
USACE / NAVFAC / AFCEC / NASA UFGS-03 30 00.00 10 (May 2014)
Change 1 - 02/15

Preparing Activity: USACE Superseding
 UFGS-03 31 00.00 10 (November 2010)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2017

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DIVISION 03 - CONCRETE

SECTION 03 30 00.00 10

CAST-IN-PLACE CONCRETE

05/14

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SECTION 03 30 00.00 10

CAST-IN-PLACE CONCRETE
05/14

NOTE: This guide specification covers the requirements for cast-in-place concrete materials, mixing, and placement not exposed to a marine or high chloride environment. For concrete exposed to a marine or high chloride environment use UFGS 03 31 29 MARINE CONCRETE.

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

NOTE: This specification covers concrete work primarily for buildings, but may also be used for other applications such as wharves, docks, drainage structures, warehouse type slabs, and driveways. The following guide specifications are relative to this section and will be included to the extent applicable in projects where this section is used:

Section 03 11 13.00 10 STRUCTURAL CAST-IN-PLACE
CONCRETE FORMING
Section 03 20 00.00 10 CONCRETE REINFORCEMENT

Section 03 15 00.00 10 CONCRETE ACCESSORIES
Section 03 35 00.00 10 CONCRETE FINISHING
Section 03 39 00.00 10 CONCRETE CURING
Section 07 92 00 JOINT SEALANTS

Specifications on concrete for bridge construction should be in a separate section and should be essentially in agreement with concrete construction requirements in the American Association of State Highway and Transportation Officials, "Standard Specifications for Highway Bridges". Requirements for deck slabs, curbs, gutters, and sidewalks forming an integral part of the bridge should be included in the section concerning concrete for bridge construction.

In addition to specified requirements the following information will be shown on project drawings:

1. Assumed temperature range when temperature stresses are a factor in design.
2. Details of concrete sections showing dimensions, reinforcement cover, and required camber.
3. Joint details showing locations and dimensions, including critical construction joints, indicating waterstop locations and splices, keys, and dowels when required.
4. Locations where structural lightweight concrete will be used.
5. Details which require a depressed structural slab for tile, terrazzo, or other floor finishes in order to provide finished surfaces at the same elevations.
6. When exposed concrete surfaces are specified, the locations in the finished structure should be indicated. If other than cast finish is required, the type and location must be indicated.
7. Loading assumptions
8. Material strengths used in design for each element, f'c.
9. Yield strength of reinforcement required 414 MPa 60,000 psi or other grades as available.

1.1 UNIT PRICES

NOTE: Remove these paragraphs when lump sum contract is required.

1.1.1 Measurement

Measurement of concrete for payment will be made on the basis of the actual volume within the pay lines of the structure as indicated on the contract drawings. Measurement for payment of concrete placed against the sides of any excavation without intervening forms will be made only within the pay lines of the structure as shown on the contract drawings. No deductions will be made for rounded or beveled edges, for space occupied by metal work, for conduits, for voids, or for embedded items which are less than 0.15 cubic meters 5 cubic feet in volume or 0.09 square meters 1 square foot in cross section.

1.1.2 Payment

Unless otherwise specified, payment for concrete will be made at the respective unit prices per cubic meter yard for the various items of the schedule, measured as specified above, which price includes the cost of all labor, materials, and the use of equipment and tools required to complete the concrete work, except for any reinforcement and embedded parts specified to be paid separately. Unit price payment will not be made for concrete placed in structures for which payment is made as a lump sum.

1.2 LUMP SUM CONTRACT

NOTE: Remove this paragraph when unit price contract is required.

Under this type of contract, concrete items will be paid for by lump sum and will not be measured. The work covered by these items consists of furnishing all concrete materials, reinforcement, miscellaneous embedded materials, and equipment, and performing all labor for the forming, manufacture, transporting, placing, finishing, curing, and protection of concrete in these structures.

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 CONCRETE INSTITUTE INTERNATIONAL (ACI)

| | |
|------------|--|
| ACI 117 | (2010; Errata 2011) Specifications for Tolerances for Concrete Construction and Materials and Commentary |
| ACI 121R | (2008) Guide for Concrete Construction Quality Systems in Conformance with ISO 9001 |
| ACI 211.1 | (1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete |
| ACI 211.2 | (1998; R 2004) Standard Practice for Selecting Proportions for Structural Lightweight Concrete |
| ACI 213R | (2014) Guide for Structural Lightweight-Aggregate Concrete |
| ACI 214R | (2011) Evaluation of Strength Test Results of Concrete |
| ACI 301 | (2016) Specifications for Structural Concrete |
| ACI 301M | (2016) Metric Specifications for Structural Concrete |
| ACI 304.2R | (1996; R 2008) Placing Concrete by Pumping Methods |
| ACI 304R | (2000; R 2009) Guide for Measuring, Mixing, Transporting, and Placing Concrete |
| ACI 305.1 | (2014) Specification for Hot Weather Concreting |
| ACI 306.1 | (1990; R 2002) Standard Specification for Cold Weather Concreting |
| ACI 309R | (2005) Guide for Consolidation of Concrete |
| ACI 318 | (2014; Errata 1-2 2014; Errata 3-5 2015; Errata 6 2016; Errata 7 2017) Building Code Requirements for Structural Concrete and Commentary |
| ACI 318M | (2014; ERTA 2015) Building Code Requirements for Structural Concrete & Commentary |
| ACI SP-15 | (2011) Field Reference Manual: Standard Specifications for Structural Concrete ACI |

301-05 with Selected ACI References

ASTM INTERNATIONAL (ASTM)

| | |
|-------------------|--|
| ASTM C1017/C1017M | (2013; E 2015) Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete |
| ASTM C1064/C1064M | (2011) Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete |
| ASTM C1077 | (2016) Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation |
| ASTM C1107/C1107M | (2014a) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink) |
| ASTM C1116/C1116M | (2010a; R 2015) Standard Specification for Fiber-Reinforced Concrete |
| ASTM C1157/C1157M | (2017) Standard Performance Specification for Hydraulic Cement |
| ASTM C1240 | (2014) Standard Specification for Silica Fume Used in Cementitious Mixtures |
| ASTM C1260 | (2014) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method) |
| ASTM C131/C131M | (2014) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine |
| ASTM C136/C136M | (2014) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates |
| ASTM C143/C143M | (2015) Standard Test Method for Slump of Hydraulic-Cement Concrete |
| ASTM C150/C150M | (2017) Standard Specification for Portland Cement |
| ASTM C1567 | (2013) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method) |
| ASTM C1602/C1602M | (2012) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete |
| ASTM C172/C172M | (2014a) Standard Practice for Sampling Freshly Mixed Concrete |

| | |
|-----------------|---|
| ASTM C173/C173M | (2016) Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method |
| ASTM C192/C192M | (2016a) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory |
| ASTM C231/C231M | (2017a) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method |
| ASTM C260/C260M | (2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete |
| ASTM C309 | (2011) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete |
| ASTM C31/C31M | (2017) Standard Practice for Making and Curing Concrete Test Specimens in the Field |
| ASTM C311/C311M | (2013) Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland-Cement Concrete |
| ASTM C33/C33M | (2016) Standard Specification for Concrete Aggregates |
| ASTM C330/C330M | (2017a) Standard Specification for Lightweight Aggregates for Structural Concrete |
| ASTM C39/C39M | (2017b) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens |
| ASTM C42/C42M | (2013) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete |
| ASTM C494/C494M | (2017) Standard Specification for Chemical Admixtures for Concrete |
| ASTM C496/C496M | (2011) Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens |
| ASTM C552 | (2016a) Standard Specification for Cellular Glass Thermal Insulation |
| ASTM C567/C567M | (2014) Determining Density of Structural Lightweight Concrete |
| ASTM C578 | (2017a) Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation |
| ASTM C591 | (2017) Standard Specification for Unfaced |

| | |
|---|--|
| | Preformed Rigid Cellular Polyisocyanurate Thermal Insulation |
| ASTM C595/C595M | (2017) Standard Specification for Blended Hydraulic Cements |
| ASTM C618 | (2012a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete |
| ASTM C685/C685M | (2014) Concrete Made by Volumetric Batching and Continuous Mixing |
| ASTM C78/C78M | (2016) Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading) |
| ASTM C937 | (2016) Grout Fluidifier for Preplaced-Aggregate Concrete |
| ASTM C94/C94M | (2017a) Standard Specification for Ready-Mixed Concrete |
| ASTM C989/C989M | (2017) Standard Specification for Slag Cement for Use in Concrete and Mortars |
| ASTM D5759 | (2012) Characterization of Coal Fly Ash and Clean Coal Combustion Fly Ash for Potential Uses |
| ASTM D75/D75M | (2014) Standard Practice for Sampling Aggregates |
| ASTM E1643 | (2011; R 2017) Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs |
| ASTM E1745 | (2017) Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs |
| ASTM E1993/E1993M | (1998; R 2013; E 2013) Standard Specification for Bituminous Water Vapor Retarders Used in Contact with Soil or Granular Fill Under Concrete Slabs |
| ASTM E96/E96M | (2016) Standard Test Methods for Water Vapor Transmission of Materials |
| CONCRETE REINFORCING STEEL INSTITUTE (CRSI) | |
| CRSI 10MSP | (2009; 28th Ed) Manual of Standard Practice |
| NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST) | |
| NIST HB 44 | (2016) Specifications, Tolerances, and Other Technical Requirements for Weighing |

and Measuring Devices

NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA)

| | |
|----------------|--|
| NRMCA CPMB 100 | (2000; R 2006) Concrete Plant Standards |
| NRMCA QC 3 | (2011) Quality Control Manual: Section 3, Plant Certifications Checklist: Certification of Ready Mixed Concrete Production Facilities |
| NRMCA TMMB 100 | (2001; R 2007) Truck Mixer, Agitator and Front Discharge Concrete Carrier Standards |

U.S. ARMY CORPS OF ENGINEERS (USACE)

| | |
|---------------|--|
| COE CRD-C 104 | (1980) Method of Calculation of the Fineness Modulus of Aggregate |
|---------------|--|

1.4 Definitions

1.4.1 Cementitious Material

As used herein, includes all portland cement, pozzolan, fly ash, ground granulated blast-furnace slag[, and silica fume].

1.4.2 Chemical Admixtures

Materials in the form of powder or fluids that are added to the concrete to give it certain characteristics not obtainable with plain concrete mixes.

1.4.3 Complementary Cementing Materials (CCM)

Coal fly ash[, silica fume], granulated blast-furnace slag, natural or calcined pozzolans, and ultra-fine coal ash when used in such proportions to replace the portland cement that result in considerable improvement to sustainability, durability.

1.4.4 Design Strength (f'_c)

The specified compressive strength of concrete at time(s) specified in this section to meet structural design criteria.

1.4.5 Mass Concrete

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

1.4.6 Mixture Proportioning

The process of designing concrete mixture proportions to enable it to meet the strength, service life and constructability requirements of the project.

1.4.7 Mixture Proportions

The masses or volumes of individual ingredients used to make a unit measure (cubic meter yard) of concrete.

1.4.8 Pozzolan

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

1.4.9 Workability or Consistency

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

1.5 SUBMITTALS

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

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

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

Use the "S" classification only in SD-11 Closeout Submittals. The "S" following a submittal item indicates that the submittal is required for the Sustainability eNotebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING.

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

Government approval is required for submittals with a "G" designation;

submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Quality Control Plan; G[, [____]]
Laboratory Accreditation
Sampling Plan; G[, [____]]

SD-03 Product Data

Recycled Content Products; (LEED)
Cementitious Materials
Vapor Retarder
Vapor Barrier
Floor Finish
Floor Hardener
Chemical Admixtures

SD-04 Samples

Surface Retarder

SD-05 Design Data

Mixture Proportions; G[, [____]]
Lightweight Aggregate Concrete

SD-06 Test Reports

Mixture Proportions; G[, [____]]
Testing and Inspection for CQC; G[, [____]]
Fly Ash
Ground Granulated Blast-Furnace (GGBF) Slag
Aggregates
Air Content
Slump
Compressive Strength
Water

SD-07 Certificates

Contractor Quality Control personnel
Ready-Mix Plant

1.6 QUALITY ASSURANCE

Submit qualifications for Contractor Quality Control personnel assigned to concrete construction as American Concrete Institute (ACI) Certified Workmen in one of the following grades or show written evidence of having completed similar qualification programs:

| | |
|---|---|
| Concrete Field Testing Technician | Grade I |
| Concrete Laboratory Testing Technician | Grade I or II |
| Concrete Construction Inspector | Level II |
| Concrete Transportation Construction Inspector or Reinforced Concrete Special Inspector | Jointly certified by American Concrete Institute (ACI), Building Official and Code Administrators International (BOCA), International Code Council (ICC), and Southern Building Code Congress International (SBCCI) |
| Foreman or Lead Journeyman of the flatwork finishing crew | Similar qualification for ACI Concrete Flatwork Technician/Finisher or equal, with written documentation |

1.6.1 Laboratory Accreditation

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

1.6.1.1 Aggregate Testing and Mix Proportioning

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

Perform aggregate testing and mixture proportioning studies in an accredited laboratory, under the direction of a [registered professional engineer in a U.S. state or territory][_____] who is competent in concrete materials. This person is required to sign all reports and designs.

1.6.1.2 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.

1.6.1.3 Contractor Quality Control

All sampling and testing must be performed by an approved, onsite, independent, accredited laboratory.

1.6.2 Quality Control Plan

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

1.6.3 Pre-installation Meeting

NOTE: When the construction includes special items such as very high strength concrete; non-sparking, conductive flooring; acid-resistant concrete; slipforming; super-flat floors, a pre-installation meeting will be required. In which case this paragraph will be retained with appropriate editing and identification.

A pre-installation meeting with the Contracting Officer is required at least 10 days prior to start of construction on [_____]. Conduct the meeting with the Project Superintendent and active installation personnel present.

1.6.4 Special Properties and Products

NOTE: If the use of a particular type of admixture is required for certain parts of the structure, this paragraph should be revised accordingly.

Concrete may contain admixtures other than air entraining agents, such as water reducers, superplasticizers, or set retarding agents to provide special properties to the concrete, if specified or approved. Include any of these materials to be used on the project in the mix design studies.

1.6.5 Technical Service for Specialized Concrete

NOTE: Use this paragraph when lightweight aggregate structural concrete is specified or for other specialized concretes like those containing silica fume.

Obtain the services of a factory trained technical representative to oversee proportioning, batching, mixing, placing, consolidating, and finishing of specialized structural concrete, such as [_____]. The technical representative must be on the job full time until the Contracting Officer is satisfied that field controls indicate concrete of specified quality is furnished and that the crews are capable of continued satisfactory work. Make the technical representative available for consultation with and advising Government forces.

1.6.6 Government Assurance Inspection and Testing

Day-to day inspection and testing is the responsibility of the Contractor Quality Control (CQC) staff. However, representatives of the Contracting Officer can and will inspect construction as considered appropriate and will monitor operations of the CQC staff. Government inspection or testing will not relieve any CQC responsibilities.

1.6.6.1 Materials

The Government will sample and test aggregates, cementitious materials, other materials, and concrete to determine compliance with the specifications as considered appropriate. 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 ASTM D75/D75M. Other materials will be sampled from storage at the jobsite or from other locations as considered appropriate. Samples may be placed in storage for later testing when appropriate.

1.6.6.2 Fresh Concrete

Fresh concrete will be sampled as delivered in accordance with ASTM C172/C172M and tested in accordance with these specifications, as considered necessary.

1.6.6.3 Hardened Concrete

Tests on hardened concrete will be performed by the Government when such tests are considered necessary.

1.6.6.4 Inspection

Concrete operations may be tested and inspected by the Government as the project progresses. Failure to detect defective work or material will not prevent rejection later when a defect is discovered nor will it obligate the Government for final acceptance.

1.7 DELIVERY, STORAGE, AND HANDLING

Follow ACI 301 and ACI 304R requirements and recommendations. Store cement and other cementitious materials in weathertight buildings, bins, or silos that exclude moisture and contaminants and keep each material completely separated. Arrange and use aggregate stockpiles in a manner to avoid excessive segregation and to prevent contamination with other materials or with other sizes of aggregates. Do not store aggregate directly on ground unless a sacrificial layer is left undisturbed. Store reinforcing bars and accessories above the ground on platforms, skids or other supports. Store other materials in a manner to avoid contamination and deterioration. Admixtures which have been in storage at the project site for longer than 6 months or which have been subjected to freezing cannot be used unless retested and proven to meet the specified requirements. Materials must be capable of being accurately identified after bundles or containers are opened.

PART 2 PRODUCTS

**NOTE: Edit this PART to include only those products
which are locally available, are required by the**

project, and are acceptable to the designer.

In accordance with Section 01 33 29 SUSTAINABILITY REPORTING submit documentation indicating: distance between manufacturing facility and the project site, distance of raw material origin from the project site, percentage of post-industrial and post-consumer recycled content per unit of product and relative dollar value of recycled content products to total dollar value of products included in project. Provide Submittals as specified in the subject Section.

2.1 SYSTEM DESCRIPTION

NOTE: This paragraph places the responsibility for mixture proportioning on the Contractor. Where Government mix design is required, the entire paragraph will be revised accordingly. Do not delete 15 percent minimum for pozzolan, unless pozzolan is prohibited.

Provide concrete composed of portland cement, other cementitious and pozzolanic materials as specified, aggregates, water and admixtures as specified.

2.1.1 Proportioning Studies-Normal Weight Concrete

Trial design batches, mixture proportions studies, and testing requirements for various types of concrete specified are the responsibility of the Contractor. Base mixture proportions on compressive strength as determined by test specimens fabricated in accordance with ASTM C192/C192M and tested in accordance with ASTM C39/C39M. Obtain mix design approval from the Contracting Officer prior to concrete placement.

- a. Samples of all materials used in mixture proportioning studies must be representative of those proposed for use in the project and be accompanied by the manufacturer's or producer's test reports indicating compliance with these specifications.
- b. Make trial mixtures having proportions, consistencies, and air content suitable for the work based on methodology described in ACI 211.1, 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 on the project.
- c. The maximum water-cementitious material ratios allowed in subparagraph WATER-CEMENTITIOUS MATERIAL RATIO below will be the equivalent water-cementitious material ratio as determined by conversion from the weight ratio of water to cement plus pozzolan by the weight equivalency method as described in ACI 211.1. In the case where silica fume or GGBF slag is used, include the weight of the silica fume and GGBF slag in the equations in ACI 211.1 for the term P, which is used to denote the weight of pozzolan. If pozzolan is used in the concrete mixture, the minimum pozzolan content is 15 percent by weight of the total cementitious material, and the maximum is 35 percent.
- d. Design laboratory trial mixtures for maximum permitted slump and air content. Make separate sets of trial mixture studies for each combination of cementitious materials and each combination of

admixtures proposed for use. No combination of either may be used until proven by such studies, except that, if approved in writing and otherwise permitted by these specifications, an accelerator or a retarder may be used without separate trial mixture study. Separate trial mixture studies must also be made for concrete for any conveying or placing method proposed which requires special properties and for concrete to be placed in unusually difficult placing locations. For previously approved concrete mix designs used within the past twelve months, the previous mix design may be re-submitted without further trial batch testing if accompanied by material test data conducted within the last six months.

- e. Report the temperature of concrete in each trial batch. For each water-cementitious material ratio, make at least three test cylinders for each test age, cure in accordance with ASTM C192/C192M and test at 7 and 28[56,][90] days in accordance with ASTM C39/C39M. From these test results, plot a curve showing the relationship between water-cementitious material ratio and strength for each set of trial mix studies. In addition, plot a curve showing the relationship between 7 day and 28[56,][90] day strengths. Design each mixture to promote easy and suitable concrete placement, consolidation and finishing, and to prevent segregation and excessive bleeding.
- f. Submit the results of trial mixture design studies along with a statement giving the maximum nominal coarse aggregate size and the proportions of ingredients that will be used in the manufacture of each strength of concrete, at least 60 days prior to commencing concrete placing operations. Base aggregate weights on the saturated surface dry condition. Accompany the statement with test results from an approved independent commercial testing laboratory, showing that mixture design studies have been made with materials proposed for the project and that the proportions selected will produce concrete of the qualities indicated. No substitutions may be made in the materials used in the mixture design studies without additional tests to show that the quality of the concrete is satisfactory.

2.1.2 Proportioning Studies-Lightweight Aggregate Structural Conc

Trial design batches, mixture proportioning studies, and testing requirements must conform to the requirements specified in paragraph PROPORTIONING STUDIES-NORMAL WEIGHT CONCRETE above, except as follows. Trial mixtures having proportions, consistencies and air content suitable for the work must be made based on methodology described in ACI 211.2, using at least three different cement contents. Proportion trial mixes to produce air dry unit weight, concrete strengths, maximum permitted slump, and air content. Test specimens and testing must be as specified for normal weight concrete except that [28-day compressive strength] [splitting tensile strength in accordance with ASTM C496/C496M] must be determined from test cylinders that have been air dried at 50 percent relative humidity for the last 21 days. Determine air dry unit weight in accordance with ASTM C567/C567M, designed to be at least 32 kg/cubic meter 2.0 pcf less than the maximum specified air dry unit weight. Plot curves using these results showing the relationship between cement factor and strength and air dry unit weight. Normal weight fine aggregate may be substituted for part or all of the lightweight fine aggregate, provided the concrete meets the strength and unit weight. A correlation must also be developed showing the ratio between air dry unit weight and fresh concrete unit weight for each mix.

2.1.3 Average Compressive Strength

The mixture proportions selected during mixture design studies must produce a required average compressive strength (f'_{cr}) exceeding the specified compressive strength (f'_c) by the amount indicated below, but may not exceed the specified strength at the same age by more than 20 percent. This required average compressive strength, f'_{cr} , will not be a required acceptance criteria during concrete production. However, whenever the daily average compressive strength at 28 days drops below f'_{cr} during concrete production, or daily average 7-day strength drops below a strength correlated with the 28-day f'_{cr} , adjust the mixture, as approved, to bring the daily average back up to f'_{cr} . During production, the required f'_{cr} must be adjusted, as appropriate, based on the standard deviation being attained on the job.

2.1.4 Computations from Test Records

Where a concrete production facility has test records, establish a standard deviation in accordance with the applicable provisions of ACI 214R. Test records from which a standard deviation is calculated must represent materials, quality control procedures, and conditions similar to those expected; must represent concrete produced to meet a specified strength or strengths (f'_c) within 7 MPa 1000 psi of that specified for proposed work; and must consist of at least 30 consecutive tests. A strength test must be the average of the strengths of two cylinders made from the same sample of concrete and tested at 28[56][90] days. Required average compressive strength f'_{cr} used as the basis for selection of concrete proportions must be in accordance with ACI 318 Chapter 5.

2.1.5 Mix Design for Bonded Topping for Heavy Duty Floors

The concrete mix design for bonded topping for heavy duty floors must contain the greatest practical proportion of coarse aggregate within the specified proportion limits. Design the mix to produce concrete having a 28-day strength of at least 34.5 MPa 5000 psi. Concrete for the topping must consist of the following proportions, by weight:

1.00 part portland cement
1.15 to 1.25 parts fine aggregate
1.80 to 2.00 parts coarse aggregate

Maximum water-cementitious material ratio must be 0.33. The topping concrete must not be air-entrained. The concrete must be mixed so as to produce a mixture of the driest consistency possible to work with a sawing motion of the strike-off and which can be floated and compacted as specified without producing water or excess cement at the surface. In no case must slump exceed 25 mm 1 inch as determined by ASTM C143/C143M.

2.1.6 Tolerances

NOTE: Insert any special tolerance requirements of the project. Select the method desired for floor finish tolerance and delete the other. Do not use both as a Contractor's option. An effort should be made to begin to convert to the F-system for floor slabs. The F-system should always be used where very flat floors are required, particularly warehouse aisles where high-lift forklift units or

other similar stackers will operate.

Except as otherwise specified herein, tolerances for concrete batching, mixture properties, and construction as well as definition of terms and application practices must be in accordance with ACI 117. Take level and grade tolerance measurements of slabs as soon as possible after finishing; when forms or shoring are used, the measurements must be made prior to removal.

2.1.7 Floor Finish

For floor finishes, see Section 03 35 00.00 10 CONCRETE FINISHING.

2.1.8 Strength Requirements

Specified compressive strength (f'_c) must be as follows:

| COMPRESSIVE STRENGTH | STRUCTURE OR PORTION OF STRUCTURE |
|--|-----------------------------------|
| 35 MPa5000 psi at 28 days | [_____] |
| 27.5 MPa4000 psi at 28 days | [_____] |
| 20 MPa3000 psi at 28 days | [_____] |
| [_____] MPa[_____] psi at [_____] days | [_____] |

NOTE: Use eight cylinders when specifying 56 or 90 day strengths. Use 150x300 6x12 cylinders for better prediction of strength and consistency.

Concrete made with high-early strength cement must have a 7-day strength equal to the specified 28-day strength for concrete made with Type I or II portland cement. Compressive strength must be determined in accordance with ASTM C39/C39M.

2.1.8.1 Evaluation of Concrete Compressive Strength

Fabricate [six] [eight] compressive strength specimens, [150 mm by 300 mm 6 inch by 12 inch] [100 mm by 200 mm 4 inch by 8 inch] cylinders, laboratory cure them in accordance with ASTM C31/C31M and test them in accordance with ASTM C39/C39M. Test two cylinders at 7 days, two cylinders at 28 days, [two cylinders at 56 days][two cylinders at 90 days] and hold two cylinder in reserve. The strength of the concrete is considered satisfactory so long as the average of all sets of three consecutive test results do not exceed the specified compressive strength f'_c by 20 percent and no individual test result falls below the specified strength f'_c by more than 3.5 MPa 500 psi), unless approved by the Contracting Officer. A "test" is defined as the average of two companion cylinders, or if only one cylinder is tested, the results of the single cylinder test. Additional analysis or testing, including taking cores and/or load tests may be required when the strength of the concrete in the structure is considered potentially

deficient.

2.1.1.8.2 Investigation of Low-Strength Compressive Test Results

When any strength test of standard-cured test cylinders falls below the specified strength requirement by more than 3.5 MPa 500 psi or if tests of field-cured cylinders indicate deficiencies in protection and curing, take steps to assure that the load-carrying capacity of the structure is not jeopardized. When the strength of concrete in place is considered potentially deficient, obtain cores and test in accordance with ASTM C42/C42M. Take at least three representative cores from each member or area of concrete in place that is considered potentially deficient. The location of cores will be determined by the Contracting Officer to least impair the strength of the structure. Concrete in the area represented by the core testing will be considered adequate if the average strength of the cores is equal to at least 85 percent of the specified strength requirement and if no single core is less than 75 percent of the specified strength requirement. Non-destructive tests (tests other than test cylinders or cores) may not be used as a basis for acceptance or rejection. Perform the coring and repair the holes; cores will be tested by the Government.

2.1.1.8.3 Load Tests

If the core tests are inconclusive or impractical to obtain or if structural analysis does not confirm the safety of the structure, load tests may be directed by the Contracting Officer in accordance with the requirements of ACI 318M ACI 318. Correct concrete work evaluated by structural analysis or by results of a load test as being understrength in a manner satisfactory to the Contracting Officer. Perform all investigations, testing, load tests, and correction of deficiencies approved by the Contracting Officer, except that if all concrete is found to be in compliance with the drawings and specifications, the cost of investigations, testing, and load tests will be at the expense of the Government.

2.1.1.9 Water-Cementitious Material Ratio

**NOTE: Refer to ACI 318M ACI 318 Chapter 4 for
maximum water-cementitious material ratios based on
the exposure class.**

Maximum water-cementitious material ratio (w/c) for normal weight concrete is as follows:

| WATER-CEMENTITIOUS MATERIAL RATIO, BY WEIGHT | STRUCTURE OR PORTION OF STRUCTURE |
|---|-----------------------------------|
| 0.40 | [_____] |
| 0.45 | [_____] |
| 0.50 | [_____] |

| WATER-CEMENTITIOUS MATERIAL RATIO, BY WEIGHT | STRUCTURE OR PORTION OF STRUCTURE |
|--|-----------------------------------|
| 0.55 | [_____] |
| [_____] | [_____] |

2.1.10 Air Entrainment

NOTE: Remove last two sentences when lightweight concrete is not required.

Refer to ACI 318M ACI 318, Chapter 4 for guidance on air content.

Entrained air should not be used for concrete to be given a smooth, dense, hard-troweled finish because blistering and delamination may occur. Refer to ACI 302.1R for a detailed discussion on how to produce high-quality concrete slabs-on-ground and suspended floors for various classes of service.

Air entrain normal weight concrete based on the following table[, except as otherwise specified for lightweight concrete].

| MINIMUM AIR CONTENT Percent | STRUCTURE OR PORTION OF STRUCTURE |
|-----------------------------|-----------------------------------|
| 4.5 | [_____] |
| 5.0 | [_____] |
| 6.0 | [_____] |
| [_____] | [_____] |

Attain specified air content at point of placement into the forms within plus or minus 1.5 percent. Determine air content for normal weight concrete in accordance with ASTM C231/C231M. [Air entrain lightweight concrete in the [_____] parts of the structure with a total air content of 4.5 to 7.5 percent, except that if the nominal maximum size coarse aggregate is 9.5 mm 3/8 inch or less, the air content must be 5.5 to 8.5 percent. Determine air content for lightweight concrete in accordance with ASTM C173/C173M.]

2.1.11 Slump

NOTE: Use the sentence in the first set of brackets when those admixtures are permitted by the specifications. When admixtures are added on site use the bracket statement requiring a 50 to 100 mm 2 to 4 inch slump before the admixtures are added.

Add special slump requirements for Class 8 and 9 floor slabs from ACI 302, when such floors are to be constructed. Edit for lightweight concrete as required.

Slump of the concrete, as delivered to the point of placement into the forms, must be within the following limits. Determine slump in accordance with ASTM C143/C143M.

| Structural Element | Slump mm inches | |
|--|-----------------|---------|
| | Minimum | Maximum |
| Walls, columns and beams | 50 2 | 100 4 |
| Foundation walls, substructure walls, footings, slabs | 25 1 | 75 3 |
| Any structural concrete approved for placement by pumping: | | |
| At pump | 50 2 | 200 8 |
| At discharge of line | 251 | 1004 |

[When use of a plasticizing admixture conforming to ASTM C1017/C1017M or when a Type F or G high range water reducing admixture conforming to ASTM C494/C494M is permitted to increase the slump of concrete, concrete must have [a slump of 50 to 100 mm 2 to 4 inches before the admixture is added and]a maximum slump of 200 mm 8 inches at the point of delivery after the admixture is added.] [For troweled floors, slump of structural lightweight concrete with normal weight sand placed by pump must not exceed 125 mm 5 inches at the point of placement. For other slabs, slump of lightweight concrete must not exceed 100 mm 4 inches at point of placement.]

2.1.12 Concrete Temperature

The temperature of the concrete as delivered must not exceed 32 degrees C 90 degrees F. When the ambient temperature during placing is 5 degrees C 40 degrees F or less, or is expected to be at any time within 6 hours after placing, the temperature of the concrete as delivered must be between 12 and 25 degrees C 55 and 75 degrees F.

2.1.13 Size of Coarse Aggregate

Use the largest feasible nominal maximum size aggregate (NMSA), specified in PART 2 paragraph AGGREGATES, in each placement. However, do not exceed nominal maximum size of aggregate for any of the following: three-fourths of the minimum cover for reinforcing bars, three-fourths of the minimum clear spacing between reinforcing bars, one-fifth of the narrowest dimension between sides of forms, or one-third of the thickness of slabs or toppings.

2.1.14 Lightweight Aggregate Structural Concrete

NOTE: Retain this paragraph when lightweight aggregate structural concrete is required. Use bracketed alternate strength inserts (compressive or splitting tensile strength) as appropriate. Correlate strength versus unit weight requirements as determined from table in ASTM C330/C330M, and as determined by consultation with local producers. Remove last sentence when floor fill is not required.

Conform lightweight aggregate structural concrete to the requirements specified for normal weight concrete except as specified herein. [Compressive strength must be at least [_____] at 28 days,] [Splitting tensile strength determined in accordance with ASTM C496/C496M must be at least [_____] at 28 days,] as determined by test specimens that have been air dried at 50 percent relative humidity for the last 21 days. Air-dry unit weight must not be over [_____] at equilibrium as determined by ASTM C567/C567M. However, use fresh unit weight for acceptance during concreting, using a correlation factor between the two types of unit weight as determined during mixture design studies. Lightweight aggregate structural concrete floor fill must have a 28-day compressive strength of at least 17.3 MPa 2500 psi and an air-dry unit weight not exceeding 1850 kg/cubic meter 115 pcf at equilibrium.

2.2 CEMENTITIOUS MATERIALS

NOTE: EPA recommends that procuring agencies use flowable fill containing coal fly ash (pozzolan) and/or ferrous foundry sands for backfill and other fill applications. EPA further recommends that procuring agencies include provisions in all construction contracts involving backfill or other fill applications, to allow for the use of flowable fill containing coal fly ash and/or ferrous foundry sands, where appropriate.

Include the limits on soluble alkalis for portland cement and for pozzolan whenever there is a possibility of alkali-aggregate reactive aggregates being furnished.

Where alkali-bearing soil or groundwater is encountered, or where the concrete will be exposed to sewage, see ACI 201.2 R for guidance on selecting cementitious material. See EM 1110-2-2000 for guidance when proposing to use any type of portland-pozzolan or portland-furnace-slag cement.

If high early strength concrete is required, specify Type III after consulting the agency's Subject Matter Expert in Concrete Materials. Low alkali cement may be required if the proposed aggregates are found to be expansive.

Cementitious Materials must be portland cement, [portland-pozzolan cement,] [portland blast-furnace slag cement,] or portland cement in combination with [pozzolan] [or ground granulated blast furnace slag] [or silica fume]

conforming to appropriate specifications listed below. Restrict usage of cementitious materials in concrete that will have surfaces exposed in the completed structure so there is no change in color, source, or type of cementitious material.

2.2.1 Portland Cement

ASTM C150/C150M, Type [I] [II] [III] [low alkali] [including false set requirements] with a maximum 10 percent amount of tricalcium aluminate, and a maximum cement-alkali content of 0.80 percent Na₂O_e (sodium oxide) equivalent. White portland cement must meet the above requirements except that it may be Type I, Type II[or Type III] [low alkali]. [Use white Type III only in specific areas of the structure, when approved in writing.]

[2.2.2 High-Early-Strength Portland Cement

ASTM C150/C150M, Type III with tricalcium aluminate limited to [5] [8] percent, [low alkali]. Use Type III cement only in isolated instances and only when approved in writing.

]2.2.3 Blended Cements

NOTE: Never specify I(PM) or I(SM) cement.

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

2.2.4 Fly Ash

Conform fly ash to ASTM C618, Class F, except that the maximum allowable loss on ignition cannot exceed [3][6] percent. If pozzolan is used, it must never be less than [15][20][30][35][40][_____] percent by weight of the total cementitious material. Report the chemical analysis of the fly ash in accordance with ASTM C311/C311M. Evaluate and classify fly ash in accordance with ASTM D5759. Comply with EPA requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING.

2.2.5 Raw or Calcined Natural Pozzolan

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

2.2.6 Ultra Fine Fly Ash and Ultra Fine Pozzolan

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

- a. The strength activity index at 28 days of age is at least 95 percent of the control specimens.
- b. The average particle size does not exceed 6 microns.
- c. The sum of $\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$ is greater than 77 percent.

2.2.7 Ground Granulated Blast-Furnace (GGBF) Slag

ASTM C989/C989M, Grade [100][120]. Slag content must be a minimum of [25][50][70] percent by weight of cementitious material. Submit test results in accordance with ASTM C989/C989M for GGBF slag. Submit test results performed within 6 months of submittal date..

2.2.8 Silica Fume

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

Supervision by manufacturer's representative should be required during batching, finishing, and curing at start-up of the job. A HRWR recommended by the manufacturer of the silica fume should be used.

Conform silica fume to ASTM C1240. Conform available alkalis to the optimal limit given in Table 2 of ASTM C1240. Silica fume may be furnished as a dry, densified material or as a slurry. Proper mixing is essential to accomplish proper distribution of the silica fume and avoid agglomerated silica fume which can react with the alkali in the cement resulting in premature and extensive concrete damage. In accordance with paragraph Technical Service for Specialized Concrete in PART 1, provide the services of a manufacturer's technical representative experienced in mixing, proportioning, placement procedures, and curing of concrete containing silica fume. This representative must be present on the project prior to and during at least the first 4 days of concrete production and placement using silica fume. Use a High Range Water Reducer (HRWR) with silica fume.

2.3 AGGREGATES

NOTE: Edit and fill in the blanks as appropriate. Consideration should always be given to the local aggregate supply situation, quality, and availability.

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. 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. Aggregate evaluations may not be practical for projects requiring small quantities of concrete (less than 200 cubic meters 250 cubic yards).

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 shall 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 Section 32 13 14.13 by incorporating the relevant paragraphs into this specification, or may use the following requirements (included in the set of brackets.

[Test and evaluate fine and coarse aggregates for alkali-aggregate reactivity in accordance with ASTM C1260. Evaluate the fine and coarse aggregates separately and in combination, which matches the proposed mix design proportioning. All results of the separate and combination testing must have a measured expansion less than 0.10 (0.08) percent at 16 days after casting. Should the test data indicate an expansion of 0.10 (0.08) percent or greater, reject the aggregate(s) or perform additional testing using ASTM C1260 and ASTM C1567. Perform the additional testing using ASTM C1260 and ASTM C1567 using the low alkali portland cement in combination with ground granulated blast furnace (GGBF) slag, or Class F fly ash. Use GGBF slag in the range of 40 to 50 percent of the total cementitious material by mass. Use Class F fly ash in the range of 25 to 40 percent of the total cementitious material by mass.] [Provide fine and coarse aggregates conforming to the following.]

2.3.1 Fine Aggregate

Conform to the quality and gradation requirements of ASTM C33/C33M.

2.3.2 Coarse Aggregate

Conform to ASTM C33/C33M, Class 5S, size designation [_____].

2.3.3 Lightweight Aggregate

Provide lightweight fine and coarse aggregate conforming to the quality and gradation requirements of ASTM C330/C330M, size [_____] for coarse aggregate. Prewet and vacuum saturate lightweight aggregate in accordance with the Manufacturer's instructions unless otherwise specified. For pumped concrete, prewet sufficiently to ensure that slump loss through the pump line does not exceed 100 mm 4 inches.

2.3.4 Materials for Bonded Topping for Heavy Duty Floors

In addition to the requirements specified above, coarse aggregate used for this purpose must be a well graded, hard, sound diabase, trap rock, emery, granite or other natural or manufactured aggregate having equivalent hardness and wearing qualities and have a percentage of loss not to exceed 30 after 500 revolutions when tested in accordance with ASTM C131/C131M. Gradation of the aggregates when tested in accordance with ASTM C136/C136M as follows:

| Coarse Aggregate | |
|------------------|--|
| Sieve Size | Cumulative Percent Cumulative Percent |
| 19 mm 3/4 inch | 100 |
| 12.5 mm 1/2 inch | 50-100 |
| 9.5 mm 3/8 inch | 25-50 |
| 4.75 mm No. 4 | 0-15 |
| 2.36 mm No. 8 | 0-8 |

| Fine Aggregate | |
|------------------|--|
| Sieve Size | Cumulative Percent Cumulative Percent |
| 9.5 mm 3/8 inch | 100 |
| 4.75 mm No. 4 | 95-100 |
| 2.36 mm No. 8 | 65-80 |
| 1.18 mm No. 16 | 45-65 |
| 0.600 mm No. 30 | 25-45 |
| 0.300 mm No. 50 | 5-15 |
| 0.150 mm No. 100 | 0-5 |

2.4 CHEMICAL ADMIXTURES

**NOTE: Edit as appropriate for the project. Do not
permit the use of calcium chloride.**

When required or permitted, conform to the appropriate specification listed. Furnish admixtures in liquid form and of suitable concentration for easy, accurate control of dispensing.

2.4.1 Air-Entraining Admixture

ASTM C260/C260M and must consistently entrain the air content in the specified ranges under field conditions.

2.4.2 Accelerating Admixture

ASTM C494/C494M, Type C or E, except that calcium chloride or admixtures containing calcium chloride cannot be used.

2.4.3 Water-Reducing or Retarding Admixture

ASTM C494/C494M, Type A, B, or D, except that the 6-month and 1-year compressive strength tests are waived.

2.4.4 High-Range Water Reducer

**NOTE: Use this paragraph only when high-range water
reducing admixture is allowed in paragraph SLUMP.**

ASTM C494/C494M, Type F or G, except that the 6-month and 1-year strength requirements are waived. Use the admixture only when approved in writing, such approval being contingent upon particular mixture control as described in the Contractor's Quality Control Plan and upon performance of separate mixture design studies.

2.4.5 Surface Retarder

ASTM C309. Submit sample of surface retarder material with manufacturer's instructions for application in conjunction with air-water cutting.

2.4.6 Expanding Admixture

Aluminum powder type expanding admixture conforming to ASTM C937.

2.4.7 Other Chemical Admixtures

**NOTE: Use this paragraph only when a plasticizing
admixture is allowed in paragraph SLUMP.**

Provide chemical admixtures for use in producing flowing concrete in compliance with ASTM C1017/C1017M, Type I or II. Use these admixtures only when approved in writing, such approval being contingent upon particular mixture control as described in the Contractor's Quality Control Plan and upon performance of separate mixture design studies.

2.5 WATER

Provide water complying with the requirements of ASTM C1602/C1602M. Provide [potable] water for mixing, free of injurious amounts of oil, acid, salt, or alkali. Submit test report showing water complies with ASTM C1602/C1602M.

2.6 NONSHRINK GROUT

Provide nonshrink grout conforming to ASTM C1107/C1107M, and a commercial formulation suitable for the proposed application.

2.7 NONSLIP SURFACING MATERIAL

Provide nonslip surfacing material consisting of 55 percent, minimum, aluminum oxide or silicon-dioxide abrasive ceramically bonded together to form a homogeneous material sufficiently porous to provide a good bond with portland cement paste; or factory-graded emery aggregate consisting of not less than 45 percent aluminum oxide and 25 percent ferric oxide. Use well graded aggregate from particles retained on the 0.6 mm No. 30 sieve to particles passing the 2.36 mm No. 8 sieve.

2.8 EMBEDDED ITEMS

Provide the size and type indicated or as needed for the application. Dovetail slots must be galvanized steel. Provide hangers for suspended ceilings as specified in Section 09 51 00 ACOUSTICAL CEILINGS. Provide inserts for shelf angles and bolt hangers of malleable iron or cast or wrought steel.

2.9 FLOOR HARDENER

NOTE: Floor hardener should only be specified on specialized indoor floors where dusting of concrete would present an unusual problem or where specially requested by the Using Service.

Provide a colorless aqueous solution containing zinc silicofluoride, magnesium silicofluoride, or sodium silicofluoride. These silicofluorides can be used individually or in combination. Proprietary hardeners may be used if approved in writing by the Contracting Officer.

2.10 PERIMETER INSULATION

NOTE: Show required K-value on the drawings.

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

[2.11 VAPOR RETARDER

Polyethylene sheeting, ASTM E1745 Class [C][A][B], with a minimum thickness of[0.25 mm 10 mils][0.38 mm 15 mils] or other equivalent material having a vapor permeance rating not exceeding 0.04 perms as determined in accordance with ASTM E96/E96M.

]2.12 VAPOR BARRIER

Polyethylene sheeting, ASTM E1745 Class [C][A][B], with a minimum thickness of 0.38 mm 15 mils or ASTM E1993/E1993M bituminous membrane or other

equivalent material having a vapor permeance rating not exceeding 0.01 perms as determined in accordance with ASTM E96/E96M.

]2.13 JOINT MATERIALS

2.13.1 Joint Fillers, Sealers, and Waterstops

**NOTE: Do not use bituminous filler with
non-bituminous sealer. Designer will edit bracketed
items for joint sealing.**

Provide materials for expansion joint fillers and waterstops in accordance with Section 03 15 00.00 10 CONCRETE ACCESSORIES. Provide materials for and sealing of joints conforming to the requirements of Section [07 92 00 JOINT SEALANTS] [32 01 19 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS] [32 13 73 COMPRESSION JOINT SEALS FOR CONCRETE PAVEMENTS].

2.13.2 Contraction Joints in Slabs

Provide materials for contraction joint inserts in accordance with Section 03 15 00.00 10 CONCRETE ACCESSORIES.

PART 3 EXECUTION

3.1 PREPARATION FOR PLACING

Before commencing concrete placement, perform the following: Clean surfaces to receive concrete, free from frost, ice, mud, and water. Place, clean, coat, and support forms in accordance with Section 03 11 13.00 10 STRUCTURAL CONCRETE FORMWORK. Place, clean, tie, and support reinforcing steel in accordance with Section 03 20 00.00 10 CONCRETE REINFORCEMENT. Transporting and conveying equipment is in-place, ready for use, clean, and free of hardened concrete and foreign material. Equipment for consolidating concrete is at the placing site and in proper working order. Equipment and material for curing and for protecting concrete from weather or mechanical damage is at the placing site, in proper working condition and in sufficient amount for the entire placement. When hot, windy conditions during concreting appear probable, equipment and material is at the placing site to provide windbreaks, shading, fogging, or other action to prevent plastic shrinkage cracking or other damaging drying of the concrete as required in Section 03 39 00.00 10 CONCRETE CURING.

3.1.1 Foundations

3.1.1.1 Concrete on Earth Foundations

Earth (subgrade, base, or subbase courses) surfaces upon which concrete is to be placed is clean, damp, and free from debris, frost, ice, and standing or running water. Prior to placement of concrete, the foundation must be well drained, satisfactorily graded and uniformly compacted.

3.1.1.2 Preparation of Rock

Rock surfaces upon which concrete is to be placed is free from oil, standing or running water, ice, mud, drummy rock, coating, debris, and loose, semidetached or unsound fragments. Clean joints in rock to a satisfactory depth, as determined by the Contracting Officer, and to firm

rock on the sides. Immediately before the concrete is placed, thoroughly clean rock surfaces by the use of air-water jets or sandblasting as specified below for Previously Placed Concrete. Keep rock surfaces continuously moist for at least 24 hours immediately prior to placing concrete thereon. Cover all horizontal and approximately horizontal surfaces, immediately before the concrete is placed, with a layer of mortar proportioned similar to that in the concrete mixture. Place concrete before the mortar stiffens.

3.1.1.3 Excavated Surfaces in Lieu of Forms

NOTE: Delete this paragraph when forms are required.

Concrete for [footings] [and] [walls] may be placed directly against the soil provided the earth or rock has been carefully trimmed, is uniform and stable, and meets the compaction requirements of Section 31 00 00 EARTHWORK. Place the concrete without becoming contaminated by loose material, and outlined within the specified tolerances.

3.1.2 Previously Placed Concrete

NOTE: If structure has few construction joints to be bonded, none of them critical, remove the following requirements except for subparagraph Preparation of Previously Placed Concrete. Otherwise, use the following requirements and remove subparagraph Preparation of Previously Placed Concrete.

Prepare concrete surfaces to which additional concrete is to be bonded for receiving the next horizontal lift by cleaning the construction joint surface with either air-water cutting, sandblasting, high-pressure water jet, or other approved method. Prepare concrete at the side of vertical construction joints as approved by the Contracting Officer. Do not use air-water cutting on formed surfaces or surfaces congested with reinforcing steel. Regardless of the method used, the resulting surfaces must be free from all laitance and inferior concrete so that clean surfaces of well bonded coarse aggregate are exposed and make up at least 10-percent of the surface area, distributed uniformly throughout the surface. Do not undercut the edges of the coarse aggregate. Keep the surface of horizontal construction joints continuously wet for the first 12 hours during the 24-hour period prior to placing fresh concrete. Wash the surface completely clean as the last operation prior to placing the next lift. For heavy duty floors and two-course floors, thoroughly scrub a thin coat of neat cement grout of about the consistency of thick cream into the existing surface immediately ahead of the topping placing. The grout must be a 1:1 mixture of portland cement and sand passing the 2.36 mm No. 8 sieve. Deposit the topping concrete before the grout coat has had time to stiffen.

3.1.2.1 Air-Water Cutting

Perform air-water cutting of a fresh concrete surface at the proper time and only on horizontal construction joints. The air pressure used in the jet must be 700 kPa 100 psi, plus or minus 70 kPa 10 psi, and the water pressure must be just sufficient to bring the water into effective

influence of the air pressure. When approved by the Contracting Officer, a surface retarder complying with the requirements of ASTM C309 may be applied to the surface of the lift in order to prolong the period of time during which air-water cutting is effective. After cutting, wash and rinse the surface as long as there is any trace of cloudiness of the wash water. Where necessary to remove accumulated laitance, coatings, stains, debris, and other foreign material, use high-pressure waterjet or sandblasting as the last operation before placing the next lift.

3.1.2.2 High-Pressure Water Jet

Use a stream of water under a pressure of not less than 20 MPa 3,000 psi for cutting and 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 waterjet is incapable of a satisfactory cleaning, clean the surface by sandblasting.

3.1.2.3 Wet Sandblasting

Use wet sandblasting after the concrete has reached sufficient strength to prevent undercutting of the coarse aggregate particles. After wet sandblasting, thoroughly wash the surface of the concrete to remove all loose materials.

3.1.2.4 Waste Disposal

Dispose of waste water employed in cutting, washing, and rinsing of concrete surfaces in a manner 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 is subject to approval.

3.1.2.5 Preparation of Previously Placed Concrete

NOTE: When the structure has few construction joints to be bonded, none of them critical, use this subparagraph and delete requirements of above subparagraphs and of paragraph Previously Placed Concrete. Renumber this specification accordingly.

Abrade concrete surfaces to which other concrete is to be bonded in an approved manner that exposes sound aggregate uniformly without damaging the concrete. Remove laitance and loose particles. Thoroughly wash surfaces, leaving them moist but without free water when concrete is placed.

3.1.3 Vapor Retarder [and Barrier]

NOTE: When this paragraph is used, coordinate drawings and specifications ensuring that drawings indicate vapor retarder beneath slabs. Locate vapor retarder below the slab-on-grade per ACI 360R, figure 4.7. Retain the penultimate sentence unless experience in the area has shown it to be unnecessary.

Provide vapor retarder beneath the interior on-grade concrete floor slabs installed in accordance with ASTM E1643. Use the greatest widths and lengths practicable to eliminate joints wherever possible. Lap joints a minimum of 300 mm 12 inches. Remove torn, punctured, or damaged vapor barrier material and provide new vapor barrier prior to placing concrete. For minor repairs, patches may be made using laps of at least 300 mm 12 inches. Seal lapped joints and patch edges with pressure-sensitive adhesive or tape not less than 50 mm 2 inches wide and compatible with the membrane. Place vapor barrier directly on underlying subgrade, base course, or capillary water barrier, unless it consists of crushed material or large granular material which could puncture the vapor barrier. In this case, a thin layer of approximately 13 mm 1/2 inch of fine graded material should be rolled or compacted over the fill before installation of the vapor barrier to reduce the possibility of puncture. Control concrete placement so as to prevent damage to the vapor barrier.

3.1.4 Perimeter Insulation

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

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

3.1.5 Embedded Items

Before placement of concrete, determine that all embedded items are firmly and securely fastened in place as indicated on the drawings, or required. Conduit and other embedded items must be clean and free of oil and other foreign matter such as loose coatings or rust, paint, and scale. The embedding of wood in concrete is permitted only when specifically authorized or directed. Temporarily fill voids in sleeves, inserts, and anchor slots with readily removable materials to prevent the entry of concrete into voids. Do not Weld on embedded metals within 300 mm 12 inches of the surface of the concrete. Do not tack weld on or to embedded items.

3.2 CONCRETE PRODUCTION

NOTE: Use this paragraph and its subparagraphs for all projects except where designer chooses to use the following optional paragraph CONCRETE PRODUCTION, SMALL PROJECTS, provided it meets the criteria described therein, in which case delete these. Do not specify both options.

3.2.1 General Requirements

NOTE: The designer must choose one of the two bracketed requirements and delete the other. Do not use the first bracketed requirement if ready-mixed concrete is not wanted.

[Batch and mix concrete onsite or furnish from a ready-mixed concrete plant. Batch, mix, and transport ready-mixed concrete in accordance with ASTM C94/C94M, except as otherwise specified. Truck mixers, agitators, and nonagitating transporting units must comply with NRMCA TMMB 100. Ready-mix plant equipment and facilities must be certified in accordance with NRMCA QC 3. Furnish approved batch tickets for each load of ready-mixed concrete. Conform site-mixed concrete to the following subparagraphs.] [Batch and mix concrete onsite, or close to onsite, conforming to the following subparagraphs.]

3.2.2 Batching Plant

**NOTE: Choose the desired bracketed options for
plant locations. Insert desired minimum capacity of
plant, it should be sufficient to accommodate the
largest placement within a reasonable time.**

Locate the batching plant [onsite in the general area indicated] [or] [offsite close to the project]. The batching, mixing and placing system must have a capacity of at least [_____] cubic meters yards per hour. Conform the batching plant to the requirements of NRMCA CPMB 100 and as specified; however, rating plates attached to batch plant equipment are not required.

3.2.3 Batching Equipment

**NOTE: Retain the bracketed sentence concerning
truck mixers unless it is desired to prohibit truck
mixers. Always retain bracketed item about silica
fume when its use is allowed, otherwise delete.**

Use semiautomatic or automatic batching controls as defined in NRMCA CPMB 100. Provide a semiautomatic batching system with interlocks such that the discharge device cannot be actuated until the indicated material is within the applicable tolerance. Equip the batching system with accurate recorder or recorders that meet the requirements of NRMCA CPMB 100. Record the weight of water and admixtures if batched by weight. Provide separate bins or compartments for each size group of aggregate and type of cementitious material, to prevent intermingling at any time. Weigh aggregates either in separate weigh batchers with individual scales or, provided the smallest size is batched first, cumulatively in one weigh batcher on one scale. Do not weigh aggregate in the same batcher with cementitious material. If both portland cement and other cementitious material are used, they may be batched cumulatively, provided that the portland cement is batched first, [except always batch silica fume separately]. Water may be measured by weight or volume. Do not weigh or measure water cumulatively with another ingredient. Interlock filling and discharging valves for the water metering or batching system so that the discharge valve cannot be opened before the filling valve is fully closed. Piping for water and for admixtures must be free from leaks and valved to prevent backflow or siphoning. Furnish admixtures as a liquid of suitable concentration for easy control of dispensing. Provide an adjustable, accurate, mechanical device for measuring and dispensing each admixture. Interlock each admixture dispenser with the batching and

discharging operation of the water so that each admixture is separately batched and individually discharged automatically in a manner to obtain uniform distribution throughout the water as it is added to the batch in the specified mixing period. [When use of truck mixers makes this requirement impractical, interlock the admixture dispensers with the sand batchers]. Different admixtures cannot be combined prior to introduction in water and are not allowed to intermingle until in contact with the cement. Provide admixture dispensers with devices to detect and indicate flow during dispensing or have a means for visual observation. Arrange the plant so as to facilitate the inspection of all operations at all times. Provide suitable facilities for obtaining representative samples of aggregates from each bin or compartment, and for sampling and calibrating the dispensing of cementitious material, water, and admixtures. Clearly mark filling ports for cementitious materials bins or silos with a permanent sign stating the contents.

3.2.4 Scales

Conform the weighing equipment to the applicable requirements of CPMB Concrete Plant Standard, and of NIST HB 44, except that the accuracy must be plus or minus 0.2 percent of scale capacity. Provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring devices. Perform the tests at the specified frequency in the presence of a Government inspector. Arrange the weighing equipment so that the plant operator can conveniently observe all dials or indicators.

3.2.5 Batching Tolerances

a. Tolerances with Weighing Equipment

| MATERIAL | PERCENT OF REQUIRED WEIGHT |
|------------------------|----------------------------|
| Cementitious materials | 0 to plus 2 |
| Aggregate | plus or minus 2 |
| Water | plus or minus 1 |
| Chemical admixture | 0 to plus 6 |

b. Tolerances with Volumetric Equipment - For volumetric batching equipment used for water and admixtures, the following tolerances apply to the required volume of material being batched:

| MATERIAL | PERCENT OF REQUIRED MATERIAL |
|--------------------|------------------------------|
| Water | plus or minus 1 |
| Chemical admixture | 0 to plus 6 |

3.2.6 Moisture Control

Provide a plant capable of ready adjustment to compensate for the varying

moisture content of the aggregates and to change the weights of the materials being batched.

3.2.7 Concrete Mixers

**NOTE: Retain bracketed phrase unless it is desired
to prohibit truck mixers, in which case delete.**

Use stationary mixers [or truck mixers] capable of combining the materials into a uniform mixture and of discharging this mixture without segregation. Do not charge the mixers in excess of the capacity recommended by the manufacturer. Operate the mixers at the drum or mixing blade speed designated by the manufacturer. Maintain the mixers in satisfactory operating condition, and keep the mixer drums free of hardened concrete. Should any mixer at any time produce unsatisfactory results, promptly discontinue its use until it is repaired.

3.2.8 Stationary Mixers

Drum-type mixers of tilting, nontilting, horizontal-shaft, or vertical-shaft type, or pug mill type provided with an acceptable device to lock the discharge mechanism until the required mixing time has elapsed. Conform the mixing time and uniformity to all the requirements in ASTM C94/C94M applicable to central-mixed concrete.

3.2.9 Truck Mixers

**NOTE: Delete this subparagraph if truck mixers have
been previously prohibited. Use bracketed item only
for small jobs.**

Conform truck mixers, the mixing of concrete therein, and concrete uniformity to the requirements of ASTM C94/C94M. A truck mixer may be used either 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. [Or, if approved, mark the number of revolutions on the batch tickets.] Do not add water at the placing site unless specifically approved; and in no case can it exceed the specified w/c. Inject any such water at the base of the mixer, not at the discharge end.

3.3 CONCRETE PRODUCTION, SMALL PROJECTS

**NOTE: Use this paragraph at the designer's option
in lieu of the previous paragraph CONCRETE
PRODUCTION and its subparagraphs, which must then be
deleted, but only when all the following conditions
exist:**

**(a) There are no particularly critical structural
items.**

(b) There are no items of particularly critical

appearance.

(c) No concrete is required with a specified compressive strength greater than 24.2 MPa 3500 psi.

(d) Not over 1150 cubic meters 1500 cubic yards of concrete are required.

Otherwise, use the above listed previous paragraph and subparagraphs only. Do not specify both options.

Use batch-type equipment for producing concrete. Batch, mix and transport ready-mixed concrete in accordance with ASTM C94/C94M, except as otherwise specified. Use truck mixers, agitators, and nonagitating transporting units in compliance with NRMCA TMMB 100. Ready-mix plant equipment and facilities must be certified in accordance with NRMCA QC 3. Furnish approved batch tickets for each load of ready-mixed concrete. Produce site-mixed concrete in accordance with ACI 301M ACI 301, with plant conforming to NRMCA CPMB 100. [In lieu of batch-type equipment, concrete may be produced by volumetric batching and continuous mixing, which conform to ASTM C685/C685M.]

3.4 LIGHTWEIGHT AGGREGATE CONCRETE

In addition to the requirements specified for normal weight concrete, conform lightweight aggregate concrete to the following. Base the batching and mixing cycle on written recommendations from the aggregate supplier furnished by the Contractor. Unless otherwise directed, charge the mixer with approximately 2/3 of the total mixing water and all of the aggregate. Mix this for at least 1.5 minutes in a stationary mixer or 15 revolutions at mixing speed in a truck mixer. Add and continue mixing the remaining ingredients as specified for normal weight concrete. Do not vibrate lightweight aggregate concrete to the extent that large particles of aggregate float to the surface. During finishing, do not work lightweight aggregate concrete to the extent that mortar is driven down and lightweight coarse aggregate appears at the surface. Lightweight aggregate concrete to be pumped must have a cement content of at least 335 kg/cubic meter 564 lb/cu. yd.[Perform a field trial run of lightweight aggregate concrete placement and finishing in accordance with ACI 213R.]

3.5 FIBER REINFORCED CONCRETE

NOTE: Only use fiber reinforcing when approved by the structural designer. Drawings should indicate where fiber reinforced concrete is located. Fiber reinforcing is used (1) to help control cracking due to drying shrinkage and thermal expansion and contraction, (2) to reduce permeability, (3) to increase impact capability, shatter resistance, abrasion resistance, and toughness. Fiber reinforcing will not: control cracking due to structural stresses, significantly increase strength, control curling or creeping, justify reducing structural members, eliminate control joints, or replace any moment or structural steel reinforcement. Include flexural toughness tests when synthetic reinforcement fibers are used to

increase toughness and when justified by size and importance of job, but not when fibers are used only to control shrinkage cracking. Include technical representative when warranted by size and importance of job.

Provide fiber reinforced concrete conforming to ASTM C1116/C1116M and as follows, using the fibers specified in Section 03 20 00.00 10 CONCRETE REINFORCING. Use a minimum of 0.9 kg of fibers per cubic m 1.5 pounds of fibers per cubic yard of concrete. Add fibers at the batch plant. [Toughness indices must meet requirements for performance level I of ASTM C1116/C1116M.] Provide the services of a qualified technical representative to instruct the concrete supplier in proper batching and mixing of materials.

3.6 TRANSPORTING CONCRETE TO PROJECT SITE

Transport concrete to the placing site in [truck mixers,] [agitators,] [nonagitator transporting equipment conforming to NRMCA TMMB 100] or by approved [pumping equipment] [conveyors]. Nonagitator equipment, other than pumps, cannot be used for transporting lightweight aggregate concrete.

3.7 PLACING CONCRETE

Discharge mixed concrete within 1.5 hours or before the mixer drum has revolved 300 revolutions, whichever comes first after the introduction of the mixing water to the cement and aggregates. When the concrete temperature exceeds 30 degrees C 85 degrees F, reduce the time to 45 minutes. Place concrete within 15 minutes after it has been discharged from the transporting unit. Handle concrete from mixer or transporting unit to forms in a continuous manner until the approved unit of operation is completed. Provide adequate scaffolding, ramps and walkways so that personnel and equipment are not supported by in-place reinforcement. Placing will not be permitted when the sun, heat, wind, or limitations of facilities prevent proper consolidation, finishing and curing. Provide sufficient placing capacity so that concrete can be kept free of cold joints.

3.7.1 Depositing Concrete

Deposit concrete in accordance with ACI 301 Section 5 and ACI 304.2R.

3.7.2 Consolidation

NOTE: For large jobs, this paragraph may be expanded. Consolidation equipment and procedures are described in detail in ACI 309.

Immediately after placing, consolidate each layer of concrete in accordance with ACI 301 Section 5 and ACI 309R.

3.7.3 Cold Weather Requirements

NOTE: When the designer is especially concerned about corrosion of reinforcing steel or embedded

items, or possibility of sulfate attack, (particularly to prestressing steel) the percentage of chloride ion in the mixture should be limited. See ACI Committee 201 report "Guide to Durable Concrete" and ACI Committee 222 report "Corrosion of Metals in Concrete" for guidance on control of chloride ion.

Perform cold weather concreting in accordance with ACI 306.1. Use special protection measures, approved by the Contracting Officer, if freezing temperatures are anticipated before the expiration of the specified curing period. The ambient temperature of the air where concrete is to be placed and the temperature of surfaces to receive concrete must be not less than 5 degrees C 40 degrees F. The temperature of the concrete when placed must be not less than 10 degrees C 50 degrees F nor more than 25 degrees C 75 degrees F. Heat the mixing water or aggregates to regulate the concrete placing temperature. Materials entering the mixer must be free from ice, snow, or frozen lumps. Do not incorporate salt, chemicals or other materials in the concrete to prevent freezing. Upon written approval, an accelerating admixture conforming to ASTM C494/C494M, Type C or E may be used, provided it contains no calcium chloride. Do not use calcium chloride.

3.7.4 Hot Weather Requirements

NOTE: If desired, placement of floor slabs may be specified to be delayed until a roof is in place. Additional information concerning hot weather concreting may be obtained from ACI 305R.

When job-site conditions are present or anticipated that accelerate the rate of moisture loss or rate of cement hydration of freshly mixed concrete, including an ambient temperature of 27 degrees C 80 degrees F or higher, and an evaporation rate that exceeds 1 kg/m²/h 0.2 lb/ft²/h, conform concrete work to all requirements of ACI 305.1.

3.7.5 Prevention of Plastic Shrinkage Cracking

During hot weather with low humidity, and particularly with appreciable wind, as well as interior placements when space heaters produce low humidity, be alert to the tendency for plastic shrinkage cracks to develop and institute measures to prevent this. Take particular care if plastic shrinkage cracking is potentially imminent and especially if it has developed during a previous placement. Conform with the requirement of ACI 305.1. In addition further protect the concrete placement by erecting shades and windbreaks and by applying fog sprays of water, sprinkling, ponding or wet covering. Fill plastic shrinkage cracks that occur by injection of epoxy resin as directed, after the concrete hardens. Never trowel over plastic shrinkage cracks or fill with slurry.

[3.7.6 Placing Concrete Underwater

NOTE: Delete this paragraph when not applicable. If major underwater concrete placement is required, use specification 03 31 29 MARINE CONCRETE.

Contractor will be required to submit proposed procedures.

Deposit concrete in water by a tremie or concrete pump. The methods and equipment used are subject to approval. Do not use concrete buckets for underwater placement of concrete except to deliver concrete to the tremie. The tremie must be watertight and large enough to permit a free flow of concrete. Deposit the concrete so that it enters the mass of the previously placed concrete from within, displacing water with a minimum disturbance to the surface of the concrete. Keep the discharge end of the pump line or tremie shaft continuously submerged in the concrete. The underwater seal at start of placing must not produce undue turbulence in the water. Keep the tremie shaft full of concrete to a point well above the water surface. Placement proceeds without interruption until the concrete has been brought to the required height. Do not move the tremie horizontally during a placing operation, and provide a sufficient number of tremies so that the maximum horizontal flow of concrete is limited to 5 m 15 feet. Do not deposit concrete in running water or in water with a temperature below 2 degrees C 35 degrees F.

13.7.7 Placing Concrete in Congested Areas

NOTE: Delete the last sentence when not applicable.

Use special care to ensure complete filling of the forms, elimination of all voids, and complete consolidation of the concrete when placing concrete in areas congested with reinforcing bars, embedded items, waterstops and other tight spacing. Use an appropriate concrete mixture, with the nominal maximum size of aggregate (NMSA) meeting the specified criteria when evaluated for the congested area. Use vibrators with heads of a size appropriate for the clearances available, and closely supervise the consolidation operation to ensure complete and thorough consolidation at all points. Where necessary, alternate splices of reinforcing bars to reduce congestion. Where two mats of closely spaced reinforcing are required, place the bars in each mat in matching alignment to reduce congestion. Reinforcing bars may be temporarily crowded to one side during concrete placement provided they are returned to exact required location before concrete placement and consolidation are completed.

3.7.8 Placing Flowable Concrete

NOTE: Delete this paragraph when flowable concrete is not permitted.

If a plasticizing admixture conforming to ASTM C1017/C1017M is used or if a Type F or G high range water reducing admixture is permitted to increase the slump, the concrete must meet all requirements of paragraph SYSTEM DESCRIPTION. Use extreme care in conveying and placing the concrete to avoid segregation. No relaxation of requirements to accommodate flowable concrete will be permitted.

3.8 JOINTS

NOTE: All joints should be indicated on the drawings. When some of the joints are not shown, the Designer must edit this paragraph for conformance with job requirements.

Locate and construct joints as indicated or approved. Locate and construct joints not indicated to minimize the impact on the strength of the structure. In general, locate such joints near the middle of the spans of supported slabs, beams, and girders unless a beam intersects a girder at this point, in which case the offset joint in the girder a distance equal to twice the width of the beam. Locate joints in walls and columns at the underside of floors, slabs, beams, or girders and at the tops of footings or floor slabs, unless otherwise approved. Construct joints perpendicular to the main reinforcement. Continue and develop all reinforcement across joints; except that reinforcement or other fixed metal items must not be continuous through expansion joints, or through construction or contraction joints in slabs on grade. Reinforcement must be 50 mm 2 inches clear from each joint. Except where otherwise indicated, construction joints between interior slabs on grade and vertical surfaces consist of preformed expansion joint filler extending for the full depth of the slab. The perimeters of the slabs must be free of fins, rough edges, spalling, or other unsightly appearance. Form reservoir for sealant for construction and contraction joints in slabs to the dimensions indicated by removing snap-out joint-forming inserts, by sawing sawable inserts, or by sawing to widen the top portion of sawed joints. Clean joints to be sealed and seal as indicated and in accordance with Section 07 92 00 JOINT SEALANTS.

3.8.1 Construction Joints

NOTE: Drawings must show details for construction joints, including any required dowels or keyways. Drawings must indicate whether dowels are conventional smooth "paving" dowels or "structural" type deformed dowels (tie-bars).

For concrete other than slabs on grade, locate construction joints so that the unit of operation does not exceed [_____] meters feet. Place concrete continuously so that each unit is monolithic in construction. Do not place fresh concrete against adjacent hardened concrete until it is at least 24 hours old. Locate construction joints as indicated or approved. Where concrete work is interrupted by weather, end of work shift or other similar type of delay, location and type of construction joint is subject to approval of the Contracting Officer. Unless otherwise indicated and except for slabs on grade, extend reinforcing steel through construction joints. Key or dowel construction joints in slabs on grade as indicated. Concrete columns, walls, or piers must be in place at least 2 hours, or until the concrete begins to lose its plasticity, before placing concrete for beams, girders, or slabs thereon. In walls having door or window openings, terminate lifts at the top and bottom of the opening. Terminate other lifts at such levels to conform to structural requirements or architectural details. Where horizontal construction joints in walls or columns are required, tack a strip of 25 mm 1 inch square-edge lumber, beveled and oiled to facilitate removal, to the inside of the forms at the construction joint. Place concrete to a point 25 mm 1 inch above the underside of the strip. Remove the strip 1 hour after the concrete has been placed, level off any irregularities in the joint line with a wood float, and remove all

laitance. Prior to placing additional concrete, prepare horizontal construction joints as specified in paragraph PREVIOUSLY PLACED CONCRETE.

3.8.2 Contraction Joints in Slabs on Grade

NOTE: Drawings must indicate desired location and detail for contraction joints.

Locate and detail contraction joints as indicated. Produce contraction joints by forming a weakened plane in the concrete slab using materials and procedures specified in Section 03 15 00.00 10 CONCRETE ACCESSORIES.

3.8.3 Expansion Joints

conform installation of expansion joints and sealing of these joints to the requirements of Section 03 15 00.00 10 CONCRETE ACCESSORIES and Section 07 92 00 JOINT SEALANTS.

3.8.4 Waterstops

Install waterstops in conformance with the locations and details indicated using materials and procedures specified in Section 03 15 00.00 10 CONCRETE ACCESSORIES.

3.8.5 Dowels and Tie Bars

Install dowels and tie bars at the locations shown on the drawings and to the details shown, using materials and procedures specified in Section 03 20 00.00 10 CONCRETE REINFORCEMENT and herein. Install conventional smooth "paving" dowels in slabs using approved methods to hold the dowel in place during concreting within a maximum alignment tolerance of 1 mm in 100 mm 1/8 inch in 12 inches. Install "structural" type deformed bar dowels, or tie bars, to meet the specified tolerances. Take care during placing adjacent to and around dowels and tie bars to ensure there is no displacement of the dowel or tie bar and that the concrete completely embeds the dowel or tie bar and is thoroughly consolidated.

3.9 SPECIALTY FLOORS

3.9.1 Heavy Duty Floors

NOTE: Heavy duty floors are to be used only for floors that will receive major traffic of tracked vehicles or steel wheeled equipment when the designer is concerned about wear. Moderate amounts of such traffic can be accommodated by ordinary concrete floors. If drawings do not indicate areas to receive heavy duty finish, they must be specified here. Delete this subparagraph if not required. Edit bracketed items. Add to and strengthen this subparagraph as needed but do not delete any of the listed requirements.

Construct heavy duty floors in [areas indicated] [the following areas [____]].

3.9.1.1 General

Construct heavy duty floor by placing a heavy duty bonded topping on a base slab which has had a rough slab finish left 50 mm 2 inches below final grade. Concrete in the base slab must be thoroughly hardened but not more than 30 hours old. The temperature of the fresh concrete topping must not vary more than 5 degrees C 10 degrees F plus or minus from the temperature of the base slab. The ambient temperature of the space adjacent to the concrete placement and of the base slab must be between 10 and 30 degrees C 50 and 90 degrees F.

3.9.1.2 Preparation of Base Slab

Keep the base slab continuously damp until topping is placed. Thoroughly clean the surface of the base slab with an air-water jet immediately before placing the topping. Thoroughly scrub a thin coat of neat cement grout of about the consistency of thick cream into the existing surface immediately ahead of the overlay placing. At the time the neat cement grout is placed, the existing concrete surface must be damp but no free water present. Deposit the overlay concrete before the grout coat has had time to stiffen.

3.9.2 Two-Course Floor Construction

NOTE: Where it is anticipated that the surface of a floor slab may be damaged during construction operations, a two-course floor may be specified with the second course applied late in the contract. If the drawings do not indicate areas to receive two-course floor construction, they must be specified here. Delete this subparagraph when two-course floor is not required. Edit bracketed items.

Construct floors with two-course construction in [areas indicated] [the following areas [____]] by placing a bonded topping on the thoroughly hardened concrete base slab which has been left with a rough slab finish 50 mm 2 inches below final grade as indicated. Apply topping at an approved time late in the contract period. The specified compressive strength of the floor topping mixture is 34.5 MPa 5000 psi at 28 days, with a 50 mm 2 inch maximum slump, 12.5 mm 1/2 inch maximum size coarse aggregate, and proportioned to obtain required finishability. Thoroughly clean the surface of the base slab by sandblasting or high-pressure waterjet immediately before placing topping. The temperature of the fresh concrete topping must not vary more than 5 degrees C 10 degrees F plus or minus from the temperature of the base slab. The ambient temperature of the space adjacent to the concrete placement and of the base slab must be between 10 and 30 degrees C 50 and 90 degrees F. Keep the base slab continuously wet for the first 12 hours during the 24 hour period immediately prior to placing the finished floor. After all free water has evaporated or has been removed from the surface, scrub in a grout. The grout must be a 1:1 mixture of portland cement and sand passing the 2.36 mm No. 8 sieve mixed to a creamlike consistency. Scrub the grout into the surface just ahead of the concrete topping placing operation. While the grout is still damp, spread and screed and darby or bull float the top course.

3.10 FLOOR HARDENER

NOTE: If the drawings do not indicate the areas to receive floor hardener, they must be specified here. Normally, floor hardener is not needed. Use only where extreme dust-free area is required or where requested by using service.

Treat the [areas indicated] [following areas [_____]] with floor hardener applied after the concrete has been cured and then air dried for [14] [28] days. Apply three coats, each the day after the preceding coat was applied. For the first application, dissolve 0.5 kg one pound of the silicofluoride in 4 liters one gallon of water. For subsequent applications, the solution must be 1.0 kg two pounds of silicofluoride to each 4 liters gallon of water. Mop the floor with clear water shortly after the preceding application has dried to remove encrusted salts. Apply proprietary hardeners in accordance with the manufacturer's instructions. Ventilate the area during application. Take precautions when applying silicofluorides due to the toxicity of the salts. Immediately remove any compound that contacts glass or aluminum with clear water.

3.11 EXTERIOR SLAB AND RELATED ITEMS

NOTE: Edit bracketed statements and use these paragraphs only when minor amounts of specified items are required in the project. Remove affected paragraph when pertinent Section (Ex: 32 13 14.13 CONCRETE PAVING FOR AIRFIELDS AND OTHER HEAVY DUTY PAVEMENTS, 32 16 13 CONCRETE SIDEWALKS AND CURBS AND GUTTERS) is included in the contract.

3.11.1 Pavements

Construct pavements where shown on the drawings. After forms are set and underlying material prepared as specified, place the concrete uniformly throughout the area and thoroughly vibrated. As soon as placed and vibrated, strike off the concrete and screed to the crown and cross section and to such elevation above grade that when consolidated and finished, the surface of the pavement is at the required elevation. Tamp the entire surface with the strike off, or consolidated with a vibrating screed, and continue this operation until the required compaction and reduction of internal and surface voids are accomplished. Take care to prevent bringing excess paste to the surface.

3.11.2 Sidewalks

Minimum concrete thickness of 100 mm 4 inches. Provide contraction joints at 1.75 m 5 feet spaces unless otherwise indicated. Cut contraction joints 25 mm 1 inch deep with a jointing tool after the surface has been finished. Provide transverse expansion joints 12 mm 1/2 inch thick at changes in direction and where sidewalk abuts curbs, steps, rigid pavement, or other similar structures. Provide a transverse slope of 1 mm per 50 mm 1/4 inch per foot, unless otherwise indicated. Limit variations in cross section to 1 mm per 250 mm 1/4 inch in 5 feet.

3.11.3 Curbs and Gutters

Form, place and finish concrete by hand using a properly shaped "mule" or construct using a slipform machine specially designed for this work. Cut contraction joints 75 mm 3 inches deep with a jointing tool after the surface has been finished. Provide 12 mm 1/2 inch wide expansion joints at 35 m 100 feet maximum spacing unless otherwise indicated.

3.11.4 Pits and Trenches

Construct pits and trenches as indicated Place bottoms and walls monolithically or provide waterstops and keys as approved.

3.12 SETTING BASE PLATES AND BEARING PLATES

NOTE: Damp-pack bedding mortar will be specified for setting base and bearing plates, except that nonshrink grout will be specified for heavy machinery bases or where design requires precision setting of plates or requires that bedding material have high resistance to shear, impact, or vibration, and where good damp packing is difficult or impossible. When using nonshrink grout on important structures, such as large machinery bases, the grout should be required to meet ASTM C1107/C1107M, Grade A, B, or C, grade or grades as selected by the designer. This nonshrink grout must not be used for embedding post-tensioned tendons or rock bolts. Edit bracketed item as appropriate, and delete entire paragraph if not needed.

After being properly positioned, set column base plates, bearing plates for beams and similar structural members, and machinery and equipment base plates to the proper line and elevation with damp-pack bedding mortar, except where nonshrink grout is indicated. The thickness of the mortar or grout must be approximately 1/24 the width of the plate, but not less than 19 mm 3/4 inch. Concrete and metal surfaces in contact with grout must be clean and free of oil and grease, and concrete surfaces in contact with grout damp and free of laitance when grout is placed. Use nonshrink grout for [_____].

3.12.1 Damp-Pack Bedding Mortar

Damp-pack bedding mortar consists of 1 part cement and 2-1/2 parts fine aggregate having water content such that a mass of mortar tightly squeezed in the hand will retain its shape but will crumble when disturbed. Pack the space between the top of the concrete and bottom of the bearing plate or base with the bedding mortar by tamping or ramming with a bar or rod until it is completely filled.

3.12.2 Nonshrink Grout

Ready-mixed material requiring only the addition of water. 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.

3.12.2.1 Mixing and Placing of Nonshrink Grout

Mix and place in conformance with the material manufacturer's instructions and as specified therein. Thoroughly dry-mix ingredients 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 machinery-bearing surface and the plate solid with the grout. Use wood forms or other equally suitable material for completely retain the grout on all sides and on top, remove forms after the grout has set. Carefully work the placed grout by rodding or other means to eliminate voids; however, avoid overworking and breakdown of the initial set. Do not subject grout to retempering or to vibration from any source. Where clearances are unusually small, place under pressure with a grout pump. Maintain the temperature of the grout, and of surfaces receiving the grout, at 18 to 30 degrees C 65 to 85 degrees F until after setting.

3.12.2.2 Treatment of Exposed Surfaces

For metal-oxidizing nonshrink grout, cut back exposed surfaces 25 mm 1 inch and immediately cover with a parge coat of mortar consisting of 1 part portland cement and 2-1/2 parts fine aggregate by weight, with sufficient water to make a plastic mixture. Smooth finish the parge coat. For other mortars or grouts, exposed surfaces must have a smooth-dense finish and be left untreated. Cure in compliance with Section 03 39 00.00 10 CONCRETE CURING.

3.13 TESTING AND INSPECTION FOR CQC

NOTE: For non-critical small projects, less than 1200 cubic meters 1500 cu. yd. of concrete, the designer may reduce, but not eliminate, the requirements of this paragraph, and edit it appropriately for the project specifications. Otherwise, retain complete.

Perform the inspection and tests described below and, based upon the results of these inspections and tests, take the action required. Submit certified copies of laboratory test reports, including mill tests and all other test data, for portland cement, blended cement, pozzolan, ground granulated blast furnace slag, silica fume, aggregate, admixtures, and curing compound proposed for use on this project.

- a. When, in the opinion of the Contracting Officer, the concreting operation is out of control, cease concrete placement and correct the operation.
- b. The laboratory performing the tests must be onsite and conform with ASTM C1077. Materials may be subjected to check testing by the Government from samples obtained at the manufacturer, at transfer points, or at the project site.
- c. The Government will inspect the laboratory, equipment, and test procedures prior to start of concreting operations and at least once per [_____] thereafter for conformance with ASTM C1077.

3.13.1 Grading and Corrective Action

3.13.1.1 Fine Aggregate

At least once during each shift when the concrete plant is operating, there must be one sieve analysis and fineness modulus determination in accordance with ASTM C136/C136M 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. Select the location at which samples are taken as the most advantageous for control. However, the Contractor is responsible for delivering fine aggregate to the mixer within specification limits. When the amount passing on any sieve is outside the specification limits, immediately resample and retest the fine aggregate. If there is another failure on any sieve, immediately report the failure to the Contracting Officer, stop concreting, and take immediate steps to correct the grading.

3.13.1.2 Coarse Aggregate

At least once during each shift in which the concrete plant is operating, there must be a sieve analysis in accordance with ASTM C136/C136M for each size of coarse aggregate. Select the location at which samples are taken as the most advantageous for 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. Limits may be adopted for control coarser than the specification limits for samples taken other than as delivered to the mixer to allow for degradation during handling. When the amount passing any sieve is outside the specification limits, immediately resample and retest the coarse aggregate. If the second sample fails on any sieve, report that failure to the Contracting Officer. Where two consecutive averages of 5 tests are outside specification limits, the operation is considered out of control and must be reported to the Contracting Officer. Stop concreting and take immediate steps to correct the grading.

3.13.2 Quality of Aggregates

Thirty days prior to the start of concrete placement, perform all tests for aggregate quality required by ASTM C33/C33M. In addition, after the start of concrete placement, perform tests for aggregate quality at least every three months, and when the source of aggregate or aggregate quality changes. Take samples for testing after the start of concrete placement immediately prior to entering the concrete mixer.

3.13.3 Scales, Batching and Recording

Check the accuracy of the scales by test weights prior to start of concrete operations and at least once every three months. Also conduct such tests as directed whenever there are variations in properties of the fresh concrete that could result from batching errors. Once a week check the accuracy of each batching and recording device during a weighing operation by noting and recording the required weight, recorded weight, and the actual weight batched. At the same time, test and ensure that the devices for dispensing admixtures are operating properly and accurately. 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. Immediately correct discrepancies in recording accuracies.

3.13.4 Batch-Plant Control

Continuously control the measurement of concrete materials, including cementitious materials, each size of aggregate, water, and admixtures. Adjust the 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 each day's plant operation.

3.13.5 Concrete Mixture

3.13.5.1 Air Content Testing

Perform air content tests when test specimens are fabricated. In addition, make at least two tests for air content on randomly selected batches of each separate concrete mixture produced during each 8-hour period of concrete production. Perform additional tests when excessive variation in workability is reported by the placing foreman or Government inspector. Conduct tests in accordance with ASTM C231/C231M for normal weight concrete and ASTM C173/C173M for lightweight concrete. [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 test result reaches either the upper or lower action limit, perform a second test immediately. Average the results of the two tests and use this average as the air content of the batch to plot on both the air content and the control chart for range, and for determining need for any remedial action. Plot the result of each test, or average as noted in the previous sentence, on a separate control chart for each mixture on which an "average line" is set at the midpoint of the specified air content range from paragraph AIR ENTRAINMENT. 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. Plot the range between each two consecutive tests on a secondary control chart for range where an upper warning limit is set at 2.0 percentage points and an upper action limit is set at 3.0 percentage points. 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 stipulated 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.]

[3.13.5.2 Air Content Corrective Action

Whenever points on the control chart for percent air reach either warning limit, immediately make an adjustment in the amount of air-entraining admixture batched. As soon as practical after each adjustment, make another test to verify the result of the adjustment. Whenever a point on the secondary control chart for range reaches the warning limit, recalibrate the admixture dispenser to ensure that it is operating accurately and with good reproducibility. Whenever a point on either

control chart reaches an action limit line, the air content is considered out of control and the concreting operation immediately halted until the air content is under control. Make additional air content tests when concreting is restarted.

]3.13.5.3 Slump Testing

In addition to slump tests which are made when test specimens are fabricated during concrete placement/discharge, make at least four slump tests on randomly selected batches in accordance with ASTM C143/C143M for each separate concrete mixture produced during each 8-hour or less period of concrete production each day. Also, make additional tests when excessive variation in workability is reported by the placing foreman or Government inspector. [Plot test results on control charts. Submit the control charts 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 test reaches or goes beyond either the upper or lower action limit, immediately perform a second test. Average the results of the two tests and use this average as the slump of the batch to plot on both the control charts for slump and the chart for range, and for determining need for any remedial action. Set limits on separate control charts for slump for each type of mixture. Set the upper warning limit at 12.5 mm 1/2 inch below the maximum allowable slump specified in paragraph SLUMP in PART 1 for each type of concrete and, set an upper action limit line and lower action limit line at the maximum and minimum allowable slumps, respectively, as specified in the same paragraph. Plot the range between each consecutive slump test for each type of mixture on a single control chart for range on which an upper action limit is set at 50 mm 2 inches. Take samples for slump at the mixer. However, the Contractor is responsible for delivering the concrete to the placement site at the stipulated slump. If the materials or transportation methods cause slump loss between the mixer and the placement, take correlation samples at the placement site as required by the Contracting Officer, and the slump at the mixer controlled as directed.]

[3.13.5.4 Slump Corrective Action

Whenever points on the control charts for slump reach the upper warning limit, make an adjustment immediately 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 allowed by the maximum w/c ratio specified, based on aggregates which are in a saturated surface dry condition. When a single slump reaches the upper or lower action limit, deliver no further concrete to the placing site until proper adjustments have been made. Immediately 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 at or above the upper action limit, halt the concreting operation immediately, and take appropriate steps to bring the slump under control. Make additional slump tests as directed.

]3.13.5.5 Temperature

Measure the temperature of the concrete when compressive strength specimens are fabricated in accordance with ASTM C1064/C1064M. Report the temperature along with the compressive strength data.

3.13.5.6 Strength Specimens

Perform on at least one set of test specimens, for compressive strength as appropriate, on each different concrete mixture placed during the day for each 380 cubic meters 500 cubic yards or portion thereof of that concrete mixture placed each day. Perform on additional sets of test specimens, as directed by the Contracting Officer, when the mixture proportions are changed or when low strengths have been detected. Develop a truly random (not haphazard) sampling plan for approval by the Contracting Officer prior to the start of construction. Show in the plan that sampling is done in a completely random and unbiased manner.

- a. A set of test specimens for concrete with a 28-day specified strength in accordance with paragraph STRENGTH REQUIREMENTS in PART 2 consists of five specimens, two to be tested at 7 days, two at 28 days, and one cylinder held in reserve.[A set of test specimens for concrete with a [56-day] [90-day] strength in accordance with the same paragraph consists of eight specimens, two tested at 7 days, two at 28 days, two at [56] [90] days, and two held in reserve.]
- b. A strength test is the average of the strengths of at least two 150 mm by 300 mm 6 inch by 12 inch cylinders or at least three 100 mm by 200 mm 4 inch by 8 inch cylinders made for the same sample of concrete.
- c. Mold and cure test specimens in accordance with ASTM C31/C31M, and test in accordance with ASTM C39/C39M for test cylinders. Immediately report results of all strength tests to the Contracting Officer.
- d. Maintain quality control charts for individual strength "tests", ("test" as defined in paragraph STRENGTH REQUIREMENTS) moving average of last 3 "tests" for strength, and moving average for range for the last 3 "tests" for each mixture. Provide charts similar to those found in ACI 214R.

3.13.6 Inspection Before Placing

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

3.13.7 Placing

The placing foreman must supervise placing operations, determine that the correct quality of concrete or grout is placed in each location as specified and as directed by the Contracting Officer, and be responsible for measuring and recording concrete temperatures and ambient temperature hourly during placing operations, weather conditions, time of placement, volume placed, and method of placement. The placing foreman must not permit batching and placing to begin until it has been verified that an adequate number of vibrators in working order and with competent operators are available. 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.

3.13.8 Cold-Weather Protection

At least once each shift and once per day on non-work days, inspect all

areas subject to cold-weather protection. Note any deficiencies, correct, and report.

[3.13.9 Mixer Uniformity

3.13.9.1 Stationary Mixers

Prior to the start of concrete placing and once every 6 months when concrete is being placed, or once for every 60,000 cubic meters 75,000 cubic yards of concrete placed, whichever results in the shortest time interval, determine uniformity of concrete mixing in accordance with ASTM C94/C94M.

3.13.9.2 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 mixing in accordance with ASTM C94/C94M. Select the 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.

3.13.9.3 Mixer Uniformity Corrective Action

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

]3.13.10 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, prepare 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.

3.14 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 report documenting these defects, which includes recommendations for repair, removal and/or remediation to the Contracting Officer for approval before any corrective work is accomplished.

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

[3.14.1 Crack Repair

Prior to final acceptance, document and repair all cracks in excess of 0.50

mm 0.02 inches wide. 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.

3.14.2 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 6 mm 1/4 inch thick to remove the weak surface. Remove and replace surfaces containing weak surfaces greater than 6 mm 1/4 inch thick, or mitigate in a manner acceptable to the Contracting Officer.

3.14.3 Failure of Quality Assurance Test Results

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

Do not proceed with proposed mitigation efforts to restore the service life until approved by the Contracting Officer.

-- End of Section --