_____] percent air entrainment using an air-entraining admixture.] [Maximum water-cement ratio shall be [_____] .]

]2.3.2.3 Required Average Strength of Mix Design

The selected mixture shall produce an average compressive strength exceeding the specified strength by the amount indicated in **ACI 301**. When a concrete production facility has a record of at least 15 consecutive tests, the standard deviation shall be calculated and the required average compressive strength shall be determined in accordance with **ACI 301**. When a concrete production facility does not have a suitable record of tests to establish a standard deviation, the required average strength shall be as follows:

- a. For f'c less than 20 MPa (3000 psi) 3000 psi, 7 MPa (1000 psi) 1000 psi plus f'c.
- b. For f'c between 20 and 35 MPa (3000 and 5000 psi) 3000 and 5000 psi, 8 MPa (1200 psi) 1200 psi plus f'c.
- c. For f'c over 35 MPa (5000 psi) 5000 psi, 10 MPa (1400 psi) 1400 psi plus f'c.

2.4 MATERIALS

2.4.1 Cement

NOTE: Acceptable types of cement are as follows:

<u>ASTM C 150</u> <u>Portland</u>	<u>ASTM C 595M</u> <u>Blended</u>	
Type I	Type IP or IS	For general use in construction.
Type II	Type IP (MS) or Type IS (MS)	For general use in construction where concrete is exposed to moderate sulfate action or where moderate heat of hydration is required. ASTM C 595M (blended hydraulic cements): add the suffix MS or MH where either moderate sulfate resistance or moderate heat of hydration, respectively, is required. Type IP is portland-pozzolan blended cement and Type IS is portland-blast furnace slag cement.
	Type IP (MH) or Type IS (MH)	For general use in construction where Concrete is exposed to moderate heat of hydration.
Type III	None	For use when high early strength is required.
Type V	None	For use when high sulfate resistance is required.
<u>ASTM C 150</u> <u>Portland</u>	<u>ASTM C 595</u> <u>Blended</u>	
Type I	Type IP or IS	For general use in construction.
Type II	Type IP (MS) or Type IS (MS)	For general use in construction where concrete is exposed to moderate sulfate action or where moderate heat of hydration is required. ASTM C 595 (blended hydraulic cements): add the suffix MS or MH where

ASTM C 150
Portland

ASTM C 595
Blended

either moderate sulfate resistance or moderate heat of hydration, respectively, is required. Type IP is portland-pozzolan blended cement and Type IS is portland-blast furnace slag cement.

Type IP (MH) or
Type IS (MH)

For general use in construction where Concrete is exposed to moderate heat of hydration.

Type III

None

For use when high early strength is required.

Type V

None

For use when high sulfate resistance is required.

Modify paragraph and specify either 50 percent Type II, IP (MS) or IS (MS) cement with 50 percent ground iron blast-furnace slag, 75 percent Type II, IP (MS) or IS (MS) cement with 25 percent Class F fly ash, or Type V cement when structure is within a saltwater spray range of 7500 mm (25 feet) 25 feet height or within a horizontal distance of 3000 mm (10 feet) 10 feet. Require cement to meet chemical requirements of ASTM C 150, Table 1A when using alkali-reactive aggregates.

The customary requirements for a low tricalcium aluminate content for concrete in seawater reduces sulfate attack but can lead to increased chloride ion penetration thereby leading to rebar rusting. There are various ways to approach the problem:

1. Use a Type III or other cement with a 6 - 8 percent tricalcium aluminate content and take the chance of sulfate attack;
2. Use a cement with a low to moderate tricalcium aluminate content plus fly ash for sulfate attack, and calcium nitrite for anti-rust protection;
3. Use a low tricalcium aluminate cement plus microsilica plus calcium nitrite.

Designer must make a decision as to what risks are to be taken and what admixtures are to be used. The Notes should give some guidance so that a cost effective decision can be made.

NOTE: For LANTNAVFACENGCOM: Typically allow Type II, IP (MS), or IS (MS). May use Type I if Type II not locally available and no sulfate problems

expected (i.e. not near seawater or sulfate soils.)
Type III is for high early strength. Type V is for
high sulfate resistance.

NOTE: Coal fly ash, slag, cenospheres, and silica
fumes are EPA designated products to be ingredients
in concrete and cement. See Section 01670
RECYCLED/RECOVERED MATERIALS and include additive
options unless designer determines that
justification for non-use exists.

ASTM C 150, Type [I or II] [_____] or ASTM C 595, Type [IP(MS) or IS(MS)]
[IP(MH)] [IS(MH)] [_____] blended cement except as modified herein. The
blended cement shall consist of a mixture of ASTM C 150, Type II, cement
and one of the following materials: ASTM C 618 pozzolan or fly ash,
ASTM C 989 ground iron blast-furnace slag. For portland cement
manufactured in a kiln fueled by hazardous waste, maintain a record of
source for each batch. [Supplier shall certify that no hazardous waste is
used in the fuel mix or raw materials.] [Supplier shall certify that the
hazardous waste is neutralized by the manufacturing process and that no
additional pollutants are discharged.] For exposed concrete, use one
manufacturer for each type of cement, ground slag, fly ash, and pozzolan.

2.4.1.1 Fly Ash and Pozzolan

NOTE: Fly ash, pozzolan, and slag cement may
produce uneven discoloration of the concrete during
the early stages of construction, depending upon the
type of curing provided. Fly ash or pozzolan
meeting the specified test results, which are more
stringent than ASTM C 618, should provide acceptable
end results. It is suggested that Type C fly ash be
used as a replacement for 70 percent of the cement.
It is suggested that Type F fly ash be used as a
replacement for 60 percent of the cement. Types F
and C fly ash increase durability of concrete. Type
F fly ash and slag are replacements for some sand
and aggregates also adding to durability.

ASTM C 618, Type N, F, or C, except that the maximum allowable loss on
ignition shall be 6 percent for Types N and F. Add with cement. Fly ash
content shall be a minimum of [15] [20] [30] [35] [40] [_____] percent by weight
of cementitious material, provided the fly ash does not reduce the amount
of cement in the concrete mix below the minimum requirements of local
building codes. Where the use of fly ash cannot meet the minimum level,
provide the maximum amount of fly ash permissible that will meet the code
requirements for cement content. Report the chemical analysis of the fly
ash in accordance with ASTM C 311. Evaluate and classify fly ash in
accordance with ASTM D 5759.

2.4.1.2 Ground Iron Blast-Furnace Slag

ASTM C 989, Grade [80] [100] [120]. Slag content shall be a minimum of
[25] [50] [70] percent by weight of cementitious material.

[2.4.1.3 Silica Fume

NOTE: Use silica fume concrete for marine structures where low permeability and enhanced durability are necessary. The silica fume and high range water reducer additive should be from the same manufacturer. Select weight percentage based-on performance required.

NOTE: Use for high durability and low permeability. The initial cost of the concrete will increase, and supervision at the batch plant, finishing, and curing is necessary. A HRWR must be used with silica fume, the slump can be increased 50 to 125 mm (2 to 5 inches) 2 to 5 inches without reducing strength. Finishing may be more difficult. Proper curing is essential because there is a tendency for plastic shrinkage cracking.

ASTM C 1240, provide silica fume that is a by-product of silicon or ferrosilicon production. Provide [5] [7.5] [10] percent by weight of the total cementitious material.

]2.4.2 Water

Minimize the amount of water in the mix. The amount of water shall not exceed 45 percent by weight of cementitious materials (cement + pozzolans), and in general, workability shall be improved by adjusting the grading rather than by adding water. Water shall be fresh, clean, and [potable][from rainwater collection][from graywater]; free from injurious amounts of oils, acids, alkalis, salts, organic materials, or other substances deleterious to concrete.

2.4.3 Aggregates

NOTE: Include the first bracketed item on large concrete projects, where concrete is exposed to seawater, alkali soils, moist conditions, or the quality of the aggregates is questionable.

When the use of alkali-reactive aggregates is permitted, delete everything after the first two sentences, add the following, and add paragraph entitled "Additional Curing When Using Alkali-Reactive Aggregates" as follows:

"Alkali-reactive aggregates may be used where not exposed to either seawater or alkali soil conditions, and when used with one of the following cements and tested in accordance with ASTM C 441 to ensure that a 75 percent minimum reduction of expansion due to alkali-aggregate reaction is provided.

1. ASTM C 150 low alkali cement (Table 1A, maximum of 0.60 percent equivalent Na₂O).

2. **ASTM C 595M** **ASTM C 595** blended cement.

3. ASTM C 150 low alkali, Type I or II cement with fly ash, pozzolan, or ground slag.

Furnish a mix design utilizing alkali-reactive aggregates with a maximum water-cement ratio of 0.45."

"Additional Curing When Using Alkali-Reactive Aggregates.

Furnish ASTM C 39/C 39M test results to verify the anticipated rate of strength development for the proposed concrete mix design. Submit an increased curing period and minimum time to strip formwork based upon the reduced rate of strength development."

NOTE: Environmentally-responsible Materials

Recovered materials, including recycled concrete and ground glass, can be used as aggregate in new concrete, depending on local availability and suitability with the concrete mix design.

ASTM C 33, except as modified herein. Furnish aggregates for exposed concrete surfaces from one source. Aggregates shall not contain any substance which may be deleteriously reactive with the alkalis in the cement. [Aggregates shall show expansions less than 0.10 percent at 6 months when tested in accordance with **ASTM C 227** using a cement with an alkali content above 0.8 percent (expressed as sodium oxide), and shall not possess properties or constituents that are known to have specific unfavorable effects in concrete when tested in accordance with **ASTM C 295**.]

[2.4.3.1 Aggregates/Combined Aggregate Gradation (Floor Slabs Only)

NOTE: Where floor slab flatness and curling and shrinkage will be a problem, use the following aggregate gradation for the floor slab mix. Ensure "Combined aggregate gradation" is specified under the Contractor Mix Design paragraph, under the "Maximum Nominal Aggregate" column.

ASTM C 33, uniformly graded and as follows: Nominal maximum aggregate size of **25 mm (1 inch) 1 inch**. A combined sieve analysis shall indicate a well graded aggregate from coarsest to finest with not more than 18 percent and not less than 8 percent retained on an individual sieve, except that less than 8 percent may be retained on coarsest sieve and on No. 50 (0.3mm) sieve, and less than 8 percent may be retained on sieves finer than No. 50 (0.3mm). Sand shall be at least 50 percent natural sand.

] 2.4.3.2 Aggregates for Lightweight Concrete

ASTM C 330.

] 2.4.3.3 Recycled Aggregate Materials

NOTE: Use of materials with recycled content,
calculated on the basis of post-industrial and
post-consumer percentage content, contributes to the
following LEED credit: MR4. Coordinate with Section
01 33 29 LEED(tm) DOCUMENTATION.

Use a minimum of [25] [_____] percent recycled aggregate, depending on local availability and conforming to requirements of the mix design. Recycled aggregate to include: [recovered glass] [recovered concrete] [recovered porcelain] [recovered stone] [] that meets the aggregate requirements specified. Submit recycled material request with the aggregate certification submittals and do not use until approved by the Contracting Officer.

] 2.4.4 Nonshrink Grout

ASTM C 1107/C 1107M.

2.4.5 Admixtures

NOTE: Do not allow calcium chloride in concrete
exposed to saltwater, severe sulfate solutions, or
both moisture and chlorides.

ASTM C 494/C 494M: Type A, water reducing; Type B, retarding; Type C, accelerating; Type D, water-reducing and retarding; and Type E, water-reducing and accelerating admixture. Do not use calcium chloride admixtures.

[2.4.5.1 Air-Entraining

NOTE: Use for concrete exposed to freeze-thaw
conditions.

ASTM C 260.

] 2.4.5.2 High Range Water Reducer (HRWR) (Superplasticizers)

ASTM C 494/C 494M, Type F [and Type G (HRWR retarding admixture)] and
ASTM C 1017/C 1017M. [Silica fume and HRWR shall come from the same
manufacturer.]

2.4.6 Vapor Retarder [Vapor Barrier]

NOTE: Edit title to correct choice. Select first

bracketed option where vapor retarder is required to contain mixing water in freshly placed concrete and a permanent vapor barrier is not required. Select second bracketed option where permanent vapor barrier is required. For protection against hydrostatic pressure or conditions of excessive dampness, specify an appropriate waterproofing membrane in Division 7.

[[ASTM D 4397](#) polyethylene sheeting, minimum [\[0.15\]](#) [\[0.25\]](#) mm ([\[6\]](#)[\[10\]](#) mil) [\[6\]](#) [\[10\]](#) mil thickness.]

[Waterproof Paper. Kraft paper, glass reinforcing fibers and layers of polyethylene laminated under heat and pressure to form a single layer meeting the requirements of [FS UU-B-790](#), Type I, Grade A, Style 4; or waterproof paper, regular, conforming to [ASTM C 171](#), consisting of two sheets of kraft paper cemented together with bituminous material in which are embedded cords or strands of fiber running in both directions not more than [30 mm](#) ([1 1/4 inch](#)) [1 1/4 inch](#) apart.]

]2.4.7 [Materials for Curing Concrete](#)

[Use water-based curing compounds, sealers, and coatings with [\[low \(maximum 160 grams/liter, less water and less exempt compounds\)\]](#) [\[zero\]](#) VOC content.]

2.4.7.1 [Impervious Sheeting](#)

[ASTM C 171](#); waterproof paper, clear or white polyethylene sheeting, or polyethylene-coated burlap.

2.4.7.2 [Pervious Sheeting](#)

[AASHTO M 182](#).

2.4.7.3 [Liquid Membrane-Forming Compound](#)

[ASTM C 309](#), white-pigmented, Type 2, Class B.

2.4.8 [Liquid Chemical Sealer-Hardener Compound](#)

Compound shall be magnesium fluosilicate which when mixed with water seals and hardens the surface of the concrete. Do not use on exterior slabs exposed to freezing conditions. Compound shall not reduce the adhesion of resilient flooring, tile, paint, roofing, waterproofing, or other material applied to concrete.

2.4.9 [Expansion/Contraction Joint Filler](#)

[ASTM D 1751](#), [ASTM D 1752](#), cork or 100% post-consumer paper meeting [ASTM D 1752](#) (subparagraphs 5.1 to 5.4). Material shall be [13 mm](#) ([1/2 inch](#)) [1/2 inch](#) thick[, unless otherwise indicated].

2.4.10 [Joint Sealants](#)

NOTE: Using low-VOC products contributes to the following LEED credit: EQ4. Include VOC submittal if pursuing this LEED credit, and coordinate with

Section 01 33 29 LEED(tm) DOCUMENTATION.

[Use concrete penetrating sealers with a low (maximum [100] [_____] grams/liter, less water and less exempt compounds) VOC content.]

2.4.10.1 Horizontal Surfaces, 3 Percent Slope, Maximum

NOTE: For horizontal surfaces subject to jet fuel, specify FS SS-S-1614.

ASTM D 1190 or ASTM C 920, Type M, Class 25, Use T. ASTM D 7116 for surfaces subjected to jet fuel.

2.4.10.2 Vertical Surfaces Greater Than 3 Percent Slope

NOTE: Specify ASTM C 920 for vertical surfaces greater than 3 percent slope and not subject to jet fuel, gasoline, fuel oil, etc. For vertical surfaces greater than 3 percent slope and subject to jet fuel, specify FS SS-S-200, no sag.

ASTM C 920, Type M, Grade NS, Class 25, Use T. [FS SS-S-1614] [FS SS-S-200, no sag].

2.4.11 Epoxy Bonding Compound

ASTM C 881/C 881M. Provide Type I for bonding hardened concrete to hardened concrete; Type II for bonding freshly mixed concrete to hardened concrete; and Type III as a binder in epoxy mortar or concrete, or for use in bonding skid-resistant materials to hardened concrete. Provide Grade 1 or 2 for horizontal surfaces and Grade 3 for vertical surfaces. Provide Class A if placement temperature is below 4 degrees C (40 degrees F) 40 degrees F; Class B if placement temperature is between 4 and 16 degrees C (40 and 60 degrees F) 40 and 60 degrees F; or Class C if placement temperature is above 16 degrees C (60 degrees F) 60 degrees F.

[2.4.12 Biodegradable Form Release Agent

NOTE: The 2002 Farm Bill - Section 9002, Federal Procurement of Biobased Products, requires each Federal Agency to develop a procurement program which will ensure that items composed of biobased products will be purchased to the maximum extent practicable and which is consistent with applicable provisions of Federal procurement law.

Form release agent shall be colorless, biodegradable, and [rapeseed oil-based] [soy oil-based] [water-based], with a [low (maximum of 55 grams/liter (g/l))] [zero] VOC content. [Biobased material shall be a minimum of [85] [_____] percent of the total product.]Product shall not bond with, stain, or adversely affect concrete surfaces and shall not impair subsequent treatments of concrete surfaces. The form release agent

shall not contain diesel fuel, petroleum-based lubricating oils, waxes, or kerosene.

] 2.5 REINFORCEMENT

[Bars, fabrics, connectors, and chairs shall be galvanized.]

2.5.1 Reinforcing Bars

NOTE: ASTM A 706/A 706M bars are mainly used in seismic design or for welding. Include ASTM A 123/A 123M for galvanized reinforcing bars.

NOTE: Use second recycled content option throughout this section if Contractor is choosing recycled content products in accordance with Section 01 33 29 LEED(tm) DOCUMENTATION.

ACI 301 unless otherwise specified. [Use deformed steel.]
ASTM A 615/A 615M and ASTM A 966/A 966M with the bars marked A, S, W, Grade [300] [420] ([40] [60]) [40] [60]; or ASTM A 966/A 966M with the bars marked R, Grade [350] [420] ([50] [60]) [50] [60]. [ASTM A 706/A 706M]. [Galvanized, ASTM A 123/A 123M.] [Zinc-coated (galvanized) bars, ASTM A 767/A 767M and ASTM A 780.] [Epoxy-coated reinforcing steel bars, ASTM A 775/A 775M.] [Epoxy-coated prefabricated steel reinforcing bars, ASTM A 934/A 934M.] [Reinforcing bars shall contain a minimum of [100] [_____] percent recycled content.] [See Section 01 33 29 LEED(tm) DOCUMENTATION for cumulative total recycled content requirements. Reinforcing bars may contain post-consumer or post-industrial recycled content.]

2.5.2 Mechanical Reinforcing Bar Connectors

ACI 301. Provide 125 percent minimum yield strength of the reinforcement bar.

2.5.3 Welded Wire Fabric

ASTM A 185/A 185M or ASTM A 497/A 497M. [Fabric shall contain a minimum of [100] [_____] percent recycled content.] [See Section 01 33 29 LEED(tm) DOCUMENTATION for cumulative total recycled content requirements. Wire fabric may contain post-consumer or post-industrial recycled content.] Provide flat sheets of welded wire fabric for slabs and toppings.

2.5.4 Wire

ASTM A 82/A 82M or ASTM A 496/A 496M.

2.5.5 Reinforcing Bar Supports

Provide bar ties and supports of coated or non corrodible material. [Use recycled plastic with 100 percent recycled content.] [Use engineered resins from recycled ABS plastic, polycarbonates, and fiberglass.]

2.5.6 Fiber-Reinforced Concrete

NOTE: Only use fiber reinforcement when approved by the designer. Drawings should indicate where fiber reinforced concrete is located. Fiber reinforcing is used to help: control cracking due to plastic shrinkage; reduce permeability; and increase impact capacity; 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 plastic shrinkage cracking. Include technical representative when warranted by size and importance of job.

In addition to the requirements specified above, fiber reinforced concrete shall be provided in accordance with [ASTM C 1116/C 1116M](#) Type III, synthetic fiber reinforced concrete, and as follows. [Synthetic reinforcing fibers](#) shall be [100 percent virgin] monofilament polypropylene fibers[, with a minimum of [5][10][_____] percent post-consumer recycled content, or a minimum of [20][40][_____] percent post-industrial recycled content]. [See Section [01 33 29](#) LEED(tm) DOCUMENTATION for cumulative total recycled content requirements. Fibers may contain post-consumer or post-industrial recycled content.] Fibers shall have a specific gravity of 0.9, a minimum tensile strength of [480 MPa \(70 ksi\)](#) [70 ksi](#), graded per manufacturer, and specifically manufactured to an optimum gradation for use as concrete secondary reinforcement. A minimum of [2.6 kg of fibers per cubic meter \(1.5 pounds of fibers per cubic yard\)](#) [1.5 pounds of fibers per cubic yard](#) of concrete shall be used. Fibers shall be added at the batch plant. [Toughness indices shall meet requirements for performance level I.] [Provide the services of a qualified technical representative to instruct the concrete supplier in proper batching and mixing of materials to be provided.]

2.5.7 Chairs and Bolsters: [Plastic] [Steel]

[Minimum [5][10][_____] percent post-consumer recycled content, or minimum [20][40][_____] percent post-industrial recycled content.] [See Section [01 33 29](#) LEED(tm) DOCUMENTATION for cumulative total recycled content requirements. Plastic and steel may contain post-consumer or post-industrial recycled content.]

PART 3 EXECUTION

3.1 PREPARATION

NOTE: Options for uses of excess concrete include: additional paving, post footing anchorage, swale riprap reinforcing, mud slab, flowable fill, footing bottom, retaining wall footing ballast, storm

structure covers, underground utility pipe kickers, storm pipe flared end section, toe wash protection, and shoulder and toe outfall restraints for temporary erosion pipes. Diverting waste from the landfill contributes to the following LEED credit: MR2. Coordinate with Section 01 33 29 LEED(tm) DOCUMENTATION.

Determine quantity of concrete needed and minimize the production of excess concrete. Designate locations or uses for potential excess concrete before the concrete is poured.

3.2 FORMS

ACI 301. Provide forms, shoring, and scaffolding for concrete placement. Set forms mortar-tight and true to line and grade. Chamfer above grade exposed joints, edges, and external corners of concrete 20 mm (0.75 inch) 0.75 inch unless otherwise indicated. Provide formwork with clean-out openings to permit inspection and removal of debris. Forms submerged in water shall be watertight.

3.2.1 Coating

Before concrete placement, coat the contact surfaces of forms with a nonstaining mineral oil, nonstaining form coating compound, or two coats of nitrocellulose lacquer. Do not use mineral oil on forms for surfaces to which adhesive, paint, or other finish material is to be applied.

3.2.2 Removal of Forms and Supports

After placing concrete, forms shall remain in place for the time periods specified in **ACI 347**. Prevent concrete damage during form removal. Clean all forms immediately after removal.

3.2.2.1 Special Requirements for Reduced Time Period

Forms may be removed earlier than specified if **ASTM C 39/C 39M** test results of field-cured samples from a representative portion of the structure indicate that the concrete has reached a minimum of 85 percent of the design strength.

3.2.3 Reshoring

Reshore concrete elements where forms are removed prior to the specified time period. Do not permit elements to deflect or accept loads during form stripping or reshoring. Forms on columns, walls, or other load-bearing members may be stripped after 2 days if loads are not applied to the members. After forms are removed, slabs and beams over 3000 mm (10 feet) 10 feet in span and cantilevers over 1200 mm (4 feet) 4 feet shall be reshored for the remainder of the specified time period in accordance with paragraph entitled "Removal of Forms." Perform reshoring operations to prevent subjecting concrete members to overloads, eccentric loading, or reverse bending. Reshoring elements shall have the same load-carrying capabilities as original shoring and shall be spaced similar to original shoring. Firmly secure and brace reshoring elements to provide solid bearing and support.

3.2.4 Reuse

Reuse forms providing the structural integrity of concrete and the aesthetics of exposed concrete are not compromised.

3.3 Waterstop Splices

Fusion weld in the field.

3.4 Formed Surfaces

3.4.1 Tolerances

ACI 347 and as indicated.

3.4.2 As-Cast Form

Provide form facing material producing a smooth, hard, uniform texture on the concrete. Arrange facing material in an orderly and symmetrical manner and keep seams to a practical minimum. Support forms as necessary to meet required tolerances. Material with raised grain, torn surfaces, worn edges, patches, dents, or other defects which will impair the texture of the concrete surface shall not be used.

3.5 PLACING REINFORCEMENT AND MISCELLANEOUS MATERIALS

ACI 301. Provide bars, wire fabric, wire ties, supports, and other devices necessary to install and secure reinforcement. Reinforcement shall not have rust, scale, oil, grease, clay, or foreign substances that would reduce the bond. Rusting of reinforcement is a basis of rejection if the effective cross-sectional area or the nominal weight per unit length has been reduced. Remove loose rust prior to placing steel. Tack welding is prohibited.

3.5.1 Vapor Barrier

NOTE: Include taping of joints when waterproof
paper is specified.

Provide beneath the on-grade concrete floor slab. Use the greatest widths and lengths practicable to eliminate joints wherever possible. Lap joints a minimum of 300 mm (12 inch) 12 inches [and tape or cement joints]. Remove torn, punctured, or damaged vapor barrier material and provide with new vapor barrier prior to placing concrete. Concrete placement shall not damage vapor barrier material. [Place a 50 mm (2 inch) 2 inch layer of clean concrete sand on vapor barrier before placing concrete.]

3.5.2 Reinforcement Supports

Place reinforcement and secure with galvanized or non corrodible chairs, spacers, or metal hangers. For supporting reinforcement on the ground, use concrete or other non corrodible material, having a compressive strength equal to or greater than the concrete being placed.

[ASTM A 934/A 934M.] [ASTM A 775/A 775M.] [Epoxy-coated reinforcing bars supported from formwork shall rest on coated wire bar supports, or on bar supports made of dielectric material or other acceptable material. Wire

bar supports shall be coated with dielectric material, compatible with concrete, for a minimum distance of 50 mm (2 inches) 2 inches from the point of contact with the epoxy-coated reinforcing bars. Reinforcing bars used as support bars shall be epoxy coated. Spreader bars, where used, shall be epoxy coated. Proprietary combination bar clips and spreaders used in construction with epoxy-coated reinforcing bars shall be made corrosion resistant or coated with dielectric material. Epoxy-coated bars shall be tied with plastic-coated tie wire; or other materials acceptable to the Contracting Officer.]

[3.5.3 Epoxy Coated Reinforcing

Shall meet the requirements of [ASTM A 934/A 934M including Appendix X2,] [ASTM A 775/A 775M including Appendix X1,] "Guidelines for Job Site Practices" except as otherwise specified herein.

3.5.3.1 Epoxy Coated Reinforcing Steel Placement and Coating Repair

Carefully handle and install bars to minimize job site patching. Use the same precautions as described in paragraph for reinforcement delivery, handling, and storage when placing coated reinforcement. Do not drag bars over other bars or over abrasive surfaces. Keep bar free of dirt and grit.

When possible, assemble reinforcement as tied cages prior to final placement into the forms. Support assembled cages on padded supports. It is not expected that coated bars, when in final position ready for concrete placement, will be completely free of damaged areas; however, excessive nicks and scrapes which expose steel will be cause for rejection. Criteria for defects which require repair and for those that do not require repair are as indicated. Inspect for defects and provide required repairs prior to assembly. After assembly, reinspect and provide final repairs.

- a. Immediately prior to application of the patching material, any rust and debonded coating shall be manually removed from the reinforcement by suitable techniques employing devices such as wire brushes and emery paper. Care shall be exercised during this surface preparation so that the damaged areas are not enlarged more than necessary to accomplish the repair. Damaged areas shall be clean of dirt, debris, oil, and similar materials prior to application of the patching material.
- b. Repair and patching shall be done in accordance with the patching material manufacturer's recommendations. These recommendations, including cure times, shall be available at the job site at all times.
- c. Allow adequate time for the patching materials to cure in accordance with the manufacturer's recommendation prior to concrete placement.
- [d. Rinse placed reinforcing bars with fresh water to remove chloride contamination prior to placing concrete.]

]3.5.4 Splicing

NOTE: When indicated, include ASTM A 767/A 767M and
ASTM A 780 for zinc-coated (galvanized) bars.

As indicated. For splices not indicated **ACI 301**. Do not splice at points of maximum stress. Overlap welded wire fabric the spacing of the cross wires, plus 50 mm (2 inches) 2 inches. [AWS D1.4/D1.4M. Welded splices shall be approved prior to use.] [Repair the cut ends of hot-dipped galvanized reinforcement steel to completely coat exposed steel, **ASTM A 780**.]

3.5.5 Future Bonding

Plug exposed, threaded, mechanical reinforcement bar connectors with a greased bolt. Bolt threads shall match the connector. Countersink the connector in the concrete. Calk the depression after the bolt is installed.

3.5.6 Cover

NOTE: Consult designer to verify that cover requirements of ACI 301 are adequate. ACI 201.2R and ACI 303R require additional cover for severe exposure conditions. Unless otherwise directed, specify 75 mm (3 inch) 3 inch cover where exposed to seawater.

ACI 301 for minimum coverage, unless otherwise indicated.

3.5.7 Setting Miscellaneous Material

Place and secure anchors and bolts, pipe sleeves, conduits, and other such items in position before concrete placement. Plumb anchor bolts and check location and elevation. Temporarily fill voids in sleeves with readily removable material to prevent the entry of concrete.

3.5.8 Construction Joints

Locate joints to least impair strength. Continue reinforcement across joints unless otherwise indicated.

3.5.9 Expansion Joints and Contraction Joints

Provide expansion joint at edges of interior floor slabs on grade abutting vertical surfaces, and as indicated. Make expansion joints 13 mm (1/2 inch) 1/2 inch wide unless indicated otherwise. Fill expansion joints not exposed to weather with preformed joint filler material. Completely fill joints exposed to weather with joint filler material and joint sealant. Do not extend reinforcement or other embedded metal items bonded to the concrete through any expansion joint unless an expansion sleeve is used. Provide contraction joints, either formed or saw cut or cut with a jointing tool, to the indicated depth after the surface has been finished. Sawed joints shall be completed within 4 to 12 hours after concrete placement. Protect joints from intrusion of foreign matter.

3.6 BATCHING, MEASURING, MIXING, AND TRANSPORTING CONCRETE

ASTM C 94/C 94M, **ACI 301**, **ACI 302.1R**, and **ACI 304R**, except as modified herein. Batching equipment shall be such that the concrete ingredients are consistently measured within the following tolerances: 1 percent for cement and water, 2 percent for aggregate, and 3 percent for admixtures. Furnish mandatory batch ticket information for each load of ready mix concrete.

3.6.1 Measuring

Make measurements at intervals as specified in paragraphs entitled "Sampling" and "Testing."

3.6.2 Mixing

NOTE: For WESTNAVFACENGCOM projects located at
Marine Corps Base, Camp Pendleton, California,
delete the first bracketed sentence.

ASTM C 94/C 94M and ACI 301. Machine mix concrete. Begin mixing within 30 minutes after the cement has been added to the aggregates. [Place concrete within 90 minutes of either addition of mixing water to cement and aggregates or addition of cement to aggregates if the air temperature is less than 29 degrees C (85 degrees F) 85 degrees F.] Reduce mixing time and place concrete within 60 minutes if the air temperature is greater than 29 degrees C (85 degrees F) 85 degrees F except as follows: if set retarding admixture is used and slump requirements can be met, limit for placing concrete may remain at 90 minutes. Additional water may be added, provided that both the specified maximum slump and water-cement ratio are not exceeded. When additional water is added, an additional 30 revolutions of the mixer at mixing speed is required. [If the entrained air content falls below the specified limit, add a sufficient quantity of admixture to bring the entrained air content within the specified limits.] Dissolve admixtures in the mixing water and mix in the drum to uniformly distribute the admixture throughout the batch.

3.6.3 Transporting

Transport concrete from the mixer to the forms as rapidly as practicable. Prevent segregation or loss of ingredients. Clean transporting equipment thoroughly before each batch. Do not use aluminum pipe or chutes. Remove concrete which has segregated in transporting and dispose of as directed.

3.7 PLACING CONCRETE

NOTE: When necessary to deposit concrete under
water, add the following paragraph:

"Depositing Concrete Under Water.

Methods and equipment used shall prevent the washing of the cement from the mixture, minimize the formation of laitance, prevent the flow of water through the concrete before it has hardened, and minimize disturbance to the previously placed concrete. Do not deposit concrete in running water [, seawater,] or in water temperatures below 2 degrees C (35 degrees F) 35 degrees F. Tremies, if used, shall be watertight and sufficiently large to permit a free flow of concrete. Keep the discharge end continuously submerged in fresh concrete. Keep the shaft full of concrete to a level well above the water surface. Discharge and spread the concrete by raising the tremie to maintain a uniform flow.

Place concrete without interruption until the top of the fresh concrete is at the required height."

Add the following to paragraph entitled "Curing Periods": "A structure permanently submerged in fresh water shall be cured for 12 hours minimum prior to being submerged in fresh water. A structure permanently submerged in seawater shall be cured for 5 days minimum prior to being submerged in seawater."

Place concrete as soon as practicable after the forms and the reinforcement have been inspected and approved. Do not place concrete when weather conditions prevent proper placement and consolidation; in uncovered areas during periods of precipitation; or in standing water. Prior to placing concrete, remove dirt, construction debris, water, snow, and ice from within the forms. Deposit concrete as close as practicable to the final position in the forms. Do not exceed a free vertical drop of 1 m (3 feet) 3 feet from the point of discharge. Place concrete in one continuous operation from one end of the structure towards the other. Position grade stakes on 3 m (10 foot) 10 foot centers maximum in each direction when pouring interior slabs and on 6 m (20 foot) 20 foot centers maximum for exterior slabs.

[3.7.1 Footing Placement

Concrete for footings may be placed in excavations without forms upon inspection and approval by the Contracting Officer. Excavation width shall be a minimum of 100 mm (4 inches) 4 inches greater than indicated.

]3.7.2 Vibration

NOTE: For prefabricated epoxy-coated rebar use ASTM A 934/A 934M. For epoxy-coated rebar use ASTM A 775/A 775M.

ACI 301 [and [ASTM A 934/A 934M] [ASTM A 775/A 775M]]. Furnish a spare, working, vibrator on the job site whenever concrete is placed. Consolidate concrete slabs greater than 100 mm (4 inches) 4 inches in depth with high frequency mechanical vibrating equipment supplemented by hand spading and tamping. Consolidate concrete slabs 100 mm (4 inches) 4 inches or less in depth by wood tampers, spading, and settling with a heavy leveling straightedge. Operate internal vibrators with vibratory element submerged in the concrete, with a minimum frequency of not less than 6000 impulses per minute when submerged. Do not use vibrators to transport the concrete in the forms. Insert and withdraw vibrators approximately 500 mm (18 inches) 18 inches apart. Penetrate the previously placed lift with the vibrator when more than one lift is required. Place concrete in 500 mm (18 inches) 18 inch maximum vertical lifts. External vibrators shall be used on the exterior surface of the forms when internal vibrators do not provide adequate consolidation of the concrete.

[3.7.3 Application of Epoxy Bonding Compound

Apply a thin coat of compound to dry, clean surfaces. Scrub compound into the surface with a stiff-bristle brush. Place concrete while compound is

stringy. Do not permit compound to harden prior to concrete placement. Follow manufacturer's instructions regarding safety and health precautions when working with epoxy resins.

] [3.7.4 Pumping

NOTE: Pumping, especially lightweight concrete, requires careful attention to mix designs and pumping procedures. Allow pumping when other means of placement will be impractical or expensive.

ACI 304R and ACI 304.2R. Pumping shall not result in separation or loss of materials nor cause interruptions sufficient to permit loss of plasticity between successive increments. Loss of slump in pumping equipment shall not exceed 50 mm (2 inches) 2 inches. Concrete shall not be conveyed through pipe made of aluminum or aluminum alloy. Rapid changes in pipe sizes shall be avoided. Maximum size of course aggregate shall be limited to 33 percent of the diameter of the pipe. Maximum size of well rounded aggregate shall be limited to 40 percent of the pipe diameter. Samples for testing shall be taken at both the point of delivery to the pump and at the discharge end.

] [3.7.4.1 Pumping Lightweight Concrete

NOTE: Specify minimum of 330 kg per cubic meter (564 pounds per cubic yard) 564 pounds per cubic yard unless structural considerations require higher cement content. Require field trial run only when justified by job complexities or size.

ACI 213R. Aggregates shall be presoaked or presaturated. Cement content shall be minimum of [330 kg per cubic meter (564 pounds per cubic yard)] [564 pounds per cubic yard] [_____] and shall be sufficient to accommodate a 100 to 150 mm (4 to 6 inch) 4 to 6 inch slump. [Field trial run shall be made in accordance with ACI 213R.]

] [3.7.5 Cold Weather

ACI 306.1. Do not allow concrete temperature to decrease below 10 degrees C (50 degrees F) 50 degrees F Obtain approval prior to placing concrete when the ambient temperature is below 4 degrees C (40 degrees F) 40 degrees F or when concrete is likely to be subjected to freezing temperatures within 24 hours. Cover concrete and provide sufficient heat to maintain 10 degrees C (50 degrees F) (5 degrees F) 50 degrees F minimum adjacent to both the formwork and the structure while curing. Limit the rate of cooling to 3 degrees C (5 degrees F) 5 degrees F in any 1 hour and 10 degrees C (50 degrees F) 50 degrees F per 24 hours after heat application.

] 3.7.6 Hot Weather

ACI 305R. Maintain required concrete temperature using Figure 2.1.5 in ACI 305R to prevent the evaporation rate from exceeding 1 kg per square meter (0.2 pound of water per square foot) 0.2 pound of water per square foot of exposed concrete per hour. Cool ingredients before mixing or use other suitable means to control concrete temperature and prevent rapid

drying of newly placed concrete. Shade the fresh concrete as soon as possible after placing. Start curing when the surface of the fresh concrete is sufficiently hard to permit curing without damage. Provide water hoses, pipes, spraying equipment, and water hauling equipment, where job site is remote to water source, to maintain a moist concrete surface throughout the curing period. Provide burlap cover or other suitable, permeable material with fog spray or continuous wetting of the concrete when weather conditions prevent the use of either liquid membrane curing compound or impervious sheets. For vertical surfaces, protect forms from direct sunlight and add water to top of structure once concrete is set.

3.7.7 Follow-up

Check concrete within 24 hours of placement for flatness, levelness, and other specified tolerances. Adjust formwork and placement techniques on subsequent pours to achieve specified tolerances.

3.8 SURFACE FINISHES EXCEPT FLOOR, SLAB, AND PAVEMENT FINISHES

3.8.1 Defects

Repair formed surfaces by removing minor honeycombs, pits greater than 600 square mm (1 square inch) 1 square inch surface area or 6 mm (0.25 inch) 0.25 inch maximum depth, or otherwise defective areas. Provide edges perpendicular to the surface and patch with nonshrink grout. Patch tie holes and defects when the forms are removed. Concrete with extensive honeycomb including exposed steel reinforcement, cold joints, entrapped debris, separated aggregate, or other defects which affect the serviceability or structural strength will be rejected, unless correction of defects is approved. Obtain approval of corrective action prior to repair. The surface of the concrete shall not vary more than the allowable tolerances of ACI 347. Exposed surfaces shall be uniform in appearance and finished to a smooth form finish unless otherwise specified.

3.8.2 Not Against Forms (Top of Walls)

Surfaces not otherwise specified shall be finished with wood floats to even surfaces. Finish shall match adjacent finishes.

3.8.3 Formed Surfaces

3.8.3.1 Tolerances

ACI 117 and as indicated.

3.8.3.2 As-Cast Rough Form

Provide for surfaces not exposed to public view. Patch this holes and defects and level abrupt irregularities. Remove or rub off fins and other projections exceeding 6 mm (0.25 inch) 0.25 inch in height.

3.8.4 [_____] Finish

NOTE: Add information where special type of finish is desired. See ACI 301 for information on smooth rubbed finish, grout cleaned finish, cork floated finish, and exposed aggregate. Areas requiring special finish should be clearly indicated on the

drawings and coordinated with the specifications.

Provide concrete indicated with a [_____] finish as follows: [_____] .

[3.8.5 Surface Finish Samples

NOTE: Include when either job complexity or aesthetics justify the additional cost associated with these requirements.

Provide a minimum of three sample concrete panels for each finish for each mix design, one by one m, 75 mm (3 by 3 feet, 3 inches) 3 by 3 feet, 3 inches thick. Use the approved concrete mix design(s). Provide sample panels on-site at locations directed. Once approved, each set of panels shall be representative of each of the finishes specified and shall be representative of the workmanship and finish(es) required. Do not remove or destroy samples until directed by the Contracting Officer.

] 3.9 FLOOR, SLAB, AND PAVEMENT FINISHES AND MISCELLANEOUS CONSTRUCTION

NOTE: Include these paragraphs where floor flatness is not critical. Coordinate concrete finish with applicable architectural finish material to be installed over concrete floor. For thin-set tile, coordinate with Section 09310, "Ceramic Tile."

ACI 302.1R, unless otherwise specified. Slope floors uniformly to drains where drains are provided. [Depress the concrete base slab where quarry tile, ceramic tile, [or] [_____] are indicated.] [Steel trowel and fine-broom finish concrete slabs that are to receive quarry tile, ceramic tile, or paver tile [_____] .] Where straightedge measurements are specified, Contractor shall provide straightedge.

3.9.1 Finish

Place, consolidate, and immediately strike off concrete to obtain proper contour, grade, and elevation before bleedwater appears. Permit concrete to attain a set sufficient for floating and supporting the weight of the finisher and equipment. If bleedwater is present prior to floating the surface, drag the excess water off or remove by absorption with porous materials. Do not use dry cement to absorb bleedwater.

3.9.1.1 Scratched

Use for surfaces intended to receive bonded applied cementitious applications. After the concrete has been placed, consolidated, struck off, and leveled to a Class C tolerance as defined below, the surface shall be roughened with stiff brushes or rakes before final set.

3.9.1.2 Floated

Use for [surfaces to receive [roofing,] [waterproofing membranes,] [sand bed terrazzo,]] [_____] [and] [exterior slabs where not otherwise specified.] After the concrete has been placed, consolidated, struck off,

and leveled, do not work the concrete further, until ready for floating. Whether floating with a wood, magnesium, or composite hand float, with a bladed power trowel equipped with float shoes, or with a powered disc, float shall begin when the surface has stiffened sufficiently to permit the operation. During or after the first floating, surface shall be checked with a 3 meter (10 foot) 10 foot straightedge applied at no less than two different angles, one of which is perpendicular to the direction of strike off. High spots shall be cut down and low spots filled during this procedure to produce a surface level within [6] [_____] mm in 3 m ([1/4] [_____] inch in 10 feet) [1/4] [_____] inch in 10 feet.

[3.9.1.3 Concrete Containing Silica Fume

Finish using magnesium floats or darbies. [Finish using techniques demonstrated in the sample installation.]

]3.9.1.4 Steel Troweled

NOTE: ACI 302.1R suggests power troweling three times for Class 5 floors and where increased wear resistance is needed.

Use for floors intended as walking surfaces[,] [and] for reception of floor coverings[, and] [_____] . First, provide a floated finish. The finish shall next be power troweled [two] [three] [_____] times, and finally hand troweled. The first troweling after floating shall produce a smooth surface which is relatively free of defects but which may still show some trowel marks. Additional trowelings shall be done by hand after the surface has hardened sufficiently. The final troweling shall be done when a ringing sound is produced as the trowel is moved over the surface. The surface shall be thoroughly consolidated by the hand troweling operations. The finished surface shall be essentially free of trowel marks and uniform in texture and appearance. The finished surface shall produce a surface level to within [6] [_____] mm in 3 m ([1/4] [_____] inch in 10 feet) [1/4] [_____] inch in 10 feet. On surfaces intended to support floor coverings, any defects of sufficient magnitude to show through the floor covering shall be removed by grinding.

[3.9.1.5 Nonslip Finish

NOTE: Include when nonslip finish using dry shake aggregate is desired.

Use on surfaces of exterior platforms, steps, and landings; and on exterior and interior pedestrian ramps. Apply dry shake aggregate of [ceramically bonded aluminum oxide] [_____] to the surface at a minimum rate of 1.2 kg per square m (25 pounds per 100 square feet) 25 pounds per 100 square feet. Blend approximately two-thirds of the aggregate with portland cement as recommended by the manufacturer and apply to the surface evenly and without segregation. After blended material has been embedded by floating, apply the remainder of the blended material to the surface at right angles to the previous application. Apply blended material heavier in any areas not sufficiently covered by the first application. Perform a second floating immediately following the first. After the selected material has been embedded by the two floatings, complete the operation with a [broomed]

[floated] [troweled] finish.

]3.9.1.6 Broomed

Use on surfaces of exterior walks, platforms, patios, and ramps, unless otherwise indicated. Perform a floated finish, then draw a broom or burlap belt across the surface to produce a coarse scored texture. Permit surface to harden sufficiently to retain the scoring or ridges. Broom transverse to traffic or at right angles to the slope of the slab.

3.9.1.7 Pavement

Screed the concrete with a template advanced with a combined longitudinal and crosswise motion. Maintain a slight surplus of concrete ahead of the template. After screeding, float the concrete longitudinally. Use a straightedge to check slope and flatness; correct and refloat as necessary.

Obtain final finish by [belting. Lay belt flat on the concrete surface and advance with a sawing motion; continue until a uniform but gritty nonslip surface is obtained.] [a burlap drag. Drag a strip of clean, wet burlap from 900 to 3000 mm wide and 600 mm longer (3 to 10 feet wide and 2 feet longer) 3 to 10 feet wide and 2 feet longer than the pavement width across the slab. Produce a fine, granular, sandy textured surface without disfiguring marks.] Round edges and joints with an edger having a radius of 3 mm (1/8 inch) 1/8 inch.

3.9.1.8 Concrete Toppings Placement

The following requirements apply to the placement of toppings of concrete on base slabs that are either freshly placed and still plastic, or on hardened base slabs.

- a. Placing on a Fresh Base: Screed and bull float the base slab. As soon as the water sheen has disappeared, lightly rake the surface of the base slab with a stiff bristle broom to produce a bonding surface for the topping. Immediately spread the topping mixture evenly over the roughened base before final set takes place. Give the topping the finish [indicated on the drawings] [specified herein].
- b. Bonding to a Hardened Base: When the topping is to be bonded to a floated or troweled hardened base, roughen the base by scarifying, grit-blasting, scabbling, planing, flame cleaning, or acid-etching to lightly expose aggregate and provide a bonding surface. Remove dirt, laitance, and loose aggregate by means of a stiff wire broom. Keep the clean base wet for a period of 12 hours preceding the application of the topping. Remove excess water and apply a 1:1:1/2 cement-sand-water grout, and brush into the surface of the base slab. Do not allow the cement grout to dry, and spread it only short distances ahead of the topping placement. Do not allow the temperature differential between the completed base and the topping mixture to exceed 5 degrees C (10 degrees F) 10 degrees F at the time of placing. Place the topping and finish as [indicated] [specified herein].

[3.9.2 Flat Floor Finishes

NOTE: Use these paragraphs where floor flatness is critical. Indicate areas where these requirements

apply. Flatness will affect the appearance and function of finishes applied to the concrete and in situations such as large or long expanses of glossy floor materials. Low tolerance for product (thin set tile and wood gymnasium floors, etc.) and equipment will dictate to the designer to specify higher than normal flatness requirements. The numbers provided in brackets are typical numbers, but A/E should research and select F numbers high enough to get desired results but not so high as to cause undue cost increases and construction problems. Ff/FL 20/15 is equivalent to 8 mm in 5.05 mm (5/16 inches in 10 feet) 5/16 inches in 10 feet. This test method is not suitable for unshored deck. Fitted partitions need FL greater than or equal to 25.

ACI 302.1R. Construct in accordance with one of the methods recommended in Table 7.15.3, "Typical Composite Ff/FL Values for Various Construction Methods." ACI 117 for tolerance tested by ASTM E 1155 ASTM E 1155M.

a. Specified Conventional Value:

Floor Flatness (Ff)	[20]	[_____]	[13]	[_____]	minimum
Floor Levelness (FL)	[15]	[_____]	[10]	[_____]	minimum

b. Specified Industrial:

Floor Flatness (Ff)	[30]	[_____]	[15]	[_____]	minimum
Floor Levelness (FL)	[20]	[_____]	[10]	[_____]	minimum

3.9.2.1 Measurement of Floor Tolerances

Test slab within 24 hours of the final troweling. Provide tests to Contracting Officer within 12 hours after collecting the data. Floor flatness inspector shall provide a tolerance report which shall include:

- a. Key plan showing location of data collected.
- b. Results required by ASTM E 1155 ASTM E 1155M.

3.9.2.2 Remedies for Out of Tolerance Work

Contractor shall repair and retest any floors not meeting specified tolerances. Prior to repair, Contractor shall submit and receive approval for the proposed repair, including product data from any materials proposed. Repairs shall not result in damage to structural integrity of the floor. For floors exposed to public view, repairs shall not result in any uneven or unusual coloring of the surface.

]3.9.3 Concrete Walks

Provide 100 mm (4 inches) 4 inches thick minimum. Provide contraction joints spaced every 1500 lineal mm (5 linear feet) 5 linear feet unless otherwise indicated. Cut contraction joints 25 mm (one inch) one inch deep with a jointing tool after the surface has been finished. Provide 13 mm (0.5 inch) 0.5 inch thick transverse expansion joints at changes in direction where sidewalk abuts curb, steps, rigid pavement, or other similar structures; space expansion joints every 15 m (50 feet) 50 feet

maximum. Give walks a broomed finish. Unless indicated otherwise, provide a transverse slope of 1/48. Limit variation in cross section to 6 mm in 1500 mm (1/4 inch in 5 feet) 1/4 inch in 5 feet.

3.9.4 Pits and Trenches

Place bottoms and walls monolithically or provide waterstops and keys.

3.9.5 Curbs [and Gutters]

Provide contraction joints spaced every 3 m (10 feet) 10 feet maximum unless otherwise indicated. Cut contraction joints 20 mm (3/4 inch) 3/4 inch deep with a jointing tool after the surface has been finished. Provide expansion joints 13 mm (1/2 inch) 1/2 inch thick and spaced every 30 mm (100 feet) 100 feet maximum unless otherwise indicated. Perform pavement finish.

[3.9.6 Splash Blocks

Provide at outlets of downspouts emptying at grade. Splash blocks may be precast concrete, and shall be 600 mm long, 300 mm wide, and 100 mm thick (24 inches long, 12 inches wide, and 4 inches thick) 24 inches long, 12 inches wide, and 4 inches thick, unless otherwise indicated, with smooth-finished countersunk dishes sloped to drain away from the building.

]3.10 CURING AND PROTECTION

NOTE: When the use of alkali-reactive aggregates is permitted, delete everything after the first two sentences, add the following, and add paragraph entitled "Additional Curing When Using Alkali-Reactive Aggregates" as follows:

"Alkali-reactive aggregates may be used where not exposed to either seawater or alkali soil conditions, and when used with one of the following cements and tested in accordance with ASTM C 441 to ensure that a 75 percent minimum reduction of expansion due to alkali-aggregate reaction is provided.

1. ASTM C 150 low alkali cement (Table 1A, maximum of 0.60 percent equivalent Na₂O).

2. ASTM C 595M ASTM C 595 blended cement.

3. ASTM C 150 low alkali, Type I or II cement with fly ash, pozzolan, or ground slag.

Furnish a mix design utilizing alkali-reactive aggregates with a maximum water-cement ratio of 0.45."

"Additional Curing When Using Alkali-Reactive Aggregates.

Furnish ASTM C 39/C 39M test results to verify the anticipated rate of strength development for the

proposed concrete mix design. Submit an increased curing period and minimum time to strip formwork based upon the reduced rate of strength development."

Add to "Curing and Protection" when using silica fume.

Prevent concrete with silica fume from drying by one or more of the following:

1. Misting surface of concrete with fog nozzle;
2. Liquid membrane-forming compound;
3. Pervious or impervious sheeting.

Increase curing time per manufacturer's recommendations.

ACI 301 unless otherwise specified. Begin curing immediately following form removal. Avoid damage to concrete from vibration created by blasting, pile driving, movement of equipment in the vicinity, disturbance of formwork or protruding reinforcement, and any other activity resulting in ground vibrations. Protect concrete from injurious action by sun, rain, flowing water, frost, mechanical injury, tire marks, and oil stains. Do not allow concrete to dry out from time of placement until the expiration of the specified curing period. Do not use membrane-forming compound on surfaces where appearance would be objectionable, on any surface to be painted, where coverings are to be bonded to the concrete, or on concrete to which other concrete is to be bonded. If forms are removed prior to the expiration of the curing period, provide another curing procedure specified herein for the remaining portion of the curing period. Provide moist curing for those areas receiving liquid chemical sealer-hardener or epoxy coating. Allow curing compound/sealer installations to cure prior to the installation of materials that adsorb VOCs, including [_____].

3.10.1 Moist Curing

Remove water without erosion or damage to the structure. Prevent water run-off.

3.10.1.1 Ponding or Immersion

Continually immerse the concrete throughout the curing period. Water shall not be more than 10 degrees C (20 degrees F) 20 degrees F less than the temperature of the concrete. For temperatures between 4 and 10 degrees C (40 and 50 degrees F) 40 and 50 degrees F, increase the curing period by 50 percent.

3.10.1.2 Fog Spraying or Sprinkling

Apply water uniformly and continuously throughout the curing period. For temperatures between 4 and 10 degrees C (40 and 50 degrees F) 40 and 50 degrees F, increase the curing period by 50 percent.

3.10.1.3 Pervious Sheetting

Completely cover surface and edges of the concrete with two thicknesses of

wet sheeting. Overlap sheeting 150 mm (6 inches) 6 inches over adjacent sheeting. Sheetting shall be at least as long as the width of the surface to be cured. During application, do not drag the sheeting over the finished concrete nor over sheeting already placed. Wet sheeting thoroughly and keep continuously wet throughout the curing period.

3.10.1.4 Impervious Sheetting

Wet the entire exposed surface of the concrete thoroughly with a fine spray of water and cover with impervious sheetting throughout the curing period. Lay sheetting directly on the concrete surface and overlap edges 300 mm (12 inches) 12 inches minimum. Provide sheetting not less than 450 mm (18 inches) 18 inches wider than the concrete surface to be cured. Secure edges and transverse laps to form closed joints. Repair torn or damaged sheetting or provide new sheetting. Cover or wrap columns, walls, and other vertical structural elements from the top down with impervious sheetting; overlap and continuously tape sheetting joints; and introduce sufficient water to soak the entire surface prior to completely enclosing.

3.10.2 Liquid Membrane-Forming Curing Compound

Seal or cover joint openings prior to application of curing compound. Prevent curing compound from entering the joint. Apply in accordance with the recommendations of the manufacturer immediately after any water sheen which may develop after finishing has disappeared from the concrete surface. Provide and maintain compound on the concrete surface throughout the curing period. Do not use this method of curing where the use of Figure 2.1.5 in ACI 305R indicates that hot weather conditions will cause an evaporation rate exceeding one kg pf water per square meter per hour (0.2 pound of water per square foot per hour) 0.2 pound of water per square foot per hour.

3.10.2.1 Application

Unless the manufacturer recommends otherwise, apply compound immediately after the surface loses its water sheen and has a dull appearance, and before joints are sawed. Mechanically agitate curing compound thoroughly during use. Use approved power-spraying equipment to uniformly apply two coats of compound in a continuous operation. The total coverage for the two coats shall be 5 square meters maximum per L (200 square feet maximum per gallon) 200 square feet maximum per gallon of undiluted compound unless otherwise recommended by the manufacturer's written instructions. The compound shall form a uniform, continuous, coherent film that will not check, crack, or peel. Immediately apply an additional coat of compound to areas where the film is defective. Re-spray concrete surfaces subjected to rainfall within 3 hours after the curing compound application.

3.10.2.2 Protection of Treated Surfaces

Prohibit pedestrian and vehicular traffic and other sources of abrasion at least 72 hours after compound application. Maintain continuity of the coating for the entire curing period and immediately repair any damage.

3.10.3 Liquid Chemical Sealer-Hardener

Apply sealer-hardener to interior floors not receiving floor covering and floors located under access flooring. Apply the sealer-hardener in accordance with manufacturer's recommendations. Seal or cover joints and openings in which joint sealant is to be applied as required by the joint

sealant manufacturer. The sealer-hardener shall not be applied until the concrete has been moist cured and has aged for a minimum of 30 days. Apply a minimum of two coats of sealer-hardener.

3.10.4 Curing Periods

ACI 301 except 10 days for retaining walls, pavement or chimneys, 21 days for concrete that will be in full-time or intermittent contact with seawater, salt spray, alkali soil or waters. Begin curing immediately after placement. Protect concrete from premature drying, excessively hot temperatures, and mechanical injury; and maintain minimal moisture loss at a relatively constant temperature for the period necessary for hydration of the cement and hardening of the concrete. The materials and methods of curing shall be subject to approval by the Contracting Officer.

3.10.5 Requirements for Type III, High-Early-Strength Portland Cement

The curing periods shall be not less than one-fourth of those specified for portland cement, but in no case less than 72 hours.

3.11 FIELD QUALITY CONTROL

3.11.1 Sampling

ASTM C 172. Collect samples of fresh concrete to perform tests specified. ASTM C 31/C 31M for making test specimens.

3.11.2 Testing

3.11.2.1 Slump Tests

ASTM C 143/C 143M. Take concrete samples during concrete placement. The maximum slump may be increased as specified with the addition of an approved admixture provided that the water-cement ratio is not exceeded. Perform tests at commencement of concrete placement, when test cylinders are made, and for each batch (minimum) or every 16 cubic meters (20 cubic yards) 20 cubic yards (maximum) of concrete.

3.11.2.2 Temperature Tests

Test the concrete delivered and the concrete in the forms. Perform tests in hot or cold weather conditions (below 10 degrees C and above 27 degrees C (below 50 degrees F and above 80 degrees F) below 50 degrees F and above 80 degrees F) for each batch (minimum) or every 16 cubic meters (20 cubic yards) 20 cubic yards (maximum) of concrete, until the specified temperature is obtained, and whenever test cylinders and slump tests are made.

3.11.2.3 Compressive Strength Tests

NOTE: When the same mix design is used for multiple elements such as slabs, beams, and walls, the design element type may be specified in lieu of or in addition to the mix design in order to better identify deficient concrete.

ASTM C 39/C 39M. Make five test cylinders for each set of tests in

accordance with **ASTM C 31/C 31M**. Precautions shall be taken to prevent evaporation and loss of water from the specimen. Test two cylinders at 7 days, two cylinders at 28 days, and hold one cylinder in reserve. Samples for strength tests of each [mix design of] [and for] [_____] concrete placed each day shall be taken not less than once a day, nor less than once for each **120 cubic meters (100 cubic yards) 100 cubic yards** of concrete, nor less than once for each **500 square meters (5000 square feet) 5000 square feet** of surface area for slabs or walls. For the entire project, take no less than five sets of samples and perform strength tests for each mix design of concrete placed. Each strength test result shall be the average of two cylinders from the same concrete sample tested at 28 days. If the average of any three consecutive strength test results is less than f'c or if any strength test result falls below f'c by more than **3 MPa (500 psi) 500 psi**, take a minimum of three **ASTM C 42/C 42M** core samples from the in-place work represented by the low test cylinder results and test. Concrete represented by core test shall be considered structurally adequate if the average of three cores is equal to at least 85 percent of f'c and if no single core is less than 75 percent of f'c. Locations represented by erratic core strengths shall be retested. Remove concrete not meeting strength criteria and provide new acceptable concrete. Repair core holes with nonshrink grout. Match color and finish of adjacent concrete.

[3.11.2.4 **Air Content**

ASTM C 173/C 173M or **ASTM C 231** for normal weight concrete [and **ASTM C 173/C 173M** for lightweight concrete]. Test air-entrained concrete for air content at the same frequency as specified for slump tests.

] [3.11.2.5 **Unit Weight of Structural Lightweight Concrete**

ASTM C 567. Determine unit weight of lightweight concrete. Perform test for every **15 cubic meters (20 cubic yards) 20 cubic yards** maximum.

] [3.11.2.6 **Ion Concentration**

**NOTE: Include only when justified by size of job or
when quality of concrete is questionable.**

ACI 318M. Determine water soluble ion concentration. Perform test once for each mix design.

]

3.12 **WASTE MANAGEMENT**

As specified in the Waste Management Plan and as follows.

3.12.1 **Mixing Equipment**

Before concrete pours, designate [Company-owned site meeting environmental standards] [on-site area to be paved later in project] for cleaning out concrete mixing trucks. Minimize water used to wash equipment.

3.12.2 **Hardened, Cured Waste Concrete**

[Hardened, cured waste concrete shall be crushed and reused as fill or as a base course for pavement.] [Hardened, cured waste concrete shall be used as aggregate in concrete mix if approved by Contracting Officer.]

3.12.3 Reinforcing Steel

Collect reinforcing steel and place in designated area for recycling.

3.12.4 Other Waste

Identify concrete manufacturer's or supplier's policy for collection or return of construction waste, unused material, deconstruction waste, and/or packaging material. [Return excess cement to supplier.] [Institute deconstruction and construction waste separation and recycling for use in manufacturer's programs. When such a program is not available, local recyclers shall be sought after to reclaim the materials.]

-- End of Section --