
USACE / NAVFAC / AFCEA / NASA UFGS-03 40 00.00 40 (April 2006)

Preparing Activity: NASA Superseding
 NASA-03300S (December 2005)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are NOT in agreement with UMRL dated 01 April 2006

Revised throughout - changes not indicated by CHG tags

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DIVISION 03 - CONCRETE

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04/06

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CAST-IN-PLACE CONCRETE
04/06

NOTE: Delete, revise, or add to the text in this section to cover project requirements. Notes are for designer information and will not appear in the final project specification.

This section covers normal-weight portland cement concrete, including formwork, reinforcement, finishing, and concrete floor toppings for building and construction.

Drawings must include a complete design indicating the character of the work to be performed and giving the following:

Loading assumptions and unit stresses used in the design

Details of reinforcement indicating reinforcing bar sizes, bends, and stopping points; details of stirrups; and location and size of welded wire fabric

Specific locations for use of the various classes of concrete as required

Details of concrete sections showing dimensions and cover over reinforcement

Details and locations of expansion and construction joints, including waterstops as required

Details and locations of isolation joints

Locations and details which require a depressed structural slab or other conditions in order to provide finished surfaces at the same elevations

Locations and details for architectural concrete as required

Location of finishes for formed surfaces, monolithic slabs, and floor topping as required

Earth fills under concrete slabs on ground are specified in Section 31 00 00.00 40 EARTHWORK.

Setting bearing plates, including bedding mortar, is specified in Section 05 12 00.00 40 STRUCTURAL STEEL and in Section 05 21 00.00 40 STEEL JOISTS.

Fire-resistance-rated construction using cast-in-place concrete is described in Underwriters Laboratorie, "Fire Resistance Ratings (BXUV)" included in UL FRD and the "Fire Resistance Ratings" contained in AIA CO-1. Fire-resistance-rated construction limits aggregate materials and concrete cover over reinforcement.

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

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

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

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.

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

ACI INTERNATIONAL (ACI)

ACI 117	(1990; R 2002) Standard Tolerances for Concrete Construction and Materials (ACI 117-90) and Commentary (ACI 117R-90)
ACI 211.1	(1991; R 2002) Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 301	(2005) Specifications for Structural Concrete
ACI 318/318R	(2005) Building Code Requirements for Structural Concrete (ACI 318-05) and Commentary (ACI 318R-05)
ACI/MCP 205	(2005) Manual of Concrete Practice Part 2 - ACI 224R-01 to ACI 313R-97
ACI/MCP 305	(2005) Manual of Concrete Practice Part 3:315-99 to 343R-95
ACI/MCP 405	(2005) Manual of Concrete Practice Part 4:345R-91(97) to 355.2R-04

AMERICAN WELDING SOCIETY (AWS)

AWS A5.1/A5.1M	(2004) Carbon Steel Electrodes for Shielded Metal Arc Welding
AWS D1.4	(1998; R 2001) Structural Welding Code - Reinforcing Steel

ASTM INTERNATIONAL (ASTM)

ASTM A 185	(2002) Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM A 497/A 497M	(2005) Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete
ASTM A 53/A 53M	(2004a) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 615/A 615M	(2005a) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A 706/A 706M	(2005a) Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement

ASTM A 767/A 767M	(2005) Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
ASTM A 775/A 775M	(2004a) Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A 82	(2005) Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
ASTM A 996/A 996M	(2004) Rail-Steel and Axle-Steel Deformed Bars or Concrete Reinforcement
ASTM C 117	(2004) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 127	(2004) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C 128	(2004a) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C 136	(2005) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C 138/C 138M	(2001a) Standard Test Method for Density ("Unit Weight"), Yield, and Air Content (Gravimetric) of Concrete
ASTM C 143/C 143M	(2005) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C 150	(2005) Standard Specification for Portland Cement
ASTM C 156	(2003) Water Retention by Concrete Curing Materials
ASTM C 171	(2003) Standard Specification for Sheet Materials for Curing Concrete
ASTM C 172	(2004) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C 192/C 192M	(2005) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 231	(2004) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 233	(2004) Standard Test Method for Air-Entraining Admixtures for Concrete

ASTM C 260	(2001) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C 29/C 29M	(1997; R 2003) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C 309	(2003) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 31/C 31M	(2003a) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C 33	(2003) Standard Specification for Concrete Aggregates
ASTM C 39/C 39M	(2004) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C 42/C 42M	(2004) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C 494/C 494M	(2005) Standard Specification for Chemical Admixtures for Concrete
ASTM C 566	(1997; R 2004) Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying
ASTM C 618	(2005) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C 70	(1994; R 2001) Standard Test Method for Surface Moisture in Fine Aggregate
ASTM C 881	(1999) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 932	(2005) Standard Specification for Surface-Applied Bonding Compounds for Exterior Plastering
ASTM C 94/C 94M	(2004a) Standard Specification for Ready-Mixed Concrete
ASTM C 990	(2003a) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM C 990M	(2003a) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants (Metric)

ASTM D 1190	(1997) Standard Specification for Concrete Joint Sealer, Hot-Applied Elastic Type
ASTM D 1557	(2002e1) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft ³) (2700 kN-m/m ³)
ASTM D 1751	(2004) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D 1752	(2004a) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D 2103	(2003) Standard Specification for Polyethylene Film and Sheeting
ASTM D 2628	(1991; R 2005) Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
ASTM D 4397	(2002) Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications
ASTM E 329	(2005b) Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction
ASTM E 648	(2004) Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source

CONCRETE REINFORCING STEEL INSTITUTE (CRSI)

CRSI MSP-2	(1998) Manual of Standard Practice
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NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST PS 1	(1996) Construction and Industrial Plywood
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U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS LLL-B-810	(Rev B) Building Board, (Hardboard) Hard Pressed, Vegetable Fiber
FS MMM-A-001993	(1978) Adhesive, Epoxy, Flexible, Filled (For Binding, Sealing, and Grouting)
FS SS-S-200	(1993e) Sealants, Joint, Two-Component, Jet-Blast-Resistant, Cold-Applied, for Portland Cement Concrete Pavement

1.2 SUBMITTALS

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

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

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

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

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.] [for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Construction Equipment Lists shall be submitted by the Contractor prior to construction in accordance with the paragraph entitled, "General Information," of this section.

Records of Historical Data shall be submitted by the Contractor in accordance with paragraph entitled, "General Information," of this section.

SD-02 Shop Drawings

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

Reinforcement Materials
Column Forms
Wall Forms
Floor Forms
Ceiling Forms
Special Construction

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.

Erection drawings for concrete Formwork shall show placement of reinforcement and accessories, with reference to the contract drawings.

SD-03 Product Data

Manufacturer's catalog data for the following items shall include printed instructions for admixtures, bonding agents, epoxy-resin adhesive binders, waterstops, and liquid chemical floor hardeners.

Concrete Aggregates
Portland Cement
Ready-Mix Concrete
Form Facing Materials
Reinforcement Materials
Joint Materials
Water-Vapor Barrier Subgrade Cover
Bonding Materials
Floor Finish Materials
Concrete Curing Materials

SD-04 Samples

The following samples shall be submitted:

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

Dumbbell Type
Rubber
Polyvinylchloride (PVC)

SD-05 Design Data

Mix design data for each class of Ready-Mix Concrete shall be submitted at least 15 calendar days prior to start of specified work.

SD-06 Test Reports

Test reports for welding electrodes shall be in accordance with [AWS A5.1/A5.1M](#).

Reports for concrete shall be in accordance with the paragraph entitled, "Quality-Control Testing During Construction," of this section. Test reports of the chemical requirements of reinforcing bars shall also be submitted.

[Chemical Composition](#)
[Mechanical Usability](#)
[Soundness](#)
[Slump](#)
[Air Entrainment](#)
[Compressive Strength](#)

[SD-07 Certificates](#)

[Welding Procedures](#) shall be in accordance with [AWS D1.4](#).

Mill certificates shall be submitted for [Steel Bar](#) according to the paragraph entitled, "Fabrication," of this section.

Certificates for concrete shall be in accordance with the paragraph entitled, "Classification and Quality of Concrete," of this section. Certificates shall contain project name and number, date, name of Contractor, name of concrete testing service, source of concrete aggregates, material manufacturer, brand name of manufactured materials, material name, values as specified for each material, and test results. Certificates for [Welder Qualifications](#) shall be in accordance with the paragraph entitled, "Qualifications for Welding Work," of this section.

[Concrete Design Mixes](#)
[Concrete Aggregates](#)
[Welding Procedures](#)

[SD-08 Manufacturer's Instructions](#)

Installation instructions shall indicate the manufacturer's recommended method and sequence of installation for the following items:

[Admixtures](#)
[Bonding Materials](#)
[Waterstops](#)
[Liquid Chemical Floor Hardener](#)

[SD-11 Closeout Submittals](#)

Records of [Communication](#) shall be submitted in accordance with paragraph entitled, "General Information," of this section.

1.3 QUALIFICATIONS FOR CONCRETE TESTING SERVICE

Concrete testing shall be performed by an approved laboratory and inspection service experienced in sampling and testing concrete. Testing agency shall meet the requirements of [ASTM E 329](#).

1.4 QUALIFICATIONS FOR WELDING WORK

NOTE: If Section 41 36 19.00 40 WELDING, STRUCTURAL is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph deleted.

[Section 41 36 19.00 40 WELDING, STRUCTURAL applies to work specified in this section.]

[Welding procedures shall be in accordance with AWS D1.4.

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

1.5 CONCRETE SAMPLING AND TESTING

Testing by the Contractor shall include sampling and testing concrete materials proposed for use in the work and testing the design mix for each class of concrete. Quality control testing during construction shall be performed by the Contractor.

NOTE: Delete paragraph heading and following paragraphs when certificates of compliance are required instead of laboratory tests. Laboratory tests are recommended when the quantity of concrete exceeds 900 cubic meter. 1,200 cubic yards. Where architectural concrete made of special aggregates, such as an exposed-aggregate finish, specify tests for the aggregates potential reactivity to alkalis and for water absorption of the concrete as specified in Section 03 45 00.00 40 PRECAST CONCRETE WALL PANELS.

Concrete aggregate materials proposed for use in the work shall be sampled and tested in accordance with ASTM C 33.

Portland cement shall be sampled and tested in accordance with ASTM C 150.

Air-entraining admixtures shall be sampled and tested in accordance with ASTM C 233.

1.6 CONCRETE DESIGN MIXES

Mix proportions for each concrete class shall be determined and tested as follows:

<u>REQUIREMENT</u>	<u>TEST METHOD</u>	<u>NUMBER OF TESTS</u>
Specific gravity absorption of fine aggregate	ASTM C 128	As required for the concrete aggre- gate for each trial mix

<u>REQUIREMENT</u>	<u>TEST METHOD</u>	<u>NUMBER OF TESTS</u>
Specific gravity and absorption of coarse aggregate	ASTM C 127	
Gradation of fine and coarse aggregates	ASTM C 117 and ASTM C 136	
Moisture content of both fine and coarse aggregates	ASTM C 70 and ASTM C 566	
Dry-rodded unit weight of coarse aggregate	ASTM C 29/C 29M	
Trial mixes using at least three different water/cement ratios, minimum allowable cement content, maximum allowable slump; both with and without air entrainment	ACI 211.1	As required to determine the concrete mix having the properties specified for each concrete class
Making and curing concrete specimens in the laboratory	ASTM C 192/C 192M	Two sets of three specimens for each design mix
Sampling fresh concrete in the laboratory	ASTM C 192/C 192M	One for each set of design mix specimens
Slump	ASTM C 143/C 143M	
Air content	ASTM C 231	
Yield	ASTM C 138/C 138M	
Compressive strength	ASTM C 39/C 39M	Three specimens tested at 7 days, and three specimens tested at 28 days for each mix design

Proportions of concrete mixtures shall be determined in accordance with ASTM E 648, ACI/MCP 205 and Method 1 of ACI 301, Section 3.8.2.1. Separate curves shall be prepared for air-entrained and nonair-entrained concretes.

1.7 DELIVERY AND STORAGE OF MATERIALS

Packaged materials shall be delivered to the project site in their original, unopened package or container bearing label clearly identifying manufacturer's name, brand name, material, weight or volume, and other pertinent information. Packaged materials shall be stored in their

original, unbroken package or container in a weathertight and dry place until ready for use in the work.

Unpackaged aggregates shall be stored to avoid excessive segregation, contamination with other materials or other size aggregates, or freezing.

Reinforcement and other metal items shall be protected from corrosion and shall be kept free from ice, grease, and other coatings that would destroy or reduce bond.

1.8 SHOP DRAWINGS

Fabrication Drawings for concrete formwork for **Reinforcement Materials**, **Column Forms**, **Wall Forms**, **Floor Forms**, **Ceiling Forms** and for **Special Construction** shall indicate concrete pressure calculations with both live and dead loads, along with material types. All design calculations shall be in accordance with **ASTM E 648**, **ACI/MCP 205** and **ACI 301**, Chapter 4.

1.9 GENERAL INFORMATION

Construction Equipment Lists of major components used during this phase of work shall be submitted.

Records of **Historical Data** shall be recorded in the presence of the Contracting Officer showing the condition of structures and other facilities indicating existing conditions of site prior to work start.

Letters of record expressing **Communication** between the Contractor and Contracting Officer shall be provided after the contract completion.

PART 2 PRODUCTS

2.1 CONCRETE MATERIALS

2.1.1 Concrete Aggregates

Fine and coarse aggregates shall conform to **ASTM C 33**.

NOTE: Delete following paragraph when architectural concrete made of specified concrete aggregates is not required. Delete following paragraph and specify required aggregates when architectural concrete made of special aggregates, such as exposed-aggregate finish, is required. Refer to Section 03 45 00.00 40 PRECAST CONCRETE WALL PANELS.

Concrete aggregate for architectural concrete shall be obtained from a single source.

2.1.2 Portland Cement

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

When concrete will be exposed to sea water, specify

Type V.

Cement shall conform to **ASTM C 150**, Type I, IA, II, or IIA. One brand and type of cement shall be used for formed concrete having exposed-to-view finished surfaces.

2.1.3 Admixtures

2.1.3.1 Air-Entraining Admixtures

Air-entraining admixtures shall conform to **ASTM C 260**.

2.1.3.2 Water-Reducing Admixtures

Water-reducing admixtures, retarding admixtures, accelerating admixtures, water-reducing and accelerating admixtures, and water-reducing and retarding admixtures shall conform to **ASTM C 494/C 494M**.

2.1.3.3 Pozzolan

Fly ash or other pozzolans used as admixtures shall conform to **ASTM C 618**, Class C or Class F with 4 percent maximum loss on ignition and 20 percent maximum cement replacement by weight.

2.1.4 Water

Water shall be potable.

2.2 READY-MIX CONCRETE

Concrete shall meet the requirements of **ASTM C 94/C 94M**.

Ready-mixed concrete manufacturer shall provide duplicate delivery tickets with each load of concrete delivered. Delivery tickets shall provide the following information in addition to that required by **ASTM C 94/C 94M**:

Type and brand cement

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

Maximum size of aggregate

Amount and brand name of admixtures

Total water content expressed by water/cement ratio

2.3 FORM FACING MATERIALS

NOTE: The following form facing materials are suitable only for standard finishes specified. When special architectural finishes are required, form facing materials for such finishes must be specified.

2.3.1 Concrete Form Plywood (Standard Rough)

Plywood shall conform to NIST PS 1, B-B, concrete form, not less than 16 millimeter 5/8-inch thick.

2.3.2 Overlaid Concrete Form Plywood (Standard Smooth)

Plywood shall conform to NIST PS 1, B-B, high density form overlay, not less than 16 millimeter 5/8-inch thick.

2.4 REINFORCEMENT MATERIALS

NOTE: Locations of reinforcing bars must be indicated.

2.4.1 Reinforcing Bars

[Reinforcing bars shall conform to ASTM A 615/A 615M and Supplemental S1, Grade 40 or Grade 60, ACI/MCP 405, ASTM E 648, ACI/MCP 305 and ACI 318/318R, Section 3.5.3.2.]

[Reinforcing bars shall conform to ASTM A 996/A 996M, Grade 50 or Grade 60, ACI/MCP 405, ASTM E 648, ACI/MCP 305 and ACI 318/318R, Section 3.5.3.2.]

[Reinforcing bars shall conform to ACI/MCP 405, ASTM E 648, ACI/MCP 305 and ACI 318/318R, Section 3.5.3.2.]

2.4.2 Galvanized Reinforcing Bars

Galvanized reinforcing bars shall conform to ASTM A 767/A 767M, Class II with galvanizing before fabrication.

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

2.4.3 Weldable Reinforcing Bars

Weldable reinforcing bars shall conform to ASTM A 706/A 706M and ASTM A 615/A 615M and Supplement S1, Grade 60, except that the maximum carbon content shall be 0.55 percent.

2.4.4 Epoxy-Coated Reinforcing Bars

Epoxy-coated reinforcing bars shall conform to ASTM A 775/A 775M, Grade 40 or Grade 60.

2.4.5 Steel Wire

Wire shall conform to ASTM A 82.

2.4.6 Dowels for Load Transfer in Floors

Dowels for load transfer in floors shall be of the type, design, weight,

and dimensions indicated. Dowel bars shall be plain-billet steel conforming to **ASTM A 615/A 615M**, Grade 40. Dowel pipe shall be steel conforming to **ASTM A 53/A 53M**.

2.4.7 Welded Wire Fabric

Fabric shall conform to **ASTM A 185** or **ASTM A 497/A 497M**.

2.4.8 Supports for Reinforcement

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

Supports shall be wire bar type conforming to **ACI/MCP 405**, **ASTM E 648**, **ACI/MCP 305ACI 318/318R** and **CRSI MSP-2**.

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

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

2.5 JOINT MATERIALS

2.5.1 Waterstops

[Waterstops shall be flat dumbbell type, not less than 5 millimeter 3/16 inch for widths up to 125 millimeter 5 inches, and not less than 10 millimeter 3/8 inch for widths 125 millimeter 5 inches and over.]

[Waterstops shall be made of rubber and shall conform to **ASTM D 1752**.]

[Waterstops shall be made of polyvinylchloride (PVC) and shall conform to [**ASTM C 990M ASTM C 990**] [**ASTM D 2628**].]

2.5.2 Preformed Joint Filler Strips

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

[Filler strips shall be nonextruding and resilient bituminous type conforming to **ASTM D 1751**.]

[Filler strips shall be nonextruding and resilient nonbituminous type conforming to **ASTM D 1752**, Type I or II.]

2.5.3 Joint Sealant Compound

NOTE: Cold-applied mastic type and hot-applied elastic type sealing compounds are suitable for

locations subject to light foot traffic only. After curing both types of sealing compound have equal physical properties. Cold-applied mastic type costs less.

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

[Compound shall be hot-poured, elastic type conforming to ASTM D 1190.]

[Compound shall be cold-applied, two-component, elastomeric polymer type conforming to FS SS-S-200.]

2.6 WATER-VAPOR BARRIER SUBGRADE COVER

Cover shall be water-resistant barrier paper, uncreped and reinforced, conforming to FS UU-B-790, Type I, Grade B, Style 4; or clear polyethylene sheeting, 0.152 millimeter 6-mil, conforming to ASTM D 2103 and ASTM D 4397

2.7 BONDING MATERIALS

2.7.1 Concrete Bonding Agent

Agent shall be an aqueous-phase, film-forming, nonoxidizing, freeze and thaw-resistant compound suitable for brush or spray application conforming to ASTM C 932.

2.7.2 Epoxy-Resin Adhesive Binder

Binder shall be two-component, epoxy-polysulfide polymer type with an amine-type curing-agent conforming to FS MMM-A-001993, Type I or ASTM C 881.

2.8 FLOOR FINISH MATERIALS

2.8.1 Liquid Chemical Floor Hardener

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

2.8.2 Abrasive Aggregate for Nonslip Aggregate Finish

NOTE: When abrasive aggregate is required, delete one of 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 shall 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 shall be rust proof

and nonglazing and shall be unaffected by freezing, moisture, and cleaning materials.]

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

[Aggregate shall be well-graded in size from particles retained on 600 micrometer sieve No. 30 sieve (0.0234 inch) to particles passing 2.36 millimeter sieve No. 8 sieve (0.0937 inch).]

2.8.3 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.

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

2.8.4 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.

[Aggregate shall be traprock or emery, as follows:

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

Emery shall 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 shall be well graded in size from particles retained on 300 micrometer sieve No. 50 sieve (0.0117 inch) to particles passing 2.36 millimeter sieve No. 8 sieve (0.0937 inch).

Aggregate shall be iron, as follows:

Iron shall be packaged, ground and graded cubicle iron particles with dispersing agents, formulated to blend with portland cement for producing wear-resistant monolithic surface treatments. Aggregate shall be free of nonferrous metals, oil, grease, soluble alkaline compounds, rust, and impurities and shall be well-graded in size from particles retained on 300 micrometer sieve No. 50 sieve (0.0117 inch)

to particles passing 2.36 millimeter sieve No. 8 sieve (0.187 inch).]

2.8.5 Aggregate for Heavy-Duty Floor Topping

Aggregate shall be emery or may be traprock or traprock-screenings fine aggregates, as specified.

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

Traprock shall be packaged, crushed, natural, fine- to medium-grained igneous rock such as diabase, basalt, or black granite. Coarse aggregate shall be uniformly graded with 100 percent passing 12.5 millimeter 1/2-inch sieve, 30 to 50 percent passing 9.5 millimeter 3/8-inch sieve, 0 to 15 percent passing 4.75 millimeter No. 4 sieve, and 0 to 5 percent passing 2.36 millimeter No. 8 sieve.

Fine aggregate using traprock shall conform to ASTM C 33, except gradation. Fine aggregate shall be graded within the following limits:

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

Traprock coarse aggregate and fine aggregate shall be delivered in

moisture-resistant bags.

2.9 CONCRETE CURING MATERIALS

2.9.1 Absorptive Cover

Cover for curing concrete shall be burlap cloth made from jute or kenaf, weighing 300 gram 9 ounces plus or minus 3 5 percent per square meter yard when clean and dry, conforming to ASTM C 171, Class 3; or cover may be cotton mats as approved.

2.9.2 Moisture-Retaining Cover

Cover for curing concrete shall be waterproof paper conforming to ASTM C 171, regular or white, or polyethylene sheeting conforming to ASTM C 171, or polyethylene-coated burlap consisting of a laminate of burlap and a white opaque polyethylene film permanently bonded to the burlap; burlap shall conform to ASTM C 171, Class 3, and polyethylene film shall conform to ASTM C 171. When tested for water retention in accordance with ASTM C 156, weight of water lost 72 hours after application of moisture retaining covering material shall not exceed 0.039 gram per square centimeter of the mortar specimen surface.

2.9.3 Water

Water shall be potable.

2.9.4 Membrane-Forming Curing Compound

Compound shall be liquid type conforming to ASTM C 309, Type 1, clear, Type 1D with fugitive dye for interior work and Type 2, white, pigmented for exterior work.

2.10 CLASSIFICATION AND QUALITY OF CONCRETE

2.10.1 Concrete Classes and Usage

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

Concrete classes, compressive strength, requirements for air entrainment, and usage shall be as follows:

CONCRETE CLASS	MIN. 28-DAY COMPRESSIVE STRENGTH POUNDS PER MEGA pascal	REQUIREMENT FOR AIR ENTRAINMENT	USAGE
3A	20	Air- entrained	For foundation concrete work exposed to freez- ing and thawing or subjected to hy- draulic pressure, such as foundation walls, grade beams, pits, tunnels. For exterior

<u>CONCRETE CLASS</u>	MIN. 28-DAY COMPRESSIVE STRENGTH POUNDS PER <u>MEGA pascal</u>	REQUIREMENT FOR AIR <u>ENTRAINMENT</u>	<u>USAGE</u> concrete slabs, such as steps, platforms, walks
3N	20	Nonair- entrained	For foundation concrete work not exposed to freezing and thawing or subjected to hydraulic pressure, such as footings, pile caps, foundation mats. For interior slabs on ground to be covered with resilient flooring
4A	27.6	Air- entrained	For structural concrete work exposed to freezing and thawing, unless otherwise indicated or specified, such as exterior columns and spandrels
4N	27.6	Nonair- entrained	For structural concrete work not exposed to freezing and thawing such as interior columns, beams, supported slabs and other structural members for interior slabs on ground subjected to foot traffic
2.5A	17.2	Air- entrained	For concrete not reinforced and not exposed to freezing and thawing
2.5N	17.2	Nonair- entrained	For concrete not reinforced and not exposed to freezing and thawing
5A	34.5	Air- entrained	For structural concrete work as indicated
5N	34.5	Nonair- entrained	For structural concrete work as indicated

<u>CONCRETE CLASS</u>	MIN. 28-DAY COMPRESSIVE STRENGTH POUNDS PER <u>SQ. IN.</u>	<u>REQUIREMENT FOR AIR ENTRAINMENT</u>	<u>USAGE</u>
3A	3,000	Air- entrained	For foundation concrete work exposed to freezing and thawing or subjected to hydraulic pressure, such as foundation walls, grade beams, pits, tunnels. For exterior concrete slabs, such as steps, platforms, walks
3N	3,000	Nonair- entrained	For foundation concrete work not exposed to freezing and thawing or subjected to hydraulic pressure, such as footings, pile caps, foundation mats. For interior slabs on ground to be covered with resilient flooring
4A	4,000	Air- entrained	For structural concrete work exposed to freezing and thawing, unless otherwise indicated or specified, such as exterior columns and spandrels
4N	4,000	Nonair- entrained	For structural concrete work not exposed to freezing and thawing such as interior columns, beams, supported slabs and other structural members for interior slabs on ground subjected to foot traffic
2.5A	2,500	Air- entrained	For concrete not reinforced and not exposed to freezing and thawing
2.5N	2,500	Nonair- entrained	For concrete not reinforced and not exposed to freezing and thawing
5A	5,000	Air- entrained	For structural concrete work as

<u>CONCRETE</u> <u>CLASS</u>	MIN. 28-DAY COMPRESSIVE STRENGTH POUNDS PER <u>SQ. IN.</u>	REQUIREMENT FOR AIR <u>ENTRAINMENT</u>	<u>USAGE</u> indicated
5N	5,000	Nonair- entrained	For structural con- crete work as indicated

2.10.2 Limits for Concrete Proportions

**NOTE: Delete following concrete classes that are
not required. Utilize ACI/MCP 305 and ACI 318/318R,
Chapter 5, and ACI A211.1.**

Limits for maximum water/cement ratio and minimum cement content for each
concrete class shall be as follows:

<u>CONCRETE</u> <u>CLASS</u>	MAX. WATER/CEMENT RATIO <u>BY WEIGHT</u>	MIN. CEMENT FOR 75 TO 100 MM SLUMP, (NO. OF 43 KILO- GRAM SACKS) PER .75 CU. METER
2.5A	0.58	4.75
2.5N	0.62	4.75
3A	0.50	5.25
3N	0.54	5.25
4A	0.46	6.0
4N	0.48	6.0
5A	0.41	6.5
5N	0.44	6.5

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

<u>CONCRETE CLASS</u>	<u>MAX. WATER/CEMENT RATIO BY WEIGHT</u>	<u>MIN. CEMENT FOR 3- TO 4-INCH SLUMP, (NO. OF 94- POUND SACKS) PER CU. YD.</u>
5A	0.41	6.5
5N	0.44	6.5

* Weight of water to weight of cement in pounds in one cubic yard of concrete

2.10.3 Maximum Size of Aggregate

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

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

<u>MAXIMUM SIZE OF AGGREGATE</u>	<u>ASTM C 33 SIZE NUMBER</u>	<u>TYPE OF CONSTRUCTION</u>
50.8 mm	357	Nonreinforced footings and other flat work having a depth of not less than 6 inches, and nonreinforced walls and other formed sections having a dimension between forms of not less than 10 inches
38.1 mm	467	Monolithic slabs on ground, concrete fill, and other flatwork having a depth of not less than 5 inches and a clear distance between reinforcing bars of not less than 2 inches
19.1 mm	67	Reinforced walls, columns, girders, beams, and other formed sections having a dimension between forms of not less than 6 inches and clear distance between reinforcing bars or reinforcing bar and face of form of not less than 1 inch
19.1 mm	67	Monolithic concrete slabs and other flatwork having a depth of not less than 2-1/2 inches and a clear distance between reinforcing bars of not less than 1 inch
12.7 mm	7	Concrete joist construction, beams, reinforced walls, and

<u>MAXIMUM SIZE OF AGGREGATE</u>	<u>ASTM C 33 SIZE NUMBER</u>	<u>TYPE OF CONSTRUCTION</u>
		other formed work having a clear distance between reinforcing bars and face of form of less than 1 inch
9.5 mm	8	Nonreinforced slabs and other flatwork having a depth of less than 2-1/2 inches

<u>MAXIMUM SIZE OF AGGREGATE</u>	<u>ASTM C 33 SIZE NUMBER</u>	<u>TYPE OF CONSTRUCTION</u>
2 inches	357	Nonreinforced footings and other flat work having a depth of not less than 6 inches, and nonreinforced walls and other formed sections having a dimension between forms of not less than 10 inches
1-1/2 inches	467	Monolithic slabs on ground, concrete fill, and other flatwork having a depth of not less than 5 inches and a clear distance between reinforcing bars of not less than 2 inches
3/4 inch	67	Reinforced walls, columns, girders, beams, and other formed sections having a dimension between forms of not less than 6 inches and clear distance between reinforcing bars or reinforcing bar and face of form of not less than 1 inch
3/4 inch	67	Monolithic concrete slabs and other flatwork having a depth of not less than 2-1/2 inches and a clear distance between reinforcing bars of not less than 1 inch
1/2 inch	7	Concrete joist construction, beams, reinforced walls, and other formed work having a clear distance between reinforcing bars and face of form of less than 1 inch
3/8 inch	8	Nonreinforced slabs and other flatwork having a depth of less than 2-1/2 inches

MAXIMUM SIZE OF AGGREGATE	ASTM C 33 SIZE NUMBER	TYPE OF CONSTRUCTION
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Maximum size of aggregate may be that required for most critical type of construction using that concrete class.

Gradation of aggregates shall be as specified for separate floor topping.

2.10.4 Slump

Slump for concrete at time and in location of placement shall be as follows:

<u>TYPE OF CONSTRUCTION</u>	<u>SLUMP</u>
Footings, unreinforced walls	Not less than 25 millimeter nor more than 75 millimeter
Columns, beams, reinforced walls, monolithic slabs	Not less than 25 millimeter nor more than 100 millimeter
Ramps and other sloping surfaces	0 nor more than 75 millimeter

<u>TYPE OF CONSTRUCTION</u>	<u>SLUMP</u>
Footings, unreinforced walls	Not less than 1 inch nor more than 3 inches
Columns, beams, reinforced walls, monolithic slabs	Not less than 1 inch nor more than 4 inches
Ramps and other sloping surfaces	0 nor more than 3 inches

2.10.5 Total Air Content

Air content of exposed concrete and interior concrete shall be in accordance with ASTM C 260 and/or as follows:

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

pressure

3/8 inch

Concrete exposed to freezing and thawing or subjected to hydraulic pressure shall be air-entrained by addition of approved air-entraining admixture to concrete mix.

PART 3 EXECUTION

3.1 FORMWORK

3.1.1 General

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

3.1.2 Design and Construction of Form work

Form work design and construction shall conform to ASTM E 648, ACI/MCP 205 and ACI 301, Chapter 4.

Forms shall be tight to prevent leakage of cement paste during concrete placing.

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

Exposed joints, edges, and external corners shall be chamfered a minimum of 19 millimeter 3/4 inch by moldings placed in corners of column, beam, and wall forms.

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

Temporary openings shall be provided in wall forms, column forms, and at other points where necessary to permit inspection and to facilitate cleaning.

Forms shall be readily removable without impact, shock, or damage to concrete.

3.1.3 Forms for Standard Rough Form Finish

Rough form finish shall be given concrete formed surfaces that are to be concealed by other construction, unless otherwise specified.

Form facing material for standard rough form finish shall be the specified concrete form plywood or other approved form facing material that will produce concrete surfaces equivalent in smoothness and appearance to that

produced by new concrete form plywood panels.

For concrete surfaces exposed only to the ground, undressed, square-edge, 25 millimeter 1-inch nominal thickness lumber may be used. Horizontal joints shall be level and vertical joints shall be plumb.

3.1.4 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.

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

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

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

Arrangement of form facing sheets shall be orderly and symmetrical, and sheets shall be in sizes as large as practical.

Panels shall be arranged to make a symmetrical pattern of joints. Horizontal and vertical joints shall be solidly backed and butted tight to prevent leakage and fins.

3.1.5 Form Ties

Ties shall be factory fabricated metal, adjustable in length, removable or snap-off type that will not allow form deflection or will not spall concrete upon removal. Portion of form ties remaining within concrete after removal of exterior parts shall be at least 38 millimeter 1-1/2 inches back from concrete surface. Form ties shall be free of devices that will leave a hole larger than 22 millimeter 7/8 inch or less than 13 millimeter 1/2 inch in diameter in concrete surface. Form ties fabricated at the project site or wire ties of any type are not acceptable.

3.1.6 Forms for Concrete Pan Joist Construction

[Forms shall be well-fitting, undamaged, factory-fabricated pan form units for concrete joist construction as indicated.

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

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

Hardboard conforming to ACI/MCP 405, ACI/MCP 305 and ACI 318/318R, 6.4 millimeter FS LLL-B-810, 1/4-inch thick, coated with waterproof plastic

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

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

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

3.1.7 Tolerances for Form Construction

Formwork shall be constructed to ensure that after removal of forms and prior to patching and finishing of formed surfaces, concrete surfaces shall be in accordance with tolerances specified in ASTM E 648, ACI 117 and ACI/MCP 205.

3.1.8 Preparation of Form Surfaces

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

3.1.9 Removal of Forms

Formwork that does not support weight of concrete, such as sides of beams, walls, columns, and similar vertical parts of the work, may be removed 24 hours after placing concrete, provided concrete is sufficiently hard not to be damaged from form-removal operations.

Formwork that supports weight of concrete, such as beam soffits, slabs, and similar horizontal parts of the work, shall remain in place at least until concrete has attained design minimum laboratory compressive strength at 28 days for applicable concrete class specified.

Form facing material may be removed before concrete has attained its required 28-day compressive strength but in no case less than 6 days after placing concrete, provided shores and other vertical supports have been arranged to permit removal of form-facing material without loosening or disturbing shores and supports. Shores and other vertical supports shall remain in place until concrete has attained its required 28-day compressive strength.

Results of control tests will be used as evidence that concrete has

attained sufficient strength to permit removal of supporting forms. Test specimens shall be removed from molds at the end of 24 hours and stored in the structure as near points of sampling as possible; shall receive same protection from elements during curing as is given those portions of the structure which they represent; and shall not be removed from the structure for transmittal to the laboratory prior to expiration of three-fourths of proposed period before removal of forms. Supporting forms of shoring shall not be removed until strength of control-test specimens has attained a value of at least 10.3 Megapascal 1,500 psi for columns and 13.8 Megapascal 2,000 psi for other work. Contractor shall ensure that newly unsupported portions of the structure are not subjected to heavy construction or material loading.

Tie-rod clamps to be removed from wall shall be loosened 24 hours after concrete is placed; form ties, except for a sufficient number to hold forms in place, may be removed at that time. Ties wholly withdrawn from wall shall be pulled toward inside face.

When formwork is removed during concrete curing period, exposed concrete shall be cured as specified.

3.1.10 Re-Use of Forms

Surfaces of forms that are to be re-used shall be cleaned and repaired, except that split, frayed, or delaminated form facing material shall not be re-used. Contact surfaces of re-used forms shall be coated as specified.

3.2 REINFORCEMENT FABRICATION AND INSTALLATION

3.2.1 General

Details of reinforcement shall be in accordance with ACI/MCP 405, ASTM E 648, ACI/MCP 305 and ACI 318/318R, and as specified.

3.2.2 Fabrication

Reinforcing bars shall be shop fabricated to conform to shapes and dimensions indicated for reinforcement, and as follows:

Fabrication tolerances shall be in accordance with ACI/MCP 205, ACI/MCP 305 and ACI 318/318R, ASTM E 648 and ACI 117.

Hooks and bends shall be in accordance with ACI/MCP 405, ASTM E 648, ACI/MCP 305 and ACI 318/318R.

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

Tolerance on nominally square-cut, reinforcing bar ends shall be in accordance with ACI/MCP 305 and ACI 318/318R.

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

Reinforcement which has any of the following defects shall not be used:

Bar lengths, depths, and bends beyond specified fabrication tolerances

Bends or kinks not indicated on drawings or approved shop drawings

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

Defective reinforcement shall be replaced with new reinforcement having required shape, form, and cross-section area.

3.2.3 Placing Reinforcement

Reinforcement shall be placed in accordance with ACI/MCP 405, ASTM E 648, ACI/MCP 305 and ACI 318/318R.

For slabs on grade (over earth or over capillary water barrier) and for footing reinforcement, bars or welded wire fabric shall be supported 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 will be less than 1 inch 25 millimeter from concrete surfaces that will be exposed to view or will be painted shall be of precast concrete units, plastic-coated steel, or stainless steel protected bar supports. Precast concrete units shall be wedge shaped, not larger than 90 by 90 millimeter, 3-1/2 by 3-1/2 inches, and of thickness equal to that indicated for concrete protection of reinforcement. Precast units shall have cast-in galvanized tie wire hooked for anchorage and shall blend with concrete surfaces after finishing is completed.

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

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

Epoxy-coated reinforcing bars shall be handled carefully to prevent damage to the coating. Plastic-coated tie wire shall be used and supports shall be of a type to prevent damage to the reinforcing bars.

Reinforcement shall be supported and secured together to prevent displacement by construction loads or by placing of wet concrete, and as follows:

Supports for reinforcing bars shall be sufficient in number and sufficiently heavy to carry the reinforcement they support, and in accordance with ACI/MCP 405, ASTM E 648, ACI/MCP 305ACI 318/318R and CRSI MSP-2. Supports shall not be used to support runways for concrete conveying equipment and similar construction loads.

Supports on ground and similar surfaces shall be equipped with sand-plates.

Welded wire fabric shall be supported as required for reinforcing bars.

Reinforcements shall be secured to supports by means of tie wire. Wire shall be black, soft iron wire, not less than 1.6 millimeter 16 gage.

With the exception of temperature reinforcement, which shall be tied to main steel approximately 600 millimeter 24 inches on center, reinforcement shall be accurately placed, securely tied at intersections with 1.3 millimeter 18-gage annealed wire, and held in position during placing of concrete by spacers, chairs, or other approved supports. Wire-tie ends shall point away from the form. Unless otherwise indicated, numbers, type, and spacing of supports shall conform to ACI/MCP 305 and ACI 318/318R.

Bending of reinforcing bars partially embedded in concrete will be permitted only as specified in ACI/MCP 405, ASTM E 648, ACI/MCP 305 and ACI 318/318R.

3.2.4 Spacing of Reinforcing Bars

Spacing shall be as indicated. If not indicated, spacing shall be in accordance with the ACI/MCP 405, ASTM E 648, ACI/MCP 305 and ACI 318/318R.

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 shall be subject to approval.

3.2.5 Splices in Reinforcement

Splices shall be as indicated on the approved drawings.

3.2.6 Concrete Protection for Reinforcement

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

Concrete protection shall be in accordance with the ACI/MCP 405, ASTM E 648, ACI/MCP 305 and ACI 318/318R.

3.2.7 Welding

Welding shall be in accordance with AWS D1.4.

3.3 JOINTS

3.3.1 Construction Joints

Joints not indicated shall be made and located so as not to impair strength and appearance of the structure and shall be as approved. Construction joints shall be located as follows:

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

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

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 shall offset a distance to twice the width of the beam. Transfer of shear through construction joint shall be made by use of inclined reinforcement.

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

Keyways at least 40 millimeter 1-1/2-inches deep shall be provided in construction joints in walls and slabs and between walls and footings; approved bulkheads may be used for slabs.

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

3.3.2 Waterstops

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

Waterstop shall be provided in construction joints as indicated.

Waterstops shall be installed to form a continuous diaphragm in each joint. Adequate provision shall be made to support and protect waterstops during progress of work. Field joints in waterstops shall be made in accordance with waterstop manufacturer's printed instructions, as approved. Waterstops protruding from joints shall be protected from damage.

3.3.3 Isolation Joints in Slabs on Ground

Joints shall be provided at points of contact between slabs on ground and vertical surfaces, such as column pedestals, foundation walls, grade beams, and elsewhere as indicated.

Joints shall be filled with premolded joint filler strips 13 millimeter 1/2 inch thick, extending full slab depth. Filler strips shall be installed 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 millimeter 3/4 inch in depth where joint will be sealed with sealing compound and not less than 6 millimeter 1/4 inch in depth where joint sealing is not required. Wood strip shall be removed after concrete has set. Contractor shall clean groove of foreign matter and loose particles after surface has dried.

3.3.4 Control Joints in Slabs on Ground

Joints shall be provided to form panels as indicated.

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

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

3.3.5 Sealing Joints in Slabs on Ground

Isolation and control joints which will not be covered with finish flooring material shall be sealed with joint sealing compound after concrete curing period. Groove shall be slightly underfilled with joint sealing compound to prevent extrusion of compound. Excess material shall be removed as soon after sealing as possible.

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

3.4 INSTALLATION OF ANCHORAGE DEVICES

3.4.1 General

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

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

3.4.2 Placing Anchorage Devices

Anchorage devices and embedded items shall be positioned accurately and supported against displacement. Openings in anchorage devices such as slots and threaded holes shall be filled with an approved, removable material to prevent entry of concrete into openings.

3.5 PREPARATIONS FOR CONCRETE PLACING

3.5.1 General

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

Standing water shall be removed without washing over freshly deposited concrete. Flow of water shall be diverted through side drains provided for such purpose.

3.5.2 Subgrade Under Foundations and Footings

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

3.5.3 Subgrade Under Slabs on Ground

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

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

Actual density of top 300 millimeter 12 inches of subgrade soil material-in-place shall not be less than the following percentages of maximum density of same soil material compacted at optimum moisture content in accordance with ASTM D 1557.

<u>SOIL MATERIAL</u>	<u>PERCENT MAXIMUM DENSITY</u>
Drainage fill	100
Cohesionless soil material	100
Cohesive soil material	95

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

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

Drainage fill surface under interior slabs on ground shall be covered with specified water-vapor barrier subgrade cover immediately prior to placing reinforcement. Subgrade cover shall be installed to avoid puncture or tear. Punctures or tears over 300 millimeter 12 inches shall be patched with separate sheets lapped not less than 150 millimeter 6 inches. All punctures or tears less than 300 millimeter 12 inches shall be sealed with

pressure-sensitive vapor barrier tape not less than 50 millimeter 2-inches wide. Lapped joints shall be sealed with vapor barrier adhesive or pressure-sensitive vapor barrier tape not less than 50 millimeter 2-inches wide. Subgrade cover sheets shall be laid with not less than a 150 millimeter 6-inch lap at edges and ends and in direction in which concrete is to be placed.

Subgrade or fill surface under exterior slabs on ground shall be prepared as specified for subgrade under foundations and footings.

3.5.4 Formwork

Formwork shall be complete and approved. Debris and foreign material shall be removed from interior of forms before start of concrete placing.

3.5.5 Edge Forms and Screed Strips for Slabs

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

3.5.6 Reinforcement and Other Embedded Items

Reinforcement, joint materials, and other embedded materials shall be secured in position, inspected, and approved before start of concrete placing.

3.6 CONCRETE CONVEYING

3.6.1 Transfer of Concrete At Project Site

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

3.6.2 Mechanical Equipment for Conveying Concrete

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

3.7 CONCRETE PLACING

3.7.1 Weather Limitations and Protection

Concrete shall not be placed when the temperature of the atmosphere is below 5 degrees C, 40 degrees F, nor during rain, sleet, or snow, unless protection is provided.

Protection shall be provided during cold weather in accordance with ASTM E 648, ACI/MCP 205 and ACI 301.

During inclement weather, protection material shall be watertight to prevent entry of rain, sleet, or snow onto surfaces to receive concrete and into fresh concrete.

Protection materials shall be stored at project site for use in event of unforeseen weather changes after start of concrete placing operations.

3.7.2 General Placing Requirements

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

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

Concrete which becomes nonplastic and unworkable or does not meet quality control limits as specified or has been contaminated by foreign materials shall not be used. Use of retempered concrete will not be permitted. Rejected concrete shall be removed from the site.

3.7.3 Placing Concrete in Forms

Concrete placed in forms shall be deposited in horizontal layers not exceeding 600 millimeter 24 inches.

Temporary spreaders in forms shall be removed when concrete placing has reached elevation of spreaders.

Concrete placed in forms shall be consolidated by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping. Vibrators shall be designed to operate with vibratory element submerged in concrete and shall maintain a speed of not less than 9,000 impulses per minute when submerged in concrete. Vibrating equipment shall be adequate in number of units and power of each unit to properly consolidate concrete. Vibration of forms and reinforcement shall not be permitted. Vibrators shall not be used to transport concrete inside forms. Vibrators shall be inserted and withdrawn vertically at uniformly spaced points not farther apart than visible effectiveness of machine. Vibrator shall not be inserted into lower courses of concrete that have begun to set. At each insertion, duration of vibration shall be limited to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing segregation of concrete mix.

Placing of concrete in supporting elements shall not be started until concrete previously placed in columns and walls is no longer plastic and has been in place a minimum of 2 hours.

3.7.4 Placing Concrete Slabs

Concrete for slabs shall be placed and consolidated in a continuous operation, within the limits of approved construction joints until placing of panel or section is completed.

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

Finish of slabs shall be as specified.

3.7.5 Bonding

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

Bonding of fresh concrete that has set shall be obtained 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 shall 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, and other structural members; and at joints in work designed to contain liquids; the roughened and cleaned surface of set concrete shall be dampened but not saturated and covered with a cement grout coating.

Cement grout shall consist of equal parts of portland cement and fine aggregate by weight with not more than [22.5 liter] 6 gallons of water per sack of cement. Cement grout shall be applied with a stiff broom or brush to a minimum thickness of 1.6 millimeter 1/16 inch. Fresh concrete shall be deposited before cement grout has attained its initial set.

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

3.8 FINISHING OF FORMED SURFACES

**NOTE: The following finishing of formed surfaces
does not include special architectural finishes such
as exposed aggregate finish, textured form finish,**

special panel finish, and aggregate transfer finish.
When special architectural finishes are required,
requirements for such finishes must be specified.
Locations of special architectural finishes must be
indicated.

3.8.1 Repairing and Patching Defective Areas

Immediately after removal of forms, defective areas shall be repaired and patched with cement mortar.

Honeycomb, rock pockets, voids over 13 millimeter 1/2 inch in diameter, and holes left by tie rods and bolts shall be cut out to solid concrete, but in no case to a depth of less than 25 millimeter 1 inch. Edges of cuts shall be perpendicular to surface of concrete. Before placing cement mortar, area to be patched at least 150 millimeter 6 inches adjacent thereto shall be cleaned, dampened with water, and brush coated with neat portland cement grout. Cement mortar for patching shall consist of one part standard portland cement to two parts fine aggregate passing 1.18 millimeter No. 16 mesh sieve and as little water as necessary for handling and placing. Where concrete surface will be exposed to view, portland cement portion of cement mortar shall be a blend of white and standard portland cement so that when dry, cement mortar will match surrounding concrete in color. Cement mortar shall be compacted in place and struck off slightly higher than the surrounding surface. Holes extending through concrete shall be filled by means of a plunger type gun or other suitable device from unexposed face, using a stop held at exposed face to ensure complete filling.

3.8.2 Standard Rough Form Finish

Finish shall be the concrete surface having texture imparted by form facing material used, defective areas repaired and patched as specified, and fins and other projections exceeding 6 millimeter 1/4 inch in height rubbed down with wood blocks.

3.8.3 Standard Smooth Finish

Finish shall be as-cast concrete surface as obtained with form facing material for standard smooth finish. Defective areas shall be repaired and patched as specified; and all fins and other projections on surface shall be removed.

3.8.4 Grout Finish

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

Finish shall be standard, smooth coated with grout as specified.

Finish shall be given to interior and exterior concrete vertical surfaces that are to be exposed to view.

Grout shall consist of one part portland cement to 1-1/2 parts fine aggregate by volume, mixed with water to produce a consistency of thick

paint. Portland cement portion shall be a blend of standard portland cement and white portland cement, proportioned as determined by trial mixes so that final color of grout when dry will approximate color of surrounding concrete. Fine aggregate shall pass 600 micrometer No. 30 mesh sieve.

Surface of concrete shall be wetted, and grout shall be applied immediately to wetted surfaces. Grout shall be spread over surface with clean burlap pads or sponge-rubber floats to fill pits, air bubbles, and surface holes. Excess grout shall be removed by scraping, then rubbing surface with clean burlap to remove visible grout film. Grout shall be kept damp by means of fog spray during setting period. Finish shall be completed the day it is started, and limits of a finished area shall be made at natural breaks in finished surface.

3.8.5 Related Unformed Surfaces

Tops of walls, horizontal offsets, and similar unformed surfaces occurring adjacent to formed surfaces shall be struck off smooth after concrete is placed and shall be finished to a texture matching that of adjacent formed surfaces. Final surface treatment on formed surfaces shall continue uniformly across adjacent unformed surfaces.

3.9 FINISHING OF SLABS

3.9.1 Scratch Finish

A scratch finish shall be given to slab surfaces that are to receive concrete floor topping, mortar setting beds, or other bonded, applied, cement, finish flooring material.

After placing concrete slabs, surface shall be plane to a tolerance not exceeding 6.4 millimeter in 600 millimeter 1/4 inch in 2 feet when tested with a 600 millimeter 2-foot straightedge placed on the surface at not less than two different angles. Surfaces shall be uniformly sloped to drains. After leveling, surface shall be roughened with stiff brushes or raked before final set.

3.9.2 Float Finish

A float finish shall be given to slab surfaces that are to receive trowel finish and other finishes as specified and to slab surfaces that are to be covered with membrane waterproofing, membrane roofing, or terrazzo.

After placing is completed, concrete shall not be worked further until ready for floating. Floating shall begin when water has disappeared, or when concrete mix has stiffened sufficiently to permit proper operation of a power-driven float, or when both conditions have occurred. Any surface water remaining shall be removed before floating. Surface shall then be consolidated with power-driven floats. Hand floating shall be used in locations inaccessible to power-driven floats. Trueness of surface shall be checked at this stage with a 3000 millimeter 10-foot straightedge. Surface shall be plane to a tolerance not exceeding 6.4 millimeter in 3000 millimeter 1/4 inch in 10 feet when tested with a 3000 millimeter 10-foot straightedge placed on the surface at not less than two different angles. High spots shall be cut down and low spots shall be filled. Surfaces shall be uniformly sloped to drains. Immediately after completion of leveling, surface shall be refloated to a uniform, smooth, granular texture.

3.9.3 Trowel Finish

Finish shall be given to slab surfaces that are to be exposed to view, and to slab surfaces to be covered with resilient flooring, paint, or other finish coating system.

After completion of float finish as specified above, the surface shall receive a trowel finish. First troweling after completion of float finish shall be done by a power-driven trowel and shall produce a smooth surface which is free of defects but which may contain some trowel marks.

Additional trowelings shall be done by hand after surface has hardened sufficiently. Final troweling shall be started when a ringing sound is produced as trowel is moved over surface. Surface shall be consolidated by hand troweling operation. Finished surface shall be free of trowel marks, uniform in texture and appearance, and plane to a tolerance not exceeding 6.4 millimeter in 3000 millimeter 1/4 inch in 10 feet when tested with a 3000 millimeter 10-foot straightedge placed on the surface in any direction. Surface defects of sufficient magnitude to show through floor covering shall be removed by grinding.

NOTE: For surfaces requiring subsequent tile
finish, change above tolerance from 1/4 inch to 1/8
inch 6.4 millimeter to 3.2 millimeter.

3.9.4 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 will not be covered with
resilient flooring, paint, or other finish coating.

[Liquid-chemical floor hardener shall be applied where indicated after curing and drying concrete surface. Liquid hardener shall be diluted with water and applied in three coats. First coat shall be one-third strength, second coat one-half strength, and third coat two-thirds strength. Each coat shall be applied evenly and allowed to dry 24 hours between coats.

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

3.9.5 Nonslip Aggregate Finish

NOTE: Slab surfaces requiring non-slip aggregate
finish must be indicated. Such finish is suitable
for surfaces of interior and exterior concrete stair
treads and platforms, ramps, and other floor
surfaces that are subject to moderate foot traffic.

[Finish shall be given to surfaces of interior concrete stair treads and platforms, and elsewhere as indicated.

After completion of float finish and before starting trowel finish, non-slip aggregate shall be uniformly spread over concrete surface at the rate of not less than 12 kilogram per 10 square meter 25 pounds per 100 square feet of surface and shall be tamped flush with surface by means of a steel trowel without burying non-slip aggregate particles. Surface shall then be given trowel finish as specified.

After curing, surface shall be brushed with a steel-wire brush or rubbed with abrasive stone and water to slightly expose non-slip aggregate.]

3.9.6 Non-Slip Broom Finish

NOTE: Slab surfaces requiring non-slip broom finish must be indicated. Such finish is suitable for surfaces of exterior concrete steps and platforms, ramps and other exterior slab surfaces that are subject to light foot traffic.

[Finish shall be given to surfaces of exterior concrete steps and platforms, and elsewhere where indicated.

Immediately after completion of trowel finish, surface shall be slightly roughened by brooming with a fiber-bristle brush in a direction transverse to that of main traffic]

3.9.7 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.

[Finish shall be given to monolithic slab surfaces where indicated.

Dry shake materials for colored wear-resistant finish shall be applied 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 shall be uniformly distributed over surface and embedded by means of power floating. After first dry-shake application has been embedded, remainder of dry-shake material shall be uniformly distributed over surface at right angles to 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 shall be as specified for float finish.

After completion of float finish, surface shall receive a trowel finish as specified.]

3.9.8 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.

Finish shall be given to slab surfaces where indicated.

Dry-shake material for heavy-duty, wear-resistant finish shall 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]

Blended dry-shake material shall be applied as follows:

NOTE: Select type of aggregate.

MAXIMUM TYPE OF AGGREGATE <u>IN DRY SHAKE</u>	AMOUNT PER 100 SQUARE <u>METER OF SURFACE</u>
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Traprock	73 kilogram
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Emery	59 kilogram
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Iron	59 kilogram
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MAXIMUM TYPE OF AGGREGATE <u>IN DRY SHAKE</u>	AMOUNT PER 100 SQUARE <u>FEET OF SURFACE</u>
---	--

Traprock	150 pounds
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Emery	120 pounds
-------	------------

Iron	120 pounds
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Immediately following the first floating operation, approximately one-half the specified weight of blended, dry-shake materials shall be uniformly distributed over the surface and embedded by means of power floating. After the first dry-shake application has been embedded, the remaining one-half of the blended dry-shake material shall be uniformly distributed 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 shall be as specified for float finish.

After completion of the float finish, the surface shall receive a trowel finish as specified.

3.10 CONCRETE FLOOR TOPPING

3.10.1 Standard Floor Topping

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

Topping shall be provided for treads and platforms of metal steel stairs
and elsewhere as indicated.

Materials

Materials shall conform to requirements specified, except aggregate
shall be as follows:

<u>TYPE OF AGGREGATE</u>	<u>SIEVE</u>	<u>PERCENT PASSING</u>
Fine aggregate	9.5 millimeter	100
	4.75 millimeter	95 to 100
	2.36 millimeter	80 to 90
	1.18 millimeter	50 to 75
	600 micrometer	30 to 50
	300 micrometer	10 to 20
	150 micrometer	2 to 5
Coarse aggregate	12.5 millimeter	100
	9.5 millimeter	95 to 100
	4.75 millimeter	40 to 60
	2.36 millimeter	0 to 5

<u>TYPE OF AGGREGATE</u>	<u>SIEVE</u>	<u>PERCENT PASSING</u>
Fine aggregate	3/8 inch	100
	No. 4	95 to 100
	No. 8	80 to 90
	No. 16	50 to 75
	No. 30	30 to 50
	No. 50	10 to 20
	No. 100	2 to 5

<u>TYPE OF AGGREGATE</u>	<u>SIEVE</u>	<u>PERCENT PASSING</u>
Coarse aggregate	1/2 inch	100
	3/8 inch	95 to 100
	No. 4	40 to 60
	No. 8	0 to 5

Standard topping mixture

Mixture shall consist of one part portland cement, one part fine aggregate, and two parts coarse aggregate, by volume. Exact proportions of fine and coarse aggregates shall be adjusted to produce a well-graded total aggregate. Mixing water shall not exceed 5 gallons per 94-pound sack of cement including unabsorbed moisture in aggregate. Maximum slump shall be 50 millimeter 2 inches.

Preparations prior to placing

When mixture will be placed on a green concrete base slab, surface of base slab shall be screeded to a level not more than 38 millimeter 1-1/2 inches nor less than 25 millimeter 1 inch below required finish surface. Water and laitance shall be removed from surface of base slab before placing topping mixture. As soon as water ceases to rise to surface of base slab, topping mixture shall be placed as specified.

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

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

Mixing

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

Each batch of 1.5 cubic meter 2 cubic yards or less shall be mixed for not less than 1-1/2 minutes. Mixing time shall be increased 15 seconds for each additional cubic yard or fraction thereof.

Mixer shall be clean, and blades in drum shall be replaced when they

have lost 10 percent of their original depth.

Truck-mixed topping may be used when approved. Truck-mixed topping shall be as specified for ready-mix concrete.

Placing

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

Finishing

Trowel finish shall be given 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.

Other finishes shall be given standard floor topping surfaces as indicated. Such finishes shall be as specified for required finish.

3.10.2 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.

Topping shall be provided where indicated.

Heavy-duty topping mixture

Mixture shall consist 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 shall conform to recommendations of aggregate manufacturer. Mixing water shall not exceed 14.2 liter per 43 kilogram 3-3/4 gallons per 94-pound sack of cement including unabsorbed moisture in aggregate. Maximum slump shall be 25 millimeter 1 inch.

Base slab

Surface of slab shall be screeded to a level no more than 38 millimeter 1-1/2 inches nor less than 25 millimeter 1 inch below grade of finished floor.

Slab shall have been given a scratch finish as specified.

Preparations prior to placing

Dirt, loose material, oil, grease, asphalt, paint and other

contaminants shall be removed from base slab surface. Prior to placing topping mixture, slab surface shall be dampened and left free of standing water. Immediately before topping mixture is placed, a coat of neat cement grout shall be broomed onto surface of slab. Cement grout shall not be allowed to set or dry before topping mixture is placed.

Mixing

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

Each batch of 2 cubic yards 1.5 cubic meter or less shall be mixed for not less than 1-1/2 minutes.

Mixing time shall be increased 15 seconds for each additional cubic yard or fraction thereof. Mixer shall be clean, and pick-up and throw-over blades in drum shall be replaced when they have lost 10 percent of their original depth.

Placing

Heavy-duty topping mixture shall be spread evenly on previously prepared base slab, and brought to correct level with a straightedge, and struck off. Topping shall be consolidated, floated, and checked for trueness of surface as specified for float finish, except that power-driven floats shall be the impact type.

Finishing

Trowel finish shall be given heavy-duty floor topping surfaces. Trowel finish shall be as specified, except that additional troweling after first power troweling shall be not less than three hand-troweling operations.

3.11 CONCRETE CURING AND PROTECTION

3.11.1 General

Freshly placed concrete shall be protected from premature drying and cold or hot temperature and shall be maintained without drying at a relatively constant temperature for the period of time necessary for hydration of cement and proper hardening of concrete.

Initial curing shall start as soon as free water has disappeared from surface of concrete after placing and finishing. Concrete shall be kept moist for minimum 72 hours.

Final curing shall immediately follow initial curing and before concrete has dried. Final curing shall continue until cumulative number of hours or fraction thereof (not necessarily consecutive) during which temperature of air in contact with the concrete is above 10 degrees C 50 degrees F has totalled 168 hours. Alternatively, if tests are made of cylinders kept adjacent to the structure and cured by the same methods, final curing may

be terminated when the average compressive strength has reached 70 percent of the 28-day design compressive strength. Rapid drying at end of final curing period shall be prevented.

3.11.2 Curing Methods

Curing shall be accomplished by moist curing, by moisture-retaining cover curing, by membrane curing, and by combinations thereof, as specified.

Moist curing:

Moisture curing shall be accomplished by any of the following methods:

Keeping surface of concrete wet by covering with water

Continuous water spraying

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

Moisture-cover curing:

Moisture-retaining cover curing shall be accomplished by covering concrete surfaces with specified moisture-retaining cover for curing concrete. Cover shall be placed directly on concrete in widest practical width, with sides and ends lapped at least **75 millimeter 3 inches**. Cover shall be weighted to prevent displacement; tears or holes appearing during curing period shall be immediately repaired by patching with pressure-sensitive, waterproof tape or other approved method.

Membrane curing:

Membrane curing shall be accomplished by applying specified membrane-forming curing compound to damp concrete surfaces as soon as moisture film has disappeared. Curing compound shall be applied uniformly in a two-coat operation by power-spraying equipment using a spray nozzle equipped with a wind guard. Second coat shall be applied in a direction at right angles to direction of first coat. Total coverage for two coats shall be not more than **5 square meter per liter 200 square feet per gallon** of curing compound. Concrete surfaces which are subjected to heavy rainfall within 3 hours after curing compound has been applied shall be resprayed by method and at rate specified. Continuity of coating shall be maintained for entire curing period and damage to coating during this period shall be repaired immediately.

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

3.11.3 Curing Formed Surfaces

Curing of formed surfaces, including undersurfaces of girders, beams, supported slabs, and other similar surfaces shall be accomplished 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, final curing of formed surfaces shall be accomplished by any of the curing methods specified above, as applicable.

3.11.4 Curing Unformed Surfaces

Initial curing of unformed surfaces, such as monolithic slabs, floor topping, and other flat surfaces, shall be accomplished by membrane curing.

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

Final curing of concrete surfaces to receive liquid floor hardener of finish flooring shall be accomplished by moisture-retaining cover curing.

3.11.5 Temperature of Concrete During Curing

When temperature of atmosphere is 5 degrees C 40 degrees F 55 degrees F and below, temperature of concrete shall be maintained at not less than 13 degrees C throughout concrete curing period or 7 degrees C 45 degrees F when the curing period is measured by maturity. When necessary, arrangements shall be made 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 will cause too rapid drying of concrete, arrangements shall be made 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 shall be uniform and shall not exceed 3 degrees C 5 degrees F in any 1 hour nor 28 degrees C 50 degrees F in any 24-hour period.

3.11.6 Protection from Mechanical Injury

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

3.11.7 Protection After Curing

Finished concrete surfaces shall be protected from damage by construction operations.

3.12 QUALITY-CONTROL TESTING DURING CONSTRUCTION

Concrete shall be sampled and tested for quality control by the Contractor during the placement of the concrete as follows:

<u>REQUIREMENT</u>	<u>TEST METHOD</u>	<u>NUMBER OF TESTS</u>
Sampling fresh concrete	ASTM C 172 except modified for slump per ASTM C 94/C 94M	As required for each test

<u>REQUIREMENT</u>	<u>TEST METHOD</u>	<u>NUMBER OF TESTS</u>
Slump test	ASTM C 143/C 143M	One for each concrete load at point of discharge and one for each set of compressive strength tests
Air content by pressure method	ASTM C 231	One for each set of compressive strength tests
Compression test specimens	ASTM C 31/C 31M	One set of six standard cylinders for each compressive strength test
Concrete temperature		Hourly when air temperature is 4.4 degrees C or below and 26.7 degrees C or above; each time a set of compression test specimens is made
Compressive strength test	ASTM C 39/C 39M	One set for each 115 cubic meter or fraction thereof of each concrete class placed in any one day; two specimens tested at 7 days, three specimens tested at 28 days and one specimen retained in reserve for testing if required

<u>REQUIREMENT</u>	<u>TEST METHOD</u>	<u>NUMBER OF TESTS</u>
Sampling fresh concrete	ASTM C 172 except modified for slump per ASTM C 94/C 94M	As required for each test
Slump test	ASTM C 143/C 143M	One for each concrete load at point of discharge and one for each set of compressive strength tests
Air content by pressure method	ASTM C 231	One for each set of compressive strength tests

<u>REQUIREMENT</u>	<u>TEST METHOD</u>	<u>NUMBER OF TESTS</u>
Compression test specimens	ASTM C 31/C 31M	One set of six standard cylinders for each compressive strength test
Concrete temperature		Hourly when air temperature is 40 degrees F or below and 80 degrees F or above; each time a set of compression test specimens is made
Compressive strength test	ASTM C 39/C 39M	One set for each 150 cubic yards or fraction thereof of each concrete class placed in any one day; two specimens tested at 7 days, three specimens tested at 28 days and one specimen retained in reserve for testing if required

Test reports for concrete for [Chemical Composition](#), [Mechanical Usability](#) and [Soundness](#) shall be submitted by the Contractor meeting all design specifications as required by referenced standards within this section.

3.13 INSPECTION AND ACCEPTANCE PROVISIONS

3.13.1 Evaluation of Compressive Strength Tests

Concrete quality control test will be evaluated as specified.

Compressive strength tests will be considered satisfactory if the average of all sets of five consecutive compressive strength tests equal or exceed the 28-day design compressive strength, or if no individual compressive strength test (average of two cylinders) falls below the required 28-day design compressive strength by more than [350 kilopascal](#) [500 pounds per square inch](#).

If compressive strength tests fail to meet minimum requirements specified, concrete represented by such tests will be considered deficient in strength and subject to provisions specified.

3.13.2 Strength of Concrete Structure

Strength of concrete structure in place will be considered deficient if it fails to comply with requirements which control strength of structure, including following conditions:

Failure to meet compressive strength tests as evaluated

Reinforcement not conforming to requirements specified

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

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

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

Poor workmanship likely to result in deficient strength

3.13.3 Testing Concrete Structure for Strength

When there is evidence that strength of concrete structure in place does not meet specification requirements, cores drilled from hardened concrete for compressive strength determination shall be made in accordance with [ASTM C 42/C 42M](#), and as follows:

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

Cores shall be tested after moisture conditioning in accordance with [ASTM C 42/C 42M](#) if concrete they represent will be more than superficially wet under service.

Cores shall be air dried, (16 to 27 degrees C 60 to 80 degrees F with relative humidity less than 60 percent) for 7 days before test and shall be tested dry if concrete they represent will be dry under service conditions.

Strength of cores from each member or area will be 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 shall be borne by the Contractor.

Core holes shall be filled solid with patching mortar and finished to match adjacent concrete surfaces.

Concrete work that is found inadequate by core tests shall be corrected in a manner approved by the Contracting Officer.

-- End of Section --