1. INTRODUCTION

1.1 Scope
This specification covers the furnishing of all material, equipment, accessories, tools, services, transportation, labor, and supervision required for the supply and installation of cast in place concrete.

1.2 Concrete
Unless otherwise indicated, concrete shall be normal weight (150 pcf) ready-mixed concrete, conforming to ASTM C94.

1.3 Items Included
This specification includes the following items:
   a. Concrete for foundations and structures
   b. Concrete for Slabs on grade
   c. Reinforcement
   d. Formwork
   e. Embedded Items, including Anchor Bolts

1.4 Certification
The concrete manufacturer shall certify that the concrete delivered conforms to the specification for Ready-Mixed Concrete ASTM C94, and furnish the certification specified in Par. 14 of ASTM C94.

2. CODES AND STANDARDS
The following codes and standards of the latest revision shall be considered as part of this specification:

2.1 American Concrete Institute, ACI 318, Building Code Requirements for Reinforced Concrete
2.2 ACI 301, Specifications for Structural Concrete for Buildings
2.3 ACI 304, Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete
2.4 ACI 305, Recommended Practice for Hot Weather Concreting
2.5 ACI 306, Recommended Practice for Cold Weather Concreting
2.6 ACI 315, Manual of Standard Practice for Detailing Reinforced Concrete Structures
2.7 ACI 347, Recommended Practice for Concrete Formwork
2.8 American Society for Testing and Materials (ASTM), as noted.
CAST-IN-PLACE CONCRETE

2.9 American Welding Society D12.1, Recommended Practices for Welding Reinforcing Steel, Metal Inserts, and Connections in Reinforced Concrete Construction.

2.10 Concrete Reinforcing Steel Institute (CRSI), as noted.

3. MATERIALS

3.1 Cement
Unless otherwise noted, all cement shall be Portland Cement conforming to ASTM C150, Type II.

3.2 Water
Water used in mixing shall be clean and free from deleterious amounts of acids, alkalis, organic matter, or other impurities likely to be injurious to concrete.

3.3 Admixtures

3.3.1 Chemical Admixtures shall conform to "Chemical Admixtures for Concrete" (ASTM C 494) and shall not be used unless prior approval in writing is obtained from the Engineer. Where approved, the admixture shall maintain or improve the strength and/or durability of concrete of the original design mix. Admixtures shall be used in strict accordance with the manufacturer's recommendations and shall be accompanied by the services of the qualified field representative of the manufacturer to supervise the use thereof. A certificate from an approved laboratory attesting that the admixture equals or exceeds ASTM C494, Type D will be required.

3.3.2 Air Entraining Admixtures shall conform to "Specifications for Air-Entraining Admixtures for Concrete" (ASTM C 260). Air content shall be determined in accordance with ASTM C231. The agent and the cement proposed for use shall be selected well in advance of concrete placing. Approved air-entraining admixtures are as follows:

Darex AEA (Grace Construction Materials)
MB-VR (Master Builders Co.)
Sika AER (Sika Chemical Corp.)

3.3.3 The use of accelerators shall not be allowed.
3.4 **Aggregate**

3.4.1 Fine aggregate shall conform to "Concrete Aggregates" (ASTM C33), except for gradation which shall be as follows:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 inch</td>
<td>100</td>
</tr>
<tr>
<td>No. 4</td>
<td>95-100</td>
</tr>
<tr>
<td>No. 16</td>
<td>65-95</td>
</tr>
<tr>
<td>No. 50</td>
<td>7-30</td>
</tr>
<tr>
<td>No. 100</td>
<td>No More Than 7%</td>
</tr>
</tbody>
</table>

3.4.2 Coarse aggregate shall conform to "Concrete Aggregates" (ASTM C33) One inch to No. 4 size.

3.4.3 Aggregates for type V cement shall be sharp acid-resistant type silica rocks. Quartz, flintstone, etc. are preferred. Absolutely no carbonate rocks such as limestone, calcite, dolomite, magnesite, siderite, etc. shall be used.

3.5 **Concrete Durability and Quality**

3.5.1 All concrete shall meet the durability and quality requirements specified in ACI 318, Chapters 4 and 5.

3.5.2 The 28 day compressive strength, \( f_c \), of the concrete shall be not less than 4000 psi or as specified on the drawings.

3.5.3 Method of proportioning shall be in accordance with ACI 211.1, "Recommended Practice for Selecting Proportions for Normal and Heavy Weight Concrete."

3.5.4 The determination of the water-cement ratio to attain the required strength shall be in accordance with ACI 301, Method 2 (For combinations of materials previously evaluated or to be established by trial mixes), and with ACI 211.1. In addition, the maximum water-cement ratio (by weight) shall be 0.45 and the minimum cement content shall be 5-1/2 sacks per cubic yard.

3.5.5 From the test results of the aforementioned procedures, a curve shall be plotted showing relationship between the water-cement ratio and compressive strength, and the maximum water-cement ratio to be used shall be the value shown by the curve to produce the strength a minimum of 25 percent greater than the strength specified.
3.5.6 The concrete mix design shall be submitted to the Engineer for approval prior to beginning of any concrete work.

3.5.7 Maximum aggregate size shall meet the requirements of ACI 318, Section 3.3.

3.5.8 Unless otherwise noted or approved, all concrete shall be air-entrained. Air entrainment shall be accomplished through the use of an approved admixture.

3.5.9 Air Content
The air content shall be as follows:
   a. 6 percent for 3/8 inch maximum aggregate size
   b. 5 1/2 percent for 1/2 inch maximum aggregate size.
   c. 5 percent for 3/4 inch maximum aggregate size.
   d. 5 percent for 1 inch maximum aggregate size.
   e. 4 1/2 percent for 1-1/2 inch maximum aggregate size.
   f. 4 1/2 percent for 2 inch maximum aggregate size.

3.5.10 Slump

<table>
<thead>
<tr>
<th>Types of Construction</th>
<th>Slump in Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinforced foundation walls, footings, &amp; small mat foundations</td>
<td>4</td>
</tr>
<tr>
<td>Reinforced slabs, beams &amp; walls</td>
<td>4</td>
</tr>
<tr>
<td>Equipment foundations</td>
<td>5</td>
</tr>
<tr>
<td>Sidewalks, driveways &amp; slabs on ground</td>
<td>4</td>
</tr>
</tbody>
</table>

3.5.11 Mixing, transporting and placing concrete shall conform to applicable portions of ACI 211, ACI 212 and ACI 304 and as specified herein.

3.6 Reinforcement

3.6.1 Deformed Bars
Deformed reinforcing steel bars shall conform to ASTM A615, Grade 60 unless noted otherwise. Bars shall be tagged with mark number and size before shipment.
3.6.2 **Steel Wire**
All cold-drawn steel wire for concrete reinforcement shall be in accordance with ASTM A 82.

3.6.3 **Accessories**
Accessories shall conform to CRSI Manual of Standard Practice of Reinforced Concrete Construction. Include all devices necessary for proper placing, spacing, supporting, and fastening steel reinforcement in place. Accessories shall be galvanized after fabrication if underside of concrete will be exposed.

3.6.4 **Concrete Squares (Precast Reinforcing Chairs)**
Squares shall be approximately two inches square and of a thickness adequate to provide the cover for the reinforcing steel as called for on the plans. The squares shall be made using a mixture of one part Portland Cement to three parts sand (fine aggregate) and the tie wires shall be cast integrally with each square.

3.7 **Form Work**
3.7.1 **Design**
Formwork shall be designed for loads and lateral pressures outlined in Chapter 1, Recommended Practice for Concrete Formwork (ACI 347) and wind loads as specified by the controlling local building code. Formwork design and construction are the responsibility of the Contractor.

3.7.2 **Forms**
Forms shall be constructed of wood, steel, or other approved material. Material shall be chosen based on strength and concrete finish requirements.

3.8 **Embedded Items**
3.8.1 **Anchor Bolts and Sleeves**
Unless noted otherwise, anchor bolts shall conform to ASTM A36 Steel as shown on the drawing. Sleeves, if required shall be of high impact plastic or schedule 40 steel pipe with sleeve bottom closures of mild steel. Furnish each bolt with one heavy hex nut and washer unless otherwise noted on the drawing.

3.8.2 **Embedded Metals**
Curb angles, frames, beams, ducts, etc., shall be fabricated of materials, and in accordance with Specification "Structural and Miscellaneous Steel".
3.8.3 Waterstops
Unless otherwise noted on the drawings, waterstops shall be Synko-Flex preformed plastic adhesive waterstop or approved equal.

3.8.4 Expansion Joint Filler
Filler shall be 1/2" thick and shall meet the requirements of ASTM D 1751 for bituminous type or ASTM D 1752 or ASTM D 2628 for nonbituminous type. Where required or shown on the drawings a non-impregnated compressible foam backer rod shall be installed in the expansion joint prior to applying joint sealer. The backer rod shall be 1/8 inch larger in diameter than the joint width and shall be placed in the joint so as to provide a clear depth above the backer rod from the finished concrete surface equal to 1/2 the joint width.

3.8.5 Joint Sealer
Unless otherwise noted, sealer shall be a semi-rigid epoxy, having a shore hardness of A-80 or D-50 (ASTM D 2240) and elongation of 6 percent. Sealant used in expansion joints requiring backer rods shall be a non-priming urethane sealant conforming to ASTM C-920.

3.8.6 Subsurface Covering (Vapor Barrier)
Polyethylene sheeting 6 mil (0.006") thick natural clear conforming to commercial standard CS238 or ASTM D2103.

3.8.7 Felt Joints
15 lb asphalt felt shall conform to ASTM D 250.

3.8.8 Fiber Board
Tempered hard board shall conform to commercial standard CS251.

4. EXECUTION

4.1 Preparation

4.1.1 In no case shall concrete be placed on muddy, spongy, or frozen subgrade.

4.1.2 All wood scraps and debris shall be removed from the areas in which concrete is to be placed.

4.1.3 All areas where concrete is to be placed shall be thoroughly cleaned to ensure proper placement and bonding.
4.1.4 Forms and subgrade shall be wetted and all standing water removed prior to placing concrete.

4.1.5 All transporting and handling equipment shall be thoroughly cleaned.

4.2 Formwork

4.2.1 Installation
Forms shall be constructed to the shape, line, and grade required and shall be maintained sufficiently rigid to prevent deformation under load, including placing and compacting of concrete. Set forms and screeds for floor and decks to provide uniform slopes to drains and positive drainage for exterior slabs and steps. Forms shall be tight enough to prevent leakage of mortar. Formwork shall be secured to prevent sagging, yielding, bulging, depressions, waves, or other defects in the finished work. Forms shall be smooth and free from warp. Temporary openings shall be provided at base of column and wall forms for cleaning and inspection. All debris including mud shall be removed before placing concrete. Use of patented prefabricated panel sections for forming straight wall sections shall receive prior approval of type and procedure including type of ties to be used. Lumber once used shall be carefully cleaned and oiled before reuse.

4.2.2 Earth Sides
Earth sides may be utilized if clean cut and stable at time of concrete placing. Earth must be undisturbed or compacted to 95% density in accordance with ASTM D 1557, and free from surface water.

4.2.3 Chamfering
Exposed corners of concrete shall have 3/4" chamfers unless shown otherwise.

4.2.4 Form Treatment
Board Forms: Keep wet previous to placing concrete; wet thoroughly just before placing.

Plywood Forms: For surfaces to be painted use silicone-type bondbreaker, Burke, West Chemical or approved equal, applied in accordance with manufacturer’s directions. Coat other surfaces with approved stainless form oil, using minimum quantity required for satisfactory removal.

Metal Forms: Approved-type release compound, applied in accordance with manufacturer’s directions.
4.2.5 Form Removal
Side forms of walls and beams can be removed after 1 to 3 days. Load-supporting forms and shoring shall not be removed until after 7 days or two-thirds of designed 28 day compressive strength is obtained or the 7-day test cylinders have been tested and results indicate an average strength adequate to support the load imposed on the concrete. All forms shall be completely removed after setting of concrete together with all temporary supports, etc., employed for construction purposes. Forms shall be readily removable without hammering or prying against the concrete. Days having temperatures below 40°F are not to be counted for form removal unless thermal protection for the concrete has been provided.

4.3 Reinforcement

4.3.1 Detailing and Fabrication
a. Reinforcing steel shall be detailed and fabricated in accordance with ACI 315.
b. The fabricating contractor shall prepare complete placing drawings and bending schedules. All drawings, thus produced, shall be submitted to the Engineer for approval. No fabrication of reinforcing steel shall be done until drawings have been approved.

4.3.2 Splicing
Bar splices shall be made in accordance with ACI 318 Chapter 12 unless noted otherwise on the design drawings. Any deviation will require approval of the Owner.

4.3.3 Installation
Before being placed, reinforcing shall be free from loose flaky rust, oil, grease, mud, or other coating, including ice that would reduce or destroy the bond. Reinforcement shall be accurately placed and properly secured in position by precast concrete squares, metal chairs or spacers. The use of heat to bend or straighten reinforcing will be permitted only if the entire operation is approved by the Engineer. Tolerances, spacing, splices, and concrete protection to conform with Chapter 7 and 12 of the ACI 318 Building Code.

4.3.4 Ties
With the exception of temperature reinforcement, which shall be tied to main steel, reinforcement shall be accurately placed and securely tied at all intersections and splices with 18 gauge black annealed wire, and shall be securely held in position during the
placing of concrete by spacers, chairs, squares, or other approved supports. Wire tie ends shall point away from the form. Unless otherwise indicated, the number, type, and spacing of supports shall conform to ACI 315 Manual.

4.3.5 Stirrups
All stirrups, except ties, shall be held in place by two spacer bars extending the full length of the beam or girder.

4.3.6 Slabs on Grade
Reinforcing for re-entrant corners and perimeter steel around the edge of each pouring unit shall be 1/2" diameter (#4) deformed bars. Bars used as dowels in joints shall be 1/2" diameter plain round bars 2' long and spaced on 24" centers, unless otherwise indicated on detailed drawings.

4.3.7 Watertight Construction
Standard accessory items (i.e. chairs, etc.) shall not be used in the construction of tanks, reservoirs, basins or other structures to contain water, waste water, or sewage. All reinforcing steel in the walls, beams, columns and slabs of such structures shall be supported on and held away from the forms by using precast concrete "squares" so that no metal is exposed on the face of the concrete when the forms are stripped.

4.4 Embedded Items

4.4.1 No pours are to be made until all embedded items, anchor bolts, electrical conduits, steel frames, pipe supports, etc., are properly positioned and secured and required inspections of same completed. The contractor shall be responsible for and coordinate with other trades to obtain necessary data and information.

4.4.2 All sleeves, inserts, anchor bolts, waterstops, and other embedded items shall be positioned accurately and supported against displacement.

4.4.3 Anchor Bolts
a. Material: Unless otherwise noted on the drawings, all anchor bolts shall be constructed with ASTM A-36 steel.

b. Fabrication: Anchor bolts shall be complete with flat plate bolt washer, semi-finished hexagon nut and, if required, anchor bolt sleeve. Anchor bolt threads shall be N.C. Class 1 fit. Welding shall be in accordance with AWS recommended practice.
c. **Installation**: Anchor bolts shall be set true to the lines and grades shown on the drawings and shall be set plumb and be securely braced to prevent displacement during placing of concrete. Threads shall be protected by coating with oil or grease and encasing them in burlap or paper before placing concrete. Upon completion of concrete placement, bolts shall be rechecked for correct location and elevations. Should any bolt exceed acceptable tolerances such corrections as are necessary shall be made at no additional cost.

d. **Anchor Tolerances**: Tolerance limits in setting of anchors and anchor bolts shall be as follows:
- Location, sleeved: 3/16 inch
- Location, unsleeved: 1/8 inch
- Projection: plus 1/4 inch, minus 0 inch

4.4.4 **Embedded Metals**

a. **Fabrication**
Curb angles, frames, beams, etc., shall have suitable anchors securely welded on centers not exceeding two feet. Anchors shall also be positioned within 6" of ends and corners. All joints, corners, splices, etc. shall be seal welded and the exposed surfaces ground flush. All metal surfaces shall be free from scale, rust, oil, grease or other contaminants.

The fabricated length of pipe sleeves shall be equal to the thickness of concrete they penetrate. Ends of pipe sleeves shall be cut square and flush with the face of concrete. Unless otherwise specified or shown on the Drawings, pipe sleeves shall be secured against movement by welding a ring or flange around the outside midpoint of the sleeve.
Ducts shall be fabricated as shown on the Drawings.

b. **Installation**
All embedded curb angles, beams, frames, pipe sleeves, etc. shall be set true to the lines and grades shown on the drawings. Embedded items shall be secured and braced to prevent shifting during concrete placing. Where dissimilar metals are to be embedded in direct contact with one another, the contacting surfaces shall be heavily coated with bituminous mastic or other Engineer-approved surface treatment to prevent galvanic coupling.
4.5 Mixing Concrete

4.5.1 The mixer and mixing time shall be in accordance with ACI 304. Hot weather concreting shall comply with ACI 305, and cold weather concreting with ACI 306.

4.5.2 No additional water shall be added to batched concrete without the permission of the Engineer. Such water shall be incorporated by additional mixing equal to at least half of the total mixing required for the batch. Any addition of water above that permitted by the limitation on specified water-cement ratio, shall be accompanied by a quantity of cement sufficient to maintain the proper water-cement ratio.

4.5.3 Concrete shall be mixed only in such quantities as are required for immediate use. The maximum allowable time between charging of the material in the mixing drum and final placing for mean ambient temperatures below 90°F shall be ninety (90) minutes or 300 drum revolutions, which ever comes first. Concrete to be delivered when the mean ambient temperature exceeds 90°F shall be mixed and delivered in accordance with the requirements of ACI 305 "Recommended Practice for Hot-Weather Concreting". Concrete not placed within these time limits, or if an initial set has developed, shall not be used. Tempering concrete by adding water or by other means will not be permitted.

4.6 Placing Concrete

4.6.1 Concrete shall not be placed prior to a recorded pre-placement inspection and authorization to proceed by the Owner’s Representative.

4.6.2 The slump may be increased up to 6 inches if concrete pumping is to be used. The proposed mix design for pumped concrete shall be approved in advance by the Engineer.

4.6.3 Conveying and placing of concrete shall be in accordance with ACI 304.

4.6.4 Each day's pour shall be properly scheduled to assure that concrete surfaces can be finished correctly and the use of cold joints can be minimized.

4.6.5 All concrete shall be mechanically vibrated, except for slabs on grade that are six inches or less in thickness.

4.6.6 Concrete shall be placed in layers not over 24 inches deep. Each layer shall be consolidated by mechanical internal-vibrating
equipment supplemented by hand spading, rodding, and tamping to work concrete into all angles and narrow places. Duration of vibration shall be limited to the time necessary to produce satisfactory consolidation without causing objectionable segregation. Vibrators shall be applied vertically and at uniformly spaced points not further apart than the visible effectiveness of the machine. The vibrator shall not be inserted into lower courses that have begun to set. Vibrators shall not be used to transport concrete inside forms. The use of form vibrators or form tamping will not be permitted.

4.6.7 The free fall of concrete from the end of the spout or chute, or from a transporting vehicle, shall not exceed 7 feet for thin walls (10 inches or less in thickness) nor more than 5 feet for other types of construction.

4.6.8 A tremie or flexible metal spout shall be used when the distance through which concrete must be dropped vertically exceeds the maximum specified above. Flexible metal spouts shall be composed of conical sections not more than three feet long, with the diameter of the outlet and the taper of the various sections such that the concrete will fill the outlet and be retarded in its flow.

4.6.9 Chutes, troughs, or pipes used as aids in placing concrete shall be arranged and used so that the ingredients of the concrete will not be separated. Chutes and troughs shall be of metal or metal-lined. When steep slopes are necessary, the chutes shall be equipped with baffle boards or a reversed section at the outlet. Open troughs and chutes shall extend, if necessary, down inside the form or through holes left in the forms; or the ends of such chutes shall terminate in vertical downspouts. All chutes, troughs, and pipes shall be kept clean and free from coatings or hardened mortar by a thorough flushing with water before and after each placement. Water used for flushing shall be discharged outside of the forms.

4.6.10 The concrete shall be deposited, as nearly as possible, in its final position and shall not be caused to flow laterally in the form for any considerable distance. Each pour shall be completed in a continuous operation with no interruptions in excess of forty-five minutes. Each layer shall be placed and compacted before the preceding layer has taken initial set.

4.6.11 The placing sequence shall always be arranged to allow for the effects of settling and shrinkage. Walls 10'-0 and over in height shall be stopped about 1 foot short of the top and allowed to settle one hour minimum before topping out. Walls and columns
bearing superimposed slabs or beams shall be allowed to settle a minimum of two hours before pouring slabs or beams. Laitance shall be removed before pouring superimposed structural members.

4.7 Bonding
The existing surfaces shall be thoroughly cleaned of all foreign material and laitance before depositing new concrete on old concrete or against concrete which has set. Existing surfaces shall be coated with a bonding agent in accordance with specification "Bonding and Grouting".

4.8 Joints

4.8.1 Construction and control joints shall be placed as indicated on drawings (when shown).

4.8.2 Use of construction and control joints, when not shown on the drawings, shall be in accordance with ACI 318, Chapter 6.4, and subject to approval of the Engineer.

4.8.3 Waterstops shall be installed as shown on the drawings, forming a continuous diaphragm in each joint. Support for waterstops shall be provided and waterstop material shall be protected from damage. Field joints in waterstops shall be fabricated in accordance with manufacturer’s instructions.

4.8.4 Saw cutting of contraction joints shall be done as soon as concrete hardens sufficiently (normally 4-12 hours) so as not to be torn or damaged by the blade. Sawing shall not be done while concrete temperature is falling. Construction and control joints shall be filled with an approved sealant, and premolded joint filler, and/or backer rod as shown on the drawings.

4.8.5 Joints not specified on the design drawings shall be in accordance with ACI 301, Chapter 6, and Section 11.5.

4.8.6 All reinforcing shall be continued across construction joints. Keys shall be provided only if required by the design drawings.

4.8.7 When called for on the design drawings, the concrete surface at construction joints shall be roughened uniformly to approximately 1/4 inch, and laitance, loosened aggregate or damaged surface concrete shall be removed.

4.8.8 Paving or slab construction joints, when not specified on the design drawings, shall be located at column centerlines and at intermediate intervals so that each panel shall be not more than 400 square feet in the area, unless slab is reinforced, in which
case the area shall not be more than 600 square feet. Maximum spacing of construction joints in unreinforced slabs shall not exceed twice the slab thickness in inches (i.e., 6 inch slab: 12 feet) nor 1-1/2 times the width for narrow slabs such as sidewalks. Concrete shall be placed in checker board patterns or in alternate paving lanes utilizing construction and contraction joints to provide panels of the size shown on the drawing (when shown).

4.9 Finishing Concrete

4.9.1 Form ties shall be broken back 1 inch from the surface of the concrete. The remaining holes shall be filled by seal patching using a 1-to-2 mix of cement-sand mortar.

4.9.2 All voids and honeycomb in formed concrete shall be filled with a 1-to-2 cement-sand mortar mix. Form ridges and other projections shall be removed immediately, after forms are removed. Exposed form concrete shall be rubbed with a carborundum brick and a thin cement grout shall be applied as necessary to produce a true, even, finished surface. Grout shall extend at least 3" below finished backfill grade on grade walls.

4.9.3 Concrete surfaces left low for grouting shall be roughened to expose aggregate, and all loose particles and laitance shall be removed. Anchor bolt threads shall be wire brushed, and greased, after concrete has set. Nuts and washers shall be placed on the bolts.

4.10 Finish for Floors

4.10.1 Interior building slabs receiving vinyl covering, shall be screeded, floated and steel troweled.

4.10.2 Unless otherwise noted slabs shall be screeded, floated and steel troweled.

4.10.3 Special care shall be exercised on floors that have drains or trenches. Floors shall be sloped uniformly to provide even fall for drainage.

4.11 Screeding, Floating, Troweling, Brooming & Nonslip Finishing

4.11.1 Surfaces shall be screeded to the elevations shown on the drawings. "Con-Film" or Engineer-approved equal shall be sprayed on the screeded surface in conformity with manufacturer's directions if the air temperature is expected to reach 80°F or above before cure is complete.
4.11.2 Floating shall start as soon as the screeded surface has stiffened sufficiently. Floating shall be performed as necessary to produce a smooth, even, textured finish. Floating shall be performed by hand using magnesium tools.

4.11.3 The slab surface shall be tested for accuracy with a straight edge after the first floating finish is completed. Any depressions shall be filled and high areas shall be cut down and reworked. Straight edge testing and refloating shall continue until there are no deviations of more than 1/8 inch under a ten foot straight edge.

4.11.4 Slabs and other surfaces, unless noted otherwise, shall be broomed after final floating to provide a nonskid surface. A soft bristled push broom shall be used, with a swirling motion.

4.11.5 Slabs shall be troweled where noted on drawings or specified otherwise. Steel troweling shall begin after straight edge testing is finished and while concrete is still green, but sufficiently hardened to bear a person's weight without deep imprint. Steel troweling shall produce a smooth troweled finish per ACI Standard 301, Section 11.7.3 "Trowel Finish". Time lapse and number of trowelings to produce a hard surface will vary depending on weather conditions.

4.11.6 Surfaces indicated shall have a nonslip finish obtained by sprinkling not less than 1/4 pound of abrasive aggregate over each square foot of the screeded and floated concrete, and finishing immediately with a steel trowel. The abrasive aggregate shall consist of not less than 55 percent aluminum-oxide or silicon-carbide abrasive ceramically bonded together to form a homogeneous material that will be sufficiently porous to provide a good bond with Portland cement. The aggregate shall have an abrasive hardness of not less than 40 as determined by the test for wear resistance in the National Bureau of Standards Report BMS 98.

4.12 Curing and Sealing

4.12.1 All finished concrete shall be cured by a curing method compatible with the final floor finish for a minimum of 7 days in accordance with ACI 301 Chapter 12. One or more of the following methods may be used, if approved by the Engineer, except where a specified curing method is called for:

- Water curing by ponding or continuous wetting of sand or burlap.
- Form curing by leaving on the forms and wetting for seven days.
An approved sprayed-on curing compound applied in accordance with the manufacturer's instruction. Steel troweled floor slabs, not covered with other materials shall receive a coat of "Cenco Seal 301" surface hardener applied after all other equipment and work in the building has been installed and/or completed and the floor has been thoroughly cleaned of all dust, dirt, masks, and foreign matter. Floor surfaces designated to receive tile or other treatment shall not be treated with sealers or hardeners.

4.13 Cold Weather Concreting

4.13.1 Thorough preparation for protection against cold weather damage to concrete shall be made well in advance. Cold weather concreting shall be performed in accordance with ACI 306.

4.13.2 Concrete shall be protected from freezing for not less than the first 48 hours after placing after the first frost, or when the mean 24-hour temperature at the job site falls below 40°F.

4.13.3 The placing temperature of the concrete shall be maintained above 50°F when the mean 24-hour temperature falls below 40°F.

4.13.4 The temperature of fresh-placed concrete shall be between 50 and 60°F.

4.14 Hot Weather Concreting

4.14.1 Thorough preparation for protection against hot weather damage to concrete shall be made well in advance. Hot weather concreting shall be performed in accordance with ACI 305.

4.14.2 The maximum concrete temperature, at time of placement, shall be limited in accordance with ACI 305, Figure 2.1.5. The evaporation rate of the mixing water shall not exceed 0.2 pounds of water per square foot per hour.

4.14.3 One or more of the ingredients may have to be cooled to keep the temperature of the concrete from being excessive at time of placement. The replacement of part of the mixing water with an equal weight of crushed ice is recommended for effective cooling per ACI 305, figure 2.3.6.

4.14.4 In-place concrete shall be protected and cured so as to minimize drying and absorption of heat.
4.15 Pumped Concrete

4.15.1 The use of pumped concrete shall be approved in each case by the Engineer.

4.15.2 The proposed mix design for each class of concrete to be pumped, including all necessary background data of test results, shall be submitted to the Engineer for approval.

4.15.3 All slump and cylinder test samples shall be taken from the end of the discharge line.

4.15.4 Cutting and patching on any portion of the work after it has been completed shall be done only with the approval of the Owner's Representative.

4.15.5 Forms, equipment, protective coverings, and rubbish resulting therefrom shall be removed from the premises upon completion of the work.

5. TESTING AND INSPECTION

5.1 Inspection

All forms, reinforcement, and anchor bolts shall be inspected and approved by the Owner’s Representative before concrete is placed. If work is found unsatisfactory, the work shall not proceed until all defects have been remedied. Repaired work shall be approved by the Owner’s Representative. Such approval will in no way relieve the contractor of his obligation to produce finished concrete as required by the drawings and specifications.

5.2 Testing

5.2.1 Testing and acceptance of tests of concrete shall be done in accordance with ASTM C31, C39, C94, C143, C172, and C173, D75 and C136.

5.2.2 A testing laboratory engaged by the Owner will be responsible for:
   a. Supplying 6 inch by 12 inch test cylinder molds to the job-site and taking of cylinder samples.
   b. Testing for air, slump, temperature, compressive strength and aggregate gradation.
   c. Preparing test reports.

5.2.3 The Contractor shall supply concrete for all tests.

5.2.4 Concrete shall be sampled, cured, tested and accepted for compressive strength in accordance with ASTM C172, C31, C39,
and C94. Compressive test cylinders shall be prepared in sets of three cylinders for each test. Specimens for each set shall be obtained from the same batch of concrete after about one half of the batch has been placed in the forms. The minimum rate of sampling shall be as follows:

a. **Structures and Foundations**
   
   One set per 100 cubic yards of concrete. At least one set shall be obtained for each structure or foundation, except when placing a number of items, each smaller than 15 cubic yards, one set per 15 cubic yards shall suffice.

b. **Floors and Slabs at Grade**
   
   One set per 50 cubic yards of concrete.

   5.2.5 Test cylinder sets shall be dated, numbered consecutively, and identified as to location.

   5.2.6 All cylinders shall be immediately stored in an insulated container under wet sand or burlap for about 24 hours after preparation. All vibration or impact shall be avoided during this critical period.

   5.2.7 After initial storage, the cylinders (still in their molds) shall be packed in sealed polyethylene bags, wet sand or other resilient material for shipment to the testing laboratory.

   5.2.8 Concrete slump tests shall be made in accordance with ASTM C143 and shall be taken as necessary to assure well-placed concrete.

   5.2.9 In-Place Tests: Where questions exist as to the quality of the concrete placed, Engineer may require tests per ASTM C42 or order a load test on structures as outlined in Chapter 20 of ACI 318, Building Code Requirements for Reinforced Concrete.

   5.2.10 Contractor shall give Owner 48 hours notice before any pour requiring testing.

6. **SUBMITTALS**

   Two (2) copies of the following (unless noted otherwise) shall be submitted to the Engineer and one (1) copy to the Owner’s Representative for review and approval:

   6.1 Design of concrete mixes in accordance with this specification and ACI 301, Chapter 3.

   6.2 Reinforcing steel and embedded items shop drawings, bar lists and bending and erection drawings. Two (2) sets of these documents shall accompany the first load of reinforcing delivered to the job site.
6.3 Test Reports and material certifications as noted elsewhere in this specification, and/or on the drawings.

6.4 One (1) reproducible of the final reinforcing steel and embedded items shop drawings shall be forwarded to the Engineer when they are issued to the shop.