SECTION 03 3100

CONCRETE WORK

PART 1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work specified in this section.

1.2 DESCRIPTION OF WORK

A. Extent of concrete work shown on drawings.

B. Concrete paving and walks are specified in Division 2.

1.3 QUALITY ASSURANCE

A. Codes and Standards: Comply with provisions of following codes, specifications and standards, except where more stringent requirements are shown or specified:

1. American Concrete Institute:

(a) ACI 318 "Building Code Requirements for Reinforced Concrete".

(b) ACI 301 "Specifications for Structural Concrete for Buildings".

(c) ACI 614 "Recommended Practice for Measuring, Mixing and Placing Concrete".

(d) ACI 311 "Recommended Practice for Concrete Inspection".

2. Concrete Reinforcing Steel Institute:

(a) CRSI "Manual of Standard Practice".

B. Concrete Testing Service: The Owner shall engage a testing laboratory acceptable to Architect to perform concrete material evaluation tests and to design concrete mixes.

1. Materials and installed work may require testing and retesting, as directed by Architect, at any time during progress of work. Allow free access to material stockpiles and facilities. Tests, including retesting of rejected materials and installed work, shall be done at Contractor's expense.

1.4 SUBMITTALS

A. Product Data: Submit data for proprietary materials and items, including reinforcement and forming accessories, admixtures, patching compounds, waterstops, joint systems, curing compounds, dry-shake finish materials, and others as requested by Architect.

B. Shop Drawings; Reinforcement: Submit shop drawings of one set of reproducibles and two sets of prints for fabrication, bending, and placement of concrete reinforcement. Comply with ACI 315 "Manual of Standard Practice for Detailing Reinforced Concrete Structures" showing bar schedules, stirrup spacing, diagrams of bent bars, arrangement of

concrete reinforcement. Include special reinforcement required and openings through concrete structures.

1. Do not reproduce contract drawings for shop drawings.

C. Samples: Submit samples of materials as specified and as otherwise requested by Architect, including names, sources and descriptions.

D. Laboratory Test Reports: Submit laboratory test reports for concrete materials and mix design test as specified.

E. Material Certificates: Provide materials certificates in lieu of materials laboratory test reports when permitted by Architect. Material certificates shall be signed by manufacturer and Contractor, certifying that each material item complies with, or exceeds, specified requirements.

PART 2. PRODUCTS

2.1 FORM MATERIALS

A. Forms for Exposed Finish Concrete: Unless otherwise indicated, construct formwork for exposed concrete surfaces with 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. Provide form material with sufficient thickness to withstand pressure of newly-placed concrete without bow or deflection.

B. Forms for Unexposed Finish Concrete: Form concrete surfaces which will be unexposed in finished structure with plywood, lumber, metal or other acceptable material. Provide lumber dressed on at least 2 edges and one side for tight fit.

C. Cylindrical Columns and Supports: Form round-section members with metal, fiberglass reinforced plastic, or paper or fiber tubes. Construct paper or fiber tubes, of laminated plies using water-resistant adhesive with wax-impregnated exterior for weather and moisture protection. Provide units with sufficient wall thickness to resist loads imposed by wet concrete without deformation.

D. 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.

2.2 REINFORCING MATERIALS

A. Reinforcing Bars: ASTM A 615, Grade 60, deformed.

B. Welded Wire Fabric: ASTM A 185, welded steel wire fabric.

C. Welded Deformed Steel Wire Fabric: ASTM A 497.

D. Supports for Reinforcement: Provide supports for reinforcement including bolsters, chairs, spacers and other devices for spacing, supporting and fastening reinforcing bars and welded wire fabric in place. Use wire bar type supports complying with CRSI recommendations, unless otherwise acceptable.

1. For slabs-on-grade, use supports with sand plates or horizontal runners where base material will not support chair legs.

2. For exposed-to-view concrete surfaces, where legs of supports are in contact with forms, provide supports with legs which are plastic protected (CRSI, Class I) or stainless steel protected (CRSI, Class 2).

2.3 CONCRETE MATERIALS

A. Portland Cement: ASTM C 150, Type I, unless otherwise acceptable to Architect.

1. Use one brand of cement throughout project, unless otherwise acceptable to Architect.

B. Fly-Ash: ASTM C 618, with a loss on ignition of less than 1 %.

1. Type C

(a) Limit use of fly ash to not exceed 25% of cement content by weight.

(b) 1 to 1 fly ash to cement replacement ratio.

2. Type F

(a) Limit use of fly ash to not exceed 15% of cement content by weight.

(b) 1.25 to 1 fly ash to cement replacement ratio.

3. Limit use of fly ash to not exceed 25% of cement content by weight.

C. Normal Weight Aggregates: ASTM C 33, and as herein specified. Provide aggregates from a single source for exposed concrete.

1. For exterior exposed surfaces, do not use fine or coarse aggregates containing spalling-causing deleterious substances.

D. Water: Drinkable.

E. Air-Entraining Admixture: ASTM C 260.

1. Available Products: Subject to compliance with requirements, products which may be incorporated in the work include, but are not limited to, the following:

(a) "Sika Aer"; Sika Corp.

(b) "MB-VR or MB-AE"; Master Builders.

(c) "Dorex AEA"; W.R. Grace.

(d) "Edoco 2001 or 2002"; Edoco Technical Products.

F. Concrete Moisture Vapor Reduction Admixture (MVRA): Concrete moisture vapor reduction admixture for all interior slab (on ground and elevated) and structural roof deck construction shall be a non-toxic, liquid admixture that is specifically designed to have a natural chemical reaction with pre-existing elements inside the concrete to eliminate the route of moisture vapor emission through the slab by restricting the integral capillary system. The chemical reaction forms a permanent barrier (capillary break) that is integral to the concrete, insoluble and irremovable.

1. “MVRA 900” manufactured by ISE Logik

2. “Barrier One PIA” manufactured by Barrier One Concrete Admixtures.

3. “Vapor Lock 20/20” manufactured by Specialty Products Group.

G. Water-Reducing Admixture: ASTM C 494, Type A, and contain not more than 0.1% chloride ions.

1. Available Products: Subject to compliance with requirements, products which may be incorporated in the work include, but are not limited to, the following:

(a) "Eucon WR-75"; Euclid Chemical Co.

(b) "Pozzolith 344"; Master Builders.

(c) "Plastocrete 160;" Sika Chemical Corp.

(d) "Chemtard"; Chem-Masters Corp.

H. High-Range Water-Reducing Admixture (Super Plasticizer): ASTM C 494, Type F or Type G and contain not more than 0.1% chloride ions.

1. Available Products: Subject to compliance with requirements, products which may be incorporated in the work include, but are not limited to, the following:

(a) "WRDA 19"; W.R. Grace.

(b) "PSP"; Protex Industries Inc.

(c) "Super P"; Anti-Hydro.

(d) "Sikament"; Sika Chemical Corp.

(e) "Mighty 150"; ICI Americas Corp.

(f) "Eucon Super 37"; Euclid Chemical Corp

(g) "PSI Super"; Gifford-Hill.

(h) "Pozzolith 400"; Master Builders.

I. Water Reducing, Non-Chloride Accelerator Admixture: ASTM C 494, Type E, and containing not more than 0.1% chloride ions.

1. Available Products: Subject to compliance with requirements, products which may be incorporated in the work include, but are not limited to, the following:

(a) "Accelguard 80"; Euclid Chemical Co.

(b) "Pozzolith 500"; Master Builders.

J. Water-Reducing, Retarding Admixture: ASTM C 494, Type D, and contain not more than 0.1% chloride ions.

1. Available Products: Subject to compliance with requirements, products which may be incorporated in the work include, but are not limited to, the following:

(a) "Edoco 20006"; Edoco Technical Products.

(b) "Pozzolith 300-R"; Master Builders.

(c) "Eucon Retarder 75"; Euclid Chemical Co.

(d) "Daratard"; W.R. Grace.

(e) "Plastiment"; Sika Chemical Co.

K. Certifications: Provide admixture manufacturer's written certification that chloride ion content complies with specified requirements.

1. Calcium chloride or admixture containing more than 0.1% chloride ions are not permitted.

2.4 RELATED MATERIALS

A. Waterstops: Provide flat, dumbbell type or centerbulb type waterstops at construction joints and other joints as indicated. Size to suit joints.

B. Moisture Barrier: Provide moisture barrier over prepared base material where indicated. See Section 03 0516 for material specification and installation.

C. Non-Shrink Grout: CRD-C 621, factory pre-mixed grout.

1. Available Products: Subject to compliance with requirements, products which may be incorporated in the work include, but are not limited to, the following:

(a) Metallic

(i) "Vibrofoil"; A.C. Horn.

(ii) "Metallic Spec. Grout"; The Burke Co.

(iii) "Embeco 636"; Master Builders.

(iv) "Ferrolith G"; Sonneborn-Contech.

(v) "Firmix"; Euclid Chemical Co.

(vi) "Kemox G"; Sika Chemical Co.

(vii) "Ferrogrout"; L & M Const. Chemical Co.

(b) Non-metallic

(i) "Masterflow 713"; Master Builders.

(ii) "Sonogrout"; Sonneborn-Contech.

(iii) "Euco-NS"; Euclid Chemical Co.

(iv) "Crystex" L & M Cons. Chemical Co.

(v) "Sure-Grip Grout", Dayton Superior Corp.

(vi) "Horngrout"; A.C. Horn.

(vii) "S88"; W.R. Meadows.

D. Absorptive Cover: Burlap cloth made from jute or kenaf, weighing approximately 9 oz. per sq. yd., complying with AASHTO M 182, Class 2.

1. Moisture-Retaining Cover: One of the following, complying with ASTM C 171.

(a) Waterproof paper.

(b) Polyethylene film.

(c) Polyethylene-coated burlap.

E. Liquid Membrane-Forming Curing Compound: Liquid type membrane- forming curing compound complying with ASTM C 309, Type I, Class A unless other type acceptable to Architect. Moisture loss not more than 0.055 gr./sq. cm. when applied at 200 sq. ft./gal.

1. Available Products: Subject to compliance with requirements, products which may be incorporated in the work include, but are not limited to, the following:

(a) “Green Seal 101 Moisture & Vapor Block”; Harrison Pacific, LLC

(b) "Masterseal"; Master Builders.

(c) "A-H 3 Way Sealer"; Anti-Hydro Waterproofing Co.

(d) "Ecocure"; Euclid Chemical Co.

(e) "Clear Seal"; W.R. Grace.

(f) "J-20 Acrylic Cure"; Dayton Superior.

(g) "Sure Cure"; A.C. Horn

(h) "Spartan-Cote"; Kaufman Products Inc.

(i) "Sealkure"; Toch Div. - Carboline.

(j) "Kure-N-Seal"; Sonneborn-Contech.

(k) "Polyclear"; Upco Chemical/USM Corp.

(l) "L&M Cure"; L & M Construction Chemicals.

(m) "Klearseal"; Setcon Industries.

(n) "LR-152"; Protex Industries.

(o) "Hardtop"; Gifford-Hill.

(p) "C.S. 309"; W.R. Meadows.

F. Bonding Compound: Polyvinyl acetate or acrylic base, rewettable type.

1. Available Products: Subject to compliance with requirements, products which may be incorporated in the work include, but are not limited to, to the following:

   (a) "J-40 Bonding Agent"; Dayton Superior Corp.

   (b) "Weldcrete"; Larson Products.

   (c) "Everbond"; L & M Construction Chemicals.

   (d) "EucoWeld"; Euclid Chemical Co.

   (e) "Hornweld"; A.C. Horn.

   (f) "Sonocrete"; Sonneborn-Contech.

   (g) "Acrylic Bondcrete"; The Burke Co.

   (h) "Intralok"; W.R. Meadows.

G. Epoxy Adhesive: ASTM C 881, two component material suitable for use on dry or damp surfaces. Provide material "Type", "Grade", and "Class" to suit project requirements.

1. Available Products: Subject to compliance with requirements, products which may be incorporated in the work include, but are not limited to, to the following:

   (a) "Epoxtite"; A.C. Horn

   (b) "Edoco 2118 Epoxy Adhesive"; Edoco Technical Prod.

   (c) "Sikadur Hi-Mod"; Sika Chemical Corp.

   (d) "Euco Epoxy 463 or 615"; Euclid Chemical Co.

   (e) "Patch and Bond Epoxy"; The Burke Co.

   (f) "Sure-Poxy"; Kaufman Products Inc.

   (g) "Rezi-Weld"; W.R. Meadows.

2.5 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. Submittals not containing substantiation of the mix design by either of these methods will be rejected. If trial batch method used, use an independent testing facility acceptable to Architect for preparing and reporting proposed mix designs. The testing facility shall not be the same as used for field quality control testing unless otherwise acceptable to Architect.

B. Submit written reports to Architect of each proposed mix for each class of concrete at least 15 days prior to start of work. Do not begin concrete production until mixes have been reviewed by Architect.

C. Design mixes to provide normal weight concrete with the following properties, as indicated on drawings and schedules:

1. 4000 psi 28-day compressive strength; W/C ratio, 0.44 maximum (non-air-entrained), 0.35 maximum (air-entrained).

2. 3000 psi 28-day compressive strength; W/C ratio, 0.58 maximum (non-air-entrained), 0.46 maximum (air-entrained).

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 Owner and as accepted by Architect. Laboratory test data for revised mix design and strength results must be submitted to and accepted by Architect before using in work.

E. Admixtures:

1. Use water-reducing admixture or high range water-reducing admixture (super plasticizer) in concrete as required for placement and workability.

2. Use non-chloride accelerating admixture in concrete slabs placed at ambient temperatures below 50°F (10°C).

3. Use air-entraining admixture in exterior exposed concrete, unless otherwise indicated. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having total air content with a tolerance of plus-or- minus 1-1/2% within following limits.

(a) Concrete structures and slabs exposed to freezing and thawing deicer chemicals, or subjected to hydraulic pressure:

(b) 4.5% (moderate exposure); 5.5% (severe exposure) 1-1/2" max. aggregate.

(c) 4.5% (moderate exposure); 6.0% (severe exposure) 1" max. aggregate.

(d) 5.0% (moderate exposure); 6.0% (severe exposure) 3/4" max. aggregate.

(e) 5.5% (moderate exposure); 7.0% (severe exposure) 1/2" max. aggregate.

(f) Other Concrete: 2% to 4% air.

4. Use admixtures for water-reducing and set-control in strict compliance with manufacturer's directions.

F. Water-Cement Ratio: Provide concrete for following conditions with maximum water-cement (WC) ratios as follows:

1. Subjected to freezing and thawing; WC 0.50.

2. Subjected to deicers/watertight; WC 0.45.

3. Subjected to brackish water, salt spray or deicers; WC 0.40.

G. Slump Limits: Proportion and design mixes to result in concrete slump at point of placement as follows:

1. Ramps slabs, and sloping surfaces: Not more than 3".

2. Reinforced foundation systems: Not less than 1" and not more than 3".

3. Concrete containing HRWR admixture (super plasticizer): Not more than 8" after addition of HRWR to verified 2"-3" slump concrete.

4. Other Concrete: Not more than 4".

2.6 CONCRETE MIXES

A. Ready-Mix Concrete: Comply with requirements of ASTM C 94, and as herein specified.

1. During hot weather, or under conditions contributing to rapid setting of concrete, a shorter mixing time than specified in ASTM C 94 may be required.

2. When air temperature is between 85ºF (30ºC) and 90ºF (32ºC), reduce mixing and delivery time from 1-1/2 hours to 75 minutes, and when air temperature is above 90ºF (32ºC), reduce mixing and delivery time to 60 minutes.

PART 3. EXECUTION

3.1 FORMS

A. Design, erect, support, brace and maintain formwork to support vertical and lateral 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.

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 backup 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 as indicated, using wood, metal, PVC or rubber chamfer strips fabricated to produce uniform smooth lines and tight edge joints.

G. Form Ties: Factory-fabricated, adjustable-length, removable or snapoff metal form ties, designed to prevent form deflection, and to prevent spalling concrete surfaces upon removal.

1. Unless otherwise indicated, provide ties so portion remaining within concrete after removal is 2" inside concrete and will not leave holes larger than 1" diameter in concrete surface.

H. 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.

I. 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. Retighten forms and bracing after concrete placement is required to eliminate mortar leaks and maintain proper alignment.

3.2 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.

B. Clean reinforcement of loose rust and mill scale, earth, ice, and other materials which reduce or destroy bond with concrete.

C. Clean reinforcement of loose rust and mill scale, earth, ice, and other materials which reduce or destroy bond with concrete.

D. Place reinforcement to obtain at least minimum 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.

E. Install welded wire fabric in as long lengths as practicable. Lap adjoining pieces at least one full mesh plus 2" and lace splices with wire. Offset end laps in adjacent widths to prevent continuous laps in either direction.

3.3 JOINTS

A. Construction Joints: Locate and install construction joints, which are not shown on drawings, so as not to impair strength and appearance of the structure, as acceptable to Architect.

1. Provide keyways at least 1-1/2" deep in construction joints in walls, slabs and between walls and footings; accepted bulkheads designed for this purpose may be used for slabs.

2. Place construction joints perpendicular to the main reinforcement. Continue reinforcement across construction joints.

3. Waterstops: Provide waterstops in construction joints as indicated. Install waterstops to form continuous diaphragm in each joint. Make provisions to support and protect exposed waterstops during progress of work. Fabricate field joints in waterstops in accordance with manufacturer's printed instructions.

B. Isolation Joints in Slabs-on-Ground: Construct isolation joints in slabs-on-ground at points of contact between slabs on ground and vertical surfaces, such as column pedestals, foundation walls, grade beams and elsewhere as indicated.

C. Contraction (Control) Joints in Slabs-on-Ground: Construct contraction joints in slabs-on-ground to form panels of patterns as shown. Use inserts or saw-cut 1/8" to 1/4" wide x 1/4 of the slab depth, unless otherwise indicated.

1. Form contraction joints by inserting premolded plastic, hardboard or fiberboard strip into fresh concrete until top surface of strip is flush with slab surface. After concrete has cured, remove inserts and clean groove of loose debris.

(a) Contraction joints may be formed by saw cuts as soon as possible after slab finishing as may be safely done without dislodging aggregate.

3.4 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.

B. Edge Forms and Screed Strips for Slabs: Set edge forms or bulkheads and intermediate screed strips for slabs to obtain required elevations and contours in finished slab surface. Provide and secure units sufficiently strong to support types of screed strips by use of strike-off templates or accepted compacting type screeds.

3.5 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, and in 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 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.

3.6 CONCRETE PLACEMENT

A. 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.

1. Coordinate the installation of joint materials and moisture barriers with placement of forms and reinforcing steel.

2. General: Comply with ACI 304 "Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete", and as herein specified.

(a) 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.

B. Placing Concrete in Forms: Deposit concrete in forms in horizontal layers not deeper than 24" and in a manner to avoid inclined construction joints. Where placement consists of several layers, place each layer while preceding layer is still plastic to avoid cold joints.

1. Consolidate placed concrete by mechanical vibrating equipment supplemented by hand-spading, rodding or tamping. Use equipment and procedures for consolidation of concrete in accordance with ACI recommended practices.

    (a) 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 of mix.

C. Placing Concrete Slabs: Deposit and consolidate concrete slabs in a continuous operation, within limits of construction joints, until the placing of a panel or section is completed.

1. Consolidate concrete during placing operations so that concrete is thoroughly worked around reinforcement and other embedded items and into corners.

2. 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.

3. Maintain reinforcing in proper position during concrete placement operations.

D. Cold Weather Placing: Protect concrete work from physical damage or reduced strength which could be caused by frost, freezing actions, or low temperatures, in compliance with ACI 306 and as herein specified.

1. When air temperature has fallen to or is expected to fall below 40ºF (4ºC), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50ºF (10ºC), and not more than 80ºF (27ºC) at point of placement.

2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.

3. Do not use calcium chloride, salt and other materials containing antifreeze agents or chemical accelerators, unless otherwise accepted in mix designs.

E. Hot Weather Placing: When hot weather conditions exist that would seriously impair quality and strength of concrete, place concrete in compliance with ACI 305 and as herein specified.

1. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90ºF (32ºC). 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. Use of liquid nitrogen to cool concrete is Contractor's option.

2. 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. Use water-reducing retarding admixture (Type D) when required by high temperatures, low humidity, or other adverse placing conditions.

3.7 FINISH OF FORMED SURFACES

A. Rough Form Finish: For formed concrete surfaces not exposed-to- view in the finish work or by other construction, unless otherwise indicated. This is the concrete surface having texture imparted by form facing material used, with tie holes and defective areas repaired and patched and fins and other projections exceeding 1/4" in height rubbed down or chipped off.

B. Smooth Form Finish: For formed concrete surfaces exposed-to-view, or that are to be covered with a coating material applied directly to concrete, or a covering material applied directly to concrete, such as waterproofing, dampproofing, painting or other similar system. This is as-cast concrete surface obtained with selected form facing material, arranged orderly and symmetrically with a minimum of seams. Repair and patch defective areas with fins or other projections completely removed and smoothed.

C. Related Unformed Surfaces: At tops of walls, horizontal offsets and similar unformed surfaces occurring adjacent to formed surfaces, strike-off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.

3.8 MONOLITHIC SLAB FINISHES

A. Scratch Finish: Apply scratch finish to monolithic slab surfaces that are to receive concrete floor topping or mortar setting beds for tile, portland cement terrazzo, and other bonded applied cementitious finish flooring material, and as otherwise indicated.

1. After placing slabs, plane surface to F-numbers Ff/Fl 20/15, with minimum local F-numbers of 15/10.. Slope surfaces uniformly to drains where required. After leveling, roughen surface before final set, with stiff brushes, brooms or rakes.

B. Float Finish: Apply float finish to monolithic slab surfaces to receive trowel finish and other finishes as hereinafter specified, and slab surfaces which are to be covered with membrane or elastic waterproofing, membrane or elastic roofing, or sand-bed terrazzo, 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 level surface plane to F-numbers Ff/Fl 20/15, with minimum local F-numbers of 15/10. 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 thinfilm finish coating system.

D. Trowel and Fine Broom Finish: Where ceramic or quarry tile is to be installed with thin-set mortar, apply trowel finish as specified, then immediately follow with slightly scarifying surface by fine brooming.

E. Non-Slip Broom Finish: Apply non-slip broom finish to exterior concrete platforms, steps and ramps, and elsewhere as indicated.

1. Immediately after trowel finishing, slightly roughen concrete surface by brooming with fiber bristle broom perpendicular to main traffic route. Coordinate required final finish with Architect before application.

F. Non-slip Aggregate Finish: Apply non-slip aggregate finish to concrete stair treads, platforms, ramps, and elsewhere as indicated.

1. After completion of float finishing, and before starting trowel finish, uniformly spread 25 lbs. of dampened non-slip aggregate per 100 sq. ft. of surface. Tamp aggregate flush with surface using a steel trowel, but do not force below surface. After broadcasting and tamping, apply trowel finishing as herein specified.

2. After curing, lightly work surface with a steel wire brush, or an abrasive stone, and water to expose non-slip aggregate.

3.9 CONCRETE CURING AND PROTECTION

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. 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.

C. 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.

D. Curing Methods: Perform curing of concrete by curing and sealing compound, by moist curing, by moisture-retaining cover curing, and by combinations thereof, as herein specified.

1. Provide moisture curing by following methods.

(a) Keep concrete surface continuously wet by covering with water.

(b) Continuous water-fog spray.

(c) 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.

2. Provide moisture-cover curing as follows:

(a) 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.

3. Provide curing and sealing compound to interior slabs with resilient flooring, carpet over cushion, or left exposed; and to exterior slabs, walks, and curbs, as follows:

(a) 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.

(b) 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, painting, and other coatings and finish materials, unless otherwise acceptable to Architect.

E. 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.

F. Curing Unformed Surfaces: Cure unformed surfaces, such as slabs, floor topping, and other flat surfaces by application of appropriate curing compound.

1. Final cure concrete surfaces to receive liquid floor hardener or finish flooring by use of moisture-retaining cover, unless otherwise directed.

G. Sealer and Dustproofer: Apply a second coat of specified curing and sealing compound only to surfaces given a first coat.

3.10 SHORES AND SUPPORTS

A. Comply with ACI 347 for shoring and reshoring in multistory construction, and as herein specified.

3.11 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, such as beam soffits, joints, slabs and other structural elements, may not be removed in less than 14 days and until concrete has attained design minimum compressive strength at 28-days. Determine potential compressive strength of inplace concrete by testing field-cured specimens representative of concrete location or members.

C. Form facing material may be removed 4 days after placement, only if shores and other vertical supports have been arranged to permit removal of form facing material without loosening or disturbing shores and supports.

3.12 RE-USE 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 Architect.

3.13 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.

E. Steel Pan Stairs: Provide concrete fill for steel pan stair treads and landings and associated items. Cast-in safety inserts and accessories as shown on drawings. Screed, tamp, and finish concrete surfaces as scheduled.

F. Reinforced Masonry: Provide concrete grout for reinforced masonry lintels and bond beams where indicated on drawings and as scheduled. Maintain accurate location of reinforcing steel during concrete placement.

3.14 CONCRETE SURFACE REPAIRS

A. Patching Defective Areas: Repair and patch defective areas with cement mortar immediately after removal of forms, when acceptable to Architect.

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 specified bonding agent. Place patching mortar after 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 color surrounding. 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.

B. Repair of Formed Surfaces: Remove and replace concrete having defective surfaces if defects cannot be repaired to satisfaction of Architect. Surface defects, as such, include color and texture irregularities, cracks, spalls, air bubbles, honeycomb, rock pockets; fins and other projections on surface; and stains and other discolorations that cannot be removed by cleaning. Flush out form tie holes, fill with dry pack mortar, or precast cement cone plugs secured in place with bonding agent.

1. Repair concealed formed surfaces, where possible, that contain defects that affect the durability of concrete. If defects cannot be repaired, remove and replace concrete.

C. Repair of Unformed Surfaces: 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.

1. Repair finished unformed surfaces that contain defects which affect durability of concrete. Surface defects, as such, 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.

2. Correct high areas in unformed surfaces by grinding, after concrete has cured at least 14 days.

3. 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 to blend into adjacent concrete. Proprietary patching compounds may be used when acceptable to Architect.

4. 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 the same manner as adjacent concrete.

5. 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 after 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.

6. Perform structural repairs with prior approval of Architect for method and procedure, using specified epoxy adhesive mortar.

7. Repair methods not specified above may be used, subject to acceptance of Architect.

3.15 QUALITY CONTROL TESTING DURING CONSTRUCTION

A. The Owner will employ a testing laboratory to perform other tests and to submit test reports.

B. Sampling and testing for quality control during placement of concrete may include the following, as directed by Architect.

1. Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASTM C 94.

2. Slump: ASTM C 143; one test at point of discharge for each day's pour of each type of concrete; 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 for each day's pour of each type of air entrained concrete.

4. Concrete Temperature: Test hourly when air temperature is 40ºF (4ºC) and below, and when 80ºC (27ºC) and above; and each time a set of compression test specimens made.

5. Compression Test Specimen: ASTM C 31; one set of 3 standard cylinders for each 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 day's pour exceeding 5 cu. yds. plus additional sets for each 50 cu. yds. over and above the first 25 cu. yds. of each concrete class placed in any one day; one specimen tested at 7 days, one specimen tested at 28 days, and one specimen retained in reserve for later testing if required.

   (a) When frequency of testing will provide less than 5 strength tests for a given class of concrete, conduct testing from at least 5 randomly selected batches or from each batch if fewer than 5 are used.

   (b) When strength of field-cured cylinders is less than 85% of companion laboratory-cured cylinders, evaluate current operations and provide corrective procedures for protecting and curing the in-place concrete.

   (c) Strength level of concrete will be considered satisfactory if averages of sets of three consecutive strength test results equal or exceed specified compressive strength, and no individual strength test result falls below specified compressive by more than 500 psi.

C. Test results will be reported in writing to Architect and Contractor on same day that tests are made. 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.

D. 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.

E. Additional Tests: The testing service will make additional tests of in-place concrete when test results indicate specified concrete strengths and other characteristics have not been attained in the structure, as directed by Architect. Testing service may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed. Contractor shall pay for such tests conducted, and any other additional testing as may be required, when unacceptable concrete is verified.

END OF SECTION