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USACE / NAVFAC / AFCEC **UFGS-03 70 00 (February 2026)**

Preparing Activity: USACE **Superseding**
UFGS-03 70 00 (February 2010)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2026
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DIVISION 03 - CONCRETE

SECTION 03 70 00

MASS CONCRETE

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SECTION 03 70 00

MASS CONCRETE
02/26

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NOTE: This guide specification covers the requirements for large projects containing mass concrete or mass and structural concrete, and major projects where the government retains the responsibility for concrete mixture proportioning. This section was originally developed for USACE Civil Works projects.

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

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

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

****

PART 1 GENERAL

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NOTE: The content of this specification is such that guidance given in EM 1110-2-2000, Standard Practice for Concrete is applicable.

****

1.1 SCOPE

This section applies to all cast in place concrete. This includes but is not limited to [list features of work in which this spec section will

cover.] These features will be classified as either mass concrete, structural concrete[, underwater concrete][, any other type you want to be covered by this spec]. This section also covers the contract requirements for Government-designed concrete mixtures and Contractor-designed concrete mixtures. The following table indicated which features of work classify for the types of concrete, and who is responsible for the concrete mixture proportioning.

TYPE OF CONCRETE	FEATURES OF WORK	Concrete Mixture Proportioning Responsibility
NON-MASS CONCRETE MIXTURES		
[Structural Cast in Place]		[Government] [Contractor]
[Self-Consolidating Concrete SCC]		[Government] [Contractor]
[Underwater - Structural Cast in Place]		[Government] [Contractor]
[Underwater - Self-Consolidating Concrete SCC]		[Government] [Contractor]
Mass Concrete Mixtures		
[Mass Concrete - Cast in Place]		[Government] [Contractor]
[Underwater - Self-Consolidating Concrete SCC]		[Government] [Contractor]
OTHER MIXTURES		

1.2 PRICE AND PAYMENT

****

NOTE: If Section 01 20 00 PRICE AND PAYMENT PROCEDURES is included in the project specifications, this paragraph titled PRICE AND PAYMENT should be deleted from this section and the remaining appropriately edited subparagraphs below should be inserted into Section 01 20 00.

Consult the concrete materials design memorandum to choose the appropriate cementitious materials and admixtures for measurement and payment.

When silica fume is used in the project, the Designer should include both bid items, Silica Fume,

Dry and Silica Fume, Slurry, to give the Contractor the option of supplying the material in dry form or in slurry form.

List all other admixtures not listed separately similar to these bid items.

****

1.2.1 Concrete for [_____]

****

NOTE: Repeat this bid item and its respective subparagraphs for each bid item of concrete, renumbering the bid items appropriately.

Use the lump sum payment method for features of work in which the contractor designs and controls the mix design.

****

1.2.1.1 Price

Concrete will be priced based upon the actual volume of concrete within the pay lines of the structures as indicated on the drawings. Measure concrete placed against the sides of any excavation without the use of intervening forms only within the pay lines of the structure. Do not make deductions for rounded or beveled edges, space occupied by metal work, electrical conduits, reinforcing steel, voids or embedded items that are either less than 0.14 cubic meters 5 cubic feet in volume or 0.09 square meter 1 square foot in cross section.

1.2.1.2 Payment

Payment will be made for costs associated with completing the concrete work for concrete placed in the [_____]. However, these costs will not include the cost of the cement, pozzolan[, slag], reinforcement[, water-reducing admixture][, high range water reducer][, silica fume], and embedded parts that are specified to be paid for separately. No payment will be made for concrete, as such, that is placed in structures of which payment is made as a lump sum.

1.2.1.3 Unit of Measure

Unit of measure: cubic meters yards.

[1.2.2 Concrete in Blockouts

[Text]

1.2.2.1 Price

Concrete will be priced for payment based upon the actual volume of concrete placed in the blockouts as indicated on the drawings.

1.2.2.2 Payment

Payment will be made for costs associated with concrete placed in the blockouts.

1.2.2.3 Unit of Measure

Unit of measure: cubic meters yards.

][1.2.3 Portland Cement

****
NOTE: List all other cementitious materials (except pozzolan), such as portland-pozzolan cement, slag cement, or portland blast-furnace cement, separately similar to this bid item, and the bid items renumbered appropriately.
****

1.2.3.1 Price

Portland cement will be measured for payment based upon the number of tons of portland cement used unless specifically excepted, wasted, or used for the convenience of the Contractor. The quantity to be paid for will be determined by multiplying the approved batch weight in kilograms per cubic meter pounds per cubic yard of portland cement in each type of concrete used by the number of cubic meters yards of concrete types placed within the pay lines of the structure, as determined in accordance with the concrete bid items, and dividing by 1000 2,000.

1.2.3.2 Payment

Payment will be made for costs associated with Portland cement, which includes the cost of required unloading, hauling, handling, and storage at the site, of all portland cement used in the work.

1.2.3.3 Unit of Measure

Unit of measure: tons Metric 2000 lbs.

]1.2.4 Pozzolan (Except Silica Fume)

1.2.4.1 Price

Pozzolan, except silica fume, will be measured for payment based upon the number of tons solid volume of pozzolan used unless specifically excepted, wasted, or used for the convenience of the Contractor. The quantity to be paid for will be determined by multiplying the approved batch weight in kilograms per cubic meter pounds per cubic yard of pozzolan in each type of concrete used by the number of cubic meters yards of concrete of the types placed within the pay lines of the structure, as determined in accordance with the concrete bid items, and dividing by the product of the average specific gravity of the pozzolan multiplied by 1000 kilograms per cubic meter 62.4 pounds per cubic foot. The average specific gravity is the average of the test results for all material accepted during the period covered by the payment.

1.2.4.2 Payment

Payment will be made for costs associated with pozzolan, which includes the cost of required unloading, hauling, handling, and storage at the site, of all pozzolan used in the concrete bid items.

1.2.4.3 Unit of Measure

Unit of measure: tons Metric 2000 lbs.

1.2.5 Slag Cement

1.2.5.1 Price

Slag cement will be measured for payment based upon the number of tons of slag cement used excluding the amount specifically excepted, wasted, or used for the convenience of the Contractor. The quantity to be paid for will be determined by multiplying the approved batch weight in kilograms per cubic meter pounds per cubic yard of slag cement in each type of concrete used by the number of cubic meters yards of concrete types placed within the pay lines of the structure, as determined in accordance with the concrete bid items, and dividing by 1000 2,000.

1.2.5.2 Payment

Payment will be made for costs associated with slag cement, which includes the cost of required unloading, hauling, handling, and storage at the site, of all slag cement used in the concrete bid items.

1.2.5.3 Unit of Measure

Unit of measure: tons Metric 2000 lbs.

1.2.6 Water-Reducing Admixture (WRA)

1.2.6.1 Price

[Water-reducing admixture (WRA) will be priced by the liters gallons used.][Water-reducing admixture (WRA) will be priced for payment based upon the actual volume of concrete containing the admixture and within the pay lines of the structures, as determined in accordance with the concrete bid items.]

1.2.6.2 Payment

[Payment will be made for costs associated with water-reducing admixture (WRA) at the applicable contract unit price per liters gallons of water-reducing admixture.][Payment will be made for costs associated with water-reducing admixture (WRA) at the applicable contract unit cost of concrete containing water-reducing admixture for:

a. First [_____] cubic meters yards.

b. All over [_____] cubic meters yards.]

1.2.6.3 Unit of Measure

Unit of measure:[liters gallons][cubic meters yards].

1.2.7 High-Range Water-Reducing Admixture (HRWA)

1.2.7.1 Price

[High-Range Water-reducing Admixture (HRWA) will be priced by the liters gallons used.][High-Range Water-reducing Admixture (HRWR) will be priced

for payment based upon the actual volume of concrete containing the admixture and within the pay lines of the structures, as determined in accordance with the concrete bid items.]

1.2.7.2 Payment

[Payment will be made for costs associated with High-Range Water-reducing Admixture (HRWA) at the applicable contract unit price per liters gallons of high range water-reducing admixture.] [Payment will be made for costs associated with High-Range Water-reducing Admixture (HRWA) at the applicable contract unit cost of concrete containing water-reducing admixture for:

a. First [_____] cubic meters yards.

b. All over [_____] cubic meters yards.]

1.2.7.3 Unit of Measure

Unit of measure:[liters gallons][cubic meters yards].

1.2.8 Air Entrainment Admixture (AEA)

1.2.8.1 Price

[Air Entrainment admixture (AEA)will be priced by the liters gallons used.][Air Entrainment admixture (AEA) will be priced for payment based upon the actual volume of concrete containing the admixture and within the pay lines of the structures, as determined in accordance with the concrete bid items.]

1.2.8.2 Payment

[Payment will be made for costs associated with air entrainment admixture (AEA) at the applicable contract unit price per liters gallons of air entrainment admixture (AEA).][Payment will be made for costs associated with air entrainment admixture (AEA) at the applicable contract unit cost of concrete containing air entrainment admixture (AEA)for:

a. First [_____] cubic meters yards.
b. All over [_____] cubic meters yards.]

1.2.8.3 Unit of Measure

Unit of measure:[liters gallons][cubic meters yards].

1.2.9 Anti-Washout Admixture (AWA)

1.2.9.1 Price

[Anti-washout admixture (AWA)will be priced by the liters gallons used.][Anti-washout admixture (AWA) will be priced for payment based upon the actual volume of concrete containing the admixture and within the pay lines of the structures, as determined in accordance with the concrete bid items.]

1.2.9.2 Payment

[Payment will be made for costs associated with anti-washout admixture

(AWA) at the applicable contract unit price per liters gallons of anti-washout admixture (AWA).][Payment will be made for costs associated with anti-washout admixture (AWA) at the applicable contract unit cost of concrete containing anti-washout admixture (AWA)for:

a. First [_____] cubic meters yards.

b. All over [_____] cubic meters yards.]

1.2.9.3 Unit of Measure

Unit of measure:[liters gallons][cubic meters yards].

1.2.10 Retarding Admixture

1.2.10.1 Price

[A retarding admixture will be priced by the liters gallons used.][A retarding admixture will be priced for payment based upon the actual volume of concrete containing the admixture and within the pay lines of the structures, as determined in accordance with the concrete bid items.]

1.2.10.2 Payment

[Payment will be made for costs associated with a retarding admixture at the applicable contract unit price per liters gallons of a retarding admixture.][Payment will be made for costs associated with a retarding admixture at the applicable contract unit cost of concrete containing a retarding admixture for:

a. First [_____] cubic meters yards.

b. All over [_____] cubic meters yards]

1.2.10.3 Unit of Measure

Unit of measure:[liters gallons][cubic meters yards].

[1.2.11 Silica Fume, Dry

1.2.11.1 Price

Silica fume, dry, will be priced for payment based upon the number of kilograms lbs of silica fume used in the concrete, excluding the amount wasted or used for the convenience of the Contractor. The quantity to be paid for will be determined by multiplying the weight in kilograms pounds of silica fume per cubic meter yard by the number of cubic meters yards of silica fume concrete placed within the pay lines of the structure as determined in accordance with the concrete bid items.

1.2.11.2 Payment

Payment will be made for costs associated with silica fume, dry, which includes price batching and recording equipment for dry silica fume used in the concrete bid items. Payment will be made at the contract price per kilograms pounds of dry silica fume for:

a. First [_____] kilograms pounds.

b. All over [_____] kilograms pounds.

1.2.11.3 Unit of Measure

Unit of measure: kilograms pounds.

][1.2.12 Silica Fume, Slurry

1.2.12.1 Price

Silica fume, slurry, will be priced for payment based upon the number of kilograms pounds of silica fume used in the concrete, excluding the amount wasted or used for the convenience of the Contractor. The quantity to be paid for will be determined by multiplying the weight in kilograms pounds of silica fume per cubic meter yard by the number of cubic meters yards of silica fume concrete placed within the pay lines of the structure as determined in accordance with the concrete bid items. The dry weight will be determined by supplier's certificate.

1.2.12.2 Payment

[Payment will be made for costs associated with silica fume, slurry, which includes the cost of silica fume, slurry; providing admixtures such as HRWR admixtures that are a component of the slurry; and furnishing storage, batching, and recording equipment for silica fume, slurry, used in the concrete bid items.][Payment for silica fume, slurry, will be made at the contract price per kilograms pounds of dry silica fume for:

a. First [_____] kilograms pounds.

b. All over [_____] kilograms pounds.]

1.2.12.3 Unit of Measure

Unit of measure: kilograms pounds.

]1.3 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 Reference Identifier (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.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182	(2005; R 2021; E 2024) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 117	(2010; R 2015) Specifications for Tolerances for Concrete Construction and Materials and Commentary
ACI 121R	(2008) Guide for Concrete Construction Quality Systems in Conformance with ISO 9001
ACI 211.1	(1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 214R	(2011) Evaluation of Strength Test Results of Concrete
ACI 301	(2020) Specifications for Structural Concrete
ACI 304R	(2000; R 2009) Guide for Measuring, Mixing, Transporting, and Placing Concrete
ACI 305.1	(2014) Specification for Hot Weather Concreting
ACI 305R	(2020) Guide to Hot Weather Concreting
ACI 306.1	(1990; R 2002) Standard Specification for Cold Weather Concreting
ACI 306R	(2016) Guide to Cold Weather Concreting
ACI 318	(2019; R 2022) Building Code Requirements for Structural Concrete (ACI 318-19) and Commentary (ACI 318R-19)
ACI 347R	(2014; Errata 1 2017) Guide to Formwork for Concrete
ACI 546.2R	(2020) Guide to Underwater Repair of Concrete
ACI 548.15	(2020) Specification for Crack Repair by Epoxy Injection
ACI MNL-15	(2020) Field Reference Manual: Specifications for Concrete Construction

ACI SPEC 308.1 >(2023) External Curing of Cast-in-Place Concrete - Specification

AMERICAN WELDING SOCIETY (AWS)

AWS D1.4/D1.4M (2018; Amd 1 2020) Structural Welding Code - Reinforcing Steel

ASTM INTERNATIONAL (ASTM)

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

ASTM A53/A53M (2024) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A615/A615M (2026) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

ASTM A706/A706M (2026) Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement

ASTM A767/A767M (2024) Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement

ASTM A775/A775M (2022) Standard Specification for Epoxy-Coated Steel Reinforcing Bars

ASTM A780/A780M (2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

ASTM A820/A820M (2022) Standard Specification for Steel Fibers for Fiber-Reinforced Concrete

ASTM A884/A884M (2025) Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement

ASTM A934/A934M (2022) Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars

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

ASTM A970/A970M (2018) Standard Specification for Headed Steel Bars for Concrete Reinforcement

ASTM A996/A996M (2016) Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement

ASTM A1022/A1022M	(2016b) Standard Specification for Deformed and Plain Stainless Steel Wire and Welded Wire for Concrete Reinforcement
ASTM A1044/A1044M	(2016a; Errata 1) Standard Specification for Steel Stud Assemblies for Shear Reinforcement of Concrete
ASTM A1055/A1055M	(2025) Standard Specification for Zinc and Epoxy Dual Coated Steel Reinforcing Bars
ASTM A1060/A1060M	(2016b) Standard Specification for Zinc-Coated (Galvanized) Steel Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM A1064/A1064M	(2024) Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM A1094/A1094M	(2020) Standard Specification for Continuous Hot-Dip Galvanized Steel Bars for Concrete Reinforcement
ASTM C29/C29M	(2023) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C31/C31M	(2026a) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2024a) Standard Specification for Concrete Aggregates
ASTM C39/C39M	(2026) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C40/C40M	(2020) Standard Test Method for Organic Impurities in Fine Aggregates for Concrete
ASTM C42/C42M	(2020) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C87/C87M	(2023) Standard Test Method for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar
ASTM C88	(2018) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C94/C94M	(2026) Standard Specification for Ready-Mixed Concrete
ASTM C117	(2023) Standard Test Method for Materials

	Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C123/C123M	(2023) Standard Test Method for Lightweight Particles in Aggregate
ASTM C127	(2025) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C128	(2025) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2025) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C138/C138M	(2024a) Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
ASTM C142/C142M	(2017; R 2023) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C143/C143M	(2026a) Standard Test Method for Slump of Concrete
ASTM C150/C150M	(2024) Standard Specification for Portland Cement
ASTM C157/C157M	(2024; E 2024) Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
ASTM C171	(2020) Standard Specification for Sheet Materials for Curing Concrete
ASTM C172/C172M	(2017) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C192/C192M	(2026) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231/C231M	(2026) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2024) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C295/C295M	(2019) Standard Guide for Petrographic Examination of Aggregates for Concrete

ASTM C309	(2025) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C330/C330M	(2017a) Standard Specification for Lightweight Aggregates for Structural Concrete
ASTM C494/C494M	(2024) Standard Specification for Chemical Admixtures for Concrete
ASTM C535	(2016; R 2024) Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C566	(2025) Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying
ASTM C595/C595M	(2025) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2025a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C666/C666M	(2026) Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
ASTM C881/C881M	(2020a) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C920	(2018; R 2024) Standard Specification for Elastomeric Joint Sealants
ASTM C928/C928M	(2025) Standard Specification for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repairs
ASTM C937	(2023) Grout Fluidifier for Preplaced-Aggregate Concrete
ASTM C989/C989M	(2025) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C1059/C1059M	(2024) Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete
ASTM C1064/C1064M	(2023) Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
ASTM C1074	(2019; E 2021) Standard Practice for Estimating Concrete Strength by the Maturity Method

ASTM C1077	(2026) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1107/C1107M	(2020) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM C1116/C1116M	(2023) Standard Specification for Fiber-Reinforced Concrete
ASTM C1240	(2020) Standard Specification for Silica Fume Used in Cementitious Mixtures
ASTM C1260	(2023) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1293	(2008; R 2015) Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction
ASTM C1567	(2025) Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1581/C1581M	(2024) Standard Test Method for Determining Age at Cracking and Induced Tensile Stress Characteristics of Mortar and Concrete under Restrained Shrinkage
ASTM C1602/C1602M	(2022) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM C1611/C1611M	(2021) Standard Test Method for Slump Flow of Self-Consolidating Concrete
ASTM C1621/C1621M	(2017; R 2023) Standard Test Method for Passing Ability of Self-Consolidating Concrete by J-Ring
ASTM C1758/C1758M	(2023) Standard Practice for Fabricating Test Specimens with Self-Consolidating Concrete
ASTM D412	(2016; R 2021) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D471	(2016a; R 2021) Standard Test Method for Rubber Property - Effect of Liquids
ASTM D1752	(2018) Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete

	Paving and Structural Construction
ASTM D2628	(2025) Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
ASTM D2835	(1989; R 2017) Standard Specification for Lubricant for Installation of Preformed Compression Seals in Concrete Pavements
ASTM D4791	(2019) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D5249	(2010; R 2016) Standard Specification for Backer Material for Use with Cold-and Hot-Applied Joint Sealants in Portland-Cement Concrete and Asphalt Joints
ASTM D6690	(2021) Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements
ASTM E11	(2024) Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves
ASTM E96/E96M	(2024a) Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials
ASTM E329	(2025b) Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection
ASTM E1745	(2017; R 2023) Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs

COMPOSITE PANEL ASSOCIATION (CPA)

ANSI/CPA A135.4	(2012; R2020) Basic Hardboard

CONCRETE REINFORCING STEEL INSTITUTE (CRSI)

CRSI 10MSP	(2018; Errata 2019) Manual of Standard Practice
CRSI RB4.1	(2016) Supports for Reinforcement Used in Concrete

FOREST STEWARDSHIP COUNCIL (FSC)

FSC STD 01 001	(2015) Principles and Criteria for Forest Stewardship

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 44	(2018) Specifications, Tolerances, and Other Technical Requirements for Weighing

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

NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA CPMB 100	(2000; R 2006) Concrete Plant Standards

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 38	(1973) Handbook for Concrete and Cement Method of Test For Temperature Rise in Concrete
COE CRD-C 55	(1992) Test Method for Within-Batch Uniformity of Freshly Mixed Concrete
COE CRD-C 61	(1989A) Test Method for Determining the Resistance of Freshly Mixed Concrete to Washing Out in Water
COE CRD-C 94	(1995) Corps of Engineers Specification for Surface Retarders
COE CRD-C 100	(1975) Method of Sampling Concrete Aggregate and Aggregate Sources, and Selection of Material for Testing
COE CRD-C 104	(1980) Method of Calculation of the Fineness Modulus of Aggregate
COE CRD-C 114	(1997) Test Method for Soundness of Aggregates by Freezing and Thawing of Concrete Specimens
COE CRD-C 130	(2001) Standard Recommended Practice for Estimating Scratch Hardness of Coarse Aggregate Particles
COE CRD-C 143	(1962) Specifications for Meters for Automatic Indication of Moisture in Fine Aggregate
COE CRD-C 144	(1992) Standard Test Method for Resistance of Rock to Freezing and Thawing
COE CRD-C 513	(1974) Corps of Engineers Specifications for Rubber Waterstops
COE CRD-C 521	(1981) Standard Test Method for Frequency and Amplitude of Vibrators for Concrete
COE CRD-C 572	(1974) Corps of Engineers Specifications for Polyvinylchloride Waterstops
COE CRD-C 661	(2006) Specification for Antiwashout Admixtures for Concrete

EM 1110-2-2000	(1994; Change 2) Standard Practice for Concrete for Civil Works Structures
EM 1110-2-2104	(2023) Strength Design for Reinforced Concrete Hydraulic Structures
ER 1110-1-8100	(1997) Laboratory Investigations and Testing
ETL 1110-2-542	(1997) Thermal Studies of Mass Concrete Structures

1.4 SUBMITTALS

****

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters 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 and Air Force projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third-Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification 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

Quality Control Program; G, [_____]

Quality Control Personnel Certifications; G, [_____]

Quality Control Organizational Chart

Laboratory Accreditation; G, [_____]

Maturity Method Data; G, [_____]

SD-02 Shop Drawings

Reinforcing Steel; G, [_____]

Concrete Lifts; G, [_____]

Equipment; G, [_____]

Formwork and Formwork Removal Schedule; G, [_____]

Formwork

SD-03 Product Data

Batch Plant; G, [_____]

Mixers

Joint Sealants; G, [_____]

Joint Filler; G, [_____]

Formwork Materials

Cementitious Materials; G, [_____]

Vapor Retarder[and Vapor Barrier]; G, [_____]

Reinforcement; G, [_____]

Admixtures; G, [_____]

Mechanical Reinforcing Bar Connectors; G, [_____]

Waterstops; G, [_____]

Nonshrink Grout; G, [_____]

Local/Regional Materials

Biodegradable Form Release Agent

Bonding Agents

Temperature Sensors; G, [_____]

Cold Weather-Protection

SD-04 Samples

Surface Finish Samples

Non-Metallic Waterstops

Aggregate Sources

SD-05 Design Data

Demonstration Section Plan; G, [_____]

Demonstration Section Evaluation Investigation Plan; G, [_____]

Formwork Calculations

Concrete Mix Design; G, [_____]

Construction Joint Treatment; G, [_____]

Plant Layout Drawings; G, [_____]

Curing and Protection Plan; G, [_____]

Cold-Weather Protection; G, [_____]

Hot-weather Placing; G, [_____]

Special Temperature-Controlled Concrete; G, [_____]

Thermal Analysis and Thermal Control Plan; G, [_____]

Repair Plan; G, [_____]

Underwater Concrete Placement Plan; G, [_____]

Concrete Curing Plan; G, [_____]

Finishing Plan

Finishing Plan And Methods; G, [_____]

SD-06 Test Reports

Concrete Mix Design; G, [_____]

Coal Ash and Natural Pozzolan; G, [_____]

Slag Cement; G, [_____]

Aggregates; G, [_____]

Water; G, [_____]

Fine Aggregate Fixed Gradation; G, [_____]

Fiber-Reinforced Concrete; G, [_____]

Compressive Strength Tests; G, [_____]

Temperature Monitoring

Scales

Mixer Uniformity

Environmental Performance; G, [_____]

SD-07 Certificates

Curing

Nonshrink Grout; G, [_____]

Bonding Agents

Expansive Admixture

Welder Qualifications

Field Testing Technician and Testing Agency

VOC Content

SD-08 Manufacturer's Instructions

Joint Sealants

Silica Fume; G, [_____]

1.5 QUALITY ASSURANCE

1.5.1 Government Preconstruction Testing

****
NOTE: Contact the Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199, ATTN: CEERD-SC for guidance in filling in the blanks.
****

1.5.1.1 Aggregate Sources

The aggregate sources listed in paragraph COMMERCIAL CONCRETE AGGREGATE SOURCES, have been tested, and at the time testing was performed, these sources were capable of producing materials of the quality and quantity required for this project provided suitable processing is performed. Deliver samples from any source selected consisting of no less than [_____] kg pounds of each size of coarse aggregate and [_____] kilograms pounds of fine aggregate, taken under the supervision of the Contracting Officer in accordance with COE CRD-C 100, to [_____] within 15 days after notice to proceed. Sampling and shipment of samples is the Contractor's expense. [_____] days will be required to complete evaluation of the aggregates.

Testing will be performed by the Government in accordance with the applicable COE CRD-C or ASTM test methods. Tests to which aggregate may be subjected are listed in paragraph AGGREGATES. The material from the proposed source must meet the quality requirements of this paragraph to be used for the project. The Government test data and other information on aggregate quality of those sources listed in paragraph COMMERCIAL CONCRETE

AGGREGATE SOURCES and are available for review in the District Office.

Quality assurance testing of aggregates by the Government does not relieve the Contractor of quality control requirements.

1.5.1.2 Cementitious Materials, Admixtures, and Curing Materials

The Contractor must notify the Contracting Officer of the source, brand name, type, and quantity of all materials (other than aggregates) to be used in the manufacture and curing of the concrete at least 60 days in advance of submitting samples for mixture proportioning studies. Assist the Contracting Officer in obtaining samples of each material. Sampling and testing as determined appropriate will be performed by and at the expense of the Government. If cement or other supplementary cementitious materials are to be obtained from more than one source, state the estimated amount of cement or other supplementary cementitious materials to be obtained from each source and the proposed schedule of shipments in the notification. When supplementary cementitious materials other than coal ash is used, it must be from one source. This paragraph covers a minimum of two coal ash sources, more discussion may be needed regarding paragraph Cementitious Materials Approval per Mill Certification Reports below.

1.5.1.3 Materials for Mixture-Proportioning Studies

****

NOTE: The required quantities will depend on the scope of the proportioning effort. The designers should determine the required scope of post-award testing during preconstruction engineering and design and coordinate with ERDC or another laboratory to determine the appropriate quantities of materials to accomplish the scope.

Contact the Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199, ATTN: CEERD-SC to fill in the blanks. At the end of the following table, insert other cementitious materials, including silica fume, as appropriate.

****

At least [_____] days in advance of the time when placing of concrete is expected to begin, deliver samples of representative materials proposed for this project and meeting all the requirements of this specification to [_____] by the Contractor at its expense. Take samples of aggregates under the supervision of the Contracting Officer in accordance with COE CRD-C 100, accompanied by test reports indicating conformance with grading and quality requirements hereinafter specified. Provide samples of materials other than aggregates that are representative of those proposed for the project and submit accompanied by manufacturer's test reports indicating compliance with applicable specified requirements. Quantities of materials required are as follows:

MATERIAL	QUANTITY
150 mm 6 inch nominal maximum-size coarse aggregate	[_____] kg pounds
75 mm 3 inch nominal maximum-size coarse aggregate	[_____] kg pounds
37.5 mm 1.5 inch nominal maximum-size coarse aggregate	[_____] kg pounds
19 mm 3/4 inch nominal maximum-size coarse aggregate	[_____] kg pounds
Fine aggregate	[_____] kg pounds
Cement	[_____] kg pounds
supplementary cementitious materials	[_____] cubic meters feet
Air-entraining admixture	[_____] L quarts
Other admixtures (each)	[_____] L gallons

Mixture-proportioning studies will be made by the Government.

1.5.2 Construction Testing by the Government

1.5.2.1 General

The Government will sample and test cementitious materials, admixtures, aggregates, and concrete during construction as considered appropriate to determine compliance with the specifications. Provide facilities and labor as may be necessary for procurement of representative test samples. Samples of aggregates will be obtained at the point of batching in accordance with COE CRD-C 100. Slump and air content will be determined in accordance with ASTM C143/C143M and ASTM C231/C231M, respectively, except the point of sampling will be as directed by the Contracting Officer's representative. Compression test specimens will be made and laboratory cured in accordance with ASTM C31/C31M and will be tested in accordance with ASTM C39/C39M.

1.5.2.2 Testing Aggregates

Testing performed by the Government will not relieve the Contractor of its responsibility for testing as appropriate for quality control. During construction, aggregates will be sampled for acceptance testing as delivered to the mixer to determine compliance with specification provisions. Provide necessary facilities and labor for the ready procurement of representative samples under Contracting Officer supervision. The Government will test such samples at its expense using appropriate COE CRD-C and ASTM methods.

1.5.2.3 Cementitious Materials Approval per Mill Certification Reports

Cementitious materials will be accepted based on mill certification reports not older than [12][24] months. Cementitious materials that have not been used within 6 months after being tested will be retested by the

Government at the expense of the Contractor when directed. Furnish cement or other supplementary cementitious materials or both from a prequalified source or, if not, it (they) will be sampled at the mill, shipping point, or site of the work by the Contracting Office. A list of prequalified cement sources and prequalified pozzolan sources is available from:

Director, U.S. Army Corps of Engineers
Engineer Research and Development Center - Structures Laboratory
3909 Halls Ferry Road
Vicksburg, MS 39180-6199
ATTN: CEERD-SC.

If tests prove that a material which has been delivered is unsatisfactory, promptly remove it from the site of the work. Cementitious materials that have not been used within 6 months after being tested will be retested by the Government at the expense of the Contractor when directed.

[1.5.2.4 Slag Cement

****
NOTE: If any other cementitious materials, including silica fume, are to be allowed, an additional paragraph should be added similar to this paragraph, with the name of the cementitious material substituted for slag cement.
****

Slag Cement will be sampled and tests at the mill or shipping point by and at the expense of the Government to determine that the material meets the requirements of the specification under which it is furnished. Do not use slag cement until notice of acceptance has been given by the Contracting Officer. slag cement will be subject to check testing from samples obtained at the project site, as scheduled, and such sampling will be by or under the supervision of the Contracting Officer and at Government expense. Remove material not meeting specifications promptly from the site of work.

]1.5.2.5 Chemical Admixtures

Provide satisfactory facilities for ready procurement of test samples. All sampling and testing of a chemical admixture will be by and at the expense of the Government. Tests will be conducted using samples of materials proposed for the project.

1.6 DESIGN AND PRECONSTRUCTION REQUIREMENTS.

[Text]

1.6.1 FIELD SAMPLES

[1.6.1.1 Slab Finish Sample

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

Install minimum of 3 meters by 3 meters 10 foot by 10 foot slab. Slab finish sample must not be part of the final project. Finish as required by specification.[Silica fume manufacturer's representative must attend and advise.]

][1.6.1.2 Surface Finish Samples

Submit a minimum of three sample concrete panels for each finish for each mix design 1 meter by 1 meter, 8 centimeters 3 feet by 3 feet, 3 inches thick. Use the approved concrete mix design(s). Provide sample panels on-site at locations directed. Once approved, each set of panels are representative of each of the finishes specified and of the workmanship and finish(es) required. Do not remove or destroy samples until directed by the Contracting Officer.

]1.6.2 TEST REPORTS

****
NOTE: Include the following requirement if using government mixture proportioning
****

[The following test reports are to be submitted no less than 30 days prior to scheduled material delivery to the Government assigned testing laboratory for mixture proportioning studies for approval.] For a contractor supplied mix design, the following test reports are to be submitted no less than 30 days prior to the scheduled placement of concrete.

1.6.2.1 Cement

Submit test results in accordance with [ASTM C595/C595M] [ASTM C150/C150M]. Submit test results performed within 2 months of submittal date. Provide [12][24] month history of mill tests reports.

1.6.2.2 Coal Ash and Natural Pozzolan

Submit test results in accordance with ASTM C618 for coal ash and natural pozzolan. Submit test results performed within 2 months of submittal date. Provide [12][24] month history of mill test reports.

1.6.2.3 Slag Cement

Submit test results in accordance with ASTM C989/C989M for slag cement. Submit test results performed within 2 months of submittal date. Provide [12][24] month history of mill test reports.

1.6.2.4 Aggregates

Prior to submission of concrete mix designs, submit test results for approval in accordance with ASTM C33/C33M, or ASTM C330/C330M for lightweight aggregate. Also include test results from aggregate quality Table in paragraph Quality of Aggregates, and ASTM C1293 or ASTM C1567 as required in the paragraph titled ALKALI-AGGREGATE REACTION. Submit periodic test reports throughout the duration of the project to show compliance with the aggregate testing requirements at the frequency specified.

1.6.2.5 Water

If non potable mixing water is proposed for use in the concrete mixtures, submit testing data to show compliance with ASTM C1602/C1602M. Submit test results prior to initial concrete mix design submittals, as well as periodic test reports throughout the duration of the project to show compliance with the aggregate testing requirements at the frequency specified.

1.6.2.6 Fine Aggregate Fixed Gradation

Submit the fixed gradation as required in paragraph Fine Aggregates.

1.6.2.7 Batch Plant

Submit the information for the on-site batch plant as required in paragraph Batch Plant

1.6.2.8 Scales

Submit scale calibration prior to initial start of construction, and periodically to meet the requirements in paragraph Scales.

1.6.2.9 Mixer Uniformity

Submit mixer uniformity testing results for each event in accordance with paragraph Mixer Uniformity.

[1.6.2.10 Fiber-Reinforced Concrete

Test and submit results that determine flexural toughness index I5 in accordance with ASTM ASTM C1116/C1116M.

]1.6.3 CONTROL SUBMITTALS

1.6.3.1 Concrete Curing Plan

Submit proposed materials, methods and duration for curing concrete elements in accordance with ACI SPEC 308.1.

1.6.3.2 Placing Concrete

Submit proposed materials and methods for placing concrete. Include mix designs, pumping equipment including type of pump and size and material for pipe, and maximum length and height concrete is to be pumped.

1.6.3.3 Demonstration Section Plan

****

NOTE: The following Demonstration paragraph requirements should be split up into relevant features of work which require a demonstration prior to production.

****

30 days prior to construction of the demonstration section, submit for approval the plan for construction. Include all means and methods to be utilized during construction. Provide details on the evaluation methods, analysis procedures, the specification requirements to be evaluated, and

corrective actions if requirements are not demonstrated.

1.6.3.4 Demonstration Section Evaluation Investigation Plan

Within 15 days of the completion of the Demonstration paragraph, submit to the government a written report in accordance with paragraph Demonstration Section Plan.

[1.6.3.5 Finishing Plan

****
NOTE: Include when finishing or special flatness are critical.
****

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

][1.6.3.6 VOC Content

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

]1.6.3.7 Safety Data Sheets

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

1.6.4 SHOP DRAWINGS

1.6.4.1 Formwork

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

Submit formwork and formwork removal schedule indicating element and minimum length of time for form removal. Design, fabricate, erect, support, brace, and maintain formwork so that it is able to support, without failure, all vertical and lateral loads that may reasonably be anticipated to be applied to the formwork.

1.6.4.2 Reinforcing Steel

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

1.6.5 DESIGN DATA

1.6.5.1 Formwork Calculations

ACI 347R. Include design calculations indicating arrangement of forms, sizes and grades of supports (lumber), panels, and related components. Furnish drawings and calculations of shoring and re-shoring methods proposed for floor and roof slabs, spandrel beams, and other horizontal concrete members. Indicate in calculations concrete pressure with both live and dead loads, along with material types.

1.6.5.2 Concrete Mix Design

Sixty days minimum prior or 120 days minimum for a concrete mix design with a 90 day specified strength, to concrete placement, submit a mix design for each strength and type of concrete. Submit all documentation required as specified in this section. Submit a complete list of materials including type; brand; source and amount of cement, supplementary cementitious materials,[fibers,] and admixtures; and applicable reference specifications. Submit mill test and all other test for cement, supplementary cementitious materials, aggregates, and admixtures. Provide documentation of maximum nominal aggregate size, gradation analysis, percentage retained and passing sieve, and a graph of percentage retained verses sieve size. Provide mix proportion data using at least three different water-cementitious material ratios for each type of mixture, which produce a range of strength encompassing those required for each type of concrete required. If source material changes, resubmit mix proportion data using revised source material. Provide only materials that have been proven by trial mix studies to meet the requirements of this specification, unless otherwise approved in writing by the Contracting Officer. Submit trial batching data. Indicate clearly in the submittal where each mix design is used when more than one mix design is submitted. For mass concrete mixtures indicate the adiabatic temperature rise of the proposed mix tested for 14 days tested in accordance with COE CRD-C 38. For underwater mixture submit washout in accordance with COE CRD-C 61. Resubmit data on concrete components if the qualities or source of components changes. Required average strength can be documented by field experience if field strength test data are available and represent a single group of at least 10 consecutive strength tests for one mixture, using materials and conditions similar to those expected for work, and encompassing a period of not less than 45 days. The average of field strength tests must equal or exceed FCR. Changes in materials, conditions, and proportions within the test record must not have been more closely restricted than those for the proposed work. Test records must not be more than 24 months old. Obtain mix design approval from the contracting officer prior to concrete placement. If material sources change, new mix designs with full testing must be submitted to the government for approval prior to use. Any schedule delays due to mix design studies or durability testing not performed to the requirements in this specification will be the responsibility of the contractor. Submit all mix durability testing required including [ASTM C1293 or ASTM C1567] and [ASTM C666/C666M].

1.6.6 Demonstration Section

****

NOTE: Include the following paragraphs for as many features of work as require a demonstration, or identify each feature of work requiring a

demonstration

****

At least 60 calendar days prior to production, demonstration sections of the each of the following features of work are required to verify the Contractor's means, methods, equipment, and materials are adequate to properly construct critical project features. The features of work are [_____], [_____], [_____]. The demonstration sections must be constructed to the dimensional requirements as shown on the contract drawings and in accordance with the requirements defined in the contract specifications, including but not limited to surface finish requirements, unless otherwise specified herein. The demonstration sections construction procedures must be the same as those included in these specifications and approved applicable submittals. The concrete placement for each demonstration section must be on different days. The Contractor must notify the Contracting Officer at least seven calendar days prior to beginning each demonstration section and at least 14 calendar days prior to placing concrete for each demonstration section. The placement of concrete must not be permitted until the onsite batch plant trial batches are completed in accordance with Paragraph Trial Operation. The demonstration sections must demonstrate adequate curing methods and procedures for three calendar days after concrete placement.

Each demonstration section must be placed in an area within the contract work limits that the Contractor deems appropriate and will not reasonably impact construction operations. Demonstration sections must remain in place until the contractor is notified by the Contracting Officer, at which time or thereafter the structures must be demolished and disposed of in accordance with Section[01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS][_____].

Upon completion of the required curing period as specified above, the interior quality of each feature must be inspected through an internal investigation plan. The internal investigation must consist of inspection at least five locations for each feature, as determined by the Contracting Officer, through controlled removal of sections of concrete, concrete coring in accordance ASTM C42/C42M, or similar procedures. The Contractor must submit, for review and approval, an internal investigation plan 30 calendar days prior to placement of the demonstration sections which must outline the proposed investigation procedures and reporting documentation.

Within 15 calendar days of completing each section, a written report for each demonstration section must be furnished to the Contracting Officer for review and approval. The report must, at a minimum, include a report of the internal investigation results and all of the quality control reports required by paragraph TESTS AND INSPECTIONS. The Contractor must provide the Contracting Officer 30 calendar days to review each submittal. The Contracting Officer will not allow the permanent construction of the concrete features to proceed until successful performance of the demonstration section for that particular feature. If the demonstration sections do not meet all of the criteria in the contract, the Contracting Officer may direct the Contractor to make revisions to the construction means, methods, equipment, or materials, and install additional demonstration sections at no additional cost to the Government until the demonstration section passes all acceptance criteria.

1.7 QUALITY CONTROL PROGRAM

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NOTE: The objective of the concrete quality control program is for the Contractor to outline the procedures that will be used to construct a structure that will obtain the design service life.

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

1.7.1 Quality Control Personnel Certifications

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

Submit American Concrete Institute certification for the following:

a. CQC personnel responsible for inspection of concrete operations, ACI Concrete Construction Special Inspector certification.

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

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

1.7.1.1 Quality Manager Qualifications

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

1.7.1.2 Field Testing Technician and Testing Agency

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

a. Work on concrete under this contract must be performed by[an ACI Concrete Field-Testing Technician Grade 1][a third party agency and not by the prime contractor.]

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

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

1.7.2 Laboratory Validation

Laboratory and testing facilities are provided by and at the expense of the Contractor. The laboratories performing the tests must be validated in accordance with ER 1110-1-8100 for all tests performed. The validation must be current and must include the required test methods, as specified. Furthermore, comply with the following requirements:

****

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

****

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

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

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

1.8 DELIVERY, STORAGE, AND HANDLING

1.8.1 Cementitious Materials

1.8.1.1 Transportation

When bulk cement, other supplementary cementitious materials, such as but limited to coal ash, natural pozzolans, slag cement, and or dry silica fume is not unloaded from primary carriers directly into weather-tight hoppers at the batching plant, accomplish transportation from the railhead, mill, or intermediate storage to the batching plant in weather-tight trucks, conveyors, or other means that will protect the material from exposure to moisture. Transportation facilities for dry bulk silica fume must be approved in advance.

1.8.1.2 Storage

****

NOTE: The designer should quantify the estimated volume of materials required before determining the specified storage. Some projects have required on-site storage for at least a 30-day supply of concrete production. This addresses potential supply chain interruptions but can add significant up-front cost to the project in the cost of extra silos. The designer must weigh the potential risk reduction vs. the estimated additional cost.

****

Furnish cementitious materials in bulk except that cement used for finishing and patching may be packaged, and silica fume may be packaged or in slurry form. Immediately upon receipt at the site of the work, store all cementitious materials in separate dry, weather-tight, and properly ventilated structures. All storage facilities must permit easy access for inspection and identification. Maintain sufficient materials in storage to complete any lift of concrete started. In order that cement may not become unduly aged after delivery, use any cement that has been stored at the site for 60 days or more before using cement of lesser age. Do not use silica fume in slurry form that has been in storage at the project site for longer than recommended by the manufacturer or that has been subjected to freezing in the work and remove from the site.
[
For on-site batch plants, provide enough back up storage for [coal ash][slag cement] and, or [cement] to cover seasonal coverage for plant down-time. These facilities will have the ability to store [_____].]

1.8.1.3 Separation of Materials

Provide separate facilities for unloading, transporting, and handling each cementitious material. Provide separate appropriate storage facilities for each type of cement and each source of coal ash, natural pozzolans, slag cement, and or dry silica fume. Plainly mark the contents of each storage facility marked with a large permanent sign posted near the loading port.

1.8.2 Aggregates Storage

Store fine aggregate and each size of coarse aggregate in separate size groups adjacent to the batch plant and in such a manner as to prevent the intermingling of size groups or the inclusion of foreign materials in the concrete. Always maintain sufficient fine and coarse aggregate at the site to permit continuous placement and completion of any lift of concrete started. Do not store aggregate directly on ground unless a sacrificial layer is left undisturbed. Maintain a constant moisture content or must be protected by changes in extreme moisture contents. It is recommended to store fine and coarse aggregates under a canopy to prevent exposure to rain, snow and ice.[Aggregates must be conditioned so that they are exposed to above SSD moisture for over 24 hours prior to being delivered to the mixer. Aggregates must be stored in a manner so that they will not freeze or experience evaporation below SSD conditions during extreme temperatures.]

1.8.3 Reinforcement

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

1.8.3.1 Epoxy Coated Reinforcing Steel

Record coating lot on each shipping notice and carefully identify and re-tag bar bundles from bending plant. Provide systems for handling coated bars which have padded contact areas such as, nylon slings, all free of dirt and grit. Lift bundled coated bars with strong back, multiple supports, or platform bridge to prevent sagging and abrasion. Pad bundling bands where in contact with bars. Do not drop or drag bars

or bundles. Store coated bars both in shop and in field, aboveground, on wooden or padded cribbing. Space the dunnage close enough to prevent excessive sags. Stack large quantities of straight bars with adequate protective blocking between layers. Schedule deliveries of epoxy coated bars to the job site to avoid the need for long term storage. Protect from direct sunlight and weather. Cover bars to be stored longer than 12 hours at the job site with opaque polyethylene sheeting or other suitable equivalent protective material.

1.9 ENVIRONMENTAL REQUIREMENTS

****

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

****

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

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

b. Supply airflow at a rate of 6 air changes per hour, when outside temperatures are between 13 degrees C 55 degrees F and 29 degrees C 84 degrees F and humidity is between 30 and 60 percent.

c. Supply airflow at a rate of 1.5 air changes per hour, when outside air conditions are not within the range stipulated above.

1.9.1 Environmental Performance

a. Provide data indication the percentage of post-industrial supplementary cementitious materials (coal ash, natural pozzolans, slag cement, dry silica fume) cement substitution as a percentage of the full product composite by weight.

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

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

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

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

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

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

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

1.10 SUSTAINABLE DESIGN REQUIREMENTS

1.10.1 Local/Regional Materials

****
NOTE: Using local materials can help minimize transportation impacts, including fossil fuel consumption, air pollution, and labor. Using materials harvested and manufactured within a 500-mile radius from the project site contributes to the following LEED credit: MR5. Coordinate with Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING. Use second option if Contractor is choosing local materials in accordance with Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING. Use second option for USACE projects. for Army projects, include option only if pursuing this LEED credit.
****
[Use materials or products extracted, harvested, or recovered, as well as manufactured, within a 805[_____] kilometers [500][_____] miles radius from the project site, if available from a minimum of three sources.][See Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING for cumulative total local material requirements. Concrete materials may be locally available.][Submit documentation indicating distance between manufacturing facility and the project site. Indicate distance of raw material origin from the project site. Indicate relative dollar value of local/regional materials to total dollar value of products included in project.]

1.10.2 Forest Stewardship Council (FSC) Certification

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

1.11 QUALIFICATIONS FOR WELDING WORK

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

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

PART 2 PRODUCTS

2.1 FORMWORK MATERIALS

****
NOTE: Use a 1/240 as a limit for structural concrete and 1/400 for architectural concrete
****

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

b. Design formwork, shores, reshores, and backshores to support loads transmitted to them and to comply with applicable building code requirements.

c. Design formwork and shoring for load redistribution resulting from stressing of post-tensioned reinforcement. Ensure that formwork allows movement resulting from application of prestressing force.

d. Design formwork to withstand pressure resulting from placement and vibration of concrete and to maintain specified tolerances.

e. Design formwork to accommodate waterstop materials in joints at locations indicated in Contract Documents.

f. Provide temporary openings in formwork if needed to facilitate cleaning and inspection.

g. Design formwork joints to inhibit leakage of mortar.

h. Limit deflection of facing materials for concrete surfaces exposed to view to[1/240][1/400] [_____] of center-to-center spacing of facing supports.

i. [Do not use earth cuts as forms for vertical or sloping surfaces.]

j. Submit product information on proposed form-facing materials if different from that specified herein.

k. [Submit shop drawings for formwork, shoring, reshoring, and backshoring, signed and sealed by a licensed design engineer.]

l. [Submit design calculations for formwork, shoring, reshoring, and backshoring, signed and sealed by a licensed design engineer.]

m. Submit procedure for reshoring and backshoring, including drawings signed and sealed by a licensed design engineer. Include on shop drawings the formwork removal procedure and magnitude of construction loads used for design of reshoring or backshoring system. Indicate in procedure the magnitude of live and dead loads assumed for required capacity of the structure at time of reshoring or backshoring.

n. Submit manufacturer's product data on form liner proposed for use with each formed surface.

2.1.1 Wood Forms

Use lumber as specified in Section 06 10 00 ROUGH CARPENTRY and as follows. Provide lumber that is square edged or tongue-and-groove boards, free of raised grain, knotholes, or other surface defects. Provide plywood that complies with NIST PS 1, B-B concrete form panels or better or ANSI/CPA A135.4, hardboard for smooth form lining.[Submit data verifying that composite wood products contain no urea formaldehyde

resins.][Virgin wood used must be FSC-certified.]

2.1.1.1 Concrete Form Plywood (Standard Rough)

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

2.1.1.2 Overlaid Concrete Form Plywood (Standard Smooth)

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

2.1.2 Plastic Forms

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

2.1.3 Carton Forms

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

2.1.4 Steel Forms

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

2.2 FORMWORK ACCESSORIES

a. Use commercially manufactured formwork accessories, including ties and hangers.

b. Form ties and accessories must not reduce the effective cover of the reinforcement.

2.2.1 Form Ties

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

****
NOTE: Specify alternative breakback distance for ferrous ties if needed.
****

a. Use form ties with ends or end fasteners that can be removed without damage to concrete.

b. Where indicated in Contract Documents, use form ties with integral water barrier plates or other acceptable positive water barriers in

walls.

c. The breakback distance for ferrous ties must be at least 50 millimeters [2 inches][19 millimeter][3/4 inch][_____] for Surface Finish-2.0 or Surface Finish-3.0, as defined in ACI 301.

[

d. If the breakback distance is less than 19 mm 3/4 inch, use coated or corrosion-resistant ties.

]

e. Submit manufacturer's data sheet on form ties.

2.2.2 Waterstops

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

2.2.2.1 PVC Waterstop

Conform to COE CRD-C 572.

2.2.2.2 Rubber

Waterstop Conform to COE CRD-C 513.

2.2.2.3 Thermoplastic Elastomeric Rubber

Waterstop Conform to ASTM D471.

2.2.2.4 Hydrophilic Waterstop

Swellable strip type compound of polymer modified chloroprene rubber that swells upon contact with water must conform to the following requirements when tested in accordance to ASTM D412: Tensile strength 2.4 MPa 350 psi minimum; ultimate elongation 600 percent minimum. Hardness must be 50 minimum on the type A durometer and the volumetric expansion ratio in distilled water at 20 degrees C 70 degrees F must be 3 to 1 minimum.

2.2.3 Tests, Inspections, And Verifications

2.2.3.1 Non-Metallic Waterstops

Samples of materials and splices as required in paragraph SUBMITTALS must be visually inspected and tested by and at the expense of the Government for compliance with COE CRD-C 572 as applicable. Sample and test every 50 factory splices or 25 field splices. If a sample fails to meet the specification requirements, new samples must be provided, and the cost of retesting will be deducted from payments due the Contractor. Current waterstop prices are $2,500 per full-lot evaluation, $250 per additional sample (tension and elongation only), and $400 per splice (tension only). Samples must be sent to:

Brett Williams
US Army Engineer Research and Development Center (ERDC)
ATTN: CEERD-GM-C
3909 Halls Ferry Rd.
Vicksburg, MS 39180-6199

[The following requirement can be waived for smaller projects where less than [30] field splices are required.][Sample and test field splices prior to the start of construction. Individuals responsible for the field

waterstop splices prior to construction will be approved and qualified for performing field splices throughout the project duration, only qualified individuals are allowed to perform splicing.]

2.2.4 Biodegradable Form Release Agent

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

a. Provide form release agent that is colorless, biodegradable, and[rapeseed oil-based][soy oil-based][water-based], with a[low (maximum of 55 grams per liter)][zero] VOC content.[A minimum of[85] [_____] percent of the total product must be biobased material.]

b. Provide product that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces.

c. Provide form release agent that reduces formwork moisture absorption, and does not contain diesel fuel, petroleum-based lubricating oils, waxes, or kerosene. Submit documentation indicating type of biobased material in product and biobased content. Indicate relative dollar value of biobased content products to total dollar value of products included in project.

d. Submit manufacturer's product data on formwork release agent for use on each form-facing material.

2.2.5 Chamfer Materials

Use lumber materials with dimensions of[19 x 19 mm 3/4 x 3/4 inch], unless otherwise specified.

Note: Larger maximum size aggregate (MSA) may require larger chamfer dimensions.

2.2.6 Construction and Movement Joints

****
NOTE: Indicate in Contract Documents the locations of required movement joints, keyways, and the locations where waterstops are required in joints.
****

a. Location of construction and movement joints must as be shown in the drawings, unless otherwise approved by the contracting officer. Submit details and locations of construction joints in accordance with the requirements herein.

b. Locate construction joints within middle one-third of spans of slabs, beams, and girders. If a beam intersects a girder within the middle one-third of girder span, the distance between the construction joint

in the girder and the edge of the beam must be at least twice the width of the larger member.

c. For members with post-tensioning tendons, locate construction joints where tendons pass through center of concrete section.

d. Locate construction joints in walls and columns at underside of slabs, beams, or girders and at tops of footings or slabs.

e. Make construction joints perpendicular to main reinforcement.

f. Provide movement joints where indicated in Contract Documents or in accepted alternate locations.

g. Submit location and detail of movement joints if different from those indicated in Contract Documents.

h. Submit manufacturer's data sheet on expansion joint materials.

i. Provide keyways where indicated in Contract Documents.[Longitudinal keyways indicated in Contract Documents must be at least 37.5 mm 1.5 inch deep, measured perpendicular to the plane of the joint.]

2.2.7 Other Embedded items

****
NOTE: Specify materials and design for sleeves, inserts, anchors, and other embedded items if not included in the Contract Documents.
****

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

2.3 SYSTEM DESCRIPTION

Provide concrete composed of cementitious materials, water, fine and coarse aggregates, and admixtures. Use cementitious materials that are [portland cement], [portland cement in combination with coal ash,][portland cement in combination with[_____,]][slag cement][portland cement in combination with slag cement][portland cement in combination with silica fume][portland cement in combination with a natural pozzolan]. Use an air-entraining admixture.[For underwater concrete use an anti-washout admixture. Viscosity modifying admixtures are allowed for underwater and self-consolidating concrete (SSC).] A retarding admixture, a[WRA,][a HRWRA,][or an accelerating admixture] may be used at the request of the Contractor when approved. Do not use chemical admixtures other than those listed above.

2.3.1 Proportioning Responsibility

****
NOTE: The last optional sentence should be used if slow strength gain cementitious materials are to be used.
****

The concrete mixtures for the following features of work[,_____], will be proportioned by the Contracting Officer.

Mixture-proportioning studies in accordance with ACI 211.1 and or thermal analysis in accordance with ETL 1110-2-542 determined by validated government laboratories in accordance with ER 1110-1-8100 Materials Testing Laboratories and Validation, using materials provided by the Contractor which are representative of those to be used in the project, are available for review in the[_____] District Office. The proportions of all material entering each concrete mixture will be furnished to the Contractor. The proportions will be changed by the Contracting Officer as necessary. Adjust the batch weights of aggregates and water as necessary to compensate for free moisture in the aggregates. Adjust the quantity of air-entrainment admixture to maintain the specified air content. Some mixtures, especially those containing higher amounts of supplementary cementitious materials, may have slow strength gain which may impact form design and form removal time. Trials batches are to be performed, ensuring the proper adjustments have been made to the mixture proportions, prior to placement of concrete for any feature of work. Failure of performing trial batches will result in the removal of noncompliant concrete at the contractor's expense.

The concrete mixtures for the following features of work[,_____], will be proportioned by the Contractor and approved by the Contracting Officer.

The contractor is responsible for developing an optimum mixture design with special considerations for concrete mixture(s) intended to be placed [above] and or [below] water. These mixture(s) must be proportioned to reduce or control the heat of hydration, and the resulting temperature rise to avoid damaging the concrete through excessive temperatures and temperature differences. Some mixtures, especially those containing higher amounts of pozzolans, may have slow strength gain which may impact form design and form removal time. As provided by ACI 211.1, subsequent to approval for use of Mix Designs for the Project, if there becomes a need to make adjustments in the field, such adjustments outside of those allowed by the approval documents (such as dosage ranges of some or all of the admixtures) must be tested at the plant for plastic properties and submitted in writing for approval by the Contracting Officer. Coarse and fine aggregate quantities adjustments in the field must be limited to 10 percent of the original quantities as approved by the Contracting Officer. The Contractor must never adjust cement type and or contents, maximum water contents, water/cementitious ratios (W/CM) without the prior written approval of the Contracting Officer.

2.3.2 Government Oversight During Proportioning and Testing Activities

2.3.2.1 Assignment of Government Materials Engineer.

At the discretion of the Contracting Officer, a Government Materials Engineer may be assigned to facilitate coordination, review, and approvals during mixture proportioning and testing activities.

2.3.2.2 Notice Requirement

The Contractor will provide a minimum of seven calendar days notice prior to trial batching and testing activities to allow for Government presence at the site. These activities include but are not limited to, mixture proportioning studies and testing, on/off site trial batching, and Thermal Properties testing for Mass Concrete mixtures.

2.3.2.3 Confirmation of Attendance

The Government will provide written confirmation by email, memorandum, or other official communication, indicating its decision to attend or not attend the specified activities.

2.3.3 Design Requirements

****

NOTE: See the concrete materials design memorandum to select the optional cementitious materials.

NOTE: When determining the specified durability requirements per structural element, use Tables 4.2.2.6(b) - 4.2.2.6(d) within ACI 301.

****

Concrete Mixture Design Requirements per Feature of Work

Structural Element	W/CM	Compressive Strength (PSI)	Air Content (percentage)	Slump inches	Slump Flow (inches)	Nominal Max Aggregate size inches	Washout (percent)

[Concrete mixture proportions must be determined by the Contractor and submitted for approval 60 days before concrete placement begins. The concrete mixture quantities of all ingredients per cubic meter yard and nominal maximum coarse aggregate size that will be used in the manufacture of each quality of concrete must be stated. Proportions must indicate the mass of cement, pozzolan and/or slag cement when used, and water; the mass of aggregates in a saturated surface-dry condition; and the quantities of admixtures (including hydration stabilizer if used). The submission must be accompanied by test reports from a laboratory complying with ASTM C1077, which show that proportions thus selected will produce concrete of the qualities indicated.

][The submission must provide information specified in paragraph Documenting Average Strength, and if applicable, paragraph Determining Standard Deviation. Mix proportions, exact slump and exact air content must be reported for each concrete cylinder used to develop the mix design. The adiabatic heat rise of the proposed mix must be tested in accordance with CRD 38 and submitted for approval. The structure or portion of the structure where the Contractor plans to use the submitted concrete mixture proportions must be submitted along with the dates he plans for placing each concrete mixture proportion and the planned concrete placement temperature to allow evaluation of the concrete mixture proportion based on the submitted thermal analysis. No substitution must be made in the source or type of materials used in the work without additional tests to show that the quality of the new materials and concrete are satisfactory.
]

2.3.3.1 Contractor Supplied Mix Design

Concrete mixture proportions must be determined by the Contractor and submitted for approval 60 days before concrete placement begins. The concrete mixture quantities of all ingredients per cubic meter yard and nominal maximum coarse aggregate size that will be used in the manufacture of each quality of concrete must be stated. Proportions must indicate the mass of cement, coal ash, natural pozzolans, slag cements, and or other supplementary cementitious materials when used, and water; the mass of aggregates in a saturated surface-dry condition; and the quantities of admixtures (including hydration stabilizer if used). The submission must be accompanied by test reports from a laboratory complying with ASTM C1077, which show that proportions thus selected will produce concrete of the qualities indicated.

The submission must provide information specified in paragraph Documenting Average Strength, and if applicable, paragraph Determining Standard Deviation. Mix proportions, exact slump and exact air content must be reported for each concrete cylinder used to develop the mix design. The adiabatic heat rise of the proposed mix must be tested in accordance with CRD 38 and submitted for approval. The structure or portion of the structure where the Contractor plans to use the submitted concrete mixture proportions must be submitted along with the dates he plans for placing each concrete mixture proportion and the planned concrete placement temperature to allow evaluation of the concrete mixture proportion based on the submitted thermal analysis. No substitution must be made in the source or type of materials used in the work without additional tests to show that the quality of the new materials and concrete are satisfactory.

2.3.4 Determining Standard Deviation

Where a concrete production facility has test records, a standard deviation must be established in accordance with the applicable provisions of ACI 214R. Test records from which a standard deviation is calculated must:

a. represent materials, quality control procedures, and conditions similar to those expected at the proposed work;

b. not be from a project where the allowable changes in materials and/or proportions were more restricted than for the proposed work;

c. represent concrete produced to meet a specified strength or strengths, f 'c , within 6895 kPa 1000 psi of that specified for the proposed work;

d. be from consecutive tests;

e. be from different batches;

f. be the average of strengths from two cylinders made from the same sample of concrete and tested at the age indicated in paragraph "Concrete Strength" and

g. be from concrete that was produced within one year of the time when concrete placement is expected to begin for the proposed work.

2.3.4.1 Standard Deviation 30 Or More Test Records

Use an unmodified standard deviation and calculate FCR as specified in paragraph 15 or More Test Records.

2.3.4.2 Standard Deviation 15 To 29 Test Records

Where a concrete production facility does not have 30 test records, but does have a record based on 15 to 29 consecutive tests, a modified standard deviation may be established as the product of the standard deviation based on 15 to 29 tests and modification factor from the following Table. Calculate FCR as specified in paragraph FCR 15 Or More Test Records.

Number of Records	Modification Factor For Standard Deviation
15	1.16
20	1.08
25	
30 or More	1.00

2.3.4.3 Standard Deviation Less Than 15 Test Records

No standard deviation is needed. Calculation of FCR must be as specified in paragraph Less Than 15 Test Records.

2.3.5 Required Average Compressive Strength

In meeting the strength requirements specified in paragraph Concrete Strength, the selected mixture must have proportions so as to produce an FCR exceeding f'c as indicated in paragraphs FCR 15 Or More Test Records, or, FCR Less Than 15 Test Records.

2.3.5.1 FCR 15 Or More Test Records

If a standard deviation is calculated as specified in paragraph Determining Standard Deviation, f 'cr must be determined based on the value of f 'c and the standard deviation, S, as follows:

Standard Deviation "S"	Required Average Compressive Strength, FCR (psi)
Less than or equal to 505	f'c + 1.34 S
Greater than 505	f'c + 2.33 S-500

2.3.5.2 FCR Less Than 15 Test Records

When a concrete production facility does not have field strength test records for calculation of standard deviation, FCR must be determined based on the value of f'c as follows:

Specified Compressive Strength, f'c (psi)	Required Average Compressive Strength, FCR (psi)
Less Than 3000	f'c + 1000
3000 - 5000	f'c + 1200
Greater Than 5000	1.1fc' + 700

2.3.6 Documenting Average Strength

Documentation that proposed concrete proportions produce the required average strength, fcr, determined in paragraph Required Average Compressive Strength, FCR, must be based on previous field experience (paragraph Field Experience) or laboratory trial batches (paragraph Laboratory Trial Batches). Documentation must include compression, slump and air content tests performed on concrete produced using the proposed mixture proportions.

2.3.6.1 Field Experience

Required average strength can be documented by field experience if compressive strength test records consisting of not less than 10 consecutive tests and encompassing a period of not less than 60 days are used. Test records must represent similar materials to those proposed and similar conditions to those expected. Changes in materials, conditions, and proportions within the test record must not have been more closely restricted than those for the proposed work. Test records must not be more than 1 year old.

2.3.6.2 Laboratory Trial Batches

The laboratory used to develop information required by this section must comply with ASTM C1077.

a. Delivery of Samples

Representative samples for all concrete materials proposed for this project and a copy of this section of the contract specifications entitled "MASS CONCRETE" must be delivered to the laboratory that performs the concrete proportioning at least 60 days (120 when pozzolan [or Slag Cement] is used) before concrete placement is expected to begin. Samples of approved aggregates must be obtained in accordance with the requirements of ASTM D 75. Samples of materials other than aggregate must be representative of those proposed for the project and must be accompanied by manufacturer's test reports indicating compliance with applicable specification requirements. When all of these materials have been delivered, the name, address, and phone number of this laboratory and a list of the sources and types of all concrete materials must be submitted to the Contracting Officer.

b. Trial Mixtures

Trial mixtures having proportions, consistencies, maximum slump or slump flow, maximum air content, and adiabatic heat rise suitable for the work must be made based on ACI 211.1, using at least three different water cementitious materials ratios (W/CM) which will produce a range of strengths encompassing those required for the work. For each portion of the structure, mixture proportions must be selected so that the strength and(W/CM) meet the minimum requirements specified. The trial mixtures

must have a slump and air content within plus or minus 19 millimeters 3/4 inch and plus or minus 0.5 percent, respectively, of the maximum permitted. The target water cementitious materials ratios required in paragraph "Maximum Water-Cementitious Materials (W/CM) Ratio," include the total weight of cement plus pozzolan and slag cement, converted from absolute volume as described in ACI 211.1. Trial mixtures must be designed in accordance with the procedure in ACI 211.1, using the absolute volume basis for determining the required amount of fine aggregate. The dry rodded weight per cubic meter foot of the coarse aggregate determined according to ASTM C29/C29M; the fineness modulus of the fine aggregate determined according to COE CRD-C 104; the adiabatic heat rise and yield, slump and air content must be reported. For each water cementitious materials ratio at least five pairs of 152 millimeters by 304 millimeters 6 inch by 12 inch test cylinders for each test age must be made and cured in accordance with ASTM C192/C192M. They must be tested in accordance with ASTM C39/C39M at 7, 14, 28, 56 and 90 days. From these test results a curve must be plotted and submitted showing the relationship between water cementitious materials ratio and strength at design age.

The results of these tests must be summarized in table form and included in the Concrete Mixture Proportioning Report. The Concrete Mixture Proportioning Report must include the concrete mixture proportions for each mix design tested, the results of the testing in table form, descriptions of the resulting properties of the different mix designs and differences between mixes, and the reasons for selecting the Contractor's recommended optimal mix design for each structural element. The report must be submitted to the Contracting Officer for approval.

The Contractor must submit the combination of materials that will produce concrete to meet the requirements of the structure with respect to workability, dimensional stability and freedom from cracking, low temperature rise, adequate strength, durability and low permeability to the Government for approval.

2.3.7 Mass Concrete Mixture

****
NOTE: For large complex mass concrete projects it is optional to use the table below for additional performance. However, it is critical to list the specified requirements. If the testing requirements are not listed it is recommended to remove the tests.
****

MASS CONCRETE MIXTURE TESTING REQUIREMENTS		
	Test Name	Test Standard
Strength Test	Test Method For Compressive Strength Of Cylindrical Concrete Specimens	ASTM C39/C39M

MASS CONCRETE MIXTURE TESTING REQUIREMENTS		
	Test Name	Test Standard
Modulus of Elasticity	Standard Test Method For Static Modulus Of Elasticity and Poisson's Ratio Of Concrete In Compression	ASTM C469/C469M at the following ages; 24 Hours, 7 Days, 28 Days, and 90 Days
Freeze and Thaw	Standard Test Method Of Resistance Of Concrete To Rapid Freezing And Thawing	ASTM C666/C666M and
Shrinkage Test	Test Method for Length Change of Hardened Hydraulic Cement Mortar and Concrete	ASTM C157/C157M and ASTM C1646/C1646M
Thermal Properties		
Concrete Heat of Hydration	Test Method For Heat Of Hydraulic Cement	ASTM C186 and COE CRD-C 229
Temperature Rise	Temperature Rise Of Concrete	USBR 4911 and COE CRD-C 38
Diffusivity	Thermal Diffusivity Of Concrete	USBR 4909 and COE CRD-C 37
Specific Heat	Specific Heat Of Aggregates, Concrete And Other Materials	USBR 4907 and COE CRD-C 124
Thermal Expansion	Coefficient Of Linear Thermal Expansion Of Concrete	AASHTO T 336-15

Provide stationary mixers[or truck mixers]. Each mixer must combine the materials into a uniform mixture and discharge this mixture without segregation. Do not charge mixers in excess of the capacity recommended by the manufacturer on the nameplate. Excessive over-mixing requiring introduction of additional water will not be permitted. Maintain mixers in satisfactory operating condition, and keep mixer drums free of hardened concrete. Replace mixer blades or paddles when worn down more than 10 percent of their depth when compared with the manufacturer's dimension for new blades. Should any mixer at any time produce unsatisfactory results, discontinue its use promptly until it is repaired or replaced. Submit the make, type, capacity, and number of the concrete mixers proposed for use, 60 days prior to installation for review by the Contracting Officer for conformance with the requirements of paragraph PLANT AND EQUIPMENT.

2.3.8 Thermal Analysis and Thermal Control Plan

All concrete [_____] requires a thermal analysis and thermal control plan to ensure that a maximum concrete temperature of 71.1 degrees C 160 degrees F and a maximum temperature differential of 2 degrees C 35 degrees F, are not exceeded. The thermal analysis and thermal control plan must be submitted at least 30 days in advance of the anticipated date of concrete placement. The adiabatic heat rise of the proposed mix designs must be submitted for 14 days. A Level 2 thermal analysis, as specified in ETL 1110-2-542 must be performed. The structure or portion of the structure where the Contractor plans to use the submitted concrete mix designs must be submitted along with the dates he plans for placing each concrete mix design and the planned concrete placement temperature to allow evaluation of the concrete mixture proportion. The thermal analysis must include all assumptions and all calculations made. If a proprietary software is used, the submittal must include, but not limited to, a description of the program including all calculations, equations, assumptions, material properties. A complete list of all input and output from the program must be included.

The thermal control plan must state the anticipated temperatures and temperature differentials. It must address the corrective measures that will be taken if these become excessive. It must address the maximum concrete placement temperature allowed based on the thermal analysis, the concrete mix, and the thermal controls to be used. The thermal control plan must include all methods, materials, and equipment the contractor intends to use to control the maximum concrete temperature and temperature differential including the timing of application and removal of the controls. The plan must also include the temperature monitoring that will be performed.

2.3.9 Temperature Monitoring

The data from all temperature monitoring must be submitted. The raw temperature data and plots of maximum concrete temperature, temperature at the surface, and the temperature difference must be included.

2.3.10 Air Content

Determine the air content by volume by ASTM C231/C231M as defined in paragraph Concrete Mixture Design Requirements per Structural Element. If another location is approved by the Contracting Officer and selected for performing air content tests other than at the point of placement, dual sampling will be performed to develop correlation between the two sampling locations.

2.3.11 Slump

The slump must be determined in accordance with ASTM C143/C143M and as defined in paragraph Concrete Mixture Design Requirements per Structural Element, except where placement by pump is approved. If another location is approved by the Contracting Officer and selected for performing slump tests other than at the point of placement, dual sampling will be performed to develop correlation between the two sampling locations.

For pump placement, the final slump after the addition of an approved high range water reducer must be 165 millimeters 6 1/2 inches plus or minus 38 millimeters 1 1/2 inches. Only polycarboxylate-based high range water reducing admixtures meeting ASTM C494/C494M Type A OR Type F must be used

to produce concrete with sufficient workability for placement without segregation. No excessive bleeding must be permitted. Sampling for pump placement is to be taken at the transfer point from the delivery vehicle to the pump hopper.

2.3.12 Slump Flow

The slump flow must be determined in accordance with ASTM C1611 Test Method for Slump Flow of Self-Consolidating Concrete (SCC) and must have a flow of[660 to 762 millimeters][26 to 30 inches][_____]. The visual index rating of the mixture must be maintained at 1 or less. Sampling for SCC placement is to be taken at the transfer point from the delivery vehicle to the transport hopper.

2.3.13 Passing Ability by J-Ring Test

For self-consolidating concrete, the passing ability of proposed mix design must be tested in accordance with ASTM C1621/C1621M. The difference between the slump flow and J-ring flow must not exceed[25 millimeters][1 inch][50 millimeters][2 inches].

2.3.14 Washout

The maximum washout allowed for concrete to be placed underwater must be[six][eight] percent when tested in accordance with COE CRD-C 61 Under Water Concrete. When concrete is intended for placement under water using the tremie technique, the concrete must be proportioned to be cohesive and flow with minimal segregation. Viscosity modifying admixtures are permitted for under water concrete. Proportioning guidance in ACI 304R must be considered. Concrete mixtures must be qualified for tremie placement methods based on a trial placement approved by the Contracting Officer. Use ACI 546.2R as a guide in developing under water concrete, however, mix design must meet contract requirements given in this section. Use non-self-consolidating under water concrete for concrete fill placements with a sloped grade.

2.3.15 Construction Tolerances

Make level and grade tolerance measurements of slabs as soon as possible after finishing. When forms or shoring are used, make the measurements prior to removal. Tolerances are not cumulative. The most restrictive tolerance controls. Do not allow tolerances to extend the structure beyond legal boundaries. Except as specified otherwise, plus tolerance increases the amount or dimension to which it applies or raises a level alignment and minus tolerance decreases the amount or dimension to which it applies or lowers a level alignment. A tolerance without sign means plus or minus. Where only one signed tolerance is specified, there is no limit in the other direction.

All concrete tolerances must be as specified in ACI 117, Cast-in-place Concrete for Buildings,[_____] except top of wall. Top of wall tolerances must be in conjunction with survey elevation requirements specified in ACI 117 and must be plus 19 millimeters 3/4 inch. Finish unformed finished surfaces subject to high-velocity flow 12 meters per second 40 feet per second to meet the tolerances for A-HV surfaces specified in Table, TOLERANCES FOR FINISHED FORMED CONCRETE SURFACES.

2.3.16 Tabulations and Definitions

****
NOTE: Delete any of the following tables that are not applicable. Most projects will require several tables to cover all parts of the structure.
****

The definitions of the terms used in the following tabulations are used as defined and used in ACI 117. Make level and grade tolerance measurements of slabs as soon as possible after finishing.

TOLERANCES FOR FOUNDATIONS		
(1)	Lateral alignment	
	As cast to the center of gravity as specified; 0.02 times width of footing in direction of misplacement but not more than	50 mm 2 inches
	Supporting masonry construction	13 mm 1/2 inch
(2)	Level alignment	
	Top of footings supporting masonry	13 mm 1/2 inch
	Top of other footings	positive 13 mm, negative 50 mmpositive 1/2 inch, negative 2 inch

TOLERANCES FOR FOUNDATIONS		
(3)	Cross-sectional dimensions	
	Horizontal dimensions of formed members	positive 50 mm, negative 13 mmpositive 2 inch, negative 1/2 inch
	Horizontal dimensions of unformed members cast against soil	
	600 mm 2 feet or less	positive 75 mm, negative 13 mmpositive 3 inch, negative 1/2 inch
	Greater than 600 mm 2 feet but less than 1800 mm 6 feet	positive 150 mm, negative 13 mmpositive 6 inch, negative 1/2 inch
	Over 1800 mm 6 feet	positive 300 mm, negative 13 mmpositive 12 inch, negative 1/2 inch
	Vertical dimension (thickness)	negative 5 percent
(4)	Relative alignment	
	Slope of footing side and top surfaces with respect to the specified plan	25 mm per 3000 mm 1 inch per 10 ft

TOLERANCES FOR CAST-IN-PLACE REINFORCED CONCRETE FOR BUILDINGS			
(1)	Vertical alignment		
	For heights30 m 100 feet		
		Lines, surfaces, and arrises	25 mm1 inch
		Outside corner of exposed corner columns and control joint grooves in concrete exposed to view	13 mm1/2 inch
	For heights greater than 30 m 100 ft		
		Lines, surfaces, and arrises, 1/1,000 times the height at any point but not more than	150 mm6 inches
		Outside corner of exposed corner columns and control joint grooves in concrete, 1/2,000 times the height at any point but not more than	75 mm3 inches
(2)	Lateral alignment		
	Members		25 mm1 inch
	In slabs, centerline location of openings 12 inches or smaller and edge location of larger openings		13 mm1/2 inch
	Sawcuts, joints, and weakened plane embedment in slabs		19 mm3/4 inch
(3)	Level alignment		
	Top of slabs		
		Elevation of slabs-on-grade	19 mm3/4 inch
		Elevation of top surfaces of formed slabs before removal of supporting shores	19 mm3/4 inch
	Elevation of formed surfaces before removal of shores		19 mm3/4 inch
	Lintels, sills, parapets, horizontal grooves, and other lines exposed to view		13 mm1/2 inch
(4)	Cross-sectional dimensions		
	Members, such as columns, beams, piers, walls (thickness only) and slabs (thickness only)		
		300 mm 12 inches dimension or less	positive 10, negative 6 mm positive 3/8, negative 1/4 inch
		More than 300 mm 12 inches but not over 900 mm 3 feet dimension	positive 13, negative 10 mm positive 1/2, negative 3/8 inch
		Over 900 mm 3 feet dimension	positive 25, negative 19 mm positive 1, negative 3/4 inch

TOLERANCES FOR CAST-IN-PLACE REINFORCED CONCRETE FOR BUILDINGS			
(5)	Relative alignment		
	Stairs		
		Different in height between adjacent risers	3 mm1/8 inch
		Different in width between adjacent treads	6 mm1/4 inch
	Grooves		
		Specified width 50 mm 2 inches or less	3 mm1/8 inch
		Specified width more than 50 mm 2 inches but not more than 300 mm 12 inches	6 mm1/4 inch
	Sawcuts, joints, and weakened plane on slab		
		Lateral, gradual	19 mm in 3000 mm 3/4 inch in 10 feet
		Lateral, abrupt	0 mm inch
(6)	Openings through members		
	Cross-sectional size of opening		plus 25 mm, minus 6 mmplus 1, minus 1/4 inch
	Location of centerline of opening		13 mm1/2 inch

TOLERANCE FOR FINISHED FORMED CONCRETE SURFACES		
(1)	Vertical alignment: Formed surfaces slope with respect to the specified plane	
	Vertical alignment of outside corner of exposed corner columns and control joint grooves in concrete exposed to view	1/4 inch in 10 feet
	All other conditions	3/8 inch in 10 feet

TOLERANCE FOR FINISHED FORMED CONCRETE SURFACES		
(2)	Abrupt variation: The offset between concrete surfaces under adjacent pieces of formwork for the following classes of surface: (For Class A-HV, positive means raise of elevation in the direction of waterflow, negative means drop of elevation in the direction of waterflow)	
	Class A-HV, in the direction of waterflow	plus 0, minus 3 mm minus 1/8 inch
	*Class A-HV, perpendicular to the direction of waterflow	3 mm1/8 inch
	Class A	3 mm1/8 inch
	Class B	6 mm1/4 inch
	Class C	6 mm1/4 inch
	Class D	25 mm1 inch
(3)	Gradual variation: Surface finish tolerances as measured by placing a freestanding (unleveled), 1.5 m 5 foot straightedge for plane surface or curved template for curved surface anywhere on the surface and allowing it to rest upon two high spots within 72 hr after concrete placement. The gap at any point between the straightedge or template and the surface must not exceed:	
	*Class A (including Class A-HV)	3 mm1/8 inch
	Class B	6 mm1/4 inch
	Class C	13 mm1/2 inch
	Class D	25 mm1 inch
*Includes any high-velocity flow surface.		

TOLERANCES FOR CAST-IN-PLACE, VERTICALLY SLIPFORMED BUILDING ELEMENTS		
(1)	Translation and rotation from a fixed point at the base of the structure:	
	For heights 30 m 100 feet or less	50 mm 2 inches
	For heights greater than 30 m 100 feet, 1/600 times the height but not more than	205 mm 8 inches
(2)	Lateral alignment	
	Between adjacent elements	50 mm 2 inches
(3)	Cross-sectional dimensions	
	Wall thickness	plus 19 mm, minus 10 mm plus 3/4 inch, minus 3/8 inch
(4)	Relative alignment	
	Formed surface slope with respect to the specified plane	19 mm in 3000 mm 3/4 inch in 10 feet

TOLERANCES FOR MASS CONCRETE STRUCTURES OTHER THAN BUILDINGS		
(1)	Vertical alignment	
	Visible surfaces	30 mm 1-1/4 inch
	Concealed surfaces	65 mm 2.5 inches
	Side walls for radial gates and similar watertight joints	5 mm 3/16 inch
(2)	Lateral alignment	
	Visible surfaces	30 mm 1-1/4 inch
	Concealed surfaces	65 mm 2.5 inches

TOLERANCES FOR MASS CONCRETE STRUCTURES OTHER THAN BUILDINGS			
(3)	Level alignment		
	Visible flatwork and formed surfaces		13 mm 1/2 inch
	Concealed flatwork and formed surfaces		25 mm 1 inch
	Sills for radial gates and similar watertight joints		5 mm 3/16 inch
(4)	Relative alignment: Formed surface slope with respect to the specified plane		
	Slopes in lateral and level alignments		
		Visible surfaces	7 mm in 3000 mm 1/4 inch in 10 feet
		Concealed surfaces	13 mm in 3000 mm 1/2 inch in 10 feet
	Slopes in vertical alignment		
		Visible surfaces	13 mm in 3000 1/2 inch in 10 feet
		Concealed surfaces	25 mm in 3000 mm 1 inch in 10 feet

TOLERANCES FOR CANAL LINING		
(1)	Lateral alignment	
	Alignment of tangents	50 mm 2 inches
	Alignment of curves	100 mm 4 inches
	Width of section at any height	0.0025 W plus 25 mm 1 inch

TOLERANCES FOR CANAL LINING			
(2)	Level alignment		
	Profile grade		25 mm 1 inch
	Surface of invert		6 mm 1/4 inch
	Surface of side slope		13 mm 1/2 inch
	Height of lining		0.005 H plus 25 mm 1 inch
(3)	Cross-sectional dimensions		
	Thickness of lining cross section: percent of specified thickness provided average thickness is maintained as determined by daily batch volumes		10
TOLERANCES FOR TUNNEL LININGS, CONDUITS, AND FILLING AND EMPTYING CULVERTS			
(1)	Lateral alignment		
	Centerline alignment		
		Water conveying tunnels, conduits, and culverts	13 mm 1/2 inch
		Other	25 mm 1 inch
	Inside dimensions		0.005 times inside dimension
(2)	Level alignment		
	Profile grade		
		Water conveying tunnels, conduits, and culverts	13 mm 1/2 inch
		Other	25 mm 1 inch
	Surface of invert		6 mm 1/4 inch
	Surface of side slope		13 mm 1/2 inch

(3)	Cross-sectional dimension		
	Thickness at any point		
		Tunnel and culvert lining	minus 0 mm inch
		Conduits	plus 5 percent thickness but not less than 13 mm 1/2 inch
			minus 2.5 percent thickness but not less than 6 mm 1/4 inch

2.4 MATERIALS

2.4.1 Cementitious Materials

****
NOTE: See the appropriate concrete aggregates design memorandum or thermal study to select the proper requirements for cementitious materials options, pozzolan, and silica fume.
****

2.4.1.1 Portland Cement

Provide portland cement conforming to ASTM C150/C150M, Type [_____],[including the heat of hydration requirement at 7 days][including early stiffening][list additional requirements if needed].

[2.4.1.2 Coal Ash or Natural Pozzolan

Provide coal ash or natural pozzolan other than silica fume conforming to ASTM C618,[Class F][Class C], including[drying shrinkage,][uniformity,][and [moderate][severe] sulfate resistance requirements] of Table 3. Loss on Ignition must not exceed 6 percent[and CaO percent must not exceed 18 percent for Class F]. Uniformity Requirements (for entrained air) must apply to all coal ash. If used, replacement of cement with coal ash must be between 15 and 40 percent by mass of cementitious material.

][2.4.1.3 Slag Cement

****
NOTE: Replacement of cement with slag cement of up to 70 percent may be considered acceptable pending approval from the Contracting Officer.
****

Provide slag cement conforming to ASTM C989/C989M, Grade [_____]. If used, replacement of cement with slag cement must be between 30 and 50 percent by mass of cementitious material.

][2.4.1.4 Silica Fume

****
NOTE: Include optional Table 2 in ASTM C1240 when used with aggregates listed to require low-alkali

cement. Other requirements in Table 4 may be specified if necessary. Refer EM 1110-2-2000 for guidance.

****

Silica fume may be furnished as a dry, densified material or as a slurry. Silica fume, unprocessed, or before processing into a slurry or a densified material, must conform to ASTM C1240 and with the Uniformity Requirements. Provide the services of a manufacturer's technical representative, experienced in mixture proportioning, placement procedures, and curing of concrete containing silica fume. The manufacturer's representative must be available for consultation by both the Contractor and the Contracting officer during mixture proportioning, planning, and production of silica-fume concrete and onsite immediately prior to and during at least the first placement of concrete containing silica fume, and at other times if directed. If used, replacement of cement with Silica fume must be between 5 and 15 percent by mass of cementitious material.

]2.4.1.5 Blended Hydraulic Cements

a. Conform to ASTM C595/C595M Type[IP][IS][IT][IP(MS)][IS(MS)][IT(MS)][IP(MH)][IS(MH)][IT(MH)][IP(LH)][IS(LH)][IT(LH)][IL] [_____].

b. Slag cement added to the Type IS or Type IT blended cements must meet ASTM C989/C989M.

c. The coal ash or natural pozzolan added to the Type IP or Type IT blended cements must meet ASTM C618[Class F,][Class C,][or][Class N] and interground with the cement clinker. The manufacturer must state in writing that the amount of coal ash or natural pozzolan in the finished cement will not vary more than plus or minus 5 mass percent of the finished cement from lot to lot or within a lot. The percentage and type of coal ash or natural pozzolan used in the blend must not change from that submitted for the aggregate evaluation and mixture proportioning.

d. MgO must be less than 6 percent and heat of hydration must not exceed [_____].

2.4.1.6 Temperature of Cementitious Materials

The temperature of the cementitious materials as delivered to the site must not exceed 65 degrees C 150 degrees F.

2.4.2 Admixtures

All chemical admixtures furnished as liquids must be in a solution of suitable viscosity for field use as determined by the Contracting Officer.

2.4.2.1 Air-Entraining Admixtures

Provide air-entraining admixture conforming to ASTM C260/C260M and consistently entrain air in the specified ranges under field conditions.

[2.4.2.2 Accelerating Admixture

****

NOTE: Accelerating admixtures are not recommended for mass concrete

****

Do not use calcium chloride. Use accelerators that meet the requirements of ASTM C494/C494M, Type C[or Type E].

][2.4.2.3 Retarding Admixture

****

NOTE: A retarding admixture should not be used where high early strength is desirable so that form stripping may proceed expeditiously. Before listing items consult the concrete materials design memorandum to determine areas where retarders may be necessary.

****

Provide retarding admixture meeting the requirements of ASTM C494/C494M, Type B, or D, except that the 6-month and 1-year compressive strength tests are waived. The admixture may be added to the concrete mixture only when approved[, except for the following structural items where a retarding admixture are not to be used: [_____]]. Do not use Type D as the reason to reduce the cementitious material content unless used in mixture proportioning studies.

][2.4.2.4 Water-Reducing Admixture

Provide a water-reducing admixture meeting the requirements of ASTM C494/C494M, Type A[or D], except that the 6-month and 1-year compressive strength tests are waived. The admixture may be added to the concrete mixture only when its use is approved or directed and after mixture proportioning studies.

][2.4.2.5 High-Range Water-Reducing Admixture (HRWRA)

Use high-range water-reducing admixture that meets the requirements of ASTM C494/C494M, Type F[or G], except the 6-month and 1-year strength requirements are waived.[The admixture may be used only after mixture proportioning studies and when approved.][Provide the services of a manufacturer's technical representative experienced in mixture proportioning and placement procedures of concrete containing HRWRA. The technical representative must be available for consultation during mixture proportioning and on-site for the first placement of concrete containing HRWRA.]

]2.4.2.6 Shrinkage Reducing Admixture

Shrinkage reducing admixture for concrete conforming to ASTM C494/C494M, Type S. Admixture must have the following characteristics:

a. Designed to facilitate expansion of concrete at the same rate as shrinkage during the curing period.

b. Designed to reduce the capillary surface tension of pore water.

c. Provides at least 80 percent shrinkage crack reduction as measured and documented by field performance.

d. Formulated for use in freezing and thawing weather.

e. Free-flowing powder used at the application rate of 5 percent, or 5 pounds for each 100 pounds of cement in concrete.

f. pH (10 percent aqueous slurry): 10 to 11.

g. Ring test, ASTM C1581/C1581M. Run with concrete (maximum aggregate size not to exceed 0.5 inches): No cracking for minimum 120 days.

h. Maximum shrinkage 0.035 percent at 56 days when tested per ASTM C157/C157M.

[2.4.2.7 Expansive Admixture

****
NOTE: Delete this paragraph and paragraph BLOCK-OUT CONCRETE in Part 3 if block-out concrete is not used.
****

Submit manufacturer's descriptive literature and certification for fluidifier to be used as expansive admixture in block-out concrete, 60 days prior to its use. Use expansive admixture in block-out concrete conforming to ASTM C937.

]2.4.2.8 Anti-Washout Admixture

Anti-washout admixture must be capable of preventing excessive washout of paste from concrete placed underwater, such that the maximum allowable washout is not exceeded when the admixture is used at the recommended dose of the manufacturer. The admixture must meet the requirements of COE CRD-C 661.

2.4.3 Curing Materials

[2.4.3.1 Sheet Materials

Provide sheet curing materials conforming to ASTM C171, type optional, except do not use polyethylene sheet[unless less than 6 mil]. Submit a manufacturer's certificate certifying that the materials comply with the requirements of ASTM C171[, if sheet curing is used].

]2.4.3.2 Membrane-Forming Curing Compound

Provide membrane-forming curing compound conforming to ASTM C309, Type 1D[or 2], except a styrene acrylate or chlorinated rubber compound meeting ASTM C309, Class B, requirements may be used for surfaces that are to be painted or are to receive subsequent coatings, or floors that are to receive adhesive applications of resilient flooring. Select curing compound selected that is compatible with any subsequent paint, roofing, coating, or flooring specified.

2.4.3.3 Burlap

Provide burlap for curing purposes conforming to AASHTO M 182.

[2.4.3.4 Insulation

Submit materials required according to Thermal Control Plan.

]2.4.4 Water

Use water for washing aggregates and for mixing and curing concrete that is free from injurious amounts of oil, acid, salt, alkali, organic matter, or other deleterious substances and in compliance with ASTM C1602/C1602M Table 1 and 2, except no combined water and water from the concrete operation is allowed. Potable water need not be tested.

2.4.5 Aggregates

****

NOTE: See the concrete materials design memorandum to select the aggregate composition options.

This note may be disregarded for regions where Alkali-Silica Reactivity (ASR) is not a concern. Some aggregate sources may exhibit an ASR potential. ASR is a potentially deleterious reaction between alkalis present in concrete and some siliceous aggregates, reference EM 1110-2-2000 paragraph 2-3b(6) and appendix D. Use of cementitious materials meeting the low alkali requirement may be effective in some applications, and insufficient in others. In regions where imposing the low alkali requirement has not been effective in controlling ASR, additional effort for evaluation and mitigation may be required. In which case, the alternate procedures to proportion cementitious materials to meet the low alkali requirement in paragraph PORTLAND CEMENT should not be used with the following requirements. Where ASR is known or suspected to pose a concern for concrete durability, it is recommended that aggregates proposed for use in concrete be evaluated to determine ASR potential and an effective mitigation. EM 1110-2-2000, provides recommendations for evaluating and mitigating ASR in concrete mixtures.

Section 32 13 14.13 CONCRETE PAVING FOR AIRFIELDS AND OTHER HEAVY DUTY PAVEMENTS, paragraph ALKALI-SILICA REACTIVITY, provides a specification method for the Contractor to evaluate and mitigate ASR in concrete mixtures. The expansion limits specified in Section 32 13 14.13 are requirements for pavements and exterior slab construction. For structural concrete applications the measured expansion must be less than 0.10 percent. It may not be economical or practical to specify different test limit requirements for use on the same project. In which case the lower limit required by the application should be used.

The designer may use the specification method in UFGS Section 32 13 14.13 by incorporating the relevant paragraphs into this specification, or may use the following requirements (retain either the 0.10 or the 0.08 percent expansion limits as

appropriate) included in the set of brackets provided like so [_____].

****

2.4.5.1 Aggregate Composition

[Provide fine aggregate consisting of natural sand, or a manufactured sand. Provide coarse aggregate consisting of gravel, crushed gravel, crushed stone, or a combination thereof.] Test and evaluate fine and coarse aggregates proposed for use in concrete for alkali-aggregate reactivity in accordance with ASTM C1260 or ASTM C1567 test results conducted with 6 months of the submittal date showing the proposed coarse and fine aggregates are either: innocuous to alkali silica reaction; or that reactivity has been mitigated by the proposed cementitious materials as modified herein. Maximum allowable expansion is 0.10 percent at 14 days per ASTM C1260. If this is not met, then maximum allowable expansion for the proposed concrete mixture/s must be [0.10 percent at 14][0.08 at 30 days] days per ASTM C1567. All aggregate sources must be tested. Also, provide documentation that the aggregate has no history of chemical deterioration in concrete. Fine and coarse aggregates to be used in all concrete must be evaluated and tested for alkali-aggregate reactivity.

2.4.5.2 Quality of Aggregates

****

NOTES: The tests selected should be those which are applicable to the concrete to be used in the project. These tests may include those in the following list in addition to others not listed. See EM 1110-2-2000 for schedule of tests.

A list of properties and test values are unique to each project and should be taken from the concrete materials design memorandum. Delete the quality tests not required in the design memorandum.

Use petrographic examination to identify deleterious substances in aggregates. List deleterious substances individually with respective limits.

****

Deliver aggregates to the mixer meeting the following requirements:

TEST LIMITS			
PROPERTY	FINE AGGREGATE	COARSE AGGREGATE	TESTS
Specific Gravity	[_____]	[_____]	ASTM C127 ASTM C128
Absorption	[_____]	[_____]	ASTM C127 ASTM C128
Durability Factor using Procedure A	[_____]	[_____]	COE CRD-C 114 ASTM C666/C666M

TEST LIMITS			
PROPERTY	FINE AGGREGATE	COARSE AGGREGATE	TESTS
Clay Lumps and Friable Particles	[_____]	[_____]	ASTM C142/C142M
Material Finer than 75 µ No. 200 Sieve	[_____]	[_____]	ASTM C117
Organic Impurities	Not Darker than No. 3, Not less than 95 percent		ASTM C40/C40M ASTM C87/C87M
L.A. Abrasion	[_____]	[_____]	ASTM C131/C131M
Soft Particles	[_____]	[_____]	COE CRD-C 130
Petrographic Examination	List unwanted deleterious materials and their limits	[_____]	ASTM C295/C295M
Chert, less than 2.40 specific gravity	[_____]	[_____]	ASTM C123/C123M
[Coal and Lignite, less than 2.00 specific gravity]	[_____]	[_____]	ASTM C123/C123M
Magnesium Sulfate Soundness	[15]	[18]	ASTM C88

2.4.5.3 Grading

****

NOTES: The Designer should invoke the optional requirement limiting the amount of material passing the 75-µm No. 200 sieve when manufactured sand is specified and may invoke the option when natural sand is specified. If the limitation is invoked here, it must be listed for fine aggregate in paragraph AGGREGATES above.

See the concrete materials design memorandum for the approved gradings. Delete gradings not required.

Note: Additional requirements for fine aggregate monitoring, such as fixed gradations and fineness modulous monitoring are optional for longer duration projects. Short projects which do not require consistency monitoring over time may eliminate this

option.
****

2.4.5.3.1 Fine Aggregate

Deliver fine aggregate to the mixers meeting the grading requirements in accordance with ASTM C33/C33M ASTM C88 [or local state DOT requirements].[The aggregate must have a grading such that the individual percent retained on any sieve does not vary more than 3 percent from the percent retained on that sieve in a fixed grading selected by the Contractor with the approval of the Contracting Officer. The fixed grading may be selected at the start of concrete placement and based upon 30 days fine aggregate production or selected after the first 30 days of concrete placement. The minimum individual percent retained on the 2.36 mm (No. 8)sieve must be 5 percent and on all smaller sieves[, except the 75 micrometers (No. 200)], must be 10 percent. In addition to the grading limits, the fine aggregate, as delivered to the mixer, must have a fineness modulus of no less than[2.25 or more than 2.85][2.3 or more than 3.1]. Also control the grading of the fine aggregate so that the fineness moduli groups (average of the current test and the previous two tests) of the fine aggregate as delivered to the mixer do not vary more than 0.10 from the target fineness modulus of the fixed grading selected by the Contractor and approved by the Contracting Officer. The range of each group must not exceed 0.20. Determine the fineness modulus in accordance with COE CRD-C 104. At the option of the Contractor, fine aggregate may be separated into two or more sizes or classifications but control the uniformity of grading of the separate sizes so that they may be combined throughout the job in fixed proportions established during the first 30 days of concrete placement. The selected fixed grading must be within the following limits, except any individual test result may be outside these limits if within the allowable 3 percent variation from the selected grading.]

SIEVE DESIGNATION U.S. STANDARD SQUARE MESH	PERMISSIBLE LIMITS PERCENT BY MASS, PASSING
9.5 mm3/8 inch	100
4.75 mmNo. 4	95 - 100
2.36 mmNo. 8	80 - 95
1.18 mmNo. 16	60 - 80
600 µmNo. 30	35 - 60
300 µmNo. 50	15 - 30
150 µmNo. 100	5 - 10
75 µmNo. 200	0 - 5

2.4.5.3.2 Coarse Aggregate

Deliver coarse aggregate to the mixers meeting the grading requirements in

accordance with ASTM C33[or local state DOT requirements].

PERCENT BY MASS PASSING INDIVIDUAL SIEVES				
U.S. STANDARD SIEVE SIZE	4.75 mm No. 4 to 19.0 mm 3/4 inch	19.0 mm 3/4 inch to 37.5 mm 1.5 inch	37.5 mm 1.5 inch to 75 mm 3 inch	75 mm 3 inch to 150 mm 6 inch
175 mm7 inch				100
150 mm6 inch				90 - 100
100 mm4 inch			100	20 - 55
75 mm3 inch			90 - 100	0 - 15
50 mm2 inch		100	20 - 55	0 - 5
37.5 mm1.5 inch		90 - 100	0 - 10	
25 mm1 inch	100	20 - 45	0 - 5	
19.0 mm3/4 inch	90 - 100	0 - 10		
9.5 mm3/8 inch	20 - 55	0 - 5		
4.75 mmNo. 4	0 - 10			
2.36 mmNo. 8	0 - 5			

2.4.5.4 Particle Shape

The quantity of flat and elongated particles in the separate size groups of coarse aggregate, as determined by ASTM D4791, using a value of 3 for width-thickness ratio and length-width ratio must not exceed 25 percent in any size group.

2.4.5.5 Nominal Maximum-Size of Aggregate

Use nominal maximum-size of coarse aggregate in the various parts of the work in accordance with the following tabulation except as directed. The NMSA may be changed for sections requiring a special quality of concrete as directed.

FEATURES	NOMINAL MAXIMUM-SIZE AGGREGATE
Sections 190 mm 7.5 inches or less in width or slabs 100 mm 4 inches or less in thickness or any section with a clear distance between reinforcement less than 55 mm 2-1/4 inches	19 mm3/4 inch

FEATURES	NOMINAL MAXIMUM-SIZE AGGREGATE
Sections over 190 mm 7.5 inches or slabs at least 100 mm 4 inch in thickness. However, do not use this size in any section in which the clear distance between reinforcement is less than 55 mm 2-1/4 inch	40 mm1.5 inch
Unreinforced sections over 300 mm 12 inches in width and reinforced sections over 450 mm 18 inches in width or slabs 255 mm 10 inches or greater in thickness. However, do not use this size in any section in which the clear distance between reinforcing bars is less than 115 mm 4.5 inches	75 mm3 inches
Massive sections exceeding 1.8 m 6 feet in width and slabs 600 mm 24 inches in thickness, in which the clear distance between reinforcing bars is at least 225 mm 9 inches	150 mm6 inches

2.4.5.6 Moisture Content

Do not place fine aggregate in bins at the batch plant until it is in a stable state of moisture content. Reach a stable moisture content when the variation in the percent of total moisture tested in accordance with ASTM C566 and when sampled at the same location will not be more than 0.5 percent during 1 hour of the 2 hours prior to placing the material in the batch plant bins and the variation in moisture content when sampled at the same location must not be more than 2.0 percent during the last 8 hour period that the aggregate remains in the stockpile. Deliver coarse aggregate to the mixers with the least amount of free moisture and the least variation in free moisture practicable under the job conditions. Under no conditions deliver coarse aggregate to the mixer dripping wet.

2.4.5.7 Commercial Concrete Aggregate Sources

****

NOTE: The list of sources and required tests will be taken from the concrete materials design memorandum.

****

Concrete aggregates may be furnished from any source capable of meeting the quality requirements stated in the paragraph Aggregates above. The following sources were evaluated during the design phase of the project in [_____] and were found at that time capable of meeting the quality requirements when suitably processed. No guarantee is given or implied that any of the following listed sources are currently capable of producing aggregates that meet the required quality stated above. A Design Memorandum containing the results of the Government investigation and test results is available for review in the [_____] District Office. Contact [_____] at [_____] to arrange for review of the memorandum. Consider test results and conclusions valid only for the sample tested and

do not take as an indication of the quality of all material from a source nor for the amount of processing required.

a. List of Sources

FINE AGGREGATE		COARSE AGGREGATE	
F1	[_____] [1/]	C1	[_____] [1/]
F2	[_____]	C2	[_____]
F3	[_____]	C3	[_____]
[1/ Low-alkali cement or the approved alternate must be used with these sources.]			

****
NOTE: The concrete materials design memorandum will list those sources requiring low-alkali cement, which must be noted herein.
****

b. Selection of Source - After the award of the contract, designate in writing only one source or combination of sources from which the Contractor proposes to furnish aggregates. If the Contractor proposes to furnish aggregates from a source or sources not listed in subparagraph a., LIST OF SOURCES, above, designate only a single source or single combination of sources for aggregates. Regardless of the source selected, provide samples for quality-assurance testing as required by paragraphs GOVERNMENT PRECONSTRUCTION TESTING and MATERIALS FOR MIXTURE-PROPORTIONING STUDIES IN part 1. If a source for coarse or fine aggregate so designated by the Contractor does not meet the quality requirements stated above, do not submit for approval other sources but furnish the coarse or fine aggregate, as the case may be, from one or a combination of the sources listed at no additional cost to the Government.

2.4.5.8 Government Furnished Concrete Aggregate Source

****
NOTE: The Specification Writer should ascertain that restoration of the pit or quarry site is specified under other sections.
****

2.4.5.8.1 Location

The deposits are [owned] [controlled] by the Government and are made available to the Contractor free of charge for production of aggregate required under this contract. Within the designated area, a supply of material is available from which concrete aggregate meeting the requirement of these specifications can be produced with suitable processing. The Government guarantees that a sufficient amount of material of suitable quality for production of all of the concrete aggregate required is available within the deposit and that concrete aggregates of suitable quality can be produced with a properly designed

and operated plant [without hand-picking or similar operations]. However, the amount of work involved or the amount of unsatisfactory materials required to be wasted to produce a sufficient quantity of suitable concrete aggregate is the responsibility of the Contractor, and the Government will not be held liable for costs resulting from such work or waste. Produce the concrete aggregate from the following sites as shown:

	QUARRY SITE	BAR	TERRACE	COORDINATES	DIST. AND DIRECTION
G1	[_____]	[_____]	[_____]	[_____]	[_____]
G2	[_____]	[_____]	[_____]	[_____]	[_____]
G3	[_____]	[_____]	[_____]	[_____]	[_____]

[2.4.5.8.2 Explorations

The deposits listed have been explored by the Government to determine the character and extent of the materials available. The locations of the explorations are shown in the contract drawings. The logs of the exploratory holes are also shown in the drawings. Samples of materials secured are available for inspection at [_____]. The results of explorations are furnished for information only. These data are the result of limited explorations and tests conducted by and for the Government and are accurate to the extent of the scope of the investigations conducted. The Government will not be responsible for any deduction, interpretation, or conclusion drawn therefrom by the Contractor.

]2.4.6 Nonshrink Grout

****
NOTE: Grade of nonshrink grout must be specified based on the application, exposure conditions, and manufacturer's recommendation.
****

Use nonshrink grout for use in setting base plates and machinery conforming to ASTM C1107/C1107M, Grade [_____], and is a commercial formulation suitable for the application proposed. Submit descriptive literature of the grout proposed for use containing certified laboratory test results showing that it meets ASTM C1107/C1107M 60 days prior to its use together with a certificate from the manufacturer stating that the grout is suitable for the application or exposure for which it is being considered. In addition, a detailed plan for review, showing equipment and procedures for use in mixing and placing the grout.

2.4.7 Packaged Dry Repair Materials

Provide packaged dry rapid-hardening cementitious materials for concrete repairs that is a commercial formulation conforming to ASTM C928/C928M requiring only the addition of water. Limit shrinkage to 0.05 percent when tested in accordance with ASTM C157/C157M.

2.4.8 Bonding Agents

Submit descriptive literature and certification in advance of their use. Bonding agents must meet the following requirements:

2.4.8.1 Latex Bonding Agent

Provide latex agents for bonding fresh to hardened concrete conforming to ASTM C1059/C1059M, Type II.

2.4.8.2 Epoxy Resin

Provide epoxy resins for use in repairs conforming to ASTM C881/C881M, Type V, Grade I or II.

2.4.9 Epoxy Material for Crack Repair

Provide epoxy material for use in crack repairs conforming to ASTM C881/C881M Type IV, Grade 1 and class suitable for ambient conditions at the time of repair. The material must also be moisture tolerant.

2.4.10 Surface Retarder

Provide surface retarder conforming to COE CRD-C 94.

2.5 PLANT AND EQUIPMENT

****
NOTE: See the concrete materials design memorandum or EM 1110-2-2000 for the plant size requirements.
****

The ready-mix batch plant will be in accordance with NRMCA CPMB 100 and be NRMCA certified, and as specified. Provide batching, mixing, conveying, and placing systems with a capacity of at least [_____] cubic meters yards per hour. Submit the methods and description of the equipment proposed for transporting, handling, and depositing the concrete for review, 60 days before concrete placement begins. Include site drawings or sketches with locations of equipment and placement site.

2.5.1 Batch Plant

****
NOTE: See EM 1110-2-2000, and the concrete materials design memorandum for selection of automatic or semiautomatic plant.
****

Submit details and data on the concrete plant, within 60 days prior to assembly, to the Contracting Officer for conformance review with the requirements of paragraph PLANT AND EQUIPMENT. Batch plant must meet the following requirements:

2.5.2 Location

The concrete plant[must][may] be located at the site of the work in the general area indicated on the drawings[, or may be located offsite].

2.5.3 Bins and Silos

Provide separate bins, compartments, or silos for each size or classification of aggregate and for each of the cementitious materials. Provide compartments of ample size and constructed so that the various materials will be maintained separately under all working conditions.

Separate all compartments containing bulk cement, coal ash or natural pozzolan, slag cement, or silica fume from each other by a free-draining air space. Clearly mark all filling ports with a permanent sign stating the contents.

2.5.4 Batching Equipment

2.5.4.1 Batchers

Weigh aggregate in separate weigh batchers with individual scales. Weigh each bulk cement and/or other cementitious materials on a separate scale in a separate weigh batcher. Measure water by weight or by volume. If measured by weight, do not weigh cumulatively with another ingredient. Measure ice separately by weight. Batch admixtures separately and batch by weight or by volume in accordance with the manufacturer's recommendations.

2.5.4.2 Water Batcher

Provide a suitable water-measuring and batching device that will be capable of measuring and batching the mixing water within the specified tolerances for each batch. Use mechanism for delivering water to the mixers that is free from leakage when the valves are closed. Interlock the filling and discharge valves for the water batcher so that the discharge valve cannot be opened before the filling valve is fully closed. When a water meter is used, provide a suitable strainer ahead of the metering device.

2.5.4.3 Admixture Dispensers

Provide a separate batcher or dispenser for each admixture. Equip each plant with the necessary calibration devices that will permit convenient checking of the accuracy of the dispensed volume of the particular admixture. Use batching or dispensing devices capable of repetitively controlling the batching of the admixtures to the accuracy specified. Use piping for liquid admixtures that are free from leaks and properly valved to prevent backflow or siphoning. Include a device or devices that will detect and indicate the presence or absence of the admixture or provide a means of visually observing the admixture in the process of being batched or discharged in the dispensing system. Ensure each system is capable of ready adjustment to permit varying the quantity of admixture to be batched. Interlock each dispenser with the batching and discharge operations so that each admixture is added separately to the batch in solution in a separate portion of the mixing water or in fine aggregate in a manner to ensure uniform distribution of the admixtures throughout the batch during the required mixing period. Store and handle admixtures in accordance with the manufacturers recommendations.

2.5.4.4 Moisture Control

Provide plant which is capable of ready adjustment to compensate for the varying moisture content of the aggregates and to change the weights of the materials being batched. Provide a moisture meter complying with the provisions of COE CRD-C 143 for measurement of moisture in the fine aggregate. Arrange the sensing element so that the measurement is made near the batcher charging gate of the fine aggregate bin or in the fine aggregate batcher.

2.5.4.5 Scales

Provide facilities for the accurate measurement and control of each of the materials entering each batch of concrete. Use weighing equipment and controls conforming to the applicable requirements of NIST HB 44, except that the accuracy must be within 0.2 percent of the scale capacity. Provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring device. Make tests at the frequency required in paragraph TESTS AND INSPECTIONS in PART 3, and in the presence of a Government quality assurance representative. Include a visible indicator for each weighing unit that indicates the scale load at all stages of the weighing operation and shows the scale in balance at zero load. Arrange weighing equipment so that the concrete plant operator can observe the indicators.

2.5.4.6 Operation and Accuracy

[Start weighing operation of each material automatically when actuated by a single starter switch and end automatically when the designated amount of each material has been reached. These requirements can be met by providing an automatic batching system as defined in NRMCA CPMB 100.] [Start weighing operation of each material automatically when actuated by one or more starter switches and end when the designated amount of each material has been reached. These requirements can be met by providing a semiautomatic or automatic batching system as defined by NRMCA CPMB 100.] Provide equipment to permit the selection of [_____] preset mixes each by the movement of not more than two switches or other control devices. Cumulative weighing will not be permitted. Construct and arrange weigh batchers so that the sequence and timing of batcher discharge gates can be controlled to produce a ribboning and mixing of the aggregates, water, admixtures, and cementitious materials as the materials pass through the charging hopper into the mixer. To include provisions to facilitate the inspection of all operations at all times. Deliver materials from the batching equipment within the following limits of accuracy:

MATERIAL	PERCENT
Cementitious materials	± 1
Water	± 1
Aggregate smaller than 37.5 mm 1.5 inch size	± 2
Aggregate larger than 37.5 mm 1.5 inch size	± 3
Chemical admixtures	± 3

2.5.4.7 Interlocks

Interlock batchers and mixers so that:

a. The charging device of each batcher cannot be actuated until all scales have returned to zero balance within ± 0.2 percent of the scale capacity and each volumetric device has reset to start or has signaled empty.

b. The charging device of each batcher cannot be actuated if the

discharge device is open.

c. The discharge device of each batcher cannot be actuated if the charging device is open.

d. The discharge device of each batcher cannot be actuated until the indicated material is within the allowable tolerances.

e. One admixture is batched automatically with the water.

f. Each additional admixture is batched automatically with a separate portion of the water or with the fine aggregate.

g. The mixers cannot be discharged until the required mixing time has elapsed.

2.5.4.8 Recorder

Provide an accurate recorder or recorders conforming to the following detailed requirements:

a. Produce a graphical or digital record on a single visible chart or tape of the weight or volume of each material in the batchers at the conclusion of the batching cycle. Produce record prior to delivery of the materials to the mixer. After the batchers have been discharged, show the return to empty condition.

b. House graphical recording or digital printout unit completely in a single cabinet that is capable of being locked.

c. Mark the chart or tape so that each batch may be permanently identified and so that variations in batch weights of each type of batch can be readily observed. Provide chart or tape which is easily interpreted in increments not exceeding 0.5 percent of each batch weight.

d. Show time of day at intervals of no more than 15 minutes.

e. The recorder chart or tape will become the property of the Government.

f. Place recorder in a position convenient for observation by the concrete plant operator and the Government inspector.

g. The recorded weights or volumes when compared to the weights or volumes actually batched must be accurate within ± 2 percent.

2.5.4.9 Batch Counters

Include devices for automatically counting the total number of batches of all concrete batched and the number of batches of each preset mixture.

2.5.4.10 Rescreening Plant

Locate, arrange, and operate rescreening plant in a manner that all coarse aggregate will be routed through the plant and that its operation will ensure delivery to the mixers of graded coarse aggregate free from excessive variation and conforming to the size groups and grading of paragraph AGGREGATES above and with moisture content conforming to the provisions of paragraph MOISTURE CONTENT above. Coarse aggregate may be

rescreened and delivered to the batch plant bins one size group at a time or two or more adjacent size groups at a time. Simultaneous rescreening of nonadjacent size groups is not permitted. Waste all material passing the bottom screen of the smallest size of coarse aggregate being screened. Contractor must perform periodic inspections on rescreening plant at least once per month. Remedial actions must be taken whenever gradations are out of control.

2.5.4.11 Washing Plant

Wash all coarse aggregates immediately prior to entering the rescreening plant. Provide rewashing plant containing water nozzles and vibrating screens to remove foreign materials and coatings from aggregate particles. Use water for washing meeting the requirements of paragraph WATER above. Water may not be reused as batch water, but may be reused for washing provided no chemicals are used.

2.5.4.12 Dust Collection

Dust produced from handling and batching materials must be collected by a dust collection system or bag house. The dust collection system must conform to NRMCA CPMB 100, as well as Section 01 57 19 ENVIRONMENTAL PROTECTION. Material collected must be disposed of in accordance with Section 01 57 19 ENVIRONMENTAL PROTECTION. Routing of material or otherwise disposing of the material in the concrete is not permitted. The collection system must be adequately sized for the production capacity of the batch plant. Filter media efficiency must capture a minimum of 99 percent of the fugitive emissions passing through the media for particles greater than 10 microns. The system must be designed to capture fugitive cementitious air emissions from emission points to include, but not limited to: silos, weigh batchers, holding hoppers, central mixers, and plant discharge.

2.5.4.13 Trial Operation

For on-site batch plants, not less than 28 [90] days prior to commencement of concrete placing, make a test of the batching and mixing plant in the presence of the Contracting Officer to check operational adequacy. Produce [the number of full-scale concrete batches required in trial runs as directed, do not exceed 20] [at least 4 batches per mix], and proportion [as directed for government mix proportioning] [as proposed in approved contractor's mix design submittal]. Waste or use all concrete produced in these tests for purposes other than inclusion in structures covered by this specification. Correct all deficiencies found in plant operation prior to the start of concrete placing operations. No separate payment will be made to the Contractor for labor or materials required by provisions of this paragraph. Notify the Contracting Officer of the trial operation not less than 7 days prior to the start of the trial operation.

2.5.4.14 Protection

Protect weighing, indicating, recording, and control equipment against exposure to dust, moisture, and vibration so that there is no interference with proper operation of the equipment.

2.5.5 Laboratory Areas

****

NOTE: The editor should use the alternate sentence

and fill in the correct Section number unless a laboratory building is to be government furnished.

****

Provide a room for contractor on-site testing to house the moisture and grading testing equipment for aggregate and to provide working space. Provide another room for testing fresh concrete and for fabricating and initial curing of concrete test specimens in accordance with ASTM C31/C31M. The size, arrangement, and location of these rooms will be subject to approval by contracting officer.

Provide electricity, air conditioning, heat, and water as required for use in these laboratory areas.[A third room must be provided for long term curing of test cylinders. The curing room must be of sufficient capacity to store the anticipated number of test cylinders produced throughout the duration of the project. The curing room must be designed to provide adequate insulation to maintain required curing temperatures and conditions, as specified in ASTM C192/C192M. If curing tanks are used, adequate means of circulation must be provided to maintain the uniform (required) temperature throughout each tank.]

[2.5.6 Plant Layout Drawings

****

NOTE: The paragraph should be included in projects for which onsite plant is a requirement. The wording should be modified as necessary to suit the particular requirements of each project. Drawings submitted in compliance with this paragraph will enable the Contracting Officer to determine in advance of erection whether or not the plant meets the requirements of these specifications.

****

Submit drawings, in triplicate, showing the layout of the plant the Contractor proposes to use on the work for review. Show the locations of the principal components of the construction plant; offices; shop and storage building; housing facilities, if any; and storage areas and yards which the Contractor proposes to construct at the site of the work and elsewhere. Also furnish for review drawings, in triplicate, showing the general features of his aggregate processing plant; aggregate transporting; storage and reclaiming facilities; aggregate rinsing and dewatering plant, if required; coarse aggregate rescreening plant, if required; concrete batching and mixing plant; concrete conveying and placing plant; and when precooling of concrete is required, the cooling plant. Appropriately show the capacity of each major feature of the plant including the rated capacity of the aggregate production plant in tons (metric) (2000 lb) per hour of fine and coarse aggregates; rated capacity of the aggregate transporting, storage and reclaiming facilities; volume of aggregate storage; capacity of cement and supplementary cementitious materials storage; rated capacity of the concrete batching and mixing plant in cubic meters yards per hour; rated capacity of the concrete transporting and placing plant in cubic meters yards per hour; and when used rated capacity of plant for precooling of concrete. Submit drawings in triplicate showing any changes in plant made during design and erection or after the plant is in operation for review. Two sets of the drawings will be retained and one set will be returned to the Contractor with comments.

]2.5.7 Mixers

****

NOTE: See the concrete materials design memorandum for information on mixer selection and concrete mixers. Truck mixers are not allowed for mixing or transporting concrete with less than 50 mm 2 inch slump or greater than 37 mm 1.5 inch nominal maximum size aggregate (NMSA).

****

Provide stationary mixers [or truck mixers]. Each mixer must combine the materials into a uniform mixture and discharge this mixture without segregation. Do not charge mixers in excess of the capacity recommended by the manufacturer on the nameplate. Excessive over-mixing requiring introduction of additional water will not be permitted. Maintain mixers in satisfactory operating condition, and keep mixer drums free of hardened concrete. Replace mixer blades or paddles when worn down more than 10 percent of their depth when compared with the manufacturer's dimension for new blades. Should any mixer at any time produce unsatisfactory results, discontinue its use promptly until it is repaired or replaced. Submit the make, type, capacity, and number of the concrete mixers proposed for use, 60 days prior to installation for review by the Contracting Officer for conformance with the requirements of paragraph PLANT AND EQUIPMENT.

2.5.7.1 Stationary Mixer Uniformity Requirements

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NOTE: The option for the government to perform the initial mixer evaluation may be invoked.

****

Adjust the size of the batch, the mixing time, the charging sequence, and other factors to provide concrete that meets the uniformity limits specified herein and in paragraph MIXER UNIFORMITY IN PART 3. Perform all testing in accordance with COE CRD-C 55. When regular testing is performed, the concrete must meet the limits of any five of the six uniformity requirements. When abbreviated testing is performed, the concrete must meet only those requirements listed for abbreviated testing. The initial mixer evaluation test is a regular test and perform prior to the start of concrete placement. Use concrete proportions for the evaluation that contains the largest size aggregate on the project and as directed. Regular testing consists of performing all six tests on three batches of concrete. The range for regular testing is the average of the ranges of the three batches. Abbreviated testing consists of performing the three required tests on a single batch of concrete. The range for abbreviated testing is the range for one batch. If more than one mixer is used and all are identical in terms of make, type, capacity, condition, speed of rotation, etc., the results of tests on one of the mixers applies to the others, subject to approval. Perform mixer evaluations as specified herein.[However, the initial evaluation will be performed by the Government. Provide labor and equipment as directed to assist the Government in performing any evaluation made by the Government.]

	ABBREVIATED	
PARAMETER	REGULAR TESTS ALLOWABLE MAXIMUM RANGE FOR AVERAGE OF 3 BATCHES	TESTS ALLOWABLE MAXIMUM RANGE FOR 1 BATCH
Unit weight of air-free mortar, kilograms per m^3 lb/cu ft	322.0	322.0
Air content, percent	1.0	---
Slump, mm inches	251.0	---
Coarse aggregate, percent	6.0	6.0
Compressive strength at 7 days, percent	10.0	10.0
Water content, percent	1.5	---

[2.5.7.2 Truck Mixers

Provide truck mixers and the mixing of concrete therein conforming to the requirements of ASTM C94/C94M. A truck mixer may be used for complete mixing (transit-mixed) or to finish the partial mixing done in a stationary mixer (shrink-mixed). Equip each truck with two counters from which it is possible to determine the number of revolutions at mixing speed and the number of revolutions at agitating speed. Do not use truck mixers to mix or agitate concrete with greater than 37.5 mm 1.5 inch nominal maximum-size aggregate or concrete with a slump of 50 mm 2 inches or less. Determine the acceptability of truck mixers by uniformity tests in accordance with ASTM C94/C94M.

]2.5.8 Sampling Facilities

Provide suitable facilities and labor for obtaining representative samples of concrete in accordance with ASTM C172/C172M for Contractor quality control (QC) and Government quality control (QA) testing.

2.5.9 Coarse Aggregate

****

NOTE: The automatic sampling plant should be required for aggregates in concrete containing larger than 75 mm 3 inch NMSA. For aggregates in concrete containing 75 mm 3 inch NMSA, a cost analysis should be made before specifying the automatic sampling plant. The automatic sampling plant should not be specified for aggregates in concrete containing 75 or 150 mm 3 or 6 inch NMSA. Note that the quarry sloping screens on the automatic plant will require slightly larger screens than those used for tests by ASTM C136/C136M for comparable results.

****

Provide suitable facilities for readily obtaining representative samples of coarse aggregate for test purposes immediately prior to the material entering the mixer.[Include automatic equipment capable of obtaining, sieving, and weighing samples of the coarse aggregate as follows:

AGGREGATE SIZE (mm) (inch)	APPROXIMATE SIZE OF SAMPLE (kg) (lb)
4.75 to 19.0No. 4 to 3/4	250500
19.0 to 37.53/4 to 1.5	250500
37.5 to 751.5 to 3	5001000
75 to 1503 to 6	10002000

Provide equipment that is capable of running a complete sieving, of any required sample, without the necessity of intermittent loading. Design the assembly to permit selection, screening, and weighing of any individual sample in 10 minutes or less. Provide equipment designed by a company engaged in the design and manufacture of aggregate sieving devices. Provide equipment that will accomplish the desired purpose. Use sieves that meet the applicable requirements of ASTM E11, except for the frame size requirements. Arrange equipment so that all controls will be enclosed and operable from a single position commanding a view of the screen device and the scale or scales. Provide communication from the batch plant operation to this control area. The Contractor is responsible for charging of the assembly as directed, disposal of waste material, and proper service and maintenance of the assembly. Provide each sieve with individual controls for frequency and angle. Run correlation tests with equipment as used for ASTM C136/C136M before concrete placement begins and at least every 60 days while concrete is being placed. The correlation test will determine the optimum angle, volume of feed, and the frequency for each sieve.]

2.5.10 Transporting Equipment

Design, operate, and maintain transporting equipment so that it does not cause or permit segregation or loss of material. Do not drop concrete vertically more than 1.5 m 5 feet except where suitable equipment is provided to prevent segregation and where specifically authorized.

2.5.10.1 Buckets

Use bottom-dump buckets conforming to the following requirements: the interior hopper slope must be no less than 70 degrees from the horizontal; the minimum dimension of the clear gate opening must be at least five times the nominal maximum size of the aggregate, and the area of the gate opening must not be less than 0.2 square meters 2 square feet; the bucket gates must be grout-tight when closed, the double clamshell type, and manually, pneumatically, or hydraulically operated; and design the gate-opening mechanism to close the gates automatically when the control is released or when the air or hydraulic line is broken. If gate actuation is dependent on integral air or hydraulic reservoirs, the capacity of the reservoirs must be sufficient to open and close the gates three times without recharging the reservoir.

2.5.10.2 Trucks

Use truck mixers or agitators for transporting central-mixed concrete conforming to the applicable requirements of ASTM C94/C94M. Do not use

truck mixers to transport concrete with larger than 37.5 mm 1.5 inch nominal maximum-size aggregate or 50 mm 2 inch or lower slump. Nonagitating trucks may be used for transporting central-mixed concrete over a smooth road when the hauling time is less than 15 minutes and the slump is less than 75 mm 3 inches. Bodies of nonagitating trucks must be smooth, watertight, metal containers specifically designed to transport concrete, shaped with rounded corners to minimize segregation, and equipped with gates that will permit positive control of the discharge of the concrete.

2.5.10.3 Chutes

When concrete can be placed directly from a truck mixer, agitator, or nonagitating truck, the chutes supplied by the truck manufacturer as standard equipment may be used. Use a discharge deflector when required by the Contracting Officer. Separate chutes and other similar equipment are not permitted for conveying concrete except when specifically approved and do not increase slump to accommodate their use.

2.5.10.4 Belt Conveyors

Design and operate belt conveyors to assure a uniform flow of concrete from mixer or delivery truck to final place of deposit without segregation of ingredients or loss of mortar and provide with positive means for preventing segregation of the concrete or loss of mortar at the transfer point(s) and the point of placing. Do not exceed idler spacing of 900 mm 36 inches. Use a minimum belt speed of 90 m 300 feet per minute and a maximum of 230 m 750 feet per minute. Belt width must be a minimum of 600 mm 24 inches if the NMSA is 150 mm 6 inches and must be a minimum of 400 mm 16 inches if the NMSA is 75 mm 3 inches or less. The NMSA required in mixture proportions furnished by the Government will not be changed to accommodate the belt width.

2.5.10.5 Pump Placement

Concrete may be conveyed by positive-displacement pump when approved. Pump placement will be approved only for areas where placement by bucket or conveyor is difficult or impractical. Provide piston or squeeze-pressure type pumping equipment. Provide rigid-steel pipe or heavy-duty flexible hose pipeline. Do not use aluminum pipe. Use pipe with an inside diameter at least 3 times the nominal maximum size of the coarse aggregate in the concrete to be pumped but no less than 100 mm 4 inches.

2.5.10.6 Tremie Placement

A funnel-shaped hopper of sufficient volume, but no less than 2 cubic yards, must be required at the top of all tremie pipes. The hopper must be of a size capable of receiving and passing the concrete into the pipe at the capacity rate of the batching, mixing, and conveying equipment. The tremie pipe must be sufficiently large enough to permit the free flow of concrete and must be a minimum internal diameter of 10 inches. Tremie pipe must be made of steel and have watertight joints. Hoisting equipment for lifting and lowering pipes and tools for connecting the pipe sections must be continuously available and on hand. Each section of tremie pipe must have threaded connections or must have gasketed fittings. For pipe connections that are coupled and not threaded, the coupling alone will not be considered watertight. Additional seals must be provided around the coupling to assure a watertight connection. The end of the tremie pipe

must be equipped with a plate and gasket or other suitable watertight cap at the start of an element placement[, or a commercially fabricated pipe pig or plug must be used. The pipe pig/plug must be specifically manufactured to be capable of maintaining a full seal with the walls of the tremie pipe to the depth of the concrete placement. The plug must be rated by the manufacturer so that it does not compress and lose the seal before the pig/plug reaches the end of the pipe.] The watertight cap must be secured to the bottom of the tremie pipe [or the pig/plug must be positioned in the entrance of the pipe before concrete is placed in the tremie pipe], and the pipe must be lowered and put in contact with the bottom of the placement. The pipe and hopper must be fully charged, then the pipe must be raised 6 to 12 inches to initiate the flow of concrete. Additional concrete must be ready at the point of placement to allow a continuous flow of concrete down the pipe.

2.5.11 Expansion/Contraction Joint Filler

[ASTM D1752] [Type I] [_____]. Provide material 1/2 inch thick[, unless otherwise indicated].

2.5.12 Joint Sealants

Submit manufacturer's product data, indicating VOC content.

2.5.12.1 Horizontal Surfaces, 3 Percent Slope, Maximum

Horizontal Surfaces, 3 Percent Slope, Maximum [ASTM D6690 or] ASTM C920, Class 100/50, Use T [and I]. Grade P or NS.

2.5.12.2 Vertical Surfaces Greater Than 3 Percent Slope

Vertical Surfaces Greater Than 3 Percent Slope ASTM C920, Grade NS, Class 100/50, Use T[NT][I].

2.5.12.3 Preformed Polychloroprene Elastomeric

Compression Type ASTM D2628.

2.5.12.4 Lubricant for Preformed Compression

Seals ASTM D2835.

2.5.12.5 Backer Rod

Backer Rod conform to ASTM D5249 Type 1 or 3.

2.5.13 Vapor Retarder[and Vapor Barrier]

****

NOTE: Edit title to correct choice. Use first paragraph where vapor retarder is required to minimize vapor transmission through the concrete and a permanent vapor barrier is not required. Select second bracketed option where permanent vapor barrier is required. Vapor barriers should only be used where required due to the required moisture content of the slab for floor covering adhesion and as required for quality concrete, see ACI 360R, figure 4.7 for guidance when a vapor retarder is

needed. For protection against hydrostatic pressure or conditions of excessive dampness, specify an appropriate waterproofing membrane in Division 7
****

ASTM E1745 Class A[B][C] polyethylene sheeting, minimum 0.25 mm 10 mil[0.38 mm 15 mil] thickness or other equivalent material with a maximum permeance rating of 0.04 perms per ASTM E96/E96M.

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

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

2.6 REINFORCEMENT

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

a. Bend reinforcement cold. Reinforcement must be bent cold in the shop to shapes as indicated. Rebending of a reinforcing bar that has been bent incorrectly is not permitted. Bending must be in accordance with the standard approved practice and by approved machine methods. Provide hooks and bends that are in accordance with the Contract Documents. Fabricate reinforcement in accordance with fabricating tolerances of ACI 117.

b. Submit manufacturer's certified test report for reinforcement.

c. Submit placing drawings showing fabrication dimensions and placement locations of reinforcement and reinforcement supports. Indicate locations of splices, lengths of lap splices, and details of mechanical and welded splices.

d. Submit request with locations and details of splices not indicated in Contract Documents.

e. Submit request to place column dowels without using templates.

****
NOTE: Specify if and where (locations) field bending or straightening of reinforcing bars is permitted.
****

f. [Submit request and procedure to field-bend or straighten reinforcing bars partially embedded in concrete at locations not indicated in Contract Documents. Field bending or straightening of reinforcing bars is permitted[where indicated in the Contract Documents][in the following locations: [_____]]]

g. [Submit request for field cutting, including location and type of bar to be cut and reason field cutting is required.] Deliver reinforcing bars bundled, tagged, and marked. Tags must be metal with bar size, length, mark, and other information pressed in by machine. Marks must correspond with those used on the placing drawings.

2.6.1 Reinforcing Bars

****

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

Use second recycled content option throughout this section if Contractor is choosing recycled content products in accordance with Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING.

****

a. Deformed, except spirals, load-transfer dowels, and welded wire reinforcement, which may be plain.

b. ASTM A615/A615M with the bars marked S, Grade [420][550][690] [60][80][100]; or ASTM A996/A996M with the bars marked R, Grade [350][420] [50][60], or marked A, Grade [300][420] [40][60]. [Cold drawn wire used for spiral reinforcement must conform to ASTM A1064/A1064M.][Provide reinforcing bars that contain a minimum of [100] [_____] percent recycled content.][See Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING for cumulative total recycled content requirements.]

c. [Reinforcing bars may contain post-consumer or post-industrial recycled content.][Submit documentation indicating percentage of post-industrial and post-consumer recycled content per unit of product. Indicate relative dollar value of recycled content products to total dollar value of products included in project.]

d. Submit mill certificates for reinforcing bars.

2.6.1.1 Galvanized Reinforcing Bars

****

NOTE: Class 1 has a zinc coating that is thicker than Class 2. For Class 1 bars, fabrication can be performed before or after coating. If fabrication is performed after coating then damage caused by fabrication should be repaired according to ASTM A767/767M. If needed, add any requirements for bars that require special finished bend diameters and indicate their locations. ASTM A1094 provides 2 mils of coating and can be fabricated after coating. Any damage should be repaired according to ASTM A1094/A1094M. The systems are not equals and the designer should choose based on the requirements of the project.

****

a. Provide zinc-coated (galvanized) reinforcing bars that conform to[ASTM A767/A767M,[Class 1][Class 2][with galvanizing[before][after] fabrication] as required by the contract Documents][or][ASTM A1094/A1094M].

b. Repair coating damage incurred during shipment, handling, and placing of zinc-coated (galvanized) reinforcing bars in accordance with ASTM A780/A780M. If damaged areas on bars exceed 2 percent of surface

area in each linear foot, bar must not be used. The 2 percent limit on maximum allowed damaged coating area includes previously repaired areas damaged before shipment as required by ASTM A767/A767M.

2.6.1.2 Epoxy-Coated Reinforcing Bars

a. Provide epoxy-coated reinforcing bars that conform to [ASTM A775/A775M] [ASTM A934/A934M], Grade[60][80][100].

b. Apply coatings in plants that are certified in accordance with Concrete Reinforcing Steel Institute (CRSI) Epoxy Coating Plant Certification Program or an equivalent program acceptable to the contracting officer.

c. Repair coating damage incurred during shipment, storage, handling, and placing of epoxy-coated reinforcing bars. Repair damaged coating areas with patching material conforming to ASTM A775/A775M or ASTM A934/A934M as applicable and in accordance with material manufacturer's written recommendations. If damaged coating area on bars exceed 2 percent of surface area in each linear foot, bar must not be used. The 2 percent limit on damaged coating area includes repaired areas damaged before shipment as required by ASTM A775/A775M or ASTM A934/A934M as applicable. Fading of coating color is not a cause for rejection of epoxy-coated reinforcing bars.

d. [Submit concrete Reinforcing Steel Institute (CRSI) Epoxy Coating Plant Certification] [inspection and quality-control program of plant applying epoxy coating if proposed plant is not certified in accordance with CRSI Epoxy Coating Plant Certification Program].

e. Handle and store coated reinforcing bars in accordance with [ASTM A775/A775M][or][ASTM A934/A934M]. If the manufacturer stores bars outdoors for more than 2 months, cover coated reinforcement with opaque protective material.

2.6.1.3 Dual-coated Reinforcing Bars

a. Zinc and epoxy dual-coated reinforcing bars must conform to ASTM A1055/A1055M

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

2.6.1.4 Dual-coated Reinforcing Bars

Bars Meet the requirements of ASTM A955/A955M.

2.6.1.5 Headed Reinforcing Bars

Conform to ASTM A970/A970M including Annex A1, and other specified requirements.

2.6.1.6 Bar Mats

a. Conform to ASTM A184/A184M.

b. If coated bar mats are required, repair damaged coating as required in the paragraph titled Galvanized Reinforcing Bars, Epoxy-Coated Reinforcing Bars And Dual-Coated Reinforcing Bars.

2.6.1.7 Headed Shear Stud Reinforcement

Headed studs and headed stud assemblies must conform to ASTM A1044/A1044M.

2.6.2 Mechanical Reinforcing Bar Connectors

a. Provide 125 percent minimum yield strength of the reinforcement bar.

b. Mechanical splices for galvanized reinforcing bars must be galvanized or coated with dielectric material.

c. Mechanical splices used with epoxy-coated or dual-coated reinforcing bars must be coated with dielectric material.

d. Submit data on mechanical splices demonstrating compliance with this paragraph.

2.6.3 Wire

****

NOTE: Include in your Contract Documents the wire size, yield strength or grade, and any additional requirements not specified here for wires. For more information on wire reinforcement refer to WRI (Wire Reinforcement Institute) documents.

****

a. [Provide wire reinforcement that contains a minimum of [100][_____] percent recycled content.][See Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING for cumulative total recycled content requirements. Wire reinforcement may contain post-consumer or post-industrial recycled content.] Provide flat sheets of welded wire reinforcement for slabs and toppings.

b. Plain or deformed steel wire must conform to ASTM A1064/A1064M.

c. Stainless steel wire must conform to ASTM A1022/A1022M.

d. Epoxy-coated wire must conform to ASTM A884/A884M. Repair coating damage incurred during shipment, storage, handling, and placing of epoxy-coated wires must be repaired. Repair damaged coating areas with patching material in accordance with material manufacturer's written recommendations. If damaged area exceeds 2 percent of surface area in each linear foot of each wire, wire must not be used. The 2 percent limit on damaged coating area includes repaired areas damaged before shipment as required by ASTM A884/A884M. Fading of coating color is not a cause for rejection of epoxy-coated wire reinforcement.

2.6.4 Welded Wire Reinforcement

****
NOTE: Include in your Contract Documents the welded wire yield strength or grade, size and spacing, and any additional requirements not specified here for wires.
****

a. Use welded wire reinforcement specified in Contract Documents and conforming to one or more of the specifications given herein.

b. Plain welded wire reinforcement must conform to ASTM A1064/A1064M, with welded intersections spaced no greater than 12 inches apart in direction of principal reinforcement.

c. Deformed welded wire reinforcement must conform to ASTM A1064/A1064M, with welded intersections spaced no greater than 16 inches apart in direction of principal reinforcement.

d. Epoxy-coated welded wire reinforcement must conform to ASTM A884/A884M. Repair coating damage incurred during shipment, storage, handling, and placing of epoxy-coated welded wire reinforcement in accordance with ASTM A884/A884M. Repair damaged coating areas with patching material in accordance with material manufacturer's written recommendations. If damaged area exceeds 2 percent of surface area in each linear foot of each wire or welded wire reinforcement, the sheet containing the damaged area must not be used. The 2 percent limit on damaged coating area includes repaired areas damaged before shipment as required by ASTM A884/A884M. Fading of coating color is not a cause for rejection of epoxy-coated welded wire reinforcement.

e. Stainless steel welded wire reinforcement must conform to ASTM A1022/A1022M.

f. Zinc-coated (galvanized) welded wire reinforcement must conform to ASTM A1060/A1060M. Repair coating damage incurred during shipment, storage, handling, and placing of zinc-coated (galvanized) welded wire reinforcement in accordance with ASTM A780/A780M. If damaged area exceeds 2 percent of surface area in each linear foot of each wire or welded wire reinforcement, the sheet containing the damaged area must not be used. The 2 percent limit on damaged coating area includes repaired areas damaged before shipment as required by ASTM A1060/A1060M.

2.6.5 Reinforcing Bar Supports

****
NOTE: Include in your Contract Documents the types of reinforcement supports and location used within the structure. Refer to Chapter 3 in CRSI MSP 2.
****

a. Provide reinforcement support types within structure as required by Contract Documents. Conform to CRSI RB4.1. Submit description of reinforcement supports and materials for fastening coated reinforcement if not in conformance with CRSI RB4.1.

b. [For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar support.][For zinc-coated

reinforcement, use galvanized wire or dielectric-polymer coated wire bar supports.]

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

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

d. [Minimum [5][10][_____] percent post-consumer recycled content, or minimum[20][40][_____] percent post-industrial recycled content.][See Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING for cumulative total recycled content requirements. Plastic and steel may contain post-consumer or post-industrial recycled content.]

2.6.6 Reinforcing Fibers

****
NOTE: Only use fiber reinforcement when approved by the designer. Drawings should indicate where fiber reinforced concrete is located. Fiber reinforcing is used to help: control cracking due to plastic shrinkage; reduce permeability; and increase impact capacity; shatter resistance, abrasion resistance, and toughness. Fiber reinforcing does not: control cracking due to structural stresses; significantly increase strength; control curling or creeping; justify reducing structural members; eliminate control joints; or replace any moment or structural steel reinforcement. Include flexural toughness tests when reinforcement fibers are used to increase toughness and when justified by size and importance of job, but not when fibers are used only to control plastic shrinkage cracking. Include technical representative when warranted by size and importance of job. For more information on fibers and their use in concrete, refer to ACI 544 documents.
****

2.6.6.1 Synthetic Fibers

In addition to the requirements specified above, provide fiber reinforced concrete in accordance with ASTM C1116/C1116M Type III, synthetic fiber reinforced concrete, and as follows. Provide synthetic reinforcing fibers of[100 percent virgin] monofilament polypropylene fibers[, with a minimum of[5][10][_____] percent post-consumer recycled content, or a minimum of[20][40][_____] percent post-industrial recycled content].[See Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING for cumulative total recycled content requirements. Fibers may contain post-consumer or post-industrial recycled content.]

Provide fibers that have a specific gravity of 0.9, a minimum tensile strength of 480 MPa 70 ksi, graded per manufacturer, and specifically manufactured to an optimum gradation for use as concrete secondary reinforcement. Add fibers at the batch plant.[Toughness indices must meet requirements for performance level I.][Provide the services of a qualified technical representative to instruct the concrete supplier in

proper batching and mixing of materials to be provided.]

2.6.6.2 Steel Fibers

If steel fiber-reinforced concrete is specified in Contract Documents for providing shear resistance, steel fibers must be deformed and conform to ASTM A820/A820M. Provide steel fibers with a length-to-diameter ratio of at least 50 and not exceed 100.

2.6.7 Dowels for Load Transfer in Floors

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

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

2.6.8 Welding

a. Provide weldable reinforcing bars that conform to ASTM A706/A706M and ASTM A615/A615M and Supplement S1, Grade 420 60, except that the maximum carbon content must be 0.55 percent.

b. Comply with AWS D1.4/D1.4M unless otherwise specified. Do not tack weld reinforcing bars.

c. Welded assemblies of steel reinforcement produced under factory conditions, such as welded wire reinforcement, bar mats, and deformed bar anchors, are allowed.

d. After completing welds on zinc-coated (galvanized), epoxy-coated, or zinc and epoxy dual-coated reinforcement, coat welds and repair coating damage as previously specified.

PART 3 EXECUTION

3.1 PREPARATION FOR PLACING

3.1.1 Vibrators

Keep an adequate number of vibrators on hand to meet placing requirements, and spare vibrators available to maintain production in the event of breakdown. Make adequate air pressure available for air vibrators and adequate voltage for electric vibrators. Use vibrators of the proper size, frequency, and amplitude for the type of work being performed in conformance with the following requirements:

APPLICATION	HEAD DIAMETER (mm) (inch)	FREQUENCY VPM	AMPLITUDE (mm) (inch)
Thin walls, beams, etc.	32 - 641-1/4 - 2.5	9,000 - 13,500	0.5 - 1.00.020 - 0.04
General construction	50 - 882 - 3.5	8,000 - 12,000	0.6 - 1.20.025 - 0.05
Heavy sections	75 - 1503 - 6	7,000 - 10,500	0.75 - 1.50.030 - 0.06
Mass concrete	125 - 1755 - 7	5,500 - 8,500	1.0 - 2.00.04 - 0.08

Use frequency and amplitude within the range indicated in the tabulation as determined in accordance with paragraph TESTS AND INSPECTIONS below.

3.1.2 Embedded Items

Before placing concrete, take care to determine that all embedded items are securely fastened in place as indicated in the drawings or required. Provide embedded items that are free of oil and other foreign matter such as loose coatings of rust, paint, and scale. The embedding of wood in concrete will be permitted only when specifically authorized or directed. Provide any air or water lines or other materials embedded in structures, as authorized construction expedients, conforming to the above requirements and upon completion of their use backfill with concrete or mortar as directed. Welding will not be permitted on embedded or otherwise exposed metals which are in contact with concrete surfaces. Tack welding of or to embedded items will not be permitted.

3.1.3 Concrete on Earth Foundations

Place concrete on earth foundations that are clean, damp, and free from frost, ice, and standing or running water. Prior to placement of concrete, compact the earth foundation satisfactorily in accordance with the provisions of Section 31 00 00 EARTHWORK.

3.1.4 Concrete on Rock Foundations

Place concrete on rock surfaces that are clean and free from oil, standing or running water, ice, mud, drummy rock, coatings, debris, and loose, semidetached, overhanging, or unsound fragments. Clean faults or joints to a satisfactory depth and to firm rock on the sides as directed by the Contracting Officer. Immediately before concrete is placed, clean all rock surfaces thoroughly by the use of air-water jet, high-pressure water jet, or sandblasting as described in the paragraph below. Keep all rock surfaces continuously wet for at least 24 hours immediately prior to placing concrete thereon. Cover all approximately horizontal surfaces immediately before the concrete is placed with a 13 mm 1/2 inch layer of mortar composed of the same sand and cementitious materials used in the concrete. The sand-cementitious materials ratio and the water-cementitious material ratio of the mortar must be approximately the same as those used in the concrete mixture. Cover mortar with concrete before the mortar has reached its initial time of setting.

3.1.5 Construction Joint Treatment

Submit the method and equipment proposed for joint cleanup and waste disposal, for review 30 days before concrete placement begins.

3.1.5.1 Joint Preparation

Prepare concrete surfaces to which other concrete is to be bonded for receiving the next lift or adjacent concrete by cleaning by sandblasting, high-pressure water jet, or air-water cutting. Surface cutting by air-water jets will not be permitted for concrete surfaces congested with reinforcing steel or if they are relatively inaccessible. If, for any other reason, it is considered undesirable to disturb the surface of a lift before it has hardened, the use of sandblasting or high-pressure water jet after hardening will be required. Regardless of the method used, the resulting surface must be free from all laitance and inferior concrete so that clean, well-bonded coarse aggregate particles are exposed uniformly over the lift surface. Apply joint treatment method such that the edges of the larger particles of aggregate are not undercut. Where joint preparation occurs more than 2 days prior to placing the next lift or where the work in the area subsequent to the joint preparation causes dirt or debris to be deposited on the surface, clean the surface as the last operation prior to placing the next lift. Keep the surface of the construction joint continuously wet for the first 12 hours of the 24 hours prior to placing concrete, except that the surface must be damp with no free water at the time of placement.

3.1.5.2 Air-Water Cutting

Perform air-water cutting of a construction joint at the proper time, generally between 4 and 12 hours after placement and only on horizontal construction joints. This period may be modified if a retarder is used to prolong the setting of the cement at surface of the concrete. Use an air pressure of 620 to 760 kPa 90 to 110 psi in the jet, and use sufficient water pressure to bring the water into effective influence of the air pressure. When approved a surface retarder complying with the requirements of COE CRD-C 94 may be applied to the surface of the lift to prolong the period of time during which air-water cutting is effective. Prior to receiving approval, furnish samples of the material to be used and demonstrate the method to be used in its application. After cutting, wash and rinse the surface until the wash water is no longer cloudy. If air-water cutting does not produce acceptable results, prepare the surface by high-pressure water jet or sandblasting.

3.1.5.3 High-Pressure Water Jet

A stream of water under a pressure of not less than 21 MPa 3,000 psi may be used for cleaning. Delay its use until the concrete is sufficiently hard so that only the surface skin or mortar is removed and there is no undercutting of coarse-aggregate particles. If the high-pressure water jet is incapable of a satisfactory cleaning, clean the surface by sandblasting.

3.1.5.4 Wet Sandblasting

This method of joint preparation may be used when the concrete has reached sufficient strength to prevent undercutting of coarse aggregate particles. Continue the operation until all accumulated laitance, coatings, stains, debris, and foreign materials are removed. Then wash

the surface of the concrete thoroughly to remove all loose material. This method may be used on both horizontal and vertical surfaces.

3.1.5.5 Waste Water Disposal

****
NOTE: Specification Writer will fill in the section number for the Environment Protection Plan.
****

Use a method in disposing of waste water employed in cutting, washing, and rinsing of concrete surfaces such that the waste water does not stain, discolor, or affect exposed surfaces of the structures, or damage the environment of the project area. The method of disposal must meet all requirements of Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS.

3.1.5.6 Below Water Joint Preparation

Concrete surfaces below water, to which other concrete is to be bonded must be prepared for receiving the next lift or adjacent concrete by clearing. All marine growth, sediment, and debris must be remove/cleaned from the surface prior to placing the next lift. The method and equipment used to clean and prepare the surfaces must include but are not limited to high-pressure water jets, chippers, abrasive jetting, mechanical scrubbers, and self-propelled water jet vehicles. The surface cleaning and preparation must be conducted a minimum of two hours prior to placing the next lift.

3.2 FORMS

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

b. Chamfer above grade exposed joints, edges, and external corners of concrete 20 mm 0.75 inch or as shown on the drawings. Place chamfer strips in corners of formwork to produce beveled edges on permanently exposed surfaces.[Do not bevel reentrant corners or edges of formed joints of concrete.]

c. Provide formwork with clean-out openings to permit inspection and removal of debris.

d. Inspect formwork and remove foreign material before concrete is placed.

e. At construction joints, lap form-facing materials over the concrete of previous placement. Ensure formwork is placed against hardened concrete so offsets at construction joints conform to specified tolerances.

f. Provide positive means of adjustment (such as wedges or jacks) of shores and struts. Do not make adjustments in formwork after concrete has reached initial setting. Brace formwork to resist lateral deflection and lateral instability.

g. Fasten form wedges in place after final adjustment of forms and before concrete placement.

h. Provide anchoring and bracing to control upward and lateral movement of formwork system.

i. Construct formwork for openings to facilitate removal and to produce opening dimensions as specified and within tolerances.

j. Provide runways for moving equipment. Support runways directly on formwork or structural members. Do not support runways on reinforcement. Loading applied by runways must not exceed capacity of formwork or structural members.

k. Position and support expansion joint materials, waterstops, and other embedded items to prevent displacement. Fill voids in sleeves, inserts, and anchor slots temporarily with removable material to prevent concrete entry into voids.

l. Clean surfaces of formwork and embedded materials of mortar, grout, and foreign materials before concrete placement.

[3.2.1 Perimeter Insulation

****
NOTE: When this paragraph is used, ensure that drawings indicate location and extent of perimeter insulation.
****

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

]3.2.2 Coating

a. Cover formwork surfaces with an acceptable material that inhibits bond with concrete.

b. If formwork release agent is used, apply to formwork surfaces in accordance with manufacturer's recommendations before placing reinforcement. Remove excess release agent on formwork prior to concrete placement.

c. Do not allow formwork release agent to contact reinforcement or hardened concrete against which fresh concrete is to be placed.

3.2.3 Reshoring

****
NOTE: Reshores, as defined in ACI 347R, are shores placed snugly under a stripped concrete slab or other structural member after the original forms and shores have been removed from a full bay, requiring the new slab or structural member to deflect and support its own weight and existing construction loads applied before installation of the reshores. Such reshores are provided to transfer additional construction loads to other slabs or members and/or to impede deflection due to creep that might otherwise occur.
****

a. Do not allow structural members to be loaded with combined dead and construction loads in excess of loads indicated in the accepted procedure.

b. Install and remove reshores or backshores in accordance with accepted procedure.

c. For floors supporting shores under newly placed concrete, either leave original supporting shores in place, or install reshores or backshores. Shoring system and supporting slabs must resist anticipated loads. Locate reshores and backshores directly under a shore position or as indicated on formwork shop drawings.

d. In multistory buildings, place reshoring or backshoring over a sufficient number of stories to distribute weight of newly placed concrete, forms, and construction live loads.

3.2.4 Reuse

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

b. Wood forms must not be clogged with paste and must be capable of absorbing high water-cementitious material ratio paste.

c. Remove leaked mortar from formwork joints before reuse.

3.2.5 Forms for Standard Rough Form Finish

****

NOTE: According to ACI 301, Surface Finish-1.0 (SF-1.0) has the following requirements:
(a) No formwork facing material is specified
(b) Patch voids larger than 1.5 inch wide or 1/2 inch deep
(c) Remove projections larger than 1 inch
(d) Tie holes need not be patched
(e) Surface tolerance Class D as specified in ACI 117
(f) Mockup not required

****

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

3.2.6 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. Specify requirements for such formwork. Select bracketed line for no mockup of the form finish otherwise mockup is required per ACI 301. According to ACI 301, surface finish-3.0 (SF-3.0) has the following requirements:
(a) Patch voids larger than 3/4 inch wide or 1/2 inch deep
(b) Remove projections larger than 1/8 inch

(c) Patch tie holes
(d) Surface tolerance Class A as specified in ACI 117
(e) Provide mockup of concrete surface appearance and texture
****

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

3.2.7 Form Ties

a. For post-tensioned structures, do not remove formwork supports until stressing records have been accepted by the Contracting Officer.

b. After ends or end fasteners of form ties have been removed, repair tie holes in accordance with ACI 301 requirements.

3.2.8 Forms for Concrete Pan Joist Construction

Factory-fabricate pan-form units for one-way or two-way concrete joist and slab construction of the approximate section indicated, consisting of steel or molded fiberglass concrete form pans. Furnish closure units as required.

3.2.9 Tolerances for Form Construction

a. Construct formwork so concrete surfaces conform to tolerances in ACI 117.

b. Position and secure sleeves, inserts, anchors, and other embedded items such that embedded items are positioned within ACI 117 tolerances.

c. To maintain specified elevation and thickness within tolerances, install formwork to compensate for deflection and anticipated settlement in formwork during concrete placement. Set formwork and intermediate screed strips for slabs to produce designated elevation, camber, and contour of finished surface before formwork removal. If specified finish requires use of vibrating screeds or roller pipe screeds, ensure that edge forms and screed strips are strong enough to support such equipment.

3.2.10 Removal of Forms and Supports

a. If vertical formed surfaces require finishing, remove forms as soon as removal operations will not damage concrete.

b. Remove top forms on sloping surfaces of concrete as soon as removal will not allow concrete to sag. Perform repairs and finishing operations required. If forms are removed before end of specified curing period, provide curing and protection.

c. Do not damage concrete during removal of vertical formwork for columns, walls, and sides of beams. Perform needed repair and finishing operations required on vertical surfaces. If forms are removed before end of specified curing period, provide curing and protection.

d. [Leave formwork and shoring in place to support construction loads and weight of concrete in beams, slabs, and other structural members until in-place required strength of concrete is reached.]

e. Form-facing material and horizontal facing support members may be removed before in-place concrete reaches specified compressive strength if shores and other supports are designed to allow facing removal without deflection of supported slab or member.

3.2.11 Strength of Concrete Required for Removal of Formwork

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NOTE: Supporting forms and shores should not be removed from beams, floors, and walls until these structural units are strong enough to carry their own weight and any approved super-imposed load. In no case should supporting forms and shores be removed from horizontal members before the concrete has achieved the specified stripping strength. Shores supporting post-tensioned construction should not be removed until sufficient tensioning force is applied to support the dead load, formwork, and anticipated construction loads.

****

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

Maturity method in accordance with ASTM C1074. Submit maturity method data using project materials and concrete mix proportions used on the project to demonstrate the correlation between maturity and compressive strength of laboratory cured test specimens to the Contracting Officer.

3.3 WATERSTOP INSTALLATION AND SPLICES

a. Provide waterstops in construction joints as indicated.

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

c. Install waterstops to form a continuous diaphragm in each joint. Make adequate provisions to support and protect waterstops during progress of work. Protect waterstops protruding from joints from damage.

3.3.1 PVC Waterstop

Make splices by heat sealing the adjacent waterstop edges together using a thermoplastic splicing iron utilizing a non-stick surface specifically designed for waterstop welding. Reform waterstops at splices with a remolding iron with ribs or corrugations to match the pattern of the waterstop. The spliced area, when cooled, must show no signs of separation, holes, or other imperfections when bent by hand in as sharp an

angle as possible.

3.3.2 Rubber Waterstop

Spliced using cold bond adhesive as recommended by the manufacturer.

3.3.3 Thermoplastic Elastomeric Rubber Waterstop

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

3.3.4 Hydrophilic Waterstop

Miter cut ends to be joined with sharp knife or shears. Adhere ends with adhesive.

3.4 PLACING REINFORCEMENT AND MISCELLANEOUS MATERIALS

3.4.1 General

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

a. Unless otherwise specified, place reinforcement and miscellaneous materials in accordance to EM 1110-2-2104. Provide bars, welded wire reinforcement, wire ties, supports, and other devices necessary to install and secure reinforcement.

b. Reinforcement must not have rust, scale, oil, grease, clay, or foreign substances that would reduce the bond. Rusting of reinforcement is a basis of rejection if the effective cross-sectional area or the nominal weight per unit length has been reduced. Remove loose rust prior to placing steel. Tack welding is prohibited.

c. Non-prestressed cast-in-place concrete members must have concrete cover for reinforcement given in the following table:

Concrete Section	Minimum Clear Cover of Reinforcement in inches
Unformed surfaces in contact with foundation	4
Formed or screeded surfaces subject to cavitation or abrasion erosion, such as baffle blocks and stilling basin slabs	6
Formed and screeded surfaces such as stilling basin walls, chute spillway slabs, and channel lining slabs on grade:	
Equal to or greater than 24 inches thick	4

Concrete Section	Minimum Clear Cover of Reinforcement in inches
Greater than 12 inches and less than 24 inches thick	3
Equal to or less than 12 inches thick	In accordance with ACI 318.
NOTE: The cover must be more than: 1.5 times the nominal maximum size of aggregate, or 2.5 times the maximum diameter of reinforcement	

[d. Cast-in-place prestressed concrete members must have concrete cover for reinforcement, ducts, and end fittings given in the following table:

Concrete	Member	Reinforcement	Specified
Cast against and permanently in contact with ground	All	All	75 [3]
Exposed to weather or in contact with ground	Slabs, joists, and walls	All	25 [1]
	All other	All	40 [1.5]
Concrete	**Member**	**Reinforcement**	**Specified**
NOT exposed to weather or in contact with ground	Slabs, joists, and walls	All	20 [3/4]
	Beams, columns, and tension ties	Primary reinforcement	40 [1.5]
		Stirrups, ties, spirals, and hoops	25 [1]

]

3.4.2 Reinforcement Supports

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NOTE: ACI 301 requirements have change for welded wire reinforcement support. If reinforcement less than W4.0 or D4.0 is specified, the continuous support spacing should be less than or equal to 12 inches

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Provide reinforcement support in accordance with CRSI RB4.1 and ACI 301 requirements. Also, coat supports for coated or galvanized bars with electrically compatible material for a distance of at least 2 inches beyond the point of contact with the bars.

[3.4.3 Epoxy Coated Reinforcing

Meet the requirements of[ASTM A934/A934M including Appendix X2,]

Guidelines for Job Site Practices except as otherwise specified herein.

3.4.3.1 Epoxy Coated Reinforcing Steel Placement and Coating Repair

Carefully handle and install bars to minimize job site patching. Use the same precautions as described in the paragraph EPOXY-COATED REINFORCING BARS. Do not drag bars over other bars or over abrasive surfaces. Keep bar free of dirt and grit. When possible, assemble reinforcement as tied cages prior to final placement into the forms. Support assembled cages on padded supports. It is not expected that coated bars, when in final position ready for concrete placement, are completely free of damaged areas; however, excessive nicks and scrapes which expose steel is cause for rejection. Criteria for defects which require repair and for those that do not require repair are as indicated. Inspect for defects and provide required repairs prior to assembly. After assembly, reinspect and provide final repairs.

a. Immediately prior to application of the patching material, manually remove any rust and debonded coating from the reinforcement by suitable techniques employing devices such as wire brushes and emery paper. Exercise cars during this surface preparation so that the damaged areas are not enlarged more than necessary to accomplish the repair. Clean damaged areas of dirt, debris, oil, and similar materials prior to application of the patching material.

b. Do repair and patching in accordance with the patching material manufacturer's recommendations. Have these recommendations, including cure times, available at the job site at all times.

c. Allow adequate time for the patching materials to cure in accordance with the manufacturer's recommendation prior to concrete placement.

[

d. Rinse placed reinforcing bars with fresh water to remove chloride contamination prior to placing concrete.]

]3.4.4 Splicing

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

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As indicated in the Contract Documents. For splices not indicated follow ACI 301. Do not splice at points of maximum stress. Overlap welded wire reinforcement the spacing of the cross wires, plus 2 inches.[AWS D1.4/D1.4M Approved welded splices prior to use.][Repair the cut ends of hot-dipped galvanized reinforcement steel to completely coat exposed steel, ASTM A780/A780M.]

3.4.5 Future Bonding

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

3.4.6 Setting Miscellaneous Material

Place and secure anchors and bolts, pipe sleeves, conduits, and other such

items in position before concrete placement and support against displacement. Plumb anchor bolts and check location and elevation. Temporarily fill voids in sleeves with readily removable material to prevent the entry of concrete.

3.4.7 Inspection of Reinforcement

Inspect and verify proper reinforcement grade, shape, cross section and condition. Do not use reinforcement with the following defects:

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

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

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

3.4.8 Placing Reinforcement

(1) Place reinforcement in accordance with ACI 301. For slabs on grade (over earth or over capillary water barrier) and for footing reinforcement, support bars or welded wire reinforcement on precast concrete blocks, spaced at intervals required by size of reinforcement, to keep reinforcement the minimum height specified above the underside of slab or footing.

(2) For slabs other than on grade, supports for which any portion is less than 1 inch from concrete surfaces that are exposed to view or to be painted may be precast concrete units, plastic-coated steel, or stainless steel protected bar supports. Precast concrete units must be wedge shaped, not larger than 3.5 by 3.5 inches, and of thickness equal to that indicated for concrete protection of reinforcement. Provide precast units that have cast-in galvanized tie wire hooked for anchorage and blend with concrete surfaces after finishing is completed.

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

(a) Provide supports for reinforcing bars that are sufficient in number and have sufficient strength to carry the reinforcements they support, and in accordance with ACI 301 and CRSI 10MSP. Do not use supports to support runways for concrete conveying equipment and similar construction loads.

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

(c) Support welded wire reinforcement as required for reinforcing bars.

(d) Secure reinforcements to supports by means of tie wire. Provide black, soft iron wire, not less than 16 gage.

(e) Accurately place reinforcement, securely tie at intersections, and hold in position during placing of concrete by spacers, chairs, or other approved supports. Point wire-tie ends away from the form. Unless otherwise indicated, numbers, type, and spacing of supports must

conform to the Contract Documents.

(f) Bending of reinforcing bars partially embedded in concrete is permitted only as specified in the Contract Documents.

3.4.9 Spacing of Reinforcing Bars

a. As indicated in the Contract Documents.

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

3.4.10 Concrete Protection for Reinforcement

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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 in the Contract Documents. ACI 201.2R and ACI 303R require additional concrete protection for severe exposure conditions. Also, refer to ACI 515.2R Guide to Selecting Protective Treatments for Concrete, for more information about providing additional protection to concrete and reinforcing steel.

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In accordance with the Contract Documents.

3.4.11 Welding

In accordance with AWS D1.4/D1.4M.

3.5 TRANSPORTING AND PLACING

3.5.1 Transporting

Methods and equipment for conveying and depositing the concrete into the form are subject to approval. Provide transporting system with sufficient capacity to supply concrete at a rate to prevent cold joints forming during placement. A properly designed and sized elephant trunk and rigid drop chute bottom section which will prevent free-fall within the elephant trunk and rigid drop chute will be used if concrete is to drop more than 1.5 m 5 feet. If concrete is to be placed through installed horizontal or sloping reinforcing bars, discharge the concrete into a pipe or elephant trunk that is long enough to extend through the reinforcing bars to within 1.5 m 5 feet of the placing surface. In no case will concrete be discharged to free fall through the reinforcing bars.

3.5.1.1 Transporting by Bucket

Provide indicating and signaling devices to control the identification of types or classes of concrete as they are mixed and discharged into buckets for transfer to the forms. Identify each type or class of concrete visually by placing a colored tag or marker on a bucket as it leaves the mixing plant so that the concrete may be positively identified in the forms and placed in the structure in the desired position.

3.5.1.2 Transporting by Pump

The nominal maximum-size coarse aggregate will not be reduced or mixture proportions changed to accommodate a pump except as specifically determined appropriate. The distance and height to be pumped must not exceed limits recommended by the pump manufacturer. Supply concrete to the pump continuously. When pumping is completed, eject concrete remaining in the pipeline without contamination of concrete in place. After each operation clean the equipment thoroughly and waste flushing water outside the forms.

3.5.1.3 Transporting by Belt Conveyor

Methods and equipment for transporting the concrete by belt conveyor into the form are subject to approval. After each operation the equipment must be thoroughly cleaned and waste flushing water outside the forms and away from the placement area.

3.5.2 Placing

Provide placing system with sufficient capacity to supply concrete at a rate which will prevent cold joints in any placement. Work concrete into the corners and angles of the forms and around all reinforcement and embedded items without permitting the material to segregate. Deposit concrete as close as possible to its final position in the forms, and in so depositing, there must be no vertical drop greater than 1.5 meters 5 feet except where suitable equipment is provided to prevent segregation and where specifically authorized. Regulate depositing of concrete so that it will be effectively placed and consolidated in horizontal layers not exceeding 609 millimeters 2 feet in thickness with a minimum of lateral movement. Deposit amount of concrete such that it can be readily and thoroughly consolidated and do not exceed 3 cubic meters 4 cubic yards in one pile. All concrete-placing equipment and methods are subject to approval. Concrete placement will not be permitted when, in the opinion of the Contracting Officer, weather conditions prevent proper placement and consolidation. Concrete placement must be carried out in a stepped progression as shown in EM 1110-2-2000 to prevent the formation of cold joints

3.5.2.1 Time Interval Between Mixing and Placing

Place concrete mixed in stationary mixers and transported by nonagitating equipment within 30 minutes after it has been mixed, unless otherwise authorized. When concrete is truck mixed or when a truck mixer or agitator is used for transporting concrete mixed by stationary mixers, deliver the concrete to the site of the work, and complete discharge within 90 minutes after introduction of the cement to either the water or aggregate.

3.5.2.2 Hot-Weather Placing

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NOTE: See EM 1110-2-2000 for the proper placing temperature.
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Concrete will not be placed without an approved Hot Weather Plan. Concrete must be properly placed and finished with approved procedures in accordance with ACI 305.1, as specified, and as stated in the approved Thermal Control Plan. The concrete-placing temperature must not exceed[29][18] degrees C[85][65] degrees F[temperature specified in thermal control plan] and 16 degrees C 60 degrees F for concrete for horizontal repairs, with the temperature of the concrete measured in accordance with ASTM C1064/C1064M. Cooling of the mixing water or aggregates or placing concrete in the cooler part of the day may be required to obtain an adequate placing temperature. Steel forms and reinforcements must be cooled prior to concrete placement when steel temperatures are greater than 120 degrees F. Conveying and placing equipment must be cooled if necessary to maintain the proper concrete-placing temperature. When the rate of evaporation of surface moisture, as determined by use of ACI 305R, may reasonably be expected to exceed 0.2 pounds per square feet per hour, provision for windbreaks, shading, fog spraying, or wet covering with a light-colored material must be made in advance of placement, and such protective measures must be taken as quickly as finishing operations will allow. Surfaces cured with non-pigmented compound must be shielded from direct rays from the sun for 3 days. When approved by the contracting officer a retarding admixture may be used in accordance with paragraph RETARDING ADMIXTURE, to facilitate placing and finishing. Submit a description of the materials and methods proposed for protection of the concrete 60 days in advance of anticipated need date for review, when concrete is to be placed under hot-weather conditions.

3.5.2.3 Cold Weather Placing

Concrete must not be placed without an approved Cold Weather Plan. Cold weather placing must be in accordance with ACI 306.1 and as specified and as stated in the approved Thermal Control Plan. Special temperature control is required for all mass concrete elements as determined by the Thermal Control Plan. The placing temperature of the non mass concrete elements must not exceed the recommended temperature as given in ACI 306R, by more than 20 degrees F, with the temperature of the concrete measured in accordance with ASTM C1064/C1064M. Heating of the mixing water and/or aggregates may be required to regulate the concrete-placing temperatures. If needed, heat the materials in such a manner that they will be free from ice, snow, and frozen lumps before entering the mixer. Air and form temperature in contact with concrete must be above 50 degrees F prior to placing concrete and maintained for the first 3 days, after placement and then at a temperature above 32 degrees F for the remainder of the specified curing period. Thermal sensors must be installed at such locations in accordance with paragraph Temperature Monitoring. During the period of protection removal, heat must be shut down and insulation or tents must be removed in a systematic schedule such that the temperature differential between the air and concrete surface does not exceed 25 degrees F. Exhaust fumes from combustion heating units must be vented to the outside of the enclosure, and heaters and ducts must be placed and directed so as not to cause areas of overheating and drying of concrete surfaces or to create fire hazards. Submit a description of the materials and methods proposed for protection of the concrete 60 days in advance of

anticipated need date for review, when concrete is to be placed under cold-weather conditions.

[3.5.2.4 Special Temperature-Controlled Concrete

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NOTE: See the appropriate concrete materials design memorandum or thermal study to fill in blanks
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Anything defined as Mass Concrete, as specified, requires special treatment to ensure that maximum temperature and maximum temperature differential as specified within paragraph THERMAL ANALYSIS AND THERMAL CONTROL PLAN(S) are not exceeded. Special treatment may involve the use of a different concrete mix design (with reduced equivalent cement content), precooling of the concrete, the use of surface insulation and/or the use of internal cooling pipes. A thermal control plan for the placement must be developed and submitted for approval prior to the concrete placement. The thermal control plan must provide information regarding how temperature monitoring will be verified using temperature sensors in the concrete.

The concrete will require a special treatment to ensure that max temperature of 160 F and the maximum temperature difference between the hottest portion of the concrete and the coolesttemperature of 35 F are not exceeded. Special treatment may involve the use of a different concrete mix design (with reduced equivalent cement content), precooling of the concrete, the use of surface insulation and/or the use of internal cooling pipes. A thermal control plan for the placement must be developed and submitted for approval prior to the concrete placement. The thermal control plan must provide information regarding how temperature control will be verified through the use of temperature monitoring using sensors in the concrete.

]3.5.2.5 Concrete Lifts

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NOTE: The required construction joints should be shown in the drawings.

For simple geometric configurations, such as a slab or column, use a sensor at the center of element and at the nearest face. For a more complex configurations use sensors at the center and each face.
****

The depth of concrete placed in each lift will be as shown in the drawings. Deposit all concrete in approximately horizontal layers about 0.5 meters 1.5 feet in thickness in stepped progression at such a rate that the formation of cold joints will be prevented. Place slabs in one lift, unless 0.8 meters 2.5 feet or more deep. Where 2.3 meters 7.5 feet or greater lift depths are permitted, furnish approved cantilever forms that are jointed or hinged approximately midheight to facilitate placement against surfaces sloping more than 10 degrees from vertical. At the beginning of the placing of a lift, retract the top half of a hinged or jointed form to such a position that it does not interfere with the operation of buckets placing concrete adjacent to the form. Use a minimum of five successive horizontal layers in stepped progression for 2.3 meters

7.5 feet lifts. Where 1.5 meters 5 feet lifts are required, use a minimum of three successive horizontal layers in stepped progression. Place each new layer of concrete on the oldest exposed layer. Do not exceed 12 meters 40 feet maximum exposed bulkhead face of concrete between adjacent monoliths except as otherwise approved. Submit a lift drawing and bill of materials for each lift of concrete. (Show only one lift on a drawing). These drawings must be to scale and show all embedded items in sufficient detail for the proper installation and prosecution of the work. Identify all embedded electrical and/or mechanical items. The drawings must not be less than 594 by 841 mm 22 by 34 inches in size and use a sufficiently large scale to clearly show all details of the structure covered by these drawings. Include a note on each lift drawing indicating all contract drawings from which the lift drawing was prepared. Submit [_____] copies of each drawing for review at least 60 days prior to scheduling the lift for placement.

3.5.2.6 Temperature Monitoring

Temperature monitoring must be performed using temperature loggers specifically designed for embedding in concrete for recording temperature. Equipment for monitoring the temperature and maturity of the in-place concrete must consist of digital, un-interruptible and non-alterable data loggers. The data loggers must be of a long enough lifespan to exceed the required time to develop the design strength of each mix. The data loggers must come equipped with shielded wires long enough to reach the transmitter from each location in the placement without splicing.

At a minimum, sensors must be located at the center of the thickest portion of the placement and at the center of[each face][face nearest to center] at 2 to 3 inches below/inside the surface of the concrete (sensors must be supported above/outside the reinforcing to maintain 2 to 3 inch depth). Two sensors must be installed at each location (a primary and a back-up). Temperature data must be downloaded at least once every hour for the first seven days then at least once every 2 days for the remainder of the period when thermal controls and temperature monitoring are required. The contractor must provide the contracting officer with the proper equipment to review most updated real time temperature data.

3.5.2.6.1 Termination of Thermal Controls and Temperature Monitoring

Thermal control and monitoring can be terminated when all the following are met:

a. The concrete is at least three days old.

b. The hottest portion of the concrete has reached its maximum temperature and has started to cool.

c. The difference between the hottest portion of the concrete and the average air temperature is less than 35 F.

d. Thermal control and monitoring must continue until all adjacent placements have been made and fulfilled the above requirements or the placement(s) have reached its final cure time.

e. If temperature monitoring is being used for maturity continue monitoring until the maturity of the entire placed element has been met.

3.5.2.7 Consolidation

Immediately after placing, consolidate each layer of concrete by internal vibrating equipment. Do not use vibrators to cause concrete to flow for significant distances within the forms. Hand spading may be used if necessary together with internal vibration along formed surfaces permanently exposed to view. Do not use form vibrators unless forms are specifically designed for this use and unless specifically approved. Insert vibrator vertically at uniform spacing over the entire area of placement. Use distance between insertions that is approximately one and a half times the radius of action of the vibrator. The vibrator must penetrate rapidly to the bottom of the layer and at least 150 mm 6 inches into the preceding unhardened layer if such exists. Hold it stationary until the concrete is consolidated and then withdraw slowly. Consolidate slabs 200 mm 8 inches or less in depth by approved methods.

[3.5.2.8 Placing Concrete in Unformed Curved Sections

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NOTE: For deeper underwater placements such as cut off walls, use specification 03 37 29
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Finish the unformed portion of the ogee crest, spillway bucket, and similar features by placing concrete slightly above grade, consolidating and striking off to grade by accurate screeding. Screeding may be accomplished by semi-mechanical devices or by a mechanical screed that consolidates and screeds the surface in one operation. Ribs embedded in the fresh concrete as guides for screeds will not be permitted.

][3.5.2.9 Underwater Placement by Tremie

All platforms, tremie pipes, ramps and walkways, as required, must be completed prior to any placements to allow safe and expeditious access for concrete and workmen. Snow, ice, flowing water, loose particles, debris and foreign matter must have been removed. Reinforcement must be secured in place; anchors and other embedded items must have been positioned and anchored. The entire preparation must be accepted by the Contracting Officer prior to placing. Underwater concrete placements must commence immediately after final inspection of the area of placement, reinforcing steel and embedded items. Underwater Concrete Placement Plan must be submitted to the Contracting Officer.

Deposit concrete, described in Bid Item [_____], through water by a tremie[or concrete pump]. Submit the methods and equipment used in advance of placement for review. Concrete buckets may be used only to charge the hopper on top of the tremie. Do not lower concrete buckets under water and discharge the concrete subaqueously. Ensure tremie is watertight and sufficiently large to permit a free flow of concrete. The discharge end of the tremie pipe(s) must be raised off the bottom of the placement 6 inches with a fully charged pipe and hopper to initiate the flow of the concrete. The tremie pipe must not be raised after the flow is started, unless the end of the pipe remains at least[5][3] feet into the previously placed concrete. The tremie pipe must only be raised vertically and must not be moved horizontally for any reason. Keep discharge end of the pump line or tremie pipe submerged continuously in the concrete after placement starts. Effect underwater seal in a manner that will not produce undue contamination of the concrete or turbulence in

the water. If the seal between the end of the pipe and the previously placed concrete is lost during placement, the tremie pipe must be fully withdrawn, the cap replaced, the pipe reset into the concrete a minimum of 5 feet or as much as practicable, and the flow of concrete must be re-established. Placement must proceed without interruption until the concrete has been brought to the required height. Do not move tremie or pump lines horizontally during a placing operation, unless removed, moved, and properly restarted, and provide a sufficient number of tremies or pump lines so that the maximum horizontal flow will be limited to 15 feet.

]3.6 FINISHING

Submit the finishing plan and methods to be used for review 30 days before concrete placement begins.

3.6.1 Unformed Surfaces

The ambient temperature of spaces adjacent to surfaces being finished must be no less than 40 degrees F. In hot weather when the rate of evaporation of surface moisture, as determined by use of ACI 305R, may reasonably be expected to exceed 0.2 pounds per square foot per hour, make provisions for windbreaks, shading, fog spraying, or evaporation retarding film in advance of placement to prevent plastic shrinkage cracks, and take such protective measures before, during, and immediately after finishing as operations require. All unformed surfaces of concrete that are not to be covered by additional concrete or backfill must have a float finish, unless a trowel finish is specified, and must be true to elevation as shown on the drawings. Bring surfaces to receive additional concrete or backfill to the elevation shown and leave true and regular. Slope exterior surfaces for drainage unless otherwise shown in the drawing or directed. Make joints carefully with a jointing or edging tool. Protect finished surfaces from stains or abrasions. Consolidate concrete thoroughly before finishing operations commence or before leaving it for future concrete or backfill placement.

3.6.1.1 Float Finish

Surfaces to receive a float finish must be screeded and darbied or bullfloated to bring the surface to the required finish level with no coarse aggregate visible. Do not add water, cement, or mortar to the surface during the finishing operation. Floating may be performed by use of suitable hand floats or power-driven equipment. Use aluminum or magnesium hand floats. After the water sheen has disappeared, float the concrete, while still green but sufficiently hardened to bear a man's weight without deep imprint, to a true even plane.

3.6.1.2 Trowel Finish

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NOTE: Refer to the appropriate design memorandum for surfaces to be trowel finished. Be sure these are shown in the drawings. Unformed surfaces subjected to high velocity flow (40 fps) must receive a trowel finish.

****

Apply a trowel finish to the following surfaces [_____]; [_____]; [_____]. First, give concrete surfaces a float finish. After surface

moisture has disappeared, trowel the surface to a smooth, even, dense finish, free from blemishes, including trowel marks. In lieu of hand finishing, an approved power finishing machine may be used in accordance with the directions of the machine manufacturer. A final hard steel troweling must be done by hand. Make joints carefully with a jointing or edging tool. Protect finished surfaces from stains or abrasions. Protect surface or edges likely to be injured during the construction period from damage.

[3.6.1.3 Broom Finish

****
NOTE: Refer to the appropriate design memorandum for surfaces to be broom finished. Be sure these are shown in the drawings.
****

Apply a broom finish to the following surfaces: [_____]; [_____]; [_____]. The concrete surface to be broom finished must first be given a float finish. The surface must then be broomed with a [stiff fiber-bristle broom] [hair broom in a direction transverse to that of the traffic].

][3.6.1.4 Abrasive Aggregate Finish

****
NOTE: Refer to the appropriate design memorandum for surfaces to receive the abrasive aggregate finish. Be sure this is shown in the drawings.
****

Apply an abrasive aggregate finish to the following surfaces: [_____]; [_____]; [_____]. First, give concrete surface a float finish. Sprinkle abrasive aggregate uniformly over the surface immediately after floating, at a rate of no less than 1.22 kilograms per square meter 1/4 pounds per square foot. Refloated the surface and then trowel to a smooth even finish that is uniform in texture and appearance including trowel marks. Immediately after curing, remove cement coating or laitance covering the abrasive aggregate by wire brushing, rubbing with abrasive stone, or sandblasting to expose the abrasive particles.

][3.6.1.5 High Velocity Finishes

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NOTE: Refer to the appropriate design memorandum for surfaces to receive high velocity finishes. Be sure these are shown in the drawings.
****

Unformed surfaces subjected to high velocity flow of 12 meters per second 40 feet per second must receive a trowel finish.

]3.6.2 Formed Surface Repair

****
NOTE: Refer to EM 1110-2-2000 for direction on class of finish. Please note that definitions for class of finish have been changed recently. Class of finish must also be shown in the drawings.

Paragraph CONSTRUCTION TOLERANCES, in PART 2, presents surface tolerances. Section 03 30 00 CAST-IN-PLACE CONCRETE presents materials for each class.

****

After removal of forms, remove all ridges, lips, and bulges on surfaces permanently exposed. Complete all repairs within 48 hours after form removal.

3.6.2.1 Classes A, A-HV, & B Finishes

For surfaces listed in Section 03 30 00 CAST-IN-PLACE CONCRETE, paragraph [_____], and as shown in the drawings to have classes A, A-HV, and B finishes, repair surface defects as follows: chip defective areas, voids, and honeycombs smaller than 10 000 square mm 16 square inches in area and less than 13 mm 1/2 inches deep; bug holes exceeding 13 mm 1/2 inch in diameter and fill with dry-packed mortar; ream holes left by removal of tie rods and fill with the below specified material; define defective and unsound concrete areas larger than described by 13 mm 1/2 inch deep dovetailed saw cuts in a rectangular pattern with lines parallel to the formwork, remove the defective concrete by chipping and repair the void with replacement concrete. Brush-coat the prepared area with an epoxy resin meeting the requirements of ASTM C881/C881M, Type V; a latex bonding agent meeting the requirements of ASTM C1059/C1059M, Type II; or a neat cement grout after dampening the area with water. Fill the void with replacement concrete in accordance with the paragraph MATERIAL AND PROCEDURE FOR REPAIRS below.

3.6.2.2 Class C Finish

For the following surfaces [State which element surface(s)require a Class C Finish], [_____], [_____], and [_____], and as shown in the drawings, repair defects as follows: chip defective areas, voids, and honeycombs smaller than 24 square inches and less than 2 inches deep; bug holes exceeding 1.5 inches in diameter and fill with dry-packed mortar; and ream holes left by removal of the tie rods and fill with dry-packed mortar. Define defective and unsound concrete areas larger than square inches and deeper than 1.5 inches by a half inch deep dovetailed saw cuts in a rectangular pattern, remove the defective concrete by chipping, and repair the void with replacement concrete. Brush-coat the prepared area with[an epoxy resin meeting the requirements of ASTM C881/C881M, Type V]; [a latex bonding agent meeting the requirements of ASTM C1059/C1059M, Type II]; or [a neat cement grout after dampening the area with water]. Fill the void with replacement concrete in accordance with the paragraph below.

3.6.2.3 Class D Finish

For the following surfaces[State which element surface(s)require a Class D Finish], [], [], and [],, and as shown in the drawings to have class D finish, repair surface defects as follows: define defective areas, voids, and honeycombs greater than 48 square inches in area or more than 2 inches deep by 1/2 inch deep dovetailed saw cuts in a rectangular pattern, remove the defective concrete by chipping and repair the void with replacement concrete. Brush-coat the prepared area with [an epoxy resin meeting the requirements of ASTM C881/C881M, Type V]; [a latex bonding agent meeting the requirements of ASTM C1059/C1059M, Type II]; or [a neat cement grout after dampening the area with water]. Fill the void with replacement concrete in accordance with the following paragraph.

3.6.2.4 Material and Procedure for Repairs

Use cement in the dry-packed mortar or replacement concrete that is a blend of the cement used for production of project concrete and white portland cement properly proportioned so that the final color of the mortar or concrete will match adjacent concrete. Use trial batches to determine the proportions required to match colors. Provide dry-packed mortar consisting of one part cement to two and one-half parts fine aggregate. Use fine aggregate for production of project concrete. Remix the mortar over a period of at least 30 minutes without addition of water until it obtains the stiffest consistency that will permit placing. Compact mortar thoroughly into the prepared void by tamping, rodding, ramming, etc. and struck off to match adjacent concrete. Produce replacement concrete using project materials and proportion as directed by the Contracting Officer. Thoroughly compact it into the prepared void by internal vibration, tamping, rodding, ramming, etc. and strike off and finish to match adjacent concrete. Use forms to confine the concrete. If an expanding agent is used in the repair concrete, confine the repair thoroughly on all sides including the top surface. Do not use metal tools to finish permanently exposed surfaces. Cure repaired areas for 7 days. The temperature of the in situ concrete, adjacent air, and replacement mortar or concrete must be above 5 degrees C 40 degrees F during placement, finishing, and curing. Packaged materials meeting the requirements of ASTM C928/C928M may be used in lieu of dry-packed mortar when approved. Other methods and materials for repair may be used only when approved in writing. Repairs of the so called plaster-type will not be permitted.

3.6.3 Grout-Cleaned Finish

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NOTE: See the appropriate design memorandum and EM 1110-2-2000 for surfaces to receive a grout cleaned finish. Be sure this is shown in the drawings.
****

Give the surfaces of[_____] a grout-cleaned finish as hereinafter described, as approved by the Contracting Officer and after all required curing, cleaning, and repairs have been completed. Moist cure surfaces to be grout-cleaned for the required period of time before application of the grout-cleaned finish. Delay grout-cleaning until near the end of construction on all surfaces not to be painted to achieve uniformity of appearance and reduce the chance of discoloring caused by subsequent construction operations. The temperature of the air adjacent to the surface must be no less than 5 degrees C 40 degrees F for 24 hours prior to and 72 hours following the application of the finish. Complete finish for any area in the same day, and make the limits of a finished area at natural breaks in the finished surface. Wet surface to receive grout-cleaned finish thoroughly to prevent absorption of water from the grout but have no free water present. Then coat the surface with grout. Apply grout as soon as the surface of the concrete approaches surface dryness and vigorously and thoroughly rub over the area with clean burlap pads, cork floats, or stones to fill all voids. Compose grout of one part portland cement as used on the project, to two parts by volume of well-graded sand passing a 600-µm (No. 30) sieve mixed with water to the consistency of thick paint. Use white cement for all or part of the cement as approved to give the desired finish color. Apply uniform coating, completely filling all pits, air bubbles, and surface voids.

While the grout is still plastic, remove all excess grout by working the surface with a rubber float, burlap pad, or other means. Then, after the surface whitens from drying (about 30 minutes at normal temperature), rub vigorously with clean burlap pads. Immediately after rubbing is completed, moist cure the finished surface continuously for 72 hours. Use burlap pads for this operation consisting of burlap stretched tightly around a board to prevent dishing the mortar in the voids.

3.7 CURING AND PROTECTION PLAN

Submit the curing media certificates and methods to be used for review 30 days before concrete placement begins.

3.7.1 Curing Time

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NOTE: Curing time may be extended if required by the thermal study. See the concrete materials design memorandum for the approved types of cementitious materials.

****

Cure all concrete by one of the following methods or combination of methods for the period of time given below corresponding to the cementing materials used in the concrete:

Portland Cements in accordance with ASTM C150/C150M	
Type I portland cement	7 days
Type II portland cement	14 days
Type III portland cement	3 days
Portland cement in combination with silica fume	3 days

Portland Cements in accordance with ASTM C150/C150M	
Portland cement in combination with 25 percent or less coal ash or Slag Cement	14 days
Portland cement in combination with more than 25 percent coal ash or Slag Cement	21 days

Blended Portland Cements in accordance with ASTM C595/C595M	
Blended portland cement Type IL	7 days
Blended portland cement in combination with 25 percent or less coal ash or Slag Cement	14 days

Blended Portland Cements in accordance with ASTM C595/C595M	
Blended portland cement in combination with more than 25 percent coal ash or Slag Cement	21 days

Begin curing immediately after placing. Provide all equipment needed for curing and protection of the concrete on hand and ready to install before actual concrete placement begins. Use curing medium and method, or the combination of media and methods, as approved in accordance with paragraph SUBMITTALS, SD-03 Product Data, submittal item Curing.

3.7.2 Moist Curing

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NOTE: This requirement is for hot weather curing only and has to be used under certain conditions only. Thermal cracking can occur when the difference in temperature between the interior concrete is more than 11 degrees C 20 degrees F higher than the surface temperature of a concrete placement. Tepid water is water at a temperature no more than 11 degrees C 20 degrees F cooler than the surface of the concrete placement. For massive placements, thermal insulation should be provided to reduce the temperature gradient between the interior and exterior of the placement.

****

[Moist cure concrete containing silica fume.] Moist cure horizontal and nearly horizontal surfaces by ponding, by covering with a minimum uniform thickness of 50 mm 2 inches of continuously saturated sand, or by covering with saturated nonstaining burlap or cotton mats. Rinse burlap and cotton mats to remove soluble substances before using. Moist cure other surfaces when approved or directed. Maintain concrete that is moist cured continuously, not periodically, wet for the duration of the entire curing period. Use water for curing complying with the requirements of the paragraph WATER in PART 2. If the water, sand, mats, etc. cause staining or discoloration of permanently exposed concrete surfaces, clean the surfaces by an approved method. When wood forms are left in place during curing, keep the forms continuously wet except for sealed insulation curing in cold weather. When steel forms are left in place on vertical surfaces during curing of concrete, [when using high-strength concrete] [when concrete being cured has a water-cement ratio less than 0.40] [placements with a minimum dimension greater than 600 mm 2 feet] carefully break loose the forms from the hardened concrete and continuously introduce curing water into the void. The temperature of the water should be tepid. Allow horizontal construction joints to dry sufficiently to remove free water immediately prior to placing the next lift.

3.7.3 Membrane Curing

Membrane curing may be used on surfaces that are not specified or directed to receive moist curing and that are not to receive a grout-cleaned finish. Do not use membrane-forming curing compound on surfaces that contain protruding steel reinforcing, that are heated by free steam, that will have additional concrete bonded to them, or that are to be

grout-cleaned.

3.7.3.1 Pigmented Curing Compound

Pigmented compound conforming to ASTM C309, Type 2, Class A, may be used on surfaces that will not be exposed to view when the project is completed. Only pigmented compound of the styrene acrylate or chlorinated rubber formulation conforming to ASTM C309, Class B, requirements may be used on surfaces that are to be painted or to receive bituminous roofing or water proofing or floors that are to receive adhesive applications of resilient flooring. Select curing compound for such use that is compatible with any subsequent paint, roofing, coating, or flooring specified elsewhere in the contract.

3.7.3.2 Nonpigmented Curing Compound

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NOTE: See the concrete materials design memorandum for guidance on the optional sentence.

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Nonpigmented compound conforming to ASTM C309, Type ID, containing a fugitive dye may be used on surfaces that will be exposed to view when the project is completed. The reflective requirements of ASTM C309 are waived. [Shield surfaces cured with nonpigmented compound from direct rays of the sun for 3 days.]

3.7.3.3 Application

Apply curing compound to formed surfaces immediately after the forms are removed. Moisten surfaces thoroughly with water, and apply the curing compound as soon as free water disappears. Apply curing compound to unformed surfaces as soon as free water has disappeared provided steps have been taken when necessary to prevent premature loss of free water due to excessive evaporation as described in paragraph UNFORMED SURFACES above. Apply curing compound in a two-coat continuous operation by motorized power-spraying equipment or pressure-tank equipment operating at a minimum pressure of 520 kPa 75 psi with provisions for continuous agitation. The application equipment must be approved in advance. Do not use hand-operated pressure applicators (garden sprayers) except in small, isolated areas as approved. Apply compound at a uniform coverage of no more than 10 square meters/L 400 square feet/gallon for each coat. Apply the second coat perpendicular to the first coat. Respray concrete surfaces that have been subjected to rainfall within 3 hours after the curing compound has been applied by the method and at the coverage specified. Protect all concrete surfaces on which the curing compound has been applied for the duration of the entire curing period from pedestrian and vehicular traffic and from any other influence that will disrupt the continuity of the curing membrane.

[3.7.4 Sheet Curing

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NOTE: The only concrete that may be cured using sheet should be horizontal or nearly horizontal finished surfaces such as roof slabs, uncolored floors or the first course of two-course floors, or floors that are to be covered with tile or resilient flooring.

****

The following concrete surfaces may be cured using sheets: [_____]; [_____]; [_____]. Use sheets only on horizontal or near horizontal surfaces. Use sheets complying with the requirements of ASTM C171, except do not use polyethylene sheet. Wet all surfaces thoroughly and completely cover with waterproof paper, or polyethylene-coated burlap. Lay covering with light-colored side up. Lap covering no less than 100 mm 4 inches and tape to form a continuous cover with completely closed joints. Use weighted sheet to prevent displacement so that it remains in contact with the concrete during the specified length of curing. Fold coverings down over exposed edges of slabs and secure by approved means. Repair sheets immediately or replace if tears or holes appear during the curing period.

]3.7.5 Sealed Insulation Curing

Between dates listed in paragraph COLD WEATHER PROTECTION below where cold weather protection is provided entirely by insulation, seal all joints in the insulation to retard moisture loss and maintain a seal throughout the curing period.

3.7.6 Protection

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NOTE: Add more sophisticated requirements for vibration control where appropriate.

****

No fire or excessive heat is permitted near or in direct contact with concrete at any time. Do not operate vibratory earth compaction equipment or pile-driving equipment within 30 m 100 feet horizontally of concrete less than 5 days old. Blasting is not permitted within 30 m 100 feet horizontally of concrete less than 90 days old. Blasting plans must be approved by the Contracting Officer. Keep all galleries, conduits, and other openings through the concrete closed or sealed during the entire construction period. Protect the surface of the concrete from rain or snow during placing.

3.7.7 Cold Weather-Protection

****

NOTE: The editor must insert the insulating value and the calendar dates in the appropriate blanks. The values will be taken from the thermal study that was performed during design of the structure. The paragraph may be revised or expanded to provide varying insulating values and dates for various concrete features of the project in accordance with the thermal study.

****

Between [_____] of each year and [_____] of the following year, cover all concrete [less than 30 days old] [immediately after placing] for a period of [_____] days with insulation that provides an R value no less than [_____] square meter degree Celsius per watt hour square foot degree Fahrenheit per BTU. Submit a description of the materials and methods proposed for protection of the concrete, 60 days in advance of anticipated need date for review, when concrete is to be placed under cold-weather conditions.

a. Maintain insulation in such a condition that the R value does not diminish during the period of protection. Protect edges and corners of the placement with a double layer of the insulation specified above for a minimum distance of 0.6 m 2 feet in all directions.

b. Insulate concrete placed prior to the starting date from the starting date until it reaches an age of [_____] days. Insulate concrete placed after the starting date continuously during and subsequent to placement [until it reaches an age of [_____] days or] until the end of the protection period [, whichever comes first].

c. Insulate forms in such a manner that the combined form-insulation system has a thermal resistance (R value) no less than that specified. Keep insulation and the combined form-insulation system in place for at least 5 days after placement of the concrete. After 5 days, forms and insulation on vertical surfaces may be removed for periods not to exceed 4 hours in a 24 hour period to allow forms to be moved, and insulation on horizontal surfaces may be removed for periods not to exceed 8 hours in a 24 hour period to allow reinforcement to be installed, insulation to be installed, lift joints to be prepared, etc. provided that suitable precautions are taken to prevent the concrete from being subjected at any time to ambient temperatures of minus 7 degrees C 20 degrees F or below.

d. Insulate the first 1.8 m 6 feet of all steel protruding from insulated concrete with material having an R value as stated. Insulate all form bolts and metal ribs on the forms in a like manner. During the period of protection there must be no holes or openings in the insulation or between the insulation and concrete which permit ambient air to penetrate the insulation except as noted for construction purposes. Give special attention to seams, corners, and edges to prevent holes or openings in the insulation.

3.8 BASE PLATES AND BEARING PLATES

3.8.1 Setting of Plates

After being plumbed and properly positioned, provide full bearing column base plates, bearing plates for beams and similar structural members, and machinery and equipment base plates using nonshrink grout. The space between the top of the concrete bearing surface and the bottom of the plate must not be less than 1/24 of the width of the plate or 13 mm 1/2 inch, whichever is greater. Concrete surfaces must be clean, free of oil, grease, and laitance, and damp. Metal surfaces must be clean and free of oil, grease, and rust.

3.8.2 Nonshrink Grout

Use nonshrink grout conforming to the requirement of paragraph NONSHRINK GROUT. Water content must be the minimum that will provide a flowable mixture and completely fill the space to be grouted without segregation, bleeding, or reduction of strength.

3.8.2.1 Mixing and Placing

Perform mixing and placing in conformance with the material manufacturer's instructions and as specified. Dry-mix ingredients thoroughly before adding water. After adding water, mix the batch for 3 minutes. Size

batches to allow continuous placement of freshly mixed grout. Discard grout not used within 30 minutes after mixing. Fill the space between the top of the concrete or masonry bearing surface and the plate with the grout. Use forms consisting of wood or other suitable material for retaining the grout and remove after the grout has hardened. If Grade A" grout is used, form all surfaces, including top surfaces, to provide restraint. Work placed grout to eliminate voids; however, avoid overworking and breakdown of the initial set. Do not retemper or subject grout to vibration from any source. Where clearances are unusually small, make placement under pressure with a grout pump. Maintain temperature of the grout, and of surfaces receiving the grout, at 20 to 30 degrees C 65 to 85 degrees F until after setting.

3.8.2.2 Treatment of Exposed Surfaces

Those types of grout containing metallic aggregate, Grade B or C grout, must, after setting, have exposed surfaces under cut back 1 inch from the edge of the base plate and immediately cover with a thick coat of mortar proportioned by weight of one part portland cement, two parts sand, and sufficient water to make the mixture placeable. The parge coat must have a smooth, dense finish. The exposed surface of other types of nonshrink grout must have a smooth, dense finish.

3.8.2.3 Curing

Cure grout and parge coats in conformance with paragraph CURING AND PROTECTION above.

[3.9 BLOCK-OUT CONCRETE

[3.9.1 Composition and Proportions

Provide block-out concrete composed of portland cement, water, fine and coarse aggregate, and admixtures. The concrete mixture proportions, including admixture, will be provided by the Contracting Officer. Use an expansive admixture to cause the blockout concrete to expand to fit snugly in the space that confines it. Use expansive admixture conforming to the requirements of ASTM C937 for grout fluidifier. Waste any block-out concrete not placed within 30 minutes after contact of the cement and admixture. Confine block-out on all sides to provide restraint.

][3.9.2 Placing Block-out Concrete

Provide block-outs as shown on the plans for the embedment of gate seal seats, gate guides, bulkhead guides, beams embedded for bulkhead seals, crane rails, and other embedded metalwork as appropriate. Prior to installation of embedded items, clean the block-outs or recesses in accordance with applicable requirements of the paragraph on construction joint treatment. After installation of embedded items and prior to placing any forms, clean all surfaces of the block-outs or recesses and surfaces of items to be embedded thoroughly of all loose material, oil, grease, and other contaminants which might reduce the bond between the surfaces of the blockouts or recesses and new concrete. Exercise extreme caution in placing block-out concrete to avoid distortion or displacement of the embedded items.

]]3.10 JOINTS

3.10.1 Construction Joints

Make and locate joints not indicated so as not to impair strength and appearance of the structure, as approved. Make joints perpendicular to main reinforcement. Continue and develop reinforcement across construction joints. Locate construction joints as follows:

3.10.1.1 Construction Joints for Constructability Purposes

a. In walls, at top of footing; at top of slabs on ground; at top and bottom of door and window openings or where required to conform to architectural details; and at underside of deepest beam or girder framing into wall.

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

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

Provide keyways at least 1.5 inches deep in construction joints in walls and slabs and between walls and footings; approved bulkheads may be used for slabs.

3.10.2 Isolation Joints in Slabs on Ground

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

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

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

3.10.3 Contraction Joints in Slabs on Ground

a. Provide joints to form panels as indicated.

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

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

d. [Provide joints 1/8 inch wide by 1/5 to 1/4 of slab depth and form by inserting hand-pressed fiberboard strip into fresh concrete until top surface of strip is flush with slab surface. After concrete has cured for at least 7 days, remove inserts and clean groove of foreign matter and loose particles.]

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

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

3.10.4 Sealing Joints in Slabs on Ground

****
NOTE: When standard floor topping is specifically required, indicate the location of standard floor topping.
****

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

b. Leave sealed groove ready to receive filling material that is provided as part of finish floor covering work.

[3.11 CONCRETE FLOOR TOPPING

3.11.1 Standard Floor Topping

****
NOTE: When standard floor topping is specifically required, indicate the location of standard floor topping.
****

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

3.11.1.1 Preparations Prior to Placing

a. When topping is placed on a green concrete base slab, screed surface of base slab to a level not more than 38 mm 1.5 inches nor less than 25 mm 1 inch below required finish surface. Remove water and laitance from surface of base slab before placing topping mixture. As soon as water ceases to rise to surface of base slab, place topping.

b. When topping is placed on a hardened concrete base slab, remove dirt, loose material, oil, grease, asphalt, paint, and other contaminants from base slab surface, leaving a clean surface. Prior to placing topping mixture, 64 mm 2 1/2 inches minimum, dampen slab surface and leave free of standing water. Immediately before topping mixture is

placed, broom a coat of neat cement grout onto surface of slab. Do not allow cement grout to set or dry before topping is placed.

3.11.1.2 Placing

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

3.11.1.3 Finishing

****
NOTE: Indicate standard floor topping surfaces requiring an applied finish such as a chemical-hardener, non-slip aggregate finish, colored wear-resistant finish, sealers, or heavy-duty, wear-resistant finish.
****

Give trowel finish standard floor topping surfaces.

Give other finishes standard floor topping surfaces as indicated.

3.11.2 Heavy-Duty Floor Topping

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NOTE: Indicate location of heavy-duty floor topping. Heavy-duty floor topping is suitable for an industrial floor subject to continuous severe abrasion and impact such as steel-tire vehicles.
****

Provide topping where indicated.

3.11.2.1 Heavy-duty Topping Mixture

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

3.11.2.2 Base Slab

a. Screed surface of slab to a level no more than 38 mm 1.5 inches nor less than 25 mm 1 inch below grade of finished floor.

b. Give slab a scratch finish as specified.

c. Preparations prior to placing.

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

placed.

3.11.2.3 Placing

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

3.11.2.4 Finishing

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

]3.12 TESTS AND INSPECTIONS

3.12.1 General

Perform the following inspection and tests as described and based upon the results of these inspections and tests, take the action required and submit reports as required. When, in the opinion of the Contracting Officer, the concreting operation is out of control, cease concrete placement.

3.12.2 Laboratory Requirements

The laboratory performing the tests and on-site inspections must conform with the requirements given in ASTM C1077 and is validated in accordance with ER 1110-1-8100 Materials Testing Laboratories and Validation. The Government will inspect the laboratory, equipment, and test procedures prior to start of concreting operations and at least[once] per year, thereafter for conformance with ASTM C1077.[Accreditation or validation by the National Voluntary Laboratory Accreditation Program][, American Association for Laboratory Accreditation][, AASHTO Laboratory Accreditation Program], or other nationally recognized independent authority must be submitted on laboratories that are performing any concrete and concrete materials testing required for this project.

3.12.3 Technician and Inspector Certification Requirements

The individuals who sample and test concrete as required in this specification must demonstrate the knowledge and ability to perform the necessary test procedures equivalent to the ACI minimum guidelines for certification of Concrete Field-Testing Technicians, Grade I[, Aggregate Testing Technician - Level 1][, Concrete Transportation Construction Inspector (CTCI)][or Concrete Construction Inspector (CCI)].

3.12.4 Testing and Inspection Requirements

3.12.4.1 Fine Aggregate

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NOTE: If the optional requirement to limit the amount of material passing the 75 µm No. 200 sieve was invoked in paragraph AGGREGATES in PART 2, the requirement to perform ASTM C117 must be invoked in

subparagraph a.

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3.12.4.1.1 Grading

At least once during each shift when the concrete plant is operating, there make one sieve analysis and fineness modulus determination in accordance with ASTM C136/C136M [, ASTM C117] and COE CRD-C 104 for the fine aggregate or for each fine aggregate if it is batched in more than one size or classification. The location at which samples are taken may be selected by the Contractor as the most advantageous for control. However, the Contractor is responsible for delivering fine aggregate to the mixer within specification limits. Record the results on a sheet on which are also shown the specification limits applicable to the project.

3.12.4.1.2 Fineness Modulus Control Chart

Group results for fineness modulus in sets of three consecutive tests, and plot the average and range of each group on a control chart. Draw the upper and lower control limits for average 0.10 units above and below the target fineness modulus, and the upper control limit for range 0.20 units above the target fineness modulus.

3.12.4.1.3 Corrective Action for Fine Aggregate Grading

When the amount passing any sieve is outside the specification limits, resample and retest the fine aggregate immediately. If there is another failure for any sieve, report the fact immediately. Whenever a point on the fineness modulus control chart, either for average or range, is beyond one of the control limits, double the frequency of testing. If two consecutive points are beyond the control limits, consider the process out of control and stop concreting. Notify the Contracting Officer, and take immediate steps to rectify the situation. After two consecutive points have fallen within the control limits, testing at the normal frequency may be resumed.

3.12.4.1.4 Moisture Content Testing

When in the opinion of the Contracting Officer the electric moisture meter is not operating satisfactorily, perform at least four tests for moisture content in accordance with ASTM C566 during each 8-hour period of mixing plant operation. Select times for the tests randomly within the 8-hour period. Make an additional test whenever the slump is shown to be out of control or excessive variation in workability is reported by the placing foreman. When an electric moisture meter is operating satisfactorily, make at least two direct measurements of moisture content per week to check the calibration of the meter. Use results of tests for moisture content to adjust the added water in the control of the batch plant.

3.12.4.1.5 Moisture Content Corrective Action

Whenever the moisture content of the fine aggregate changes by 0.5 percent or more, adjust the scale settings for the fine-aggregate batcher and water batcher (directly or by means of a moisture compensation device).

3.12.4.2 Coarse Aggregate

3.12.4.2.1 Grading

At least once during each shift in which the concrete plant is operating, perform a sieve analysis in accordance with ASTM C136/C136M for each size of coarse aggregate. The location at which samples are taken may be selected by the Contractor as the most advantageous for production control. However, the Contractor is responsible for delivering the aggregate to the mixer within specification limits. A test record of samples of aggregate taken at the same locations must show the results of the current test as well as the average results of the five most recent tests including the current test. The Contractor may adopt limits for control coarser than the specification limits for samples taken other than as delivered to the mixer to allow for degradation during handling. When facilities are available to test samples five times as large as those required in ASTM C136/C136M, averaging is not permitted.

3.12.4.2.2 Corrective Action for Grading

When the amount passing any sieve is outside the specification limits, resample and retest the coarse aggregate immediately. If the second sample fails on any sieve, report that fact. Where two consecutive averages of five tests (or two consecutive tests where large samples are used) are outside specification limits, consider the operation out of control, and report that fact, stop concreting, and take immediate steps to correct the grading.

3.12.4.2.3 Coarse Aggregate Moisture Content

Make a test for moisture content of each size group of coarse aggregate at least once a shift. When two consecutive readings for smallest size coarse aggregate differ by more than 1.0 percent, increase frequency of testing to that specified previously for fine aggregate.

3.12.4.2.4 Coarse Aggregate Moisture Corrective Action

Whenever the moisture content of any size of coarse aggregate changes by 0.5 percent or more, adjust the scale setting for the coarse aggregate batcher and the water batcher to compensate for this.

3.12.4.2.5 Particle Shape Testing

When directed, a problem exists in connection with aggregate particle shape, make tests in accordance with ASTM D4791. Testing frequency must not be less than one per day, when directed.

3.12.4.2.6 Particle Shape Corrective Action

When testing for particle shape is required, report two consecutive failures in the same sieve size immediately, and determine what corrective action is needed.

3.12.4.2.7 Material Finer than the 75-µm No. 200 Sieve

When in the opinion of the Contracting Officer, a problem exists in connection with the cleanliness of aggregate, make tests in accordance with ASTM C117. Testing frequency must be as directed.

3.12.4.2.8 Corrective Action for Material Finer than the 75-µm No. 200 Sieve

When material finer than the 75-µm No. 200 sieve exceeds 1.0 percent of the weight of the aggregate finer than 37.5 mm 1.5 inches or 0.5 percent of the weight of the aggregate coarser than 37.5 mm 1.5 inches, notify the Contracting Officer and initiate steps, such as washing or other corrective action, immediately.

3.12.4.3 Quality of Aggregates

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NOTES: Tests should be those listed in paragraph QUALITY OF AGGREGATES.

Use petrographic examination to identify deleterious substances in aggregates. List deleterious substances individually with respective limits.

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3.12.4.3.1 Frequency of Quality Tests

Prior to submitting samples for mixture proportioning studies and 30 days prior to the start of concrete placement, perform the tests for aggregate quality in the following list. In addition, after the start of concrete placement, perform tests for aggregate quality in accordance with the following frequency schedule. Take samples tested after the start of concrete placement immediately prior to entering the concrete mixer.

PROPERTY	FINE AGGREGATE	FREQUENCY COARSE AGGREGATE	TEST
Particle Shape Testing	Not applicable	Every 6 months	ASTM D4791
[Bulk SSD] Specific Gravity	Every 3 months	Every 3 months	ASTM C127 ASTM C128
Absorption	Every 3 months	Every 3 months	ASTM C127 ASTM C128
Durability Factor (Procedure A)	Factor using Every 12 months	Every 12 months	COE CRD-C 144 ASTM C666/C666M
Clay Lumps and Friable Particles	Every 3 months	Every 3 months	ASTM C142/C142M
Material Finer than the 75-µm (No. 200) Sieve	Every 3 months	Every 3 months	ASTM C117
Organic Impurities	Every 3 months	Not applicable	ASTM C40/C40M

PROPERTY	FINE AGGREGATE	FREQUENCY COARSE AGGREGATE	TEST
L.A. Abrasion	Not applicable	Every 6 months	ASTM C131/C131M ASTM C535
Soft and Friable (Scratch Hardness)	Not applicable	Every 6 months	COE CRD-C 130
Petrographic Examination	Every 6 months	Every 6 months	ASTM C295/C295M
Chert, less than 2.40 specific gravity	Every 6 months	Every 6 months	ASTM C123/C123M
Coal and lignite, less than 2.00 specific gravity	Every 6 months	Every 6 months	ASTM C123/C123M
ASR	Every 12 months	Every 12 Months	ASTM C1527
Soundness by Magnesium Sulfate	Every 3 months	Every 3 months	ASTM C88

3.12.4.3.2 Corrective Action for Aggregate Quality

If the result of a quality test fails to meet the requirements for quality during submittal of samples for mixture-proportioning studies or immediately prior to start of concrete placement, change production procedures or materials and perform additional tests until the material meets the quality requirements prior to proceeding with either mixture-proportioning studies or starting concrete placement. After concrete placement commences, whenever the result of a test for quality fails the requirements, rerun the test immediately. If the second test fails the quality requirement, report the fact and take immediate steps to rectify the situation.

3.12.4.4 Scales

3.12.4.4.1 Weighing Accuracy

Check accuracy of the scales by test weights at least once a month for conformance with the applicable requirements of paragraph PLANT AND EQUIPMENT. Also make such tests as directed whenever there are variations in properties of the fresh concrete that could result from batching errors.

3.12.4.4.2 Batching and Recording Accuracy

Check the accuracy of each batching and recording device once a week during a weighing operation by noting and recording the required weight, recorded weight, and the actual weight batched. Confirm that the calibration devices described in paragraph PLANT AND EQUIPMENT in PART 2, for checking the accuracy of dispensed admixtures, are operating properly.

3.12.4.4.3 Scales Corrective Action

When either the weighing accuracy or batching accuracy does not comply with specification requirements, do not operate the plant until necessary

adjustments or repairs have been made. Correct discrepancies in recording accuracies immediately.

3.12.4.5 Batch-Plant Control

Control the measurement of all constituent materials including cementitious materials, each size of aggregate, water, and admixtures continuously. Adjust aggregate weights and amount of added water as necessary to compensate for free moisture in the aggregates. Adjust the amount of air-entraining agent to control air content within specified limits. Prepare a report indicating type and source of cement used, type and source of pozzolan or slag used, amount and source of admixtures used, aggregate source, the required aggregate and water weights per cubic meter yard, amount of water as free moisture in each size of aggregate, and the batch aggregate and water weights per cubic meter yard for each class of concrete batched during plant operation.

3.12.4.6 Concrete

3.12.4.6.1 Unit Weight

Determine unit weight of normal weight concrete in accordance to ASTM C138/C138M when compressive strength specimens are fabricated.

3.12.4.6.2 Air Content

The air content of the concrete must be measured when compressive strength specimens are fabricated. The air content test must be conducted in accordance with ASTM C231/C231M. Additional tests must be made when excessive variation in workability is reported, or as directed. Plot test results on control charts. Submit the control charts weekly and make the readily available to the Government. Keep copies of the current control charts in the field by testing crews and results plotted as tests are made. When a single test result reaches either the upper or lower action limit, perform a second test immediately. Plot the result of each test on a control chart for each mixture on which an average line is set at the midpoint of the specified air content range, respectively. Set an upper warning limit and a lower warning limit line 1.0 percentage point above and below the average line, respectively. Set an upper action limit and a lower action limit line 1.5 percentage points above and below the average line, respectively. Samples for air content may be taken at the mixer, however, the Contractor is responsible for delivering the concrete to the placement site at the specified air content. If the materials or transportation methods cause air content loss between the mixer and the placement, take correlation samples at the placement site as required by the Contracting Officer, and the control the air content at the mixer as directed.

3.12.4.6.3 Air Content Corrective Action

Whenever points on the control chart approach the upper or lower control limits, an adjustment should be made in the amount of air-entraining admixture batched. If a single test result is outside the specification limit, immediate adjustment is mandatory. As soon as practical after each adjustment, make another test to verify the correction of the adjustment. Whenever a point falls above the upper control for range, calibrate the dispenser to ensure that it is operating correctly and with good reproducibility. Whenever two consecutive points either for average or range are outside the control limits, notify the Contracting Officer.

3.12.4.6.4 Slump Testing

The slump or slump flow of the concrete must be measured when compressive strength specimens are fabricated. The slump test must be conducted in accordance with ASTM C143/C143M. The slump flow test must be conducted in accordance with ASTM C1611/C1611M. Visual Stability Index (VSI) must be determined at each slump flow test. Additional tests must be made when excessive variation in workability is reported, or as directed. Plot test results on control charts. Submit the control charts weekly and make them readily available to the Government. Keep copies of the current control charts in the field by testing crews and results plotted as tests are made. When a single slump/slump flow test reaches or goes beyond either the upper or lower action limit, immediately perform a second test. Set the upper warning limit at 1/2 inch below the maximum allowable slump/slump flow specified for each type of concrete and, set an upper action limit line and lower action limit line at the maximum and minimum allowable slumps/slump flows, respectively, as specified in the same paragraph. Take samples for slump/slump flow at the mixer. However, the Contractor is responsible for delivering the concrete to the placement site at the stipulated slump/slump flow. If the materials or transportation methods cause slump/slump flow loss between the mixer and the placement, take correlation samples at the placement site as required by the Contracting Officer, and the slump/slump flow at the mixer controlled as directed.

3.12.4.6.5 Slump Corrective Action

Whenever points on the control chart approach the upper or lower control limits, make an adjustment in the batch weights of water and fine aggregate. The adjustments are to be made so that the total water content does not exceed that amount specified in the mixture proportions provided based on the free water available with the aggregates and that amount of water batched. If the adjustments to the batch weights of water and aggregates do not satisfactorily produce the required slump, the Contracting Officer may adjust the mixture proportions if the fine-aggregate moisture content is stable and within the required limits. When a single slump is outside the control limits, such adjustment is mandatory. As soon as practical after each adjustment, make another test to verify the correctness of the adjustment. Whenever two consecutive individual slump tests, made during a period when there was no adjustment of batch weights, produce a point on the control chart for range above the upper control limits, consider the slump to be out of control, halt the concreting operation, and undertake additional testing for aggregate moisture content required, and take action immediately to correct the problem.

3.12.4.6.6 Temperature

The temperature of the concrete must be measured when compressive strength specimens are fabricated. Measurement must be in accordance with ASTM C1064/C1064M. The temperature must be reported along with the compressive strength data.

3.12.4.6.7 Compression Test Cylinders

At least one set of test cylinders must be made for every cubic meters yards[_____] produced, for each different concrete mixture containing Type I, Type II Portland cement or Type IL Portland Limestone blended cement

placed during the shift. Additional sets of test cylinders must be made, as directed, when the mixture proportions are changed or when low strengths have been detected. Develop a random sampling plan for approval by the Contracting Officer prior to start of construction. Assure that sampling is done in a completely random and unbiased, not just haphazard, manner. From each sample, a set of compression test cylinders must be made in accordance with ASTM C31/C31M. For self-consolidating concretewith a slump flow of 500 mm 20 inches or greater, cylinders must be made in accordance with ASTM C1758/C1758M. If the slump flow is less than 500 mm 20 inches follow ASTM C31/C31M. A set of cylinders for concrete containing 1.5 inches aggregate, or larger, must consist of ten 6 x 12 inch cylinders. From each set of ten cylinders, two are tested at 3 days, two at 7 days, two at 28 days, two at 56 days, and two at 90 days.

A set of cylinders for concrete containing 3/4 inch aggregate must consist of twelve 4 x 8 inch cylinders. Three to be tested at 3 days, three at 7 days, three at 28 days, three at 56 days, and three at 90 days.

All test cylinders must be molded and cured in accordance with ASTM C31/C31M and tested in accordance with ASTM C39/C39M. Compression test specimens must be cured while in the field in accordance with ASTM C31/C31M. If cylinders are not delivered to the testing laboratory within 24 to 48 hours after molding, they must be submerged in a water tank provided by the Contractor, where the surrounding water temperature is maintained by the Contractor at (73.4 plus or minus 3 degrees F) and saturated with calcium hydroxide. Cylinders must be transported in accordance with ASTM C31/C31M (with cushioning material) and unloaded in the Contractor's designated testing location. All compressive strength tests must be reported immediately. Quality control charts must be kept for individual strength tests, moving average for strength and moving average for range for each mixture. The charts must be similar to those found in ACI 214R.

3.12.4.7 Inspection Before Placing

Inspect foundation or construction joints, forms, and embedded items in sufficient time prior to each concrete placement in order to certify that they are ready to receive concrete. Report results of each inspection in writing.

3.12.4.8 Concrete Placement

3.12.4.8.1 Placing Inspection

The placing foreman must supervise all placing operations, must determine that the correct quality of concrete or grout is placed in each location as directed, and is responsible for measuring and recording concrete temperatures and ambient temperature hourly during placing operations, weather conditions, time of placement, volume yardage placed, and method of placement.

3.12.4.8.2 Placing Corrective Action

Do not permit placing to begin until an adequate number of vibrators in working order with competent operators are available is verified. Do not continue placing if any pile of concrete is inadequately consolidated. If any batch of concrete fails to meet the temperature requirements, take immediate steps to improve temperature controls.

3.12.4.9 Vibrators

3.12.4.9.1 Vibrator Testing and Use

Determine frequency and amplitude of each vibrator in accordance with COE CRD-C 521prior to initial use and at least once a month when concrete is being placed. Make additional tests as directed when a vibrator does not appear to be adequately consolidating the concrete. Determine the frequency while the vibrator is operating in concrete with the tachometer being held against the upper end of the vibrator head while almost submerged and just before the vibrator is withdrawn from the concrete. Determine the amplitude with the head vibrating in air. Take two measurements, one near the tip and another near the upper end of the vibrator head, and average these results. Report make, model, type, and size of the vibrator and frequency and amplitude results in writing.

3.12.4.9.2 Vibrator Corrective Action

Remove any vibrator not meeting the requirements of paragraph PREPARATION FOR PLACING above immediately from service and repair or replace.

3.12.4.10 Curing

3.12.4.10.1 Moist Curing Inspections

At least twice each shift, and twice per day on nonworking days, inspect all areas subject to moist curing. Note and record the surface moisture condition.

3.12.4.10.2 Moist Curing Corrective Action

When a daily inspection report lists an area of inadequate moistness, take immediate corrective action, and extend the required curing period for those areas by one day.

3.12.4.10.3 Membrane Curing Inspection

Do not apply curing compound until the Contractor's authorized representative has verified that the compound is properly mixed and ready for spraying. At the end of each operation, estimate the quantity of compound used by measurement of the container and the area of concrete surface covered and compute the rate of coverage in square meters per Liter square feet per gallon. Note whether or not coverage is uniform.

3.12.4.10.4 Membrane Curing Corrective Action

When the coverage rate of the curing compound is less than that specified or when the coverage is not uniform, spray the entire surface again.

3.12.4.10.5 Sheet Curing Inspection

At least once each shift and once per day on nonworking days, inspect all areas being cured using sheets. Note and record the condition of the covering and the tightness of the laps and tapes.

3.12.4.10.6 Sheet Curing Corrective Action

When a daily inspection report lists any tears, holes, or laps or joints that are not completely closed, repair the tears and holes promptly or

replace the sheets, close the joints, and extend the required curing period for those areas by one day.

3.12.4.11 Cold Weather Protection and Sealed Insulation Curing

At least once each shift and once per day on nonworking days inspect all areas subject to cold weather protection. Inspect the protection system for holes, tears, unsealed joints, or other incongruities which could result in damage to the concrete. Take special attention at edges, corners, and thin sections. Note, correct, and report any deficiencies.

3.12.4.12 Cold Weather Protection Corrective Action

When a daily inspection report lists any holes, tears, unsealed joints, or other incongruities, correct the deficiency immediately and extend the period of protection for one (1) day.

3.12.4.13 Mixer Uniformity

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NOTE: The optional phrases should be used if the Contractor is to perform the initial test. Correlate with paragraph PLANT AND EQUIPMENT in PART 2.
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3.12.4.13.1 Stationary Mixers

Prior to the start of concrete placing and once every 3 months when concrete is being placed, or once for every 57,000 cubic meters 75,000 cubic yards of concrete placed, whichever results in the longest time, determine interval uniformity of concrete mixing in accordance with paragraph PLANT AND EQUIPMENT.[The initial and every][Every] fourth set of tests must be regular tests performed on three batches of concrete. Intermediate uniformity tests must be abbreviated tests performed on a single batch of concrete. If the mixer fails the abbreviated test, perform a regular test immediately. Whenever adjustments in a mixer or increased mixing time are required because of failure of a uniformity test, reevaluate the mixer by a regular test after the adjustments have been completed. If the Contractor proposes to reduce a mixing time, perform a regular test to evaluate the proposed time. Perform additional testing when directed when there is visible evidence of possible improper mixer performance. Report results of all uniformity tests in writing.

3.12.4.13.2 Truck Mixers

Prior to the start of concrete placing and at least once every 6 months when concrete is being placed, determine uniformity of concrete in accordance with ASTM C94/C94M. Select truck mixers randomly for testing. When satisfactory performance is found in one truck mixer, the performance of mixers of substantially the same design and condition of the blades may be regarded as satisfactory. Report results of tests in writing.

3.12.4.14 Mixer Uniformity Corrective Action

When a mixer fails to meet mixer uniformity requirements, either increase the mixing time, change batching sequence, reduce batch size, or make adjustments to the mixer until compliance is achieved.

3.12.5 Reports

Report all results of tests or inspections conducted informally as they are completed and in writing daily. Prepare a weekly report for the updating of control charts covering the entire period from the start of the construction season through the current week. During periods of cold weather protection, make daily reports of pertinent temperatures. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in preceding paragraphs. Confirm such reports of failures and the action taken in writing in the routine reports. The Contracting Officer has the right to examine all contractor quality control records.

3.13 REPAIR, REHABILITATION AND REMOVAL

Before the Government accepts the structure and final payment is made, inspect the structure for cracks, damage and substandard concrete placements that may adversely affect the service life of the structure. Submit a Repair Plan report documenting these defects, which includes recommendations for repair, removal, surface preparation, and repair materials for remediation to the Contracting Officer for approval before any corrective work is accomplished.

3.13.1 Repair of Major Defects

Major defects are those which involve more than 36 square inches of concrete or expose reinforcing steel. Submit a repair plan to the contracting officer for approval.

3.13.2 Crack Repair

Prior to final acceptance, document and repair all cracks greater than or equal to 0.02 inches wide in accordance with ACI 548.15. Submit the proposed method and materials to repair the cracks to the Contracting Officer for approval. Address the amount of movement expected in the crack due to temperature changes and loading.

3.13.3 Repair of Weak Surfaces

Weak surfaces are defined as mortar-rich, rain-damaged, uncured, or containing exposed voids or deleterious materials. Diamond grind concrete surfaces with weak surfaces less than 1/4 inch thick to remove the weak surface. Remove and replace surfaces containing weak surfaces greater than 1/4 inch thick or mitigate in a manner acceptable to the Contracting Officer.

-- End of Section --