SECTION 03 30 00

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SCOPE

A. These specification provisions govern the construction of cast-in-place concrete including the following:

1. Requirements for materials, proportioning, production, and delivery of concrete

2. Production of cast-in-place structural concrete including methods and procedures for obtaining quality concrete through proper handling, placing, finishing, curing, and repair of surface defects.

1.2 RELATED SECTIONS

Section 03 10 00 Concrete Forming and Accessories

Section 03 20 00 Concrete Reinforcing

1.3 REFERENCED CODES AND STANDARDS

A. Standards and References listed below apply where designation is cited in this Section. Where applicable year of adoption or revision is not listed below, the latest edition applies.

B. San Francisco Building Code (SFBC) 2019

C. American Concrete Institute (ACI) Standards

1. 117 – Specifications for Tolerances for Concrete Construction and Materials
2. 301 – Specifications for Structural Concrete
3. 304R – Guide for Measuring, Mixing, Transporting, and Placing Concrete
4. 305R – Guide to Hot Weather Concreting
5. 306R – Guide to Cold Weather Concreting
6. 308R – Guide to External Curing of Concrete
7. 309R – Guideline for Consolidation of Concrete
8. 318-– Building Code Requirements for Structural Concrete
9. 347R – Guide to Formwork for Concrete
10. MNL – Field Reference Manual: Specifications for Structural Concrete (ACI 301-16) (Formerly SP-15) with Selected ACI and ASTM References

D. American Society for Testing and Materials (ASTM) Standards, latest edition

1. C31 – Standard Practice for Making and Curing Concrete Test Specimens in the Field
2. C33 – Standard Specification for Concrete Aggregates
3. C39 – Standard Test Method for Compressive Strength of Cylindrical Concrete

Specimens

4. C42 – Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
5. C94 – Standard Specification for Ready-Mixed Concrete
6. C150 – Standard Specification for Portland Cement
7. C171 – Standard Specification for Sheet Materials for Curing Concrete
8. C172 – Standard Specification for Sampling Freshly Mixed Concrete
9. C227 – Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)
10. C260– Standard Specification for Air-Entraining Admixture for Concrete
11. C309 – Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
12. C494 – Standard Specification for Chemical Admixtures for Concrete
13. C618 – Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
14. C685 – Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
15. C881– Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
16. C920 – Standard Specification for Elastomeric Joint Sealants
17. C989 – Standard Specification for Slag Cement for Use in Concrete and Mortars
18. C1017 – 07 Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
19. C1077 – Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
20. C1240 – Standard Specification for Silica Fume Used in Cementitious Mixtures
21. C1615 – Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete
22. C1602 – Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
23. D1751 – Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction
24. E329 – Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection

E. San Francisco Public Works, City and County of San Francisco, Standard Specifications (SFSS).

F. Concrete Reinforcing Steel Institute (CRSI)

1. CRSI MSP-2-01 – Manual of Standard Practice, 27th edition

1.4 SUBMITTALS

The Contractor shall submit the following to the City Representative for review prior to concrete

placement in accordance with Division 1:

A. Mixture Proportions: Submit concrete mixture proportions and characteristics including water-cementitious material (w/cm) ratio, weights, slump and compressive strength at 28 days.

B. Mixture Proportion Data: Submit field test records and/or trial mixture records used to establish the required average strength for the concrete mixture to be used.

C. Concrete Materials:

1. Cementitious materials: Information showing type, manufacturing locations, shipping locations, manufacturer's quality control reports, and certificates showing compliance with ASTM C150, ASTM C595, ASTM C618, ASTM C845, ASTM C989, ASTM C1157, or ASTM C1240.

2. Aggregates: Information showing types, pit or quarry locations, producers' names, gradings, specific gravities, and evidence not more than 90 days old demonstrating compliance with requirements herein.

3. Admixtures: Information showing types, brand names, producers' names, manufacturers' technical data sheets, and certificates showing compliance with ASTM C494/C494M, or ASTM C1017/C1017M.

D. Curing Materials: Submit manufacturer's product information including storage, handling, and application procedures.

E. Sealing Compounds: Submit manufacturer's product information including storage, handling, and application procedures.

F. Epoxy Bonding Adhesives: Submit manufacturer's product information including storage, handling, and application procedures.

G. Contraction or Expansion Joints: Submit manufacturer's product information including storage, handling, and application procedures. When contraction or expansion joints other than those indicated in the Drawings are proposed, submit locations for acceptance.

H. Construction Joints: Submit information for acceptance of proposed location and treatment of construction joints not indicated in the Drawings.

I. Manufacturer's product data specifications with application and installation instructions for all proprietary products, including admixtures, bonding agents, joint materials and systems, embedded items, curing materials, sealants, non-shrink grout and any materials that are integral to the final color, texture and finish of exposed concrete work.

1.5 QUALITY CONTROL

A. The responsibility for furnishing and placing concrete conforming to the requirements of the contract documents rests solely with the Contractor.

B. The Contractor is responsible for the quality control of the Work.

C. Perform work in accordance with the applicable standard and/or guide, including but not limited to ACI 301 and ACI 318.

D. Compliance requirements for concrete mixture proportions:

1. The concrete mixture proportions shall be established in accordance with Article 4.2.3 of ACI 301 or by an alternative method acceptable to the City Representative. The strength test records used for establishing and documenting concrete mixture proportions shall not be more than 24 months old.

2. If different concrete mixtures are to be used for different portions of the Work, each mixture shall comply with the concrete mixture requirements stated in the construction documents.

1.6 QUALITY ASSURANCE

A. Specifications herein set minimum results required. The Contractor is responsible for the quality of concrete cast-in-place and bears the burden of proof that all concrete as cast meets minimum requirements.

B. Codes and Standards: Comply with provisions specified in latest editions of all applicable standards of “ACI Manual of Concrete Practice”, including but not limited to the following:

1. ACI 301 – Specifications for Structural Concrete.
2. ACI 304R – Guide for Measuring, Mixing, Transporting, and Placing Concrete.
3. ACI 305R – Guide to Hot Weather Concreting.
4. ACI 306R – Guide to Cold Weather Concreting.
5. ACI 308 – Guide to Concrete Curing.
6. ACI 309 – Guideline for Consolidation of Concrete.
7. ACI 315 – Details and Detailing for Concrete Reinforcement.
8. ACI 318 – Building Code Requirements for Structural Concrete.

Maintain copies of all applicable Codes and Standards at the project site at all times.

C. Compliance requirements for concrete mixture proportions:

1. Contractor shall submit concrete mixture designs, including material certificates, to the City Representative for review and approval. No concrete shall be used in the Work until the materials and mixture designs have been accepted by the City Representative.

2. The concrete mixture proportions shall be established in accordance with Article 4.2.3 of ACI 301 or by an alternative method acceptable to the City Representative. The strength test records used for establishing and documenting concrete mixture proportions shall not be more than 24 months old.

D. Tolerances:

1. Formed surfaces: Tolerances on formed surfaces shall be as specified in ACI 347, except where other tolerances are indicated.

2. Unformed surfaces: Tolerances on unformed surfaces shall be as specified in ACI 301 for the applicable surface finish, except where other tolerances are indicated.

E. Mockup Wall Panel: Cast concrete wall panels to demonstrate typical joints, surface finish, texture, tolerance, and standard of workmanship. Mockup wall panels shall be a minimum of 6 feet tall by 12 feet long.

F. Defective Work

1. Defective work is any work, which does not comply with all requirements of the Contract Documents.

2. The City Representative may require defective work to be demolished and rebuilt whenever, in his opinion, the work cannot satisfactorily be corrected, to comply with Contract requirements.

3. If concrete appears that it might be defective, the City Representative may request that the Contractor's testing laboratory take core borings in accordance with ASTM C 42 and make compressive and/or other tests of concrete removed.

4. The Contractor shall repair all core holes to the satisfaction of the City Representative.

1.7 SPECIAL INSPECTION

A. An independent special inspection and testing agency will perform special inspections and field quality control tests as required in the Statement of Special Inspections noted in the Contract Drawings. This does not preclude the Contractor's responsibility for inspections by the Contractor's Testing Agency.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Cementitous Materials: Cementitious materials shall be of the same brand and type and from the same manufacturing plant as the cementitious materials used in the concrete represented by the submitted field test records or used in the trial mixtures. Cementitious materials shall conform to the following:

1. Portland Cement: ASTM C150, Type II

2. Fly Ash: ASTM C618, Class F. When fly ash is used, the minimum amount shall be 15% by weight of the total cementitious materials, unless otherwise noted.

3. Blast-Furnace Slag: ASTM C989, finely ground granulated

4. Silica Fume: ASTM C1240

B. Aggregates: Both fine and coarse aggregates shall conform to the requirements of ASTM C33 and shall be from sources with a proven history of successful use. Aggregates used in concrete shall be obtained from the same sources and have the same size range as aggregates used in the concrete represented by the submitted field test records or used in the trial mixtures. The maximum size of aggregates shall be 1 inch for normal weight aggregate.

1. Coarse: Cleanness value shall not be less than 75 when tested in accordance with California Test Method No. 227.

2. Fine: Sand equivalent shall not be less than 75 when tested in accordance with California Test Method No. 217.

3. For exposed exterior surfaces, do not use fine or coarse aggregates that contain substances that cause spalling.

4. Sample of coarse and fine aggregates shall be tested for alkali reactivity in accordance with ASTM C227. Submit certification of materials for review with the

concrete mix design submittal.

C. Lightweight Aggregates: Both fine and coarse aggregates shall conform to the requirements of ASTM C330 and shall be from sources with a proven history of successful use. Aggregates shall be vacuum saturated. Maximum dry weight shall be 115 pcf. The maximum size of aggregates shall be ¾-inch for lightweight concrete.

D. Water: Water shall be clean and potable, free from impurities detrimental to concrete.

E. Admixtures:

1. Admixtures shall be compatible and contain no chlorides, sulfides or nitrides.

2. Admixtures for water reduction and setting time modification shall conform to ASTM C494.

3. Admixtures for use in producing flowing concrete shall conform to ASTM C1017.

4. Air entraining admixture shall conform to ASTM C260.

5. Crystalline waterproofing admixture such as Xypex Admix C-500 as manufactured by Xypex Chemical Corporation or approved equal.

F. Curing Materials:

1. Liquid Membrane-Forming Curing Compounds: ASTM C309, Type 1, approved clear resin type, free of oil, wax, grease, or other substance which might discolor concrete or prove deleterious to or adversely affect the bonding of any material applied to the concrete.

2. Curing paper: ASTM C171, non-staining waterproof paper, regular type.

G. Sealing Compounds: ASTM C1315

H. Epoxy Bonding Adhesives: ASTM C881

I. Expansion Joint Materials: Refer to Specifications Section 03 10 00 Concrete Forming and Accessories.

J. Polymer Grit Additive: Additive shall be compatible with sealer and applied per manufacturer's instruction.

2.2 CONCRETE MIXTURE DESIGNS

A. Concrete mixture designs for concrete shall be at the Contractor's expense. The designs shall be tested by a qualified Testing Agency, approved by the City. Concrete mixture designs, including quantities of admixture, shall be submitted for review and approval at least 30 days prior to placing any concrete. Refer to SUBMITTALS and QUALITY ASSURANCE Articles in this Specification Section.

B. Concrete mixture designs shall be proportioned in accordance with ACI 318 Section 5.3, "Proportioning on the Basis of Field Experience or Trial Mixtures or Both" with a maximum w/cm ratio of 0.45. The w/cm ratio shall be based on total cementitious material, including Supplementary Cementitious Material (SCM). SCM, as a percentage of total weight of cementitious material shall be a minimum of 25 percent and a maximum of 50 percent. Fly ash shall be a maximum of 20 percent. Submit mix designs for each class of concrete for review.

C. Concrete mixture proportions shall be such as to produce a dense, workable mix that can be placed without segregation or excess free surface water. Super-plasticizers may be used to improve workability in thin or congested sections.

D. If the concrete is to be placed by pumping, recommendations of ACI 304.2R shall be followed.

E. At sub-sidewalk basement locations, crystalline waterproofing admixture shall be added into the concrete mix design.

2.3 SCHEDULE OF CONCRETE CLASSES

A. General: The concrete class and slump for the various types of construction shall be as designated in the following table:

Location	Strength [psi]	Test Age [days]	Maximum Aggregate Size [inches]	Maximum Water/Cement Ratio	Maximum Slump [inches]
CIDH Piles	4,000	28	1	0.45	6
Bus Shelter Mat Slab	3,000	28	1	0.40	4

B. Strength: Concrete shall develop compressive strengths as noted above and on Drawings. The tests shall be performed on concrete cylinders in accordance with ASTM C39. The averages of all sets of three consecutive strength tests shall be equal to or greater than the specified strength and no individual strength test result shall fall below the specified strength by more than 500 psi.

C. Slump: Concrete shall be of such consistency and mix composition that it can be readily worked into the corners and angles of the forms and around the reinforcement, inserts, and wall castings without permitting materials to segregate or free water to collect on the surface.

PART 3 - EXECUTION

3.1 PRODUCTION OF CONCRETE

A. Concrete shall be ready-mixed concrete in conformance with ASTM C94. Measure, batch, and mix concrete materials and concrete in conformance with ASTM C94. Equipment shall be adequate for the purpose and kept in good mechanical condition at all times. No hand-mixing will be permitted.

B. Ready-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 completed within 1-1/2 hours, or before the drum has revolved 300 revolutions, whichever comes first, after the introduction of water to the mix. Under conditions contributing to quick stiffening of the concrete, or when the temperature of the concrete is 85°F or above, discharge of concrete shall be completed within 1 hour. 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 charging the truck, followed by agitation without interruption until discharged.

C. Mixers shall be equipped with an automatic device for recording number of revolutions of drum or blades prior to completion of mixing operation. Revolution counters shall be set

at “0” and shall commence to operate when drum revolution begins after introduction of ingredients into the mixer. Delivery tickets shall show departure time from plants.

D. Re-tempering of concrete, that is, remixing with or without additional cement, aggregates, water, or admixtures, will not be permitted.

E. No water shall be added to the mix after the initial introduction of mixing water for the batch except when, on arrival at the job site, the slump of the concrete is less than that specified. In this case, additional water may be added only if neither maximum permissible w/cm ratio nor maximum slump is exceeded and if the addition of water is approved by the City Representative. The drum or blades shall then be turned an additional 30 revolutions or more until the mix is uniform.

F. All concrete used in suspended slabs and slabs-on-grade shall be designed with a shrinkage limitation of 0.04% after 28 days of drying.

3.2 PLACEMENT OF CONCRETE

A. General:

1. Maintain continuous and accurate log of placing of concrete in structures. Record date, location, quantity, air temperature, test samples taken. A copy of the log shall be given to the City Representative.

2. Notify City Representative a minimum of 72 hours prior to placing of any concrete.

3. Do not place concrete until data on materials and mixture proportions are accepted by the City Representative.

B. Preparation

1. Forms shall be constructed to sizes, shapes, lines, and dimensions as required in order to obtain accurate alignment, location, grades, level, and plumb work in the finished structure. Refer to Specification Section 03 10 00.

2. Remove debris, mud, water, and all foreign materials from places to receive concrete. All surfaces of forms and embedded materials shall be cleaned of all mortar or grout before the surrounding or adjacent concrete is placed.

3. Absorbent forms shall be thoroughly wetted before concrete is placed. Aggregate base/sand beds for slabs on grade shall be moist but not saturated when concrete is placed.

4. No concrete shall be placed until reinforcing is fastened in place and inspected nor until forms are complete. No concrete shall be placed before work that is to be embedded has been set. Reinforcement or other materials that have been set in place shall not be disturbed.

5. Before placing concrete, embedded pipes and conduits shall be sleeved providing ¼” minimum clearance all around. Sleeves shall be positioned so as not to impair the strength of surrounding elements. All items to be embedded in the concrete shall be free from oil, or foreign matter, that would impede the bond of the concrete to these items.

6. Where new concrete is to be cast against existing concrete, the existing concrete surface shall be roughened to a minimum of ¼” amplitude by sandblasting or bush hammering. The existing surface shall be cleaned and laitance removed.

Apply bonding adhesive to existing concrete surface prior to placement of new concrete in accordance with manufacturer's recommendations.

C. Weather Considerations:

1. Hot Weather: Comply with the recommended practices of ACI 305R and the requirements specified herein. Procedures for hot weather concreting will be subject to the approval of the City Representative.

2. Cold Weather: Comply with the recommended practices of ACI 306R and the requirements specified herein. Procedures for cold weather concreting will be subject to the approval of the City Representative.

D. Conveying:

1. Transport concrete from mixer to place of final deposit as rapidly and directly as practicable and by methods which prevent segregation or loss of ingredients and displacement of reinforcement, and which avoid re-handling. Do not deposit partially hardened concrete.

2. Conveying equipment shall be acceptable to the City Representative and shall be of a size and design such that detectable setting of concrete shall not occur before adjacent concrete is placed. Conveying equipment shall be cleaned at the end of each operation or work day. Equipment having components made of aluminum or magnesium alloys, which would have contact with plastic concrete during pumping, chuting or tremie operations, shall not be used.

E. Depositing:

1. Place no concrete when sun, wind, heat or other limitation of facilities will prevent proper finishing and curing procedures. Depositing under water will not be permitted.

2. Within the planned placement, deposit concrete continuously and as near as practicable to the final position.

3. Concrete shall not be dropped through the reinforcing steel in such a manner as to cause segregation of the aggregates. In no case, within the formwork or otherwise, shall concrete be permitted to fall from a height greater than 4 feet except through elephant trunks or other approved devices.

4. Deposit concrete in layers not exceeding 18 inches in thickness, force concrete around and under reinforcing and embedded items without displacing them. Integrate fresh concrete with that already placed; no re-tempering of concrete already placed will be allowed. After concrete has taken an initial set, protect forms from jarring and do not place any strain on ends of projecting reinforcement.

5. Splash or accumulation of hardened or partially hardened concrete shall be removed. Contact faces of forms for exposed concrete shall be protected from splash during placing of adjacent concrete.

6. Do not deposit fresh concrete on concrete that has hardened sufficiently to cause formation of cold joints, unless construction joint requirements are met.

7. Concrete shall be placed as a continuous operation until the completion of a panel or section, as defined by its boundaries or predetermined joints.

8. Do not place concrete over columns or walls until concrete in columns and walls

has reached final set.

9. Place concrete for beams, girders, brackets, column capitals, haunches, and drop panels at the same time as the concrete for adjacent slabs.

10. Interruption in depositing longer than 45 minutes shall be cause for discontinuing casting of the section of work. In this event, cut back concrete and provide construction joints as the City Representative directs; clean forms and reinforcing as necessary to receive concrete at later time.

F. Consolidating

1. Concrete shall be thoroughly consolidated by placing the mechanical vibrator directly in concrete at 18” to 30” intervals for a period of approximately 5 to 15 seconds and withdrawing slowly or as directed. Thoroughly work concrete around reinforcing and embedded items and into corners and shapes of formwork. One vibrator will be required for each location where simultaneous concrete placing takes place, to ensure thorough vibrating of all sections. Provide sufficient spare vibrators on the job so as to have them readily available in case any vibrator in use should suddenly cease to function properly.

2. Mechanical vibrator shall be of the flexible immersion type having a frequency of not less than 8,000 rpm. Use and type of vibrator shall conform to ACI 309.

   a. Penetrate placed layer and at least 6 inches into preceding layer. Do not consolidate placed concrete by mechanical vibrating supplemented by hand spading, rodding, or tamping. Use equipment and procedures for consolidation of concrete complying with ACI 309.

   b. Do not use vibrators to transport concrete inside forms. Move the vibrators vertically at uniformed spaced locations with no effectiveness of the machine function. Place vibrators into the lower layers of concrete that have begun to set.

   c. Contractor shall have a minimum of one spare vibrator on site during concrete placement operations to be used as needed.

3. Consolidate slabs six inches and less in thickness by means of vibrating screeds or, for small areas such as curbs, wood tampers.

4. Completely eliminate honeycombing or planes of weakness due to air voids and stone pockets.

G. Construction Joints

1. All pours shall be terminated at construction joints.

2. Placement of construction joints and the manner in which they are provided for shall be approved by the City Representative or as shown on the Drawings. Construction joints shall be as few as possible and will not be permitted simply to save forms.

3. Construction joints including keys shall be cleaned and roughened in an acceptable manner that exposes aggregate uniformly and does not leave laitance, loosened aggregate particles, or damaged concrete at the surface. Forms and reinforcing shall be cleaned of drippings, debris, etc. Apply bonding adhesive to hardened concrete surface prior to placement of fresh concrete in accordance with manufacturer’s recommendations.

3.3 CONCRETE FINISH

A. Exposed Surfaces: At all exposed surfaces of the structure, produce smooth form finish in accordance with ACI 301.

B. Unexposed Form Finish: Rub down or chip off fins or other raised areas 1/4 inch (6 mm) or more in height.

C. Exposed Form Finish: Rub down or chip off and smooth fins or other raised areas 1/4 inch (6 mm) or more in height.

D. Concrete Slabs: Finish to requirements of ACI 302.1R and as follows:

1. Surfaces to Receive Thick Floor Coverings: "Wood float" as described in ACI 302.1R; thick floor coverings include quarry tile, ceramic tile, and terrazzo with full bed setting system.

2. Surfaces to Receive Thin Floor Coverings: "Steel trowel" as described in ACI 301.1R; thin floor coverings include carpeting, resilient flooring, seamless flooring, thin set quarry tile, and thin set ceramic tile.

E. Decorative Exposed Surfaces: "Steel trowel" as described in ACI 302.1R; use steel-reinforced plastic trowel blades instead of steel blades to avoid black-burnish marks; decorative exposed surfaces include surfaces to be stained or dyed, pigmented concrete, surfaces to be polished, and all other slab surfaces.

3.4 SAWED JOINTS

A. Where saw-cut joints are required or permitted, start cutting as soon as concrete has gained sufficient strength to prevent raveling, or the dislodgment of coarse aggregate particles.

B. Saw a continuous slot to a depth one-fourth the thickness of the slab but not less than 1 inch.

C. Complete sawing within 12 hours after placement.

3.5 CURING AND PROTECTION

A. Curing: All newly placed concrete shall be cured by one or more of the following methods:

1. Water Method. The concrete shall be kept continuously wet by the application of water for a minimum of 7 days after the concrete has been placed. Cotton-mats, rugs, carpets, or earth or sand blankets may be used as a curing medium to retain the moisture during the curing period.

2. Waterproof Membrane Method for Slabs. All slabs shall be saturated such that free moisture occurs over the entire area. After dampening, slabs shall be immediately covered with curing paper lapped 4 inches at all joints and sealed with adhesive tape or waterproof glue. Curing paper shall remain in place for not less than 10 calendar days. Curing floor slab with chemical hardener/sealer may be used. Application shall be promptly in accordance with the manufacturer's instructions. Impervious sheeting is then applied over the slabs with sealed laps, and planks are laid over the slab to prevent injury from traffic.

3. Liquid Membrane-Forming Curing Compound: Application shall commence

immediately following completion of specified finishing. When applying compound, the surfaces shall be damp but shall be free from standing water. Using pressurized spray equipment, apply as recommended by Manufacturer. Curing compounds shall not be used on surfaces when their use may be detrimental to bonding of concrete, caulking and sealants or the specified surface hardener.

4. Forms-in-Place Method: Keep formed concrete surfaces continuously wet both in forms and after removal of forms for at least seven (7) days after placing. Wood forms and any metal forms exposed to the sun shall be kept wet. If forms are removed prior to expiration of curing period, exposed concrete surfaces shall be kept continuously wet by means of fog sprays or non-staining cotton or burlap mats kept moist or by approved curing compound.

5. Difficult Access: For formed concrete surfaces that have access difficulties, Contractor shall provide a method for concrete curing to City Representative for review and approval.

B. Protection:

1. All concrete placed in forms shall have a temperature of between 50°F and 70°F and adequate means shall be provided for maintaining this temperature for as much time as is necessary to ensure proper curing of the concrete. The housing, covering or other protection used in connection with curing shall remain in place and intact at least 24 hours after the artificial heating is discontinued.

2. Wherever practicable, finished surface and slabs shall be protected from the direct rays of the sun to prevent checking and crazing. During hot weather, as defined in ACI 305R, the Contractor shall implement the requirements of ACI 305R.

3.6 REPAIR OF SURFACE DEFECTS

A. Immediately after removing forms, all concrete surfaces shall be inspected and any pour joints, voids, rock pockets, tie holes, etc., shall be patched within 48 hours after removal of forms, but not until surfaces have first been examined by the City Representative.

B. If rock pockets, in the opinion of the City Representative, are of such an extent or character as to affect the strength of the structure materially or does not provide adequate protection of steel reinforcement, the City Representative may declare the concrete defective and require the removal and replacement of the portions of the structure affected at the Contractor's expense.

C. Sacking: Tie holes, superficial air voids and irregularities shall be filled solid with a cement mortar grout with all excess grout "sacked" off without the use of water. The following formula (by volume) for cement grout shall be used for this purpose:

5 ½ parts sand
2 ½ parts Portland Cement
1 ½ parts lime hydrate

Care shall be taken in the application of the grout and in sacking the excess grout from the surface in order that all voids are filled without grout built up on the smooth surface.

D. Patching: Honeycombed or otherwise defective areas shall be cut out to solid concrete to a depth of not less than 1 inch. The edges of the cut shall be perpendicular to the surface of the concrete. After cleaning the exposed concrete by air-blasting, saturate the area to be

patched and at least 6 inches adjacent thereto with water before placing the mortar. Mix the mortar approximately one hour before placing and remix occasionally during this period with a trowel without the addition of water. A grout of cement and water mixed to the consistency of paint shall then be brushed on to the surfaces to which the mortar is to be bonded. The mortar shall be compacted into place and screeded slightly higher than the surrounding surface. Finish patches on exposed surfaces to match the adjoining surfaces, after they have set for an hour or more. Cure patches as specified for the concrete. Application of patch mortar shall be in accordance with ACI 301. Patchwork mixture shall match adjacent surfaces in color and texture. Determine exact mix by trial mixtures before patching, and obtain approval of mix proposed prior to application.

E. Site-Mixed Portland Cement Repair Mortar: Mix repair mortar using the same materials as concrete to be patched, with no coarse aggregate. For repairs in exposed concrete, make a trial batch and check color compatibility of repair material with surrounding concrete. Use a repair mortar at a stiff consistency with no more mixing water than necessary for handling and placing.

3.7 FIELD QUALITY CONTROL

A. Contractor shall provide quality control of concrete placement to ensure conformance with construction documents. Contractor to verify that concrete is placed to the lines and grades shown on Contract Drawings.

B. Concrete that has been contaminated or has lost its initial workability to the extent that it can no longer be consolidated by the intended methods shall not be used.

C. Certification: In addition to the information specified in ASTM C94 to be provided on the delivery ticket with each batch of concrete, provide the following information on the same ticket:

1. Mix identification

2. Times of day at which cement and aggregates are first intermingled, and at which water and cement are first intermingled.

3. Weight of cement, aggregate, water and admixtures, and aggregate size.

D. Indicate that all ingredients are as previously approved for use.

E. Testing:

1. Compression Tests: Work related to compression tests shall be performed by the Contractor's Inspection and Testing Agency. During progress of work, 4 compression test cylinders shall be taken for each placement of 150 cubic yards or 5,000 square feet of surface area for slabs or walls, or fraction thereof of each class of concrete placed each day. Make, cure and store test cylinders as per ASTM C31. One cylinder shall be tested at 7 days for information; two at 28 days for acceptance; and the fourth held in reserve. Cylinders will be numbered in sets (1A, 1B, 1C, 1D) and a record kept on extent of pour represented by each set and type of concrete tested. Cylinders will be tested in accordance with ASTM C39. If any test report indicates 28-day specimen below required strength level (within standard of acceptability established by ACI 318), and if required by the City at its sole discretion, the Testing Agency will take test cores of hardened concrete in accordance with ASTM C42. Such concrete shown to be defective shall be removed and replaced. Cost of core tests, repairs and removal and replacement of defective concrete shall be paid by the Contractor.

2. Slump Test: Slump tests will be performed as per ASTM C143 at time of taking test cylinders.

3. The Contractor's Inspection and Testing Agency shall be notified for testing not less than 48 hours prior to concrete placement.

3.8 QUALITY ASSURANCE

A. Inspection:

1. The Contractor shall advise the City Representative of his readiness to proceed at least 72 hours prior to each concrete placement. No placement shall be made without the inspection and acceptance of the City Representative.

2. When forms are removed, voids, stone pockets and other defects shall not be remedied until the City Representative has inspected them and given directions.

B. Special Inspection:

1. Continuous special inspection by an approved independent Special Inspection and Testing Agency is required during concrete placement. As a minimum, two special inspectors are required – one at the concrete truck/pump and one at the point of concrete placement.

2. The Special Inspection and Testing Agency shall be notified for concrete placement special inspection not less than 48 hours prior to concrete placement.

C. Testing:

1. Concrete cylinders and compression test results obtained and performed by the Contractor's Inspection and Testing agency may be accepted by the City Representative for quality assurance.

2. At the City Representative's direction, an approved independent Special Inspection and Testing Agency shall obtain concrete cylinders and perform compression tests at the intervals noted in Section 3.07.E.1 above.

D. Structural Observation:

1. Where required by the contract documents, structural observation of the concrete placement shall be provided by the registered design professional in responsible charge of the work.

2. Registered design professional shall be notified for structural observation not less than 72 hours prior to concrete placement.

3.9 DEFECTIVE CONCRETE PATCHING AND REPAIRS

A. Concrete shall be considered defective for the following reasons:

1. Failure of finished concrete profiles, and dimensional tolerances, to conform to the requirements specified in the Formwork section of this specification or the requirements specified in ACI 117, whichever is more critical for the surface or profile being considered.

2. Failure to meet the specified cylinder strength requirements set forth in paragraph 16.5.1 of ASTM C94.

3. Concrete showing cracks, rock pockets, voids, spalls, honeycomb or other defects

that adversely affect the structural adequacy of the concrete.

B. All defective concrete shall be subject to removal and replacement by the Contractor, at his expense, unless it is determined by the City at its sole discretion that defective area can be patched as specified below or that the location of this defective concrete is not detrimental to the function and the appearance of the structure.

C. As directed by the City Representative, the Contractor shall take cores, as needed, from any questionable area in the concrete work, for determination of concrete quality. The Contractor shall repair all core holes as required. Core specimens shall be drilled and tested in accordance with the requirements of ASTM C42. The results of tests on such cores shall be the basis for acceptance, rejection or determining the continuation of concrete work.

3.10 DAMAGED WORK

A. Before final acceptance of the work, damaged surfaces, corners of concrete, and concrete finish, whether such damage shall have resulted from the action of the elements or from any cause whatsoever, shall be neatly repaired. Any damaged places where surface repairs are permitted shall be brought to a smooth, dense, watertight condition to the satisfaction of the City Representative.

3.11 CLEAN-UP

A. Remove from site all debris resulting from the work of this section.

B. Ensure removal of bituminous materials, form release agents, bond breakers, curing compounds or other materials employed in work of concreting which would otherwise prevent proper application of sealants, liquid waterproofing, or other delayed finishes or treatments.

C. Where cleaning is required, take care not to damage surrounding surfaces or leave residue from cleaning agents.

END OF SECTION