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USACE / NAVFAC / AFCEC / NASA | **UFGS-03 30 00 (May 2014) Change 1 - 02/15**

Preparing Activity: NAVFAC | **Superseding UFGS-03 30 00 (November 2011)**

UNIFIED FACILITIES GUIDE SPECIFICATION

References are in agreement with UMRL dated April 2016

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DIVISION 03 - CONCRETE

SECTION 03 30 00

CAST-IN-PLACE CONCRETE

05/14

-- End of Section Table of Contents --

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SECTION 03 30 00

CAST-IN-PLACE CONCRETE
05/14

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NOTE: This guide specification covers the requirements for cast-in-place concrete not exposed to a marine or high chloride environment. For concrete exposed to a marine or high chloride environment, use Section 03 31 29 MARINE 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)**.**

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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 for each element, f'c.

4. Yield strength of reinforcement required 414 MPa 60,000 psi or other grades available.

5. Details of concrete sections, showing

dimensions, reinforcement cover, and required camber.

6. Locations where structural lightweight concrete or lightweight insulation or fill concrete are used.

7. 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.

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

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

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

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

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 117	(2010; Errata 2011) Specifications for Tolerances for Concrete Construction and Materials and Commentary
ACI 121R	(2008) Guide for Concrete Construction Quality Systems in Conformance with ISO 9001
ACI 211.1	(1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 211.2	(1998; R 2004) Standard Practice for

	Selecting Proportions for Structural Lightweight Concrete
ACI 213R	(2014) Guide for Structural Lightweight-Aggregate Concrete
ACI 301	(2010; ERTA 2015) Specifications for Structural Concrete
ACI 302.1R	(2015) Guide for Concrete Floor and Slab Construction
ACI 304.2R	(1996; R 2008) Placing Concrete by Pumping Methods
ACI 304R	(2000; R 2009) Guide for Measuring, Mixing, Transporting, and Placing Concrete
ACI 305R	(2010) Guide to Hot Weather Concreting
ACI 306.1	(1990; R 2002) Standard Specification for Cold Weather Concreting
ACI 306R	(2010) Guide to Cold Weather Concreting
ACI 308.1	(2011) Specification for Curing Concrete
ACI 318	(2014; Errata 1-2 2014; Errata 3-5 2015; Errata 6 2016) Building Code Requirements for Structural Concrete and Commentary
ACI 347	(2004; Errata 2008; Errata 2012) Guide to Formwork for Concrete
ACI SP-15	(2011) Field Reference Manual: Standard Specifications for Structural Concrete ACI 301-05 with Selected ACI References
ACI SP-2	(2007; Abstract: 10th Edition) ACI Manual of Concrete Inspection
ACI SP-66	(2004) ACI Detailing Manual

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 A1064/A1064M	(2015) Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

ASTM A36/A36M	(2014) Standard Specification for Carbon Structural Steel
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A615/A615M	(2015a; E 2015) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A706/A706M	(2014) Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A767/A767M	(2009; R 2015) Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
ASTM A780/A780M	(2009; R 2015) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A934/A934M	(2013) Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars
ASTM A955/A955M	(2016) Standard Specification for Deformed and Plain Stainless-Steel Bars for Concrete Reinforcement
ASTM A996/A996M	(2015) Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
ASTM C1017/C1017M	(2013; E 2015) Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C1077	(2015) Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C1107/C1107M	(2014a) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM C1116/C1116M	(2010a; R 2015) Standard Specification for Fiber-Reinforced Concrete
ASTM C1157/C1157M	(2011) Standard Specification for Hydraulic Cement
ASTM C1218/C1218M	(1999; R 2008) Standard Specification for Water-Soluble Chloride in Mortar and Concrete
ASTM C1240	(2014) Standard Specification for Silica

	Fume Used in Cementitious Mixtures
ASTM C1260	(2014) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C138/C138M	(2014) Standard Test Method for Density ("Unit Weight"), Yield, and Air Content (Gravimetric) of Concrete
ASTM C143/C143M	(2012) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2015) Standard Specification for Portland Cement
ASTM C1567	(2013) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602/C1602M	(2012) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM C172/C172M	(2014a) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C173/C173M	(2014) Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C192/C192M	(2015) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231/C231M	(2014) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C295/C295M	(2012) Petrographic Examination of Aggregates for Concrete
ASTM C31/C31M	(2015a; E 2016) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C311/C311M	(2013) Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland-Cement Concrete
ASTM C33/C33M	(2013) Standard Specification for Concrete Aggregates
ASTM C330/C330M	(2014) Standard Specification for Lightweight Aggregates for Structural

	Concrete
ASTM C39/C39M	(2015a) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C42/C42M	(2013) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C494/C494M	(2015a) Standard Specification for Chemical Admixtures for Concrete
ASTM C552	(2015) Standard Specification for Cellular Glass Thermal Insulation
ASTM C567/C567M	(2014) Determining Density of Structural Lightweight Concrete
ASTM C578	(2015b) Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation
ASTM C591	(2015) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM C595/C595M	(2015; E 2015) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2012a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C78/C78M	(2015b) Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C920	(2014a) Standard Specification for Elastomeric Joint Sealants
ASTM C94/C94M	(2015) Standard Specification for Ready-Mixed Concrete
ASTM C989/C989M	(2014) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM D1751	(2004; E 2013; R 2013) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2004a; R 2013) 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 D2835	(1989; R 2012) Lubricant for Installation of Preformed Compression Seals in Concrete Pavements
ASTM D412	(2015a) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D471	(2015a) Standard Test Method for Rubber Property - Effect of Liquids
ASTM D5759	(2012) Characterization of Coal Fly Ash and Clean Coal Combustion Fly Ash for Potential Uses
ASTM D6690	(2015) Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements
ASTM E1155	(2014) Standard Test Method for Determining Floor Flatness and Floor Levelness Numbers
ASTM E1643	(2011) Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs
ASTM E1745	(2011) Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs
ASTM E1993/E1993M	(1998; R 2013; E 2013) Standard Specification for Bituminous Water Vapor Retarders Used in Contact with Soil or Granular Fill Under Concrete Slabs
ASTM E329	(2014a) Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction
ASTM E96/E96M	(2014) Standard Test Methods for Water Vapor Transmission of Materials

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 513	(1974) Corps of Engineers Specifications for Rubber Waterstops
COE CRD-C 572	(1974) Corps of Engineers Specifications for Polyvinylchloride Waterstops

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

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. "Supplementary cementing materials" (SCM) include coal fly ash, [silica fume,]granulated blast-furnace slag, natural or calcined pozzolans, and ultra-fine coal ash when used in such proportions to replace the portland cement that result in improvement to sustainability and durability and reduced cost.

e. "Design strength" (f'c) is the specified compressive strength of concrete at time(s) specified in this section to meet structural design criteria.

f. "Mass Concrete" is any concrete system that approaches a maximum temperature of 70 degrees C 158 degrees F within the first 72 hours of placement. In addition, it includes all concrete elements with a section thickness of 1 meter 3 feet or more regardless of temperature.

g. "Mixture proportioning" is the process of designing concrete mixture proportions to enable it to meet the strength, service life and constructability requirements of the project while minimizing the initial and life-cycle cost.

h. "Mixture proportions" are the masses or volumes of individual ingredients used to make a unit measure (cubic meter or cubic yard) of

concrete.

i. "Pozzolan" is a siliceous or siliceous and aluminous material, which in itself possesses little or no cementitious value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties.

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

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

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

An "S" following a submittal item indicates that the submittal is required for the Sustainability Notebook to fulfill federally mandated sustainable requirements in accordance with 01 33 29 SUSTAINABILITY REPORTING.

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

****

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

"G" designation identifies the office that will review the submittal for the Government.] Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Concrete Curing Plan

Quality Control Plan; G[, [_____]]

Quality Control Personnel Certifications; G[, [_____]]

Quality Control Organizational Chart

Laboratory Accreditation; G[, [_____]]

Form Removal Schedule; G[, [_____]]

SD-02 Shop Drawings

****

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.

****

[Formwork

] Reinforcing Steel; G[, [_____]]

SD-03 Product Data

Joint Sealants; (LEED NC)

Joint Filler; (LEED NC)

Materials for Forms

Recycled Aggregate Materials; (LEED NC)

Cementitious Materials; (LEED NC)

Vapor Retarder [and Vapor Barrier]

Concrete Curing Materials

Reinforcement; (LEED NC)

Liquid Chemical Floor Hardener

Admixtures

[Synthetic Reinforcing Fibers

] Mechanical Reinforcing Bar Connectors

Waterstops

[Local/Regional Materials; (LEED NC)

][Biodegradable Form Release Agent
]

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

[Pumping Concrete

][Finishing Plan

] SD-04 Samples

****
NOTE: Where flat surface finishing is important ask for a sample installation to train the crew.
****

[Slab Finish Sample

][Surface Finish Sample

] SD-05 Design Data

Concrete Mix Design; G[, [_____]]

****
NOTE: Formwork design calculations only need to be submitted for large complex projects.
****

[Formwork Calculations

] SD-06 Test Reports

Concrete Mix Design; G[, [_____]]

Fly Ash

Pozzolan

Ground Granulated Blast-Furnace Slag

Aggregates

[Fiber-Reinforced Concrete; G[, [_____]]

][Tolerance Report

] Compressive Strength Tests; G[, [_____]]

[Unit Weight of Structural 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 should be tested for minimum air entrainment in freeze/thaw areas.

[Air Content

] Slump Tests

Water

SD-07 Certificates

Reinforcing Bars

Welder Qualifications

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

[Silica Fume Manufacturer's Representative

][VOC Content for Form Release Agents, Curing Compounds, and Concrete Penetrating Sealers

] Material Safety Data Sheets

Forest Stewardship Council (FSC) Certification

Field Testing Technician and Testing Agency

SD-08 Manufacturer's Instructions

Liquid Chemical Floor Hardener

[Curing Compound

]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.

****

Follow ACI 301, ACI 304R and ASTM A934/A934M requirements and recommendations. Do not deliver concrete until vapor retarder, [vapor barrier,] forms, reinforcement, embedded items, and chamfer strips are in place and ready for concrete placement. 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 such as, nylon slings, 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 347. Include design calculations indicating arrangement of forms, sizes and grades of supports (lumber), panels, and related components. Furnish drawings and calculations of shoring and re-shoring methods proposed for floor and roof slabs, spandrel beams, and other horizontal concrete members. Calculations must indicate concrete pressure with both live and dead loads, along with material types.

]1.6.1.2 Concrete Mix Design

****

NOTE: Silica Fume may only be used for OCONUS projects where Class F fly ash and GGBF slag are not

available, after approval by the Contracting Officer. Guidance for use of silica fume should be sought from the agency's Subject Matter Expert in Concrete Materials.

****

Sixty 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, complementary cementitious materials, [polypropylene fibers], and admixtures; and applicable reference specifications. Submit mill test and all other test for cement, complementary cementitious materials, aggregates, and admixtures. Provide documentation of maximum nominal aggregate size, gradation analysis, percentage retained and passing sieve, and a graph of percentage retained verses sieve size. Provide mix proportion data using at least three different water-cementitious material ratios for each type of mixture, which produce a range of strength encompassing those required for each 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. Resubmit data on concrete components if the qualities or source of components changes. For previously approved concrete mix designs used within the past twelve months, the previous mix design may be re-submitted without further trial batch testing if accompanied by material test data conducted within the last six months. Obtain mix design approval from the contracting officer prior to concrete placement.

1.6.2 Shop Drawings

[1.6.2.1 Formwork

Drawings showing details of formwork including, but not limited to; joints, supports, studding and shoring, and sequence of form and shoring removal. Indicate placement schedule, construction, location and method of forming control joints. Include locations of inserts, conduit, sleeves and other embedded items. Reproductions of contract drawings are unacceptable. Submit form removal schedule indicating element and minimum length of time for form removal.

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.

]1.6.2.2 Reinforcing Steel

ACI SP-66. Indicate bending diagrams, assembly diagrams, splicing and laps of bars, shapes, dimensions, and details of bar reinforcing, accessories, and concrete cover. Do not scale dimensions from structural drawings to determine lengths of reinforcing bars. Reproductions of contract drawings are unacceptable.

[1.6.3 Control Submittals

[1.6.3.1 Concrete Curing Plan

Submit proposed materials, methods and duration for curing concrete

elements in accordance with ACI 308.1.

][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.
****

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 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.

]1.6.3.6 Material Safety Data Sheets

Submit Material Safety Data Sheets (MSDS) for all materials that are regulated for hazardous health effects. MSDS must be readily accessible during each work shift to employees when they are at the construction site.

]1.6.4 Test Reports

1.6.4.1 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.

1.6.4.2 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.

[1.6.4.3 Aggregates

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

ASTM C1260 for potential alkali-silica reactions, ASTM C295/C295M for petrographic analysis.

][1.6.4.4 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. Slab finish sample must not be part of the final project. Finish as required by specification. [Silica fume manufacturer's representative must attend and advise.]

]1.6.5.2 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 m by one m, 75 mm 3 feet 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.

1.6.6 Quality Control Plan

****
NOTE: The objective of the concrete quality control

program is for the Contractor to outline the procedures that will be used to construct a structure that will obtain the design service life.

****

Develop and submit for approval a concrete quality control program in accordance with the guidelines of ACI 121R and as specified herein. The plan must include approved laboratories. Provide direct oversight for the concrete qualification program inclusive of associated sampling and testing. All quality control reports must be provided to the Contracting Officer, Quality Manager and Concrete Supplier. Maintain a copy of ACI SP-15 and CRSI 10MSP at project site.

1.6.7 Quality Control Personnel Certifications

The Contractor must submit for approval the responsibilities of the various quality control personnel, including the names and qualifications of the individuals in those positions and a quality control organizational chart defining the quality control hierarchy and the responsibility of the various positions. Quality control personnel must be employed by the Contractor.

Submit American Concrete Institute certification for the following:

a. CQC personnel responsible for inspection of concrete operations.

b. Lead Foreman or Journeyman of the Concrete Placing, Finishing, and Curing Crews.

c. Field Testing Technicians: ACI Concrete Field Testing Technician, Grade I.

1.6.7.1 Quality Manager Qualifications

The quality manager must hold a current license as a professional engineer in a U.S. state or territory with experience on at least five (5) similar projects. Evidence of extraordinary proven experience may be considered by the Contracting Officer as sufficient to act as the Quality Manager.

1.6.7.2 Field Testing Technician and Testing Agency

Submit data on qualifications of proposed testing agency and technicians for approval by the Contracting Officer prior to performing testing on concrete.

a. Work on concrete under this contract must be performed by an ACI Concrete Field Testing Technician Grade 1 qualified in accordance with ACI SP-2 or equivalent. Equivalent certification programs must include requirements for written and performance examinations as stipulated in ACI SP-2.

b. Testing agencies that perform testing services on reinforcing steel must meet the requirements of ASTM E329.

c. Testing agencies that perform testing services on concrete materials must meet the requirements of ASTM C1077.

1.6.8 Laboratory Qualifications for Concrete Qualification Testing

The concrete testing laboratory must have the necessary equipment and experience to accomplish required testing. The laboratory must meet the requirements of ASTM C1077 and be Cement and Concrete Reference Laboratory (CCRL) inspected.

1.6.9 Laboratory Accreditation

Laboratory and testing facilities must be provided by and at the expense of the Contractor. The laboratories performing the tests must be accredited in accordance with ASTM C1077, including ASTM C78/C78M and ASTM C1260. The accreditation must be current and must include the required test methods, as specified. Furthermore, the testing must comply with the following requirements:

****

NOTE: Use second set of brackets for OCONUS projects to specify alternate licensinc requirement where a registered U.S. professional would not be feasible.

****

a. Aggregate Testing and Mix Proportioning: Aggregate testing and mixture proportioning studies must be performed by an accredited laboratory and under the direction of a [registered professional engineer in a U.S. state or territory competent in concrete materials][_____] who is competent in concrete materials and must sign all reports and designs.

b. Acceptance Testing: Furnish all materials, labor, and facilities required for molding, curing, testing, and protecting test specimens at the site and in the laboratory. Furnish and maintain boxes or other facilities suitable for storing and curing the specimens at the site while in the mold within the temperature range stipulated by ASTM C31/C31M.

c. Contractor Quality Control: All sampling and testing must be performed by an approved, onsite, independent, accredited laboratory.

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 period or for 72 hours after installation:

a. Supply 100 percent outside air 24 hours a day.

b. Supply airflow at a rate of 6 air changes per hour, when outside temperatures are between 13 degrees C 55 degrees F and 29 degrees C 84 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.] [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.

]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 WELDING WORK

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.

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 NIST PS 1, B-B concrete form panels or better or AHA A135.4, hardboard for smooth form lining.[Submit data verifying that composite wood products contain no urea formaldehyde resins.][Virgin wood used 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

Provide a form tie system that does not leave mild steel after break-off or removal any closer than 50 mm 2 inches from the exposed surface. Do not use wire alone. Form ties and accessories must not reduce the effective cover of the reinforcement.

2.2.1 Waterstops

2.2.1.1 PVC Waterstop

Polyvinylchloride waterstops must conform to COE CRD-C 572.

2.2.1.2 Rubber Waterstop

Rubber waterstops must conform to COE CRD-C 513.

2.2.1.3 Thermoplastic Elastomeric Rubber Waterstop

Thermoplastic elastomeric rubber waterstops must conform to ASTM D471.

2.2.1.4 Hydrophilic Waterstop

Swellable strip type compound of polymer modified chloroprene rubber that swells upon contact with water must conform to ASTM D412 as follows: Tensile strength 2.9 MPa 420 psi minimum; ultimate elongation 600 percent minimum. Hardness must be 50 minimum on the type A durometer and the volumetric expansion ratio in distilled water at 20 degrees C 70 degrees F must be 3 to 1 minimum.

2.2.2 Dovetail Anchor Slot

Preformed metal slot approximately 25 mm by 25 mm 1 inch 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.

2.2.3 Perimeter Insulation

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

Perimeter insulation must be polystyrene conforming to ASTM C578, Type II; polyurethane conforming to ASTM C591, Type II; or cellular glass conforming to ASTM C552, Type I or IV. Comply with EPA requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING.

2.3 CONCRETE MIX DESIGN

[2.3.1 Contractor's Option for Material Only

****
NOTE: 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: Refer to ACI 318 Chapter 4 for guidance on the minimum f'c, maximum water-cementitious material ratio, and air content based on the exposure class and nominal maximum aggregate size.

****

ACI 211.1, ACI 301, and ACI 318 [and ACI 211.2] ACI 304.2R [and] [ACI 213R] except as otherwise specified. Indicate the compressive strength (f'c) of the concrete for each portion of the structure(s) as specified below. Where faster set time is required, use Type III cement before using calcium chloride with approval from the contracting officer.

****
NOTE: Typically concrete strength is specified at 28 days; however, the Contracting Officer and Engineer of Record are encouraged to consider specifying strength at 56 or 90 days for structures that may take a year or more to complete. Doing so will better allow the Contractor to develop and place concrete mixtures with less portland cement. Excessive use of cement leads to more cracks and shorter-lived structures. Embracing this approach will result in structures that are less expensive, greener and more sustainable. For high-volume fly ash concrete mixtures, mixtures where fly ash replacement of portland cement is greater than 50 percent by weight, the duration must be a minimum of

56 days.
****

2.3.2.1 Footings

Proportion normal-weight concrete mixture as follows:

a. Minimum Compressive Strength: [34.5 MPa 5000 psi][31 MPa 4500 psi][27.6 MPa 4000 psi][24.1 MPa 3500 psi][20.7 MPa 3000 psi] [_____] at 28 [56][90] days.

b. Maximum Water-Cementitious Materials Ratio: [0.50] [0.45] [0.40] [_____].

c. Slump Limit: [100 mm 4 inches][125 mm 5 inches][200 mm 8 inches for concrete with verified slump of 50 to 100 mm 2 to 4 inches before adding high-range water-reducing admixture or plasticizing admixture] [_____], plus or minus 25 mm 1 inch.

[d. Air Content: [5.5] [_____] percent, plus or minus 1.5 percent at point of delivery for 38 mm 1-1/2 inch nominal maximum aggregate size.

] e. Air Content: [6] [_____] percent, plus or minus 1.5 percent at point of delivery for[25 mm 1 inch][19 mm 3/4-inch] nominal maximum aggregate size.

2.3.2.2 Foundation Walls

Proportion normal-weight concrete mixture as follows:

a. Minimum Compressive Strength: [34.5 MPa 5000 psi][31 MPa 4500 psi][27.6 MPa 4000 psi][24.1 MPa 3500 psi][20.7 MPa 3000 psi] [_____] at 28 [56][90] days.

b. Maximum Water-Cementitious Materials Ratio: [0.50] [0.45] [0.40] [_____].

c. Slump Limit: [100 mm 4 inches][125 mm 5 inches][200 mm 8 inches for concrete with verified slump of 50 to 100 mm 2 to 4 inches before adding high-range water-reducing admixture or plasticizing admixture] [_____], plus or minus 25 mm 1 inch.

[d. Air Content: [5.5] [_____] percent, plus or minus 1.5 percent at point of delivery for 38 mm 1-1/2 inch nominal maximum aggregate size.

] e. Air Content: [6] [_____] percent, plus or minus 1.5 percent at point of delivery for[25 mm 1 inch][19 mm 3/4 inch] nominal maximum aggregate size.

2.3.2.3 Slab-on-Grade

Proportion normal-weight concrete mixture as follows:

a. Minimum Compressive Strength: [34.5 MPa 5000 psi][31 MPa 4500 psi][27.6 MPa 4000 psi][24.1 MPa 3500 psi][20.7 MPa 3000 psi] [_____] at 28 [56][90] days.

b. Maximum Water-Cementitious Materials Ratio: [0.50] [0.45] [0.40] [_____].

c. Slump Limit: [100 mm 4 inches][125 mm 5 inches][200 mm 8 inches for concrete with verified slump of 50 to 100 mm 2 to 4 inches before adding high-range water-reducing admixture or plasticizing admixture] [_____], plus or minus 25 mm 1 inch.

[d. Air Content: [5.5] [_____] percent, plus or minus 1.5 percent at point of delivery for 38 mm 1-1/2 inch nominal maximum aggregate size.

] e. Air Content: [6] [_____] percent, plus or minus 1.5 percent at point of delivery for[25 mm 1 inch][19 mm 3/4 inch] nominal maximum aggregate size.

f. Air Content: Do not allow air content of trowel-finished floors to exceed 3 percent.

g. Synthetic Micro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than[0.60 kg/cu. m 1.0 lb/cu. yd.][0.90 kg/cu. m 1.5 lb/cu. yd.] [_____].

h. Synthetic Macro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than[2.4 kg/cu. m 4.0 lb/cu. yd.][3 kg/cu. m 5 lb/cu. yd.] [_____].

2.3.2.4 Suspended Slabs

Proportion normal-weight concrete mixture as follows:

a. Minimum Compressive Strength: [34.5 MPa 5000 psi][31 MPa 4500 psi][27.6 MPa 4000 psi][24.1 MPa 3500 psi][20.7 MPa 3000 psi] [_____] at 28 [56][90] days.

b. Maximum Water-Cementitious Materials Ratio: [0.50] [0.45] [0.40] [_____].

c. Slump Limit: [100 mm 4 inches][125 mm 5 inches][200 mm 8 inches] for concrete with verified slump of 50 to 100 mm 2 to 4 inches before adding high-range water-reducing admixture or plasticizing admixture [_____], plus or minus 25 mm 1 inch.

[d. Air Content: [5.5] [_____]percent, plus or minus 1.5 percent at point of delivery for 38 mm 1-1/2 inch nominal maximum aggregate size.

] e. Air Content: [6] [_____]percent, plus or minus 1.5 percent at point of delivery for[25 mm 1 inch][19 mm 3/4 inch] nominal maximum aggregate size.

f. Air Content: Do not allow air content of trowel-finished floors to exceed 3 percent.

g. Synthetic Micro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than[0.60 kg/cu. m 1.0 lb/cu. yd.][0.90 kg/cu. m 1.5 lb/cu. yd.] [_____].

h. Synthetic Macro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than[2.4 kg/cu. m 4.0 lb/cu. yd.][3 kg/cu. m 5 lb/cu. yd.] [_____].

****

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

****

Proportion structural lightweight concrete mixture as follows:

a. Minimum Compressive Strength: [34.5 MPa 5000 psi][31 MPa 4500 psi][27.6 MPa 4000 psi][24.1 MPa 3500 psi][20.7 MPa 3000 psi][_____] at 28 [56][90] days.

b. Calculated Equilibrium Unit Weight: [1842 kg/cu. m 115 lb/cu. ft][1762 kg/cu. m 110 lb/cu. ft.][1682 kg/cu. m 105 lb/cu. ft.], plus or minus 48.1 kg/cu. m 3 lb/cu. ft. as determined by ASTM C567/C567M.

c. Slump Limit: [100 mm 4 inches][125 mm 5 inches][200 mm 8 inches] for concrete with verified slump of 50 to 100 mm 2 to 4 inches before adding high-range water-reducing admixture or plasticizing admixture [_____], plus or minus 25 mm 1 inch.

[d. Air Content: 6 percent, plus or minus 2 percent at point of delivery for nominal maximum aggregate size greater than 10 mm 3/8 inch.

] e. Air Content: 7 percent, plus or minus 2 percent at point of delivery for nominal maximum aggregate size 10 mm 3/8 inch or less.

f. Air Content: Do not allow air content of trowel-finished floors to exceed 3 percent.

g. Synthetic Micro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than[0.60 kg/cu. m 1.0 lb/cu. yd.][0.90 kg/cu. m 1.5 lb/cu. yd.] [_____].

h. Synthetic Macro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than[2.4 kg/cu. m 4.0 lb/cu. yd.][3 kg/cu. m 5 lb/cu. yd.] [_____].

2.3.2.5 Concrete Toppings

Proportion normal-weight concrete mixture as follows:

a. Minimum Compressive Strength: [34.5 MPa 5000 psi][31 MPa 4500 psi][27.6 MPa 4000 psi][24.1 MPa 3500 psi][20.7 MPa 3000 psi][_____] at 28 [56][90] days.

b. Maximum Water-Cementitious Materials Ratio: [0.50] [0.45] [0.40] [_____].

c. Slump Limit: [100 mm 4 inches][125 mm 5 inches][200 mm 8 inches for concrete with verified slump of 50 to 100 mm 2 to 4 inches before adding high-range water-reducing admixture or plasticizing admixture] [_____], plus or minus 25 mm 1 inch.

[d. Air Content: [5.5] [_____]percent, plus or minus 1.5 percent at point of delivery for 38 mm 1-1/2 inch nominal maximum aggregate size.

] e. Air Content: [6] [_____]percent, plus or minus 1.5 percent at point of delivery for[25 mm 1 inch][19 mm 3/4 inch] nominal maximum aggregate size.

f. Air Content: Do not allow air content of trowel-finished floors to exceed 3 percent.

g. Synthetic Micro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than[0.60 kg/cu. m 1.0 lb/cu. yd.][0.90 kg/cu. m 1.5 lb/cu. yd.] [_____].

h. Synthetic Macro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than[2.4 kg/cu. m 4.0 lb/cu. yd.][3 kg/cu. m 5 lb/cu. yd.] [_____].

2.3.2.6 Building Frame Members

Proportion normal-weight concrete mixture as follows:

a. Minimum Compressive Strength: [34.5 MPa 5000 psi][31 MPa 4500 psi][27.6 MPa 4000 psi][24.1 MPa 3500 psi][20.7 MPa 3000 psi] [_____] at 28 [56][90] days.

b. Maximum Water-Cementitious Materials Ratio: [0.50] [0.45] [0.40] [_____].

c. Slump Limit: [100 mm 4 inches][125 mm 5 inches][200 mm 8 inches for concrete with verified slump of 50 to 100 mm 2 to 4 inches before adding high-range water-reducing admixture or plasticizing admixture] [_____], plus or minus 25 mm 1 inch.

[d. Air Content: [5.5] [_____]percent, plus or minus 1.5 percent at point of delivery for 38 mm 1-1/2 inch nominal maximum aggregate size.

] e. Air Content: [6] [_____]percent, plus or minus 1.5 percent at point of delivery for[25 mm 1 inch][19 mm 3/4 inch] nominal maximum aggregate size.

2.3.2.7 Building Walls

Proportion normal-weight concrete mixture as follows:

a. Minimum Compressive Strength: [34.5 MPa 5000 psi][31 MPa 4500 psi][27.6 MPa 4000 psi][24.1 MPa 3500 psi][20.7 MPa 3000 psi] [_____] at 28 [56][90] days.

b. Maximum Water-Cementitious Materials Ratio: [0.50] [0.45] [0.40] [_____].

c. Slump Limit: [100 mm 4 inches][125 mm 5 inches][200 mm 8 inches for concrete with verified slump of 50 to 100 mm 2 to 4 inches before adding high-range water-reducing admixture or plasticizing admixture] [_____], plus or minus 25 mm 1 inch.

[d. Air Content: [5.5] [_____]percent, plus or minus 1.5 percent at point of delivery for 38 mm 1-1/2 inch nominal maximum aggregate size.

] e. Air Content: [6] [_____]percent, plus or minus 1.5 percent at point of delivery for[25 mm 1 inch][19 mm 3/4 inch] nominal maximum aggregate size.

Maximum slump may be increased 25 mm 1 inch for methods of consolidation

other than vibration.[Provide air entrainment using air-entraining admixture.]

2.3.2.8 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 211.1. In the trial mixture, use at least three different water-cementitious material 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-cementitious material ratio allowed must be based on equivalent water-cementitious material ratio calculations as determined by the conversion from the weight ratio of water to cement plus pozzolan 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-cementitious material 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, 28, [56,][90] days. From these results, plot a curve showing the relationship between water-cementitious material ratio and strength for each set of trial mix studies. In addition, plot a curve showing the relationship between 7 and 28 [56,][90] day strengths.

[2.3.2.9 Lightweight Concrete Proportion

ACI 211.2, using weight method. Provide ASTM C330/C330M aggregates for concrete.

]2.3.2.10 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 301, but may not exceed the specified strength at the same age by more than 20 percent. 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 301.

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 and complementary cementitious materials 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 cementitious material ratio

2.3.4 Concrete Curing Materials

Provide concrete curing material in accordance with ACI 301 Section 5 and ACI 308.1 Section 2. Submit product data for concrete curing compounds. Submit manufactures instructions for placement of curing compound.

2.4 MATERIALS

2.4.1 Cementitious Materials

****

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.**
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. Confer with the agency's Subject Matter Expert in Concrete Materials before specifying Type III cement.**

ASTM C150/C150M Portland	ASTM C595/C595M Blended	Use
Type V	None.	For use when high sulfate resistance is required.

For concrete subjected to salt water, near salt water or exposed to alkali/sulfate soils use specification Section 03 31 29 MARINE CONCRETE.

****

****

NOTE: For NAVFAC 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 33 29 SUSTAINABILITY REPORTING and include additive options unless designer determines that justification for non-use exists.

****

For exposed concrete, use one manufacturer and one source for each type of cement, ground slag, fly ash, and pozzolan.

2.4.1.1 Fly Ash

****

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 fly ash be used as a replacement for 35 percent of the cement. Class C fly ash is not permitted.

****

ASTM C618, Class F, except that the maximum allowable loss on ignition must not exceed [3][6] percent. Class F fly ash for use in mitigating Alkali-Silica Reactivity must have a Calcium Oxide (CaO) content of less than 8 percent and a total equivalent alkali content less than 1.5 percent.

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/C311M. Evaluate and classify fly ash in accordance with ASTM D5759.

2.4.1.2 Raw or Calcined Natural Pozzolan

Natural pozzolan must be raw or calcined and conform to ASTM C618, Class N, including the optional requirements for uniformity and effectiveness in controlling Alkali-Silica reaction and must have an ignition loss not exceeding 3 percent. Class N pozzolan for use in mitigating Alkali-Silica Reactivity must have a Calcium Oxide (CaO) content of less than 13 percent and total equivalent alkali content less than 3 percent.

2.4.1.3 Ultra Fine Fly Ash and Ultra Fine Pozzolan

Ultra Fine Fly Ash (UFFA) and Ultra Fine Pozzolan (UFP) must conform to ASTM C618, Class F or N, and the following additional requirements:

a. The strength activity index at 28 days of age must be at least 95 percent of the control specimens.

b. The average particle size must not exceed 6 microns.

c. The sum of $SiO_2 + Al_2O_3 + Fe_2O_3$ must be greater than 77 percent.

2.4.1.4 Ground Granulated Blast-Furnace Slag

ASTM C989/C989M, Grade [100] [120]. Slag content must be a minimum of [25][50][70] percent by weight of cementitious material.

[2.4.1.5 Silica Fume

****
NOTE: Silica Fume must only be used for OCONUS projects where Class F fly ash and GGBF slag are not available, and when approved by the Contracting Officer. Guidance for use of silica fume should be sought from the agency's Subject Matter Expert in Concrete Materials.
****

****
NOTE: 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.
****

Silica fume must conform to ASTM C1240, including the optional limits on reactivity with cement alkalis. Silica fume may be furnished as a dry, densified material or as slurry. Proper mixing is essential to accomplish proper distribution of the silica fume and avoid agglomerated silica fume which can react with the alkali in the cement resulting in premature and extensive concrete damage. Supervision at the batch plant, finishing, and curing is essential. Provide at the Contractor's expense the services of a

manufacturer's technical representative, experienced in mixing, proportioning, placement procedures, and curing of concrete containing silica fume. This representative must be present on the project prior to and during at least the first 4 days of concrete production and placement using silica fume. A High Range Water Reducer (HRWR) must be used with silica fume.

]2.4.1.6 Portland Cement

****

NOTE: If high early strength concrete is required, specify Type III after consulting the agency's Subject Matter Expert in Concrete Materials.

When concrete is exposed to sea water use specification Section 03 31 29 MARINE CONCRETE.

When high-volume fly ash mixtures, mixtures where fly ash replacement of portland cement is greater than 50 percent by weight, are specified they may be blended with Type II or Type III cement for higher early strength. Consult the agency's Subject Matter Expert in Concrete Materials prior to using Type III cement.

Low alkali cement or Type II cement with high SCM content may be required if the proposed aggregates are found to be expansive.

****

Provide cement that conforms to ASTM C150/C150M, Type [I][II][III], [low alkali] [including false set requirements] with tri-calcium aluminates (C3A) content less than 10 percent and a maximum cement-alkali content of 0.80 percent Na2Oe (sodium oxide) equivalent.. Use one brand and type of cement for formed concrete having exposed-to-view finished surfaces.

[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.

]2.4.1.7 Blended Cements

Blended cement must conform to ASTM C595/C595M and ASTM C1157/C1157M, Type IP or IS, including the optional requirement for mortar expansion [and sulfate soundness] and consist of a mixture of ASTM C150/C150M Type I, or Type II cement and a complementary cementing material. The slag added to the Type IS blend must be ASTM C989/C989M ground granulated blast-furnace slag. The pozzolan added to the Type IP blend must be ASTM C618 Class F and must be interground with the cement clinker. The manufacturer must state in writing that the amount of pozzolan in the finished cement will not vary more than plus or minus 5 mass percent of the finished cement from lot-to-lot or within a lot. The percentage and type of mineral admixture used in the blend must not change from that submitted for the aggregate evaluation and mixture proportioning.

2.4.2 Water

Water must comply with the requirements of ASTM C1602/C1602M. Minimize the amount of water in the mix. Improve workability by adjusting the grading rather than by adding water. Water must be [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. Submit test report showing water complies with ASTM C1602/C1602M.

2.4.3 Aggregates

****

NOTE: Include the first bracketed item on large concrete projects, where concrete is exposed to 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 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-cementitious materialratio of 0.45. Aggregates must meet the following requirements."

When using Alkali-Reactive Aggregates, follow curing requirements detailed in the Note in the section entitled, "CURING AND PROTECTION".

****

****

NOTE: <u>Environmentally-responsible Materials</u>

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. Submit test report showing compliance with ASTM C33/C33M.

[Fine and coarse aggregates must show expansions less than 0.08 percent at 28 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 28 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

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. Submit product data for admixtures used in concrete.

[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.]

[2.4.6 Vapor Retarder [and Vapor Barrier]

****

NOTE: Edit title to correct choice. Use first paragraph where vapor retarder is required to minimize vapor transmission through the concrete and a permanent vapor barrier is not required. Select second bracketed option where permanent vapor barrier is required. Vapor barriers should only be used where required due to the required moisture content of the slab for floor covering adhesion and as required for quality concrete, see ACI 360R, figure 4.7 for guidance when a vapor retarder is needed. For protection against hydrostatic pressure or conditions of excessive dampness, specify an appropriate waterproofing membrane in Division 7.

****

ASTM E1745 Class C [A] [B] polyethylene sheeting, minimum 0.25 mm 10 mil[0.38 mm 15 mil] thickness or other equivalent material with a maximum

permeance rating of 0.04 perms per ASTM E96/E96M.

[ASTM E1745 Class C [A] [B] polyethylene sheeting, minimum 0.38 mm 15 mil thickness or ASTM E1993/E1993M bituminous membrane or other equivalent material with a maximum permeance rating of 0.01 perms per ASTM E96/E96M.]

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

]2.4.7 Expansion/Contraction Joint Filler

ASTM D1751 or ASTM D1752 Type I or II. Material must be 13 mm 1/2 inch thick[, unless otherwise indicated].

2.4.8 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.
****

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

]2.4.8.1 Horizontal Surfaces, 3 Percent Slope, Maximum

ASTM D6690 or ASTM C920, Type M, Class 25, Use T.

2.4.8.2 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, or other caustic liquids. 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 [NT].[FS SS-S-200, no sag].

[2.4.8.3 Preformed Polychloroprene Elastomeric Type

ASTM D2628.

2.4.8.4 Lubricant for Preformed Compression Seals

ASTM D2835.

][2.4.9 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. 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.

]2.5 REINFORCEMENT

2.5.1 Reinforcing Bars

****

NOTE: ASTM A706/A706M bars are mainly used in seismic design or for welding. Include ASTM A767/A767M for galvanized reinforcing bars.

****

****

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

****

ACI 301 unless otherwise specified. [Use deformed steel.] ASTM A615/A615M with the bars marked A, Grade [420][520][690] [60][75][100]; or ASTM A996/A996M with the bars marked R, Grade [350][420] [50][60], or marked A, Grade [300][420] [40][60]. [Cold drawn wire used for spiral reinforcement must conform to ASTM A1064/A1064M.] [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.] [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.] Submit mill certificates for reinforcing bars.

2.5.1.1 Galvanized Reinforcing Bars

Provide galvanized reinforcing bars that conform to ASTM A767/A767M, Class II with galvanizing after 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 A934/A934M, Grade [60][75][100].

2.5.1.4 Stainless Steel Reinforcing Bars

ASTM A955/A955M.

2.5.2 Mechanical Reinforcing Bar Connectors

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

2.5.3 Wire

2.5.3.1 Welded Wire Reinforcement

ASTM A1064/A1064M. [Provide wire reinforcement that contains a minimum of [100][_____] percent recycled content.][See Section 01 33 29 LEED(tm) DOCUMENTATION for cumulative total recycled content requirements. Wire reinforcement may contain post-consumer or post-industrial recycled content.] Provide flat sheets of welded wire reinforcement for slabs and toppings.

2.5.3.2 Steel Wire

Wire must conform to ASTM A1064/A1064M.

2.5.4 Reinforcing Bar Supports

Supports include bolsters, chairs, spacers, and other devices necessary for proper spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. [Use engineered resins from recycled ABS plastic, polycarbonates, and fiberglass.]

Provide wire bar type supports of coated or non-corrodible material conforming to ACI SP-66 and CRSI 10MSP. [For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar support.][For zinc-coated reinforcement, use galvanized wire or dielectric-polymer coated wire bar supports.]

****
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.

[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.

]2.5.5 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 Dowels for Load Transfer in Floors

Provide greased 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.

[Plate dowels must conform to ASTM A36/A36M, and must be of size and spacing indicated. Plate dowel system must minimize shrinkage restraint by [using a tapered shape] [or] [formed void] [or] [by having compressible material on the vertical faces with a thin bond breaker on the top and bottom dowel surfaces.]

]2.6 FLOOR FINISH MATERIALS

2.6.1 Liquid Chemical Floor Hardener

Hardener must be a colorless aqueous solution containing a blend of inorganic silicate or siliconate material and proprietary components combined with a wetting agent; that penetrates, hardens, and densifies concrete surfaces. Submit manufactures instructions for placement of liquid chemical floor hardener.

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

]2.6.2 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.

]2.6.3 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.

]2.6.4 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.

]2.6.5 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

SIEVE	PERCENT PASSING
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.

PART 3 EXECUTION

3.1 EXAMINATION

Do not begin installation until substrates have been properly constructed; verify that substrates are level.

If substrate preparation is the responsibility of another installer, notify Contracting Officer of unsatisfactory preparation before processing.

Check field dimensions before beginning installation. If dimensions vary too much from design dimensions for proper installation, notify Contracting Officer 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, or seal subgrade surface by covering surface with specified vapor retarder. When subgrade material is porous, seal subgrade surface by covering surface with specified vapor retarder.

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.

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.

3.2.4 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.

3.2.5 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

Provide forms, shoring, and scaffolding for concrete placementin accordance with ACI 301 Section 2 and 5 and ACI 347. 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.

3.3.1 Coating

Before concrete placement, coat the contact surfaces of forms with a form release agent.

3.3.2 Reshoring

Reshore concrete elements in accordance with ACI 301 Section 2.

3.3.3 Reuse

Reuse forms providing the structural integrity of concrete and the aesthetics of exposed concrete are not compromised. Wood forms must not be clogged with paste and must be capable of absorbing high water-cementitious material ratio paste.

3.3.4 Forms for Standard Rough Form Finish

Provide formwork in accordance with ACI 301 Section 5 with a surface finish, SF-1.0, for formed surfaces that are to be concealed by other construction.

3.3.5 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. Select bracketed line for no mockup of the form finish otherwise mockup is required per ACI 301.

****

Provide formwork in accordance with ACI 301 Section 5 with a surface finish, SF-3.0, for formed surfaces that are exposed to view. [Do not provide mockup of concrete surface appearance and texture.]

3.3.6 Form Ties

Provide ties in accordance with ACI 301 section 2.

3.3.7 Forms for Concrete Pan Joist Construction

Pan-form units for one-way or two-way concrete joist and slab construction must be factory-fabricated units of the approximate section indicated. Units must consist of steel or molded fiberglass concrete form pans. Closure units must be furnished as required.

3.3.8 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 301 Section 5 and ACI 117.

3.3.9 Removal of Forms and Supports

After placing concrete, removal of forms must be in accordance with ACI 301 Section 2 except as modified by approved form removal schedule.

3.4 WATERSTOP INSTALLATION AND SPLICES

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. Protect waterstops protruding from joints from damage.

3.4.1 PVC Waterstop

Make splices by heat sealing the adjacent waterstop edges together using a thermoplastic splicing iron utilizing a non-stick surface specifically designed for waterstop welding. Reform waterstops at splices with a remolding iron with ribs or corrugations to match the pattern of the

waterstop. The spliced area, when cooled, must show no signs of separation, holes, or other imperfections when bent by hand in as sharp an angle as possible.

3.4.2 Rubber Waterstop

Rubber waterstops must be spliced using cold bond adhesive as recommended by the manufacturer.

3.4.3 Thermoplastic Elastomeric Rubber Waterstop

Fittings must be shop made using a machine specifically designed to mechanically weld the waterstop. A portable power saw must be used to miter or straight cut the ends to be joined to ensure good alignment and contact between joined surfaces. Maintain continuity of the characteristic features of the cross section of the waterstop (for example ribs, tabular center axis, and protrusions) across the splice.

3.4.4 Hydrophilic Waterstop

Miter cut ends to be joined with sharp knife or shears. The ends must be adhered with adhesive.

3.5 PLACING REINFORCEMENT AND MISCELLANEOUS MATERIALS

ACI 301 and ACI SP-66. Provide bars, welded wire reinforcement, 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.

3.5.1 General

Provide details of reinforcement that are in accordance with ACI 301 and ACI SP-66 and as specified.

3.5.2 Vapor Retarder [and Vapor Barrier]

****
NOTE: Locate vapor retarder below the slab-on-grade per ACI 360R, figure 4.7.
****

Install in accordance with ASTM E1643. 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. 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.]

3.5.3 Perimeter Insulation

****
NOTE: When this paragraph is used, ensure that

drawings indicate location and extent of perimeter insulation.

****

Install perimeter insulation at locations indicated. Adhesive must be used where insulation is applied to the interior surface of foundation walls and may be used for exterior application.

3.5.4 Reinforcement Supports

Support reinforcement in accordance with ACI 301 Section 3. Supports for coated or galvanized bars must also be coated with electrically compatible material for a distance of at least 2 inches beyond the point of contact with the bars.

[3.5.5 Epoxy Coated Reinforcing

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

3.5.5.1 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 EPOXY COATED REINFORCING STEEL. 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.

]]3.5.6 Splicing

****

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

****

As indicated. For splices not indicated ACI 301. Do not splice at points of maximum stress. Overlap welded wire reinforcement 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.]

3.5.7 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.

3.5.8 Setting Miscellaneous Material

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

3.5.9 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 318 and ACI SP-66.

Provide hooks and bends that are in accordance with ACI 318 and ACI SP-66.

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 SP-66.

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.

3.5.10 Placing Reinforcement

Place reinforcement in accordance with ACI 301 and ACI SP-66.

For slabs on grade (over earth or over capillary water barrier) and for footing reinforcement, support bars or welded wire reinforcement 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.

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 have sufficient strength to carry the reinforcement they support, and in accordance with ACI 318, ACI SP-66 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 reinforcement 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.

Reinforcement must be accurately placed, securely tied at intersections, 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 SP-66.

Bending of reinforcing bars partially embedded in concrete is permitted only as specified in ACI SP-66 and ACI 318.

3.5.11 Spacing of Reinforcing Bars

Spacing must be as indicated. If not indicated, spacing must be in accordance with the ACI 318 and ACI SP-66.

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 preapproval by the Contracting Officer.

3.5.12 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. ACI 201.2R and ACI 303R require additional concrete protection for severe exposure conditions.

****

Concrete protection must be in accordance with the ACI 318 and ACI SP-66.

3.5.13 Welding

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

3.6 BATCHING, MEASURING, MIXING, AND TRANSPORTING CONCRETE

ASTM C94/C94M, ACI 301, ACI 302.1R and ACI 304R, 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.

3.6.1 Measuring

Make measurements at intervals as specified in paragraphs SAMPLING and TESTING.

3.6.2 Mixing

ASTM C94/C94M, ACI 301 and ACI 304R. 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-cementitious material ratio are not exceeded and the required concrete strength is still met. 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. Do not reconstitute concrete that has begun to solidify.

3.6.3 Transporting

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

3.7 PLACING CONCRETE

****
NOTE: When necessary to deposit concrete under water use specifications 03 31 29 MARINE CONCRETE.
****

Place concrete in accordance with ACI 301 Section 5.

[3.7.1 Footing Placement

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

][3.7.2 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 304R and ACI 304.2R. 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 at discharge/placement. 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.

[3.7.2.1 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 213R. 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 213R.]

]][3.7.3 Cold Weather

ACI 306.1. 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.

]3.7.4 Hot Weather

Maintain required concrete temperature using Figure 4.2 in ACI 305R 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.

3.7.5 Bonding

Surfaces of set concrete at joints, 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.

3.8 WASTE MANAGEMENT

Provide as specified in the Waste Management Plan and as follows.

3.8.1 Mixing Equipment

Before concrete pours, designate[Contractor-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.

****

NOTE: The use of crushed waste concrete as an

aggregate in the production of new concrete should follow the recommendations of ACI 555R.

****

3.8.2 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.

]3.8.3 Reinforcing Steel

Collect reinforcing steel and place in designated area for recycling.

3.8.4 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.]

3.9 SURFACE FINISHES EXCEPT FLOOR, SLAB, AND PAVEMENT FINISHES

3.9.1 Defects

Repair surface defects in accordance with ACI 301 Section 5.

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 117 and as indicated.

3.9.3.2 As-Cast Rough Form

Provide for surfaces not exposed to public view a surface finish SF-1.0. Patch holes and defects in accordance with ACI 301.

3.9.3.3 Standard Smooth Finish

Provide for surfaces exposed to public view a surface finish SF-3.0. Patch holes and defects in accordance with ACI 301.

3.9.4 [Smooth-Rubbed][Grout-Cleaned Rubbed][Cork-Floated][Exposed Aggregate] Finish

****

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

drawings and coordinated with the specifications.
****

[Provide a smooth-rubbed finish per ACI 301 Section 5 in the locations indciated.][Provide a grout-cleaned rubbed finish per ACI 301 Section 5 in the locations indicated.][Provide a cork-floated finish per ACI 301 Section 5 in the locations indicated.][Provide an exposed aggregate finish per ACI 301 Section 5 in the locations indicated.]

3.10 FLOOR, SLAB, AND PAVEMENT FINISHES AND MISCELLANEOUS CONSTRUCTION

****
NOTE: Where floor flatness is critical use paragraph FLAT FLOOR FINISHES. Coordinate concrete finish with applicable architectural finish material to be installed over concrete floor. For thin-set tile, coordinate with Section 09 30 10 CERAMIC, QUARRY, AND GLASS TILING
****

ACI 301 and ACI 302.1R, unless otherwise specified. Slope floors uniformly to drains where drains are provided. [Depress the concrete base slab where quarry tile, ceramic tile, [or] [_____] are indicated.] [Steel trowel and fine-broom finish concrete slabs that are to receive quarry tile, ceramic tile, or paver tile [_____].] Where straightedge measurements are specified, Contractor 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. Finish concrete in accordance with ACI 301 Section 5 for a scratched finish.

3.10.1.2 Floated

Use for [surfaces to receive [roofing,] [waterproofing membranes,] [sand bed terrazzo,]][_____] [and] [exterior slabs where not otherwise specified.] Finish concrete in accordance with ACI 301 Section 5 for a floated finish.

[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 302.1R suggests power troweling three times for Class 5 floors and where increased wear

resistance is needed.
****

Use for floors intended as walking surfaces[,] [and] for reception of floor coverings[, and] [_____]. Finish concrete in accordance with ACI 301 Section 5 for a steel troweled finish.

[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. Finish concrete in accordance with ACI 301 Section 5 for a dry-shake finish. 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. Finish concrete in accordance with ACI 301 Section 5 for a broomed finish.

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 (for example thin set tile and wood gymnasium floors) 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.

When specifying floors where flatness is important, adhere primarily to good concrete fundamentals, including equalizing hydration on top and bottom, reducing shrinkage prone cement paste content, and paying attention to curing protocol (slower is better).

****

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

3.11.1 Construction Joints

Make and locate joints not indicated so as not to impair strength and appearance of the structure, as approved. Joints must be perpendicular to main reinforcement. Reinforcement must be continued and developed across construction joints. Locate construction joints as follows:

3.11.1.1 Maximum Allowable Construction Joint Spacing

a. In walls at not more than 18.3 meter 60 feet in any horizontal direction.

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

3.11.1.2 Construction Joints for Constructability Purposes

a. In walls, 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.

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.

3.11.2 Isolation Joints in Slabs on Ground

****
NOTE: If inserts are to be used for slab on ground contraction joint use bracketed paragraph and remove pargraph related to sawcut joints.
****

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 inch in 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.

3.11.3 Contraction 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 reinforcement before placing concrete.

Sawcut contraction joints into slab on ground in accordance with ACI 301 Section 5.

[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. After concrete has cured for at least 7 days, the Contractor must remove inserts and clean groove of foreign matter and loose particles.
]

****
NOTE: Use the following barcketed sentence for projects in Hawaii.
****

[Sawcutting will be limited to within 12 hours after set and at 1/4 slab depth.

]3.11.4 Sealing Joints in Slabs on Ground

Contraction 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.

Sealed groove must be left ready to receive filling material that is provided as part of finish floor covering work.

3.12 CONCRETE FLOOR TOPPING

3.12.1 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.

Preparations Prior to Placing

When topping 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.

When topping 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 is placed.

When topping 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.

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.

****
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.

3.12.2 Heavy-Duty Floor Topping

****
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.
****

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.

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.

3.13 CURING AND PROTECTION

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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 when the cement and aggregates meet the requirements of the section entitled "AGGREGATES" (and Note on alkali-reactive aggregates).

Furnish a mix design utilizing alkali-reactive

aggregates with a maximum water-cementitious materialratio 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.

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ACI 301 Section 5, 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 [_____].

3.13.1 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.

3.13.2 Curing Periods

ACI 301 Section 5, except 10 days for retaining walls, pavement or chimneys. 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.

3.13.3 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.

3.13.4 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, as applicable.

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

3.13.5 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.

3.13.6 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.

3.13.7 Protection After Curing

Protect finished concrete surfaces from damage by construction operations.

3.14 FIELD QUALITY CONTROL

3.14.1 Sampling

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

3.14.2 Testing

3.14.2.1 Slump Tests

ASTM C143/C143M. Take concrete samples during concrete placement/discharge. The maximum slump may be increased as specified with the addition of an approved admixture provided that the water-cementitious material 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.

3.14.2.2 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.

3.14.2.3 Compressive Strength Tests

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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.

Use eight cylinders when specifying 56 or 90 day strengths. Use 6x12 cylinders for better prediction of strength and consistency.

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ASTM C39/C39M. Make six [eight] 150 mm by 300 mm 6 inch by 12 inch[100 mm by 200 mm 4 inch by 8 inch] test cylinders for each set of tests in accordance with ASTM C31/C31M, ASTM C172/C172M and applicable requirements of ACI 305R and ACI 306R. Take precautions to prevent evaporation and loss of water from the specimen. Test two cylinders at 7 days, two cylinders at 28 days, [two cylinders at 56 days][two cylinders at 90 days] and hold two 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 75 cubic meters 100 cubic yards of concrete for the first 380 cubic meters 500 cubic yards, then every 380 cubic meters 500 cubic yards thereafter, 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[56 days][90 days]. Concrete compressive tests must meet the requirements of ACI 318 Section 5.6. Retest locations represented by erratic core strengths. Where retest does not meet concrete compressive strength requirements submit a mitigation or remediation plan for review and approval by the contracting officer. Repair core holes with nonshrink grout. Match color and finish of adjacent concrete.

[3.14.2.4 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.

][3.14.2.5 Unit Weight of Structural Concrete

ASTM C567/C567M and ASTM C138/C138M. Determine unit weight of lightweight and normal weight concrete. Perform test for every 15 cubic meters 20 cubic yards maximum.

][3.14.2.6 Ion Concentration

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NOTE: Include only when justified by size of job or when quality of concrete is questionable.
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ACI 318. Determine water soluble ion concentration in accordance with ASTM C1218/C1218M. Perform test once for each mix design.

]3.14.2.7 Strength of Concrete Structure

The strength of the concrete structure will be considered to be deficient if any of the following conditions are identified:

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

Where the strength of the concrete structure is considered deficient submit a mitigation or remediation plan for review and approval by the contracting officer.

3.14.2.8 Non-Conforming Materials

Factors that indicate that there are non-conforming materials include (but not limited to) excessive compressive strength, inadequate compressive strength, excessive slump, excessive voids and honeycombing, concrete delivery records that indicate excessive time between mixing and placement, or excessive water was added to the mixture during delivery and placement. Any of these indicators alone are sufficient reason for the Contracting Officer to request additional sampling and testing.

Investigations into non-conforming materials must be conducted at the Contractor's expense. The Contractor must be responsible for the investigation and must make written recommendations to adequately mitigate or remediate the non-conforming material. The Contracting Officer may accept, accept with reduced payment, require mitigation, or require removal and replacement of non-conforming material at no additional cost to the

Government.

3.14.2.9 Testing Concrete Structure for Strength

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NOTE: If the government is going to take cores and test them then include the bracketed paragraph.
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When there is evidence that strength of concrete structure in place does not meet specification requirements or there are non-conforming materials, 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.

3.15 REPAIR, REHABILITATION AND REMOVAL

Before the Contracting Officer accepts the structure the Contractor must inspect the structure for cracks, damage and substandard concrete placements that may adversely affect the service life of the structure. A report documenting these defects must be prepared which includes recommendations for repair, removal or remediation must be submitted to the Contracting Officer for approval before any corrective work is accomplished.

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NOTE: Include this paragraph if the concrete structure is a water tank designed in accordance with ACI 530.
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[3.15.1 Crack Repair

Prior to final acceptance, all cracks in excess of 0.50 mm 0.02 inches wide must be documented and repaired. The proposed method and materials to

repair the cracks must be submitted to the Contracting Officer for approval. The proposal must address the amount of movement expected in the crack due to temperature changes and loading.

]3.15.2 Repair of Weak Surfaces

Weak surfaces are defined as mortar-rich, rain-damaged, uncured, or containing exposed voids or deleterious materials. Concrete surfaces with weak surfaces less than 6 mm 1/4 inch thick must be diamond ground to remove the weak surface. Surfaces containing weak surfaces greater than 6 mm 1/4 inch thick must be removed and replaced or mitigated in a manner acceptable to the Contracting Officer.

3.15.3 Failure of Quality Assurance Test Results

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NOTE: Test results accomplished on concrete samples during concrete production that fall short of the acceptance criteria alert the Contractor to something in the production and placement process that has drifted out of calibration or that an error has been made. The goal is to track down the problem and correct it as quickly as possible. Unless the concrete producer makes a large error in batching or in placing, the chance that hardened concrete needs to be removed is remote. Removal and replacement is a last resort.

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Proposed mitigation efforts by the Contractor must be approved by the Contracting Officer prior to proceeding.

-- End of Section --