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USACE / NAVFAC / AFCESA / NASA **UFGS-03 30 00 (November 2011)**

Preparing Activity: NAVFAC **Superseding UFGS-03 30 00 (November 2010)**

UNIFIED FACILITIES GUIDE SPECIFICATION

References are in agreement with UMRL dated October 2012
****

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DIVISION 03 - CONCRETE

SECTION 03 30 00

CAST-IN-PLACE CONCRETE

11/11

-- End of Section Table of Contents --

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USACE / NAVFAC / AFCESA / NASA | UFGS-03 30 00 (November 2011)

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SECTION 03 30 00

CAST-IN-PLACE CONCRETE
11/11

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

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

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

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

****
NOTE: Show the following information 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 are 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. Indicate the locations in the finished structure, when exposed concrete surfaces are specified. Indicate the type and location, if other than cast finish is required.

****

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.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182	(2005; R 2009) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats
AASHTO M 322M/M 322	(2010) Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI/MCP-1	(2012) Manual of Concrete Practice Part 1
ACI/MCP-2	(2012) Manual of Concrete Practice Part 2
ACI/MCP-3	(2012) Manual of Concrete Practice Part 3
ACI/MCP-4	(2012) Manual of Concrete Practice Part 4

AMERICAN HARDBOARD ASSOCIATION (AHA)

AHA A135.4	(1995; R 2004) Basic Hardboard

AMERICAN WELDING SOCIETY (AWS)

AWS D1.4/D1.4M	(2011) Structural Welding Code - Reinforcing Steel

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2012) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and

	Steel Products
ASTM A185/A185M	(2007) Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM A496/A496M	(2007) Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement
ASTM A497/A497M	(2007) Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A615/A615M	(2012) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A706/A706M	(2009b) Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A767/A767M	(2009) Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
ASTM A775/A775M	(2007b) Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A780/A780M	(2009) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A82/A82M	(2007) Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
ASTM A934/A934M	(2007) Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars
ASTM A996/A996M	(2009b) Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
ASTM C1017/C1017M	(2007) Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C1107/C1107M	(2011) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM C1116/C1116M	(2010a) Standard Specification for Fiber-Reinforced Concrete
ASTM C1240	(2011) Standard Specification for Silica Fume Used in Cementitious Mixtures

ASTM C1260	(2007) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C143/C143M	(2010a) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C156	(2011) Standard Test Method for Water Retention by Concrete Curing Materials
ASTM C1567	(2011) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C171	(2007) Standard Specification for Sheet Materials for Curing Concrete
ASTM C172/C172M	(2010) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C173/C173M	(2010b) Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C192/C192M	(2007) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231/C231M	(2010) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C233/C233M	(2011) Standard Test Method for Air-Entraining Admixtures for Concrete
ASTM C260/C260M	(2010a) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C295/C295M	(2012) Petrographic Examination of Aggregates for Concrete
ASTM C309	(2011) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C31/C31M	(2010) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C311	(2011b) Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland-Cement Concrete
ASTM C33/C33M	(2011a) Standard Specification for Concrete Aggregates

ASTM C330/C330M	(2009) Standard Specification for Lightweight Aggregates for Structural Concrete
ASTM C39/C39M	(2012) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C42/C42M	(2012) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C494/C494M	(2011) Standard Specification for Chemical Admixtures for Concrete
ASTM C567/C567M	(2011) Determining Density of Structural Lightweight Concrete
ASTM C595/C595M	(2012) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2012) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C881/C881M	(2010) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C920	(2011) Standard Specification for Elastomeric Joint Sealants
ASTM C932	(2006) Standard Specification for Surface-Applied Bonding Compounds for Exterior Plastering
ASTM C94/C94M	(2012) Standard Specification for Ready-Mixed Concrete
ASTM C989/C989M	(2012) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C990	(2009) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM C990M	(2009) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants (Metric)
ASTM D1557	(2012) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D1751	(2004; R 2008) Standard Specification for

	Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2004a; R 2008) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D2628	(1991; R 2011) Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
ASTM D5759	(1995; R 2005) Characterization of Coal Fly Ash and Clean Coal Combustion Fly Ash for Potential Uses
ASTM D6690	(2007) Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements
ASTM D7116	(2005) Standard Specification for Joint Sealants, Hot Applied, Jet Fuel Resistant Types, for Portland Cement Concrete Pavement
ASTM E1155	(1996; R 2008) Standard Test Method for Determining Floor Flatness and Floor Levelness Numbers
ASTM E1745	(2011) Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs
ASTM E329	(2011c) Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction

CONCRETE REINFORCING STEEL INSTITUTE (CRSI)

CRSI 10MSP	(2009; 28th Ed) Manual of Standard Practice

FOREST STEWARDSHIP COUNCIL (FSC)

FSC STD 01 001	(2000) Principles and Criteria for Forest Stewardship

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST PS 1	(2009) DOC Voluntary Product Standard PS 1-07, Structural Plywood

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 572	(1974) Corps of Engineers Specifications for Polyvinylchloride Waterstops

U.S. DEPARTMENT OF COMMERCE (DOC)

DOC/NIST PS1	(1995) Construction and Industrial Plywood with Typical APA Trademarks

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

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

U.S. GREEN BUILDING COUNCIL (USGBC)

LEED NC	(2009) Leadership in Energy and Environmental Design(tm) New Construction Rating System

1.2 DEFINITIONS

a. "Cementitious material" as used herein must include all portland cement, pozzolan, fly ash, ground granulated 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.

c. "Chemical admixtures" are materials in the form of powder or fluids that are added to the concrete to give it certain characteristics not obtainable with plain concrete mixes.

d. "Workability (or consistence)" is the ability of a fresh (plastic) concrete mix to fill the form/mould properly with the desired work (vibration) and without reducing the concrete's quality. Workability depends on water content, chemical admixtures, aggregate (shape and size distribution), cementitious content and age (level of hydration).

1.3 SUBMITTALS

****

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

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

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

SD-02 Shop Drawings

Fabrication Drawings for concrete formwork must be submitted by the Contractor in accordance with paragraph entitled, "Shop Drawings," of this section, to include the following:

[Formwork
Column Forms
Wall Forms
Floor Forms
Ceiling Forms
Special Construction]

Reinforcing steel[; G][; G, [_____]]

Reproductions of contract drawings are unacceptable.

****

NOTE: Shop drawings for formwork may be required for unusually complicated structures, for structures whose designs were predicted on a particular method of construction, for structures in which the forms impart a desired architectural finish, for folded plates, for thin shells, and for long-span roof structures if required.

****

Provide erection drawings for concrete Formwork that show placement of reinforcement and accessories, with reference to the contract drawings.

SD-03 Product Data

Materials for curing concrete
Joint sealants; (LEED NC)[

Submit manufacturer's product data, indicating VOC content. Manufacturer's catalog data for the following items must include printed instructions for admixtures, bonding agents, epoxy-resin adhesive binders, waterstops, and liquid chemical floor hardeners.]

Joint filler; (LEED NC)
Plastic Forms
Carton Forms
Recycled Aggregate Materials; (LEED NC)
Cement; (LEED NC)
Portland Cement
Ready-Mix Concrete
Vapor retarder [and Vapor barrier]
Bonding Materials
Floor Finish Materials
Concrete Curing Materials
Reinforcement; (LEED NC)
Reinforcement Materials
Liquid Chemical Floor Hardener

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 [and Vapor barrier]

[Epoxy bonding compound]

[Synthetic reinforcing fibers]

Waterstops

[Wood Forms]

[Local/Regional Materials; (LEED NC)

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

Submit the following samples:

Three samples of each type waterstop, 300 mm 1/2 inch long.

Dumbbell Type
Rubber
Polyvinylchloride (PVC)

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 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. Provide only materials that have been proven by trial mix studies to meet the requirements of this specification, unless otherwise approved in writing by the Contracting Officer. Indicate clearly in the submittal where each mix design is used when more than one mix design is submitted. Submit additional data regarding concrete aggregates if the source of aggregate changes. Submit copies of the fly ash, [silica fume],[polypropylene fibers] and pozzolan test results, in addition. The approval of fly ash, [silica fume], and pozzolan [, and polypropylene fibers] test results must be 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 granulated 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]

Slump

Air Entrainment

[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 granulated blast-furnace slag

Welding Procedures must be in accordance with AWS D1.4/D1.4M.

Submit mill certificates for Steel Bar according to the paragraph entitled, "Fabrication," of this section.

Provide certificates for concrete that are in accordance with the paragraph entitled, "Classification and Quality of Concrete,"

of this section. Provide certificates that contain project name and number, date, name of Contractor, name of concrete testing service, source of concrete aggregates, material manufacturer, brand name of manufactured materials, material name, values as specified for each material, and test results. Provide certificates for Welder Qualifications that are in accordance with the paragraph entitled, "Qualifications for Welding Work," of this section.

Welding Procedures

SD-11 Closeout Submittals

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. 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 retarder, [vapor barrier,] forms, reinforcement, embedded items, and chamfer strips are in place and ready for concrete placement. ACI/MCP-2 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. Pad bundling bands 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.

Cover bars to be stored longer than 12 hours at the job site 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/MCP-4. Include design calculations indicating arrangement of forms, sizes and grades of supports (lumber), panels, and related components. Furnish drawings and calculations of shoring and re-shoring methods proposed for floor and roof slabs, spandrel beams, and other horizontal concrete members.

]1.6.2 Drawings

1.6.2.1 Shop Drawings

Fabrication Drawings for concrete formwork for Reinforcement Materials, Column Forms, Wall Forms, Floor Forms, Ceiling Forms and for Special Construction must indicate concrete pressure calculations with both live and dead loads, along with material types. Provide all design calculations in accordance with ACI/MCP-2 and ACI/MCP-3.

[1.6.2.2 Formwork

Drawings showing details of formwork including, but not limited to; joints, supports, studding and shoring, and sequence of form and shoring removal. Reproductions of contract drawings are unacceptable.

Design, fabricate, erect, support, brace, and maintain formwork so that it is capable of supporting without failure all vertical and lateral loads that may reasonably be anticipated to be applied to the formwork.

]1.6.2.3 Reinforcing Steel

ACI/MCP-4. 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 must include mix designs, pumping equipment including type of pump and size and material for pipe, and maximum length and height concrete is to 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 must 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 must 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.

****

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 of measuring equipment to be used, and a 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 must be suitable for the job conditions. Include mill test and all other test for cement, [silica fume,] aggregates, and admixtures in the laboratory test reports. Provide maximum nominal aggregate size, gradation analysis, percentage retained and passing sieve, and a graph of percentage retained verses sieve size. Submit test reports 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 C618 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 Granulated Blast-Furnace Slag

Submit test results in accordance with ASTM C989/C989M for ground granulated 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 C1260 for potential alkali-silica reactions, ASTM C295/C295M for petrographic analysis.

][1.6.4.5 Fiber-Reinforced Concrete

Test to determine flexural toughness index I5 in accordance with ASTM C1116/C1116M.

]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 slab. Finish as required by specification. [Silica fume manufacturer's representative must 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 must have a minimum of 3 years' experience finishing high-volume fly ash concrete.

1.7 ENVIRONMENTAL REQUIREMENTS

****
NOTE: In some regions, designer must 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 C55 degrees F and 29 degrees C84 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.

1.7.1 Submittals for Environmental Performance

a. Provide data indication the percentage of post-industrial pozzolan (fly ash, blast furnace slag) cement substitution as a percentage of the full product composite by weight.

b. Provide data indicating the percentage of post-industrial and post-consumer recycled content aggregate.

c. Provide product data indicating the percentage of post-consumer recycled steel content in each type of steel reinforcement as a percentage of the full product composite by weight.

d. Provide product data stating the location where all products were manufactured

e. For projects using FSC certified formwork, provide chain-of-custody documentation for all certified wood products.

f. For projects using reusable formwork, provide data showing how formwork is reused.

g. Provide MSDS product information data showing that form release agents meet any environmental performance goals such as using vegetable and soy based products.

h. Provide MSDS product information data showing that concrete adhesives meet any environmental performance goals including low emitting, low volatile organic compound products.

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 must include option only if pursuing this LEED credit.

****

[Use materials or products extracted, harvested, or recovered, as well as manufactured, within a [805][_____] kilometer [500][_____] mile 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.

1.9 QUALIFICATIONS FOR CONCRETE TESTING SERVICE

Perform concrete testing by an approved laboratory and inspection service experienced in sampling and testing concrete. Testing agency must meet the requirements of ASTM E329.

1.10 QUALIFICATIONS FOR WELDING WORK

****

NOTE: If Section 05 05 23 WELDING, STRUCTURAL is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph deleted.

****

[Section 05 05 23 WELDING, STRUCTURAL applies to work specified in this section.
]
[Welding procedures must be in accordance with AWS D1.4/D1.4M.

Verify that Welder qualifications are in accordance with AWS D1.4/D1.4M or under an equivalent qualification test approved in advance. Welders are permitted to do only the type of welding for which each is specifically qualified.
]

1.11 CONCRETE SAMPLING AND TESTING

Testing by the Contractor must include sampling and testing concrete materials proposed for use in the work and testing the design mix for each class of concrete. Perform quality control testing during construction.

****

NOTE: Delete paragraph heading and following paragraphs when certificates of compliance are required instead of laboratory tests. Laboratory tests are recommended when the quantity of concrete exceeds 900 cubic meter 1,200 cubic yards. Where architectural concrete made of special aggregates, such as an exposed-aggregate finish, specify tests for the aggregates potential reactivity to alkalis

and for water absorption of the concrete as specified in Section 03 45 00 PRECAST ARCHITECTURAL CONCRETE.

****

Sample and test concrete aggregate materials proposed for use in the work in accordance with ASTM C33/C33M.

Sample and test portland cement in accordance with ASTM C150/C150M.

Sample and test air-entraining admixtures in accordance with ASTM C233/C233M.

Testing must be performed by a Grade I Testing Technician.

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. Provide lumber that is square edged or tongue-and-groove boards, free of raised grain, knotholes, or other surface defects. Provide plywood that complies with DOC/NIST PS1, 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 must be FSC-certified.]

2.1.1.1 Concrete Form Plywood (Standard Rough)

Provide plywood that conforms to NIST PS 1, B-B, concrete form, not less than 16 mm 5/8-inch thick.

2.1.1.2 Overlaid Concrete Form Plywood (Standard Smooth)

Provide plywood that conforms to NIST PS 1, B-B, high density form overlay, not less than 16 mm 5/8-inch thick.

2.1.2 Plastic Forms

Plastic lumber as specified in Section 06 10 00 ROUGH CARPENTRY. Provide plastic forms that 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. Provide carton forms that 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

Provide steel form surfaces that do not contain irregularities, dents, or sags.

2.2 FORM TIES AND ACCESSORIES

The use of wire alone is prohibited. Provide form ties and accessories that do 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 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 NAVFAC SE 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 NAVFAC LANT projects.
****

At the option of the Contractor, those applicable material sections of [_____] DOT RBS for Class [A] [_____] strength concrete must 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) (in.)	Size No.	Air Content, Percent Moderate Exposure
10 3/8	8	8
13 1/2	7	7
20 3/4	67	7
25 1	57	5
35 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/MCP-2 and ACI/MCP-2): 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 psi	Slump mm in.
1	Light foot	Residential or tile covered	20 3000	100 4
2	Foot	Offices, churches, schools, hospitals, residences	24 3500	100 4
3	Light foot and pneumatic wheels	Drives, garage floors and sidewalks for residence	25 3500	100 4

Class	Usual Traffic	Typical Uses	28 day Max.	
			Str. MPa psi	Slump mm in.
4	Foot and pneumatic wheels	Light industrial, commercial	30 4000	75 3
5	Foot and wheels abrasive wear	Single-course industrial, integral topping	35 4500	75 3
6	Foot and steel-tire vehicles -- severe abrasion	Two-course heavy industrial topping	See ACI/MCP-2	

]

GUIDELINES FOR CONCRETE NOT EXPOSED TO SEVERE CONDITIONS FOR MAXIMUM WATER-CEMENT RATIO:		
Compressive Strength	Without AE	With AE
20 MPa 3000 PSI	0.58	0.50
25 MPa 3500 PSI	0.54	0.48
30 MPa 4000 PSI	0.50	0.45
AE= air-entrainment		

REQUIREMENTS FOR SPECIAL EXPOSURE CONDITIONS (From ACI/MCP-3):	
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:	

REQUIREMENTS FOR SPECIAL EXPOSURE CONDITIONS (From ACI/MCP-3):	
Exposure Condition	**Max. Water-Cement Ratio (Normal Weight Aggregate)**
(a) Curbs, gutters, guardrails, or thin sections	**0.45**
(b) Other elements	**0.50**
(c) In presence of deicing chemicals	**0.45**
For corrosion protection for reinforced concrete exposed to deicing salts, brackish water, seawater, or spray from these sources:	
Min. concrete cover per ACI 318M ACI 318	**0.40**
(b) ACI 318M/318RM ACI 318 cover exceeded by 13 mm 0.50 in.	**0.45**

****

ACI/MCP-1, ACI/MCP-2, and ACI/MCP-3 [and ACI/MCP-1] [ACI/MCP-2] [and] [ACI/MCP-1] except as otherwise specified. Indicate the compressive strength (f'c) of the concrete for each portion of the structure(s) [and as specified below].

Location	f'c (Min. 28-Day Comp. Strength (MPa)	ASTM C33/C33M 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]]	[[_____]]	[[_____]]

Location	f'c (Min. 28-Day Comp. Strength (MPa)	ASTM C33/C33M Maximum Nominal Aggregate (Size No.)	Range of Slump (mm)	[Maximum Water-Cement Ratio] (by weight)	[Air Entr.] (percent)
[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)_]]
[Floor toppings]	[[_____]]	[[_____]]	[[_____]]	[[_____]]	[[_____]]
[Walks, curbs and gutters]	[[_____]]	[[_____]]	[[_____]]	[[_____]]	[[_____]]
[Utility structures]	[[_____]]	[[_____]]	[[_____]]	[[_____]]	[[_____]]
[Drainage structures]	[[_____]]	[[_____]]	[[_____]]	[[_____]]	[[_____]]
[[_____]]	[[_____]]	[[_____]]	[[_____]]	[[_____]]	[[_____]]

Location	f'c (Min. 28-Day Comp. Strength (psi)	ASTM C33/C33M 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 for methods of consolidation other than vibration. Slump may be increased to 200 mm 8 inches when superplasticizers are used.[Provide air entrainment using air-entraining admixture. Provide air entrainment 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 must not exceed [0.15] [1.00] [0.30]].[Note (a): Entrapped air must be 3 percent 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 are the responsibility of the Contractor. Base mixture proportions on compressive strength as determined by test specimens fabricated in accordance with ASTM C192/C192M and tested in accordance with ASTM C39/C39M. Samples of all materials used in mixture proportioning studies must be representative of those proposed for use in the project and must be accompanied by the manufacturer's or producer's test report indicating compliance with these specifications. Base trial mixtures having proportions, consistencies, and

[air content] suitable for the work on methodology described in ACI/MCP-1. In the trial mixture, use at least three different water-cement ratios for each type of mixture, which must 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 must 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. Design laboratory trial mixture for maximum permitted slump and air content. Each combination of material proposed for use must have separate trial mixture, except for accelerator or retarder use can be provided without separate trial mixture. Report the temperature of concrete in each trial batch. For each water-cement ratio, at least three test cylinders for each test age must be made and cured in accordance with ASTM C192/C192M and tested in accordance with ASTM C39/C39M for 7 and 28 days. From these results, plot a curve showing the relationship between water-cement ratio and strength for each set of trial mix studies. In addition, plot a curve 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/MCP-1 provides recommendations for lightweight concrete.
****

ACI/MCP-1, using weight method. Provide ASTM C330/C330M 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 must be between [_____] and [_____] mm inches.[Provide [_____] percent air entrainment using an air-entraining admixture.][Maximum water-cement ratio must be [_____].]

]2.3.2.3 Required Average Strength of Mix Design

The selected mixture must produce an average compressive strength exceeding the specified strength by the amount indicated in ACI/MCP-2. When a concrete production facility has a record of at least 15 consecutive tests, the standard deviation must be calculated and the required average compressive strength must be determined in accordance with ACI/MCP-2. When a concrete production facility does not have a suitable record of tests to establish a standard deviation, the required average strength must follow ACI/MCP-2 requirements.

2.3.3 Ready-Mix Concrete

Provide concrete that meets the requirements of ASTM C94/C94M.

Ready-mixed concrete manufacturer must provide duplicate delivery tickets with each load of concrete delivered. Provide delivery tickets with the following information in addition to that required by ASTM C94/C94M:

Type and brand cement

Cement content in 43 kilogram 94-pound bags per cubic meter yard of concrete

Maximum size of aggregate

Amount and brand name of admixtures

Total water content expressed by water/cement ratio

2.3.4 Concrete Curing Materials

2.3.4.1 Absorptive Cover

Provide burlap, cotton mats, and other absorbent materials for curing concrete, as described in ACI 308R.

2.3.4.2 Moisture-Retaining Cover

Provide waterproof paper cover for curing concrete conforming to ASTM C171, regular or white, or polyethylene sheeting conforming to ASTM C171, or polyethylene-coated burlap consisting of a laminate of burlap and a white opaque polyethylene film permanently bonded to the burlap; burlap must conform to ASTM C171, Class 3, and polyethylene film must conform to ASTM C171. When tested for water retention in accordance with ASTM C156, weight of water lost 72 hours after application of moisture retaining covering material must not exceed 0.039 gram per square centimeter of the mortar specimen surface.

2.3.4.3 Membrane-Forming Curing Compound

Provide liquid type compound conforming to ASTM C309, Type 1, clear, Type 1D with fugitive dye for interior work and Type 2, white, pigmented for exterior work.

2.4 MATERIALS

2.4.1 Cement

****

NOTE: Acceptable types of cement are as follows:

ASTM C150/C150M Portland	**ASTM C595/C595M Blended**	**Use**
Type I	**Type IP or IS**	**For general use in construction.**

ASTM C150/C150M Portland	ASTM C595/C595M Blended	Use
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 C595/C595M (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.

Modify paragraph and specify either 50 percent Type II, IP(MS) or IS(MS) cement with 50 percent ground granulated 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 height or within a horizontal distance of 3000 mm 10 feet. Require cement to meet chemical requirements of ASTM C150/C150M, 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 NAVFA LANT: 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 01 62 35 RECYCLED/RECOVERED MATERIALS and include additive options unless designer determines that justification for non-use exists.

ASTM C150/C150M, Type [I or II] [_____] or ASTM C595/C595M, Type [IP(MS) or IS(MS)] [IP(MH)] [IS(MH)] [_____] blended cement except as modified herein. Provide blended cement that consists of a mixture of ASTM C150/C150M, Type II, cement and one of the following materials: ASTM C618 pozzolan or fly ash, ASTM C989/C989M ground granulated blast-furnace slag. For portland cement manufactured in a kiln fueled by hazardous waste, maintain a record of source for each batch.[Supplier must certify that no hazardous waste is used in the fuel mix or raw materials.][Supplier must 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 C618, should provide acceptable end results. It is suggested that Type C fly ash be used as a replacement for 35 percent of the cement. It is suggested that Type F fly ash be used as a replacement for 25 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 C618, Type N, F, or C, except that the maximum allowable loss on ignition must be 6 percent for Types N and F. Add with cement. Fly ash content must 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 permittable that meets the code requirements for cement content. Report the chemical analysis of the fly ash in accordance with ASTM C311. Evaluate and classify fly ash in accordance with ASTM D5759.

High contents of supplementary cementitious materials can have some detrimental effects on the concrete properties, such as slowing excessively the strength gain rate, and delaying and increasing the difficulty of finishing. The recommended maximum content (by weight of the total cementitious material) for these materials are:

1. For GGBF slag: 50 percent

2. For fly ash or natural pozzolan: 40 percent (25 percent in cold climates)

3. For silica fume: 10 percent

2.4.1.2 Ground Granulated Blast-Furnace Slag

ASTM C989/C989M, Grade [80] [100] [120]. Slag content must 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 must 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 without reducing strength. Finishing may be more difficult. Proper curing is essential because there is a tendency for plastic shrinkage cracking.
****

ASTM C1240, 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.

]2.4.1.4 Portland Cement

****
NOTE: If high early strength concrete is required, specify Type III.

When concrete is exposed to sea water, specify Type V.

****

Provide cement that conforms to ASTM C150/C150M, Type I, IA, II, or IIA. Use one brand and type of cement for formed concrete having exposed-to-view finished surfaces.

2.4.2 Water

Minimize the amount of water in the mix. The amount of water must not exceed 45 percent by weight of cementitious materials (cement plus pozzolans), and in general, improve workability by adjusting the grading rather than by adding water. Water must be fresh, clean, and [potable][from rainwater collection][from graywater][from recycled water]; 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, or when the use of alkali-reactive aggregates is permitted.

When the use of alkali-reactive aggregates is permitted, add the following in front of the first bracket, and add the 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:

1. ASTM C150/C150M low alkali cement (Table 1A, maximum of 0.60 percent equivalent Na2O).

2. ASTM C595/C595M blended cement.

3. ASTM C150 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. Aggregates must meet the following requirements."

When using Alkali-Reactive Aggregates, follow curing requirements detailed in the Note in Section 3.11.

****

****

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. Note that the use of glass can result in deleterious expansion unless it is ground very fine. Very fine glass could classify as a pozzolan under ASTM C618.

****

ASTM C33/C33M, except as modified herein. Furnish aggregates for exposed concrete surfaces from one source. Provide aggregates that do not contain any substance which may be deleteriously reactive with the alkalies in the cement.

[Fine and coarse aggregates must show expansions less than 0.08 percent at 16 days after casting when testing in accordance with ASTM C1260. Should the test data indicate an expansion of 0.08 percent or greater, reject the aggregate(s) or perform additional testing using ASTM C1567 using the Contractor's proposed mix design. In this case, include the mix design low alkali portland cement and one of the following supplementary cementitious materials:

1. GGBF slag at a minimum of 40 percent of total cementitious

2. Fly ash or natural pozzolan at a minimum of total cementitious of
   a. 30 percent if (SiO_2 plus Al_2O_3 plus Fe_2O_3) is 65 percent or more,
   b. 25 percent if (SiO_2 plus Al_2O_3 plus Fe_2O_3) is 70 percent or more,
   c. 20 percent if (SiO_2 plus Al_2O_3 plus Fe_2O_3) is 80 percent or more,
   d. 15 percent if (SiO_2 plus Al_2O_3 plus Fe_2O_3) is 90 percent or more.

3. [Silica fume at a minimum of 7 percent of total cementitious.]

If a combination of these materials is chosen, the minimum amount must be a linear combination of the minimum amounts above. Include these materials in sufficient proportion to show less than 0.08 percent expansion at 16 days after casting when tested in accordance with ASTM C1567.

Aggregates must not possess properties or constituents that are known to have specific unfavorable effects in concrete when tested in accordance with ASTM C295/C295M.]

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

****

NOTE: Where floor slab flatness and curling and shrinkage presents 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 C33/C33M, uniformly graded and as follows: Nominal maximum aggregate size of 25 mm 1 inch. A combined sieve analysis must 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). Provide sand that is at least 50 percent natural sand.

][2.4.3.2 Aggregates for Lightweight Concrete

ASTM C330/C330M.

][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 C1107/C1107M.

2.4.5 Admixtures

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

ASTM C494/C494M: 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. Do not use to enhance workability.
****

ASTM C260/C260M.

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

ASTM C494/C494M, Type F [and Type G (HRWR retarding admixture)] and ASTM C1017/C1017M.[Silica fume and HRWR must come from the same manufacturer.]

2.4.5.3 Pozzolan

Provide fly ash or other pozzolans used as admixtures that conform to ASTM C618.

2.4.6 Vapor Retarder[and 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 E1745 Class A polyethylene sheeting, minimum [0.25] mm [10] mil thickness or other equivalent material.

][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 C171, 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 apart.

Consider plastic vapor retarders and adhesives with a high recycled content, low toxicity low VOC (Volatile Organic Compounds) levels.

]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.]

Consider the use of water based or vegetable or soy based curing agents in lieu of petroleum based products. Consider agents that are not toxic and emit low or no Volatile Organic Compounds (VOC). Consider the use of admixtures that offer high performance to increase durability of the finish product but also have low toxicity and are made from bio-based materials such as soy, and emit low levels of Volatile Organic Compounds (VOC).

2.4.7.1 Impervious Sheeting

ASTM C171; 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 C309, white-pigmented, Type 2, Class B.

2.4.8 Liquid Chemical Sealer-Hardener Compound

Provide surface treatments containing certain chemicals, including sodium silicate and the fluosilicates of magnesium and zinc. Provide compound that does 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 D1751, ASTM D1752, cork or 100 percent post-consumer paper meeting ASTM D1752 (subparagraphs 5.1 to 5.4). Material must be 13 mm 1/2 inch thick[, unless otherwise indicated].

2.4.9.1 Preformed Joint Filler Strips

****
NOTE: Bituminous joint fillers are suitable for use with hot-applied elastic or cold-applied mastic joint sealing compound; nonbituminous joint fillers are preferred for use with cold-applied elastomeric polymer sealing compound.
****

[Provide nonextruding and resilient bituminous type filler strips conforming to ASTM D1751.

][Provide nonextruding and resilient nonbituminous type filler strips conforming to ASTM D1752, Type I or II.

]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

ASTM D6690 or ASTM C920, Type M, Class 25, Use T. ASTM D7116 for surfaces subjected to jet fuel.

2.4.10.2 Vertical Surfaces Greater Than 3 Percent Slope

****
NOTE: Specify ASTM C920 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 C920, Type M, Grade NS, Class 25, Use T.[FS SS-S-200, no sag].

2.4.10.3 Waterstops

[Provide waterstops that are flat dumbbell type, not less than 5 mm 3/16 inch for widths up to 125 mm 5 inches, and not less than 10 mm 3/8 inch for widths 125 mm 5 inches and over.]

[Provide waterstops made of rubber and that conform to ASTM D1752.]

[Provide waterstops made of polyvinylchloride (PVC) and that conform to [ASTM C990M ASTM C990] [ASTM D2628].]

2.4.10.4 Joint Sealant Compound

****

NOTE: Cold-applied mastic type and hot-applied elastic type sealing compounds are suitable for locations subject to light foot traffic only. After curing both types of sealing compound have equal physical properties. Cold-applied mastic type costs less.

Cold-applied, two-component elastomeric polymer type sealing compound is suitable for locations subject to moderate foot traffic and pneumatic tire wheeled traffic.

****

[Provide hot-poured, elastic type compound conforming to ASTM D6690.]

[Provide cold-applied, two-component, elastomeric polymer type compound conforming to FS SS-S-200.]

2.4.11 Epoxy Bonding Compound

ASTM C881/C881M. 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; Class B if placement temperature is between 4 and 16 degrees C 40 and 60 degrees F; or Class C if placement temperature is above 16 degrees C 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 ensures that items composed of biobased products are be purchased to the maximum extent practicable and which is consistent with applicable provisions of Federal procurement law.

****

Provide form release agent that is colorless, biodegradable, and [rapeseed oil-based] [soy oil-based] [water-based], with a [low (maximum of 55 grams/liter (g/l))] [zero] VOC content. [A minimum of [85] [_____] percent of the total product must be biobased material.]Provide product that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces. Provide form release agent that does not contain diesel fuel, petroleum-based lubricating oils, waxes, or kerosene.

]2.5 REINFORCEMENT

[Galvanize bars, fabrics, connectors, and chairs.]

2.5.1 Reinforcing Bars

****
NOTE: ASTM A706/A706M bars are mainly used in seismic design or for welding. Include ASTM A123/A123M 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/MCP-2 unless otherwise specified. [Use deformed steel.] ASTM A615/A615M and AASHTO M 322M/M 322 with the bars marked A, S, W, Grade [300][420][520] [40][60][75]; or ASTM A996/A996M with the bars marked R, Grade [350][420] [50][60], or marked A, Grade [300][420] [40][60]. [ASTM A706/A706M.] [Galvanized, ASTM A123/A123M.][Zinc-coated (galvanized) bars, ASTM A767/A767M and ASTM A780/A780M.] [Epoxy-coated reinforcing steel bars, ASTM A775/A775M.] [Epoxy-coated prefabricated steel reinforcing bars, ASTM A934/A934M.] [Provide reinforcing bars that 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.]

2.5.1.1 Galvanized Reinforcing Bars

Provide galvanized reinforcing bars that conform to ASTM A767/A767M, Class II with galvanizing before fabrication.

****
NOTE: Galvanizing after fabrication may be specified, but larger bend diameters are required. Class I may be specified if heavier galvanizing is needed.
****

2.5.1.2 Weldable Reinforcing Bars

Provide weldable reinforcing bars that conform to ASTM A706/A706M and ASTM A615/A615M and Supplement S1, Grade 60, except that the maximum carbon content must be 0.55 percent.

2.5.1.3 Epoxy-Coated Reinforcing Bars

Provide epoxy-coated reinforcing bars that conform to ASTM A775/A775M, Grade 40 or Grade 60.

2.5.2 Mechanical Reinforcing Bar Connectors

ACI/MCP-2. Provide 125 percent minimum yield strength of the reinforcement bar.

2.5.3 Wire

ASTM A82/A82M or ASTM A496/A496M.

2.5.3.1 Welded Wire Fabric

ASTM A185/A185M or ASTM A497/A497M. [Provide fabric that contains 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.

2.5.3.2 Steel Wire

Wire must conform to ASTM A82/A82M.

2.5.4 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.]

2.5.5 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 does 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, provide fiber reinforced concrete in accordance with ASTM C1116/C1116M Type III, synthetic fiber reinforced concrete, and as follows. Synthetic reinforcing fibers must 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.] Provide fibers that have a specific gravity of 0.9, a minimum tensile strength of 480 MPa 70 ksi, graded per manufacturer, and specifically manufactured to an optimum gradation for use as concrete secondary reinforcement. Use a minimum of 0.9 kg of fibers per cubic meter 1.5 pounds of fibers per cubic yard of concrete. Add fibers at the batch

plant. [Toughness indices must 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.]

2.5.6 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.]

2.5.7 Dowels for Load Transfer in Floors

Provide dowels for load transfer in floors of the type, design, weight, and dimensions indicated. Provide dowel bars that are plain-billet steel conforming to ASTM A615/A615M, Grade 40. Provide dowel pipe that is steel conforming to ASTM A53/A53M.

2.5.8 Supports for Reinforcement

Supports include bolsters, chairs, spacers, and other devices necessary for proper spacing, supporting, and fastening reinforcing bars and wire fabric in place.

Provide wire bar type supports conforming to ACI/MCP-3, ACI/MCP-4 and CRSI 10MSP.

****
NOTE: Supports must be coated when using epoxy-coated reinforcing bars.
****

Legs of supports in contact with formwork must be hot-dip galvanized, or plastic coated after fabrication, or stainless-steel bar supports.

2.6 BONDING MATERIALS

2.6.1 Concrete Bonding Agent

Provide aqueous-phase, film-forming, nonoxidizing, freeze and thaw-resistant compound agent suitable for brush or spray application conforming to ASTM C932.

2.6.2 Epoxy-Resin Adhesive Binder

Provide two-component, epoxy-polysulfide polymer type binder with an amine-type curing-agent conforming to ASTM C881/C881M.

2.7 FLOOR FINISH MATERIALS

2.7.1 Liquid Chemical Floor Hardener

Hardener must be a colorless aqueous solution containing a blend of magnesium fluorosilicate and zinc fluorosilicate combined with a wetting agent. Solution must contain not less than 240 gram 1/2 pounds of fluorosilicates per liter gallon. An approved proprietary chemical hardener may be used provided hardener is delivered ready for use in

manufacturer's original containers.

2.7.2 Abrasive Aggregate for Nonslip Aggregate Finish

****
NOTE: When abrasive aggregate is required, delete one of the following two paragraphs as required. Aluminum oxide and emery abrasive grits are blackish-gray and nonsparkling; silicon carbide abrasive grits are black and sparkling.
****

[Aggregate must be packaged, factory-graded fused aluminum oxide grits, or it may be crushed emery containing not less than 40-percent aluminum oxide and not less than 25-percent ferric oxide. Aggregate must be rust proof and nonglazing and must be unaffected by freezing, moisture, and cleaning materials.]

[Aggregate must be packaged, factory-graded, silicon carbide grits. Aggregate must be rust proof and must be unaffected by freezing, moisture, and cleaning materials.]

[Aggregate must be well-graded in size from particles retained on 600 micrometer sieve No. 30 sieve (0.0236 inch) to particles passing 2.36 mm sieve No. 8 sieve (0.0929 inch).]

2.7.3 Dry Materials for Colored Wear-Resistant Finish

****
NOTE: When color must be indicated, available colors are natural, bright red, dark red, terra cotta, green, and gray.
****

[Provide materials that are packaged, dry, and a combination of materials formulated for producing colored and wear-resistant monolithic surface treatments; they must include portland cement, graded-quartz aggregate, coloring pigments, and dispersing agents. Provide coloring pigments that are finely ground, nonfacing mineral oxides prepared especially for the purpose and interground with the cement.]

2.7.4 Aggregate for Heavy-Duty Wear-Resistant Finish

****
NOTE: When heavy-duty, wear-resistant finish is required, delete first paragraph. Delete following paragraphs when mineral aggregate is not required. Delete second paragraph when iron aggregate is not required.
****

[Provide aggregate that is traprock or emery, as follows:

Traprock must be packaged, crushed, natural, fine-to-medium-grained, igneous rock, such as diabase, basalt, or black granite. Traprock aggregate must be well-graded in size from particles retained on 4.75 mm sieve No. 4 sieve (0.187 inch) to particles passing 9.5 mm 3/8-inch sieve.

Emery must be packaged, factory-graded, crushed, natural-emery ore, cubical or polyhedral in form, containing not less than 35-percent aluminum oxide and not less than 24-percent ferric oxide. Emery aggregate must be well graded in size from particles retained on 300 micrometer sieve No. 50 sieve (0.0118 inch) to particles passing 2.36 mm sieve No. 8 sieve (0.0929 inch).

Provide iron aggregate, as follows:

Iron must be packaged, ground and graded cubicle iron particles with dispersing agents, formulated to blend with portland cement for producing wear-resistant monolithic surface treatments. Provide aggregate that is free of nonferrous metals, oil, grease, soluble alkaline compounds, rust, and impurities and must be well-graded in size from particles retained on 300 micrometer sieve No. 50 sieve (0.0118 inch) to particles passing 2.36 mm sieve No. 8 sieve (0.0929 inch).]

2.7.5 Aggregate for Heavy-Duty Floor Topping

Provide emery (or may be traprock or traprock-screenings) fine aggregates, as specified.

Provide emery that is packaged, factory-graded, crushed natural emery ore containing not less than 35-percent aluminum oxide and not less than 24-percent ferric oxide. Provide aggregate that is cubical or polyhedral in form and does not change its physical or chemical nature in the presence of moisture. Grade aggregate to a fineness modulus of 3.9 to 4.0, with 100 percent passing 9.5 mm 3/8-inch sieve and not less than 95 percent retained on 150 micrometer No. 100 sieve. Deliver emery in moisture-resistant bags.

Provide traprock that is packaged, crushed, natural, fine- to medium-grained igneous rock such as diabase, basalt, or black granite. Uniformly grade coarse aggregate with 100 percent passing 12.5 mm 1/2-inch sieve, 30 to 50 percent passing 9.5 mm 3/8-inch sieve, 0 to 15 percent passing 4.75 mm No. 4 sieve, and 0 to 5 percent passing 2.36 mm No. 8 sieve.

Provide fine aggregate using traprock that conforms to ASTM C33/C33M, except gradation. Grade fine aggregate within the following limits:

SIEVE	PERCENT PASSING
9.5 mm 3/8 in.	100
4.75 mm No. 4	95 to 100
2.36 mm No. 8	65 to 80
1.18 mm No. 16	45 to 65
600 micrometer No. 30	25 to 45
300 micrometer No. 50	5 to 15
150 micrometer No. 100	0 to 5

Deliver traprock coarse aggregate and fine aggregate in moisture-resistant bags.

2.8 CLASSIFICATION AND QUALITY OF CONCRETE

2.8.1 Concrete Classes and Usage

****
NOTE: Delete following concrete classes and usages that are not required.
****

Provide concrete classes, compressive strength, requirements for air entrainment, and usage as follows:

CONCRETE CLASS	MIN. 28-DAY COMPRESSIVE STRENGTH POUNDS PER MEGA pascal POUNDS PER SQ. IN.	REQUIREMENT FOR AIR ENTRAINMENT	USAGE
3a	20 3000	Air-entrained	For foundation concrete work exposed to freezing and thawing or subjected to hydraulic pressure, such as foundation walls, grade beams, pits, tunnels. For exterior concrete slabs, such as steps, platforms, walks
3N	20 3000	Nonair-entrained	For foundation concrete work not exposed to freezing and thawing or subjected to hydraulic pressure, such as footings, pile caps, foundation mats. For interior slabs on ground to be covered with resilient flooring
4A	27.6 4000	Air-entrained	For structural concrete work exposed to freezing and thawing, unless otherwise indicated or specified, such as exterior columns and spandrels
4N	27.6 4000	Nonair-entrained	For structural concrete work not exposed to freezing and thawing such as interior columns, beams, supported slabs and other structural members for interior slabs on ground subjected to foot traffic

CONCRETE CLASS	MIN. 28-DAY COMPRESSIVE STRENGTH POUNDS PER MEGA pascal POUNDS PER SQ. IN.	REQUIREMENT FOR AIR ENTRAINMENT	USAGE
2.5A	17.2 2500	Air-entrained	For concrete not reinforced and not exposed to freezing and thawing
2.5N	17.2 2500	Nonair-entrained	For concrete not reinforced and not exposed to freezing and thawing
5A	34.5 5000	Air-entrained	For structural concrete work as indicated
5N	34.5 5000	Nonair-entrained	For structural concrete work as indicated

2.8.2 Limits for Concrete Proportions

****
NOTE: Delete following concrete classes that are not required. Utilize ACI/MCP 306, ACI 318 and and ACI A211.1.
****

Provide limits for maximum water/cement ratio and minimum cement content for each concrete class as follows:

CONCRETE CLASS	MAX. WATER/CEMENT RATIO BY WEIGHT	MIN. CEMENT FOR 75 TO 100 MM 3-TO 4-INCH SLUMP, (NO. OF 43 KILOGRAM 94-POUND SACKS) PER .75 CU. METER CU. YD.
2.5A	0.58	4.75
2.5N	0.62	4.75
3A	0.50	5.25
3N	0.54	5.25
4A	0.46	6.0
4N	0.48	6.0

CONCRETE CLASS	MAX. WATER/CEMENT RATIO BY WEIGHT	MIN. CEMENT FOR 75 TO 100 MM 3-TO 4-INCH SLUMP, (NO. OF 43 KILOGRAM 94-POUND SACKS) PER .75 CU. METER CU. YD.
5A	0.41	6.5
5N	0.44	6.5
* Weight of water to weight of cement in pounds in one cubic yard of concrete.		

2.8.3 Maximum Size of Aggregate

****
NOTE: Delete following maximum size of aggregate and type of construction that are not required. Utilize ACI 318.
****

Size of aggregate, designated by the sieve size on which maximum amount of retained coarse aggregate is 5 to 10 percent by weight, must be as follows:

MAXIMUM SIZE OF AGGREGATE	ASTM C33/C33M SIZE NUMBER	TYPE OF CONSTRUCTION
50.8 mm 2 inches	357	Nonreinforced footings and other flat work having a depth of not less than 150 mm 6 inches, and nonreinforced walls and other formed sections having a dimension between forms of not less than 250 mm 10 inches
38.1 mm 1-1/2 inches	467	Monolithic slabs on ground, concrete fill, and other flatwork having a depth of not less than 125 mm 5 inches and a clear distance between reinforcing bars of not less than 50 mm 2 inches

19.1 mm 3/4 inch	67	Reinforced walls, columns, girders, beams, and other formed sections having a dimension between forms of not less than 150 mm 6 inches and clear distance between reinforcing bars or reinforcing bar and face of form of not less than 25 mm 1 inch
19.1 mm 3/4 inch	67	Monolithic concrete slabs and other flatwork having a depth of not less than 65 mm 2-1/2 inches and a clear distance between reinforcing bars of not less than 25 mm 1 inch
12.7 mm 1/2 inch	7	Concrete joist construction, beams, reinforced walls, and other formed work having a clear distance between reinforcing bars and face of form of less than 25 mm 1 inch
9.5mm 3/8 inch	8	Nonreinforced slabs and other flatwork having a depth of less than 65 mm 2-1/2 inches

Maximum size of aggregate may be that required for most critical type of construction using that concrete class.

Specify gradation of aggregates for separate floor topping.

2.8.4 Slump

Provide slump for concrete at time and in location of placement as follows:

TYPE OF CONSTRUCTION	SLUMP
Footings, unreinforced walls	Not less than 25 millimeter 1 inch nor more than 75 millimeter 3 inches
Columns, beams, reinforced walls, monolithic slabs	Not less than 25 millimeter 1 inch nor more than 100 millimeter 4 inches
Ramps and other sloping surfaces	0 nor more than 75 millimeter 3 inches

2.8.5 Total Air Content

Air content of exposed concrete and interior concrete must be in accordance with ASTM C260/C260M and/or as follows:

LIMITS OF CONCRETE EXPOSURE	REQUIREMENT FOR AIR ENTRAINMENT	MAXIMUM SIZE OF AGGREGATE	TOTAL AIR CONTENT BY VOLUME
Exposed to freezing and thawing or subjected to hydraulic pressure	Air-entrained	38.1 or 69.9 mm 1-1/2 or 2 inches	4 to 6 percent
		19 mm 3/4 inch	5 to 7 percent
		12.7 or 9.5 mm 1/2 or 3/8 inch	6 to 8.5 percent

Provide concrete exposed to freezing and thawing or subjected to hydraulic pressure that is air-entrained by addition of approved air-entraining admixture to concrete mix.

PART 3 EXECUTION

3.1 EXAMINATION

Do not begin installation until substrates have been properly constructed; verify that substrates are plumb and true.

If substrate preparation is the responsibility of another installer, notify Architect/Engineer of unsatisfactory preparation before processing.

Check field dimensions before beginning installation. If dimensions vary too much from design dimensions for proper installation, notify Architect/Engineer and wait for instructions before beginning installation.

3.2 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.

3.2.1 General

Surfaces against which concrete is to be placed must be free of debris, loose material, standing water, snow, ice, and other deleterious substances before start of concrete placing.

Remove standing water without washing over freshly deposited concrete. Divert flow of water through side drains provided for such purpose.

3.2.2 Subgrade Under Foundations and Footings

When subgrade material is semiporous and dry, sprinkle subgrade surface with water as required to eliminate suction at the time concrete is deposited. When subgrade material is porous, seal subgrade surface by covering surface with specified vapor retarder; this may also be used over semiporous, dry subgrade material instead of water sprinkling.

3.2.3 Subgrade Under Slabs on Ground

Before construction of slabs on ground, have underground work on pipes and conduits completed and approved.

Previously constructed subgrade or fill must be cleaned of foreign materials and inspected by the Contractor for adequate compaction and surface tolerances as specified.

Actual density of top 300 mm 12 inches of subgrade soil material-in-place must not be less than the following percentages of maximum density of same soil material compacted at optimum moisture content in accordance with ASTM D1557.

SOIL MATERIAL	PERCENT MAXIMUM DENSITY
Capillary water barrier	100
Cohesionless soil material	100
Cohesive soil material	95

Finish surface of capillary water barrier under interior slabs on ground must not show deviation in excess of 6.4 mm 1/4 inch when tested with a 3000 mm 10-foot straightedge parallel with and at right angles to building lines.

Finished surface of subgrade or fill under exterior slabs on ground must not be more than 6.10 mm 0.02-foot above or 30.50 mm 0.10-foot below elevation indicated.

Prepare subgrade or fill surface under exterior slabs on ground as specified for subgrade under foundations and footings.

3.2.4 Formwork

Complete and approve formwork. Remove debris and foreign material from interior of forms before start of concrete placing.

3.2.5 Edge Forms and Screed Strips for Slabs

Set edge forms or bulkheads and intermediate screed strips for slabs to obtain indicated elevations and contours in finished slab surface and must be strong enough to support vibrating bridge screeds or roller pipe screeds if nature of specified slab finish requires use of such equipment. Align concrete surface to elevation of screed strips by use of strike-off templates or approved compacting-type screeds.

3.2.6 Reinforcement and Other Embedded Items

Secure reinforcement, joint materials, and other embedded materials in position, inspected, and approved before start of concrete placing.

3.3 FORMS

ACI/MCP-2. 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 unless otherwise indicated. Provide formwork with clean-out openings to permit inspection and removal of debris. Forms submerged in water must be watertight.

3.3.1 General

Construct forms to conform, within the tolerances specified, to shapes dimensions, lines, elevations, and positions of cast-in-place concrete members as indicated. Forms must be supported, braced, and maintained sufficiently rigid to prevent deformation under load.

3.3.2 Design and Construction of Formwork

Provide formwork design and construction that conforms to ACI/MCP-2, Chapter 4.

Provide forms that are tight to prevent leakage of cement paste during concrete placing.

Support form facing materials by structural members spaced close to prevent deflection of form facing material. Fit forms placed in successive units for continuous surfaces to accurate alignment to ensure a smooth completed surface within the tolerances specified. Where necessary to maintain the tolerances specified, such as long spans where immediate supports are not possible, camber formwork for anticipated deflections in formwork due to weight and pressure of fresh concrete and to construction loads.

Chamfer exposed joints, edges, and external corners a minimum of 19 mm 3/4 inch by moldings placed in corners of column, beam, and wall forms.

Provide shores and struts with a positive means of adjustment capable of taking up formwork settlement during concrete placing operations. Obtain adjustment with wedges or jacks or a combination thereof. When adequate foundations for shores and struts cannot be secured, provide trussed supports.

Provide temporary openings in wall forms, column forms, and at other points where necessary to permit inspection and to facilitate cleaning.

Provide forms that are readily removable without impact, shock, or damage to concrete.

3.3.3 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.

3.3.4 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, reshore slabs and beams over 3000 mm 10 feet in span and cantilevers over 1200 mm 4 feet 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. Provide reshoring elements with the same load-carrying capabilities as original shoring and spaced similar to original shoring. Firmly secure and brace reshoring elements to provide solid bearing and support.

3.3.5 Reuse

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

3.3.6 Forms for Standard Rough Form Finish

Give rough form finish concrete formed surfaces that are to be concealed by other construction, unless otherwise specified.

Form facing material for standard rough form finish must be the specified concrete form plywood or other approved form facing material that produces concrete surfaces equivalent in smoothness and appearance to that produced by new concrete form plywood panels.

For concrete surfaces exposed only to the ground, undressed, square-edge, 25 mm 1-inch nominal thickness lumber may be used. Provide horizontal joints that are level and vertical joints that are plumb.

3.3.7 Forms for Standard Smooth Form Finish

****
NOTE: When exposed to view, formed surfaces require a special architectural finish such as textured form finishes, sculptured inserts, special panel finish, and aggregate transfer finish. Requirements for such formwork must be specified.
****

Give smooth form finish concrete formed surfaces that are to be exposed to view or that are to be covered with coating material applied directly to concrete or with covering material bonded to concrete, such as waterproofing, dampproofing, painting, or other similar coating system.

Form facing material for standard smooth finish must be the specified overlaid concrete form plywood or other approved form facing material that is nonreactive with concrete and that produce concrete surfaces equivalent in smoothness and appearance to that produced by new overlaid concrete form plywood panels.

Maximum deflection of form facing material between supports and maximum deflection of form supports such as studs and wales must not exceed 0.0025 times the span.

Provide arrangement of form facing sheets that are orderly and symmetrical, and sheets that are in sizes as large as practical.

Arrange panels to make a symmetrical pattern of joints. Horizontal and vertical joints must be solidly backed and butted tight to prevent leakage and fins.

3.3.8 Form Ties

Provide ties that are factory fabricated metal, adjustable in length, removable or snap-off type that do allow form deflection or do not spall concrete upon removal. Portion of form ties remaining within concrete after removal of exterior parts must be at least 38 mm 1-1/2 inches back from concrete surface. Provide form ties that are free of devices that

leave a hole larger than 22 mm 7/8 inch or less than 13 mm 1/2 inch in diameter in concrete surface. Form ties fabricated at the project site or wire ties of any type are not acceptable.

3.3.9 Forms for Concrete Pan Joist Construction

[Provide forms that are well-fitting, undamaged, factory-fabricated pan form units for concrete joist construction as indicated.

Form units complete with covers and end closures as required for the installation must be one of the following materials:

Steel, 1.6 mm 16-gage, free from irregularities, dents, sag, and rust

Hardboard conforming to ACI/MCP-3 and ACI/MCP-4

Glass-fiber-reinforced plastic, molded under pressure, with matched dies, 2.8 mm 0.11-inch maximum wall thickness

Asphalt-impregnated, corrugated material treated for moisture resistance with factory-applied polyethylene coating, with top and side cover joints taped where concrete is exposed.

Provide tight forms for concrete pan joist construction to prevent cement paste loss during concrete placing and to form a true, clean, smooth surface, free of honeycomb and rough exposed-aggregate areas. Take precautions, including blocking of adjoining pan units, to avoid lateral deflection of formwork during compaction of concrete.]

3.3.10 Tolerances for Form Construction

Construct formwork to ensure that after removal of forms and prior to patching and finishing of formed surfaces, provide concrete surfaces in accordance with tolerances specified in ACI/MCP-1 and ACI/MCP-2.

3.3.11 Removal of Forms and Supports

After placing concrete, forms must remain in place for the time periods specified in ACI/MCP-4. Do not remove forms and shores (except those used for slabs on grade and slip forms) until the client determines that the concrete has gained sufficient strength to support its weight and superimposed loads. Base such determination on compliance with one of the following:

a. The plans and specifications stipulate conditions for removal of forms and shores, and such conditions have been followed, or

b. The concrete has been properly tested with an appropriate ASTM standard test method designed to indicate the concrete compressive strength, and the test results indicate that the concrete has gained sufficient strength to support its weight and superimposed loads.

Prevent concrete damage during form removal. Clean all forms immediately after removal.

3.3.11.1 Special Requirements for Reduced Time Period

Forms may be removed earlier than specified if ASTM C39/C39M 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.

3.4 WATERSTOP SPLICES

Fusion weld in the field.

3.5 FORMED SURFACES

3.5.1 Preparation of Form Surfaces

Coat contact surfaces of forms with form-coating compound before reinforcement is placed. Provide a commercial formulation form-coating compound that does not bond with, stain, nor adversely affect concrete surfaces and impair subsequent treatment of concrete surfaces that entails bonding or adhesion nor impede wetting of surfaces to be cured with water or curing compounds. Do not allow excess form-coating compound to stand in puddles in the forms nor to come in contact with concrete against which fresh concrete is placed. Make thinning of form-coating compound with thinning agent of the type, in the amount, and under the conditions recommended by form-coating compound manufacturer's printed or written directions.

3.5.2 Tolerances

ACI/MCP-4 and as indicated.

3.5.3 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. Do not use material with raised grain, torn surfaces, worn edges, patches, dents, or other defects which can impair the texture of the concrete surface.

3.6 PLACING REINFORCEMENT AND MISCELLANEOUS MATERIALS

ACI/MCP-2. Provide bars, wire fabric, wire ties, supports, and other devices necessary to install and secure reinforcement. Reinforcement must 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.

3.6.1 General

Provide details of reinforcement that are in accordance with ACI/MCP-3 and ACI/MCP-4 and as specified.

3.6.2 Vapor Retarder [and 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 inches [and tape or cement joints]. Remove torn, punctured, or damaged vapor retarder [and vapor barrier] material and provide with new vapor retarder [and vapor barrier] prior to placing concrete. Concrete placement must not damage vapor retarder [and vapor barrier material]. [Place a 50 mm 2 inch layer of clean concrete sand on vapor retarder [and vapor barrier] before placing concrete.]

3.6.3 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 A934/A934M.][ASTM A775/A775M.][Rest epoxy-coated reinforcing bars supported from formwork on coated wire bar supports, or on bar supports made of dielectric material or other acceptable material. Coat wire bar supports with dielectric material, compatible with concrete, for a minimum distance of 50 mm 2 inches from the point of contact with the epoxy-coated reinforcing bars. Reinforcing bars used as support bars must be epoxy coated. Spreader bars, where used, must be epoxy coated. Make proprietary combination bar clips and spreaders used in construction with epoxy-coated reinforcing bars corrosion resistant or coated with dielectric material. Tie epoxy-coated bars with plastic-coated tie wire; or other materials acceptable to the Contracting Officer.]

[3.6.4 Epoxy Coated Reinforcing

Epoxy Coated Reinforcing must meet the requirements of [ASTM A934/A934M including Appendix X2,][ASTM A775/A775M including Appendix X1,] "Guidelines for Job Site Practices" except as otherwise specified herein.

3.6.4.1 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, are completely free of damaged areas; however, excessive nicks and scrapes which expose steel is 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, manually remove any rust and debonded coating from the reinforcement by suitable techniques employing devices such as wire brushes and emery paper. Exercise cars during this surface preparation so that the damaged areas are not enlarged more than necessary to accomplish the repair. Clean damaged areas of dirt, debris, oil, and similar materials prior to application of the patching material.

b. Do repair and patching in accordance with the patching material manufacturer's recommendations. These recommendations, including cure times, must 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.]

]3.6.5 Splicing

****
NOTE: When indicated, include ASTM A767/A767M and ASTM A780/A780M for zinc-coated (galvanized) bars.
****

As indicated. For splices not indicated ACI/MCP-2. Do not splice at points of maximum stress. Overlap welded wire fabric the spacing of the cross wires, plus 50 mm 2 inches. [AWS D1.4/D1.4M. Approve welded splices prior to use.] [Repair the cut ends of hot-dipped galvanized reinforcement steel to completely coat exposed steel, ASTM A780/A780M.]

3.6.6 Future Bonding

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

3.6.7 Cover

****
NOTE: Consult designer to verify that cover requirements of ACI/MCP-2 are adequate. ACI 201.2R and ACI 303R require additional cover for severe exposure conditions. Unless otherwise directed, specify 75 mm 3 inch cover where exposed to seawater.
****

ACI/MCP-2 for minimum coverage, unless otherwise indicated.

3.6.8 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.

3.6.9 Construction Joints

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

3.6.10 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 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. Complete saw joints within 4 to 12 hours after concrete placement. Protect joints from intrusion of foreign matter.

3.6.11 Fabrication

Shop fabricate reinforcing bars to conform to shapes and dimensions indicated for reinforcement, and as follows:

Provide fabrication tolerances that are in accordance with ACI/MCP-1, ACI/MCP-2 and ACI/MCP-3.

Provide hooks and bends that are in accordance with ACI/MCP-3 and ACI/MCP-4.

Reinforcement must be bent cold to shapes as indicated. Bending must be done in the shop. Rebending of a reinforcing bar that has been bent incorrectly is not be permitted. Bending must be in accordance with standard approved practice and by approved machine methods.

Tolerance on nominally square-cut, reinforcing bar ends must be in accordance with ACI/MCP-3.

Deliver reinforcing bars bundled, tagged, and marked. Tags must be metal with bar size, length, mark, and other information pressed in by machine. Marks must correspond with those used on the placing drawings.

Do not use reinforcement that has any of the following defects:

a. Bar lengths, depths, and bends beyond specified fabrication tolerances

b. Bends or kinks not indicated on drawings or approved shop drawings

c. Bars with reduced cross-section due to rusting or other cause

Replace defective reinforcement with new reinforcement having required shape, form, and cross-section area.

3.6.12 Placing Reinforcement

Place reinforcement in accordance with ACI/MCP-3 and ACI/MCP-4.

For slabs on grade (over earth or over capillary water barrier) and for footing reinforcement, support bars or welded wire fabric on precast concrete blocks, spaced at intervals required by size of reinforcement, to keep reinforcement the minimum height specified above the underside of slab or footing.

For slabs other than on grade, supports for which any portion is less than 25 mm 1 inch from concrete surfaces that are exposed to view or to be painted must be of precast concrete units, plastic-coated steel, or stainless steel protected bar supports. Precast concrete units must be wedge shaped, not larger than 90 by 90 mm, 3-1/2 by 3-1/2 inches, and of thickness equal to that indicated for concrete protection of reinforcement. Provide precast units that have cast-in galvanized tie wire hooked for anchorage and blend with concrete surfaces after finishing is

completed.

Contractor must cooperate with other trades in setting of anchor bolts, inserts, and other embedded items. Where conflicts occur between locating reinforcing and embedded items, the Contractor must notify the Contracting Officer so that conflicts may be reconciled before placing concrete. Anchors and embedded items must be positioned and supported with appropriate accessories.

****
NOTE: Include the following paragraph when epoxy-coated reinforcing bars are specified.
****

Handle epoxy-coated reinforcing bars carefully to prevent damage to the coating. Use plastic-coated tie wire and supports of a type to prevent damage to the reinforcing bars.

Provide reinforcement that is supported and secured together to prevent displacement by construction loads or by placing of wet concrete, and as follows:

Provide supports for reinforcing bars that are sufficient in number and sufficiently heavy to carry the reinforcement they support, and in accordance with ACI/MCP-3, ACI/MCP-4 and CRSI 10MSP. Do not use supports to support runways for concrete conveying equipment and similar construction loads.

Equip supports on ground and similar surfaces with sand-plates.

Support welded wire fabric as required for reinforcing bars.

Secure reinforcements to supports by means of tie wire. Wire must be black, soft iron wire, not less than 1.6 mm 16 gage.

With the exception of temperature reinforcement, tied to main steel approximately 600 mm 24 inches on center, reinforcement must be accurately placed, securely tied at intersections with 1.3 mm 18-gage annealed wire, and held in position during placing of concrete by spacers, chairs, or other approved supports. Point wire-tie ends away from the form. Unless otherwise indicated, numbers, type, and spacing of supports must conform to ACI/MCP-3.

Bending of reinforcing bars partially embedded in concrete is permitted only as specified in ACI/MCP-3 and ACI/MCP-4.

3.6.13 Spacing of Reinforcing Bars

Spacing must be as indicated. If not indicated, spacing must be in accordance with the ACI/MCP-3 and ACI/MCP-4.

Reinforcing bars may be relocated to avoid interference with other reinforcement, or with conduit, pipe, or other embedded items. If any reinforcing bar is moved a distance exceeding one bar diameter or specified placing tolerance, resulting rearrangement of reinforcement is subject to approval.

3.6.14 Concrete Protection for Reinforcement

****
NOTE: If the required concrete protection for reinforcement is greater than the thicknesses specified in the ACI building code requirements for reinforced concrete, (such as in extremely corrosive atmospheres or other severe exposures, for fire protection covering, and for concrete surface to receive exposed aggregate or tooled finish), such concrete protection for reinforcement must be indicated.
****

Concrete protection must be in accordance with the ACI/MCP-3 and ACI/MCP-4.

3.6.15 Welding

Welding must be in accordance with AWS D1.4/D1.4M.

3.7 BATCHING, MEASURING, MIXING, AND TRANSPORTING CONCRETE

ASTM C94/C94M, and ACI/MCP-2, except as modified herein. Batching equipment must 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.

3.7.1 Measuring

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

3.7.2 Mixing

ASTM C94/C94M and ACI/MCP-2. 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 84 degrees F. Reduce mixing time and place concrete within 60 minutes if the air temperature is greater than 29 degrees C 84 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.

3.7.3 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.

3.8 PLACING CONCRETE

****

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

"Depositing Concrete Under Water.

Methods and equipment used must 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. Tremies, if used, must 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 must be cured for 12 hours minimum prior to being submerged in fresh water. Cure a structure permanently submerged in seawater 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 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 centers maximum in each direction when pouring interior slabs and on 6 m 20 foot centers maximum for exterior slabs.

3.8.1 General Placing Requirements

Deposit concrete continuously or in layers of such thickness that no concrete is placed on concrete which has hardened sufficiently to cause formation of seams or planes of weakness within the section. If a section cannot be placed continuously, provide construction joints as specified. Perform concrete placing at such a rate that concrete which is being integrated with fresh concrete is still plastic. Deposit concrete as nearly as practical in its final position to avoid segregation due to rehandling or flowing. Do not subject concrete to procedures which cause segregation.

Concrete to receive other construction must be screeded to proper level to avoid excessive skimming or grouting.

Do not use concrete which becomes nonplastic and unworkable or does not meet quality control limits as specified or has been contaminated by foreign materials. Use of retempered concrete is permitted. Remove rejected concrete from the site.

[3.8.2 Footing Placement

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

]3.8.3 Vibration

****
NOTE: For prefabricated epoxy-coated rebar use ASTM A934/A934M. For epoxy-coated rebar use ASTM A775/A775M.
****

ACI/MCP-2[and[ASTM A934/A934M][ASTM A775/A775M]]. Furnish a spare, working, vibrator on the job site whenever concrete is placed. Consolidate concrete slabs greater than 100 mm 4 inches in depth with high frequency mechanical vibrating equipment supplemented by hand spading and tamping. Consolidate concrete slabs 100 mm 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. Penetrate the previously placed lift with the vibrator when more than one lift is required. Use external vibrators on the exterior surface of the forms when internal vibrators do not provide adequate consolidation of the concrete.

[3.8.4 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.

][3.8.5 Pumping

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

ACI/MCP-2. Pumping must 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 must not exceed 50 mm 2 inches. Do not convey concrete through pipe made of aluminum or aluminum alloy. Avoid rapid changes in pipe sizes. Limit maximum size of course aggregate to 33 percent of the diameter of the pipe. Limit maximum size of well rounded aggregate to 40 percent of the pipe diameter. Take samples for testing at both the point of delivery to the pump and at the

discharge end.

[3.8.5.1 Pumping Lightweight Concrete

****
NOTE: Specify minimum of 330 kg per cubic meter 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/MCP-1. Presoak or presaturate aggregates. Cement content must be minimum of [330 kg per cubic meter] [564 pounds per cubic yard] [_____] and be sufficient to accommodate a 100 to 150 mm 4 to 6 inch slump. [Make field trial run in accordance with ACI/MCP-1.]

]][3.8.6 Cold Weather

ACI/MCP-2. Do not allow concrete temperature to decrease below 10 degrees C 50 degrees F. Obtain approval prior to placing concrete when the ambient temperature is below 4 degrees C 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 minimum adjacent to both the formwork and the structure while curing. Limit the rate of cooling to 3 degrees C 37 degrees F in any 1 hour and 10 degrees C 50 degrees F per 24 hours after heat application.

]3.8.7 Hot Weather

Maintain required concrete temperature using Figure 2.1.5 in ACI/MCP-2 to prevent the evaporation rate from exceeding 1 kg per square meter 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.

3.8.8 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.

3.8.9 Placing Concrete in Forms

Deposit concrete placed in forms in horizontal layers not exceeding 600 mm 24 inches.

Remove temporary spreaders in forms when concrete placing has reached elevation of spreaders.

Consolidate concrete placed in forms by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping. Provide vibrating equipment adequate in number of units and power of each unit to properly consolidate concrete. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced points not farther apart than visible effectiveness of machine. Do not insert vibrator into lower courses of concrete that have begun to set. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing segregation of concrete mix.

Do not start placing of concrete in supporting elements until concrete previously placed in columns and walls is no longer plastic and has been in place a minimum of 2 hours.

3.8.10 Placing Concrete Slabs

Place and consolidate concrete for slabs in a continuous operation, within the limits of approved construction joints until placing of panel or section is completed.

During concrete placing operations, consolidate concrete by mechanical vibrating equipment so that concrete is worked around reinforcement and other embedded items and into corners. Consolidate concrete placed in beams and girders of supported slabs and against bulkheads of slabs on ground by mechanical vibrators as specified. Consolidate concrete in remainder of slabs by vibrating bridge screeds, roller pipe screeds, or other approved method. Limit consolidation operations to time necessary to obtain consolidation of concrete without bringing an excess of fine aggregate to the surface. Concrete to be consolidated must be as dry as practical and surfaces thereof must not be manipulated prior to finishing operations. Bring concrete correct level with a straightedge and struck-off. Use bull floats or darbies to smooth surface, leaving it free of humps or hollows. Sprinkling of water on plastic surface is not permitted.

Provide finish of slabs as specified.

3.8.11 Bonding

Surfaces of set concrete at joints, except where bonding is obtained by use of concrete bonding agent, must be roughened and cleaned of laitance, coatings, loose particles, and foreign matter. Roughen surfaces in a manner that exposes the aggregate uniformly and does not leave laitance, loosened particles of aggregate, nor damaged concrete at the surface.

Obtain bonding of fresh concrete that has set as follows:

At joints between footings and walls or columns, between walls or columns and the beams or slabs they support, and elsewhere unless otherwise specified; roughened and cleaned surface of set concrete must be dampened, but not saturated, immediately prior to placing of fresh concrete.

At joints in exposed-to-view work; at vertical joints in walls; at joints near midpoint of span in girders, beams, supported slabs, other structural members; in work designed to contain liquids; the roughened and cleaned surface of set concrete must be dampened but not saturated

and covered with a cement grout coating.

Provide cement grout that consists of equal parts of portland cement and fine aggregate by weight with not more than 22.5 liters 6 gallons of water per sack of cement. Apply cement grout with a stiff broom or brush to a minimum thickness of 1.6 mm 1/16 inch. Deposit fresh concrete before cement grout has attained its initial set.

Bonding of fresh concrete to concrete that has set may be obtained by use of a concrete bonding agent. Apply such bonding material to cleaned concrete surface in accordance with approved printed instructions of bonding material manufacturer.

3.9 SURFACE FINISHES EXCEPT FLOOR, SLAB, AND PAVEMENT FINISHES

3.9.1 Defects

Repair formed surfaces by removing minor honeycombs, pits greater than 600 square mm 1 square inch surface area or 6 mm 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 must not vary more than the allowable tolerances of ACI/MCP-4. Exposed surfaces must be uniform in appearance and finished to a smooth form finish unless otherwise specified.

3.9.2 Not Against Forms (Top of Walls)

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

3.9.3 Formed Surfaces

3.9.3.1 Tolerances

ACI/MCP-1 and as indicated.

3.9.3.2 As-Cast Rough Form

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

3.9.3.3 Standard Smooth Finish

Finish must be as-cast concrete surface as obtained with form facing material for standard smooth finish. Repair and patch defective areas as specified; and all fins and remove other projections on surface.

3.9.4 [_____] Finish

****

NOTE: Add information where special type of finish is desired. See ACI/MCP-2 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: [_____].

[3.9.5 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 thick. Use the approved concrete mix design(s). Provide sample panels on-site at locations directed. Once approved, each set of panels must be representative of each of the finishes specified and of the workmanship and finish(es) required. Do not remove or destroy samples until directed by the Contracting Officer.

]3.9.6 Grout Finish

****

NOTE: Delete paragraph heading and following paragraphs if architectural requirements do not require grout finish.

****

Provide finish that is standard, smooth coated with grout as specified.

Give finish to interior and exterior concrete vertical surfaces that are to be exposed to view.

Grout is required consisting of one part portland cement to 1-1/2 parts fine aggregate by volume, mixed with water to produce a consistency of thick paint. Portland cement portion must be a blend of standard portland cement and white portland cement, proportioned as determined by trial mixes so that final color of grout when dry approximates color of surrounding concrete. Fine aggregate must pass 600 micrometer No. 30 mesh sieve.

Surface of concrete is required to be wetted, and grout must be applied immediately to wetted surfaces. Spread grout over surface with clean burlap pads or sponge-rubber floats to fill pits, air bubbles, and surface holes. Remove excess grout by scraping, then rubbing surface with clean burlap to remove visible grout film. Keep grout damp by means of fog spray during setting period. Complete finish the day it is started, and make limits of a finished area at natural breaks in finished surface.

3.10 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 09 30 00, CERAMIC TILE,

QUARRY TILE, AND PAVER TILE.

****

ACI/MCP-2, 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 must provide straightedge.

3.10.1 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.

3.10.1.1 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,roughen the surface with stiff brushes of rakes before final set.

3.10.1.2 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 must begin when the surface has stiffened sufficiently to permit the operation. During or after the first floating, check surface with a 3 meter 10 foot straightedge applied at no less than two different angles, one of which is perpendicular to the direction of strike off. Cut down high spots and fill low spots during this procedure to produce a surface level within [6] [_____] mm in 3 m [1/4] [_____] inch in 10 feet.

[3.10.1.3 Concrete Containing Silica Fume

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

]3.10.1.4 Steel Troweled

****

NOTE: ACI/MCP-2 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. Next, the finish must be power troweled [two] [three] [_____] times, and finally hand troweled. The first troweling after floating needs to produce a smooth surface which is relatively free of defects but which may still show some

trowel marks. Perform additional trowelings done by hand after the surface has hardened sufficiently. The final troweling is done when a ringing sound is produced as the trowel is moved over the surface. Thoroughly consolidate the surface by the hand troweling operations. The finished surface must be essentially free of trowel marks and uniform in texture and appearance. The finished surface must produce a surface level to within [6] [_____] mm in 3 m [1/4] [_____] inch in 10 feet. On surfaces intended to support floor coverings, remove any defects of sufficient magnitude to show through the floor covering by grinding.

[3.10.1.5 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. 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.

]3.10.1.6 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.

3.10.1.7 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 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.

3.10.1.8 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 41 degrees F at the time of placing. Place the topping and finish as[indicated][specified herein].

3.10.1.9 Chemical-Hardener Treatment

****
NOTE: Slab surfaces requiring a chemical hardener must be indicated. Such treatment is suitable for surfaces of concrete floors in equipment rooms and on other floor surfaces that are subject to light foot traffic only and must not be covered with resilient flooring, paint, or other finish coating.
****

[Apply liquid-chemical floor hardener where indicated after curing and drying concrete surface. Dilute liquid hardener with water and apply in three coats. First coat must be one-third strength, second coat one-half strength, and third coat two-thirds strength. Apply each coat evenly and allow to dry 24 hours between coats.

Approved proprietary chemical hardeners must be applied in accordance with manufacturer's printed directions.]

3.10.1.10 Colored Wear-Resistant Finish

****
NOTE: Slab surfaces requiring colored, wear-resistant finish must be indicated. Such finish is suitable for exterior and interior slabs that are subject to medium-heavy foot traffic.
****

[Give finish to monolithic slab surfaces where indicated.

Apply dry shake materials for colored wear-resistant finish at the rate of 29 kilogram per 10 square meter 60 pounds per 100 square feet of surface.

Immediately following first floating operation, approximately two-thirds of specified weight of dry shake material must be uniformly distributed over surface and embedded by means of power floating. After first dry-shake application has been embedded, uniformly distribute remainder of dry-shake material over surface at right angles to first dry-shake application and

embed by means of power floating. Trueness of surface and other requirements for floating operations not specified in this paragraph must be as specified for float finish.

After completion of float finish, apply a trowel finish as specified.]

3.10.1.11 Heavy-Duty Wear-Resistant Finish

****
NOTE: Delete paragraph heading and following paragraphs when not applicable. Slab surfaces requiring heavy-duty wear-resistant finish must be indicated. Traprock and emery aggregate finish are suitable for exterior and interior slabs that are subject to abrasive wear. Iron aggregate finish is suitable for interior slabs that are not subject to excessive amounts of moisture and are subject to abrasive wear and some impact.
****

Give finish to slab surfaces where indicated.

Dry-shake material for heavy-duty, wear-resistant finish must consist of a mixture of standard portland cement and aggregate for heavy-duty, wear-resistant finish proportioned by weight as follows:

One part standard portland cement and [two parts traprock aggregate for heavy-duty wear-resistant finish] [four parts emery aggregate for heavy-duty wear-resistant finish] [two parts by weight iron aggregate for heavy-duty, wear-resistant finish]

Apply blended dry-shake material as follows:

****
NOTE: Select type of aggregate.
****

MAXIMUM TYPE OF AGGREGATE IN DRY SHAKE	AMOUNT PER 100 SQUARE METER FEET OF SURFACE
Traprock	73 kilogram 160 pounds
Emery	59 kilogram 130 pounds
Iron	59 kilogram 130 pounds

Immediately following the first floating operation, approximately one-half the specified weight of blended, uniformly distribute dry-shake materials over the surface and embedded by means of power floating. After the first dry-shake application has been embedded, uniformly distribute the remaining one-half of the blended dry-shake material over the surface at right angles to the first dry-shake application and embedded by means of power floating. Trueness of surface and other requirements for floating operations not specified in this paragraph must be as specified for float finish.

After completion of the float finish, trowel finish the surface as

specified.

[3.10.2 Flat Floor Finishes

****
NOTE: Use these paragraphs where floor flatness is critical. Indicate areas where these requirements apply. Flatness affects 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 dictates 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. This test method is not suitable for unshored deck. Fitted partitions need FL greater than or equal to 25.
****

ACI/MCP-2. Construct in accordance with one of the methods recommended in Table 7.15.3, "Typical Composite Ff/FL Values for Various Construction Methods." ACI/MCP-1 for tolerance tested by ASTM E1155.

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

3.10.2.1 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 is required to provide a tolerance report which must include:

a. Key plan showing location of data collected.

b. Results required by ASTM E1155.

3.10.2.2 Remedies for Out of Tolerance Work

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

]3.10.3 Concrete Walks

Provide 100 mm 4 inches thick minimum. Provide contraction joints spaced every 1500 lineal mm 5 linear feet unless otherwise indicated. Cut contraction joints 25 mm one inch deep with a jointing tool after the surface has been finished. Provide 13 mm 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 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.

3.10.4 Pits and Trenches

Place bottoms and walls monolithically or provide waterstops and keys.

3.10.5 Curbs[and Gutters]

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

[3.10.6 Splash Blocks

Provide at outlets of downspouts emptying at grade. Splash blocks may be precast concrete, and must be 600 mm long, 300 mm wide and 100 mm 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.

]3.11 CURING AND PROTECTION

****

NOTE: When the use of alkali-reactive aggregates is permitted, 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 the cement and aggregates meet the requirements of Section 2.4.3 (and Note on alkali-reactive aggregates)

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 C39/C39M 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/MCP-2 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 [_____].

3.11.1 General

Protect freshly placed concrete from premature drying and cold or hot temperature and maintain without drying at a relatively constant temperature for the period of time necessary for hydration of cement and proper hardening of concrete.

Start initial curing as soon as free water has disappeared from surface of concrete after placing and finishing. Keep concrete moist for minimum 72 hours.

Final curing must immediately follow initial curing and before concrete has dried. Continue final curing until cumulative number of hours or fraction thereof (not necessarily consecutive) during which temperature of air in contact with the concrete is above 10 degrees C 50 degrees F has totaled 168 hours. Alternatively, if tests are made of cylinders kept adjacent to the structure and cured by the same methods, final curing may be terminated when the average compressive strength has reached 70 percent of the 28-day design compressive strength. Prevent rapid drying at end of final curing period.

3.11.2 Moist Curing

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

3.11.2.1 Ponding or Immersion

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

3.11.2.2 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, increase the curing period by 50 percent.

3.11.2.3 Pervious Sheeting

Completely cover surface and edges of the concrete with two thicknesses of wet sheeting. Overlap sheeting 150 mm 6 inches over adjacent sheeting. Provide sheeting that is 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.

3.11.2.4 Impervious Sheeting

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

3.11.3 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/MCP-2 indicates that hot weather conditions cause an evaporation rate exceeding one kg pf water per square meter per hour 0.2 pound of water per square foot per hour.

3.11.3.1 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 must be 5 square meters maximum per L 200 square feet maximum per gallon of undiluted compound unless otherwise recommended by the manufacturer's written instructions. The compound must form a uniform, continuous, coherent film that does 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.

3.11.3.2 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.

3.11.4 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. Do not apply the sealer hardener 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.

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

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

3.11.6 Curing Periods

ACI/MCP-2 except 10 days for retaining walls, pavement or chimneys, 21 days for concrete that is 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 are subject to approval by the Contracting Officer.

3.11.7 Curing Methods

Accomplish curing by moist curing, by moisture-retaining cover curing, by membrane curing, and by combinations thereof, as specified.

Moist curing:

Accomplish moisture curing by any of the following methods:

Keeping surface of concrete wet by covering with water

Continuous water spraying

Covering concrete surface with specified absorptive cover for curing concrete saturated with water and keeping absorptive cover wet by water spraying or intermittent hosing. Place absorptive cover to provide coverage of concrete surfaces and edges with a slight overlap over adjacent absorptive covers.

Moisture-cover curing:

Accomplish moisture-retaining cover curing by covering concrete surfaces with specified moisture-retaining cover for curing concrete. Place cover directly on concrete in widest practical width, with sides and

ends lapped at least 75 mm 3 inches. Weight cover to prevent displacement; immediately repair tears or holes appearing during curing period by patching with pressure-sensitive, waterproof tape or other approved method.

Membrane curing:

Accomplish membrane curing by applying specified membrane-forming curing compound to damp concrete surfaces as soon as moisture film has disappeared. Apply curing compound uniformly in a two-coat operation by power-spraying equipment using a spray nozzle equipped with a wind guard. Apply second coat in a direction at right angles to direction of first coat. Total coverage for two coats must be not more than 5 square meter per liter200 square feet per gallon of curing compound. Respray concrete surfaces which are subjected to heavy rainfall within 3 hours after curing compound has been applied by method and at rate specified. Maintain continuity of coating for entire curing period and immediately repair damage to coating during this period.

Membrane-curing compounds must not be used on surfaces that are to be covered with coating material applied directly to concrete or with a covering material bonded to concrete, such as other concrete, liquid floor hardener, waterproofing, dampproofing, membrane roofing, painting, and other coatings and finish materials.

3.11.8 Curing Formed Surfaces

Accomplish curing of formed surfaces, including undersurfaces of girders, beams, supported slabs, and other similar surfaces by moist curing with forms in place for full curing period or until forms are removed. If forms are removed before end of curing period, accomplish final curing of formed surfaces by any of the curing methods specified above, as applicable.

3.11.9 Curing Unformed Surfaces

Accomplish initial curing of unformed surfaces, such as monolithic slabs, floor topping, and other flat surfaces, by membrane curing.

Unless otherwise specified, accomplish final curing of unformed surfaces by any of curing methods specified above, as applicable.

Accomplish final curing of concrete surfaces to receive liquid floor hardener of finish flooring by moisture-retaining cover curing.

3.11.10 Temperature of Concrete During Curing

When temperature of atmosphere is 5 degrees C 41 degrees F and below, maintain temperature of concrete at not less than 13 degrees C 55 degrees F throughout concrete curing period or 7 degrees C 45 degrees F when the curing period is measured by maturity. When necessary, make arrangements before start of concrete placing for heating, covering, insulation, or housing as required to maintain specified temperature and moisture conditions for concrete during curing period.

When the temperature of atmosphere is 27 degrees C 80 degrees F and above or during other climatic conditions which cause too rapid drying of concrete, make arrangements before start of concrete placing for installation of wind breaks, of shading, and for fog spraying, wet sprinkling, or moisture-retaining covering of light color as required to

protect concrete during curing period.

Changes in temperature of concrete must be uniform and not exceed 3 degrees C 37 degrees F in any 1 hour nor 27 degrees C 80 degrees F in any 24-hour period.

3.11.11 Protection from Mechanical Injury

During curing period, protect concrete from damaging mechanical disturbances, particularly load stresses, heavy shock, and excessive vibration and from damage caused by rain or running water.

3.11.12 Protection After Curing

Protect finished concrete surfaces from damage by construction operations.

3.12 FIELD QUALITY CONTROL

3.12.1 Sampling

ASTM C172/C172M. Collect samples of fresh concrete to perform tests specified. ASTM C31/C31M for making test specimens.

3.12.2 Testing

3.12.2.1 Slump Tests

ASTM C143/C143M. 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 (maximum) of concrete.

3.12.2.2 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) for each batch (minimum) or every 16 cubic meters 20 cubic yards (maximum) of concrete, until the specified temperature is obtained, and whenever test cylinders and slump tests are made.

3.12.2.3 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 C39/C39M. Make five test cylinders for each set of tests in accordance with ASTM C31/C31M. Take precautions 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. Take samples for strength tests of each [mix design of] [and for] [_____] concrete placed each day not less than once a day, nor less than once for each 120 cubic

meters 160 cubic yards of concrete, nor less than once for each 500 square meters 5400 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 must 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 450 psi, take a minimum of three ASTM C42/C42M core samples from the in-place work represented by the low test cylinder results and test. Concrete represented by core test is 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. Retest locations represented by erratic core strengths. Remove concrete not meeting strength criteria and provide new acceptable concrete. Repair core holes with nonshrink grout. Match color and finish of adjacent concrete.

[3.12.2.4 Air Content

ASTM C173/C173M or ASTM C231/C231M for normal weight concrete [and ASTM C173/C173M for lightweight concrete]. Test air-entrained concrete for air content at the same frequency as specified for slump tests.

][3.12.2.5 Unit Weight of Structural Lightweight Concrete

ASTM C567/C567M. Determine unit weight of lightweight concrete. Perform test for every 15 cubic meters 20 cubic yards maximum.

][3.12.2.6 Ion Concentration

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

ACI/MCP-3. Determine water soluble ion concentration. Perform test once for each mix design.

]3.12.2.7 Strength of Concrete Structure

Compliance with the following is considered deficient if it fails to meet the requirements which control strength of structure in place, including following conditions:

Failure to meet compressive strength tests as evaluated

Reinforcement not conforming to requirements specified

Concrete which differs from required dimensions or location in such a manner as to reduce strength

Concrete curing and protection of concrete against extremes of temperature during curing, not conforming to requirements specified

Concrete subjected to damaging mechanical disturbances, particularly load stresses, heavy shock, and excessive vibration

Poor workmanship likely to result in deficient strength

3.12.2.8 Testing Concrete Structure for Strength

When there is evidence that strength of concrete structure in place does not meet specification requirements, make cores drilled from hardened concrete for compressive strength determination in accordance with ASTM C42/C42M, and as follows:

Take at least three representative cores from each member or area of concrete-in-place that is considered potentially deficient. Location of cores will be determined by the Contracting Officer.

Test cores after moisture conditioning in accordance with ASTM C42/C42M if concrete they represent is more than superficially wet under service.

Air dry cores, (16 to 27 degrees C 60 to 80 degrees F with relative humidity less than 60 percent) for 7 days before test and test dry if concrete they represent is dry under service conditions.

Strength of cores from each member or area are considered satisfactory if their average is equal to or greater than 85 percent of the 28-day design compressive strength of the class of concrete.

Core specimens will be taken and tested by the Government. If the results of core-boring tests indicate that the concrete as placed does not conform to the drawings and specification, the cost of such tests and restoration required must be borne by the Contractor.

Fill core holes solid with patching mortar and finished to match adjacent concrete surfaces.

Correct concrete work that is found inadequate by core tests in a manner approved by the Contracting Officer.

3.13 WASTE MANAGEMENT

As specified in the Waste Management Plan and as follows.

3.13.1 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.

3.13.2 Hardened, Cured Waste Concrete

[Crush and reuse hardened, cured waste concrete as fill or as a base course for pavement.][Use hardened, cured waste concrete as aggregate in concrete mix if approved by Contracting Officer.]

3.13.3 Reinforcing Steel

Collect reinforcing steel and place in designated area for recycling.

3.13.4 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, seek local recyclers to reclaim the materials.]

3.14 JOINTS

3.14.1 Construction Joints

Make and locate joints not indicated so as not to impair strength and appearance of the structure, as approved. Locate construction joints as follows:

a. In walls at not more than 18.3 meter 60 feet in any horizontal direction; at top of footing; at top of slabs on ground; at top and bottom of door and window openings or where required to conform to architectural details; and at underside of deepest beam or girder framing into wall

b. In columns or piers, at top of footing; at top of slabs on ground; and at underside of deepest beam or girder framing into column or pier

c. Near midpoint of spans for supported slabs, beams, and girders unless a beam intersects a girder at the center, in which case construction joints in girder must offset a distance equal to twice the width of the beam. Make transfer of shear through construction joint by use of inclined reinforcement.

d. In slabs on ground, so as to divide slab into areas not in excess of 111.5 square meter 1,200 square feet

Provide keyways at least 40 mm 1-1/2-inches deep in construction joints in walls and slabs and between walls and footings; approved bulkheads may be used for slabs.

Joints must be perpendicular to main reinforcement. Reinforcement must be continued across construction joints.

3.14.2 Waterstops

****
NOTE: Waterstops must be used in construction joints in foundation walls, pit walls, and other construction subject to hydraulic pressure. Location of waterstops must be indicated.
****

Provide waterstops in construction joints as indicated.

Install waterstops to form a continuous diaphragm in each joint. Make adequate provisions to support and protect waterstops during progress of work. Make field joints in waterstops in accordance with waterstop manufacturer's printed instructions, as approved. Protect waterstops protruding from joints from damage.

3.14.3 Isolation Joints in Slabs on Ground

Provide joints at points of contact between slabs on ground and vertical surfaces, such as column pedestals, foundation walls, grade beams, and elsewhere as indicated.

Fill joints with premolded joint filler strips 13 mm 1/2 inch thick, extending full slab depth. Install filler strips at proper level below finish floor elevation with a slightly tapered, dress-and-oiled wood strip temporarily secured to top of filler strip to form a groove not less than 19 mm 3/4 inch in depth where joint is sealed with sealing compound and not less than 6 mm 1/4 inchin depth where joint sealing is not required. Remove wood strip after concrete has set. Contractor must clean groove of foreign matter and loose particles after surface has dried.

3.14.4 Control Joints in Slabs on Ground

Provide joints to form panels as indicated.

Under and on exact line of each control joint, cut 50 percent of welded wire fabric reinforcement before placing concrete.

Joints must be 4 mm 1/8-inch wide by 1/5 to 1/4 of slab depth and formed by inserting hand-pressed fiberboard strip into fresh concrete until top surface of strip is flush with slab surface or by cutting the concrete with a saw after the concrete has set. After concrete has cured for at least 7 days, the Contractor must remove inserts and clean groove of foreign matter and loose particles.

In Hawaii, sawcutting will be limited to within 12 hours after set and at 1/4 slab depth.

3.14.5 Sealing Joints in Slabs on Ground

Isolation and control joints which are to receive finish flooring material must be sealed with joint sealing compound after concrete curing period. Slightly underfill groove with joint sealing compound to prevent extrusion of compound. Remove excess material as soon after sealing as possible.

Sealing is not required for isolation and control joints to be covered with finish flooring material. Groove must be left ready to receive filling material that is provided as part of finish floor covering work.

3.15 INSTALLATION OF ANCHORAGE DEVICES

3.15.1 General

****
NOTE: Anchorage devices for other work that is attached to or supported by cast-in-place concrete must be specified in applicable section of specifications. Anchorage devices include dovetail slots for masonry facing, inserts for suspended ceilings, inserts for shelf angles, and inserts for bolt hangers.
****

Anchorage devices and embedded items required for other work that is attached to, or supported by, set and build in cast-in-place concrete as part of the work of this section, using setting drawings, instructions, and directions for work to be attached thereto.

3.15.2 Placing Anchorage Devices

Anchorage devices and embedded items must be positioned accurately and

supported against displacement. Fill openings in anchorage devices such as slots and threaded holes with an approved, removable material to prevent entry of concrete into openings.

3.16 CONCRETE CONVEYING

3.16.1 Transfer of Concrete At Project Site

Handle concrete from point of delivery and transfer to concrete conveying equipment and to locations of final deposit as rapidly as practical by methods which prevent segregation and loss of concrete mix materials.

3.16.2 Mechanical Equipment for Conveying Concrete

Equipment must ensure a continuous flow of concrete at delivery end, as approved. Provide runways for wheeled concrete-conveying equipment from concrete delivery point to locations of final deposit. Interior surfaces of concrete conveying equipment must be free of hardened concrete, debris, water, snow, ice, and other deleterious substances.

3.17 CONCRETE FLOOR TOPPING

3.17.1 Standard Floor Topping

****
NOTE: When standard floor topping is specifically required, the location of standard floor topping must be indicated.
****

Provide topping for treads and platforms of metal steel stairs and elsewhere as indicated.

Materials

Provide materials that conform to requirements specified, except aggregate must be as follows:

TYPE OF AGGREGATE	SIEVE	PERCENT PASSING
Fine aggregate	9.5 mm 3/8 in.	100
	4.75 mm No. 4	95 to 100
	2.36 mm No. 8	80 to 90
	1.18 mm No. 16	50 to 75
	600 micrometer No. 30	30 to 50
	300 micrometer No. 50	10 to 20
	150 micrometer No. 100	2 to 5
Coarse aggregate	12.5 mm 1/2 in.	100

	9.5 mm 3/8 in.	95 to 100
	4.75 mm No. 4	40 to 60
	2.36 mm No. 8	0 to 5

Standard Topping Mixture

Provide mixture that consists of one part portland cement, one part fine aggregate, and two parts coarse aggregate, by volume. Adjust exact proportions of fine and coarse aggregates to produce a well-graded total aggregate. Mixing water must not exceed 5 gallons per 94-pound sack of cement including unabsorbed moisture in aggregate. Maximum slump must be 50 mm 2 inches.

Preparations Prior to Placing

When mixture is placed on a green concrete base slab, screed surface of base slab to a level not more than 38 mm 1-1/2 inches nor less than 25 mm 1 inch below required finish surface. Remove water and laitance from surface of base slab before placing topping mixture. As soon as water ceases to rise to surface of base slab, place topping mixture as specified.

When mixture is placed on a hardened concrete base slab, remove dirt, loose material, oil, grease, asphalt, paint, and other contaminants from base slab surface, leaving a clean surface. Prior to placing topping mixture, (64 mm 2-1/2-inches minimum) slab surface must be dampened and left free of standing water. Immediately before topping mixture is placed, broom a coat of neat cement grout onto surface of slab. Do not allow cement grout to set or dry before topping mixture is placed.

When mixture is placed on a metal surface, such as metal pans for steel stairs, remove dirt, loose material, oil, grease, asphalt, paint, and other contaminants from metal surface. Immediately before topping mixture is placed, spray or brush a coating of concrete bonding agent onto metal surfaces and do not be allow to set or dry before topping mixture is applied.

Mixing

Do the mixing of topping material at the site in a mechanical mixer of the batch type. Equip batch mixer with a suitable charging hopper, water storage tank, and water-measuring device and must be capable of mixing aggregates, cement, and water into a uniform mix within specified mixing time and of discharging mix without segregation. Provide mixer that bear a rating plate indicating rated capacity and recommended revolutions per minute.

Mix each batch of 1.5 cubic meter 2 cubic yards or less for not less than 1-1/2 minutes. Increase mixing time 15 seconds for each additional cubic yard or fraction thereof.

Clean mixer, and replace blades in drum when they have lost 10 percent of their original depth.

Truck-mixed topping may be used when approved. Specify truck-mixed topping for ready-mix concrete.

Placing

Spread standard topping mixture evenly on previously prepared base slab or metal surface, brought to correct level with a straightedge, and struck off. Topping must be consolidated, floated, checked for trueness of surface, and refloated as specified for float finish.

Finishing

Give trowel finish standard floor topping surfaces.

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NOTE: Standard floor topping surfaces requiring an applied finish such as a chemical-hardener, non-slip aggregate finish, colored wear-resistant finish, or heavy-duty, wear-resistant finish must be indicated.
****

Give other finishes standard floor topping surfaces as indicated. Specify such finishes for required finish.

3.17.2 Heavy-Duty Floor Topping

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NOTE: Location of heavy-duty floor topping must be indicated. Heavy-duty floor topping is suitable for an industrial floor subject to continuous severe abrasion and impact such as steel-tire vehicles.
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Provide topping where indicated.

Heavy-duty Topping Mixture

Provide mixture that consists of 1 part portland cement and 2-1/2 parts emery aggregate or 1 part fine aggregate and 1-1/2 parts traprock coarse aggregate, by volume. Exact proportions of mixture must conform to recommendations of aggregate manufacturer. Mixing water must not exceed 14.2 liter per 43 kilogram 3-1/4 gallons per 94-pound sack of cement including unabsorbed moisture in aggregate. Maximum slump must be 25 mm 1 inch.

Base Slab

Screed surface of slab to a level no more than 38 mm 1-1/2 inches nor less than 25 mm 1 inch below grade of finished floor.

Give slab a scratch finish as specified.

Preparations prior to placing

Remove dirt, loose material, oil, grease, asphalt, paint and other contaminants from base slab surface. Prior to placing topping mixture, dampen slab surface and leave free of standing water. Immediately before topping mixture is placed, broom a coat of neat cement grout

onto surface of slab. Allow cement grout to set or dry before topping mixture is placed.

Mixing

Do mixing of topping material at the site in a mechanical mixer of the batch type. Equip batch mixer with a charging hopper, water storage tank, and a water-measuring device and the batch mixer must be capable of mixing aggregates, cement, and water into a uniform mix within the specified mixing time and of discharging mix without segregation. Provide mixer that bears a rating plate indicating rated capacity and recommended revolutions per minute.

Mix each batch of 1.5 cubic meter 2 cubic yards or less for not less than 1-1/2 minutes.

Increase mixing time 15 seconds for each additional cubic yard or fraction thereof. Clean mixer, and replace pick-up and throw-over blades in drum when they have lost 10 percent of their original depth.

Placing

Spread heavy-duty topping mixture evenly on previously prepared base slab, and bring to correct level with a straightedge, and strike off. Provide topping that is consolidated, floated, and checked for trueness of surface as specified for float finish, except that power-driven floats is the impact type.

Finishing

Give trowel finish heavy-duty floor topping surfaces. Provide trowel finish as specified, except that additional troweling after first power troweling must be not less than three hand-troweling operations.

-- End of Section --