SECTION 03002
CONCRETE

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Cast-in-place concrete and grout.

B. Related Sections include but are not necessarily limited to:
   1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 1 - General Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Concrete Institute (ACI):
      a. 116R, Cement and Concrete Terminology.
      b. 211.1, Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete.
      c. 212.3R, Chemical Admixtures for Concrete.
      d. 304R, Guide for Measuring, Mixing, Transporting, and Placing Concrete.
      e. 304.2R, Placing Concrete by Pumping Methods.
      f. 305R, Hot Weather Concreting.
      g. 306R, Cold Weather Concreting.
      h. 318, Building Code Requirements for Structural Concrete.
      i. 347R, Recommended Practice for Concrete Formwork.
   2. ASTM International (ASTM):
      a. A82, Standard Specification Steel Wire, Plain, for Concrete Reinforcement.
      b. A185, Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement.
      c. A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement (Including Supplementary Requirements S1).
      d. A775, Standard Specification for Epoxy-Coated Reinforcing Steel Bars.
      e. C31, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
      f. C33, Standard Specification for Concrete Aggregates.
      g. C39, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
      h. C94, Standard Specification for Ready-Mixed Concrete.
      i. C138, Standard Method of Test for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete.

j. C143, Standard Test Method for Slump of Hydraulic Cement Concrete.
k. C150, Standard Specification for Portland Cement.
l. C157, Standard Test Method for Length Change of Hardened Hydraulic Cement Mortar and Concrete.
m. C171, Standard Specification for Sheet Materials for Curing Concrete.
n. C172, Standard Practice for Sampling Freshly Mixed Concrete.
o. C173, Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
p. C231, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
q. C260, Standard Specification for Air Entraining Admixtures for Concrete.
r. C289, Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method).
s. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
t. C494, Standard Specification for Chemical Admixtures for Concrete.
u. C595, Standard Specification for Blended Hydraulic Cements.
v. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.
w. C1315, Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.
x. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
y. D1056, Standard Specification for Flexible Cellular Materials Sponge or Expanded Rubber.
z. D1751, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
aa. E329, Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction.

3. United States Army Corps of Engineers (COE):
   a. CRD-C572, Specifications for Polyvinylchloride Waterstop.
   b. CRD-C621, Standard Specification for Non-Shrink Grout.

B. Quality Control:
   1. Concrete testing agency:
      a. Contractor to employ and pay for services of a testing laboratory to:
         1) Perform materials evaluation.
         2) Design concrete mixes.
      b. Concrete testing agency to meet requirements of ASTM E329.
   2. Do not begin concrete production until proposed concrete mix design has been approved by Engineer.
      a. Approval of concrete mix design by Engineer does not relieve Contractor of his responsibility to provide concrete that meets the requirements of this Specification.

3. Adjust concrete mix designs when material characteristics, job conditions, weather, strength test results or other circumstances warrant.
   a. Do not use revised concrete mixes until submitted to and approved by Engineer.
4. Perform structural calculations as required to prove that all portions of the structure in combination with remaining forming and shoring system has sufficient strength to safely support its own weight plus the loads placed thereon.

C. Qualifications:
1. Ready mixed concrete batch plant certified by National Ready Mixed Concrete Association (NRMCA).
2. Formwork, shoring and reshoring for slabs and beams except where cast on ground to be designed by a professional engineer currently registered in the state where the project is located.

1.3 DEFINITIONS

A. Per ACI 116R except as modified herein:
1. Concrete fill: Non-structural concrete.
2. Concrete Testing Agency: Testing agency employed to perform materials evaluation, design of concrete mixes or testing of concrete placed during construction.
3. Exposed concrete: Exposed to view after construction is complete.
4. Indicated: Indicated by Contract Documents.
5. Lean concrete: Concrete with low cement content.
6. Nonexposed concrete: Not exposed to view after construction is complete.
7. Required: Required by Contract Documents.
8. Specified strength: Specified compressive strength at 28 days.
9. Submitted: Submitted to Engineer.

1.4 SUBMITTALS

A. Shop Drawings:
1. See Section 01340 for requirements for the mechanics and administration of the submittal process.
2. Concrete mix designs proposed for use.
   a. Concrete mix design submittal to include the following information:
      1) Sieve analysis and source of fine and coarse aggregates.
      2) Test for aggregate organic impurities.
      3) Test for deleterious aggregate per ASTM C289.
      4) Proportioning of all materials.
      5) Type of cement with mill certificate for cement.
      6) Type of fly ash with certificate of conformance to specification requirements.
      7) Slump.
      8) Air content.
      9) Brand, type, ASTM designation, and quantity of each admixture proposed for use.

10) 28-day cylinder compressive test results of trial mixes per ACI 318 and as indicated herein.
11) Shrinkage test results.
12) Standard deviation value for concrete production facility.

3. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Manufacturer's installation instructions.
   c. Manufacturers and types:
      1) Joint fillers.
      2) Curing agents.
      3) Chemical sealer.
      4) Bonding and patching mortar.
      5) Construction joint bonding adhesive.
      6) Non-shrink grout with cure/seal compound.
      7) Waterstops.
4. Reinforcing steel:
   a. Show grade, sizes, number, configuration, spacing, location and all fabrication and placement details.
   b. In sufficient detail to permit installation of reinforcing without having to make reference to Contract Drawings.
   c. Obtain approval of Shop Drawings by Engineer before fabrication.
   d. Mill certificates.
5. Strength test results of in place concrete including slump, air content and concrete temperature.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Storage of Material:
   1. Cement and fly ash:
      a. Store in moistureproof, weathertight enclosures.
      b. Do not use if caked or lumpy.
   2. Aggregate:
      a. Store to prevent segregation and contamination with other sizes or foreign materials.
      b. Obtain samples for testing from aggregates at point of batching.
      c. Do not use frozen or partially frozen aggregates.
      d. Do not use bottom 6 IN of stockpiles in contact with ground.
      e. Allow sand to drain until moisture content is uniform prior to use.
   3. Admixtures:
      a. Protect from contamination, evaporation, freezing, or damage.
      b. Maintain within temperature range recommended by manufacturer.
      c. Completely mix solutions and suspensions prior to use.
   4. Reinforcing steel: Support and store all rebars above ground.

B. Delivery:
   1. Concrete:
      a. Prepare a delivery ticket for each load for ready-mixed concrete.

b. Truck operator shall hand ticket to Engineer at the time of delivery.
c. Ticket to show:
   1) Mix identification mark.
   2) Quantity delivered.
   3) Amount of each material in batch.
   4) Outdoor temp in the shade.
   5) Time at which cement was added.
   6) Numerical sequence of the delivery.
   7) Amount of water added.

2. Reinforcing steel:
   a. Ship to jobsite with attached plastic or metal tags with permanent mark numbers.
   b. Mark numbers to match Shop Drawing mark number.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Nonshrink, nonmetallic grout:
   a. Sika "SikaGrout 212."
   b. Euclid Chemial "NS Grout."
   c. Master Builders "Masterflow 713."
2. Epoxy grout:
   a. Master Builders "Brutem MPG."
   b. Euclid Chemical Company, "E3-G."
   c. Fosroc, "Conbextra EPHF".
3. Expansion joint fillers:
   a. Permaglaze Co.
   b. Rubatex Corp.
   c. Williams Products, Inc.
4. Waterstops, PVC:
   a. Greenstreak Plastic Products, Inc.
   b. W.R.Meadows, Inc.
   c. Burke Company.
5. Form coating:
   a. Richmond "Rich Cote."
   b. Industrial Lubricants "Nox-Crete Form Coating."
   c. Euclid Chemical "Eucoslip VOX."
6. Prefabricated forms:
   a. Simplex "Industrial Steel Frame Forms."
   b. Symons "Steel Ply."
   c. Universal "Uniform."
7. Chemical sealer:
   a. L & M Construction Chemicals, Inc.
   b. Euclid Chemical Company.

c. Dayton Superior.

8. Bonding agent:
   a. Euclid Chemical Co.
   b. Master Builders Inc.
   c. L & M Construction Chemicals Inc.

2.2 MATERIALS

A. Portland Cement: Conform to ASTM C150 Type I.

B. Fly Ash:
   1. ASTM C618, Class F or Class C.
   2. Nonstaining.
      a. Hardened concrete containing fly ash to be uniform light gray color.
   3. Maximum loss on ignition: 4 percent.
   4. Compatible with other concrete ingredients.
   5. Obtain proposed fly ash from a source approved by the State Highway Department in the state where the Project is located for use in concrete for bridges.

C. Admixtures:
   1. Air entraining admixtures: ASTM C260.
   2. Water reducing, retarding, and accelerating admixtures:
      a. ASTM C494 Type A through E.
      b. Conform to provisions of ACI 212.3R.
      c. Do not use retarding or accelerating admixtures unless specifically approved in writing by Engineer and at no cost to Owner.
      d. Follow manufacturer's instructions.
      e. Use chloride free admixtures only.
   3. Maximum total water soluble chloride ion content contributed from all ingredients of concrete including water, aggregates, cementitious materials and admixtures by weight percent of cement:
      a. 0.10 all concrete.
   4. Do not use calcium chloride.
   5. Pozzolanic admixtures: ASTM C618.
   6. Provide admixtures of same type, manufacturer and quantity as used in establishing required concrete proportions in the mix design.

D. Water: Potable, clean, free of oils, acids and organic matter.

E. Aggregates:
   1. Normal weight concrete: ASTM C33, except as modified below.
   2. Fine aggregate:
      a. Clean natural sand.
      b. No manufactured or artificial sand.
   3. Coarse aggregate:
      a. Crushed rock, natural gravel, or other inert granular material.
      b. Maximum amount of clay or shale particles: 1 percent.
   4. Gradation of coarse aggregate:
      a. Lean concrete and concrete topping: Size #7.

b. All other concrete: Size #57 or #67.

F. Concrete Grout:
1. Nonshrink nonmetallic grout:
a. Nonmetallic, noncorrosive, nonstaining, premixed with only water to be added.
b. Grout to produce a positive but controlled expansion.
c. Mass expansion not to be created by gas liberation.
d. Minimum compressive strength of nonshrink grout at 28 days: 6500 psi.
e. In accordance with CRD-C621.
2. Epoxy grout:
a. 3-component epoxy resin system.
1) Two liquid epoxy components.
2) One inert aggregate filler component.
b. Each component packaged separately for mixing at jobsite.

G. Reinforcing Steel:
1. Reinforcing bars: ASTM A615, Grade 60.
2. Welded wire fabric: ASTM A185.
a. Minimum yield strength: 60,000 psi.
3. Column spirals: ASTM A82.

H. Forms:
1. Prefabricated or job built.
2. Wood forms:
a. New 5/8 or 3/4 IN 5-ply structural plywood of concrete form grade.
b. Built-in-place or prefabricated type panel.
c. 4 x 8 FT sheets for built-in-place type except where smaller pieces will cover entire area.
d. When approved, plywood may be reused.
3. Metal forms:
a. Metal forms excluding aluminum may be used.
b. Forms to be tight to prevent leakage, free of rust and straight without dents to provide members of uniform thickness.
4. Chamfer strips: Clear white pine, surface against concrete planed.
5. Form ties:
a. Removable end, permanently embedded body type with cones on outer ends not requiring auxiliary spreaders.
b. Cone diameter: 3/4 IN minimum to 1 IN maximum.
c. Embedded portion 1-1/2 IN minimum back from concrete face.
d. If not provided with threaded ends, constructed for breaking off ends without damage to concrete.
e. Provide ties with built-in waterstops at all walls that will be in contact with process liquid during plant operation.
6. Form release: Nonstaining and shall not prevent bonding of future finishes to concrete surface.

I. Waterstops:
1. Plastic: Corp of Engineers Specification CRD-C572.

2. Serrated with center bulb.
3. Thickness: 3/8 IN.
4. Length (general use): 6 IN unless indicated otherwise.
5. Expansion joints:
   a. Length: 9 IN.
   b. Center bulb: 1 IN OD x 1/2 IN ID.
6. Provide hog rings or grommets spaced at maximum 12 IN OC along the length of the water stop.
7. Provide factory made waterstop fabrications at all changes of direction, intersections and transitions leaving only straight butt splices for the field.

J. Chairs, Runners, Bolsters, Spacers, and Hangers:
   1. Stainless steel, epoxy coated, or plastic coated metal.
      a. Plastic coated: Rebar support tips in contact with the forms only.

K. Chemical Floor Sealer:
   1. Colorless low VOC water-based solution containing acrylic copolymers.
      a. ASTM C1315, Class B, minimum 30 percent solids.
   2. Similar to L & M Construction Chemicals Inc. Dress & Seal WB 30.

L. Vapor Retarder:
   1. Vapor transmission not exceeding 0.1 perm.
   2. Tear strength 15 psi.
   3. Similar to: Alumiseal "Zero Perm".

M. Membrane Curing Compound:
   1. ASTM C309, Type I-D.
   2. Resin based, dissipates upon exposure to UV light.
   3. Curing compound shall not prevent bonding of any future coverings, coatings or finishes.
   4. Curing compounds used in water treatment plant construction to be nontoxic and taste and odor free.

N. Bonding Agent:
   1. High solids acrylic latex base liquid for interior or exterior application as a bonding agent to improve adhesion and mechanical properties of concrete patching mortars.
   2. Euclid Chemical Co. "Flex-Con."
   3. Master Builders Inc. "Acryl-Set."
   4. L & M Construction Chemicals "Everbond."
   5. Thoro System Products "Acryl 60."

O. Expansion Joint Filler:
   1. In contact with water or sewage:
      a. Closed cell neoprene.
      b. ASTM D1056, Class SC (oil resistant and medium swell) of 2 to 5 psi compression deflection (Grade SCE41).
   2. Exterior driveways, curbs and sidewalks:
      a. Asphalt expansion joint filler.
      b. ASTM D994.

3. Other use:
   a. Fiber expansion joint filler.
   b. ASTM D1751.

2.3 CONCRETE MIXES

A. General:
   1. All concrete to be ready mixed concrete conforming to ASTM C94.
   2. Provide concrete of specified quality capable of being placed without segregation and, when cured, of developing all properties required.
   3. All concrete to be normal weight concrete.

B. Strength:
   1. Provide specified strength and type of concrete for each use in structure(s) as follows:

TYPE	WEIGHT	SPECIFIED STRENGTH*
Concrete fill	Normal weight	3000 psi
Lean concrete	Normal weight	3000 psi
Concrete topping	Normal weight and lightweight	4000 psi
Precast concrete	Normal weight and lightweight	5000 psi
All other general use concrete	Normal weight	4000 psi

* Minimum 28-day compressive strength.

C. Air Entrainment:
   1. Provide air entrainment in all concrete resulting in a total air content percent by volume as follows:

MAX AGGREGATE SIZE	TOTAL AIR CONTENT PERCENT
1 IN or 3/4 IN	5 to 7
1/2 IN	5 1/2 to 8

   2. Air content to be measured in accordance with ASTM C231, ASTM C173, or ASTM C138.

D. Slump - 4 IN maximum, 1 IN minimum:
   1. Measured at point of discharge of the concrete into the concrete construction member.
   2. Concrete of lower than minimum slump may be used provided it can be properly placed and consolidated.
   3. Pumped concrete:
      a. Provide additional water at batch plant to allow for slump loss due to pumping.
      b. Provide only enough additional water so that slump of concrete at discharge end of pump hose does not exceed maximum slump specified above.
   4. Determine slump per ASTM C143.

E. Selection of Proportions:

1. General:
   a. Proportion ingredients to:
      1) Produce proper workability, durability, strength, and other required properties.
      2) Prevent segregation and collection of excessive free water on surface.
2. Minimum cement contents and maximum water cement ratios for concrete to be as follows:

SPECIFIED STRENGTH	MINIMUM CEMENT, LB/CY MAXIMUM AGGREGATE SIZE			MAXIMUM WATER CEMENT RATIO BY WEIGHT
	1/2 IN	3/4 IN	1 IN	
3000	---	517	517	0.45
4000	611	611	611	0.45
5000	---	686	665	0.40

3. Substitution of fly ash: Maximum of 25 percent by weight of cement at rate of 1 LB fly ash for 1 LB of cement.
4. Sand cement grout:
   a. Three parts sand.
   b. One part Portland cement.
   c. Entrained air: Six percent plus or minus one percent.
   d. Sufficient water for required workability.
   e. Minimum 28-day compressive strength: 3,000 psi.
5. Pan stair fill:
   a. Coarse aggregate: 100 percent passing a 1/2 IN sieve.
   b. Proportions:
      1) 1 sack cement.
      2) 150 LBS coarse aggregate.
      3) 150 LBS fine aggregate (sand).
   c. Adjust mix to obtain satisfactory finishing.
6. Normal weight concrete:
   a. Proportion mixture to provide desired characteristics using one of methods described below:
      1) Method 1 (Trial Mix): Per ACI 318, Chapter 5, except as modified herein.
         a) Air content within range specified above.
         b) Record and report temperature of trial mixes.
         c) Proportion trial mixes per ACI 211.1.
      2) Method 2 (Field Experience): Per ACI 318, Chapter 5, except as modified herein:
         a) Field test records must be acceptable to Engineer to use this method.
         b) Test records shall represent materials, proportions and conditions similar to those specified.

7. Required average strength to exceed the specified 28-day compressive strength by the amount determined or calculated in accordance with the requirements of Paragraph 5.3 of ACI 318 using the standard deviation of the proposed concrete production facility as described in Paragraph 5.3.1 of ACI 318.

F. Allowable Shrinkage: 0.048 percent per ASTM C157.

PART 3 EXECUTION

3.1 FORMING AND PLACING CONCRETE

A. Formwork:
1. Contractor is responsible for design and erection of formwork.
2. Construct formwork so that concrete members and structures are of correct size, shape, alignment, elevation and position.
   a. Allowable tolerances: As recommended in ACI 347R.
3. Provide slabs and beams of minimum indicated depth when sloping foundation base slabs or elevated floor slabs to drains.
   a. For slabs on grade, slope top of subgrade to provide floor slabs of minimum uniform indicated depth.
   b. Do not place floor drains through beams.
4. Openings: Provide openings in formwork to accommodate work of other trades.
   a. Accurately place and securely support items built into forms.
5. Chamfer strips: Place 3/4 IN chamfer strips in forms to produce 3/4 IN wide beveled edges on permanently exposed corners of members.
6. Clean and adjust forms prior to concrete placement.
7. Tighten forms to prevent mortar leakage.
8. Coat form surfaces with form release agents prior to placing reinforcing bars in forms.

B. Reinforcement:
1. Position, support and secure reinforcement against displacement.
2. Locate and support with chairs, runners, bolsters, spacers and hangers, as required.
3. Set wire ties so ends do not touch forms and are directed into concrete, not toward exposed concrete surfaces.
4. Lap splice lengths: ACI 318 Class B top bar tension splices unless indicated otherwise on the Drawings.
5. Extend reinforcement to within 2 IN of concrete perimeter edges.
   a. If perimeter edge is earth formed, extend reinforcement to within 3 IN of the edge.
6. Minimum concrete protective covering for reinforcement: As shown on Drawings.
7. Do not weld reinforcing bars.
8. Welded wire fabric:
   a. Install welded wire fabric in maximum practical sizes.

b. Splice sides and ends with a splice lap length measured between outermost cross wires of each fabric sheet not less than:
   1) One spacing of cross wires plus 2 IN.
   2) 1.5 x development length.
   3) 6 IN.
c. Development length: ACI 318 basic development length for the specified fabric yield strength.

C. Construction, Expansion, and Contraction Joints:
1. Provide at locations indicated.
2. Locate wall vertical construction joints at 30 FT maximum centers and wall horizontal construction joints at 10 FT maximum centers.
3. Locate construction joints in floor slabs and foundation base slabs so that concrete placements are approximately square and do not exceed 2500 SF.
4. Locate construction joints in columns and walls:
   a. At the underside of beams, girders, haunches, drop panels, column capitals, and at floor panels.
   b. Haunches, drop panels, and column capitals are considered part of the supported floor or roof and shall be placed monolithically therewith.
   c. Column based need not be placed monolithically with the floor below.
5. Locate construction joints in beams and girders:
   a. At the middle of the span, unless a beam intersects a girder at that point.
   b. If the middle of the span is at an intersection of a beam and girder, offset the joint in the girder a distance equal to twice the beam width.
   c. Provide satisfactory means for transferring shear and other forces through the construction joint.
6. Locate construction joints in suspended slabs:
   a. At or near the center of span in flat slab or T-beam construction.
   b. Do not locate a joint between a slab and a concrete beam or girder unless so indicated on Drawings.
7. In pan-formed joists:
   a. At or near span center when perpendicular to the joists.
   b. Centered in the slab, midway between joists, when parallel to the joists.
8. Install construction joints perpendicular to main reinforcement with all reinforcement continued across construction joints.
9. At least 48 HRS shall elapse between placing of adjoining concrete construction.
10. Thoroughly clean and remove all laitance and loose and foreign particles from construction joints.
11. Before new concrete is placed, coat all construction joints with an approved bonding adhesive used and applied in accordance with manufacturer's instructions.

D. Embedments:
1. Set and build in anchorage devices and other embedded items required for other work that is attached to, or supported by concrete.
2. Use setting diagrams, templates and instructions for locating and setting.

3. Secure waterstops in correct position using hog rings or grommets spaced along the length of the waterstop and wire tie to adjacent reinforcing steel.

E. Placing Concrete:
1. Place concrete in compliance with ACI 304R and ACI 304.2R.
2. Place in a continuous operation within planned joints or sections.
3. Begin placement when work of other trades affecting concrete is completed.
4. Place concrete by methods which prevent aggregate segregation.
5. Do not allow concrete to free fall more than 4 FT.
6. Where free fall of concrete will exceed 4 FT, place concrete by means of tremie pipe or chute.

F. Consolidation: Consolidate all concrete using mechanical vibrators supplemented with hand rodding and tamping, so that concrete is worked around reinforcement and embedded items into all parts of forms.

G. Protection:
1. Protect concrete from physical damage or reduced strength due to weather extremes.
2. In cold weather comply with ACI 306R except as modified herein.
   a. Do not place concrete on frozen ground or in contact with forms or reinforcing bars coated with frost, ice or snow.
   b. Minimum concrete temperature at the time of mixing:

OUTDOOR TEMPERATURE AT PLACEMENT (IN SHADE)	CONCRETE TEMPERATURE AT MIXING
Below 30 DegF	70 DegF
Between 30-45 DegF	60 DegF
Above 45 DegF	50 DegF

   c. Do not place heated concrete that is warmer than 80 DegF.
   d. If freezing temperatures are expected during curing, maintain the concrete temperature at or above 50 DegF for 7 days or 70 DegF for 3 days.
   e. Do not allow concrete to cool suddenly.
3. In hot weather comply with ACI 305R except as modified herein.
   a. At air temperature of 90 DegF and above, keep concrete as cool as possible during placement and curing.
   b. Do not allow concrete temperature to exceed 90 DegF at placement.
   c. Prevent plastic shrinkage cracking due to rapid evaporation of moisture.
   d. Do not place concrete when the actual or anticipated evaporation rate equals or exceeds 0.2 LBS/SF/HR as determined from ACI 305R, Figure 2.1.5.

H. Curing:
1. Begin curing concrete as soon as free water has disappeared from exposed surfaces.
2. Cure concrete by use of moisture retaining cover, burlap kept continuously wet or by membrane curing compound.

3. Provide protection as required to prevent damage to concrete and to prevent moisture loss from concrete during curing period.
4. Provide curing for minimum of 7 days.
5. Form materials left in place may be considered as curing materials for surfaces in contact with the form materials except in periods of hot weather.
6. In hot weather follow curing procedures outlined in ACI 305R.
7. In cold weather follow curing procedures outlined in ACI 306R.
8. If forms are removed before 7 days have elapsed, finish curing of formed surfaces by one of above methods for the remainder of the curing period.
9. Curing vertical surfaces with a curing compound:
   a. Cover vertical surfaces with a minimum of two coats of the curing compound.
   b. Allow the preceding coat to completely dry prior to applying the next coat.
   c. Apply the first coat of curing compound immediately after form removal.
   d. Vertical surface at the time of receiving the first coat shall be damp with no free water on the surface.
   e. A vertical surface is defined as any surface steeper than 1 vertical to 4 horizontal.

I. Form Removal:
1. Remove forms after concrete has hardened sufficiently to resist damage from removal operations or lack of support.
2. Where no reshoring is planned, leave forms and shoring used to support concrete until it has reached its specified 28-day compressive strength.
3. Where reshoring is planned, supporting formwork may be removed when concrete has sufficient strength to safely support its own weight and loads placed thereon.
   a. While reshoring is underway, no superimposed loads shall be permitted on the new construction.
   b. Place reshores as soon as practicable after stripping operations are complete but in no case later than the end of working day on which stripping occurs.
   c. Tighten reshores to carry their required loads.
   d. Leave reshores in place until concrete being supported has reached its specified 28-day compressive strength.

3.2 CONCRETE FINISHES

A. Tolerances:
1. Class A: 1/8 IN in 10 FT.
2. Class B: 1/4 IN in 10 FT.

B. Surfaces Exposed to View:
1. Provide a smooth finish for exposed concrete surfaces and surfaces that are:
   a. To be covered with a coating or covering material applied directly to concrete.
   b. Scheduled for grout cleaned finish.

2. Remove fins and projections, and patch voids, air pockets, and honeycomb areas with cement grout.
3. Fill tie holes with nonshrink nonmetallic grout.

C. Surfaces Not Exposed to View:
1. Patch voids, air pockets and honeycomb areas with cement grout.
2. Fill tie holes with nonshrink nonmetallic grout.

D. Grout Cleaned Finish:
1. Mix one part Portland cement and 1-1/2 parts fine sand with sufficient bonding agent/water mixture to produce a grout with the consistency of thick paint.
   a. White Portland cement shall be substituted for gray Portland cement to produce a color that matches color of surrounding concrete as determined by trial patch for areas not to be painted.
2. Wet surface of concrete to prevent absorption of water by grout and uniformly apply grout with brushes or spray gun.
3. Immediately scrub the surface with a cork float or stone to coat and fill air bubbles and holes.
4. While grout is still plastic, remove all excess grout by working surface with rubber float, sack or other approved means.
5. After the surface whitens from drying, rub vigorously with clean burlap.
6. Keep final finish damp for a minimum of 36 HRS after final rubbing.

E. Slab Float Finish:
1. After concrete has been placed, consolidated, struck off, and leveled, do no further work until ready for floating.
2. Begin floating when water sheen has disappeared and surface has stiffened sufficiently to permit operation.
3. During or after first floating, check planeness of entire surface with a 10 FT straightedge applied at not less than two different angles.
4. Cut down all high spots and fill all low spots during this procedure to produce a surface within Class B tolerance throughout.
5. Refloat slab immediately to a uniform sandy texture.

F. Troweled Finish:
1. Float finish surface.
2. Next power trowel, and finally hand trowel.
3. Produce a smooth surface which is relatively free of defects with first hand troweling.
4. Perform additional trowelings by hand after surface has hardened sufficiently.
5. Final trowel when a ringing sound is produced as trowel is moved over surface.
6. Thoroughly consolidate surface by hand troweling.
7. Leave finished surface essentially free of trowel marks, uniform in texture and appearance and plane to a Class A tolerance.
8. On surfaces intended to support floor coverings remove any defects of sufficient magnitude that would show through floor covering by grinding.

G. Broom Finish: Immediately after concrete has received a float finish as specified, give it a transverse scored texture by drawing a broom across surface.

H. Apply chemical floor hardener to permanently exposed interior concrete floor slab surfaces where indicated.
   1. Apply in accordance with manufacturer's instructions.

3.3 GROUT

A. Preparation:
   1. Nonshrinking nonmetallic grout:
      a. Clean concrete surface to receive grout.
      b. Saturate concrete with water for 24 HRS prior to grouting.
   2. Rock anchors:
      a. Clean rock anchors of all loose material.
      b. Orient hook or bends in anchor bars to clear anchor bolts, reinforcements, and other embedments to be installed later.
   3. Epoxy grout: Apply only to clean, dry, roughened (where appropriate), sound surface.

B. Application:
   1. Nonshrinking nonmetallic grout:
      a. Mix in a mechanical mixer.
      b. Use no more water than necessary to produce flowable grout.
      c. Place in accordance with manufacturer's instructions.
      d. Completely fill all spaces and cavities below the bottom of baseplates.
      e. Provide forms where baseplates and bedplates do not confine grout.
      f. Where exposed to view, finish grout edges smooth.
      g. Except where a slope is indicated on Drawings, finish edges flush at the baseplate, bedplate, member, or piece of equipment.
      h. Protect against rapid moisture loss by covering with wet rags or polyethylene sheets.
      i. Wet cure grout for 7 days, minimum.
   2. Rock anchors:
      a. See Item 1 above.
      b. If rodded:
         1) Fill each hole so that it overflows when anchor bar is inserted.
         2) Force anchor bars into place.
      c. If pressure placed, set anchor bar before grouting.
      d. Take special care to avoid any movement of anchors that have been placed.
   3. Epoxy grout:
      a. Mix and place in accordance with manufacturer's instructions.
      b. Completely fill all cavities and spaces around dowels and anchors without voids.
      c. Obtain manufacturer's field technical assistance as required to ensure proper placement.

3.4 FIELD QUALITY CONTROL

A. Owner will employ and pay for services of a concrete testing laboratory to perform testing of concrete placed during construction.
   1. Contractor to cooperate with Owner in obtaining and testing samples.

B. Tests During Construction:
   1. Strength test - procedure:
      a. Three cylinders, 6 IN DIA x 12 IN high, will be taken from each sample per ASTM C172 and ASTM C31.
      b. Cylinders will be tested per ASTM C39:
         1) One at 7 days.
         2) Two at 28 days.
   2. Strength test - frequency:
      a. Not less than one test each day concrete placed.
      b. Not less than one test for each 50 CY or major fraction thereof placed in one day.
      c. Not less than one test for each type of concrete poured.
      d. Not less than one test for each concrete structure exceeding 2 CY volume.
   3. Slump test:
      a. Per ASTM C143.
      b. Determined for each strength test sample.
      c. Additional slump tests may be taken.
   4. Air content:
      a. Per ASTM C231, ASTM C173, and ASTM C138.
      b. Determined for each strength test sample.
   5. Temperature: Determined for each strength test sample.

C. Evaluation of Tests:
   1. Strength test results:
      a. Average of 28-day strength of two cylinders from each sample.
         1) If one cylinder manifests evidence of improper sampling, molding, handling, curing or testings, strength of remaining cylinder will be test result.
         2) If both cylinders show any of above defects, test will be discarded.

D. Acceptance of Concrete:
   1. Strength level of each type of concrete shall be considered satisfactory if both of the following requirements are met:
      a. Average of all sets of three consecutive strength tests equals or exceeds the required specified 28-day compressive strength.
      b. No individual strength test falls below the required specified 28-day compressive strength by more than 500 psi.
   2. If tests fail to indicate satisfactory strength level, perform additional tests and/or corrective measures as directed by Engineer.
      a. Perform additional tests and/or corrective measures at no additional cost to Owner.

3.5 SCHEDULES

A. Form Types:
   1. Surfaces exposed to view:
      a. Prefabricated or job-built wood forms.
      b. Laid out in a regular and uniform pattern with long dimensions vertical and joints aligned.
      c. Produce finished surfaces free from offsets, ridges, waves, and concave or convex areas.
      d. Construct forms sufficiently tight to prevent leakage of mortar.
   2. Surfaces normally submerged or not normally exposed to view: Wood or steel forms sufficiently tight to prevent leakage of mortar.
   3. Other types of forms may be used:
      a. For surfaces not restricted to plywood or lined forms.
      b. As backing for form lining.

B. Grout:
   1. Nonshrinking nonmetallic grout: General use.
   2. Epoxy grout:
      a. Grouting of dowels and anchor bolts into existing concrete.
      b. Other uses indicated on Drawings.
   3. Sand cement grout: Keyways of precast members.

C. Concrete:
   1. Precast concrete: Where indicated on Drawings.
   2. Lean concrete: Where indicated on Drawings.
   3. Concrete fill: Where indicated on Drawings.
   4. Lightweight concrete: Where indicated on Drawings.
   5. Normal weight concrete: All concrete.
   6. Concrete pan fill: Stair and landings where indicated on Drawings.
   7. General use concrete: All other locations.

D. Concrete Finishes:
   1. Grout cleaned finish: Where indicated on Drawings.
   2. Slab finishes:
      a. Use following finishes as applicable, unless otherwise indicated:
         1) Floated finish: Surfaces intended to receive roofing, concrete topping, lean concrete, concrete fill and waterproofing.
         2) Troweled finish: Interior floor slabs, exposed roof slabs and base slabs of structures, equipment bases, and column bases.
         3) Broom finish: Sidewalks, docks, concrete stairs, and ramps.

END OF SECTION