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SECTION 03 30 00

CAST-IN-PLACE CONCRETE

02/19

PART 1 GENERAL.

1.1 REFERENCES.

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 (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 213R	(2014; E2017) Guide for Structural Lightweight-Aggregate Concrete
ACI 301	(2016) Specifications for Structural Concrete
ACI 302.1R	(2015) Guide for Concrete Floor and Slab Construction
ACI 304.2R	(2017) Guide to Placing Concrete by Pumping Methods
ACI 304R	(2000; R 2009) Guide for Measuring, Mixing, Transporting, and Placing Concrete
ACI 305.1	(2014) Specification for Hot Weather Concreting
ACI 305R	(2010) Guide to Hot Weather Concreting
ACI 306.1	(1990; R 2002) Standard Specification for Cold Weather Concreting
ACI 306R	(2016) Guide to Cold Weather Concreting
ACI 308.1	(2011) Specification for Curing Concrete
ACI 347R	(2014; Errata 1 2017) Guide to Formwork for Concrete
ACI SP-2	(2007; Abstract: 10th Edition) ACI Manual of Concrete Inspection
ACI SP-15	(2011) Field Reference Manual: Standard

Specifications for Structural Concrete ACI
301-05 with Selected ACI References

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 A36/A36M (2019) Standard Specification for Carbon
Structural Steel

ASTM A53/A53M (2018) Standard Specification for Pipe,
Steel, Black and Hot-Dipped, Zinc-Coated,
Welded and Seamless

ASTM A184/A184M (2019) Standard Specification for Welded
Deformed Steel Bar Mats for Concrete
Reinforcement

ASTM A615/A615M (2020) Standard Specification for Deformed
and Plain Carbon-Steel Bars for Concrete
Reinforcement

ASTM A706/A706M (2016) Standard Specification for
Low-Alloy Steel Deformed and Plain Bars
for Concrete Reinforcement

ASTM A767/A767M (2016) Standard Specification for
Zinc-Coated (Galvanized) Steel Bars for
Concrete Reinforcement

ASTM A775/A775M (2017) Standard Specification for
Epoxy-Coated Steel Reinforcing Bars

ASTM A780/A780M (2009; R 2015) Standard Practice for
Repair of Damaged and Uncoated Areas of
Hot-Dip Galvanized Coatings

ASTM A820/A820M (2016) Standard Specification for Steel
Fibers for Fiber-Reinforced Concrete

ASTM A884/A884M (2019) Standard Specification for
Epoxy-Coated Steel Wire and Welded Wire
Reinforcement

ASTM A934/A934M (2016) Standard Specification for
Epoxy-Coated Prefabricated Steel
Reinforcing Bars

ASTM A955/A955M (2020c) Standard Specification for
Deformed and Plain Stainless-Steel Bars
for Concrete Reinforcement

ASTM A970/A970M (2018) Standard Specification for Headed

	Steel Bars for Concrete Reinforcement
ASTM A996/A996M	(2016) Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
ASTM A1022/A1022M	(2016b) Standard Specification for Deformed and Plain Stainless Steel Wire and Welded Wire for Concrete Reinforcement
ASTM A1044/A1044M	(2016a) Standard Specification for Steel Stud Assemblies for Shear Reinforcement of Concrete
ASTM A1055/A1055M	(2016) Standard Specification for Zinc and Epoxy Dual Coated Steel Reinforcing Bars
ASTM A1060/A1060M	(2016b) Standard Specification for Zinc-Coated (Galvanized) Steel Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM A1064/A1064M	(2017) Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM C31/C31M	(2019a) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C39/C39M	(2020) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C42/C42M	(2020) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C78/C78M	(2018) Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C94/C94M	(2020) Standard Specification for Ready-Mixed Concrete
ASTM C138/C138M	(2017a) Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
ASTM C143/C143M	(2015) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2020) Standard Specification for Portland Cement
ASTM C172/C172M	(2017) Standard Practice for Sampling Freshly Mixed Concrete

ASTM C173/C173M	(2016) Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C231/C231M	(2017a) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C311/C311M	(2018) Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete
ASTM C330/C330M	(2017a) Standard Specification for Lightweight Aggregates for Structural Concrete
ASTM C494/C494M	(2019) Standard Specification for Chemical Admixtures for Concrete
ASTM C552	(2017; E 2018) Standard Specification for Cellular Glass Thermal Insulation
ASTM C567/C567M	(2019) Determining Density of Structural Lightweight Concrete
ASTM C578	(2019) Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation
ASTM C591	(2019a) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM C595/C595M	(2020) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2019) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C803/C803M	(2018) Standard Test Method for Penetration Resistance of Hardened Concrete
ASTM C845/C845M	(2018) Standard Specification for Expansive Hydraulic Cement
ASTM C873/C873M	(2015) Standard Test Method for Compressive Strength of Concrete Cylinders Cast in Place in Cylindrical Molds
ASTM C900	(2015) Standard Test Method for Pullout Strength of Hardened Concrete
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM C989/C989M	(2018a) Standard Specification for Slag Cement for Use in Concrete and Mortars

ASTM C1012/C1012M	(2018b) Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution
ASTM C1017/C1017M	(2013; E 2015) Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C1074	(2011) Standard Practice for Estimating Concrete Strength by the Maturity Method
ASTM C1077	(2017) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1107/C1107M	(2020) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM C1116/C1116M	(2010a; R 2015) Standard Specification for Fiber-Reinforced Concrete
ASTM C1157/C1157M	(2020) Standard Performance Specification for Hydraulic Cement
ASTM C1218/C1218M	(2017) Standard Test Method for Water-Soluble Chloride in Mortar and Concrete
ASTM C1240	(2020) 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 C1293	(2008; R 2015) Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction
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	(2018) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM C1778	(2016) Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete
ASTM D412	(2016) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D471	(2016a) Standard Test Method for Rubber Property - Effect of Liquids

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	(2018) Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D2628	(1991; R 2016) Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
ASTM D2835	(1989; R 2017) Standard Specification for Lubricant for Installation of Preformed Compression Seals in Concrete Pavements
ASTM D3042	(2017) Standard Test Method for Insoluble Residue in Carbonate Aggregates
ASTM D5759	(2012; R 2020) 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 E96/E96M	(2016) Standard Test Methods for Water Vapor Transmission of Materials
ASTM E329	(2020) Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection
ASTM E1155	(2014) Standard Test Method for Determining Floor Flatness and Floor Levelness Numbers
ASTM E1643	(2018a) 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	(2017) Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs
ASTM E1993/E1993M	(1998; R 2020) Standard Specification for Bituminous Water Vapor Retarders Used in Contact with Soil or Granular Fill Under Concrete Slabs

CONCRETE REINFORCING STEEL INSTITUTE (CRSI)

CRSI 10MSP	(2018) Manual of Standard Practice
CRSI RB4.1	(2016) Supports for Reinforcement Used in

Concrete

FOREST STEWARDSHIP COUNCIL (FSC)

FSC STD 01 001 (2015) 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, slag cement.
- 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, slag cement, 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 158 degrees F within the first 72 hours of placement. In addition, it includes all concrete elements with a section

thickness of 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.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the government officer that will review the submittal for the Government.

SD-01 Preconstruction Submittals

Concrete Curing Plan

Quality Control Plan; G, COR

Quality Control Personnel Certifications; G, COR

Quality Control Organizational Chart

Laboratory Accreditation; G, COR [

Form Removal Schedule; G, COR

SD-02 Shop Drawings

Reinforcing Steel; G, COR

SD-03 Product Data

Joint Sealants; (LEED NC)

Joint Filler; (LEED NC)

Formwork Materials

Recycled Aggregate Materials; (LEED NC)

Cementitious Materials; (LEED NC)

Vapor Retarder
Concrete Curing Materials
Reinforcement; (LEED NC)
Liquid Chemical Floor Hardeners and Sealers
Admixtures
Reinforcing Fibers
Mechanical Reinforcing Bar Connectors
Waterstops
Local/Regional Materials; (LEED NC)
Biodegradable Form Release Agent
Nonshrink Grout

SD-04 Samples

SD-05 Design Data

Concrete Mix Design; G, COR

SD-06 Test Reports

Aggregates
Compressive Strength Tests; G, COR
Air Content
Slump Tests
Water

SD-07 Certificates

Reinforcing Bars
Safety Data Sheets
Field Testing Technician and Testing Agency

SD-08 Manufacturer's Instructions

Joint Sealants; (LEED NC)
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 "Engineer," and the "Architect/Engineer" to mean the Contracting Officer.

1.5 DELIVERY, STORAGE, AND HANDLING.

Follow [ACI 301](#), [ACI 304R](#) and [ASTM A934/A934M](#) requirements and recommendations. Do not deliver concrete until vapor retarder, 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. Do not store concrete curing compounds or sealers in occupied spaces.

1.5.1 Reinforcement

1.5.2 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.

1.6 QUALITY CONTROL.

1.6.1 [Quality Control Plan](#)

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.

1.6.2 [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.

1.6.2.1 [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.

1.6.2.2 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.

1.6.2.3 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:

- 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 SUSTAINABLE DESIGN REQUIREMENTS.

1.7.1 Local/Regional Materials

Use materials or products extracted, harvested, or recovered, as well as manufactured, within a 500mile radius from the project site, if available from a minimum of three sources.

PART 2 PRODUCTS.

2.1 FORMWORK MATERIALS.

- a. Form-facing material in contact with concrete must be [lumber,] [plywood,] [tempered concrete-form-grade hardboard,] [metal,] [plastic,] or [treated paper that creates specified appearance and texture of concrete surface]. Submit product information on proposed form-facing materials if different from that specified herein.

- b. Design formwork, shores, reshores, and backshores to support loads transmitted to them and to comply with applicable building code requirements.
- c. Design formwork and shoring for load redistribution resulting from stressing of post-tensioned reinforcement. Ensure that formwork allows movement resulting from application of prestressing force.
- d. Design formwork to withstand pressure resulting from placement and vibration of concrete and to maintain specified tolerances.
- e. Design formwork to accommodate waterstop materials in joints at locations indicated in Contract Documents.
- f. Provide temporary openings in formwork if needed to facilitate cleaning and inspection.
- g. Design formwork joints to inhibit leakage of mortar.
- h. Limit deflection of facing materials for concrete surfaces exposed to view to 1/240 of center-to-center spacing of facing supports.
- i. Submit product information on proposed form-facing materials if different from that specified herein.
- j. Submit shop drawings for formwork, shoring, reshoring, and backshoring. Shop drawings must be signed and sealed by a licensed design engineer.
- k. Submit design calculations for shoring, reshoring, and backshoring. Design calculations must be signed and sealed by a licensed design engineer.
- l. Submit procedure for reshoring and backshoring, including drawings signed and sealed by a licensed design engineer. Include on shop drawings the formwork removal procedure and magnitude of construction loads used for design of reshoring or backshoring system. Indicate in procedure the magnitude of live and dead loads assumed for required capacity of the structure at time of reshoring or backshoring.
- n. Submit manufacturer's product data on form liner proposed for use with each formed surface.

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

2.1.1.1 Concrete Form Plywood (Standard Rough)

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

2.1.2 Plastic Forms

Provide plastic forms that contain a minimum of 50 percent post-consumer recycled content, or a minimum of 50 percent post-industrial recycled content.

2.1.3 Steel Forms

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

2.2 FORMWORK ACCESSORIES.

- a. Use commercially manufactured formwork accessories, including ties and hangers.
- b. Form ties and accessories must not reduce the effective cover of the reinforcement.

2.2.1 Form Ties

NOTE: Form ties: a mechanical connection in tension used to prevent concrete forms from spreading due to the fluid pressure of fresh concrete.

- a. Use form ties with ends or end fasteners that can be removed without damage to concrete.
- b. Where indicated in Contract Documents, use form ties with integral water barrier plates or other acceptable positive water barriers in walls.
- c. The breakback distance for ferrous ties must be at least 2 in.
- d. If the breakback distance is less than 19 mm 3/4 in., use coated or corrosion-resistant ties.
- e. Submit manufacturer's data sheet on form ties.

2.2.2 Waterstops

Submit manufacturer's data sheet on waterstop materials and splices.

2.2.2.1 PVC Waterstop

Polyvinylchloride waterstops must conform to COE CRD-C 572.

2.2.2.2 Rubber Waterstop

Rubber waterstops must conform to COE CRD-C 513.

2.2.2.3 Thermoplastic Elastomeric Rubber Waterstop

Thermoplastic elastomeric rubber waterstops must conform to ASTM D471.

2.2.2.4 Hydrophilic Waterstop

Swellable strip type compound of polymer modified chloroprene rubber that swells upon contact with water must conform to the following requirements when tested in accordance to ASTM D412: Tensile strength 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.

2.2.3 Biodegradable Form Release Agent

- a. Provide form release agent that is colorless, biodegradable, and with a zero VOC content.
- b. Provide product that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces.
- c. Provide form release agent that reduces formwork moisture absorption, and 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.
- d. Submit manufacturer's product data on formwork release agent for use on each form-facing material.

2.2.4 Chamfer Materials

Use lumber materials with dimensions of 3/4 x 3/4 in.

2.2.5 Construction and movement joints

- a. Submit details and locations of construction joints in accordance with the requirements herein.
- b. Locate construction joints within middle one-third of spans of slabs, beams, and girders. If a beam intersects a girder within the middle one-third of girder span, the distance between the construction joint in the girder and the edge of the beam must be at least twice the width of the larger member.
- c. For members with post-tensioning tendons, locate construction joints where tendons pass through centroid of concrete section.
- d. Locate construction joints in walls and columns at underside of slabs, beams, or girders and at tops of footings or slabs.
- e. Make construction joints perpendicular to main reinforcement.
- f. Provide movement joints where indicated in Contract Documents or in accepted alternate locations.
- g. Submit location and detail of movement joints if different from those indicated in Contract Documents.
- h. Submit manufacturer's data sheet on expansion joint materials.
- i. Provide keyways where indicated in Contract Documents. [Longitudinal keyways indicated in Contract Documents must be at least 37.5 mm 1-1/2 in. deep, measured perpendicular to the plane of the joint.]

2.2.6 Other Embedded items

Use sleeves, inserts, anchors, and other embedded items of material and design indicated in Contract Documents.

2.3 CONCRETE MATERIALS.

2.3.1 Cementitious Materials

2.3.1.1 Portland Cement

- a. Unless otherwise specified, provide cement that conforms to [ASTM C150/C150M](#) Type I or II and meets low alkali content Requirements. Contractor shall use [ASTM C150/C150M](#) Type III where high early strength is required.
- b. Use one brand and type of cement for formed concrete having exposed-to-view finished surfaces.
- c. Cementitious materials must be stored and kept dry and free from contaminants.

2.3.1.2 Fly Ash

- a. [ASTM C618](#), Class F, except that the maximum allowable loss on ignition must not exceed 3 percent.
- b. Fly ash content must be a minimum of 15 percent by weight of cementitious material, provided the fly ash does not reduce the amount of cement in the concrete mix below the minimum requirements of local building codes. Where the use of fly ash cannot meet the minimum level, provide the maximum amount of fly ash permissible that meets the code requirements for cement content.

2.3.2 Water

- a. Water or ice must comply with the requirements of [ASTM C1602/C1602M](#).
- b. Minimize the amount of water in the mix. Improve workability by adjusting the grading of the aggregate and using admixture rather than by adding water.
- c. Water must be potable; free from injurious amounts of oils, acids, alkalis, salts, organic materials, or other substances deleterious to concrete.
- d. Protect mixing water and ice from contamination during storage and delivery.
- e. Submit test report showing water complies with [ASTM C1602/C1602M](#).

2.3.3 Aggregate

2.3.3.1 Normal-Weight Aggregate

- a. Aggregates must conform to [ASTM C33/C33M](#).
- b. Aggregates used in concrete must be obtained from the same sources and

have the same size range as aggregates used in concrete represented by submitted field test records or used in trial mixtures.

- c. Provide sand that is at least 50 percent natural sand.
- d. Store and handle aggregate in a manner that will avoid segregation and prevents contamination by other materials or other sizes of aggregates. Store aggregates in locations that will permit them to drain freely. Do not use aggregates that contain frozen lumps.
- e. Submit types, pit or quarry locations, producers' names, aggregate supplier statement of compliance with [ASTM C33/C33M](#), and [ASTM C1293](#) expansion data not more than 18 months old.

2.3.3.2 Lightweight Aggregate

Lightweight aggregate in accordance with [ASTM C330/C330M](#).

2.3.4 Admixtures

- a. Chemical admixtures must conform to [ASTM C494/C494M](#).
- b. Air-entraining admixtures must conform to [ASTM C260/C260M](#).
- c. Chemical admixtures for use in producing flowing concrete must conform to [ASTM C1017/C1017M](#).
- d. Do not use calcium chloride admixtures.
- e. Admixtures used in concrete must be the same as those used in the concrete represented by submitted field test records or used in trial mixtures.
- f. Protect stored admixtures against contamination, evaporation, or damage.
- g. To ensure uniform distribution of constituents, provide agitating equipment for admixtures used in the form of suspensions or unstable solutions. Protect liquid admixtures from freezing and from temperature changes that would adversely affect their characteristics.
- h. Submit types, brand names, producers' names, manufacturer's technical data sheets, and certificates showing compliance with standards required herein.

2.4 MISCELLANEOUS MATERIALS.

2.4.1 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.

2.4.2 Nonshrink Grout

Nonshrink grout in accordance with [ASTM C1107/C1107M](#).

2.4.3 Expansion/Contraction Joint Filler

[ASTM D1751](#) or [ASTM D1752](#) Type I or Type II. Material must be 13 mm 1/2

inch thick[, unless otherwise indicated].

2.4.4 Joint Sealants

Submit manufacturer's product data, indicating VOC content.

2.4.4.1 Horizontal Surfaces, 3 Percent Slope, Maximum ASTM D6690 or ASTM C920, Type M, Class 25, Use T.

2.4.5.2 Vertical Surfaces Greater Than 3 Percent Slope

ASTM C920, Type M, Grade NS, Class 25, Use T.

2.4.5.3 Preformed Polychloroprene Elastomeric Type

ASTM D2628.

2.4.5.4 Lubricant for Preformed Compression Seals

ASTM D2835.

2.5 CONCRETE MIX DESIGN.

2.5.1 Properties and Requirements

- a. Use materials and material combinations listed in this section and the contract documents.
- b. Cementitious material content must be adequate for concrete to satisfy the specified requirements for strength, w/cm, durability, and finishability described in this section and the contract documents.
- c. Selected target slump must meet the requirements this section, the contract documents, and must not exceed 9 in. Concrete must not show visible signs of segregation.
- d. The target slump must be enforced for the duration of the project. Determine the slump by ASTM C143/C143M. Slump tolerances must meet the requirements of ACI 117.
- e. The nominal maximum size of coarse aggregate for a mixture must not exceed three-fourths of the minimum clear spacing between reinforcement, one-fifth of the narrowest dimension between sides of forms, or one-third of the thickness of slabs or toppings.
- f. Concrete must be air entrained for members assigned to Exposure Class F1, F2, or F3. The total air content must be in accordance with the requirements of the paragraph titled DURABILITY.
- g. Measure air content at the point of delivery in accordance with ASTM C173/C173M or ASTM C231/C231M.
- h. Concrete for slabs to receive a hard-troweled finish must not contain an air-entraining admixture or have a total air content greater than 3 percent.

2.5.2 Durability

2.5.2.1 Alkali-Aggregate Reaction

Do not use any aggregate susceptible to alkali-carbonate reaction (ACR). Use one of the three options below for qualifying concrete mixtures to reduce the potential of alkali-silica reaction (ASR):

- a. For each aggregate used in concrete, the expansion result determined in accordance with [ASTM C1293](#) must not exceed 0.04 percent at one year.
- b. For each aggregate used in concrete, the expansion result of the aggregate and cementitious materials combination determined in accordance with [ASTM C1567](#) must not exceed 0.10 percent at an age of 16 days.

2.5.2.2 Concrete Temperature

The temperature of concrete as delivered must not exceed 95°F.

2.5.3 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](#):

- a. Type and brand cement
- b. Cement and supplementary cementitious materials content in 43-kilogram 94-pound bags per cubic meter yard of concrete
- c. Maximum size of aggregate
- d. Amount and brand name of admixtures
- e. Total water content expressed by water cementitious material ratio

2.6 REINFORCEMENT.

- a. Bend reinforcement cold. Fabricate reinforcement in accordance with fabricating tolerances of [ACI 117](#).
- b. When handling and storing coated reinforcement, use equipment and methods that do not damage the coating. If stored outdoors for more than 2 months, cover coated reinforcement with opaque protective material.

2.6.1 Reinforcing Bars

- a. Reinforcing bars must be deformed, except spirals, load-transfer dowels, and welded wire reinforcement, which may be plain.
- b. [ASTM A615/A615M](#) with the bars marked A, Grade 60; or [ASTM A996/A996M](#) with the bars marked R, Grade 60, or marked A, Grade 60.
- c. Reinforcing bars may contain post-consumer or post-industrial recycled content.

2.6.1.1 Galvanized Reinforcing Bars

- a. Provide zinc-coated (galvanized) reinforcing bars that conform to [ASTM A767/A767M](#), Class 1 or Class 2 as required by the contract Documents.
- b. Coating damage incurred during shipment, handling, and placing of zinc-coated (galvanized) reinforcing bars must be repaired in accordance with [ASTM A780/A780M](#). Damaged areas must not exceed 2 percent of surface area in each linear foot of each bar or bar must not be used. The 2 percent limit on maximum allowed damaged coating area must include previously repaired areas damaged before shipment as required by [ASTM A767/A767M](#).

2.6.1.2 Epoxy-Coated Reinforcing Bars

- a. Provide epoxy-coated reinforcing bars that conform to [ASTM A775/A775M](#) or [ASTM A934/A934M](#)], Grade 60.
- b. Coatings must be applied in plants that are certified in accordance with Concrete Reinforcing Steel Institute (CRSI) Epoxy Coating Plant Certification Program or an equivalent program acceptable to the contracting officer.
- c. Coating damage incurred during shipment, storage, handling, and placing of epoxy-coated reinforcing bars must be repaired. Repair damaged coating areas with patching material conforming to [ASTM A775/A775M](#) or [ASTM A934/A934M](#) as applicable and in accordance with material manufacturer's written recommendations. Damaged coating area must not exceed 2 percent of surface area in each linear foot of each bar or bar must not be used. The 2 percent limit on damaged coating area must include repaired areas damaged before shipment as required by [ASTM A775/A775M](#) or [ASTM A934/A934M](#) as applicable. Fading of coating color shall not be cause for rejection of epoxy-coated reinforcing bars.

2.6.1.3 Dual-coated Reinforcing Bars

- a. Zinc and epoxy dual-coated reinforcing bars must conform to [ASTM A1055/A1055M](#)
- b. Coating damage incurred during shipment, storage, handling, and placing of zinc and epoxy dual-coated reinforcing bars must be repaired. Repair damaged coating areas with patching material conforming to [ASTM A1055/A1055M](#) and in accordance with material manufacturer's written recommendations. Damaged coating area must not exceed 2 percent of surface area in each linear foot of each bar or bar must not be used. The 2 percent limit on damaged coating area must include repaired areas damaged before shipment as required by [ASTM A1055/A1055M](#). Fading of coating color shall not be cause for rejection of zinc and epoxy dual-coated reinforcing bars.

2.6.1.4 Stainless Steel Reinforcing Bars

Stainless steel bars must meet the requirements of [ASTM A955/A955M](#).

2.6.1.5 Headed Reinforcing Bars

Headed reinforcing bars must conform to [ASTM A970/A970M](#) including Annex A1, and other specified requirements.

2.6.1.6 Bar Mats

- a. Bar mats must conform to [ASTM A184/A184M](#).
- b. If coated bar mats are required, repair damaged coating as required in the paragraph titled GALVANIZED REINFORCING BARS EPOXY-COATED REINFORCING BARS and DUAL-COATED REINFORCING BARS.

2.6.2 Wire

- a. Provide flat sheets of welded wire reinforcement for slabs and toppings.
- b. Plain or deformed steel wire must conform to [ASTM A1064/A1064M](#).
- c. Stainless steel wire must conform to [ASTM A1022/A1022M](#).
- d. Epoxy-coated wire must conform to [ASTM A884/A884M](#). Coating damage incurred during shipment, storage, handling, and placing of epoxy-coated wires must be repaired. Repair damaged coating areas with patching material in accordance with material manufacturer's written recommendations. If damaged area exceeds 2 percent of surface area in each linear foot of each wire, wire must not be used. The 2 percent limit on damaged coating area must include repaired areas damaged before shipment as required by [ASTM A884/A884M](#). Fading of coating color shall not be cause for rejection of epoxy-coated wire reinforcement.

2.6.3 Welded wire reinforcement

- a. Use welded wire reinforcement specified in Contract Documents and conforming to one or more of the specifications given herein.
- b. Plain welded wire reinforcement must conform to [ASTM A1064/A1064M](#), with welded intersections spaced no greater than 300 mm 12 in. apart in direction of principal reinforcement.
- c. Deformed welded wire reinforcement must conform to [ASTM A1064/A1064M](#), with welded intersections spaced no greater than 400 mm 16 in. apart in direction of principal reinforcement.
- d. Epoxy-coated welded wire reinforcement must conform to [ASTM A884/A884M](#). Coating damage incurred during shipment, storage, handling, and placing of epoxy-coated welded wire reinforcement must be repaired in accordance with [ASTM A884/A884M](#). Repair damaged coating areas with patching material in accordance with material manufacturer's written recommendations. If damaged area exceeds 2 percent of surface area in each linear foot of each wire or welded wire reinforcement, the sheet containing the damaged area must not be used. The 2 percent limit on damaged coating area must include repaired areas damaged before shipment as required by [ASTM A884/A884M](#). Fading of coating color shall not be cause for rejection of epoxy-coated welded wire reinforcement.
- e. Stainless steel welded wire reinforcement must conform to [ASTM A1022/A1022M](#).
- f. Zinc-coated (galvanized) welded wire reinforcement must conform to [ASTM A1060/A1060M](#). Coating damage incurred during shipment, storage,

handling, and placing of zinc-coated (galvanized) welded wire reinforcement must be repaired in accordance with [ASTM A780/A780M](#). If damaged area exceeds 2 percent of surface area in each linear foot of each wire or welded wire reinforcement, the sheet containing the damaged area must not be used. The 2 percent limit on damaged coating area shall include repaired areas damaged before shipment as required by [ASTM A1060/A1060M](#).

2.6.4 Reinforcing Bar Supports

- a. Provide reinforcement support types within structure as required by Contract Documents. Reinforcement supports must conform to [CRSI RB4.1](#). Submit description of reinforcement supports and materials for fastening coated reinforcement if not in conformance with [CRSI RB4.1](#).
- b. [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.]
- c. Legs of supports in contact with formwork must be hot-dip galvanized, or plastic coated after fabrication, or stainless-steel bar supports.

2.6.5 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](#).

PART 3 EXECUTION

PART 3 EXECUTION.

3.1 EXAMINATION.

- a. Do not begin installation until substrates have been properly constructed; verify that substrates are level.
- b. If substrate preparation is the responsibility of another installer, notify Contracting Officer of unsatisfactory preparation before processing.
- c. 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.

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

- a. 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.

- b. 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

- a. When subgrade material is semi-porous 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.
- b. When subgrade material is porous, seal subgrade surface by covering surface with specified vapor retarder.

3.2.3 Subgrade Under Slabs on Ground

- a. Before construction of slabs on ground, have underground work on pipes and conduits completed and approved.
- b. Previously constructed subgrade or fill must be cleaned of foreign materials
- c. 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.
- d. 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

- a. 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.
- b. 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

- a. Secure reinforcement, joint materials, and other embedded materials in position, inspected, and approved before start of concrete placing.
- b. When concrete is placed, reinforcement must be free of materials deleterious to bond. Reinforcement with rust, mill scale, or a combination of both will be considered satisfactory, provided minimum nominal dimensions, nominal weight, and minimum average height of deformations of a hand-wire-brushed test specimen are not less than applicable ASTM specification requirements.

3.3 FORMS.

- a. Provide forms, shoring, and scaffolding for concrete placement. Set forms mortar-tight and true to line and grade.

- b. Chamfer above grade exposed joints, edges, and external corners of concrete [20 mm] [0.75 inch]. Place chamfer strips in corners of formwork to produce beveled edges on permanently exposed surfaces.[Do not bevel reentrant corners or edges of formed joints of concrete.]
- c. Provide formwork with clean-out openings to permit inspection and removal of debris.
- d. Inspect formwork and remove foreign material before concrete is placed.
- e. At construction joints, lap form-facing materials over the concrete of previous placement. Ensure formwork is placed against hardened concrete so offsets at construction joints conform to specified tolerances.
- f. Provide positive means of adjustment (such as wedges or jacks) of shores and struts. Do not make adjustments in formwork after concrete has reached initial setting. Brace formwork to resist lateral deflection and lateral instability.
- g. Fasten form wedges in place after final adjustment of forms and before concrete placement.
- h. Provide anchoring and bracing to control upward and lateral movement of formwork system.
- i. Construct formwork for openings to facilitate removal and to produce opening dimensions as specified and within tolerances.
- j. Provide runways for moving equipment. Support runways directly on formwork or structural members. Do not support runways on reinforcement. Loading applied by runways must not exceed capacity of formwork or structural members.
- k. Position and support expansion joint materials, waterstops, and other embedded items to prevent displacement. Fill voids in sleeves, inserts, and anchor slots temporarily with removable material to prevent concrete entry into voids.
- l. Clean surfaces of formwork and embedded materials of mortar, grout, and foreign materials before concrete placement.

3.3.1 Coating

- a. Cover formwork surfaces with an acceptable material that inhibits bond with concrete.
- b. If formwork release agent is used, apply to formwork surfaces in accordance with manufacturer's recommendations before placing reinforcement. Remove excess release agent on formwork prior to concrete placement.
- c. Do not allow formwork release agent to contact reinforcement or hardened concrete against which fresh concrete is to be placed.

3.3.2 Reuse

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

- b. Wood forms must not be clogged with paste and must be capable of absorbing high water-cementitious material ratio paste.
- c. Remove leaked mortar from formwork joints before reuse.

3.3.3 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.

3.3.4 Forms for Standard Smooth Form Finish

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.]

3.3.5 Form Ties

- a. For post-tensioned structures, do not remove formwork supports until stressing records have been accepted by the Contracting Officer.
- b. After ends or end fasteners of form ties have been removed, repair tie holes in accordance with ACI 301 Section 5 requirements.

3.3.6 Tolerances for Form Construction

- a. Construct formwork so concrete surfaces conform to tolerances in ACI 117.
- b. Position and secure sleeves, inserts, anchors, and other embedded items such that embedded items are positioned within ACI 117 tolerances.
- c. To maintain specified elevation and thickness within tolerances, install formwork to compensate for deflection and anticipated settlement in formwork during concrete placement. Set formwork and intermediate screed strips for slabs to produce designated elevation, camber, and contour of finished surface before formwork removal. If specified finish requires use of vibrating screeds or roller pipe screeds, ensure that edge forms and screed strips are strong enough to support such equipment.

3.3.7 Removal of Forms and Supports

- a. If vertical formed surfaces require finishing, remove forms as soon as removal operations will not damage concrete.
- b. Remove top forms on sloping surfaces of concrete as soon as removal will not allow concrete to sag. Perform repairs and finishing operations required. If forms are removed before end of specified curing period, provide curing and protection.
- c. Do not damage concrete during removal of vertical formwork for columns, walls, and sides of beams. Perform needed repair and finishing operations required on vertical surfaces. If forms are removed before end of specified curing period, provide curing and protection.

- d. Leave formwork and shoring in place to support construction loads and weight of concrete in beams, slabs, and other structural members until in-place required strength of concrete is reached.
- e. Form-facing material and horizontal facing support members may be removed before in-place concrete reaches specified compressive strength if shores and other supports are designed to allow facing removal without deflection of supported slab or member.

3.3.8 Strength of Concrete Required for Removal of Formwork

If removal of formwork, reshoring, or backshoring is based on concrete reaching a specified in-place strength, mold and field-cure cylinders in accordance with [ASTM C31/C31M](#). Test cylinders in accordance with [ASTM C39/C39M](#). Alternatively, use one or more of the methods listed herein to evaluate in-place concrete strength for formwork removal.

- a. Tests of cast-in-place cylinders in accordance with [ASTM C873/C873M](#). This option is limited to slabs with concrete depths from 5 to 12 in.
- b. Penetration resistance in accordance with [ASTM C803/C803M](#).
- c. Pullout strength in accordance with [ASTM C900](#).

3.4 WATERSTOP INSTALLATION AND SPLICES.

- a. Provide waterstops in construction joints as indicated.
- b. Install formwork to accommodate waterstop materials. Locate waterstops in joints where indicated in Contract Documents. Minimize number of splices in waterstop. Splice waterstops in accordance with manufacturer's written instructions. Install factory-manufactured premolded mitered corners.
- c. 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.

- a. Unless otherwise specified, placing reinforcement and miscellaneous materials must be in accordance to **ACI 301**. Provide bars, welded wire reinforcement, wire ties, supports, and other devices necessary to install and secure reinforcement.
- b. 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.
- c. Nonprestressed cast-in-place concrete members must have concrete cover for reinforcement given in the following table:

d.

Concrete Exposure	Member	Reinforcement	Specified cover, mm in.
Cast against and permanently in contact with ground	All	All	3
Exposed to weather or in contact with ground	All	No. 6 through No. 18 bars	2
		No. 5 bar, W31 or D31 wire, and smaller	1-1/2
Not exposed to weather or in contact with ground	Slabs, joists, and walls	No. 14 and No. 18 bars	1-1/2
		No. 11 bar and smaller	3/4

	Beams, columns, pedestals, and tension ties	Primary reinforcement, stirrups, ties, spirals, and hoops	1-1/2
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- e. Cast-in-place prestressed concrete members must have concrete cover for reinforcement, ducts, and end fittings given in the following table:

Concrete	Member	Reinforcement	Specified
Cast against and permanently in contact with ground	All	All	75 3
Exposed to weather or in contact with ground	Slabs, joists, and walls	All	25 1
	All other	All	40 1-1/2
Concrete	Member	Reinforcement	Specified
Not exposed to weather or in contact with ground	Slabs, joists, and walls	All	20 3/4
	Beams, columns, and tension ties	Primary reinforcement	40 1-1/2
		Stirrups, ties, spirals, and hoops	25 1

- f. Precast nonprestressed or prestressed concrete members manufactured under plant conditions must have concrete cover for reinforcement, ducts, and end fittings given in the following table:

Concrete Exposure	Member	Reinforcement	Specified cover, mm in.
Exposed to weather or in contact with ground	Walls	No. 14 and No. 18 bars; tendons larger than 1-1/2 in. diameter	1-1/2
		No. 11 bars and smaller; W31 and D31 wire, and smaller; tendons and strands 1-1/2 in.	3/4

	All other	No. 14 and No.18 bars; tendons larger than 1-1/2 in.	2
		No. 6 through No. 11 bars; tendons and strands larger than 5/8 in. diameter through 1-1/2 in.	1-1/2
		No. 5 bar, W31 or D31 wire, and smaller; tendons and strands 5/8 in. diameter and smaller	1-1/4
Concrete Exposure	Member	Reinforcement	Specified cover, in.
Not exposed to weather or in contact with ground	Slabs, joists, and walls	No. 14 and No. 18 bars; tendons larger than 1-1/2 in. diameter	1-1/4

		Tendons and strands 1-1/2 in. diameter and smaller	3/4
		No. 11 bar, W31 or D31	5/8
	Beams, columns, pedestals, and tension ties	Primary reinforcement	Greater of bar diameter and 5/8 and need not exceed 1-1/2
		Stirrups, ties, spirals, and hoops	3/8

3.5.1 General

Provide details of reinforcement that are in accordance with the Contract Documents.

3.5.2 2111Reinforcement Supports

Provide reinforcement support in accordance with [CRSI RB4.1](#) and [ACI 301](#) Section 3 requirements. 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.

3.5.2.1 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 the paragraph titled EPOXY-COATED REINFORCING BARS. 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 care 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.

3.5.3 Splicing

As indicated in the Contract Documents. For splices not indicated follow [ACI 301](#). Do not splice at points of maximum stress. Overlap welded wire reinforcement the spacing of the cross wires, plus [2 inches](#)

3.5.4 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.

3.5.5 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.

3.5.6 Fabrication

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

- a. Provide fabrication tolerances that are in accordance with [ACI 117](#).
- b. Provide hooks and bends that are in accordance with the Contract Documents.

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 permitted. Bending must be in accordance with standard approved practice and by approved machine methods.

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.

3.5.7 Placing Reinforcement

Place reinforcement in accordance with [ACI 301](#).

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 [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 [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:

- a. 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 301](#) and [CRSI 10MSP](#). Do not use supports to support runways for concrete conveying equipment and similar construction loads.
- b. Equip supports on ground and similar surfaces with sand-plates.
- c. Support welded wire reinforcement as required for reinforcing bars.
- d. Secure reinforcements to supports by means of tie wire. Wire must be black, soft iron wire, not less than [16 gage](#).
- e. 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 the Contract Documents.
- f. Bending of reinforcing bars partially embedded in concrete is permitted only as specified in the Contract Documents.

3.5.8 Spacing of Reinforcing Bars

- a. Spacing must be as indicated in the Contract Documents.
- b. 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.

3.5.9 Concrete Protection for Reinforcement

Additional concrete protection must be in accordance with the Contract Documents.

3.5.10 Welding

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

3.6 BATCHING, MEASURING, MIXING, AND TRANSPORTING CONCRETE.

In accordance with 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 within 48 hrs of delivery.

3.6.1 Measuring

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

3.6.2 Mixing

- a. Mix concrete in accordance with ASTM C94/C94M, ACI 301 and ACI 304R.
- b. 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 84 degrees F.
- c. Reduce mixing time and place concrete within 60 minutes if the air temperature is greater than 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 submitted 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.
- d. 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.
- e. When fibers are used, add fibers together with the aggregates and never as the first component in the mixer. Fibers must be dispensed into the mixing system using appropriate dispensing equipment and procedure as recommended by the manufacturer.

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.

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 4 inches greater than indicated.

3.7.3 Cold Weather

Cold weather concrete must meet the requirements of ACI 301 unless otherwise specified. Do not allow concrete temperature to decrease below 50 degrees F. Obtain approval prior to placing concrete when the ambient temperature is below 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 50 degrees F minimum adjacent to both the formwork and the structure while curing. Limit the rate of cooling to 37 degrees F in any 1 hour and 50 degrees F per 24 hours after heat application.

3.7.4 Hot Weather

Hot weather concrete must meet the requirements of ACI 301 unless otherwise specified. Maintain required concrete temperature using Figure 4.2 in ACI 305R to prevent the evaporation rate from exceeding 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:

- a. 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.

- b. 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.
- c. Provide cement grout that consists of equal parts of portland cement and fine aggregate by weight with not more than 6 gallons of water per sack of cement. Apply cement grout with a stiff broom or brush to a minimum thickness of 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 on-site area to be paved later in project for cleaning out concrete mixing trucks. Minimize water used to wash equipment.

3.8.2 Reinforcing Steel

Collect reinforcing steel and place in designated area for recycling.

3.8.3 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

Tolerances in accordance with 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.

3.10 FLOOR, SLAB, AND PAVEMENT FINISHES AND MISCELLANEOUS CONSTRUCTION.

In accordance with ACI 301 and ACI 302.1R, unless otherwise specified. Slope floors uniformly to drains where drains are provided.

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 exterior slabs where not otherwise specified. Finish concrete in accordance with ACI 301 Section 5 for a floated finish.

3.10.1.3 Steel Troweled

Use for floors intended as walking surfaces. Finish concrete in accordance with ACI 301 Section 5 for a steel troweled finish. [3.10.1.5 Nonslip Finish

3.10.1.4 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.

3.10.1.5 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 a burlap drag. Drag a strip of clean, wet burlap from 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 1/8 inch.

3.10.1.6 Heavy-Duty Wear-Resistant Finish

- a. Give finish to slab surfaces where indicated.
- b. 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].

c. Apply blended dry-shake material as follows:

Maximum type of aggregate in dry shake	Amount per 100 square meter feet of Surface
Traprock	160 pounds
Emery	130 pounds
Iron	130 pounds

d. 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.

e. After completion of the float finish, trowel finish the surface as specified.

3.10.3 Concrete Walks

Provide 4 inches thick minimum. Provide contraction joints spaced every 5 linear feet unless otherwise indicated. Cut contraction joints 1 inch deep, or one fourth the slab thickness whichever is deeper, with a jointing tool after the surface has been finished. Provide 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 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 10 feet maximum unless otherwise indicated. Cut contraction joints 3/4 inch deep with a jointing tool after the surface has been finished. Provide expansion joints 1/2 inch thick and spaced every 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 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 60 feet in any horizontal direction.
- b. In slabs on ground, so as to divide slab into areas not in excess of 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 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

- a. 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.
- b. 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

- a. Provide joints to form panels as indicated.
- b. Under and on exact line of each control joint, cut 50 percent of welded wire reinforcement before placing concrete.
- c. Sawcut contraction joints into slab on ground in accordance with **ACI 301** Section 5.
- d. 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.

3.12.1.1 Preparations Prior to Placing

- a. 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.
- b. 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.
- c. 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.

3.12.1.2 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 re-floated as specified for float finish.

3.12.1.3 Finishing

Give trowel finish standard floor topping surfaces.

3.12.2 Heavy-Duty Floor Topping

Provide topping where indicated.

3.12.2.1 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.

3.12.2.2 Base Slab

- a. 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.
- b. Give slab a scratch finish as specified.
- c. 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.

3.12.2.3 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.

3.12.2.4 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.

Curing and protection in accordance with 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

- a. Accomplish initial curing of unformed surfaces, such as monolithic slabs, floor topping, and other flat surfaces, by membrane curing.
- b. Accomplish final curing of unformed surfaces by any of curing methods specified, as applicable.

3.13.5 Temperature of Concrete During Curing

When temperature of atmosphere is 41 degrees F and below, maintain temperature of concrete at not less than 55 degrees F throughout concrete curing period or 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 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 50 degrees F and above 80 degrees F) for each batch (minimum) or every 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

ASTM C39/C39M. Make six 6 inch by 12 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, and hold two cylinder in reserve. Take samples for strength tests for concrete placed each day not less than once a day, nor less than once for each 100 cubic yards of concrete for the first 500 cubic yards, then every 500 cubic yards thereafter, nor less than once for each 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. Concrete compressive tests must meet the requirements of this section, the Contract Document, and **ACI 301**. 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 Strength of Concrete Structure

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

- a. Failure to meet compressive strength tests as evaluated.
- b. Reinforcement not conforming to requirements specified.
- c. Concrete which differs from required dimensions or location in such a manner as to reduce strength.
- d. Concrete curing and protection of concrete against extremes of temperature during curing, not conforming to requirements specified.
- e. Concrete subjected to damaging mechanical disturbances, particularly load stresses, heavy shock, and excessive vibration.
- f. 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.

3.14.2.6 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.

3.14.2.7 Testing Concrete Structure for Strength

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:

- a. 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.
- b. Test cores after moisture conditioning in accordance with [ASTM C42/C42M](#) if concrete they represent is more than superficially wet under service.
- c. 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.
- d. 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.

[e. 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.

3.15.1 Failure of Quality Control Test Results

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

-- End of Section --