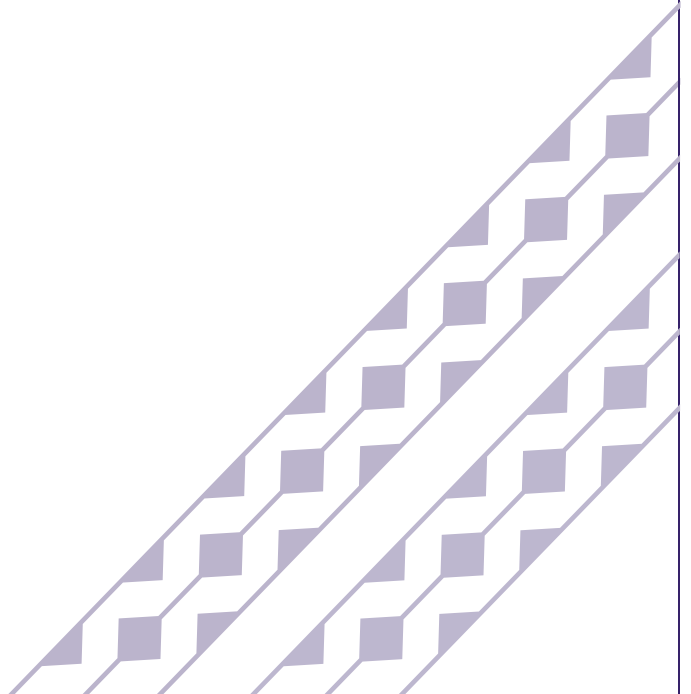




**Hawaiian
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The information found in this document are general guidelines that may be used to aid in the preparation of your service request proposal. Please be advised that depending on the specific needs and actual conditions of your project, Hawaiian Electric may require your design to comply with different specifications including specifications that include more stringent requirements than those included in these design specification guidelines. For further guidance and clarification on the actual specifications that will apply to your particular project, please refer to instructions issued by Hawaiian Electric's Planner or Engineer who is assigned to your particular (Project/Review Request/...). Additionally, please be advised that Hawaiian Electric reserves the right to require additional modifications to any approved design if it is determined during actual construction that additional modifications must be made to address certain field conditions that were not detected or Hawaiian Electric was unaware of during the design review process.



HAWAIIAN ELECTRIC CO., INC.

SPECIFICATION NO. CS9301-2

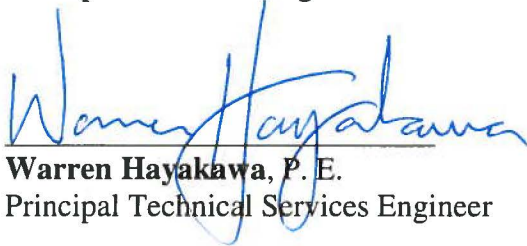
FOR

CAST-IN-PLACE CONCRETE WORK

Prepared by **Asset Management** Department



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HECO SPECIFICATION NO. CS9301-2

CAST-IN-PLACE CONCRETE WORK

PART 1 GENERAL

1.01 GENERAL SUMMARY

- A. The Contractor shall furnish all labor, materials, tools, equipment and services necessary and reasonably incidental to complete construction of all cast-in-place concrete work including but not limited to structures, foundations, pads, anchors and duct encasement called for on the drawings and/or specified herein, unless specifically excepted.
- B. Cast-in-place concrete shall be ready-mixed concrete except concrete batches of one cubic yard or less may be jobsite batched (mixed) when approved by the Engineer.
- C. Cooperation with the various trades and accurate timing of the installations are essential to properly placing work specified under this section. Where items must fit spaces previously constructed, measurements shall be verified at the site. Coordinate with other work to ensure that all required inserts and attachments are properly set and that adequate provision is made for embedding this work, where required.
- D. Related Specifications:
 - 1. HECO Specification No. CS7001 Construction of Underground Facilities (latest edition).
 - 2. HECO Specification No. CS9401 Design and Construction of Precast Concrete Manholes and Handholes (latest edition).

1.02 SUBMITTALS

- A. General Requirements: Two weeks before commencing the work, three (3) sets of product data, shop drawings, and mix design as described below shall be submitted to HECO. After review by the Engineer one set will be returned, marked accepted or with notations requiring change. If corrections are required, the Contractor shall make and clearly mark such corrections and resubmit for final review.
 - 1. Product Data shall include manufacturer's specifications, technical data, certificates of conformance and product descriptions for proprietary materials and items, including reinforcement and forming accessories, admixtures, patching compounds, waterstops, joint systems, curing compounds, and other products or items as requested by the Engineer.

2. Steel Reinforcement Shop Drawings for fabrication, bending, and placement of concrete reinforcement shall comply with **ACI 315**, "Details and Detailing of Concrete Reinforcement" and shall show bar schedules, stirrup spacing, diagrams of bent bars, arrangement of concrete reinforcement, and any special reinforcement required for openings through concrete structures. Drawings which bear the final review by the Engineer shall not relieve the Contractor of responsibility for completeness and accuracy of all dimensions and details.
3. Concrete Mix Design shall include a tabulation of the proposed materials, aggregates, source location of aggregates, additives, water-cement ratio, strength, applicable reference specifications for each class of concrete. Include verification test results and reports for each class of concrete showing that the mix design has been tested to produce concrete with the properties specified and will be appropriate for the job conditions. If allowed by the mix design, indicate the amount of water and conditions whereby water may be added to ready-mix concrete at the project site.
4. Test Reports shall include the laboratory test results of items described in Section 3.18 Quality Control Testing During Construction.

1.03 QUALITY ASSURANCE

- A. Specifications and Standards: **Comply with the cross referenced versions of the specifications and standards corresponding to the code noted below. Where no version is cross referenced by the code, then** comply with the latest edition of the following codes, specifications, and standards, except where more stringent requirements are shown or specified:
 1. **ACI 117** Specifications for Tolerances for Concrete Construction and Materials **and Commentary**.
 2. **ACI 301** Specifications for Structural Concrete.
 3. **ACI 308.1** **Standard Specification for Curing Concrete.**
 4. **ACI 305.1** **Specification for Hot Weather Concreting.**
 5. **Concrete Reinforcing Institute (CRSI), "Manual of Standard Practice".**
- B. Codes and Ordinances: **ACI 318 Building Code Requirements for Structural Concrete.** Wherever provisions of the current **State Building Code** or the local current ordinances are more stringent than the **specified code**, the local codes and ordinances shall govern.

- C. Concrete Testing Service: Testing of concrete cylinders, to determine compression strengths of concrete delivered to and concrete mixed at the jobsite, shall be performed by an independent testing laboratory approved by the Engineer. Tests shall be paid for by the Contractor. Testing requirements are specified in QUALITY CONTROL TESTING DURING CONSTRUCTION paragraph 3.18.
- D. Materials and installed work may require testing and retesting at any time during progress of work. Tests, including retesting of rejected materials for installed work, shall be done at Contractor's expense.
- E. Special Inspections required by the Building Code are described in the SPECIAL INSPECTION paragraph 3.19.

PART 2 PRODUCTS

2.01 FORM MATERIALS

- A. Forms for Exposed Finish Concrete (Smooth Form Finish): Plywood, metal, metal-framed plywood faced, or other acceptable panel-type materials, to provide continuous, straight, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system shown on drawings.
 - 1. Use overlaid plywood complying with U.S. Product Standard PS-1 "A-C or B-B High Density Overlaid Concrete Form," Class I, Exterior.
- B. Forms for Unexposed Finish Concrete (Rough Form Finish): Plywood, lumber, metal, or other acceptable material. Provide lumber dressed on at least 2 edges and one side or tight fit.
- C. Form Coatings: Provide commercial formulation form-coating compounds that will not bond with, stain, nor adversely affect concrete surfaces, and will not impair subsequent treatments of concrete surfaces, or finishes requiring bond or adhesion, nor impede wetting of concrete surfaces by water or curing compound.
- D. Form Ties: Factory-fabricated, adjustable-length, removable or snap-off metal form ties, designed to prevent form deflection and to prevent spalling concrete upon removal. Provide units which will leave no metal closer than 1-1/2" to surface.

2.02 REINFORCING STEEL MATERIALS

- A. Reinforcing steel bars shall be deformed, free from loose rust, scale, and other coatings and shall conform to the following:
 - 1. **ASTM A 615**, Grade 60 for normal use (not to be welded).

2. **ASTM A 706** for rebars which will be welded.
- B. Steel Wire: **ASTM A 82**, cold-drawn metal, hot dipped galvanized.
- C. Welded Wire Fabric: **ASTM A 185**, galvanized, welded steel wire fabric, or sizes and types indicated in drawings.
- D. Supports for Reinforcement: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire fabric in place shall be precast concrete or all plastic bar supports complying with CRSI Manual of Standard Practice.
1. For slabs-on-grade and footings, use precast concrete bar supports.
 2. For concrete surfaces, where legs of supports are in contact with forms, use CRSI all-plastic bar supports.
 3. For underground structures and structures in highly corrosive environment, use CRSI precast concrete bar supports or CRSI all-plastic bar supports.
- Wire bar supports with plastic protected legs (CRSI, Class 1) may be used only when approved by the Engineer.
- E. Tie Wires: Soft, annealed iron wire not smaller than 16 gage.

2.03 CONCRETE MATERIALS

- A. Portland Cement: **ASTM C 150**, Type I. Use one brand of cement throughout project, unless otherwise acceptable to the Engineer.
- B. Normal Weight Aggregates: Aggregates shall conform to **ASTM C 33**. Provide aggregates from a single source for exposed concrete.
1. Fine aggregate shall be clean, hard, dense, free of foreign matter and shall consist of **natural** sand, manufactured fines, or a combination thereof.
 2. Coarse aggregate shall consist of crushed stone or gravel manufactured from clean, hard, tough, dense, basalt, free from deleterious substances.
- C. Water: potable
- D. Admixtures: Admixtures shall be compatible with other admixtures, cementitious materials and components in the mix design. Do not use admixtures containing calcium chloride. Admixtures containing thiocyanates at dosage levels which promote corrosion of steel will not be permitted in the concrete mix. For admixtures containing thiocyanates, submit test data regarding corrosion of steel in concrete including corrosion results associated with dosage range. Admixtures shall conform to the following:

1. Air-Entraining Admixtures: **ASTM C 260**, certified by the manufacturer to be compatible with other required admixtures. Subject to compliance with requirements, products which may be incorporated in the work include but not limited to the following:
 - a. Degussa Construction Chemicals: Micro-Air
 - b. Euclid: AEA-92, AEA-92S
 - c. Grace Construction Products: Darex II AEA
2. Water-reducing Admixtures: **ASTM C 494**, Type A, certified by the manufacturer to be compatible with other required admixtures. Subject to compliance with requirements, products which may be incorporated in the work include but not limited to the following:
 - a. Degussa Construction Chemicals: Glenium 3030 NS, Pozzolith 220N
 - b. Euclid: Eucon WR 91, Eucon 37
 - c. Grace Construction Products: WRDA-HA, Daracem 19
3. Retarding Admixtures: **ASTM C 494**, Type B, certified by the manufacturer to be compatible with other required admixtures. Subject to compliance with requirements, products which may be incorporated in the work include but not limited to the following:
 - a. Degussa Construction Chemicals: Pozzolith 100XR
 - b. Euclid: Eucon Retarder 100
 - c. Grace Construction Products: Daratard HC.
4. Accelerating Admixtures: **ASTM C 494**, Type C, certified by the manufacturer to be compatible with other required admixtures. Subject to compliance with requirements, products which may be incorporated in the work include but not limited to the following:
 - a. Degussa Construction Chemicals: Pozzolith NC 534, Rheocrete CNI.
 - b. Euclid: Accelguard 80
 - c. Grace Construction Products: Polarset
5. Water Reducing and Retarding Admixtures: **ASTM C 494**, Type D, certified by the manufacturer to be compatible with other required admixtures. Subject to compliance with requirements, products which may be incorporated in the work include but not limited to the following:
 - a. Degussa Construction Chemicals: Pozzolith 100XR.
 - b. Euclid: Eucon Retarder 100
 - c. Grace Construction Products: WRDA-HA, Daratard HC
6. High Range Water Reducing Admixtures: **ASTM C 494**, Type F or G, certified by the manufacturer to be compatible with other required admixtures. Subject to compliance with requirements, products which may be incorporated in the work include but not limited to the following:
 - a. Degussa Construction Chemicals: Glenium 3030 NS
 - b. Euclid: Eucon 37
 - c. Grace Construction Products: Daracem 19

7. **Corrosion-Inhibiting Admixture:** Commercially formulated, anodic inhibitor or mixed cathodic and anodic inhibitor capable of forming a protective barrier around the reinforcing steel and also capable of minimizing chloride reactions with the reinforcing steel in the concrete. Admixture shall be certified by the manufacturer to be compatible with other required admixtures. Subject to compliance with requirements, products which may be incorporated in the work include but not limited to the following:
 - a. Degussa Construction Chemicals: Rheocrete 222+, Rheocrete CNI
 - b. Euclid: Eucon CIA
 - c. Grace Construction Products: DCI S.
8. **Integral Waterproofing:** Crystalline admixture that promotes the growth of microstructures in the concrete matrix to fill and block the capillary pores to reduce permeability. Subject to compliance with requirements, products which may be incorporated in the work include but not limited to the following:
 - a. Kryton Corporation: Krytol Internal Membrane
 - b. Xypex, Inc.: Xypex C1000

2.04 RELATED MATERIALS

- A. **Non-Shrink Grout:** Conform to CRD-C 621, non-metallic, factory pre-mixed grout.
- B. **Absorptive Cover:** Burlap cloth made from jute or kenaf, weighing approximately 9 oz. per sq. yd., complying with AASHTO M 182, Class 2.
- C. **Moisture-Retaining Cover:** One of the following, complying with **ASTM C 171**.
 1. Waterproof paper.
 2. Polyethylene film.
 3. Polyethylene-coated burlap.
- D. **Liquid Membrane-Forming Curing and Sealing Compound:** Liquid type membrane-forming curing and sealing compound complying with **ASTM C 1315**, Type I, Class A. Moisture loss not more than 0.04 gr./sq. cm. when applied at 200 sq. ft./gal. Curing compound shall be compatible with and shall not be detrimental to surface finish and coatings.
- E. **Expansion Joint Filler:** **ASTM D 1751**, non-extruding premolded material of 1/2 inch thickness, unless otherwise noted, composed of fiberboard impregnated with asphalt.
- F. **Joint Sealant:** Single-component, self leveling, elastomeric polyurethane sealant including compatible primer and backer rod conforming to **ASTM C 920**, Type S, Grade P, Class 25, Use T and M (Sonolastic SL-2 with Primer 733; Tremco Vulkem 116 with primer; or approved equal). **Where hydrophilic joint sealant is specified, provide MC-2010MN by Adeka Corporation or approved equal.**

- G. Waterstops: PVC (CE CRD-C513) or rubber water stops (CE CRD-C572), dumbbell or centerbulb type as indicated, of proper size to suit joints. Factory fabricate corners, intersections, and directional changes. **Hydrophilic joint sealant may be substituted when allowed by the Engineer.**
- H. Connectors: Provide hot dipped galvanized metal connectors required for **embedment** in cast-in-place concrete, for the attachment of precast concrete members.
- I. Anchor Rods, Bolts, Nuts and Washers: Unless otherwise shown on the drawings, conform to **ASTM A36**, hot dipped galvanized.
- J. Cementitious Coatings: Cement based polymer modified cement finishing materials. Subject to compliance with requirements, products which may be incorporated in the work include but not limited to the following: Pro-Finish by Bonded Materials Company; Durus Cement Wash by Durus International Corporation.

2.05 PROPORTIONING AND DESIGN OF MIXES

- A. Prepare design mixes for each type and strength of concrete by either laboratory trial batch or field experience methods as specified in **ACI 301** and **ACI 318**. If trial batch method used, use an independent testing facility acceptable to the Engineer for preparing and reporting proposed mix designs. The testing facility shall not be the same as used for field quality control testing. Proportion design mixes by weight for each class of concrete required, complying with **ACI 211.1**, "Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete" for normal weight concrete and with **ACI 211.2**, "Standard Practice for Selecting Proportions for Structural Lightweight Concrete" for structural lightweight concrete.
- B. Design mixes shall provide concrete compressive strengths and properties shown in Table 1, unless otherwise indicated on the drawings or special conditions.

TABLE 1 – CONCRETE CLASSES AND LOCATIONS					
Class of Concrete (Normal weight concrete unless otherwise indicated)	Min. 28 day compressive strength, psi	Max. Water- Cement Ratio, W/C	Max. Size Aggregate, in.	Slump at Point of Discharge, in.	Typical Locations (unless otherwise shown on the drawings)
HECO 2500	2,500*	0.8	3/4	6-7	Duct encasement
HECO 3000	3,000	0.5	1	4-5	Slabs on grade
HECO 4000	4,000	0.45	3/4	5-6**	Foundations
HECO 5000	5,000	0.4	3/4	6-7** typical (4" at ramps)	Beams, suspended slabs, walls, and columns. Handholes, manholes, vaults, and underground structures.
HECO 6000	6,000	0.4	3/4	6-7**	Where shown on the drawings
<p>* Prior to backfilling operations, concrete strength shall be a minimum of 500 psi compressive strength.</p> <p>** Initial design slump shall be 2-4 inches. Add appropriate water-reducing and/or high range water-reducing admixtures as required to obtain specified slump at point of discharge.</p>					

C. Admixtures:

1. Use water-reducing admixture or high range water-reducing (HRWR) admixture (super plasticizer) in concrete as required to obtain specified slump and for placement and workability.
2. Air entraining admixtures shall be added where the concrete shall be subject to freeze thaw cycles, where concrete is more than 8000 feet above sea level, or as directed by the Engineer. Air content shall be 4% or as directed by the Engineer.
3. Use admixtures for water-reducing and set-control in strict compliance with manufacturer's directions.

D. Adjustment to Concrete Mixes: Mix design adjustments may be requested by Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant; at no additional cost to HECO and as accepted by the Engineer. Laboratory test data for revised mix design and strength results must be submitted to and accepted by the Engineer before using in work.

- E. Submit written mix designs to the Engineer for each design mix at least 15 calendar days prior to the start of the work. Include in each mix design the project name, date of report, contractor, concrete supplier, concrete class, source of aggregates, manufacturer and brand name of manufactured materials, the precise proportions of the mix including additives, the water-cement ratio, the properties specified herein for the type and class of concrete. Include verification test results and reports for each class of concrete showing that the mix design has been tested to produce concrete with the properties specified and will be appropriate for the job conditions. If allowed by the mix design, indicate on the reports the amount of water and conditions whereby water may be added to ready-mix concrete at the project site.
- F. Provide test results from the concrete supplier for each of his proposed design mixes, to establish the following:
 - 1. Gross weight and yield per cu. yd. of trial mixtures.
 - 2. Measured slump.
 - 3. Measured air content.
 - 4. Compressive strength developed at 7 days and 28 days, from not less than 3 test cylinders cast for each compressive strength.

PART 3 EXECUTION

3.01 GENERAL

- A. Coordinate the installation of joint materials and vapor retarders with placement of forms and reinforcing steel.
- B. Before commencing work, check indicated lines and levels. Report any discrepancies to the Engineer for adjustment. Erect substantial bench marks and preserve throughout the work.
- C. Deliver materials other than ready-mix concrete to site in their original packaging bearing manufacturer's brand name and store in a weather protected, well ventilated place, having a floor clear off the ground. Hardened cement shall not be used. Store reinforcing steel off the ground and maintain free from mud or other foreign materials. Protect aggregate materials against mixing with the ground or with other types of aggregate.

3.02 FORMS

- A. Design, erect, support, brace, and maintain formwork in accordance with **ACI 347** to support vertical and lateral, static, and dynamic loads that might be applied until such loads can be supported by concrete structure. Construct formwork so concrete members and structures are of correct size, shape, alignment, elevation, and position. Maintain formwork construction tolerances complying with **ACI 347**. Crown all suspended concrete floors and ceiling soffits 1/4" in all directions for every 16 feet of span, unless otherwise noted.
- B. Design formwork to be readily removable without impact, shock, or damage to cast-in-place concrete surfaces and adjacent materials.
- C. Construct forms to sizes, shapes, lines, and dimensions shown, and to obtain accurate alignment, location, grades, level and plumb work in finished structures. Provide for openings, offsets, sinkages, keyways, recesses, moldings, rustications, reglets, chamfers, blocking, screeds, bulkheads, anchorages and inserts, and other features required in work. Use selected materials to obtain required finishes. Solidly butt joints and provide back-up at joints to prevent leakage of cement paste.
- D. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces where slope is too steep to place concrete with bottom forms only. Kerf wood inserts for forming keyways, reglets, recesses, and the like, to prevent swelling and for easy removal.
- E. Provide temporary openings where interior area of formwork is inaccessible for cleanout, for inspection before concrete placement, and for placement of concrete. Securely brace temporary openings and set tightly to forms to prevent loss of concrete mortar. Locate temporary openings on forms at inconspicuous locations.
- F. Chamfer exposed corners and edges using 1/2" chamfers or as indicated, using wood, metal, PVC, or rubber chamfer strips fabricated to produce uniform smooth lines and tight edge joints.
- G. Provisions for Other Trades: Provide openings in concrete formwork to accommodate work of other trades. Determine size and location of openings, recesses, and chases from trades providing such items. Accurately place and securely support items built into forms.
- H. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, or other debris just before concrete is placed. Retightening forms and bracing after concrete placement is required to eliminate mortar leaks and maintain proper alignment.

3.03 PREPARATION OF FORM SURFACES

- A. Clean re-used forms of concrete matrix residue, repair and patch as required to return forms to acceptable surface condition.
- B. Coat contact surfaces of forms with a form-coating compound before reinforcement is placed.
- C. Thin form-coating compounds only with thinning agent of type, amount, and under conditions of form-coating compound manufacturer's directions. Do not allow excess form-coating material to accumulate in forms or to come into contact with in-place concrete surfaces against which fresh concrete will be placed. Apply in compliance with manufacturer's instructions.
- D. Coat steel forms with a non-staining, rust-preventative form oil or otherwise protect against rusting. Rust-stained steel formwork is not acceptable.

3.04 INSTALLATION OF EMBEDDED ITEMS

- A. General: Set and build into work anchorage devices and other embedded items required for other work that is attached to, or supported by, cast-in-place concrete. Use setting drawings, diagrams, instructions, and directions provided by suppliers of items to be attached thereto. Properly locate embedded items in cooperation with other trades and secure in position before concrete is poured.
- B. Install inserts, dowels, reglets, hangers, metal ties, anchors, bolts, nailing strips, blocking, ground, and other fastening devices as required for attachment of other work.
- C. Provide non-rusting sleeves for electrical conduits, pipes, and fittings that penetrate slabs, walls, or beams.
- D. Edge Forms and Screed Strips for Slabs: Set edge forms or bulkheads and intermediate screed strips for slabs to obtain the required elevations and contours in the finished slab surface. Provide and secure units sufficiently strong to support the types of screed strips by the use of strike-off templates or accepted compacting type screeds.
- E. Manholes, handholes, vaults and underground structures: Set and secure duct connectors in walls at required elevations and spacings.
- F. Embedded Conduits and Fittings
 - 1. Conduits and fittings in concrete shall be subject to acceptance by the Engineer and shall be located such that they do not impair the strength of the concrete member. Conduits include pipes, ducts and electrical conduits. Conduits and

fittings shall conform to the following, unless otherwise shown on the structural drawings:

- a. Concrete walls:
 - 1) Conduits larger than 1-inch outside diameter shall not be embedded vertically in any wall. Conduits shall be spaced a minimum of 10 times the outside diameter of the conduit and shall be placed in the middle of the wall thickness.
 - 2) Conduits shall not be embedded horizontally in any wall, lengthwise.
 - 3) Conduits passing through wall shall not impair the strength of the wall and shall be provided with Schedule 40 galvanized steel pipe (**ASTM A53**) sleeve.
- b. Concrete columns: Conduits shall not penetrate or be embedded in columns unless specifically approved by the Engineer.
- c. Concrete beams:
 - 1) Vertical conduits larger than 1 inch outside diameter shall not be embedded vertically in any concrete beam. Conduits shall be spaced a minimum of 10 times the outside diameter and shall be placed in the middle third of the beam thickness.
 - 2) Conduits shall not be embedded horizontally in any beam, lengthwise.
 - 3) Conduits passing through beams shall not impair the strength of the beam and shall be provided with Schedule 40 galvanized steel pipe (**ASTM 53**) sleeve.
- d. Suspended Concrete Slabs and Toppings:
 - 1) Conduits shall not be embedded in any slabs and toppings on metal decking and in toppings less than 3" thick.
 - 2) For other conditions, conduits larger than 1-inch outside diameter shall not be embedded in any concrete slab or topping. Conduits shall be spaced a minimum of 10 times the outside diameter and shall be placed in the middle third of the slab thickness. Conduit crossings shall be avoided.
 - 3) Conduits passing through slabs shall be provided with Schedule 40 galvanized steel pipe (**ASTM A53**) sleeve.
- e. Concrete slabs on grade: Conduits shall not be embedded within the thickness of any concrete slabs on grade. Conduits may be placed below the

bottom surface of slabs on grade and shall be spaced a minimum of 10 times the outside conduit diameter.

2. Where a number of conduits are intended to penetrate a structural member at a location which may unduly impair the strength of a member, such as near the surface of a beam or slab, the Engineer shall be informed and his approval must be obtained before the concrete is placed.
3. Contractor shall coordinate the installation of all embedded items and penetrations. Cost of any added reinforcement required at pipe and conduit penetration and embedment shall be borne by the Contractor.

3.05 PLACING REINFORCEMENT

- A. Comply with Concrete Reinforcing Steel Institute's recommended practice for "Placing Reinforcing Bars," for details and methods of reinforcement placement and supports, and as herein specified. Reinforcing steel bars, wire and wire fabric shall be provided in sizes, lengths and configurations as indicated on drawings; shall be thoroughly cleaned of loose mill scale, rust, oil, and all coatings that will destroy or reduce the bond before placing and again before pouring of concrete. All items shall be accurately positioned and secured in place as indicated in the drawings and as herein specified. Annealed steel wire of not less than 16 gage shall be used to secure reinforcement. Reinforcement shall be placed in specified positions.
- B. Supports and spacers shall be used to secure the proper spacing. Stirrups shall be accurately and securely wired to the bars at both top and bottom. At slabs, footings and beams in contact with earth, pre-cast concrete solid blocks (not hollow tile) shall be used to hold reinforcement at a proper distance above earth.
- C. Bars shall be tied at all intersections, and distances from forms shall be maintained by means of blocks, ties, metal chains, runners, bolsters, spacers, hangers or other approved supports.
- D. Reinforcement Splices: Splicing of rebars, except where shown, will not be permitted without approval of the Engineer. Splices where permitted shall be staggered as far as possible and shall be set as to maintain clear depth of member and minimum clear distance to surfaces of concrete.
 1. Lap splices: Unless otherwise shown on the plans, splices for #11 bars and smaller shall be lapped 48 bar diameters or 24 inches, whichever is larger.
 2. Welding: Welded splices only shall be used when bar size exceeds #11 and where shown on the drawings. Welding shall conform to American Welding Society, AWS D1.4, "Structural Welding Code – Reinforcing Steel."
- E. Place reinforcement to obtain **specified** coverages for concrete protection. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement operations. Set wire ties so ends are directed into concrete, not

toward exposed concrete surfaces. **Unless otherwise noted**, minimum concrete protection over bar reinforcement shall conform to **ACI 318** and the following minimum clear cover **whichever is greater**:

Concrete directly against earth (above water table).....	3"
Concrete directly against earth (below water table)	6"
Concrete poured against forms but exposed to earth	2"
Column spirals and ties	2"
Formed surfaces exposed to weather	2"
Columns, beams and girders not exposed to weather or earth.....	1-1/2"
Slabs and walls not exposed to weather or earth	3/4"

In all cases, minimum concrete protection **and clearance between rebars shall not be less than** the bar diameter.

- F. Install welded wire fabric in as long lengths as practicable. Lap adjoining pieces at least one full mesh plus 2 inches and lace splices with wire. Offset end laps in adjacent widths to prevent continuous laps in either direction. Support mesh on chairs to assure position in the middle third of slab thickness. Install in accordance with the Wire Reinforcing Institute "Manual of Standard Practice for Welded Wire Fabric."
- G. All reinforcement shall be inspected and reviewed by the Engineer and Special Inspector before placing of any concrete. Contractor shall notify Engineer and Special Inspector at least 3 working days prior to placing reinforcement. This review, however, shall not be construed to relieve the Contractor of his responsibility to place all reinforcement in accordance with the contract drawings.

3.06 JOINTS

- A. Construction Joints: Locate and install construction joints as indicated or, if not indicated, locate so as not to impair strength and appearance of the structure, as acceptable to the Engineer.
 - 1. Provide keyways at least 1-1/2" deep in construction joints in walls, slabs, and between walls and footings **unless otherwise specified**; accepted bulkheads designed for this purpose may be used for slabs.
 - 2. Place construction joints perpendicular to main reinforcement. Continue reinforcement across construction joints, except as otherwise indicated.
 - 3. Waterstops: Install waterstops in construction joints where indicated on the drawings, to form a continuous diaphragm in each joint. Follow manufacturer's recommendations and make provisions to support and protect waterstops during the concrete pour and during the progress of the work. Fabricate waterstop field joints in accordance with manufacturer's printed instructions. Protect waterstop material from damage where it protrudes from any point.

- B. Control Joints in Slabs-on-Grade: Construct sawcut control joints in slabs-on-grade to form panels or patterns as indicated, 1/8" wide x 1/5 to 1/4 of the slab depth, unless otherwise indicated. Time saw-cutting with the concrete set, but not later than 6 hours after concrete is poured. After concrete has cured, clean joints and apply joint sealant.
- C. Expansion Joints: Provide expansion joints at locations indicated. Do not permit reinforcement to extend continuously through any expansion joint.

3.07 CONCRETE MIXING

- A. Concrete shall be mixed only in such quantity as is required for immediate use. No retempering will be permitted and concrete that has started to harden shall be discarded and promptly removed from the job. Excessive over-mixing requiring additions of water in order to preserve the required consistency will not be permitted.
- B. Hand mixing will not be permitted.
- C. Ready-Mix Concrete: Comply with requirements of **ASTM C 94**, and as herein specified.
 - 1. Concrete shall be batched by a central batching plant, and delivered in a revolving truck mixer. The plant shall have sufficient capacity and transportation equipment to deliver concrete at the rate desired.
 - 2. The time elapsed between the introduction of the mixing water to the cement and aggregates or the cement to the aggregates, and the placing of concrete in its final position shall not exceed ninety (90) minutes.
 - 3. Gap graded concrete shall not be used. Concrete mixes shall contain all aggregate size groups up to and including the maximum size to be used in the concrete.
- D. Project-Site Mixing: When approved by the Engineer, small quantities of concrete of one cubic yard or less may be batched and mixed at the jobsite. Mixing at the jobsite shall be done in accordance with the applicable provisions of **ACI 304R** and as follows:
 - 1. Concrete shall be thoroughly mixed in a batch mixer of an approved type and size which will ensure a uniform distribution of materials throughout its mass. The machine shall have a control device to prevent materials from being discharged until they have been mixed for the specified minimum time.
 - 2. The entire contents of the drum shall be discharged before materials of the succeeding batch are placed therein.

3.08 CONCRETE PLACEMENT

- A. Special Inspector shall be present during the concrete pour. Notify the Engineer and Special Inspector 3 working days before placing any concrete.

- B. Preplacement Inspection: Before placing concrete, inspect and complete formwork installation, reinforcing steel, and items to be embedded or cast-in. Notify other crafts to permit installation of their work; cooperate with other trades in setting such work. Moisten wood forms immediately before placing concrete where form coatings are not used. Make sure soil treatment for termite control has been applied to cushion fill before vapor barrier and concrete are installed. Coordinate the installation of joint materials and vapor barriers with placement of forms and reinforcing steel.
1. Apply temporary protection covering to lower 3' of finished walls adjacent to poured floor slabs and similar conditions, and guard against spattering during placement.
- C. General: Comply with **ACI 304R**, "Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete," and as herein specified
1. Deposit concrete continuously or in layers of such thickness that no concrete will be placed on concrete which has hardened sufficiently to cause the formation of seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as herein specified. Deposit concrete as nearly as practicable to its final location to avoid segregation.
- D. Conveying: Convey concrete from the mixer to the place of final deposit by methods which will prevent the separation or loss of the materials. Provide equipment for chuting, pumping, and pneumatically conveying concrete of proper size and design as to ensure a practically continuous flow of concrete at the point of delivery and without segregation of the materials. Keep open troughs and chutes clean and free from coating of hardened concrete. Do not allow concrete to drop freely more than 8 feet. All equipment and methods used for conveying are subject to the approval of the Engineer.
- E. Placing Concrete in Forms:
1. Do not place concrete during rain. Protect fresh concrete from rain until it reaches its initial set.
 2. Concrete shall be deposited in horizontal layers not deeper than 2 feet for structures and not deeper than 8 inches for duct encasement avoiding inclined layers and inclined construction joints. The depth of layers shall be shallow enough so that the succeeding layer will be placed before the previous layer has attained its initial set. Concrete shall not be allowed nor shall it be caused to flow horizontally or on slopes. Concrete placing on a slope shall begin at the lower end of the slope and progress upward to increase compaction of the concrete. Special care shall be used in placing duct line concrete to avoid "floating" of ducts and damage to ducts.
 3. Deposit concrete for slabs in a continuous operation, within the limits of construction joints, until placing of a panel or section is completed. When less

than a complete layer of concrete is placed in one operation, terminate in a vertical bulkhead in areas of minimum shear as acceptable by the Engineer.

4. Maintain reinforcing in proper location during concrete placement operations.
 5. Bring slab surfaces to correct level with straightedge and strikeoff. Use bull floats or darbies to smooth surface, free of humps or hollows. Do not disturb slab surfaces prior to beginning finishing operations.
 6. Protect adjacent finish materials from damage or spatter during concrete placement.
- F. Consolidating Placed Concrete: Consolidate concrete during placing operations so that concrete is thoroughly worked around reinforcement and other embedded items and into corners.
1. Consolidate placed concrete by high frequency (7000 impulses per minute) mechanical vibrating equipment, supplemented by hand-spading, rodding, or tamping. Use equipment and procedures for consolidation of concrete in accordance with the recommended practices of **ACI 309R** to suit the type of concrete and project conditions. Provide a sufficient number of vibrators to properly consolidate all concrete immediately after placing. Have at least one standby vibrator on hand at all times during placement of the concrete.
 2. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations not farther than visible effectiveness of machine. Place vibrators to rapidly penetrate placed layer and at least 6" into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to set. At each insertion limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing segregation mix. Do not vibrate forms or reinforcement.
 3. Maintain reinforcing in the proper position during concrete placement operations.
 4. Bring slab surfaces to the correct level with a straightedge and strikeoff. Use bull floats or darbies to smooth the surface, leaving it free of humps or hollows. Do not sprinkle water on the plastic surface. Do not disturb the slab surfaces prior to beginning finishing operations.
 5. Unless otherwise authorized, all duct line concrete shall be compacted by use of hand spades. The spade shall be inserted into the fresh concrete to the level of the bottom ducts, on both sides of each row of ducts and at intervals not greater than 9 inches along the ducts. Spading shall be done in a manner to prevent damage to or displacement of ducts.

G. Miscellaneous

1. Hot Weather Placing: When hot weather conditions exist that would seriously impair quality and strength of concrete, place concrete in compliance with **ACI 305.1** and as herein specified.
2. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90° F (32° C). Mixing water may be chilled, or chopped ice may be used to control temperature provided water equivalent of ice is calculated to total amount of mixing water.
3. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that steel temperature will not exceed the ambient air temperature immediately before embedment in concrete.
 - a. Fog spray forms, reinforcing steel, and subgrade just before concrete is placed.

3.09 FINISHING TOP SURFACES

After concrete has been placed and compacted, the surface shall be struck off with a strike board. After striking off, the surface shall be floated, not less than two times with wood floats, until all excess water is removed. After the concrete has hardened sufficiently a final finish shall be applied to the various surfaces as follows:

- A. Tops of encased duct lines, manholes and handholes over which backfill is to be placed - wood floated.
- B. Tops of vaults, manholes and handholes at sidewalk grade - edged and broom finished.
- C. Tops of equipment pads - edged and steel troweled.
- D. Tops of foundation pedestals supporting column bases - roughened with a stiff brush or rake for grouted bases or edged and steel troweled for ungrouted bases.
- E. Floors of buildings, vaults, manholes and handholes - steel troweled unless otherwise noted.

3.10 MONOLITHIC SLAB FINISHES

- A. Tolerances: Surfaces shall be finished to the tolerances indicated in **ACI 117**.
 1. Surfaces to be level which support transformers or other equipment shall be finished in accordance with **ACI 117**, Classification "Very Flat". This standard requires the floor to be flat to within 1/8 of an inch as measured by a 10 foot straight edge placed anywhere on the floor.

2. Surfaces to be level that do not support transformers or other equipment shall be finished in accordance with **ACI 117**, Classification “Flat”. This standard requires the floor to be flat to within 3/16 of an inch as measured by a 10 foot straight edge placed anywhere on the floor.
 3. Surfaces to be sloped shall uniformly slope to drains. Surfaces shall not deviate more than 1/4 of an inch from true plane as measured with a 10 foot straight edge placed anywhere in the area to be a true plane.
- B. Float Finish: Apply float finish to monolithic slab surface to receive trowel finish and other finishes as hereinafter specified, and slab surfaces which are to be covered with waterproofing membrane or elastic roofing and as otherwise indicated.
1. After screeding, consolidating, and leveling concrete slabs, do not work surface until ready for floating. Begin floating when surface water has disappeared or when concrete has stiffened sufficiently to permit operation of power-driven floats, or both. Consolidate surface with power-driven floats, or by hand-floating if area is small or inaccessible to power units. Check and finish surface plane to tolerances. Cut down high spots and fill low spots. Uniformly slope surfaces to drains. Immediately after leveling, refloat surface to a uniform, smooth, granular texture.
- C. Trowel Finish: Apply trowel finish to monolithic slab surfaces to be exposed-to-view, and slab surfaces to be covered with resilient flooring, carpet, ceramic or quarry tile, paint, or other thin film finish coating, system.
1. After floating, begin first trowel finish operation using a power- driven trowel. Begin final troweling when surface produces a ringing sound as trowel is moved over surface. Consolidate concrete surface by final hand-troweling operation, free of trowel marks, uniform in texture and appearance, and with surface finished to tolerances. Grind smooth surface defects which would telegraph through applied floor covering system.

3.11 FINISHING FORMED SURFACES

- A. Rough Formed Finish: As-cast formed concrete finish shall be reasonably true to line and plane with tie holes and defective areas patched per **CONCRETE SURFACE REPAIRS** paragraph 3.17. Remove fins and other projections exceeding 1/4 inch in height and also those that are required to be removed by the applied finish.
- B. Cement Wash Finish: Finish shall be true to line and plane within tolerances per **ACI 117**, Class A surface with tie holes and defective areas patched per **CONCRETE SURFACE REPAIRS** paragraph 3.17.
1. Joint marks and fins shall be removed and surfaces left smooth, dense and free from prominent grain markings.

2. Prepare, apply and cure pre-mixed, packaged cementitious coating described in paragraph 2.04J per manufacturer's requirements. Apply in 1/16 inch thick coats. Do not use products containing gypsum.
- C. Location of Finishes: Unless otherwise indicated on the plans, the location of formed surface finishes shall be as follows:
1. Apply rough formed finish on concrete surfaces not exposed to view.
 2. Apply cement wash finish on concrete surfaces exposed to view.

3.12 CONCRETE CURING AND PROTECTION

- A. General: Protect freshly placed concrete from premature drying and excessive hot temperatures, and from injurious action by the sun, rain, wind, flowing water, and mechanical injury.
1. Start initial curing as soon as free water has disappeared from concrete surface after placing and finishing. Weather permitting, keep continuously moist for not less than 7 days.
 2. Begin final curing procedures immediately following initial curing and before concrete has dried. Continue final curing for at least 7 days in accordance with **ACI 301** procedures. Avoid rapid drying at end of final curing period.
- B. Curing Methods: Perform curing of concrete by curing and sealing compound, by moist curing, by moisture-retaining cover curing, **or** by combinations thereof, as herein specified.
- C. Provide moisture curing by following methods.
1. Keep concrete surface continuously wet by covering with water.
 2. Continuous water-fog spray.
 3. Covering concrete surface with specified absorptive cover, thoroughly saturating cover with water and keeping continuously wet. Place absorptive cover to provide coverage of concrete surfaces and edges, with 4" lap over adjacent absorptive covers.
- D. Provide moisture-cover curing as follows:
1. Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width with sides and ends lapped at least 3" and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

- E. Provide curing and sealing compound to exposed interior slabs and to exterior slabs, walks, and curbs, as follows:
1. Do not use membrane curing compounds on surfaces which are to be covered with coating material applied directly to concrete, liquid floor hardener, waterproofing, dampproofing, membrane roofing, flooring (such as ceramic or quarry tile, glue-down carpet), painting, and other coatings and finish materials, unless otherwise acceptable to the coating manufacturer, coating applicator and Engineer.
 2. Apply specified curing and sealing compound to concrete slabs as soon as final finishing operations are complete (within 2 hours). Apply uniformly in continuous operation by power-spray or roller in accordance with manufacturer's directions. Recoat areas subjected to heavy rainfall within 3 hours after initial application. Maintain continuity of coating and repair damage during curing period.
- F. Curing Formed Surfaces: Cure formed concrete surfaces, including undersides of beams, supported slabs, and other similar surfaces by moist curing with forms in place for full curing period or until forms are removed. If forms are removed, continue curing by methods specified above, as applicable.
- G. Curing Unformed Surfaces: Cure unformed surfaces, such as slabs, floor topping, and other flat surfaces by application of appropriate curing method.
1. Final cure concrete surfaces to receive liquid floor hardener or finish flooring by use of moisture-retaining cover, unless otherwise directed.
- H. Sealer and Dustproofers: Apply a second coat of specified curing and sealing compound only to surfaces given a first coat.
- I. No wheeling, working, or walking on finished surfaces will be allowed for 16 hours after the concrete is placed.
- J. After 21 days curing, treat treads, risers, and nosings of interior stairs, driving and parking areas (including ramps) with concrete hardener.

3.13 SHORES AND SUPPORTS

- A. Design, construct and maintain shoring and reshoring in accordance with **ACI 347** and as herein specified.
- B. Extend shoring from ground to roof for structures 4 stories or less, unless otherwise permitted.
- C. No construction load shall be supported upon, nor any shoring removed from any part of the structure under construction until the portion of the structure has attained sufficient strength to support safely its weight and the loads placed thereon. In

addition, no construction loads exceeding the structural design live loads shall be supported upon any unshored portion of the structure.

- D. Contractor shall be responsible for all shoring and bracing as required to maintain structural stability of the structure during all phases of construction.

3.14 REMOVAL OF FORMS

- A. Formwork not supporting weight of concrete, such as sides of beams, walls, columns, and similar parts of the work, may be removed after cumulatively curing at not less than 50°F (10°C) for 24 hours after placing concrete provided concrete is sufficiently hard to not be damaged by form removal operations, and provided curing and protection operations are maintained.
- B. Formwork supporting weight of concrete, forms for beam soffits, joists, slabs, and other structural elements, may not be removed until concrete has attained its required minimum 28-day compressive strength. Forms may be incrementally stripped in 7 days but concrete must be continuously shored or reshored for at least an additional 21 days. Earlier stripping and reshoring procedures may be used where design calculations and/or testing indicate acceptable performance and where approved by the Engineer. Costs of design calculations and testing shall be borne by the Contractor.

3.15 REUSE OF FORMS

- A. Clean and repair surfaces of forms to be re-used in work. Split, frayed, delaminated, or otherwise damaged form facing material will not be acceptable for exposed surfaces. Apply new form coating compound as specified for new formwork.
- B. When forms are extended for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close joints. Align and secure joint to avoid offsets. Do not use "patched" forms for exposed concrete surfaces, except as acceptable to the Engineer.

3.16 MISCELLANEOUS CONCRETE ITEMS

- A. Filling-In: Fill-in holes and openings left in concrete structures for passage of work by other trades, unless otherwise shown or directed, after work of other trades is in place. Mix, place, and cure concrete as herein specified, to blend with in-place construction. Provide other miscellaneous concrete filling shown or required to complete work.
- B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.
- C. Equipment Bases and Foundations: Provide machine and equipment bases and foundations, as shown on drawings. Set anchor bolts for machines and equipment to

template at correct elevations, complying with certified diagrams or templates of manufacturer furnishing machines and equipment.

- D. Grout base plates and foundations as indicated, using specified non-shrink grout. Use non-metallic grout for exposed conditions, unless otherwise indicated.

3.17 CONCRETE SURFACE REPAIRS

A. General

1. Repair and patch defective areas only when acceptable to the Engineer. Remove and replace concrete if defects cannot be repaired to the satisfaction of the Engineer. Costs of all repairs and replacement work shall be borne by the Contractor.
2. Concrete repairs shall result in a durable monolithic finish with uniform color and texture and shall be free of irregularities and discontinuities.

- B. Patching Mortar: Patching mortar shall consist of one part portland cement to two and one-half parts fine aggregate passing a No. 16 sieve. Mix mortar using only enough water for handling and placing. Proprietary patching materials may be used when approved by the Engineer.

C. Patching Defective Areas:

1. Cut out honeycomb, rock pockets, voids over 1/4" in any dimension, and holes left by tie rods and bolts, down to solid concrete but, in no case to a depth of less than 1". Make edges of cuts perpendicular to the concrete surface. Thoroughly clean, dampen with water, and brush-coat the area to be patched with bonding agent compatible with patching mortar. Place and compact patching mortar before bonding compound has dried.
2. For exposed-to-view surfaces, blend white portland cement and standard portland cement so that, when dry, patching mortar will match surrounding color. Provide test areas at inconspicuous location to verify mixture and color match before proceeding with patching. Compact mortar in place and strike-off slightly higher than surrounding surface.

D. Repair of Formed Surfaces:

1. Repair exposed-to-view formed concrete surface defects which affect the finish appearance or durability, where possible. Remove and replace concrete having defective surfaces if defects cannot be repaired to satisfaction of the Engineer. Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycomb, rock pockets; fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning. Flush out form tie holes and fill with dry pack mortar.

2. Repair concealed formed surfaces, where possible, that contains defects that affect the durability of concrete as determined by the Engineer. If defects cannot be repaired, remove and replace concrete.

E. Repair of Unformed Surfaces:

1. Test unformed surfaces, such as monolithic slabs, for smoothness and verify surface plane to tolerances specified for each surface and finish. Correct low and high areas as herein specified. Test unformed surfaces sloped to drain for trueness of slope in addition to smoothness using a template having required slope.
2. Repair finished unformed surfaces that contain defects which affect durability of concrete. Surface defects include crazing, cracks in excess of 0.01" wide or which penetrate to reinforcement or completely through non-reinforced sections regardless of width, spalling, pop-outs, honeycomb, rock pockets, and other objectionable conditions.
3. Correct high areas in unformed surfaces by grinding, after concrete has cured at least 14 days.
4. Correct low areas in unformed surfaces during or immediately after completion of surface finishing operations by cutting out low areas and replacing with fresh concrete. Finish repaired areas shall blend into adjacent concrete. Proprietary patching compounds may be used when acceptable to the Engineer.
5. Repair defective areas, except random cracks and single holes not exceeding 1" diameter, by cutting out and replacing with fresh concrete. Remove defective areas to sound concrete with clean, square cuts and expose reinforcing steel with at least 3/4" clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding compound. Mix patching concrete of same materials to provide concrete of same type or class as original concrete. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.
6. Repair isolated random cracks and single holes not over 1" in diameter by dry-pack method. Groove top of cracks and cut-out holes to sound concrete and clean of dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding compound. Mix dry-pack, consisting of one part portland cement to 2-1/2 parts fine aggregate passing a No. 16 mesh sieve, using only enough water as required for handling and placing. Place dry pack before bonding compound has dried. Compact dry-pack mixture in place and finish to match adjacent concrete. Keep patched area continuously moist for not less than 72 hours.

- F. Perform structural repairs with prior approval of the Engineer for method and procedure, using specified epoxy adhesive and mortar.

- G. Repair methods not specified above may be used, subject to acceptance of the Engineer.

3.18 QUALITY CONTROL TESTING DURING CONSTRUCTION

- A. The Contractor shall employ a testing laboratory to perform tests and to submit test reports three (3) each. Costs of all testing shall be borne by the Contractor.

Sampling and testing for quality control during placement of concrete shall include the following:

1. Sampling Fresh Concrete: **ASTM C 172**, except modified for slump to comply with **ASTM C 94**. Field sampling and testing of concrete shall be conducted by a currently certified ACI Concrete Field Testing Technician, Grade I or approved equivalent.
 2. Slump: **ASTM C 143**; one test at point of discharge for each set of compressive strength test cylinders made; additional tests when concrete consistency seems to have changed.
 3. Air Content: **ASTM C 173**, volumetric method for lightweight or normal weight concrete; **ASTM C 231** pressure method for normal weight concrete; one test for each day's pour of each type of air- entrained concrete and one test for each set of compressive strength test cylinders made.
 4. Concrete Temperature: Test hourly when air temperature is 80°F (27°C) and above; and each time a set of compression test specimens made.
 5. Compression Test Specimens: **ASTM C 31**; one set consisting of 4 each, 6" x 12", standard cylinders for each required compressive strength test, unless otherwise directed. Mold and store cylinders for laboratory cured test specimens except when field-cure test specimens are required.
 6. Compressive Strength Tests: **ASTM C 39**; one set for each class of concrete poured each day plus additional sets for each 100 cubic yards or fraction thereof over and above the first 25 cubic yards of each concrete class placed in any one day; one specimen tested at 7 days, two specimens tested at 28 days, and one specimen retained reserve for later testing if required. Compressive strength tests shall be conducted by a currently certified ACI Concrete Laboratory Testing Technician, Grade I or II or approved equivalent.
- B. Test results shall be reported in writing to the Engineer within 24 hours after tests. Reports of compressive strength tests shall contain the project identification name and number, date of concrete placement, name of concrete testing service, concrete type and class, location of concrete batch in structure, design compressive strength at 28 days, concrete mix proportions and materials; compressive breaking strength and type of break for both 7-day tests and 28-day tests.

- C. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted but shall not be used as the sole basis for acceptance or rejection.
- D. In all cases where the strength of any group of 3 cylinders or of any individual cylinder falls below the minimum compressive strength specified, the Engineer shall have the right to require that test specimens be cut from the structure. Specimens shall be selected by the Engineer from the location in the structure represented by the test specimen or specimens which failed. Specimens shall be secured, prepared, and tested in accordance with **ASTM C 42** within a period of 60 days after placing the concrete. Concrete shall be considered to meet the strength requirement of this specification if it meets the strength requirements of **ACI 318**. Should laboratory analysis indicate, however, that the proper concrete mix has not been used by the Contractor, all such concrete poured using the improper mix shall be subject to rejection. The cost of cutting specimens from the structure, patching the resulting holes, and making the laboratory analysis shall be borne by the Contractor. The holes from which the cored samples are taken shall be packed solid with no slump concrete proportioned in accordance with **ACI 211.3R** "Guide for Selecting Proportions of No-Slump Concrete." The patching concrete shall have the same design strength as the specified concrete. If any of the specimens cut from the structure fail to meet the requirements of **ACI 318**, the Engineer shall have the right to require any and all defective concrete be replaced and all costs resulting there from shall be borne by the Contractor.
- E. Contractor Sampling: In addition to the slump tests specified above, keep a slump cone (mold) and rod apparatus on the jobsite for random testing of batches. If, when concrete is being discharged from the mixer, the Engineer believes the concrete does not meet the specified maximum slump requirements, the Contractor shall immediately perform a slump test in accordance with **ASTM C 143**. Remove from the jobsite concrete not meeting the slump requirements.

3.19 SPECIAL INSPECTION

- A. Special inspections per Building Code requirements are required for the following types of concrete work:
 - 1. Reinforcing steel.
 - 2. Bolts installed in concrete.
 - 3. Concrete placement and testing.
 - 4. Other designated work as indicated on the drawings.
- B. Special Inspector shall be provided by HECO. Contractor shall arrange for special inspections and shall notify Engineer and Special Inspector at least 3 working days prior to performing work requiring special inspections.

- C. Special Inspector shall observe the construction work and notify HECO and the Contractor of discrepancies in the work. Contractor shall correct deficiencies in a timely manner.
- D. Special Inspector shall submit inspection reports to HECO and the engineer or architect of record. A final report per Building Code requirements shall also be submitted to HECO and the building official.

3.20 CLEAN-UP

Contractor shall clean up all concrete and cement materials, equipment and debris upon completion of any portion of the concrete work when so directed by the Engineer and upon completion of the entire concrete and related work.

3.21 MEASUREMENT AND PAYMENT

- A. All concrete placed, finished, and cured shall be measured for payment based on unit prices or lump sum as set forth in the proposal. Where payment is provided for on unit prices, measurement shall be by the cubic yard of concrete based on the dimensions shown on the plans or ordered by the Engineer.
- B. Payment will be made at the unit bid prices or lump sum price and shall be full compensation for furnishing the materials, tools, equipment and labor necessary to complete the structure in place.
- C. Unless otherwise specified, no direct payment will be made for reinforcing steel, but full compensation shall be considered as included in the price bid for concrete.
- D. Concrete for duct encasement shall not be measured and paid for separately, but shall be included in the bid prices for underground ducts.

End of Specification