

World Plaza
Relocalización de Compactadora de Basura

DIVISION - 3 CONCRETE

SECTION - 03 30 00 CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 DESCRIPTION

- a. This section specifies cast-in-place structural concrete and materials and mixes for other concrete.

1.2 RELATED WORK

- a. DIVISION 1, GENERAL REQUIREMENTS.
- b. Concrete roads, walks, and similar exterior site work: Section 02 52 00, SITE WORK CONCRETE.

1.3 TESTING SERVICES FOR CONCRETE MIX DESIGN

- a. The use of testing services shall in no way relieve the Contractor of his responsibility to furnish materials and construction in full compliance with the plans and specifications. Testing agency retained and reimbursed by the Contractor and approved by Architect.
- b. To facilitate testing services, the Contractor shall:
 - 1. Secure and deliver to the Architect or his testing agency, without cost, the preliminary representative samples of the materials he proposes to use and which are required to be tested.
 - 2. Submit through the testing agency to the Architect the concrete mix design he proposes to use, and make written request for approval.
 - 3. Furnish any necessary labor to assist the designated testing agency in obtaining and handling samples at the project or other sources of materials.
 - 4. Advise the testing agency sufficiently in advance of operations to allow for completion of quality tests and for the assignment of personnel.
 - 5. Provide and maintain for the sole use of the testing agency adequate facilities for safe storage and proper curing of concrete test cylinders on the project site for the first 24 hours, as required by ASTM C31.
 - 6. Furnish copies of mill test reports of all shipments of cement and reinforcing steel to the Architect and the testing agency, if required.
- c. Testing agency maintaining active participation in Program of Cement and Concrete Reference Laboratory (CCRL) of National Institute of Standards and Technology.
- d. Testing agency shall furnish equipment and qualified technicians to establish proportions of ingredients for concrete mixes.

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1.4 TOLERANCES

- a. Formwork: ACI 117, except the elevation tolerance of formed surfaces before removal of shores is +0 inch and -3/4 inch.
- b. Reinforcement Fabricating and Placing: ACI 117, except that fabrication tolerance for bar sizes #3, #4, and #5 (Tolerance Symbol 1 in Fig. 2.1(a), ACI, 117) used as column ties or stirrups is +0 inch and -1/2 inch where gross bar length is less than 12 feet, or +0 inch and -3/4 inch where gross bar length is 12 feet or more.
- c. Cross-Sectional Dimension: ACI 117, except tolerance for thickness of slabs 12 inches or less is +3/4 inch and -1/4 inch. Tolerance of thickness of beams more than 12 inch but less than 3 feet is +3/4 inch and -3/8 inch.
- d. Slab Finishes: ACI 117, Section 4.5.6, F-number method in accordance with ASTM E1155, except as follows:
 - 1. Test entire slab surface, including those areas within 2 feet of construction joints and vertical elements that project through slab surface.
 - 2. Maximum elevation change, which may occur within 2 feet of any column or wall element, is 1/4 inch.
 - 3. Allow sample measurement lines that are perpendicular to construction joints to extend past joint into previous placement no further than 5 feet.

1.5 REGULATORY REQUIREMENTS

- a. American Concrete Institute (ACI).
 - 1. ACI 315 - Manual of Standard Practice for Detailing Reinforced Concrete Structures.
 - 2. ACI 318 - Building Code Requirements for Reinforced Concrete.
 - 3. ACI 301 - Specifications for Structural Concrete for Buildings.

1.6 SUBMITTALS

- a. Submit in accordance with Section 01 30 00, SUBMITTALS.
- b. Samples:
 - 1. Portland cement, 8 lbs.
- c. Shop Drawings:

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1. Reinforcing steel: Complete shop drawings
- d. Mill Test Reports:
 1. Reinforcing steel
- e. Manufacturer's Certificates:
 1. Abrasive aggregate
 2. Lightweight aggregate for structural concrete
 3. Air-entraining admixture
 4. Chemical admixtures
 5. Waterproof paper for curing concrete
 6. Liquid membrane forming compounds for curing concrete
 7. Non-shrinking grout
 8. Liquid hardener
 9. Waterstops
 10. Expansion joint filler
 11. Adhesive binder
- f. Testing Agency for Concrete Mix Design: Approval request including qualifications of principals and technicians and evidence of active participation in program of Cement and Concrete Reference Laboratory (CCRL) of National Institute of Standards and Technology.
- g. Test Report for Concrete Mix Designs: Trial mixes including water-cement and ratio curves Concrete mix ingredients Admixtures

1.7 DELIVERY, STORAGE, AND HANDLING

- a. Conform to ACI 304. Store aggregate separately for each kind or grade, to prevent segregation of sizes and avoid inclusion of dirt and other materials.
- b. Deliver cement in original sealed containers bearing name of brand and manufacturer, and marked with net weight of contents. Store in suitable watertight building in which floor is raised at least 1 foot above ground. Store bulk cement in suitable bins.
- c. Deliver other packaged materials for use in concrete in original sealed containers, plainly marked with manufacturer's name and brand, and protect from damage until used.
- d. Storage of Reinforcement shall be in separate piles or stacks to avoid confusion or loss of identification after bundles are broken.

1.8 APPLICABLE PUBLICATIONS

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- a.** Publications listed below form a part of this specification to extent referenced. Publications are referenced in text by basic designation only.
- b.** American Concrete Institute (ACI):
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| 117R-90 | Standard Tolerances for Concrete Construction and Materials |
| 211.1-91 | Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete |
| 211.2-91 | Standard Practice for Selecting Proportions for Structural Lightweight Concrete |
| 214-77(1989) | Recommended Practice for Evaluation of Strength Test Results of Concrete |
| 301-89 | Specification for Structural Concrete for Buildings |
| 304R-89 | Guide for Measuring, Mixing, Transporting, and Placing Concrete |
| 305R-91 | Hot Weather Concreting |
| 308-92 | Standard Practice for Curing Concrete |
| 309R-87 | Guide for Consolidation of Concrete |
| 315-92 | Details and Detailing of Concrete Reinforcement |
| 318/318R-95 | Building Code Requirements for Reinforced Concrete |
| 347R-94 | Guide to Formwork for Concrete |
- c.** American National Standards Institute and American Hardboard Association (ANSI/AHA):
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| A135.4-82 | Basic Hardboard |
|-----------|-----------------|
- d.** American Society for Testing and Materials (ASTM):
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|---------------|---|
| A185-94 | Steel Welded Wire, Fabric, Plain for Concrete Reinforcement |
| A446/A446M-93 | Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Structural (Physical) Quality |
| A525-93 | General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process |
| A615/A615M-95 | Deformed and Plain Billet-Steel Bars for Concrete Reinforcement |
| A616/A616M-95 | Rail-Steel Deformed and Plain Bars for Concrete Reinforcement |
| A617/A617M-95 | Axle-Steel Deformed and Plain Bars for Concrete Reinforcement |
| C31-91 | Making and Curing Concrete Test Specimens in the field |
| C33-93 | Concrete Aggregates |
| C39-94 | Compressive Strength of Cylindrical Concrete Specimens |
| C94-94 | Ready-Mixed Concrete |
| C143-90, | Rev.A Slump of Portland Cement Concrete |
| C150-95 | Portland Cement |
| C171-95 | Sheet Materials for Curing Concrete |
| C172-90 | Sampling Freshly Mixed Concrete |
| C173-94 | (E1-E5)...Air Content of Freshly Mixed Concrete by the Volumetric Method |

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| C192-90 | Making and Curing Concrete Test Specimens in the Laboratory |
| C231-91 | Air Content of Freshly Mixed Concrete by the Pressure Method |
| C260-95 | Air-Entraining Admixtures for Concrete |
| C309-95 | Liquid Membrane-Forming Compounds for Curing Concrete |
| C330-89 | Lightweight Aggregates for Structural Concrete |
| C494-92 | Chemical Admixtures for Concrete |
| C496-90 | Test Method for Splitting Tensile Strength of Cylindrical Concrete |
| C567-91 | Unit Weight of Structural Lightweight Concrete |
| C881-90 | Epoxy-Resin-Base Bonding Systems for Concrete |
| C1107-91 | Packaged, Dry, Hydraulic-Cement Grout (Non-Shrinkable) |
| D1751-83 (R 91) | Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types) |
| D4397-91 | Polyethylene Sheeting for Construction, Industrial and Agricultural Applications |
| E1155-87 | Standard Test Method for Determining Floor Flatness and Levelness Using the F-Number System |
- e.** American Welding Society (AWS):
- | | |
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| D1.4-92 | Structural Welding Code - Reinforcing Steel |
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- f.** Concrete Reinforcing Steel Institute (CRSI):
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| MSP 1-80 | Manual of Standard Practice |
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PART 2 - PRODUCTS

2.1 FORMS

- a.** Wood: free from loose knots and suitable to facilitate finishing concrete surface specified; tongue and grooved.
- b.** Plywood: PS-1 Exterior Grade B-B (concrete-form) inch, or ¾ inch thick for unlined contact form. B-B High Density Concrete Form Overlay optional.
- c.** Metal For Concrete Rib-Type Construction: Steel (removal type) of suitable weight and form to provide required rigidity.
- d.** Permanent Steel Form for Concrete Slabs: Corrugated, ASTM A446, Grade E, and Galvanized, ASTM A525, G90. Provide venting where insulating concrete fill is used.
- e.** Corrugated Fiberboard Void Boxes: Double faced, completely impregnated with paraffin and laminated with moisture resistant adhesive, size as shown. Design

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forms to support not less than 1,000 psf and not lose more than 15 percent of their original strength after being completely submerged in water for 24 hours and then air dried.

- f.** Form Lining:
 - 1. Hardboard: ANSI/AHA A208.1, Type 2, Grade 2-M-2, exterior bond not less than 3/16 inch thick.
 - 2. Plywood: Grade B-B Exterior (concrete-form) not less than 1/4 inches thick.

- g.** Form Ties: Develop a minimum working strength of 3000 pounds when fully assembled. Ties shall be adjustable in length to permit tightening of forms and not have any lugs, cones, washers to act as spreader within form, nor leave a hole larger than 3/4 inch diameter, or a depression in exposed concrete surface, or leave metal closer than 1-1/2 inches to concrete surface. Wire ties not permitted. Cutting ties back from concrete face not permitted.

2.2 MATERIALS

- a.** Portland Cement: ASTM C150 Type I or ASTM C150 Type II at the Contractor's option.

- b.** Coarse Aggregate: ASTM C33.
 - 1. Size 67. Size 467 may be used for footings and walls over 12- inches thick.
 - 2. Coarse aggregate for applied topping, encasement of steel columns, and metal pan stair fill shall be Size 7.
 - 3. Maximum size of coarse aggregates not more than one-fifth of narrowest dimension between sides of forms, one-third of depth of slabs, nor three-fourth of minimum clear spacing between reinforcing bars.

- c.** Lightweight Aggregates for Structural Concrete: ASTM C330, Table 1. Maximum size of aggregate not larger than one-fifth of narrowest dimension between forms, nor three-fourth of minimum clear distance between reinforcing bars.

- d.** Fine Aggregate: ASTM C33. Fine aggregate for applied concrete floor topping shall pass a No. 4 sieve, 10 percent maximum shall pass a No. 100 sieve.

- e.** Mixing Water: Fresh, clean, and potable.

- f.** Admixtures:
 - 1. Water Reducing Admixture: ASTM C494, Type A and not contain more chloride ions than are present in municipal drinking water.
 - 2. Water Reducing, Retarding Admixture: ASTM C494, Type D and not contain more chloride ions than are present in municipal drinking water.

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3. High-Range Water-Reducing Admixture (Superplasticizer): ASTM C494, Type F or G, and not contain more chloride ions than are present in municipal drinking water.
 4. Non-Corrosive, Non-Chloride Accelerator: ASTM C494, Type C or E, and not contain more chloride ions than are present in municipal drinking water. Admixture manufacturer must have long-term non-corrosive test data from an independent testing laboratory of at least one year duration using an acceptable accelerated corrosion test method such as that using electrical potential measures.
 5. Air Entraining Admixture: ASTM C260.
 6. Prohibited Admixtures: Calcium chloride, thiocyanate or admixtures containing more than 0.05 percent chloride ions are not permitted. Certification: Written conformance to the requirements above and the chloride ion content of the admixture prior to mix design review. Before approval of any material the Contractor will be required to submit the results of complete chemicals and sieve analysis made by an acceptable testing laboratory. The use of any material added to the mix, which in the opinion of the Architect may have an injurious effect on the concrete, will not be permitted.
- g.** Vapor Barrier: ASTM D4397, 6 mil.
1. Reinforcing Steel: ASTM A615, or ASTM A616, or ASTM A617 deformed, grade as shown.
- h.** Welded Wire Fabric: ASTM A185.
- i.** Supports, Spacers, and Chairs: Types, which will hold reinforcement in position shown in accordance with requirements of ACI 318 except as specified.
- j.** Expansion Joint Filler: ASTM D1751.
- k.** Sheet Materials for Curing Concrete: ASTM C171.
- l.** Non-Shrink Grout:
1. ASTM C1107, pre-mixed, produce a compressive strength of at least 5000-psi at three days. Furnish test data from an independent laboratory indicating that the grout when placed at a fluid consistency shall achieve 95 percent bearing under a 4 foot by 4 foot base plate.
 2. Where high fluidity or increased placing time is required, furnish test data from an independent laboratory indicating that the grout when placed at a fluid consistency shall achieve 95 percent under an 18 inch by 36 inch base plate.
- m.** Adhesive Binder: ASTM C881.
- n.** Polyvinyl Chloride Waterstop: CRD C572.
- o.** Rubber Waterstops: CRD C513.

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- p.** Cement: ASTM C150.
- q.** Porous Backfill: Crushed stone or gravel graded from 1 inch to 3/4 inch.
- r.** Epoxy Joint Filler: Two component, 100 percent solids compound, with a minimum shore D hardness of 50.
- s.** Bonding Admixture: Non-rewettable, polymer modified, bonding compound.

2.3 CONCRETE MIXES

- a.** Mix Designs Proportioned in accordance with Section 5.3, "Proportioning on the Basis of Field Experience and/or Trial Mixtures" of ACI 318.
 - 1. If trial mixes are used, make a set of at least six cylinders in accordance with ASTM C192 for test purposes from each trial mix; test three for compressive strength at 7 days and three at 28 days.
 - 2. Submit a report of results of each test series, include a detailed listing of the proportions of trial mix or mixes, including cement, admixtures, weight of fine and coarse aggregate per cubic foot measured dry rodded and damp loose, specific gravity, fineness modulus, percentage of moisture, air content, water-cement ratio, and consistency of each cylinder in terms of slump. Include dry unit weight of lightweight structural concrete.
 - 3. Prepare a curve showing relationship between water-cement ratio at 7-day and 28-day compressive strengths. Plot each curve using at least three specimens.
 - 4. If the field experience method is used, submit complete standard deviation analysis.
- b.** After approval of mixes no substitution in material or change in proportions of approval mixes may be made without additional tests and approval of Architect or as specified. Making and testing of preliminary test cylinders may be carried on pending approval of cement, providing Contractor and manufacturer certify that ingredients used in making test cylinders are the same. The Architect may allow Contractor to proceed with depositing concrete for certain portions of work, pending final approval of cement and approval of design mix.
- c.** Cement Factor: Maintain minimum cement factors in Table I regardless of compressive strength developed above minimums.

TABLE I - CEMENT AND WATER FACTORS FOR CONCRETE

Concrete: Type & Strength		Non-Air-Entrained		Air-Entrained	
T y p e	Min. 28 Day Comp. Str. Psi	Min. Cement lbs/c.yd	Max. Water Cement Ratio	Min. Cement lbs/c.yd	Max. Water Cement Ratio

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E	5000 ^{1,3}	630	0.45	650	0.40
D	4000 ^{1,3}	550	0.55	570	0.50
C	3000 ^{1,3}	470	0.65	490	0.55
C	3000 ^{1,2}	500	*	520	*
L					

1. If trial mixes are used, the proposed mix design shall achieve a compressive strength 1200 psi in excess of f'c.
2. Lightweight Structural Concrete. Pump mixes may require higher Cementitious values.
3. For concrete exposed to high sulfate content soils maximum water cement ratio 0.44.

* Determined by Laboratory in accordance with ACI 211.1 for normal concrete or ACI 211.2 for lightweight structural concrete.

- d. Maximum Slump: Maximum slump, as determined by ASTM C143 with tolerances as established by ASTM C94, for concrete to be vibrated shall be as shown in Table II.

TABLE II - MAXIMUM SLUMP, INCHES*

Type of Construction	Normal Weight Concrete	Lightweight Structural Concrete
Reinforced Footings and Substructure Walls	3 inches	3 inches
Slabs, Beams, Reinforced Walls, and Building Columns	4 inches	4 inches

* Slump may be increased by the use of the approved high-range water-reducing admixture (Superplasticizer). Tolerances as established by ASTM C94. Concrete containing the high-range-water-reducing admixture may have a maximum slump of 9 inches. The concrete shall arrive at the job site at a slump of 2 inches to 3 inches, and 3 inches to 4 inches for lightweight concrete. This should be verified, and then the high-range-water-reducing admixture added to increase the slump to the approved level.

- e. Air-Entrainment: Air-entrainment of normal weight concrete shall conform with Table III. Air-entrainment of lightweight structural concrete shall conform with Table IV. Determine air content by either ASTM C173 or ASTM C231.

TABLE III - TOTAL AIR CONTENT FOR VARIOUS SIZES OF COARSE AGGREGATES (NORMAL CONCRETE)

Nominal Maximum Size of Coarse Aggregate, Inches	Total Air Content Percentage by Volume
3/8 in.	6 to 10
1/2 in.	5 to 9
3/4 in.	4 to 8
1 in.	3-1/2 to 6-1/2
1-1/2 in.	3 to 6

TABLE IV - AIR CONTENT OF LIGHTWEIGHT STRUCTURAL CONCRETE

Nominal Maximum Size of Coarse Aggregate, Inches	Total Air Content Percentage by Volume
3/8 in.	4 to 8
3/8 in. or less	5 to 9

- f. High early strength concrete, made with Type III cement or Type I cement plus non-corrosive accelerator, shall have a 7-day compressive strength equal to specified minimum 28-day compressive strength for concrete type specified made with standard Portland cement.
- g. Lightweight structural concrete shall not weigh more than air-dry unit weight shown. Air-dry unit weight determined on 6 inch by 12 inch test cylinders after seven days standard moist curing followed by 21 days drying at 73.4 ± 3 degrees Fahrenheit, and plus or minus 7 percent relative humidity. Use wet unit weight of fresh concrete as basis of control in field.
- h. Enforcing Strength Requirements: During the progress of the work. Seven-day tests may be used as indicators of 28-day strength. Average of any three 28-day consecutive strength tests of laboratory-cured specimens representing each type of concrete shall be equal to or greater than specified strength. No single test shall be more than 500 psi below specified strength. Interpret field test results in accordance with ACI 214. Should strengths shown by test specimens fall below required values, Architect may require any one or any combination of the following corrective actions, at no additional cost to the Owner:
 - 1. Require changes in mix proportions by selecting one of the other appropriate trial mixes or changing proportions, including cement content, of approved trial mix.
 - 2. Require additional curing and protection.
 - 3. If five consecutive tests fall below 95 percent of minimum values given in Table I or if test results are so low as to raise a question as to the safety of the structure, Resident Engineer may direct Contractor to take cores from portions of the structure. Use results from cores tested by the Contractor retained testing agency to analyze structure.
 - 4. If strength of core drilled specimens falls below 85 percent of minimum value given in Table I, Architect may order load tests, made by Contractor retained testing agency, on portions of building so affected. Load tests in accordance with ACI 318 and criteria of acceptability of concrete under test as given therein.
 - 5. Concrete work, judged inadequate by structural analysis or by results of load test, shall be reinforced with additional construction or replaced, if directed by the Resident Engineer.

2.4 BATCHING AND MIXING

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- a. General: Concrete shall be "Ready-Mixed" and comply with ACI 318 and ASTM C94, except as specified. Batch mixing at the site is permitted. Mixing process and equipment must be approved by Architect. With each batch of concrete, furnish certified delivery tickets listing information in Paragraph 16.1 and 16.2 of ASTM C94. Maximum delivery temperature of concrete is 100F.
 1. Services of aggregate manufacturer's representative shall be furnished during the design of trial mixes and as requested by the Architect for consultation during batching, mixing, and placing operations of lightweight structural concrete. Services will be required until field controls indicate that concrete of required quality is being furnished. Representative shall be thoroughly familiar with the structural lightweight aggregate, adjustment and control of mixes to produce concrete of required quality. Representative shall assist and advise Architect in establishing and maintaining these controls.

- b. Ready-mixed: May be plant-mixed or transit-mixed.
 1. Plant-mixed concrete: Plant equipped for accurate proportioning and mixing and has sufficient capacity and transportation facilities to deliver concrete at rate required.
 - a. Concrete shall have initial mixing at plant not less than one minute for mixer capacity of 1 cubic yard or less, increasing 15 seconds for each additional cubic yard or less, after materials are in mixer.
 - b. Maximum time elapsing between discharge of concrete from mixer to its final position in structure is 1-1/2 hours or 300 revolutions of drum.
 - c. Transportation of concrete from plant to job shall be in agitator trucks or transit mixers operated at agitation speed until concrete is discharged.
 - d. Capacity of truck mixer or of truck agitator in accordance with manufacturer's rating.
 - e. Maximum volume of mixed concrete carried is 80 percent of gross volume of drum or container. Minimum agitating speed is two revolutions per minute. Maximum agitating speed is six revolutions per minute of drum or mixing blade.

 2. Transit-mixed concrete: Batch and discharge materials into truck mixers capable of transporting and mixing separate ingredients into thoroughly mixed and uniform mass while in transit.
 - a. Quality and characteristics of mix conform to requirements specified.
 - b. Flush water not permitted in mixing water. Deliver concrete to site and complete placement in final position within 1-1/2 hours after introduction of mixing water or cement.

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- c. Begin mixing operation within 30 minutes after introduction of cement.
 - d. Minimum number of revolutions of mixer is four revolutions of drum per minute and a maximum peripheral velocity of 225 feet per minute.
 - e. Mix concrete for not less than 70 nor more than 100 revolutions of drum at rate of rotation designated by manufacturer of equipment at mixing speed.
 - f. Additional mixing shall not exceed 200 revolutions at agitation speed designated by manufacturer of equipment. Agitating speed for transit mixer shall be not less than two nor more than six revolutions per minute.
 - g. Operate truck mixers within limits of capacity and speed or rotation designated by manufacturer.
Equip transit mixer with a device for recording number of revolutions made by drum.
3. Mixing structural lightweight concrete: Charge mixer with aggregate and 2/3 of the total mixing water. Mix ingredients for not less than 30 seconds in a stationary mixer or not less than 10 revolutions at mixing speed in a truck mixer. Add remaining mixing water and other ingredients and continue mixing. Above procedure may be modified as recommended by aggregate producer.

PART 3 - EXECUTION

3.1 FORMWORK

- a. General: Design in accordance with ACI 347 is the responsibility of the Contractor. The Contractor shall retain a registered Professional Engineer to design the formwork, shores, and reshores. Deflections of flat slab area are of concern, and shall be addressed. If, in the opinion of Architect, construction operations result in excessive flat slab deflections, Contractor shall revise the sequence, subject to approval. Revisions could include (1) timing; (2) camber, or other features. Forms shall be rigid, true, plumb, well braced, restrained from warping or displacement, sufficiently tight to hold concrete without leakage, and sufficiently strong to withstand depositing and vibration of concrete and to carry, without exceeding deformation and tolerances, dead and live loads to which they may be subjected. Place supporting shores and reshores, to extent necessary, on firm supports and set with wedges. Construct wood forms for beams, girders and lintels, so that at least one side may be removed for inspection and cleaning but without disturbing bottom of form or its supports. Construct removable sections at bottoms of two sides of column forms and where directed on interior side of wall forms or provide other methods acceptable to Architect for cleaning out and for inspection of steel before concrete is placed. Chamfer exposed edges and external corners 1 inch face, unless otherwise shown.

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1. Spreaders: Locate spreaders in wall forms adjacent to ties and opposite studs, approximately 3 feet apart at each line of wales. Provide means of removing spreaders as placing of concrete progresses.
 2. Bulkheads: Provide construction joint bulkheads to definitely limit each concrete placement. Set bulkheads using either optical or laser instruments. Maximum distance between construction joints is 80 feet in horizontal direction, unless otherwise shown. Set bulkheads normal and vertical to section to receive concrete and leave in place until concrete has sufficiently set. Remove concrete passing bulkheads at completion of concrete placement.
 3. Form boards and plywood forms may be reused for contact surfaces of exposed concrete only if thoroughly cleaned, patched, and repaired and their reuse is approved by Architect.
 4. Provide forms for concrete footings unless Architect determines forms are not necessary.
 5. Corrugated fiberboard forms: Place forms on a smooth firm bed, set tight, with no buckled cartons to prevent horizontal displacement, and in a dry condition when concrete is placed.
- b.** Treating and Wetting: Treat or wet contact forms as follows:
1. Coat plywood and board forms with non-staining form sealer. In hot weather cool forms by wetting with cool water just before concrete is placed.
 2. Clean and coat removable metal forms with light form oil before reinforcement is placed. In hot weather cool metal forms by thoroughly wetting with water just before placing concrete.
 3. Use sealer on reused plywood forms as specified for new material.
- c.** Size and Spacing of Studs: Size and space studs, wales and other framing members for wall forms so as not to exceed safe working stress of kind of lumber used nor to develop deflection greater than $1/270$ of free span of member.
- d.** Unlined Forms: Use plywood forms to obtain a smooth finish for concrete surfaces. Tightly butt edges of sheets to prevent leakage. Back up all vertical joints solidly and nail edges of adjacent sheets to same stud with 6d box nails spaced not over 6 inches apart.
- e.** Lined Forms: May be used in lieu of unlined plywood forms. Back up form lining solidly with square edge board lumber securely nailed to studs with all edges in close contact to prevent bulging of lining. No joints in lining and backing may coincide. Nail abutted edges of sheets to same backing board. Nail lining at not over 8 inches on centers along edges and with at least one nail to each square foot of surface area; nails to be 3d blued shingle or similar nails with thin flatheads.
- f.** Architectural Liner: Attach liner as recommended by the manufacturer with tight joints to prevent leakage.

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- g.** Wall Form Ties: Locate wall form ties in symmetrically level horizontal rows at each line of wales and in plumb vertical tiers. Space ties to maintain true, plumb surfaces. Provide one row of ties within 6 inches above each construction joint. Space through-ties adjacent to horizontal and vertical construction joints not over 18 inches on centers.
1. Tighten row of ties at bottom of form just before placing concrete and, if necessary, during placing of concrete to prevent seepage of concrete and to obtain a clean line. Ties to be entirely removed shall be loosened 24 hours after concrete is placed and shall be pulled from least important face when removed.
 2. Coat surfaces of all metal that are to be removed with paraffin cup grease or a suitable compound to facilitate removal.
- h.** Inserts, Sleeves, and Similar Items: Flashing reglets, steel strips, masonry ties, anchors, wood blocks, nailing strips, grounds, inserts, wire hangers, sleeves, drains, guard angles, forms for floor hinge boxes, inserts or bond blocks for elevator guide rails and supports, and other items specified as furnished under this and other sections of specifications and required to be in their final position at time concrete is placed shall be properly located, accurately positioned, and built into construction, and maintained securely in place.
1. Locate inserts or hanger wires for furred and suspended ceilings only in bottom of concrete joists, or similar concrete member of overhead concrete joist construction.
 2. Install sleeves, inserts and similar items for mechanical services in accordance with drawings prepared specially for mechanical services. Contractor is responsible for accuracy and completeness of drawings and shall coordinate requirements for mechanical services and equipment.
 3. Do not install sleeves in beams, joists or columns except where shown or permitted by Architect. Install sleeves in beams, joists, or columns that are not shown, but are permitted by the Architect, and require no structural changes, at no additional cost to the Owner.
 4. Minimum clear distance of embedded items such as conduit and pipe is at least three times diameter of conduit or pipe, except at stub-ups and other similar locations.
 5. Provide recesses and blockouts in floor slabs for door closers and other hardware as necessary in accordance with manufacturer's instructions.
- i.** Construction Tolerances:
1. Set and maintain concrete formwork to assure erection of completed work within tolerances specified and to accommodate installation of other rough and finish materials. Accomplish remedial work necessary for correcting excessive tolerances. Erected work that exceeds specified tolerance limits shall be remedied or removed and replaced, at no additional cost to the Owner.
 2. Permissible surface irregularities for various classes of materials are defined as "finishes" in specification sections covering individual

materials. They are to be distinguished from tolerances specified, which are applicable to surface irregularities of structural elements.

3.2 PLACING REINFORCEMENT

- a. General: Details of concrete reinforcement in accordance with ACI 318 and ACI 315, unless otherwise shown.
- b. Placing: Place reinforcement conforming to CRSI MSP1, unless otherwise shown.
 - 1. Place reinforcing bars accurately and tie securely at intersections and splices with 16 gauge black annealed wire. Secure reinforcing bars against displacement during the placing of concrete by spacers, chairs, or other similar supports. Portions of supports, spacers, and chairs in contact with formwork shall be made of plastic in areas that will be exposed when building is occupied. Type, number, and spacing of supports conform to ACI 315. Where concrete slabs are placed on ground, use concrete blocks or other non-corrodible material of proper height, for support of reinforcement. Use of brick or stone supports will not be permitted.
 - 2. Lap welded wire fabric at least 1-1/2 meshes plus end extension of wires not less than 12 inches in structural slabs. Lap welded wire fabric at least 1/2 mesh plus end extension of wires not less than 6 inches slabs on grade.
 - 3. Splice column steel at no points other than at footings and floor levels unless otherwise shown.
- c. Spacing: Minimum clear distances between parallel bars, except in columns and multiple layers of bars in beams shall be equal to nominal diameter of bars. Minimum clear spacing is 25 mm (1 inch) or 1-1/3 times maximum size of coarse aggregate.
- d. Splicing: Splices of reinforcement made only as required or shown or specified. Accomplish splicing as follows:
 - 1. Lap splices: Do not use lap splices for bars larger than #11. Minimum lengths of lap as shown.
 - 2. Welded splices: Splicing by butt-welding of reinforcement permitted providing the weld develops in tension at least 125 percent of the yield strength (f_y) for the bars. Welding conform to the requirements of AWS D1.4. Welded reinforcing steel conforms to the chemical analysis requirements of AWS D1.4.
 - a. Submit test reports indicating the chemical analysis to establish weldability of reinforcing steel.
 - b. Submit a field quality control procedure to insure proper inspection, materials and welding procedure for welded splices.
 - 3. Mechanical Splices: Develop in tension and compression at least 125 percent of the yield strength (f_y) of the bars. Stresses of transition splices between two reinforcing bar sizes based on

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area of smaller bar. Provide mechanical splices at locations indicated. Use approved exothermic, tapered threaded coupling, or swaged and threaded sleeve. Exposed threads and swaging in the field not permitted.

- a. Initial qualification: In the presence of Architect, make three test mechanical splices of each bar size proposed to be spliced. Department of Veterans Affairs retained testing laboratory will perform load test.
- b. During installation: Furnish, at no additional cost to the Owner, one companion (sister) splice for every 50 splices for load testing.
- e. Bending: Bend bars cold, unless otherwise approved. Do not field bend bars partially embedded in concrete, except when approved by Architect.
- f. Cleaning: Metal reinforcement, at time concrete is placed, shall be free from loose flaky rust, mud, oil, or similar coatings that will reduce bond.
- g. Future Bonding: Protect exposed reinforcement bars intended for bonding with future work by wrapping with felt and coating felt with a bituminous compound unless otherwise shown.

3.3 VAPOR BARRIER

- a. Except where membrane waterproofing is required, interior concrete slab on grade shall be placed on continuous vapor barrier installed between slab and grade, or slab and fill.
 1. Vapor barrier joints lapped 6 inches and sealed with compatible waterproof pressure-sensitive tape.
 2. Patch punctures and tears.

3.4 PLACING CONCRETE

- a. Preparation
 1. Remove hardened concrete, wood chips, shavings and other debris from forms.
 2. Remove hardened concrete and foreign materials from interior surfaces of mixing and conveying equipment.
 3. Have forms and reinforcement inspected and approved by Architect before depositing concrete.
 4. Provide runways for wheeling equipment to convey concrete to point of deposit. Keep equipment on runways, which are not supported by or bear on reinforcement. Provide similar runways for protection of vapor barrier on coarse fill.
- b. Bonding: Before depositing new concrete on or against concrete which has been set, thoroughly roughen and clean existing surfaces of laitance, foreign matter, and loose particles.

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1. Preparing surface for applied topping:
 - a. Remove laitance, mortar, oil, grease, paint, or other foreign material by sand blasting. Clean with vacuum type equipment to remove sand and other loose material.
 - b. Broom clean and keep base slab wet for at least four hours before topping is applied.
 - c. Use a thin coat of one part Portland cement, 1.5 parts fine sand, bonding admixture, and water at a 50:50 ratio and mix to achieve the consistency of thick paint. Apply to a damp base slab by scrubbing with a stiff fiber brush. New concrete shall be placed while the bonding grout is still tacky.

- c. Placing: For special requirements see Paragraphs, HOT WEATHER.
 1. Do not place concrete when weather conditions prevent proper placement and consolidation, or when concrete has attained its initial set, or has contained its water or cement content more than 1-1/2 hours.
 2. Deposit concrete in forms as near as practicable in its final position. Prevent splashing of forms or reinforcement with concrete in advance of placing concrete.
 3. Do not drop concrete freely more than 10 feet for concrete containing the high-range water-reducing admixture (superplasticizer) or 5 feet for conventional concrete. Where greater drops are required, use a tremie or flexible spout (canvas elephant trunk), attached to a suitable hopper.
 4. Discharge contents of tremies or flexible spouts in horizontal layers not exceeding 20 inches in thickness, and space tremies such as to provide a minimum of lateral movement of concrete.
 5. Continuously place concrete until an entire unit between construction joints is placed. Rate and method of placing concrete shall be such that no concrete between construction joints will be deposited upon or against partly set concrete, after its initial set has taken place, or after 45 minutes of elapsed time during concrete placement.
 6. On bottom of members with severe congestion of reinforcement, deposit 1-inch layer of flowing concrete containing the specified high-range water-reducing admixture (superplasticizer). Successive concrete lifts may be a continuation of this concrete or concrete with a conventional slump.
 7. Concrete on metal deck:
 - a. Concrete on metal deck shall be class and minimum thickness shown. Allow for deflection of steel beams and metal deck under the weight of wet concrete in calculating concrete quantities for slab.
 - 1) The Contractor shall become familiar with deflection characteristics of structural frame to include proper amount of additional concrete due to beam/deck deflection.

- d. Consolidation: Conform to ACI 309. Immediately after depositing, spade concrete next to forms, work around reinforcement and into angles of forms, tamp lightly by hand, and compact with mechanical vibrator applied directly into

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concrete at approximately 1-1/2 foot intervals. Mechanical vibrator shall be power driven, hand operated type with minimum frequency of 5,000 cycles per minute having an intensity sufficient to cause flow or settlement of concrete into place. Vibrate concrete to produce thorough compaction, complete embedment of reinforcement and concrete of uniform and maximum density without segregation of mix. Do not transport concrete in forms by vibration.

1. Use of form vibration shall be approved only when concrete sections are too thin or too inaccessible for use of internal vibration.
2. Carry on vibration continuously with placing of concrete. Do not insert vibrator into concrete that has begun to set.

3.5 HOT WEATHER

- a. Follow the recommendations of ACI 305 or as specified to prevent problems in the manufacturing, placing, and curing of concrete that can adversely affect the properties and serviceability of the hardened concrete. When temperature is 75°F and rising with a low humidity that is not rising, obtain approval by Architect and clearance as to procedures of placing concrete. Maximum temperature of concrete when being placed is 100°F. Cool water, cement, and aggregate to a temperature that will assure that placing temperature of concrete does not exceed 100°F. Dampen forms, sub-grade, and reinforcing steel and protect from sun and wind. Take special care in timing and execution of curing methods. Methods proposed for cooling materials and arrangements for protecting concrete shall be made in advance of concrete placement and approved by Owner. Take protective measures, as quickly as concrete hardening and finishing operation will allow.

3.6 PROTECTION AND CURING

- a. Conform to ACI 308. Initial curing shall immediately follow the finishing operation. Protect exposed surfaces of concrete from premature drying, wash by rain and running water, wind, mechanical injury, and excessively hot temperatures. Keep concrete not covered with membrane or other curing material continuously wet for at least 7 days after placing, except wet curing period for high-early-strength concrete shall be not less than 3 days. Keep wood forms continuously wet to prevent moisture loss until forms are removed. Cure exposed concrete surfaces as described below. Other curing methods may be used if approved by Architect.
 1. Liquid curing and sealing compounds: Apply by power-driven spray or roller in accordance with the manufacturer's instructions. Apply immediately after finishing. Maximum coverage 400 square feet per gallon on steel troweled surfaces and 300 square feet per gallon on floated or broomed surfaces for the curing/sealing compound.
 2. Plastic sheets: Apply as soon as concrete has hardened sufficiently to prevent surface damage. Utilize widest practical width sheet and overlap adjacent sheet 2 inches. Tightly seal joints with tape.

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3. Paper: Utilize widest practical papers width and overlap adjacent sheets 2 inches. Tightly seal joints with sand, wood planks, pressure-sensitive tape, mastic or glue.

3.7 REMOVAL OF FORMS

- a. Remove in a manner to assure complete safety of structure after the following conditions have been met.
 1. Where structure as a whole is supported on shores, forms for beams and girder sides, columns, and similar vertical structural members may be removed after 24 hours, provided concrete has hardened sufficiently to prevent surface damage and curing is continued without any lapse in time as specified for exposed surfaces.
 2. Take particular care in removing forms of architectural exposed concrete to insure surfaces are not marred or gouged, and that corners and arises are true, sharp and unbroken.
- b. Control Test: Use to determine if the concrete has attained sufficient strength and curing to permit removal of supporting forms. Cylinders required for control tests taken in accordance with ASTM C172, molded in accordance with ASTM C31, and tested in accordance with ASTM C39. Control cylinders cured and protected in the same manner as the structure they represent. Supporting forms or shoring not removed until strength of control test cylinders have attained at least 70 percent of minimum 28-day compressive strength specified. Exercise cares to assure those newly unsupported portions of structure are not subjected to heavy construction or material loading.
- c. Reshoring: Reshoring required if superimposed load plus dead load of floor construction exceeds the capacity of floor construction at time of loading. Reshoring accomplished in accordance with ACI 347 at no additional cost to the Owner.

3.8 CONCRETE SURFACE PREPARATION

- a. Metal Removal: Unnecessary metal items cut back flush with face of concrete members.
- b. Patching: Maintain curing and start patching as soon as forms are removed. Do not apply curing compounds to concrete surfaces requiring patching until patching is completed. Use cement mortar for patching of same composition as that used in concrete. Use white Portland cement for gray as necessary to obtain finish color matching surrounding concrete. Thoroughly clean areas to be patched. Cut out honeycombed or otherwise defective areas to solid concrete to a depth of not less than 1 inch. Cut edge perpendicular to surface of concrete. Saturate with water area to be patched, and at least 6 inches surrounding before placing patching mortar. Give area to be patched a brush coat of cement grout followed immediately by patching mortar. Cement grout composed of one part Portland cement, 1.5 parts fine sand, bonding admixture, and water at a 50:50 ratio, mix to achieve consistency of thick paint. Mix patching mortar

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approximately 1 hour before placing and remix occasionally during this period without addition of water. Compact mortar into place and screed slightly higher than surrounding surface. After initial shrinkage has occurred, finish to match color and texture of adjoining surfaces. Cure patches as specified for other concrete. Fill form tie holes which extend entirely through walls from unexposed face by means of a pressure gun or other suitable device to force mortar through wall. Wipe excess mortar off exposed face with a cloth.

- c. Upon removal of forms, clean vertical concrete surface that is to receive bonded applied cementitious application with wire brushes or by sand blasting to remove unset material, laitance, and loose particles to expose aggregates to provide a clean, firm, granular surface for bond of applied finish.

3.9 CONCRETE FINISHES

- a. Vertical and Overhead Surface Finishes:

- 1. Unfinished areas: Vertical and overhead concrete surfaces exposed above suspended ceilings, manholes, and other unfinished areas will not require additional finishing.
- 2. Interior and exterior exposed areas to be painted: Remove fins, burrs and similar projections on surfaces flush, and smooth by mechanical means approved by Architect, and by rubbing lightly with a fine abrasive stone or hone. Use ample water during rubbing without working up a lather of mortar or changing texture of concrete.
- 3. Interior and exterior exposed areas finished: Give a grout finish of uniform color and smooth finish treated as follows:
 - a. After concrete has hardened and laitance fins and burrs removed, scrub concrete with wire brushes. Clean stained concrete surfaces by use of a hone stone.
 - b. Apply grout composed of one part of Portland cement, one part fine sand (smaller than No. 30 Sieve). Work grout into surface of concrete with cork floats or fiber brushes until all pits and honeycombs are filled.
 - c. After grout has hardened slightly, but while still plastic, scrape grout off with a sponge rubber float and, about one-hour later, rub concrete vigorously with burlap to remove any excess grout remaining on surfaces.
 - d. In hot, dry weather use a fog spray to keep grout wet during setting period. Complete finish of area in same day. Make limits of finished areas at natural breaks in wall surface. Leave no grout on concrete surface overnight.

- b. Slab Finishes:

- 1. Monitoring and Adjustment: Provide continuous cycle of placement, measurement, evaluation and adjustment of procedures to produce slabs within specified tolerances. Monitor elevations of structural steel in key locations before and after concrete placement to establish typical deflection patterns for the structural steel. Determine elevations of cast-

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- in-place slab soffits prior to removal of shores. Provide information to Architect and floor consultant for evaluation and recommendations for subsequent placements.
2. Set perimeter forms to serve as screed using either optical or laser instruments. For slabs on grade, wet screeds may be used to establish initial grade during strikeoff, unless Architect determines that the method is proving insufficient to meet required finish tolerances and directs use of rigid screed guides. Where wet screeds are allowed, they shall be placed using grade stakes set by optical or laser instruments. Use rigid screed guides, as opposed to wet screeds, to control strikeoff elevation for all types of elevated (non slab-on-grade) slabs. Divide bays into halves or thirds by hard screeds. Adjust as necessary where monitoring of previous placements indicates unshored structural steel deflections to other than a level profile.
 3. Place slabs monolithically. Once slab placement commences, complete finishing operations within same day. Slope finished slab to floor drains where they occur, whether shown or not.
 4. Use straightedges specifically made for screeding, such as hollow magnesium straightedges or power strikeoffs. Do not use pieces of dimensioned lumber. Strike off and screed slab to a true surface at required elevations. Use optical or laser instruments to check concrete finished surface grade after strikeoff. Repeat strikeoff as necessary. Complete screeding before any excess moisture or bleeding water is present on surface. Do not sprinkle dry cement on the surface.
 5. Immediately following screeding, and before any bleed water appears, use a 10-foot wide highway straightedge in a cutting and filling operation to achieve surface flatness. Do not use bull floats or darbys, except that darbying may be allowed for narrow slabs and restricted spaces.
 6. Wait until water sheen disappears and surface stiffens before proceeding further. Do not perform subsequent operations until concrete will sustain foot pressure with maximum of 1/4 inch indentation.
 7. Scratch Finish: Finish base slab to receive a bonded applied cementitious application as indicated above, except that bull floats and darbys may be used. Thoroughly coarse wire broom within two hours after placing to roughen slab surface to insure a permanent bond between base slab and applied materials.
 8. Float Finish: Slabs to receive unbonded toppings, steel trowel finish, fill, mortar setting beds, or a built-up roof, and ramps, stair treads, platforms (interior and exterior), and equipment pads shall be floated to a smooth, dense uniform, sandy textured finish. During floating, while surface is still soft, check surface for flatness using a 10-foot highway straightedge. Correct high spots by cutting down and correct low spots by filling in with material of same composition as floor finish. Remove any surface projections and refloat to a uniform texture.
 9. Steel Trowel Finish: Concrete surfaces to receive resilient floor covering or carpet, monolithic floor slabs to be exposed to view in finished work, future floor roof slabs, applied toppings, and other interior surfaces for which no other finish is indicated. Steel trowel immediately following floating. During final troweling, tilt steel trowel at a slight angle and exert heavy pressure to compact cement paste and form a dense, smooth

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- surface. Finished surface shall be smooth, free of trowel marks, and uniform in texture and appearance.
10. Broom Finish: Finish exterior slabs, ramps, and stair treads with a bristle brush moistened with clear water after surfaces have been floated. Brush in a direction transverse to main traffic. Match texture approved by Architect from sample panel.
 11. Remedial Measures for Rejected Slabs: Correct rejected slab areas by grinding, planing, surface repair with underlayment compound or repair topping, re-topping, or removal and replacement of entire rejected slab areas, as directed by Architect, until a slab finish constructed within specified tolerances is accepted.

3.10 SURFACE TREATMENTS

- a. Use on exposed concrete floors except those specified to receive non-slip finish.
- b. Liquid Floor Hardener and Dustproofer: Apply in accordance with manufacturer's directions just prior to completion of construction.
- c. Non-Slip Finish: Except where safety nosing and tread coverings are shown, apply non-slip abrasive aggregate to treads and platforms of concrete steps and stairs, and to surfaces of exterior concrete ramps and platforms. Broadcast aggregate uniformly over concrete surface at rate of application of 7.5 percent per square foot of area. Trowel concrete surface to smooth dense finish. After curing, rub treated surface with abrasive brick and water to slightly expose abrasive aggregate.

3.11 APPLIED TOPPING

- a. Separate concrete topping on floor base slab of thickness and strength shown. Topping mix shall have a maximum slump of 8 inches for concrete containing the high-range water-reducing admixture (superplasticizer) and 4 inches for conventional mix. Neatly bevel or slope at door openings applied finish on slab adjoining small spaces not receiving an applied finish.
- b. Placing: Place continuously until entire section is complete, struck off with straightedge, leveled with a highway straightedge or highway bull float, floated and troweled by machine to a hard dense finish. Slope to floor drains as required. Do not start floating until free water has disappeared and no water sheen is visible. Allow drying of surface moisture naturally. Do not hasten by "dusting" with cement or sand.

3.12 RESURFACING FLOORS

- a. Remove existing flooring areas to receive resurfacing to expose existing structural slab and extend not less than 1 inch below new finished floor level. Prepare exposed structural slab surface by roughening, broom cleaning, and

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dampening. Apply specified bonding grout. Place topping while the bonding grout is still tacky.

3.13 RETAINING WALLS

- a. Use air-entrained concrete.
- b. Expansion and contraction joints, waterstops, weep holes, reinforcement and railing sleeves installed and constructed as shown.
- c. Exposed surfaces finished to match adjacent concrete surfaces, new or existing.
- d. Place porous backfill as shown.

3.14 PRECAST CONCRETE ITEMS

- a. Precast concrete items, not specified elsewhere. Cast using Type C, 3000-psi air-entrained concrete to shapes and dimensions shown. Finish to match corresponding adjacent concrete surfaces. Reinforce with steel for safe handling and erection.

END OF SECTION