Section 03301 - CONCRETE

1. SCOPE. This section covers all cast-in-place concrete, including reinforcing steel, forms, finishing, curing, and appurtenant work. All concrete shall be air-entrained.

2. GENERAL. All cast-in-place concrete shall be accurately formed and properly placed and finished, as indicated on the drawings and specified herein.

The Contractor shall inform the Engineer at least 24 hours in advance of the times and places at which he intends to place concrete.

3. MATERIALS.

3.01	Portland Cement	ASTM C150, Type I, IA, II, IIA, III or IIIA.
3.02	Fine Aggregate	Clean natural sand, ASTM C33. Artificial or manufactured sand will not be acceptable.
3.03	Coarse Aggregate	Crushed rock, washed gravel, or other inert granular material conforming to ASTM C33, except that clay and shale particles shall not exceed one percent. Smooth or rounded stone will not be acceptable.
3.04	Water	Clean and free from deleterious amounts of oil, acids, alkalies, and organic materials.
3.05	Admixtures	
	a. Water-Reducing	ASTM C494, Type A or D.
	b. Air-Entraining	ASTM C260.
3.06	Reinforcing Steel	
	a. Bars	ASTM A615,Grade 60, deformed in accordance with ASTM A305, except 1/4" bars may be plain.
	b. Welded Wire Fabric	ASTM A185.
	c. Bar Supports	CRSI Class 1, plastic protected, or Class 2, stainless steel protected.

3.07 Forms

a.	Plywood	Product Standard PS1, waterproof, resin-bonded, exterior type, Douglas fir.
b.	Lumber	Straight, uniform width and thickness, and free from knots, offsets, holes, dents, and other surface defects.
c.	Form Oil	Light-colored paraffin oil or other acceptable nonstaining material.

3.08 Polyethylene Film — Product Standard PS17, 6 mils or thicker.

3.09 Membrane Curing Compound — ASTM C-309, Type 2.

4. PRELIMINARY REVIEW. The source and quality of concrete materials and the concrete proportions proposed for the work shall be submitted to the Engineer for review at least 48 hours before concrete is placed.

5. LIMITING REQUIREMENTS. Concrete shall be watertight, resistant to freeze-thaw cycles and moderate sulfate attack, abrasion resistant, workable, and finishable. Unless otherwise specified, concrete shall be controlled within the following limiting requirements.

5.01. Minimum Cement Factors. The quantity of portland cement, expressed in pounds per cubic yard, shall be not less than that indicated in the following table:

	Coarse Aggregate Size from No. 4 Sieve to			
Concrete Slump	3/8"	1/2"	3/4"	1"
	lbs/cy	lbs/cy	lbs/cy	lbs/cy
3 inches	629	592	564	536
4 inches	639	611	583	555
5 inches	658	630	602	573

5.02. Ratio of Fine to Total Aggregates. The ratio of fine to total aggregates based on solid volumes (not weights) shall be:

Coarse Aggregate Size	Minimum Ratio	Maximum Ratio
3/8 inch	0.45	0.60
1/2 inch	0.40	0.55
3/4 inch	0.35	0.50
1 inch	0.30	0.46

5.03. Total Water Content. Total water content of concrete shall not exceed 5.4 gallons of water per hundred pounds of cement in the mix.

5.04. Slump. Concrete slump shall be kept as low as possible consistent with proper handling and thorough compaction. Unless otherwise authorized by the Engineer, slump shall be a minimum of 3 inches and a maximum of 5 inches.

5.05. Total Air Content. The total volumetric air content of concrete after placement shall be a minimum of 4% and a maximum of 6%.

5.06. Admixtures. The admixture content, batching method, and time of introduction to the mix shall be in accordance with the manufacturer's recommendations. A water-reducing admixture and an air-entraining admixture shall be included in all concrete. No calcium chloride or admixture containing chloride from other than impurities from admixture ingredients will be acceptable.

5.07. Strength. The minimum acceptable compressive strength, as determined by ASTM C39, unless otherwise specified shall be:

Age	Minimum Compressive Strength
7 days	3,000 psi
28 days	4,000 psi

6. STORAGE OF MATERIALS. Cement shall be stored in suitable moisture-proof enclosures. Cement that has become caked or lumpy shall not be used.

Aggregates shall be stored so that segregation and the inclusion of foreign materials are prevented. The bottom 6 inches of aggregate piles in contact with the ground shall not be used.

Reinforcing steel shall be carefully handled and shall be stored on supports which will keep the steel from contact with the ground.

7. BATCHING AND MIXING. Concrete shall be furnished by an acceptable ready-mixed concrete supplier and shall conform to ASTM C94.

7.01. Consistency. The consistency of concrete shall be suitable for the placement conditions. Aggregates shall float uniformly throughout the mass, and the concrete shall flow sluggishly when vibrated or spaded. The slump shall be kept uniform.

7.02. Delivery Tickets. A delivery ticket shall be prepared for each load of ready-mixed concrete. A copy of each ticket shall be handed to the Engineer by the truck operator at the time of delivery. Tickets shall show the quantity delivered, the amount of each material in the batch, the outdoor temperature in the shade, the time at which the cement was added, and the numerical sequence of the delivery.

8. FORMS. Forms shall be designed to produce hardened concrete having the shape, lines, and dimensions indicated on the drawings. Forms shall be substantial and sufficiently tight to prevent leakage of concrete and shall be maintained in proper position and accurate alignment.

Forms for pavement, curbs, or gutters shall be made of steel and shall be supported on thoroughly compacted earth. The top face of pavement forms shall not vary from a true plane more than 1/4 inch in 10 feet.

Forms shall be thoroughly cleaned and oiled before concrete is placed.

Where concrete is placed against gravel or crushed rock which does not contain at least 25 percent material passing a No. 4 sieve, such surfaces shall be covered with polyethylene film to protect the concrete from loss of water. Joints in the film shall be lapped at least 4 inches.

8.01. Form Ties. Form ties shall be of the removable end, permanently embedded body type, and shall have sufficient strength and rigidity to support and maintain the form in proper position and alignment without the use of auxiliary spreaders.

8.02. Edges and Corners. Chamfer strips shall be placed in forms to bevel all salient edges and corners, except the top edges of walls and slabs which are to be tooled and edges which are to be buried. Unless otherwise noted, bevels shall be 3/4 inch wide.

8.03. Form Removal. Forms shall not be removed or disturbed until the concrete has attained sufficient strength to safely support all dead, live, and construction loads. Care shall be taken in form removal to avoid surface gouging, corner or edge breakage, and other damage to the concrete.

9. REINFORCEMENT. Reinforcement shall be accurately formed and positioned, and shall be maintained in proper position while the concrete is being placed and compacted. Unless otherwise indicated on the drawings, the details of fabrication shall conform to ACI 315 and 318. In case of conflict, ACI 318 shall govern. Mechanical connections shall be used only as indicated on the drawings.

All reinforcing bars and supplies shall be stored off the ground, and protected from oil, paint, grease, rusting, or scale. Bending of bars shall be done in accordance with the requirements of ACI 315. All bars shall be bent cold and in the shop.

Steel reinforcing shall be accurately positioned and secured against displacement by using concrete or metal chairs, spacers, or other devices to properly support and fasten the reinforcing. Splices shall not be made at points of maximum stress, nor shall all bars be spliced at the same location. All bars shall have a splice of a minimum 30 bar diameters.

Metal accessories shall include all spacers, ties, chairs, bolsters, and other devices required to support and fasten and hold the reinforcing steel in place, shall meet the requirements of ACI 315.

Wire mesh reinforcing shall have the spacing and gauge shown on the contract drawings. Mesh shall be pulled taut and furnished with sufficient support to hold it in position during placing of the concrete. Mesh shall be lapped one space at all splices and wired together at every other interval.

10. PLACEMENT. Concrete shall be conveyed to the point of final deposit and placed by methods that will prevent segregation or loss of ingredients. During and immediately after placement, concrete shall be thoroughly compacted and worked around all reinforcement and embedments and into the corners of the forms. Concrete shall be compacted by immersion-type vibrators, vibrating screeds, or other suitable mechanical compaction equipment. The use of jitterbug tampers to compact concrete flatwork will not be permitted.

Concrete shall not be placed in any forms until all reinforcing steel, pipes, sleeves, inserts, anchors, and other appurtenances have been installed and inspected.

Concrete that has contained its mixing water for more than 45 minutes shall not be placed. Concrete shall not be placed when the temperature is 40 degrees F and falling or when freezing temperatures are predicted for the next 24 hours. All concrete placed in weather above 90 degrees F shall be covered by shading, sprinkling, or other approved means for a minimum of 24 hours. Construction joints shall be made where shown on the contract drawings. When replacing existing concrete, the concrete shall be sawed, thoroughly cleaned and all laitance removed.

11. TESTING.

11.01. Air Content. An air content test shall be made from each batch of concrete from which concrete compression test cylinders are made. The Contractor shall provide all equipment and supplies necessary for the testing. Air content shall be determined in accordance with ASTM C173 or ASTM C231.

11.02. Slump. A slump test shall be made from each batch of concrete from which concrete compression test cylinders are made. Slump shall be determined in accordance with ASTM C143.

11.03. Test Cylinders. Compression test specimens shall be made, cured, stored, and delivered to the laboratory in accordance with ASTM C31 and C39.

One set of concrete test cylinders shall be cast for each concrete pour. A set of test cylinders shall consist of four cylinders, two to be broken and to have compressive strengths averaged at 7 days, and two to be broken and to have compressive strengths averaged at 28 days. All concrete required for testing shall be furnished by the Contractor. No additional compensation will be paid to the Contractor for concrete so used.

Testing of the cured cylinders shall be performed by an independent testing laboratory at the expense of the Owner.

12. FINISHING. Recesses from form ties shall be filled flush with mortar. Fins and other surface projections shall be removed from all formed surfaces, except exterior surfaces that will be in contact with earth backfill.

Unless otherwise specified, unformed surfaces shall be screeded and given an initial float finish as soon as the concrete has stiffened sufficiently for proper working. Any piece of coarse aggregate which is disturbed by the float or which causes a surface irregularity shall be removed and replaced with mortar. Initial floating shall produce a surface of uniform texture and appearance, with no unnecessary working of the surface.

Initial floating shall be followed by a second floating at the time of initial set. The second floating shall produce a finish of uniform texture and color. The completed finish for unformed surfaces shall be the finish produced by the second floating.

12.01. Pavement. Following placement, consolidation, and the disappearance of bleed water, the concrete surface shall be broom finished with a broom acceptable to the Engineer. The broom shall be not less than 18 inches wide and made from good quality bass or bassine fibers not more than 5 inches long. The broom finishing shall produce regular corrugations not over 1/8 inch deep. The broom shall be pulled square across the

surface, from edge to edge, with adjacent strokes slightly overlapped, and shall not tear the concrete surface.

The surface of pavements shall not vary more than 1/8 inch under a 10 foot straightedge placed parallel to the center line.

12.02. Curb and Gutter. Curb and gutter shall be finished to the shape indicated on the drawings. After the forms have been removed, all exposed edges shall be rounded, using an edging tool having a 1/8 inch corner radius. Exposed surfaces shall be float finished and given a light broom finish at the time of initial set, using a horsehair broom applied at right angles to the length of curb and gutter.

12.03. Sidewalks. Concrete surfaces shall be screeded to the proper elevation and contour. All aggregates shall be completely embedded in mortar. Screeded surfaces shall be given an initial float finish as soon as the concrete has stiffened sufficiently for proper working. Any piece of coarse aggregate which is disturbed by the float or which causes a surface irregularity shall be removed and replaced with mortar. Initial floating shall produce a surface of uniform texture and appearance, with no unnecessary working of the surface. Initial floating shall be followed by a second floating at the time of initial set.

Floated surfaces shall be given a light broom finish, using a horsehair broom, to provide a nonslip surface. Brooming shall be done at right angles to the length of the walk.

Sidewalks shall be edged, using a 3 or 4 inch wide edging tool having a 1/8 inch corner radius. Edger lap marks at corners of each slab shall be carefully removed. False joints shall be provided at right angles to the length of the walk, using a grooving tool with 1/8 inch radius. The finished edge on each side of the joint shall be the same width as the edging tool used. False joints shall divide each sidewalk into sections having a length equal to the width of the walk.

The finished surface of all sidewalks shall be neat in appearance, shall be sloped to drain, and shall not pond water.

13. CURING. Concrete shall be protected from loss of moisture by water saturation or by membrane curing for at least 7 days after placement.

Water saturation of concrete surfaces shall begin as quickly as possible after initial set of the concrete. Unformed surfaces shall be covered with polyethylene film, tarpaulins, or sand to retain the water. Water shall be applied as often as necessary to keep the concrete saturated for the entire curing period.

Membrane curing compound may be used in lieu of water curing on concrete which will not be covered later with mortar or additional concrete. Membrane curing compound

shall be spray applied at a coverage of not more than 300 square feet per gallon. Unformed surfaces shall be covered with curing compound within 30 minutes after final finishing. If forms are removed before the end of the specified curing period, curing compound shall be immediately applied to the formed surfaces before they dry out. Curing compound shall be suitably protected against abrasion during the curing period.

Concrete shall be protected against freezing for at least 7 days after placement.

14. REPAIRING DEFECTIVE CONCRETE. Defects in concrete surfaces shall be repaired to the satisfaction of the Engineer. All concrete which is honeycombed or otherwise defective shall be cut out and removed to sound concrete, with edges square cut to avoid feathering.

Concrete repair work shall conform to Chapter 9 of ACI 301 and shall be performed in a manner that will not interfere with thorough curing of surrounding concrete. Repair work shall be adequately cured.

15. CONCRETE FOR MANHOLES, PIPE BLOCKING, AND PIPE ENCASEMENT. Concrete for manholes, buried blocking and encasement of pipe shall conform to the limiting requirements specified herein, except that the cement factor and total water content may be adjusted to provide a minimum compressive strength of 3,000 psi at 28 days. Concrete shall have a slump of not less than 3 inches nor more than 5 inches when placed.

16. DATA AND DRAWINGS. All submittals of data and drawings shall be in accordance with the submittals section, except as noted herein.

End of Section