

DIVISION 3 – CONCRETE

<u>Section</u>	<u>Title</u>	<u>Page</u>
03200	Concrete Reinforcement	03200-1
03300	Cast-In-Place Concrete	03300-1

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 03200

CONCRETE REINFORCEMENT

PART 1 - GENERAL

1.1 WORK INCLUDED:

- A. This section of the specification covers the furnishing of labor, materials, equipment and incidentals required for the installation of reinforcement for cast-in-place concrete as shown on the Drawings and as specified herein.

1.2 RELATED WORK:

- A. Section 03300 - Cast-in-Place Concrete

1.3 REFERENCES:

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

American Concrete Institute (ACI)

ACI SP-66 ACI Detailing Manual

ACI 301 Structural Concrete for Buildings

ACI 315 Manual of Engineering and Placing Drawings for Reinforced Concrete Structures

ACI 117 Standard Tolerance for Concrete Construction and Materials

ACI 318 Building Code Requirements for Concrete

ACI 350 Environmental Engineering Concrete Structures

American Society for Testing and Materials (ASTM)

ASTM A185 Standard Specification for Welded Steel Wire Fabric for Concrete Reinforcement

ASTM A615 Deformed Billet-Steel Bars for Concrete Reinforcement

American Welding Society (AWS)

AWS 12.1 Recommended Practices for Welding Reinforcing Steel, Metal Inserts and Connections in Reinforced Concrete Construction

ANSI/AWS D1.4 Structural Welding Code for Reinforcing Steel

CONCRETE REINFORCEMENT

03200-1

Concrete Reinforcement Steel Institute

CRSI Concrete Reinforcing Steel Institute Handbook

- B. Where reference is made to one of the above standards, the revision in effect at the time of the bid opening shall apply.

1.4 SUBMITTALS

- A. General: Submit in accordance with Condition of Contract and Division 1 – General Requirements Specification Section.
- B. The Contractor shall furnish the Engineer with complete checked, reinforcing steel shop drawings and bar lists, showing materials of construction and details of installation for:
 - 1. Reinforcing steel. Placement drawings shall conform to the recommendations of ACI 315 and include all reinforcement, additional reinforcement around openings and at corners, bending details referenced to the same bars on the placement drawings, special coatings, grade of steel used and splice lengths. Bars to have special coatings and/or to be of special steel or special yield strength are to be clearly identified.
 - 2. Bar bending details. The bars shall be referenced to the same identification marks shown on the placement drawings. Bars to have special coatings and/or to be of special steel or special yield strength are to be clearly identified.
- C. Mill test reports shall accompany drawings. Fabrication shall not commence until the drawings and mill test reports have been released by the Engineer.
- D. Welder's certification. The certification shall be in accordance with AWS D1.4 when welding of reinforcement is required.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Reinforcing steel shall be substantially free from mill scale, rust, dirt, grease, or other foreign matter.
- B. Reinforcing steel shall be shipped and stored with bars of the same size and shape fastened in bundles with durable tags, marked in a legible manner with waterproof markings showing the same "mark" designations as those shown on the submitted Placing Drawings.
- C. Reinforcing steel shall be stored off the ground, protected from moisture, and kept free from dirt, oil, or other injurious contaminants.

1.6 QUALITY ASSURANCE

- A. Any material failing to meet the requirements of this specification or the drawings will be rejected and shall be removed from the site immediately.

PART 2 - PRODUCTS

2.1 MATERIALS:

- A. Materials shall be new, of domestic manufacture, and shall comply with the following material specifications.
 - 1. Steel reinforcing bars shall conform to ASTM A615, Grade 60.
 - 2. Welded steel wire fabric shall conform to ASTM A185. Gauge and spacing of wires shall be as indicated on the drawings.
- B. Any bar showing cracks after bending shall be discarded.
- C. Reinforcing Steel Accessories
 - 1. Plastic Protected Bar Supports: CRSI Bar Support Specifications, Class 1 – Maximum Protection.
 - 2. Precast Concrete Block Bar Supports: CRSI Bar Support Specifications, Precast Blocks. Use precast concrete blocks where the reinforcing steel is to be supported over soil.

2.2 TIE WIRE

- A. Tie wires for reinforcement shall be 16-gauge or heavier, black annealed wire.

2.3 SPLICES

- A. Mechanical splices shall be Bar-Lock (MBT) Couplers, Dowel Bar Splicers (DB-SAE) and Dowel In (DI) by Richmond Screw Anchor Co. or approved equal.

2.4 FABRICATION

- A. Fabrication of reinforcement shall be in compliance with the CRSI Manual of Practice.
- B. Bars shall be cold bent. Bars shall not be straightened or rebent.
- C. Bars shall be bent around a revolving collar having a diameter of not less than that recommended by the CRSI.

PART 3 - EXECUTION

3.1 STEEL INSTALLATION:

- A. Before being placed in position, reinforcement shall be thoroughly cleaned of loose mill and rust scale, dirt, and other coatings (including ice), that reduce or destroy bond. When there is a delay in depositing concrete after reinforcement is in place, bars shall be reinspected and cleaned as necessary.

- B. The Contractor shall be solely responsible for determining, providing and installing required number of bars and accessories such as chairs, chair bars, and the like recommended in the latest edition of the “ACI Detailing Manual” SP-66 in sufficient quantities and strength to adequately support the reinforcement and prevent its displacement during the erection of the reinforcement and the placement of concrete.
- C. Except as otherwise indicated on the Drawings, the minimum concrete cover of reinforcement shall be as follows:
 - 1. Concrete against and permanently exposed to earth: 3-in.
 - 2. Concrete exposed to soil, liquid, and/or weather: 2-in.
 - 3. Concrete not exposed to soil, liquid and/or weather:
 - a. Slabs (top and bottom cover), walls: 1-in.
 - b. Bollards: 1-1/2-in.
- D. After forms have been oiled, but before concrete is placed, all steel shall be securely wired in the exact position called for, and shall be maintained in that position until all concrete is placed and compacted. Chair bars and supports shall be provided in a number and arrangement satisfactory to the Engineer.
- E. Concrete blocks having a minimum bearing area of 2-inches by 2-inches and equal in quality to that specified for the slab, shall be used for supporting reinforcing bars for slabs on grade. Wood blocks, stones, brick chips, etc., shall not be used to support reinforcement.
- F. Metal supports shall be of types which will not penetrate the surface of formwork or slab and which will not show through or stain surfaces which are to be exposed to view, painted or unpainted.
- G. Welding of reinforcing bars will be permitted only where permission of the Engineer has been obtained in advance. Such welding shall be performed only under conditions established by the Engineer, and in accordance with AWS 12.1.
- H. Reinforcement which is to be exposed for a considerable length of time after having been placed shall be painted with a heavy coat of cement grout, if required by the Engineer.
- I. Reinforcing steel bars shall not be field bent except where shown on the Drawings or specifically authorized in writing by the Engineer. If authorized, bars shall be cold-bent around the standard diameter pin specified in the CRSI. Closely inspect the reinforcing steel for breaks. If the reinforcing steel is damaged, replace or otherwise repair as directed by the Engineer. Do not bend reinforcement after it is embedded in concrete unless specifically approved in writing by the Engineer.
- J. All reinforcing steel shall be continuous through construction joints.
- K. Reinforcing steel interfering with the location of other reinforcing steel, conduits or embedded items, may be moved within the specified tolerances or one bar diameter, whichever is greater. Greater displacement of bars to avoid interference, shall only be made with the approval of the Engineer. Do not cut reinforcement to install inserts, conduits, mechanical opening or other items without the prior approval of the Engineer.

- L. Securely support and tie reinforcing steel to prevent movement during concrete placement. Secure dowels in place before placing concrete.

3.2 SPLICING OF REINFORCEMENT

- A. Splices designated as compression splices on the Drawings, unless otherwise noted, shall be 40 bar diameter, but not less than 12-in.
- B. Tension lap splices shall be provided at all laps. Length of splice shall be as shown on Contract Drawings.
- C. Splicing of reinforcing steel in concrete elements noted to be “Tension Members” on the Drawings shall be avoided whenever possible. However, if required for constructability, splices in the reinforcement subject to direct tension shall be welded to develop, in tension, at least 125 percent of the specified yield strength of the bar. Splices in adjacent bars shall be offset by the distance of a Class B splice.
- D. Install wire fabric in as long lengths as practicable. Splices in welded wire fabric shall be lapped in accordance with the requirements of ACI-318 but not less than 12-in. The spliced fabrics shall be tied together with wire ties spaced not more than 24-in on center and laced with wire of the same diameter as the welded wire fabric. Do not position laps midway between supporting beams of continuous structures. Offset splices in adjacent widths to prevent continuous splices.
- E. All mechanical splices must develop 125% of the bar capacity in both compression and tension.

3.3 INSPECTION

- A. In no case shall any reinforcing steel be covered with concrete until the installation of the reinforcement, including the size, spacing and position of the reinforcement has been observed by the Engineer and the Engineer’s release to proceed with the concreting has been obtained. The Engineer shall be given ample prior notice of the readiness of placed reinforcement for observation. The forms shall be kept open until the Engineer has finished observing the reinforcing steel.

END OF SECTION 03200

SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. This Section covers all concrete and all related items necessary to place and finish the concrete work.
- B. General: Submit in accordance with Condition of Contract and Division 1 – General Requirements Specification Section.

1.2 REFERENCES

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

American Concrete Institute (ACI)

ACI 301 Structural Concrete for Buildings

ACI 302 Recommended Practice for Concrete Floor and Slab Construction

ACI 304 Recommended Practice for Measuring, Mixing, Transporting, and Replacing Concrete

ACI 304.2R Placing Concrete by Pumping Methods

ACI 305 Recommended Practice for Hot Weather Concreting

ACI 306 Recommended Practice for Cold Weather Concreting

ACI 308 Standard Practice for Curing Concrete

ACI 318 Building Code Requirements for Reinforced Concrete

American Society for Testing and Materials (ASTM)

ASTM C31 Making and Curing Concrete Test Specimen

ASTM C33 Concrete Aggregates

ASTM C39 Compressive Strength of Cylindrical Concrete Specimens

CAST-IN-PLACE CONCRETE

03300-1

ASTM C42 Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

ASTM C87 Effect of Organic Impurities in Fine Aggregate on Strength of Mortar

ASTM C94 Ready-Mixed Concrete

ASTM C143 Standard Method for Slumps of Portland Cement Concrete

ASTM C150 Portland Cement

ASTM C231 Air Content of Freshly Mixed Concrete by the Pressure Method

ASTM C260 Air-Entraining Admixtures for Concrete

ASTM C309 Liquid Membrane-Forming Compounds for Curing Concrete

ASTM C494 Chemical Admixtures for Concrete

- B. Where reference is made to one of the above standards, the revisions in effect at the time of bid opening shall apply.

1.3 SUBMITTALS

- A. General: Submit in accordance with Condition of Contract and Division 1 – General Requirements Specification Section.
- B. Six sets of shop drawings of the materials specified herein shall be submitted to the Engineer for review.
- C. Submit sources of cement and aggregates and their conformance to referenced standards.
- D. Provide one copy of the "Certificate of Delivery" for each load of concrete as it arrives on the site, under the provisions of ASTM C94.
- E. Air-entraining admixture. Product data including catalogue cut, technical data, storage requirements, product life, recommended dosage, temperature considerations and conformity to ASTM standards.
- F. Water reducing admixture. Product data including catalogue cut, technical data, storage requirements, product life, recommended dosage, temperature considerations and conformity to ASTM standards.
- G. Mid or high range water-reducing admixture (plasticizer). Product data including catalogue cut, technical data, storage requirements, product life, recommended

dosage, temperature considerations, retarding effect, slump range and conformity to ASTM standards. Identify proposed locations of use.

- H. Sheet curing material. Product data including catalogue cut technical data and conformity to ASTM standard.
- I. Liquid curing compound. Product data including catalogue cut technical data, storage requirements, product life, application rate and conformity to ASTM standards. Identify proposed locations of use.
- J. Grout. Catalog cuts, technical data, storage requirements, product life, working time after mixing, temperature considerations, conformity to specified standards.
- K. Submit concrete placing sequence to the Engineer for review and comment.
- L. Test Report
 - 1. Concrete mix for each formulation of concrete proposed for use including constituent quantities per cubic yard, water-cementitious materials ratio, type and manufacturer of cement.
 - a. Standard deviation data for each proposed concrete mix based on statistical records.
 - b. Water-cementitious materials ratio curve for concrete mixes based on laboratory test. Give average cylinder strength test results at 28 days for laboratory concrete mix designs. Provide results of 7 and 14 day tests if available.
- M. Certifications
 - 1. Certify that admixtures used in the same concrete mix are compatible with each other and the aggregates.
 - 2. Certify that the Contractor is not associated with the independent testing laboratory nor does the Contractor or its officers have a beneficial interest in the laboratory.
- N. Qualifications
 - 1. Independent testing laboratory: Name, address and qualifications. Laboratories affiliated with the Contractor or in which the Contractor or corporate officers have a beneficial interest are not acceptable.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Sheet Curing Materials: Store in weathertight buildings or off the ground and under cover.
- B. Grout: Non-shrink cement-based grouts shall be delivered as preblended, prepackaged mixes requiring only the addition of water.

1.5 QUALITY ASSURANCE

- A. Only one source of cement and aggregates shall be used on any one structure. Concrete shall be uniform in color and appearance.
- B. Damages and imperfections shall be corrected by the Contractor to the satisfaction of the Engineer at no additional cost to the Owner.
- C. All field-testing and inspection services required shall be provided by the Owner. The cost of such work, except as specifically stated otherwise, shall be paid for by owner. Methods of testing shall comply in detailed with the latest applicable ASTM method.
- D. If, during the progress of the work, it is impossible to secure concrete of the required workability and strength with the materials being furnished, the Engineer may order such changes in proportions or materials, or both, as may be necessary to secure the desired properties. All changes so ordered shall be made at the Contractor's expense.
- E. If, during the progress of the work, the materials from the sources originally accepted change in characteristics, the Contractor shall, at the Contractor's expense, make new acceptance tests of aggregates and establish new design mixes. Such testing and design shall be accomplished with the assistance of a certified independent testing laboratory, retained by the Contractor, acceptable to the Engineer.

1.6 DEFINITION

- A. Non-shrink grout: A commercially manufactured product that does not shrink in either the plastic or hardened state, is dimensionally stable in the hardened state and bonds to a clean base material surface.

PART 2 - PRODUCTS

2.1 CEMENT

- A. The cement shall be an approved brand of American manufactured Portland Cement, Type II conforming to ASTM C150. The brand name and type of cement proposed for use shall be submitted to the Engineer for approval immediately following award

of contract. Only one color of cement, all of the same manufacture, shall be used for the work.

- B. When the use of Portland cement Type III is permitted by the Engineer the same strength requirements shall apply, but the indicated strengths shall be attained in 7 days instead of 28 days.

2.2 AGGREGATES

- A. Except as otherwise noted, aggregates shall conform to the requirements of ASTM C33.
- B. Fine aggregate shall consist of washed inert natural sand conforming to the requirements of ASTM C33 and the following additional requirements:

Sieve	Retained Percent
#4	0 to 5
#16	25 to 40
#50	70 to 87
#100	93 to 97
Fineness Modulus	2.80 (\pm 0.20)
Organic	Plate 2 maximum
Silt	2.0% maximum
Mortar Strength	100% minimum compression ratio
Soundness	5% maximum loss, magnesium sulfate, five cycles

- C. Coarse aggregate shall consist of well-graded crushed stone or washed gravel conforming to the requirements of ASTM C33 and the following additional requirements:

Designated Size (inches)	3	2	1-1/2	1	3/4	1/2	3/8
Fineness Modulus (\pm -0.20)	7.95	7.45	7.20	6.95	6.70	6.10	4.50
Organic	Plate 1 maximum						
Silt	1.0% maximum						
Soundness	5% maximum loss, magnesium sulfate, five cycles						

Grading requirements shall be as listed in ASTM C33, Table 2 for the size number corresponding to the appropriate maximum coarse aggregate size. Limits of Deleterious Substances and Physical Property Requirements shall be as listed in ASTM C33, Table 3 for severe weathering regions. Size numbers for the concrete mixes shall be as shown in Table 03300-1.

TABLE 03300-1

Description	Maximum Coarse Aggregate Size	Size Number (ASTM C33 Table 2)
24-in thick or greater	1-1/2-in	467
Greater than 12-in thick	1-in	57
12-in thick or less	3/4-in	67
Peastone mix	3/8-in	8

2.3 WATER

- A. Water shall be potable. Water for curing shall not contain any substance injurious to concrete, or which causes staining.

2.4 ADMIXTURES

- A. Admixtures shall be free of chlorides and alkalis (except for those attributable to water). When it is required to use more than one admixture in a concrete mix, the admixtures shall be from the same manufacturer. Admixtures shall be compatible with the concrete mix including other admixtures.
1. Air entraining agent shall be in accordance with ASTM C260. Proportioning and mixing shall be in accordance with manufacturer's recommendations.
 2. Water reducing agent shall be a mid-range water reducer meeting ASTM C494, Type A, and contain no more than .05% chloride ions. Proportioning and mixing shall be in accordance with manufacturer's recommendations.
 3. Superplasticizer agent shall be in accordance with ASTM C494, Type F or Type G and contain no more than 0.05% chloride ions. Product may be plant added or field added based on the best application considering distance, temperature and time. The treated concrete shall be capable of maintaining plastic state for two hours or longer depending on application. Proportioning and mixing shall be in accordance with manufacturer's recommendations.
 4. Admixtures causing retarded or accelerated setting of concrete shall not be used without written approval from the Engineer. When allowed, the admixtures shall be retarding or accelerating water reducing or high range water reducing admixtures.
 5. Prohibited admixtures: Calcium chloride, thiocyanates and admixtures containing more than 0.05% chloride ions are not permitted.

2.5 MIXES

- A. Development of mix designs and testing shall be by an independent testing laboratory acceptable to the Engineer engaged by and at the expense of the Contractor.
- B. Select properties of ingredients to meet the design strength and materials limits specified in Tables 03300-2 and 03300-3 and to produce concrete having proper placeability, durability, strength, appearance and other required properties. Proportion ingredients to produce a homogenous mixture which will readily work into corners and angles of forms and around reinforcement without permitting materials to segregate or allowing excessive free water to collect on the surface.
- C. The design mix shall be based on standard deviation data of prior mixes with essentially the same proportions of the same constituents or, if not available, be developed by laboratory test. Water content of the concrete shall be based on a curve showing the relation between water cementitious ratio and 7 and 28 day compressive strengths of concrete made using the proposed materials. The curves shall be determined by four or more points, each representing a average value of at least three test specimens at each age. The curves shall have a range of values sufficient to yield the desired data, including the compressive strength specified, without extrapolation. The resulting mix shall not conflict with the limiting values for maximum water cementitious ratios and net minimum cementitious content as specified in Table 03300-3.

TABLE 03300-2

Design Strength*	Minimum Lab Strength at 7 Days
3000 psi	2100 psi
4000 psi	2800 psi

*Specified compressive strength at 28 days

In no case, however, shall the resulting mix conflict with the limiting values for maximum water content and net minimum cement factor specified in Table 03300-3.

- D. The limiting strengths, cement factors and water contents for each mix shall be in accordance with Table 03300-3.

TABLE 03300-3

Minimum 28 Day Design Strength (psi)	Net Minimum Cement Factor* Content in (100 lbs/cy)	Maximum Water Content** gals/100 lbs of Cement)	Maximum Water- Cementitious Materials Ratio (by weight)
3000	6.11	6.4	0.58
4000	6.3	5.4	0.45

Pumped Concrete	6.3	0.45
-----------------	-----	------

* Minimum. Increase as necessary to meet other requirements. These cement factors apply to “controlled” concrete subject to specific inspection.

** Maximum. Decrease if possible. This represents total water in mix at time of mixing, including free water on aggregates and water in admixture solutions.

- E. Compression Test: Provide testing of the proposed concrete mix or mixes to demonstrate compliance with the compression strength requirements in conformity with the provisions of ACI 318.
- F. Entrained air, as measured by ASTM C231, shall be as shown in Table 03300-4.

TABLE 0033-4

<u>Concrete Placement</u>	<u>Total Air Measured at Discharge From Truck (Percent)</u>
Trowel finished slabs	3.5 maximum
All other concrete	4-6

- 1. If the air entraining agent proposed for use in the mix requires testing methods other than ASTM C231 to accurately determine air content, make special note of this requirement in the admixture submittal required under Paragraph 1.04.

- G. Slump of the concrete as measured by ASTM C143, shall be as shown in Table 03300-5. If plasticizer is used, the slump indicated shall be that measured before plasticizer is added. Plasticized concrete shall have a maximum slump of eight inches.

TABLE 03300-5

<u>Portion of Structure</u>	<u>Slump (inches)</u>	
	<u>Recommended</u>	<u>Range</u>
Pavement and slabs on ground	2	1-3
Plain footings, slabs, beams		
Pads, curbs and sludge tank walls	2-3	1-4
Heavy reinforced foundation		
Walls and footings	3-4	2-5
Thin reinforced wall and columns	4	3-5

- H. Proportion admixtures according to the manufacturer’s recommendations. Two or more admixtures specified may be used in the same mix provided that the admixtures in combination retain full efficiency and have no deleterious effect on the concrete or on the properties of each other.

2.6 CONCRETE

- A. Concrete conforming to the requirements listed below shall be used where indicated on the drawings. Unless otherwise indicated, concrete fill and concrete used as fill under foundations (mud slab), and elsewhere approved by the Engineer, shall be the 3,000 psi mix.

CONCRETE STRENGTHS

<u>Minimum Comp. Strength at 28 days (psi)</u>	<u>Maximum Water/ Cement Ratio Gallons per bag of cement)*</u>	<u>Cement Factor: 94 lb. bags Per cubic yard minimum**</u>
3000	0.59 (6.9)	5.5
4000	0.48 (5.6)	6.5

* Based on air-entrained concrete. If non-air-entrained concrete is called for, the listed maximum water/cement ratios may be increased slightly, as approved by the Engineer. The water is the total water in the mix, including free water on the aggregate.

** These are minimum amounts; increase as necessary to meet mix requirements

- B. Concrete shall conform to ASTM C94. One copy of the Certificate of Delivery required by ASTM C94 shall be delivered to the Engineer immediately upon arrival of each load of concrete at the site. The Contractor shall be responsible for the design of the concrete mixtures.
- C. Standard compression tests in conformity with the provisions of ACI 318 of all proposed mixes shall be made by the testing laboratory or other satisfactory evidence shall be presented that the design mixes will attain the minimum strengths listed on the design drawings or called for herein, within the limitations of the ACI Code. No concrete shall be delivered to the job site until the Engineer has approved the design mixes.
- D. All concrete (unless otherwise directed) shall contain an air-entraining agent. Air entrained concrete shall have an air content by volume, measured at discharge from truck, of 3 to 6 percent for 1-1/2-inch aggregate and 4 to 8 percent for 3/4-inch aggregate. The air content shall be the responsibility of the testing laboratory and in accordance with ASTM C231.
- E. All concrete shall contain a mid-range water reducer to minimize cement and water content of the mix, at the specified slump, in accordance with ASTM C494.
- F. Slump for all concrete shall be from 3-inch to 4-inch, except for concrete using a superplasticizer, when the maximum slump shall be 8 inches. Any concrete having a

slump greater than 4 inches (8 inches with superplasticizer) shall be promptly removed from the site.

- G. No calcium chloride or admixtures containing calcium chloride shall be added to the concrete. No admixture other than those specified shall be used in concrete without the specific written permission of the Engineer in each case.
- H. No additional water, except for the amount indicated by the design mix shall be added to the concrete without the prior permission of the Engineer.

2.7 GROUT

- A. Non-metallic, non-shrink grout shall be pre-mixed, non metallic, non-corrosive, non-staining product containing selected silica sands, Portland cement, shrinkage compensation agents, plasticizing and water reducing agents, complying with CRD-C588.

2.8 CURING MATERIALS

- A. Curing compound shall be a curing/hardener compound such as Acurion by AntiHydro, Sikaguard Cure/Hard by Sika, Super Diamond Clear by Euclid or approved equal. Liquid membrane-forming curing compound shall comply with the requirements of ASTM C309 Type 1-D (clear or translucent with fugitive dye) and shall contain no wax, paraffin, or oil.

2.9 FLOOR HARDENER

- A. Floor hardener shall be a colorless aqueous solution containing zinc silicofluoride, magnesium silicofluoride, or sodium silicofluoride. These silicofluoride can be used individually or in combination. Proprietary hardeners may be used if approved by the contracting officer.

PART 3 - EXECUTION

3.1 GENERAL

- A. Under no circumstances shall concrete which has set or partially set before placing be used; and no retempering of concrete or grout will be permitted.
- B. The batching, mixing, transporting, placing and curing of concrete shall be subject to the inspection of the Engineer at all times. The Contractor shall advise the Engineer of his readiness to proceed at least six working hours prior to each concrete placement. The Engineer will inspect the preparations for concreting including the preparation of previously placed concrete, the reinforcing and the alignment,

cleanliness and tightness of formwork. No placement shall be made without the inspection and acceptance of the Engineer.

- C. Concrete mix showing either poor cohesion or poor coating of the coarse aggregate with paste shall be remixed. If this does not correct the condition, the concrete shall be rejected. If the slump is within the allowable limit, but excessive bleeding, poor workability, or poor finishability are observed, changes in the concrete mix shall be obtained only by adjusting one or more of the following:
 - 1. The gradation of aggregate
 - 2. The proportion of fine and coarse aggregate.
 - 3. The percentage of entrained air, within the allowable limits.
- D. Furnish a delivery ticket for ready mixed concrete to the Engineer as each truck arrives. Each ticket shall provide a printed record of the weight of cement and each aggregate as batched individually. Clearly indicate the weight of fine and coarse aggregate, cement and water in each batch, the quantity delivered, the time any wage is added and the numerical sequence of the delivery. Show the time of day batched and time of discharge from the truck. Indicate the number of revolutions of transit mix trucks.

3.2 PREPARATION

- A. Before placing concrete, forms and the space to be occupied by the concrete shall be thoroughly cleaned, and reinforcing steel and embedded metal shall be free from dirt, oil, mill scale, loose rust, paint or other material which would tend to reduce the bond.
- B. Earth, concrete, masonry, or other water-permeable material against which concrete is to be placed shall be thoroughly saturated with water immediately before concrete is placed. No concrete shall be placed until the consolidation of the ground and the arrangement and details of forms and reinforcing have been inspected and approved by the Engineer.
- C. When joining fresh concrete to concrete which has attained full set, the latter shall be cleaned by chipping, roughen to a ¼ inch amplitude, and washing off all dirt, scum and laitance. It then shall be moistened prior to placing new concrete.

3.3 MIXING AND TRANSPORTATION

- A. Ready-mixed concrete shall be batched, mixed and transported in accordance with ASTM C94, except as otherwise specified. Truck mixers, agitators, and non-agitating units shall comply with National Ready-Mix Concrete Association (NRMCA) and Truck Mixer Manufacturers' Bureau (TMMB). Ready-mix plant

equipment and facilities shall be certified in accordance with NMRCA QC 3. Site-mixed concrete shall be mixed in accordance with ACI 301. On-site plant shall conform to the NRMCA CPMB 100.

- B. No water from the truck system or elsewhere shall be added after the initial introduction of mixing water for the batch except when on arrival at the jobsite, the slump of the concrete is less than that specified. Water added to bring the slump within the specified range shall not change the total water in the concrete to a point that the approved water-cement ratio is exceeded. The drum shall be turned an additional 30 revolutions, or more, if necessary, until the added water is uniformly mixed into the concrete. Water shall not be added to the batch at any later time.
- C. Ready-mix or transit-mixed concrete shall be transported to the site in watertight agitator or mixer trucks loaded not in excess of rated capacities for the respective conditions as stated on the name plate. Discharge at the site shall be within 1-1/2 hours after cement was first introduced into the mix. Central mixed concrete shall be plant-mixed a minimum of 1-1/2 minutes per batch and then shall be truck-mixed or agitated a minimum of 8 minutes. Agitation shall begin immediately after the pre-mixed concrete is placed in the truck and shall continue without interruption until discharge. Transit-mixed concrete shall be mixed at mixing speed for at least 10 minutes immediately after charging the truck, followed by agitation without interruption until discharged.
- D. All central plant and rolling stock equipment and methods shall conform to the latest Truck Mixer and Agitator Standards of the Truck Mixer Manufacturers' Bureau of the National Ready-Mixed Concrete Association, as well as ACI 304 and ASTM C94.
- E. Attention is called to the importance of dispatching trucks from the batching plant so that they shall arrive at the site of the work just before the concrete is required, thus avoiding excessive mixing of concrete while waiting or delays in placing successive layers of concrete in the forms.
- F. Concrete shall be discharged within 1-1/2 hours after introduction of the cement to the aggregates, except that when the concrete temperature exceeds 85 degrees F, this time shall be reduced to 45 minutes. Concrete shall be placed within 15 minutes after it has been discharged from the truck.
- G. Temperature and Mixing Time Control:
 - 1. In cold weather, maintain the as-mixed temperature of the concrete and concrete temperatures at the time of placement in the forms as indicated in Table 03300-6.
 - 2. If water or aggregate has been heated, combine water with aggregate in the mixer before cement is added. Do not add cement to mixtures of water and aggregate when the temperature of the mixture is greater than 90 degrees F.

3. In hot weather, cool ingredients before mixing to maintain temperature of the concrete below the maximum placing temperature of 90 degrees F. If necessary, substitute well-crushed ice for all or part of the mixing water.
4. The maximum time interval between the addition of mixing water and/or cement to the batch, and the placing of concrete in the forms shall not exceed the following:

TABLE 03300-6

AIR OR CONCRETE TEMPERATURE (WHICHEVER IS HIGHER)	MAXIMUM TIME
80 degrees F to 90 degrees F	45 minutes
70 degrees F to 79 degrees F	60 minutes
40 degrees F to 69 degrees F	90 minutes

If an approved mid or high range water reducer (plasticizer) is used to produce plasticized concrete, the maximum time interval shall not exceed 90 minutes or other appropriate time such that workability and Contractor's ability to properly place the concrete will not be adversely compromised.

3.4 INSTALLATION/APPLICATION/ERECTION

A. PLACING:

1. Verify that all formwork completely encloses concrete to be poured and is securely braced prior to concrete placement. Remove ice, excess water, dirt and other foreign materials from form. Confirm that reinforcement and other embedded items are securely in place.
2. No concrete shall be placed by pumping methods without the prior written approval of the Engineer. Should the Contractor be allowed to place concrete by pumping methods, procedures, mix design of concrete, and all other precautions shall be in accordance with ACI 304.2R and as approved by the Engineer.
3. Concrete shall be placed in alternate areas, as defined by the construction and control joints indicated on the design drawings. A minimum of 3 days shall elapse between placement of adjacent sections.
4. Deposit concrete as near its final position as possible to avoid segregation due to rehandling or flowing. Should any segregation occur, the concrete shall be remixed before it is placed. Concrete shall be placed in the forms in horizontal layers not over 1 to 2 feet thick. Concrete shall not be allowed to drop freely more than 4 feet. If the free drop to the point of placement must

exceed 4 feet, the Contractor shall obtain the approval of the Engineer for the proposed method of depositing the concrete. The concrete shall not be required to flow over distances greater than 3 feet in any direction in the forms or on the ground, unless otherwise permitted by the Engineer.

5. Do not place concrete for supported elements until concrete previously placed in the supporting element (column, slabs and/or walls) has reached 70% of its 28 day strength.
6. Unless otherwise noted, the work begun on any day shall be completed in daylight of the same day.
7. "Cold Joints" are to be avoided, but if they occur, they are to be treated as bonded construction joints.
8. Chutes for conveying concrete shall be of U-shaped design and sized to insure a continuous flow of concrete. Flat (coal) chutes shall not be employed. Chutes shall be metal or metal-lined, and each section shall have approximately the same slope. The slope shall not be less than 25 nor more than 45 degrees and shall be such as to prevent segregation of the ingredients. The discharge end of the chute shall be provided with a baffle plate or spout to prevent segregation. If the discharge end of the chute is more than 5 feet above the surface of the concrete in the forms, a spout shall be used and the lower end maintained as near the surface of deposit as practicable. When the operation is intermittent, the chute shall discharge into a hopper. Chutes shall be thoroughly cleaned before and after each run, and the debris and any water shall be discharged outside the forms. Concrete shall not be allowed to flow horizontally more than 5 feet.
9. Concrete during and immediately after depositing shall be thoroughly compacted by means of suitable tools. Internal type mechanical vibrators shall be employed to produce the required quality of finish. Vibration shall be done by experienced operators under close supervision and shall be carried on long enough to produce homogeneity and optimum consolidation without permitting segregation of the solid constituents or "pumping" or migration of air. All vibrators shall be supplemented by proper wooden spade puddling adjacent to forms to remove included bubbles and honeycomb. This is essential for the top lifts of walls. All vibrators shall travel at least 10,000 rpm and be of adequate capacity. At least one vibrator shall be used for every 10 cubic yards of concrete per hour. In addition, one spare vibrator in operating condition shall be on the site.
10. Concrete slabs on the ground shall be well-tamped into place and foundation material shall be wet, tamped, and rolled until thoroughly compacted prior to placing concrete.

11. Concrete shall be deposited continuously in layers of such thickness that no concrete will be deposited on concrete which has hardened sufficiently to cause the formation of seams and planes of weakness within the section. If a section cannot be placed continuously, construction joints may be located at points as provided for in the drawings or approved by the Engineer.
12. Chutes, hoppers, spouts, adjacent work, etc., shall be thoroughly cleaned before and after each run, and the water and debris shall not be discharged inside the form.

B. CONCRETE PLACING DURING COLD WEATHER

1. For this Specification, cold weather is defined as a period when for more than three successive days, the average daily outdoor temperature drops below 40 degrees F. The average daily temperature shall be calculated as the average of the highest and the lowest temperature during the period from midnight to midnight.
2. Concrete placed during cold weather shall be batched, delivered, placed, cured and protected to compliance with the recommendations of ACI 306R and the additional requirements of this section.
3. Concrete shall not be placed on frozen ground, and no frozen material or material containing ice shall be used. Materials for concrete shall be heated when concrete is mixed, placed, or cured when the mean daily temperature is below 40oF, or is expected to fall to below 40 degrees F, within 72 hours, and the concrete after placing shall be protected by covering, heat, or both. No accelerant shall be used to prevent freezing.
4. The temperature of concrete surfaces shall not be permitted to drop below 50 degrees F. for at least 7 days after placement of the concrete.
5. All details of Contractor's handling and protecting of concrete during freezing weather shall be subject to the approval and direction of the Engineer. All procedures shall be in accordance with provisions of ACI 306. Cold weather concreting shall not begin until the work plan is acceptable to the Engineer.

C. CONCRETE PLACING DURING HOT WEATHER

1. For this Specification, hot weather is defined as any combination of high air temperatures, low relative humidity, and wind velocity which produces a rate of evaporation as estimated in ACI 305R, approaching or exceeding 0.2 pounds per square foot per hour.
2. Concrete just placed shall be protected from the direct rays of the sun and the forms and reinforcement just prior to placing shall be sprinkled with cold

water. The Contractor shall make every effort to minimize delays which will result in excessive mixing of the concrete after arrival on the job.

3. During periods of excessively hot weather (90 degrees F, or above) ingredients in the concrete shall be cooled insofar as possible and cold mixing water shall be used to maintain the temperature of the concrete at permissible levels all in accordance with the provisions of ACI 305. Any concrete with a temperature above 90 degrees F, when ready for placement will not be acceptable, and will be rejected.
4. Temperature records shall be maintained throughout the period of hot weather giving air temperature, general weather conditions (calm, windy, clear, cloudy, etc.) and relative humidity. The record shall include checks on temperature of concrete as delivered and after placing in forms. Data should be correlated with the progress of the work so that conditions surrounding the construction of any part of the structure can be ascertained.
5. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that steel
6. Temperature will not exceed the ambient air temperature immediately before embedment in concrete.
7. Wet form, particularly metal deck, before placing concrete.
8. Keep permanent temperature record showing date and outside temperature for concreting operations. Thermometer reading shall be taken at start of work in morning, at noon, and again late in afternoon. Locations of concrete placed during such periods shall likewise be recorded, in such manner as to show any effect temperatures may have had on construction. Copies of temperature record shall be distributed daily to Owner.

D. COMPACTING

1. Concrete during and immediately after depositing shall be thoroughly compacted by means of suitable tools. Internal type mechanical vibrators shall be employed to produce the required quality of finish. Vibration shall be done by experienced operators under close supervision and shall be carried on long enough to produce homogeneity and optimum consolidation without permitting segregation of the solid constituents or "pumping" or migration of air. All vibrators shall be supplemented by proper wooden spade puddling adjacent to forms to remove included bubbles and honeycomb. This is essential for the top lifts of walls. All vibrators shall travel at least 10,000 rpm and be of adequate capacity. At least one vibrator shall be used for every 10 cu. yd. of concrete per hour. In addition, one spare vibrator in operating condition shall be on the site.

2. A minimum frequency of 7000 revolutions per minute is required for mechanical vibrators. Do not use vibrators to transport concrete within forms. Insert vibrators and withdraw at points from 18-in to 30-in apart. At each insertion, vibrate sufficiently to consolidate concrete, generally from five to 15 seconds. Do not over vibrate so as to segregate.

E. CURING

1. Immediately after placement, concrete shall be protected from premature drying extremes in temperatures, rapid temperature change, mechanical injury and injury from rain and flowing water. All materials and equipment needed for adequate curing and protection shall be available and at the placement prior to placing concrete. No fire or excessive heat shall be permitted near or in direct contact with the concrete at any time. Concrete curing shall be performed as specified in ACI 301 and as stated herein. All curing procedures shall have prior approval of the Engineer.
2. Curing procedure shall be continued for at least 7 days.
 - a. Moisture loss from surface placed against metal or wood forms shall be minimized by keeping forms wet until removal.
 - b. Curing shall be continued for at least 7 days. When forms are removed during the curing period, surfaces shall be cured by spraying or by the use of a curing compound as previously specified.
 - c. Surfaces shall be protected from traffic or damage until surfaces have hardened sufficiently. If necessary, 1/2-inch thick plywood sheets shall be used to protect the exposed surface.

F. FINISHING OF FORMED SURFACES

1. Schedule of Finishes:
 - a. Concrete for the Project shall be finished in the various specified manners either to remain as natural concrete or to receive an additional applied finish or material under another Section.
 - b. Finishes to the base concrete for the following conditions shall be finished as noted and as further specified herein:
 - i. Exposed exterior formed concrete, except exposed slabs and walking surfaces – Rubbed finish.

- ii. Concrete to receive chemical hardener – Light broom finish, non slip, except at electrical rooms provide wood float, non slip.
 - iii. Exterior concrete slab, stairs and other horizontal areas - Broomed finish, non-slip.
 - iv. Walls and vertical surfaces in process tanks and basins – Off form finish.
 - v. Concrete receiving sheet membrane waterproofing – cleared of laitance and foreign materials and rubbed at vertical surfaces, steel trowel finish at horizontal/sloping surfaces.
 - vi. Concrete to receive paint – Rubbed finish
 - vii. Top of curbs and pads – Steel troweled finish
- 2. Concrete shall not be stripped before the concrete has been cured and attained required strength.
 - 3. Care shall be exercised to prevent damaging edges or obliterating the lines of chamfers, rustications or corners when removing the forms or doing any other work adjacent thereto.
 - 4. Clean all exposed concrete surfaces and adjoining work stained by leakage of concrete, to the satisfaction of the Engineer.
 - 5. Off-Form Finish – Fins and other projections shall be removed, dull of and sharpen edges, and tie cones and defects filled.
 - 6. Rubbed Finish
 - a. Immediately upon stripping forms and before concrete has changed in color, all fins shall be carefully removed with a hammer. While the wall is still damp apply a thin coat of medium consistency neat cement slurry by means of bristle brushes to provide a bonding coat with all pits, air holes or blemishes in the parent concrete; avoid coating large areas of the finished surface with this slurry
 - b. Before the slurry has dried or changed color, apply a dry (almost crumbly) grout consisting of one volume cement to 1-1/2 volumes of clean masonry sand having a fineness modulus of approximately 2.25 and complying with the gradation requirements of the ASTM for such a material. Grout shall be uniformly applied by means of camp (neither dripping wet nor dry) pads of coarse burlap approximately 6-in square used as a float. Grout shall be well scrubbed into the pits and air holes to provide a dense mortar in the imperfections to be patched.

- c. Allow the mortar to partially harden for one or two hours depending upon the weather. If the air is hot and dry, keep the wall damp during this period using a fine fog spray. When the grout has hardened sufficiently so it can be scraped from the surface with the perpendicular edge of a steel trowel without damaging the grout in the small pits or holes, cut off all that can be removed with a trowel. Grout allowed to remain on the wall to long will get too hard and will be difficult to remove.
- d. Allow the surface to dry thoroughly and rub it vigorously with clean dry burlap to completely remove any dried grout. No visible film of grout should remain after this rubbing. The entire cleaning operation for any area must be completed the day it is started. Do not leave grout on surfaces overnight. Allow sufficient time for grout to dry after it has been cut with the trowel so it can be wiped off clean with the burlap.
- e. On the day following the repair of pits, air holes and blemishes, the walls again shall be wiped off clean with dry, used pieces of burlap containing old hardened mortar which will act as a mild-abrasive. After this treatment, there shall be no built-up firm remaining on the parent surface. If, however, such is present a fine abrasive stone shall be used to remove all such material without breaking through the surface film of the original concrete. Such scrubbing shall be light and sufficient only to remove excess material without working up a lather or mortar or change the texture of the concrete. Rubbing shall be performed while the surface is wet using a carborundum or cement sand brick, to achieve a smooth uniform, even textured finish. Patched and chipped areas shall be blended to match as closely as possible the appearance of the rest of the surface. No cement wash or plastering will be permitted, and no mortar shall be used except as required above.
- f. A thorough wash-down with stiff bristle brushes shall follow the final bagging or stoning operation in order that no extraneous materials remain on the surface of the wall. The wall shall be sprayed with a fine fog spray periodically to maintain a continually damp condition for at least 3 days after the application of the repair grout.
- g. In addition to scraping, interior concrete surfaces which will be exposed to view and concrete surfaces which are to be prepared and painted, shall receive a smooth rubbed finish, in accordance with ACI 301 and as described below.
- h. Form tie holes and other voids and faults shall be patched. Voids shall be cleaned out, roughened, thoroughly wetted, coated with neat cement paste, and filled with mortar of cement and sand in the same proportions, materials, and color as used in the concrete. The surface of the patch shall be flush with the surrounding surface after finishing operations are

complete. Surface shall be kept continuously damp until patches are firm enough to be rubbed without damage.

G. TESTING

1. Concrete inspection and testing shall be performed by an independent inspection laboratory, engaged and paid for by the Contractor. The Engineer shall approve the inspection laboratory before concrete work commences. Testing equipment shall be supplied by the laboratory, and the preparation of samples and all testing shall be performed by the laboratory personnel. Full assistance and cooperation, concrete for samples, and such auxiliary personnel and equipment as needed shall be provided by the Contractor.
2. At least one slump test shall be performed from each truck load of concrete. The sample for slump shall be taken from the middle third of a truck load. Air content tests shall be made at the discretion of the Engineer. If the measured slump or air content falls outside the specified limits, a check test shall be made immediately on another portion of the same sample. In the event of a second failure, the concrete shall be considered to have failed the requirements of the specification and shall be immediately removed from the jobsite to be discarded.
3. The Contractor shall advise the Engineer of his readiness to proceed with concrete placement at least one working day prior to each placement. The Engineer will inspect the preparations for concrete, including the preparation of previously placed concrete, the reinforcing, and the alignment and tightness of formwork. No placement shall be made without the prior approval of the Engineer.
4. A minimum of four standard compression test cylinders shall be made and tested for each 100 cubic yards or fraction thereof for each type and design strength of concrete from each day's placement of concrete. One cylinder shall be tested at 7 days and two cylinders at 28 days. The fourth cylinder from each set shall be kept until the 28 day test report on the second and third cylinders in the same set has been received. The Engineer reserves the right to require test cylinders to be made for each truckload of concrete if the nature of the project or project experience indicates such additional tests are required for proper control of concrete quality.
5. The strength level shall be considered satisfactory so long as the averages of all sets of three consecutive strength test results equal or exceed the specified strength f'_c , and no individual strength test (average of two cylinders) result falls below the specified strength f'_c by more than 500 psi.

6. In the event the average compressive strength of the two 28 day cylinders does not achieve the required level, the Engineer may elect to test the fourth cylinder immediately or test it after 56 days.

H. FAILURE TO MEET REQUIREMENTS

1. The Engineer shall have the right to reject concrete represented by low strength tests or to agree to further testing of the concrete. Rejected concrete shall be promptly removed and replaced with concrete conforming to the specification. The decision of the Engineer as to whether substandard concrete is to be accepted or rejected or additional tests shall be conducted shall be final. All direct and indirect costs associated with further curing and testing of the concrete shall be at the Contractor's expense.
2. If the Engineer agrees to consider further curing and/or testing of the concrete before making a final decision, the Contractor shall submit a detailed plan to the Engineer, including proposed criteria for acceptance of the concrete. The plan may include additional curing of the concrete, drilling and testing of cores, load testing of the structure, or a combination.
3. If additional curing is permitted before further inspection and testing, the Contractor shall provide any necessary materials and labor to further cure the suspect concrete.
4. If drilling and testing of cores is permitted, the Contractor shall be responsible for obtaining the cores, including provision of ladders, scaffolding, and such incidental equipment as may be required. If additional curing is permitted, cores shall be drilled after the curing period, and shall be in accordance with ASTM Methods C39 and C42. The Contractor shall repair all core holes to the satisfaction of the Engineer.
5. The burden of proof, including, but not limited to the work of cutting and testing the cores, inspection, evaluation, engineering, repair of the holes, or removal and replacement of the concrete in question, and all associated costs therefore, shall be at the expense of the Contractor.
6. If load testing of the concrete is permitted, and if not otherwise indicated, slabs or beams under load test shall be loaded with their own weights plus a superimposed load of 2 times the design live load. The load shall be applied uniformly over the portion being tested in the approved manner and left in position for 24 hours. The structure shall be considered satisfactory if deflection "D" in feet, at end of 24-hour period, does not exceed the following value:

$$D \text{ equals } 0.001 (L \times L)/t$$

in which "L" is span in feet, "t" is depth of slab, or beam in inches. If deflection exceeds "D" in the above formula, the concrete shall be considered faulty unless within 24 hours after removal of the load, the slab, or beam under test recovers at least 75 percent of the observed deflection.

7. If the suspect concrete still fails to meet specification requirements, the Engineer shall have the right to reject the concrete, have it removed and replaced, in accordance with paragraph 5 above, or to require mechanical strengthening of the concrete to satisfy project requirements. The Contractor shall submit a removal and replacement plan for review by the Engineer.

END OF SECTION 03300