PART 1 GENERAL

1.1 DESCRIPTION
A. Provide cast-in-place concrete as indicated on the Drawings and as specified and required. Work includes but is not limited to the following:
   1. Furnishing all materials, labor, equipment, and supplies.
   2. Mixing, placing, testing, finishing, and curing cast in place concrete.

1.2 QUALITY ASSURANCE
A. Conform to applicable requirements of the International Building Code currently in force unless more stringent requirements are specified or shown on the Drawings.
B. Perform work in accordance with ACI 301, ACI 304, ACI 305R, ACI 306R, ACI 318, ACI 347, and ACI 350. Maintain the latest copy of these and other appropriate documents referred to therein on the project site at all times.
   1. Do not exceed 1.5-hrs. between batching and complete discharge of concrete.
   2. Use mechanical high-frequency internal vibrators to compact concrete during and immediately after depositing.
      a. Provide sufficient standby equipment to ensure vibration will be continuous.
      b. Only use approved external vibrators for compacting concrete when concrete is inaccessible for adequate compaction by other means.
      c. Vibrate concrete to ensure no movement of reinforcing steel from its final position.
   3. Acquire cement and aggregate from same source for all work.
   4. Do not use excess grout or mortar to lubricate pipelines when pumping concrete. Also, do not discharge washout water into the forms.
C. Unless otherwise indicated, use an independent testing agency hired by the Contractor and approved by the Engineer to perform all testing. Sampling shall be the Contractor’s responsibility.
D. Engineer may require additional sampling and testing by an independent testing laboratory to determine that specifications are being met. Such testing shall be the Owner’s responsibility.
E. Field sampling and testing
   1. Sampling and Test Methods
      a. Aggregate
         1) Sampling: ASTM D75
         2) Testing: ASTM C33
      b. Cement
1) Sampling: ASTM C183
2) Testing: ASTM C150

c. Concrete
1) Sampling: ASTM C172
2) Slump Test: ASTM C143
3) Air Content Test: ASTM C231
4) Making and Curing Test Cylinders: ASTM C31

2. Testing Requirements
   a. Inspect, sample, and test cement and aggregate at the batching plant. Comply with referenced standards.
   b. Slump Test: Perform one test on each concrete sample tested for compressive strength.
   c. Air Content: Perform one test on each concrete sample tested for compressive strength.
   d. Compressive Strength Testing
      1) Prepare at least 8 test cylinders for each concrete sample tested.
         a) Break 2 test cylinders at an age of 7 days.
         b) Break 2 test cylinders at an age of 14 days.
         c) Break 2 test cylinders at an age of 28 days.
         d) Hold the remaining cylinders in reserve.
      2) Provide at least the following number of test cylinders:

<table>
<thead>
<tr>
<th>Concrete Class</th>
<th>Size of Pour (cu. yd.)</th>
<th>No. of Samples</th>
<th>No. of Cylinders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A</td>
<td>1 – 4</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Class A or B</td>
<td>4 - 100</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Class A or B</td>
<td>101 - 200</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>Class A or B</td>
<td>201 - 300</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>Class A or B</td>
<td>Over 300</td>
<td>1 per 100 cu. yd. or fraction</td>
<td>8 per 100 cu. yd. or fraction</td>
</tr>
</tbody>
</table>

1.3 SUBMITTALS
   A. Provide submittals in accordance with Section 01300.
B. Contractor may request the Engineer’s review and approval of modifications to the cast-in-place concrete mix designs to improve performance, efficiency, quality control and quality assurance.

1. Such requests shall be developed by an independent engineering and testing firm specializing in the design, testing and placement of cast-in-place concrete.

2. The engineering and testing firm shall have a minimum of five (5) years of experience in the development and testing of various concrete mix designs to meet requirements for strength, appearance, durability, workability, watertightness, economy, etc.

3. The firm shall also maintain accreditations, certifications and laboratory approvals from at least one of the following:
   a. ACI,
   b. US Army Corps of Engineers,
   c. ASTM,
   d. CSI,
   e. ASCE.

C. Submit Contractor’s Drawings and Shop Drawings in accordance with GP-5.04 and SP-07:

1. Show reinforcing steel in accordance with ACI 315. Include bar lists and bending diagrams, placement drawings, and special details.

2. Show location, types, and details of joints.

3. Sequence of pours.

4. Working Drawings with calculations showing concrete strength to be attained at the proposed time of removal of formwork, falsework and centering.

5. Provide complete engineering and product data for the following:
   a. Admixtures,
   b. Curing compounds,
   c. Dyes,
   d. Bonding agents,
   e. Hardeners,
   f. Sealers,
   g. Waterstops.

D. Submit certified concrete mix designs for all concrete strengths used.

1. Include proposed admixtures.

2. Provide certified laboratory or mill test reports on all aggregate and cement used in the proposed mix.
3. Provide certified laboratory test reports on the compressive strength of concrete resulting from each mix design.

4. For record purposes include the following information for each class of concrete:
   a. Minimum dry weights of cement; fine and course aggregates;
   b. Quantity, type and name of admixture; and
   c. Volume of water per cubic yard of concrete that will be used in the mix.

E. Submit certified delivery tickets for all concrete provided. Show at least the following information.
   1. Name and location of batch plant and name of plant inspector.
   2. Ticket number.
   3. Load number and batch number.
   4. Date
   5. Truck number.
   6. Destination including name and location of project.
   7. Concrete type, class (strength), and design mix designation.
   8. Actual quantities of all materials including admixtures and amount of concrete in cubic yards.
   9. Time at which mixer drum was charged with cement.
   10. Amount of free moisture by percentage of permissible mixing water in aggregates, plus maximum amount of mixing water which can be added at job site to obtain specified water/cement ratio.
   11. Blank space for initials of on-site receiving party.
   12. Time of arrival of concrete truck on site.
   13. Amount of mix water added on-site.

F. Submit a sample delivery ticket with the concrete mix design. A mix design shall not be approved without the inclusion of a sample delivery ticket from the concrete vendor that includes all the information required by this specification.

G. Submit notarized certificates from Suppliers that each of the materials listed below comply with the Specifications and are of the gradation required for each class of concrete. Submit prior to incorporating materials into the Work. If testing is required, submit mill certificates for each test. Conform to specified ASTM Standards.
   2. Stone Aggregate for Concrete shall comply with the following:
b. Organic Impurities. ASTM C40. Fine Aggregate Only

c. Soundness.
   1) ASTM C88.
   2) Do not exceed 8 percent loss for coarse aggregate and 10 percent loss for fine aggregate after 5 cycles.

d. Abrasion of Concrete Aggregate.
   1) ASTM C131.
   2) Do not exceed 10-1/2 percent loss after 100 revolutions and 42 percent loss after 500 revolutions.

e. Deleterious Materials. ASTM C33.

f. Material Finer Than 200 (75um) Sieve.
   1) ASTM C117.
   2) Do not exceed 1 percent for gravel, 1.5 percent for crushed aggregate per ASTM C33.

3. If notarized certificates acceptable to the Engineer are not provided, perform the required tests at Contractor's expense using an Independent Testing Laboratory.

   a. Perform tests for each 250 barrels of cement, in accordance with ASTM C150.
      1) Determine the tensile strength at 7 days.
      2) Tag the Cement for identification at location of sampling.

   b. Test aggregate before the concrete mix is established and whenever character or source of material is changed.
      1) Include a sieve analysis to determine conformance with limits of gradation.
      2) Sample aggregates at source of supply or at the ready-mix concrete plant in accordance with ASTM D75.

G. Submit certified test reports for all admixtures submitted for use on the project.

H. Submit a detailed step-by-step QC plan for review and approval by the Engineer for the following items.

   1. All field sampling and testing procedures related to this specification section.
   2. All finishing procedures related to exposed concrete.
   3. All proposed curing procedures.

I. Submit notarized test results for all aggregate to be used in the submitted mix design identifying the aggregates alkali silica reactivity potential. Test shall be conducted in accordance with the following:

   1. ASTM C295.
   2. ASTM C1260.
3. Where aggregate is determined to have reactive constituents through a petrographic examination and/or mortar bar tests show expansion in excess of 0.10% the mix design shall include a means of alkali silica reactivity mitigation.

4. Additional testing shall be done in accordance with ASTM C1567. Any proposed mitigation technique shall successfully limit expansion due to alkali silica reaction to less than 0.1% in accordance with ASTM C1567 for the mix design to be approved.

5. Perform testing in accordance with ASTM C1293 where pozzolans are used that contain more than 4% sodium oxide.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Ship cement to the site of the mixer plant in bulk or in paper or cloth bags, at the option of the Contractor.

1. Store immediately upon arrival in a dry, weather tight and properly ventilated building or enclosure

2. Include adequate provisions to prevent the absorption of moisture.

3. Store in a manner that will permit easy access for inspection and identification of each shipment.

4. Provide separate storage facilities for cement that are approved by the Engineer prior to arrival of the first shipment. Do not use cement that is caked or lumpy.

C. Store sand and coarse aggregates in separate stockpiles at points selected to provide maximum drainage and to prevent the inclusion of any foreign material during rehandling.

1. Construct stockpiles of coarse aggregates in horizontal layers to avoid segregation and breakage.

2. Where concrete volumes require batching of various aggregate sizes, provide a separate stockpile for each size maintained.

3. Do not use the bottom 6 inches of aggregate piles.

D. Deliver primers, bond breaking grout, mastic, epoxy, hardener, curing compound and other materials to ensure uninterrupted progress of Work.

E. Store materials in a manner that will preclude damage and permit ready access for inspection and identification.

PART 2 PRODUCTS

2.1 GENERAL

A. Concrete Classification

1. Use Class A for all reinforced concrete unless noted otherwise within the scope of ACI 318 or ACI 350.

2. Use Class B concrete for items such as pipe cradles, pipe and conduit encasement, bedding, collars, thrust blocks and non-reinforced concrete.

3. If Class is not otherwise identified, provide Class A concrete.
B. Design all Class A cast in place concrete in accordance with applicable requirements of ACI 318 and ACI 350.

C. Strength

1. Proportion mix designs according to the section on Trial Batches of ACI 318, latest edition.
   a. Produce a watertight, durable concrete.
   b. Develop the following minimum compressive strengths at an age of 28 days when sampled, cured, and tested in accordance with the procedures specified in ASTM C31 and C39:

<table>
<thead>
<tr>
<th>Class of Concrete</th>
<th>Age</th>
<th>Average of Three Consecutive Specimens</th>
<th>Minimum any One Specimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>28 days</td>
<td>4,500 psi</td>
<td>4,000 psi</td>
</tr>
<tr>
<td>B</td>
<td>28 days</td>
<td>3,000 psi</td>
<td>2,500 psi</td>
</tr>
</tbody>
</table>

2. If the average compressive strength of three consecutive specimens falls below the minimum strength specified above, or if the compressive strength of any single specimen falls more than 500 psi below the minimum strengths specified above; the Engineer may require the following:
   a. Change in mix design for the remaining portion of the work.
   b. Additional curing of the affected concrete followed by cores taken in accordance with the latest editions of ASTM C42 and ACI 318, all at the expense of the Contractor.
   c. If additional curing does not bring three average compressive strength of three cores taken in the affected area to at least the minimum strength specified, the Engineer may require that the Contractor strengthen the structure by means of additional concrete and steel or he may require that the Contractor replace the affected portions.
   d. The cost of all such changes in mix designs and any modifications to or replacement of deficient concrete shall be borne by the Contractor at no additional cost to the Owner.

D. Consistency

1. Make consistency such that concrete can be worked readily into the corners and angles of the forms and around the reinforcement without excessive spading and without permitting the materials to segregate or free water to collect on the surface.
   a. When dropped from the discharge chute, the concrete mass should flatten out at the center and spread out slowly at the edges.

2. Adjust proportions to secure the lowest water/cement ratio which is consistent with good workability and a plastic cohesive mixture.
3. Provide concrete which is within the following slump range as determined in accordance with ASTM C143.

<table>
<thead>
<tr>
<th>Concrete Use</th>
<th>Slump in Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walls</td>
<td>2½ - 4</td>
</tr>
<tr>
<td>Floors and Slabs</td>
<td>2 – 4</td>
</tr>
<tr>
<td>Beams</td>
<td>2 – 4</td>
</tr>
<tr>
<td>Blocks and Footings</td>
<td>2 – 4</td>
</tr>
</tbody>
</table>

Do not use concrete with a slump greater than 1-inch over the specified maximum.

4. Pumped concrete:
   a. Increase the maximum concrete slump at the suction of the pump by the amount of slump loss in the pumping system up to a maximum of 1 inch above the maximum specified slump.
   b. The amount of slump loss is the difference between slump tests made at both ends of pumping system.
      1) Limit to a total loss of 1 inch.
      2) If tests indicate a loss greater than 1 inch, take corrective measures acceptable to the Engineer.

5. For thin sections and construction with limited clearance between reinforcing steel and when placement conditions preclude the use of vibrators, the Engineer may authorize the use of concrete having a slump of 5 inches.

E. Materials used in concrete shall be limited to those noted in this section of the specification. Alternate material shall be submitted for approval by the Engineer prior to submission of the concrete mix design.

2.2 PORTLAND CEMENT
   A. Use standard brand of Domestic Portland cement. Do not change brand of cement during the Work without the written approval of the Engineer.
   B. Comply with ASTM C150, Type II.
   C. Do not use cement of dark color or resacked, lumpy or partially set cement.
   D. Each sack of cement shall contain 94 pounds (net) of cement and the volume of that quantity of cement shall be 1.0 cubic foot.

2.3 AGGREGATE
   A. Furnish natural aggregates from approved pits, free from opaline, chert, feldspar, mica, siliceous magnesium limestone, and other deleterious and reactive substances.
   B. Comply with ASTM C33.
   C. Fine aggregate
1. Fineness Modulus – 2.4 minimum and 3.0 maximum
2. Material passing No. 200 sieve – less than 3% (by weight) of the total sample.
3. Coal and lignite – less than 0.5% (by weight) of the total sample for all concrete.

D. Coarse aggregate
   1. Conform to ASTM C33, Class Designation 3S
   2. Maximum size of aggregate
      a. No larger than one-fifth the narrowest dimension between sides of forms.
      b. Less than three-quarters of the minimum clear spacing between reinforcing bars or between bars and forms.
      c. Limit size to ¾-inch for pumped concrete.

2.4 WATER FOR MIXING AND CURING CONCRETE
   A. Use clean, fresh, potable quality water that is free from injurious substances.
   B. If water is of questionable quality, meet limits of comparison tests with distilled water in accordance with AASHTO T26.
   C. The weight of water shall be considered to be 8.33 pounds per gallon.

2.5 ADMIXTURES
   A. Provide an air entraining admixture conforming to ASTM C260 in all concrete.
      1. Manufacturers
         a. W. R. Grace “Darex AEA”
         b. Master Builders “MB-VR”
         c. Sika “AEA 15”
         d. Boral “Boral Air 30”
         e. Or equal
   B. Plasticizer or Water Reducing Admixture
      1. Chloride free
      2. Conform to ASTM C494, Type A
      3. Manufacturers
         a. W. R. Grace “WRDA 35”
         b. Master Builders “Pozzolith Normal”
         c. Sika “Plastocrete”
         d. Boral “Boral NR”
         e. Or equal
C. Accelerators and Retarders

1. May be used only when authorized in writing by Engineer

2. Accelerators
   a. Calcium chloride conforming to ASTM D98
   b. Dispense as a solution
   c. Calcium chloride shall not exceed one percent (by weight) of cement content.
   d. Manufacturers
      1) W. R. Grace “Daraset”
      2) Master Builders “Pozzutec 20”
      3) Sika “Plastocrete 161 FL”
      4) Boral “Boral can”
      5) Or equal

3. Retarders
   a. Chloride free
   b. Conform to ASTM C494, Type D
   c. Manufacturers
      1) W. R. Grace “Daratard-HC”
      2) Master Builders “MBL-8”
      3) Sika “Plastiment”
      4) Boral “Boral HC”
      5) Or equal

D. High Range Water Reducers and Super Plasticizers

1. May be used only when authorized in writing by Engineer

2. Conform to ASTM C494, Type F or G

3. Manufacturers
   a. W. R. Grace “Darucem 19”
   b. Master Builders “Pozzolith 440N”
   c. Sika “Sikament 300”
   d. Boral “Boral SP”
   e. Or equal

E. Fly Ash

1. Conform to ASTM C618
2. May be no more than 20 percent of the cement plus pozzolan by weight.
   a. Consider a maximum of 50 percent of the fly ash as a cement replacement.
   b. Add a maximum of 50 percent of the fly ash weight to the cement weight to calculate
      the water to cement plus pozzolan ratio.
   c. The water to cement plus pozzolan ratio shall be equal to the specified water to
      cement ratio.
3. May contain a maximum of 10 percent calcium and a maximum of 50 percent carbon
   by volume.
4. Manufacturer
   b. Or equal.

2.6 WATERSTOPS
A. General
   1. Conform to the details shown on the Drawings.
   2. Do not use split flange waterstops.
   3. Provide manufactured accessories at waterstop intersections.
B. PVC waterstops
   1. Conform to Corps of Engineers specification CRD-C-572.
   2. Use serated type
   3. Use ribbed waterstop 6-inches wide, 3/8-inches thick, with a 1-inch outside diameter
      center bulb for expansion joints, unless otherwise shown on drawings.
   4. Use ribbed waterstop 6-inches wide, 3/8-inches thick, with no center bulb for
      construction and contraction joints, unless otherwise shown on drawings.
   5. Submit a manufacturer’s certificate or test report by an independent testing laboratory
      as evidence that waterstop complies with these specifications.
   6. Manufacturer
      a. Greenstreak PVC Style No. 717
      b. Greenstreak PVC Style No. 679
      c. Or equal.
   7. All PVC waterstop shall be held in place prior to pouring concrete by an acceptable
      means. PVC waterstop shall not be manually placed into wet concrete for any reason.
C. Injected Vinylester-Based Resin Waterstop
   1. Injection Hose: Multiple use injection hose composed of polyvinyl chloride (PVC)
      compound with solid core to absorb concrete pressure and lateral openings along each
      side, at staggered intervals, to ensure a uniform discharge of the injection material.
a. Outside diameter: 3/4 inch.

b. Longitudinal internal injection hole diameter: 1/4 inch.

c. Discharge internal injection hole diameter: 1/8 inch.

d. Injection hose to be field measured, cut and fabricated complete with reinforced PVC vent ends, color coded connecting nozzles, heat shrink-on sleeves and closure plugs, in strict accordance with the dimensions shown on the plans and as recommended by the manufacturer.

e. Acceptable Manufacturers:
   1) Fuko Injection Hose, BBZ USA, Inc.
   2) Or equal.

2. Injection Material: Solvent free, low viscosity, two-part, water-swelling, acrylate-ester based injection resin.
   a. Non-foaming and acrylamide free.
   b. Increases volume 100% to 200% when in contact with water.
   c. Swelling behavior reversible and not subject to aging.
   d. Passive toward steel and harmless to bitumen, membranes and concrete.
   e. Bonds well to moist surfaces.
   f. Resistant to weak acids, salt solutions, oil, fats, hydrocarbons, alcohol, and alkali.
   g. Acceptable Manufacturers:
      1) Duroseal Inject, BBZ USA, Inc.
      2) Or equal.

3. Junction Box:
   a. Non-corroding.
   b. Complete with cover.

4. Use only where shown on the drawings or as approved by the Engineer.

D. Non-movement construction joints with Hydrophilic Waterstop
   Use Adeka MC2010 Hydrophilic Waterstop installed per the manufacturer’s requirements, or equal, where noted on the Drawings.

E. Compression Seals
   1. Use for expansion or contraction joints in concrete slabs where noted on the Drawings.
   2. Use G-Seal by Greenstreak, Style No. 628, or equal.

F. Field splices
   1. Comply with manufacturers recommendations
2. Heat sealed splices:
   a. Develop water tightness equal to that of unspliced material.
   b. Have tensile strength of not less than 50 percent of unspliced material.

2.7 POLYETHYLENE FILM
A. Conform to Product Standard PS 17.
B. Provide minimum material thickness of 6 mils.

2.8 EPOXY BONDING AGENT
A. Epoxy adhesives shall be two-component, 100% solids, 100% reactive.
   1. Suitable for use on dry or damp surfaces.
   2. Provide a one-day compressive strength of not less than 5,000 psi and a 28-day strength of not less than 12,000 psi when cured at a temperature of 73°F. Conduct strength testing in accordance with ASTM D695.
   3. Provide a 28-day tensile strength of not less than 3,500 psi, when tested in accordance with ASTM D638.
B. Manufacturers
   1. Euco Epoxy #452, and #620 by The Euclid Chemical Company
   2. Sikadur 32 Hi-Mod by Sika Chemical Corporation.
   3. Or equal.

2.9 EPOXY FLOOR SEALER
A. Use a two-component, 100 percent solid, epoxy coating that provides a smooth, tough, flexible, wear abrasion, and chemical resistant surface.
   1. Sealer shall be U.S.D.A. approved for use in food processing plants.
   2. Apply to all new floor slabs and other exposed horizontal concrete surfaces unless otherwise indicated on the Drawings.
   3. Color sealer gray unless otherwise specified.
B. Manufacturer
   1. Euclid “Euco Epoxy No. 452 LV”
   2. Sonneborn-Contech “Sonoflex”
   3. Sika “Sikadur Lo-Mod LV”
   4. Or equal.

2.10 VAPOR BARRIER
A. Provide under all slabs poured on earth, unless otherwise noted.
   1. FHA approved.
   a. Form a moisture, scuff, and puncture resistant membrane.
   b. Provide moisture permeance less than or equal to 0.10 perms per ASTM E96, procedure A.

B. Manufacturer
   1. St. Regis Paper Company “Moistop Ultra 6-Vapor Barrier”
   2. Or equal.

2.11 CURING MATERIALS
   A. Use only non-staining, clear or translucent curing compounds with a 100 percent resin base meeting requirements of ASTM C309, Type I, Class B.
      1. Add fugitive dye in sufficient amount to produce a definite, distinguishing color.
      2. Select to be compatible with liquid hardeners and epoxy sealers.
      3. Manufacturers
         a. W.R. Meadows Inc.” 1100 Clear Series”
         b. Or equal.
   B. Sheet materials for curing: Comply with ASTM C171.
   C. Burlap cloth made from jute or kenaf for curing shall meet requirements of AASHTO M182, Class 1.

2.12 EXPANSION JOINT FILLER
   A. Filler not exposed to traffic or weather: Comply with ASTM D994.
   B. Filler exposed to traffic and/or weather: Comply with ASTM D1751 or ASTM D1752.

2.13 TEMPORARY JOINT FILLER
   A. Use straight, sound strips of wood of the width and depth indicated on the drawings or as approved.
   B. Taper the strips slightly from face-to-back.
   C. Coat with paraffin or the equivalent to seal against moisture and to promote ready removal with forms.
   D. Design to produce true, straight joint edges.

2.14 JOINT SEALER
   A. Hot applied: Comply with ASTM D1190.
   B. Cold applied: Comply with ASTM D1850.

2.15 FIBER REINFORCEMENT
   A. Monofilament polypropylene micro-fiber.
B. Modulus of Elasticity 800 ksi or greater.
C. Alkali Resistant.
D. Dose and mix per manufacturer’s recommendations.
E. Sika Fiber HP or equal.

PART 3 EXECUTION

3.1 DESIGN MIXES

A. Engineer shall approve mix design prior to beginning any concreting operations.
   1. Prepare mix design in accordance with ACI 318 and ACI 350 for each class of concrete used.
   2. If mix design is based on trial batches, provide sufficient data to establish a standard deviation. If insufficient data is provided to establish a standard deviation, the mix must produce the following average 28 day compressive strength to be acceptable:
      a. Class A: 1,200 psi greater than specified strength.
      b. Class B: 1,000 psi greater than specified strength.
   3. Include the following information with the mix design:
      a. Fine aggregate (Sample per ASTM D75)
         1) Source and type
         2) Sieve analysis – ASTM C136
         3) Magnesium sulfate soundness – ASTM C88
         5) Saturated surface dry weight per cubic yard of concrete.
         6) Bulk specific gravity – ASTM C128
         7) Fineness modulus – ASTM C136
      b. Coarse aggregate (Sample per ASTM D75)
         1) Source and type
         2) Sieve analysis – ASTM C136
         3) Abrasion loss – ASTM C131
         4) Magnesium sulfate soundness – ASTM C88
         6) Saturated surface dry weight per cubic yard of concrete.
         7) Bulk specific gravity – ASTM C127
      c. Cement (Sample per ASTM C183)
1) Manufacturer, type and ASTM designation.
2) Pounds per cubic yard of concrete.
3) Total gallons of water per sack (cu. ft.) of cement
4) Compressive strength at 7 and 28 days – ASTM C109
5) Chemical analysis – ASTM C114
d. Slump – ASTM C143
e. Air Content – ASTM C173 or C231
f. Unit Weight – ASTM C138
g. Time to initial set at 70 degrees F – ASTM C403
h. Compressive Strength at 7, 14, and 28 days – ASTM C192 and C39.
   1) Prepare 9 cylinders for each mix design
   2) Cure in the laboratory
   3) Test 3 cylinders at each of 7, 14, and 28 days.
i. Testing laboratory verification of the water cement ratio. Required before mix is approved.
j. Admixtures
   1) Manufacturer, type, and ASTM designation.
   2) Certification of chloride content.
   3) Dosage and point of introduction into the mix.
k. Pozzolans
   1) Manufacturer, type, and ASTM designation
B. Unless otherwise indicated, use the following specified 28 day compressive strengths of concrete:
   1. 4,500 psi (Class A) for all reinforced structural concrete.
   2. 3,000 psi (Class B) for non-reinforced concrete.
   3. 2,000 psi for mud mats, pipe encasement, filling voids between pipes and casing, limited site voids, soil boring voids, and for under foundations where excavated to excessive depth.
   4. Lean mix concrete for filling abandoned manholes, pipes, and similar items.
      a. Minimum 94 pounds of cement per cubic yard of concrete.
      b. Aggregate no larger than 1 1/2-inch.
C. Mix Proportioning
   1. Design Class A concrete for structures to conform to ACI 301 and the following
a. Provide air entrainment as follows:
   1) 5±1 percent - Coarse Aggregate No. 467
   2) 6±1 percent - Coarse Aggregate No. 57 or 67

2. Proportion all other concrete mixes in accordance with ACI 301 except as noted herein.

D. Admixtures
   1. Except as specified otherwise, water reducing and retarding admixtures may be used with prior approval of the Engineer.
   2. The Contractor shall be responsible for compatibility of all admixtures.

3.2 PROPORTIONING

A. Accurately proportion concrete materials and mix to produce a homogeneous and workable mixture having the consistency and minimum compressive strength specified herein.

B. Proportion concrete materials by weight. Use equipment and methods that are acceptable to the Engineer when measuring ingredients.

C. Use the minimum amount of water and cement necessary to produce a concrete mixture of the required strength and consistency.
   1. Do not exceed the water-cement ratio specified herein.
   2. The cement content shall not be less than that specified herein.

D. Compressive strength may not necessarily be the most critical factor in proportioning concrete mixes.
   1. Other factors, such as durability and watertightness, may require lower water-cement ratios than are required to meet strength requirements.
   2. In such cases compressive strength will, of necessity, be in excess of that specified.

E. Use the minimum cement content and maximum water-cement ratios as shown below:

<table>
<thead>
<tr>
<th>Maximum Aggregate Size</th>
<th>Minimum Cement Factor, Sacks/cy</th>
<th>Maximum Water-to-Cement Ratio, lb./lb.</th>
<th>Maximum Water-to-Cement Ratio, Gal./Sack</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-in</td>
<td>1½-in</td>
<td>1-in</td>
<td>¾-in</td>
</tr>
<tr>
<td>A</td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Cement Factor, Sacks/cy</td>
<td>A</td>
<td>6.1</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>5.0</td>
<td>5.5</td>
</tr>
<tr>
<td>Maximum Water-to-Cement Ratio, lb./lb.</td>
<td>A</td>
<td>0.42</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0.65</td>
<td>0.65</td>
</tr>
<tr>
<td>Maximum Water-to-Cement Ratio, Gal./Sack</td>
<td>A</td>
<td>4.51</td>
<td>4.51</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>7.0</td>
<td>7.0</td>
</tr>
</tbody>
</table>

F. Base the water content of the mix on the total amount of water in the mixture,
1. Include any free water in the aggregate or adhering to the surface of the aggregate.

2. Do not include water absorbed by the aggregate.

G. Determine the total volume of aggregate used in each cubic yard of concrete by recognized standards for designing concrete mixes. Use the actual screen analysis of the aggregates.

H. The proportion of fine and coarse aggregate shall be such that the ratio of the coarse to the fine based on weight shall not be less than 1.0 or more than 2.0.

3.3 MIXING CONCRETE

A. Use mixing equipment that is capable of combining the aggregates, cement, admixtures, and water within the time specified into a thoroughly mixed and uniform mass.

B. Mix concrete by one of the following methods:
   1. Operation of one or more batch-type mixing plants, each with a rated capacity of $\frac{1}{2}$ cubic yard or more, installed at the site of work;
   2. Operation of a proportioning plant installed in the vicinity of the work and the use of transit mixers for mixing concrete and transporting it to the forms.
   3. Use of ready-mixed concrete from a central mixing and proportioning plant.
   4. Remote dry-mix batch plant may be used only with approval of the Engineer.

C. The mixing method selected by the Contractor shall be subject to the approval of the Engineer.

D. Provide mixing and proportioning plants with equipment and facilities to accurately measure and control the quantities of material and water used in the concrete. Include provisions to readily change the proportions to conform to the varying conditions and requirements of the work.

E. Stationary Mixed Concrete
   1. Use a batch mixer of an approved type which will ensure a uniform distribution of materials throughout the mass.
      a. Accurately proportion and control all materials entering the drum, including water.
      b. Proportion the cement and aggregate by weight. Volumetric batching will not be allowed.
      c. Equip the mixer with an automatic timing device to lock the discharge level before aggregate and cement enters the drum. Release such level only after the specified mixing time has elapsed.
      d. Comply with the “Concrete Mixer Standards” adopted by the Mixer Manufacturer’s of the Associated General Contractors of America. Provide a nameplate giving the manufacturer’s rated capacity of the mixer.
   2. Discharge the entire batch before recharging the mixer.
      a. Do not exceed the manufacturer’s rated capacity of the mixer.
b. Mix each batch for the period indicated herein, during which time the drums shall rotate at a peripheral speed as recommended by the manufacturer.

3. Mixing time shall be as follows:

<table>
<thead>
<tr>
<th>Capacity of Mixer</th>
<th>Mixing Time in Seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>½ cubic yard</td>
<td>75</td>
</tr>
<tr>
<td>¾ to 1 ½ cubic yards</td>
<td>75</td>
</tr>
<tr>
<td>Larger than 1 ½ cubic yards</td>
<td>120</td>
</tr>
</tbody>
</table>

4. Measure mixing time from the time all cement and aggregates and most of the water are in the mixer.
   a. Excessive over-mixing, requiring additional water to preserve the required consistency will not be permitted.
   b. All of the mixing water shall be introduced before ¼ of the total mixing time has elapsed.

F. Transit Mixed Concrete

1. Conform to the following:
   a. The current “Standards for Operation of Truck Mixers and Agitators of the National Ready-Mixed Concrete Association,”
   b. The “Truck Mixer and Agitator Standards of the Truck Mixer manufacturers Bureau,”
   c. ASTM C94.

2. Transit Mixer
   a. Automatically record the number of revolutions of the drum during the mixing period.
   b. Attach a metal plate on each mixer and agitator in a prominent location. Plainly mark the following:
      1) Capacity of the drum in terms of the volume of mixed concrete
      2) The speed of rotation for the agitating and mixing speeds of the mixing drum or mixer blades.
   c. Paint an identification number on each mixer in a location that can be easily read from the batching platform.
   d. Do not exceed the manufacturer’s guaranteed mixing capacity.

3. Reduce the amount of materials charged into the mixer if the concrete does not meet the uniformity requirements of this specification.

4. Completely empty the mixer drum of any previously mixed load.
a. Place the proper proportions of aggregate, cement, and water for each load of concrete in the mixer.

b. Mix the contents therein for not less than 70 or more than 100 revolutions of the drum or mixer blades. Use the speed designated by the equipment manufacturer as the mixing speed.

c. For additional drum revolutions, use the speed designated by the equipment manufacturer as the agitating speed.

d. Immediately prior to discharging the concrete, revolve the drum at the mixing speed for a minimum of three minutes.

e. Revolution of the drum shall be continuous until the concrete is completely emptied from the drum.

5. Class A concrete: Empty all wash water from the mixer before any portion of the succeeding load is placed therein.

6. Class B concrete: Empty the mixer or carry no more than 10 gallons of water in the drum.

7. Add water at the point of discharge only with the prior approval and in the presence of the Engineer and in the presence of the concrete testing representative.
   a. Mix water so added into the load for a minimum mixing time of three minutes.
   b. Do not add water to the load during transit.

8. Do not exceed 90 minutes between the time water is added to the cement and aggregate or cement is added to the water and aggregate and the time concrete is placed in the forms, except if retarding admixtures are utilized and approved by the Engineer.
   a. When allowed by the Engineer, use a water-reducing and retarding admixture whenever concrete cannot be delivered to the forms within the time period specified.
      1) Use only to supplement (not to replace) other acceptable hot weather procedures.
      2) The retarding admixture used shall not interfere with strength development and other properties of the concrete.
      3) Retarding admixture use shall be carefully controlled by the concrete supplier.
      4) Test with job site materials and demonstrate the admixture’s ability under these conditions to produce the desired properties before using.

9. Add water at the job site to offset evaporation of mixing water only with the Engineer’s approval and in his presence.
   a. The addition of any water during transit to offset evaporation losses is not permitted.

10. Avoid prolonged mixing, even at agitating speed. Where feasible, stop the mixer and then agitate intermittently.
11. Provide the Engineer with a legible, certified weighmaster’s certificate for each load of ready-mixed concrete.
   a. Provide at the time of delivery.
   b. Delivery ticket shall be identical to that submitted and approved with the concrete mix design.
   c. All information shall be entered on to the delivery ticket at the mixing plant except the following:
      1) Blank space for initials of on-site receiving party.
      2) Time of arrival of concrete truck on site.
      3) Amount of mix water added on-site.
      4) Time of concrete placement.

3.4 CONVEYING CONCRETE
   A. Convey concrete from the mixer to the place of final deposit by methods that will prevent separation or loss of the materials.
   B. If the concrete is to be transported more than fifty feet in carts or buggies, equip them with pneumatic tires.
      1. Deliver concrete to the carts, buggies or conveyors from spouts, troughs, or mixer trucks.
      2. Do not allow a free fall of more than three feet.
      3. Prevent the separation or loss of ingredients.
      4. Keep delivery carts, buggies, conveyor trucks or barrows on temporary runways built over the floor system. Do not allow runway support to bear upon reinforcing steel or fresh concrete.

3.5 CONCRETE PLACEMENT
   A. General
      1. Ensure the following before placing concrete:
         a. All reinforcement is securely and properly fastened in position and protected against displacement
         b. All items to be embedded in the concrete are in place and securely anchored in position
         c. All forms have been thoroughly coated or wetted
         d. All form ties at construction joints have been retightened
         e. Concrete surfaces to be covered have had all free water, form coating, loose concrete, and debris removed,
         f. All conveyances, buggies, and barrows are clean and wetted.
2. Notify Engineer at least 24 hours prior to placing concrete.
   a. The Engineer will inspect forms, reinforcing steel, screeds, construction joints, openings, anchors, pipe sleeves, conduit, and inserts.
   b. Do not pour concrete until the condition of the forms and place of pouring has been inspected and approved by the Engineer.
   c. Wet down formwork and reinforcement before placing concrete to prevent the leaching of water from the concrete.
   d. Do not allow free standing water in the forms.
   e. Do not place concrete when the sun, wind, heat, or humidity prevents proper placement and consolidation.
   f. Do not add water or cement to the mix without the Engineer’s approval or in his absence. Do not deposit partially hardened concrete.

B. Placing Concrete

1. Unless otherwise specified, place all concrete upon clean, damp surfaces, free from water.
   a. Do not place concrete upon soft mud, dry absorbent earth or rock.
   b. Do not place concrete upon dills that have not been tamped to provide ultimate settlement.

2. Maintain groundwater below subgrade until the concrete has set. When subgrade is dry earth, thoroughly dampen soil with water to ensure that no moisture is absorbed from the fresh concrete.

3. Where shown on the Drawings, directed by the Engineer or where concrete is placed against gravel or crushed rock with less than 25% of the material passing a No. 4 sieve; cover the surfaces against which concrete is cast with polyethylene film to protect the concrete from loss of water.
   a. Lap joints in the film at least 12 inches and tape.
   b. Protect the polyethylene film against puncture from the underlying crushed rock.
      1) Use a cushion of natural or imported sand complying with ASTM D1073
      2) Place the sand on top of the crushed rock.
      3) Where concrete is placed against rock, remove all loose pieces of rock and clean the exposed surface with a high-pressure hose.

4. Place concrete within 90 minutes after adding cement, aggregates, water and admixtures.

5. Dispose of concrete which has not been placed within these time limits off site.


7. Comply with ACI 301 when bonding new concrete to existing concrete.
a. Apply approved bonding compound.
b. Allow bonding compound to cure in accordance with the manufacturer’s recommendations or as directed by the Engineer.

8. Place a vapor barrier under all slabs poured on earth.
   a. Extend the barrier the full area of the slab.
   b. Turn barrier up or down footings as indicated.
   c. Lap all seams at least 12 inches and seal per manufacturer’s instruction.
   d. Install reinforcement with care so as not to puncture vapor barrier.
   e. Tape all cuts, tears, punctures, and pipe penetrations before pouring concrete.

9. Deposit concrete in batches in its final position to prevent segregation of the mix.
   a. The limits of each concrete pour shall be predetermined by the Contractor and approved by the Engineer. Place all concrete within such limits in one continuous operation.
   b. Do not move concrete laterally in the forms more than 5 feet.
   c. Use a crane and a bottom dump concrete bucket wherever possible.
   d. Unless authorized by the Engineer, do not drop concrete freely into place from a height of greater than 5 feet.
      1) Deposit concrete in walls by means of prefabricated, rectangular tremies, constructed in short sections and spaced laterally not over 5 feet apart.
      2) Take special care to avoid slopping concrete over forms when placing.

10. After the concrete has been deposited, distribute it over the entire area within the forms in approximately horizontal layers of not more than 18-in. deep.
   a. Bring up the layers evenly in all parts of the form.
   b. Ensure each concrete layer is still plastic when covered with the succeeding layers.
   c. Fill the forms at a rate of vertical rise of not less than 2-ft per hour or more than 6-ft per hour.
   d. Stop concrete placement if a layer of concrete reaches its initial set before the next lift is placed, or if more than 60 minutes elapses between the placing of successive concrete lifts.
   e. Prepare the surface of the previous lift in accordance with the procedures specified under Construction Joints in this Section.

11. Do not allow workmen to walk on concrete during placing or finishing with any earth or foreign matter on footgear.
   a. Use forks and shovels for hand spreading
   b. Do not use rakes.
12. Place and compact concrete in wall or column forms before any reinforcing steel is placed in the structural system to be supported by such walls or columns.
   a. Do not exceed 6 feet of vertical height for any portion of a wall or column placed monolithically with a floor or roof slab.
   b. Allow concrete in walls or columns to set at least two hours before concrete is placed in the structural systems to be supported by such walls or columns.
   c. Pour brackets, haunches and fillets monolithically with the floor or roof slab system.

C. Consolidation
   1. Thoroughly consolidate concrete during and immediately after placement.
      a. Work concrete into all corners and angles and around reinforcement and embedded fixtures in a manner to fill all voids, prevent honeycombing against the forms and avoid segregation of coarse aggregate.
      b. Use spades, forks and internal vibrators to perform this operation.
   2. Transmit vibration directly to the concrete. Do not transmit it through the forms.
      a. Use a vibrator with a driving mechanism that revolves at not less than 7,000 rpm.
      b. Vibrate with sufficient intensity to cause the concrete to flow and settle readily into place and to visibly affect the concrete over a radius of at least 18 inches.
      c. Supplement vibration with manual forking or spading adjacent to the forms on exposed faces in order to secure smooth, dense surfaces.
      d. Take special care to consolidate around reinforcement, pipes and other shapes built into the work.
      e. Do not use vibrators to transport concrete within the forms.
      f. Keep vibrators in motion at all times to prevent excessive vibration in one spot. The operation shall be continuous and all concrete shall be in final position before initial set has started.
   3. Maintain at least one operable vibrator on site as a spare in case of equipment failure. Do not place any concrete until all vibrating equipment, including spares, are at the placement site.
   4. Thoroughly consolidate concrete prior to top finishing.
      a. Remove all laitance, debris, and surplus water from concrete surfaces at tops of forms by screeding, scraping, or other effective means.
      b. Wherever the top of a wall will be exposed to weathering, overfill forms; and after the concrete has been compacted, screed off excess.

D. Placement Sequence
   1. Unless otherwise indicated on the Drawings or directed by the Engineer, follow the placement sequence identified below to reduce shrinkage cracking:
a. Bottom Slab
   1) Placed a center section (as outlined by the construction joints shown on the Drawings) first.
   2) Not less than 72 hours after the center section has been placed, place an adjoining section.
   3) Place the remaining sections alternately, first on one side and then on the other side of previously placed sections.
   4) Schedule pours so that two adjacent sides of each section are free, except at closures.

b. Walls
   1) Divide walls into sections by the construction joints shown on the Drawings or as submitted by Contractor.
   2) Place a section near the center of each wall first.
   3) Place the remaining sections alternately, first on one side and then on the other side of the previously placed section.
   4) Schedule pours so that one end of each section is free, except at corner closures.

c. Footings
   1) Pour all footings except wall footings in one operation with no joints unless noted otherwise on the contract drawings.

E. Special Requirements Due to Adverse Weather Conditions

1. Rain
   a. Do not place concrete during rain.
   b. Do not place concrete if rain is forecast unless there is sufficient time to complete the placement and finishing.
   c. Protect all concrete placed prior to rain by whatever means necessary to prevent damage to finish or water entering the mix.
      1) Maintain protection equipment and materials on hand prior to beginning placement operations.
      2) Protect freshly placed concrete from scour by flowing water and from mud deposits or other injurious conditions.

2. Cold weather concrete placement
   a. Comply with ACI 306, except as modified herein.
   b. Ensure the concrete temperature at the time of placing is not less than that shown in the following table for the corresponding ambient outdoor air temperature (in shade) existing at the time of placement:
<table>
<thead>
<tr>
<th>Ambient Outdoor Air Temperature</th>
<th>Minimum Concrete Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 35°F</td>
<td>70°F</td>
</tr>
<tr>
<td>Between 35°F and 45°F</td>
<td>60°F</td>
</tr>
<tr>
<td>Above 45°F</td>
<td>45°F</td>
</tr>
</tbody>
</table>

c.  Do not place concrete when the ambient air temperature at the time of placement is 45°F or less unless specifically authorized by the Engineer.
   1)  Heat the concrete in a manner acceptable to the Engineer.
   2)  If the use of heated concrete is authorized, temperature of the concrete at time of placement shall not exceed 80°F.
   3)  Avoid rapid dry-out due to overheating.
   4)  Avoid thermal shock due to sudden cooling or heating.

d.  Maintain the air temperature surrounding the concrete at 70°F for three days, or 50°F for five days, or for as long as is necessary to ensure proper curing of the concrete.
   1)  Prevent rapid cooling of the concrete.
   2)  Leave housing, covering, or other protection used in connection with heating in place and intact at least 24 hours.
   3)  Chemicals to prevent freezing shall not be permitted.

e.  Do not place concrete on frozen subgrade or subgrade containing frozen materials. Ensure forms, reinforcing steel, and adjacent concrete surfaces are completely free of frost, snow and ice before placing concrete.

3.  Hot weather concrete placement
   a.  Comply with ACI 305 except as modified herein.
   b.  Follow hot weather precautions whenever the maximum ambient outdoor air temperature (in shade) during the day exceeds 85°F.
      1)  Cover reinforcing steel with water-soaked burlap so the steel temperature does not exceed the ambient air temperature immediately before embedment in concrete.
      2)  Do not place concrete when hot weather conditions may result in loss of slump, flash set or cold joints.
   c.  If rapid mixing water evaporation in transit causes the concrete to be delivered in an unworkable condition, initial correction may be made at the job site.
      1)  Add water in the form of a cement paste having the same water to cement ratio as the batch in the truck.
      2)  Operate the drum or mixer blades at mixing speed for at least 70 revolutions after the paste addition.
3) Once need for water has been observed, subsequent additions shall be at the batching plant until the need has passed.
   a) Provide a simultaneous and proportionate increase of water and cement, up to 10% of the stated quantity of each material in the batch.
   b) Such increases in cement shall not constitute grounds for an increase in the contract price.

d. Do not exceed a concrete temperature of 85° F at the time of placement.
e. Take extra caution to prevent rapid evaporation of water.
   1) Cool forms by frequent wettings.
   2) Protect flat work from drying winds, direct sun, and high temperatures whenever conditions of temperature and humidity are such as to cause plastic shrinkage cracking.
   3) Do not use set-control admixtures in mix designs unless approved by the Engineer in advance.

f. In order to prevent plastic shrinkage cracking due to rapid evaporation of moisture, do not place concrete when the rate of evaporation, determined by using Figure 2.1.4 in ACI 305, latest edition, equals or exceeds 0.2 pound per square foot per hour.

3.6 FINISHES

A. Finish concrete surfaces as set forth in these Contract Documents and as specified in ACI 301.

B. Formed surfaces
   1. Begin finishing immediately after form removal. Complete concrete finishing in that area before any other work begins.
   2. Provide a smooth-rubbed finish in accordance with ACI-301 for all permanently exposed surfaces and two (2) feet below high water elevation.
      a. Clean all holes, pits or imperfections in the concrete surface with a wire brush.
      b. Thoroughly wet the concrete and completely fill imperfections with damp cement mortar composed of 1 part portland cement to 2 parts fine aggregate.
      c. Make the entire surface smooth with all lines or markings smoothed over to obtain uniform appearance.
      d. Prior to the commencement of concrete work the contractor shall provide a 5’ x 5’ concrete sample panel displayed vertically with a smooth-rubbed finish for approval by the Engineer. Once the smooth-rubbed finish of the sample panel has been approved all applicable concrete finishes shall meet the quality of the sample panel. If, in the opinion of the Engineer, the concrete surface is unsatisfactory, repair it as follows:
         1) Thoroughly and continuously wet the entire surface.
2) Rub the surface with a No. 0 carborundum stone until all lines, markings and surplus materials have been removed from the surface. When complete, wash the surface clean with water.

3) Rubbing may be done either by hand or with power tools.

C. Unformed Surfaces

1. Buried or permanently submerged concrete not forming an integral part of a structure does not need surface treatment except as that required to remove laitance.

   1. Screed the unformed surfaces of all other concrete and give it the following treatment:
      a. An initial float finish.
      b. Additional floating followed by troweling where required.
      c. Take care that no excess water is present when the finish is made.
      d. Do not use a special concrete or cement mortar topping course unless shown on the Drawings.

2. Screeding
   a. Use a straight edge and accurately and securely set screeding strips to produce an even surface.
   b. Arrange screeds so as not to interfere with the top bar reinforcement.
   c. Provide a concrete surface conforming to the proper elevation and contour with all aggregates completely embedded in mortar. Ensure surfaces are free of surface irregularities with a height or depth in excess of ¼-inch as measured from a 10-foot straight edge.

3. Floating
   a. Give screeded surfaces an initial float finish as soon as the concrete has stiffened sufficiently for proper working.
      1) Remove any coarse aggregate which is disturbed by the float or which causes a surface irregularity. Replace it with mortar.
      2) Produce a surface of uniform texture and appearance with no unnecessary working of the surface.
   b. Follow initial floating with a second floating at the time of initial set.
      1) Produce a finish of uniform texture and color.
      2) This is the completed finish for unformed surfaces unless additional finishing is specifically required.
   c. Use hand floats or suitable mechanical compactor floats.

4. Brooming
   a. Provide a non-slip surface.
   b. Perform after the second floating.
c. For traffic areas, perform at right angles to the normal traffic direction.

5. Troweling
   a. Provide a steel trowel finish for surfaces to be covered with resilient floor coverings and other surfaces designated on the Drawings.
   b. Trowel finishing will not be required for floors, which are normally submerged.
   c. Perform troweling after the second floating when the surface has hardened sufficiently to prevent an excess of fines being drawn to the surface.
   d. Produce a dense, smooth, uniform surface free from blemishes and trowel marks.

6. Edging
   a. Chamfer all permanently exposed edges of unformed surfaces.
   b. Use a ¾-in approved edging tool unless other edge treatment is indicated on the Drawings.

D. Unless otherwise specified or required, provide the following finishes:
   1. Curbs and equipment bases: broom finish
   2. Exterior slabs: broom finish, Class B tolerance.
   3. Interior slabs: troweled finish, Class A tolerance.
   4. Other concrete not exposed to view: rough form finish.

E. Other concrete exposed to view: Smooth form finish with voids filled and rubbed smooth.

3.7 CURING, PROTECTION

A. Cure and protect concrete as specified in ACI 301 and as set forth in these Contract Documents.

B. Protect from loss of moisture by curing for at least 14 days following placement.
   1. Begin immediately after concrete finishing is complete or forms are removed.
   2. Breaking of form ties or otherwise breaking the seal between the concrete surface and the form shall be considered form removal.

C. Use water curing, membrane curing, film curing, or any other curing method acceptable to the Engineer which does not injure or discolor exposed surfaces nor destroy the bond on surfaces to receive subsequent concrete pours or protective coatings.

D. Water Curing
   1. Keep concrete surfaces being water-cured constantly and visibly wet for a period of not less than 14 days.
      a. Saturate concrete surfaces as quickly as possible after the initial set of the concrete.
      b. Regulate the rate of water application to provide complete surface saturation with a minimum of runoff.
   2. Slabs poured on grade and decks may be water-cured by the following methods:
a. Ponding. Standard canvas seep hose placed in parallel runs on 8-foot centers is recommended for ponding.

b. Covering with wet burlap sacks, sand, or sawdust and keeping this covering continually and visibly wet during this period.

3. Walls may be cured by leaving the forms tied in place and keeping the forms and all exposed surfaces of the concrete continually and visibly wet for the duration of the curing period.

E. Membrane Curing

1. Use for all interior slabs to be covered with resilient tile, carpet or left exposed and all exterior slabs, sidewalks, curbs, etc. Apply in strict accordance with the manufacturer’s recommendations.

2. Apply the curing and sealing compound by power spray, roller, or squeegee.
   a. Use a coverage rate not to exceed 400 sq. ft. per gallon for troweled surfaces.
   b. Use a coverage rate not to exceed 300 sq. ft. for floated or broomed finishes.

3. Apply the curing and sealing compound immediately after final finishing (within 30 minutes).
   a. If forms are removed before the end of the specified curing period, the curing and sealing compound or other moisture retaining method must be applied to the formed surfaces before they dry out.
   b. The Engineer shall determine which method shall be used.

4. Protect the curing compound against abrasion during the curing period. If the compound will be subjected to damage from traffic or other cause, protect it with Sisalcraft paper or other means acceptable to the Engineer.

5. Reapply improperly applied Compound or compound applied without sufficient dye to produce a distinguishing color to the satisfaction of the Engineer.

F. Film Curing

1. Film curing with polyethylene sheeting may be used in lieu of water curing on concrete that will be covered later with mortar or additional concrete or will otherwise be covered or hidden from view.

2. Begin film curing as quickly as possible after initial set of the concrete.
   a. Completely cover the surfaces with polyethylene sheeting.
   b. Overlap the sheeting edges sufficiently to obtain proper sealing and anchorage.
      1) Overlap joints between sheets at least 12 inches and seal.
      2) Promptly repair all tears, holes, and other damage.
      3) Anchor covering continuously at edges. Anchor on the surface as necessary to prevent billowing.
3.8 CONSTRUCTION JOINTS

A. Use construction joints only at locations indicated on the Drawings, submitted by the Contractor and approved by the Engineer or specified herein.
   1. Do not use at other locations without concurrence of the Engineer.
   2. Do not use vertical construction joints in walls unless specifically approved by the Engineer.
   3. Lay out and conduct the work to minimize the number of construction joints.

B. Use only keyed construction joints.
   1. Make keys continuous.
   2. Make the key width equal to 1/3 of the thickness of the wall and the key depth equal to 1/6 of the thickness of the wall.
   3. Do not use keys smaller than 3-in wide and 1½-in deep unless indicated otherwise on the Drawings.

C. Provide waterstops of the type specified where indicated on the Drawings and in all construction joints in concrete walls and slabs having one face exposed in a dry pit or room and having the other face in contact with backfill, subgrade, groundwater, or other liquid.

D. Thoroughly clean the horizontal surface immediately before placing the next lift using water or air as required.
   1. Cover the concrete surface with a uniform, evenly distributed layer of cement-sand mortar to a thickness of 1-in.
   2. Make the cement-sand mortar using a mixture of 1.3 parts by volume Portland Cement and 1 part by volume fine aggregate. Use a water-to-cement ratio equal to that of the concrete to follow.

3.9 EXPANSION AND CONTRACTION JOINTS

A. Provide expansion joints as shown on the Drawings. If not shown use full-depth, pre-formed, asphalt plank material conforming to ASTM D994.

B. PVC, Hydrophilic Rubber and compression seal waterstop joints
   1. Install in strict accordance with the manufacturer’s recommendation and these specifications.
   2. In case of conflict, use the most stringent requirement as determined by the Engineer.

C. Hydrophilic Rubber:
   1. Cut coil ends square (or at proper angle for mitered corners) with shears or sharp blade to fit splices together without overlaps.
   2. Seal splices using cyanacrylate adhesive
   3. Seal any exposed cells of Hydrophilic Rubber using LEAKMASTER by Greenstreak or equal. Make watertight.
D. Compression Seal:

1. Seal field butt splices shall be using Greenstreak “G-SEAL” adhesive or equal.
2. Attach compression Seal to expansion board using staples or nails driven through bottom flange area of the Compression Seal.
3. Attach Compression Seal prior to concrete placement.

E. Injected Vinylester-Based Resin Waterstops

1. Installation of injection hoses:
   a. Install in lengths not to exceed 40 feet.
   b. Install in center of walls and slabs as shown on the Drawings. Encase the injection hose and vent ends in not less than 3 inches of concrete.
   c. Attach to the substrate with plastic anchor clips spaced in accordance with the manufacturer's recommendations.
   d. Do not fasten injection hoses to reinforcing steel.
   e. Do not criss-cross any injection hoses. Use reinforced PVC vent ends for crossing over the injection hoses.
   f. Encase reinforced PVC vent ends in a junction box covered with a matching face plate and mounted firmly against the formwork.
   g. Inspect and obtain approval by the Engineer of all installations prior to pouring concrete.
2. Injection Application:
   a. Prepare injection material in strict accordance with the manufacturer's printed instructions and specifications regarding mixing, injection procedures, application life and equipment requirements.
   b. Inject the sealing material only when ambient temperatures are between 45º and 100ºF.
   c. Injection operations should not begin prior to the normal 28-day concrete curing time period, in order to allow for shrinkage.
   d. Inject vinyl ester-based resin in accordance with manufacturer's recommendations.
   e. If the injection material penetrates the wall or slab surfaces, wipe clean with water and patch with rapid-setting cement.
   f. After injection is complete, evacuate injection hose with water following the manufacturer's recommended procedure.
3. Field support by manufacturer: A manufacturer's representative shall be present for the first installation operation and first injection operation and at any other times deemed necessary by the Engineer to ensure proper installation and injection of vinyl ester-based resin injection system.
4. If joints are determined to be leaking after water is placed inside structure, drain water from structure and re-inject vinyl ester based resin in injection hoses within the limits of the leak in accordance with the injection procedures previously described herein.

3.10 BONDING NEW CONCRETE TO EXISTING CONCRETE

A. Where new concrete is to be cast against and permanently bonded to an existing concrete surface, chip or cut the existing concrete back at least 1½-in or as necessary to expose sound concrete.

1. Remove loose or weathered concrete and provide a roughened surface for bonding to the new concrete.
2. Cut edges square. Feathered edges will not be permitted.
3. Remove all loose material remaining after chipping or cutting operations by sandblasting and/or stiff wire brushing.

B. Where chipping back of existing concrete is not possible and where approved by the Engineer, the surface of existing concrete may be prepared by sandblasting or acid etching.

1. Ensure the surface of the existing concrete is bare, clean, dry, and structurally sound.
2. Remove all grease, oil, wax, or other residue by scraping followed by washing with a nonionic detergent or a suitable solvent compatible with the epoxy-bonding agent to be used.
3. Remove animal fats by scrubbing with a 10% solution of caustic soda to saponify them.

C. After all loose material, grease, etc., has been removed, etch the surface of the existing concrete by either sandblasting or scrubbing with a 10%-20% solution of hydrochloric acid in water.

1. Apply etching solution at a rate of 1-quart per square yard followed by a thorough rinsing with clean water.
2. Allow the surface to completely dry before applying the epoxy-bonding agent.
3. Wear goggles, rubber boots, and rubber gloves when applying caustic soda or acids.

D. When the surface is dry and just before placing the new concrete, apply an epoxy bonding agent to the surface of existing concrete with a whitewash brush or stiff broom.

1. Spread the epoxy bonding agent evenly over the surface to be bonded, avoiding skips and holidays, to a wet film thickness of 40 to 60 mils.
2. Place the new concrete as soon as the epoxy-bonding agent becomes tacky.
3. If the epoxy-bonding agent is allowed to dry before placement of new concrete, recoat the surface with epoxy.

E. The epoxy-bonding agent shall comply with the material requirements of this specification

1. Apply the material in strict conformance to the manufacturer’s recommendations.
2. Take appropriate safety precautions during the handling and use of the epoxy-bonding agent.

3.11 EMBEDDED ITEMS

A. Wherever steel, wrought or cast iron piping, fittings, valves, collars, sleeves, structural steel, electrical conduits, appurtenances and fixtures, equipment anchorages or castings are shown for embedment in the concrete, such items must be on hand before concrete is poured.
   1. Accurately set embedded items in place.
   2. Firmly brace items before concrete is poured around them.
   3. Do not use cutouts for future installation of these items.

B. Thoroughly clean embedded items and ensure they are free from any coating, rust, scale, oil or other foreign matter.
   1. Avoid embedding wood in concrete whenever possible.
   2. If wood must be embedded, thoroughly wet it before the concrete is placed.
   3. After placement, clean surfaces not in contact with concrete of concrete spatter and other foreign substances.

C. Install conduit between reinforcing steel in walls or slabs that have reinforcement in both faces. In slabs with only a single layer of reinforcing steel, place conduit under the reinforcement.

D. Unless installed in pipe sleeves, embed anchor bolts with sufficient threads to permit a nut and washer to be installed on the concrete side of the form or template.
   1. Provide a second nut and washer on the other side of the form or template.
   2. Adjust the two nuts so that the bolt will be held rigidly in the proper position.

E. Coordinate the work and ensure that all embedded items or openings are placed in the forms before concrete is placed. Also confer with subcontractors and suppliers regarding their embedment and opening requirements.

F. Set forms, sleeves, and inserts, and cast concrete to the lines and grades indicated on the Drawings and as detailed in these Contract Documents.
   1. Do not exceed the maximum deviation from true line and grade shown below. Deviation in alignment of slabs or walls shall not exceed a rate of 1/8-inch in 10 feet within the tolerances specified.

<table>
<thead>
<tr>
<th>Item</th>
<th>Maximum Tolerance (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleeves and inserts</td>
<td>+ 1/8</td>
</tr>
<tr>
<td></td>
<td>- 1/8</td>
</tr>
<tr>
<td>Projected ends of anchor bolts</td>
<td>+ 1/4</td>
</tr>
<tr>
<td></td>
<td>- 0.0</td>
</tr>
<tr>
<td>Anchor bolt setting</td>
<td>+ 1/16</td>
</tr>
<tr>
<td></td>
<td>-1/16</td>
</tr>
<tr>
<td>Concrete forms</td>
<td>+ 1/8*</td>
</tr>
<tr>
<td></td>
<td>-1/8*</td>
</tr>
</tbody>
</table>
*Or as outlined in ACI 117 and approved by the Engineer

G. Carefully finish all slabs true to grade such that the surface is free draining and contains no depressions that can hold or collect water.

H. Regardless of the tolerances listed herein, limit deviations in line and grade to tolerances that will permit proper installation and operation of mechanical equipment and piping.

3.12 WATERPROOFING MATERIALS

A. Apply to those joints and concrete surfaces shown on the drawings.
   1. Application shall be by or under the direct supervision of the manufacturer’s representative.
   2. Prior to application, the waterproofing manufacturer’s representative shall inspect the facilities receiving waterproofing and certify:
      a. Surfaces to receive the waterproofing are properly prepared and suitable for the application.
      b. Waterproofing materials comply with the requirements of these specifications.

B. Surface preparation and material application shall comply with the requirements in Section 07100. Submit recommended procedures at least 30 days prior to waterproofing application.

3.13 CONCRETE EMBEDMENT AND PIPE ENCASEMENT

A. Install concrete for embedment and encasement where shown on the Drawings and at such other locations where deemed necessary to protect existing or proposed piping as determined by the Engineer.

B. Embedment and encasement of pipe shall include the following steps:
   1. Remove all loose material from the trench before placing concrete. Ensure concrete will be in continuous contact with undisturbed soil on sides and bottom of trench.
   2. Accurately screed a base course of concrete to such grade and elevation that the pipe will be at specified grade when pipe bells are supported on, and in contact with, the top surface of such base course.
   3. Rigidly hold each length of pipe in alignment and anchor it to prevent flotation in a manner acceptable to the Engineer.

3.14 ACCEPTANCE OF STRUCTURE

A. For environmental engineering structures as defined by ACI 350, concrete strength will be acceptable if it meets the acceptance criteria of ACI 301 and ACI 350, whichever is the more stringent. The Engineer may, however, reject the concrete, if cores fail to meet the specified 28-day strength.

B. For structures other than environmental engineering structures, the concrete strength will be acceptable if it meets the acceptance criteria of ACI 301.
C. The Engineer shall be the sole judge of concrete strength acceptability. Concrete not meeting the above requirements shall be removed from the project site, disposed of properly, and replaced with concrete meeting the specified requirements.

D. All structures which contain water shall be subject to a hydrostatic leakage test in accordance with Section 2 of ACI 350.1 unless otherwise required as follows:

1. Do not begin cleaning and testing for at least 14 days after the concrete has been poured and the joints sealed.

2. Clean exposed surfaces prior to testing
   a. Thoroughly hose all surfaces to remove surface laittance and loose matter.
   b. Remove wash water and debris from structures. Do not use plant piping for removal.

3. Ensure that all concrete has attained its specified compressive strength prior to testing.

4. Provide all required piping, valves, meters, and related equipment necessary to test the structures. Coordinate with the Engineer.

5. Fill structures to be tested with potable water to the normal operating liquid level indicated on the contract drawings or otherwise provided by the Engineer.
   a. Do not exceed a filling rate of 4 feet of water depth per 1-hour period.
   b. Fill at a uniform rate with continuous monitoring.
   c. For structures with adjacent bays, fill all bays simultaneously.
   d. Empty adjacent bays alternately.
   e. Repair all running leaks that appear during filling prior to continuing.

6. Add water as necessary to keep the structure at its normal operating level indicated on the contract drawings or otherwise provided by the Engineer for 72-hours.
   a. At the end of 72-hours, it will be assumed that moisture absorption by the concrete is complete.
   b. Close all valves and gates to and from the structure.
   c. Measure the change in water surface each day for a 5-day period. Quantative water loss shall not exceed 0.050% of volume per day.
   d. Examine exposed portions of the structure and mark all visible leaks and damp spots.
      1) Damp spots shall be defined as areas where moisture can be felt on a dry hand.
      2) Repair visible leaks and damp spots after the structure is dewatered.
   e. Determine surface moisture evaporation using a 24-inch deep, white colored, watertight container of not less than 10 square foot surface area exposure.
      1) Position the container to experience environmental conditions similar to the structure being tested.
      2) Fill the container with a known volume of water.
3) Measure the water loss due to evaporation each day and determine the loss in gallons per square foot of surface area.

4) Use the evaporation rate determined above to calculate the quantity of water lost from the test structure due to evaporation.

5) Subtract the water loss due to evaporation from the measured water loss in the structure being tested to determine the water loss due to leakage.

f. If leakage is excessive, drain the structure.
   1) Repair the leaks and damp spots.
   2) Refill the structure using the procedures outlined above and re-test.
   3) Continue the process until the results meet these specifications.

7. If an underdrain system is provided, inspect the underdrain manholes for evidence of leakage. If leaks are apparent, locate and repair them.

8. If leakage is excessive and leaks cannot be found through other means, seed the floor slab of each water containing structure with one bag of cement per 250 square feet of surface area.
   a. Seed the structure after the test filling has reached 18-inches in depth.
   b. Detect leaks in construction and expansion joints with the aid of a diver.
   c. Stir cementitious deposits on the floor and observe the deposits flowing toward leaks.
   d. Repair all defects.

E. All repairs, additional fillings, and testing shall be performed by the Contractor at no additional cost to the Owner.

   1. Repair leaking concrete cracks in accordance with Section 03720 of these specifications.

F. The Engineer may reject any fluid retaining structure that does not meet the acceptance criteria of ACI 350.1 Section 2 and the requirements of this specification for water tightness.

   1. All cost for repairs required to meet the above criteria and provide an acceptable water tight structure shall be borne by the Contractor.

3.15 DEFECTIVE WORK AND METHODS OF REPAIR

A. Remove and replace or repair all defective or damaged work as directed by the Engineer.

   1. Any work which is not constructed in accordance with these Contract Documents is defective.

   2. Do not patch, repair or cover defective or damaged work without prior inspection and approval of the Engineer.

B. Repair defects in formed concrete surfaces to the satisfaction of the Engineer within 24-hours of placement.
1. Replace defective concrete within 48-hours after adjacent forms have been removed.
2. Cut out and remove honeycombed or otherwise defective concrete to sound concrete. Square cut the edges to avoid feathering.

C. Conform to Chapter 9 of ACI 301, except as modified herein.
   1. Do not interfere with the thorough curing of surrounding concrete.
   2. Adequately cure all repair work.

D. Where authorized by the Engineer, patching conducted as specified herein may be used.
   1. Permission to patch shall not waive the Engineer’s right to have the defective work completely removed if the patch or repairs do not, in the Engineer’s opinion satisfactorily restore the quality and appearance of the work.
   2. Patching shall be conducted as follows:
      a. Chip away defective areas at least 1-½” deep perpendicular to the surface
      b. Wet the area and 6” around it to prevent absorption of water form patching mortar.
      c. Brush a sand-cement grout consisting of one part fine aggregate to one part portland cement into the surface, following with patching mortar.

3. Patching mortar
   a. Use no more than one part portland cement to three parts fine aggregate.
   b. Use white portland cement to replace a portion of the gray cement as determine by a trial patch.
   c. Use only the minimum mixing water required for placing.
   d. Re-temper the mortar if necessary without the addition of water by allowing it to stand for one hour. Mixed with a trowel during that time to prevent setting.

4. Compact the Mortar into place and screed to leave the patch higher than the surrounding surface.
   a. Leave undisturbed for one to two hours to permit initial shrinkage.
   b. Finish to match the adjoining surface.
   c. Cure patch in accordance with this specification section.

3.16 LOADS APPLIED TO NEW CONCRETE

A. Do not impose loads upon new concrete until it has reached its specified 28-day strength.
   1. Loads include, but are not limited to, earth loads, loads exerted from bracing or shoring, wind loads, hydrostatic or hydraulic loads, equipment or vehicle loads, or loads exerted by stacked materials.

B. Repair or replace concrete which has cracked or is otherwise damaged due to overloading or loading before required strength has developed, as determined by the Engineer.

**END OF SECTION**