

DIVISION 36

CONCRETE FOR WATER & SEWER

36.01 SCOPE: The Contractor shall furnish all labor, materials, equipment and supplies and shall perform all work necessary for the complete installation of all concrete and concrete structure and accessories in accordance with the requirements of this division and the plans.

36.02 STANDARDS: All work shall be performed in accordance with the applicable sections of the standards noted.

36.03 MATERIALS:

A. Portland Cement shall conform to AASHTO M85 OR ASTM C150, Type I or Type II and shall be manufactured by a well known manufacturer and approved by the Engineer. Type III (High Early Strength) may be used in lieu of Type I or Type II with the approval of, or at the direction of the Engineer.

B. Aggregates

1. Fine aggregate shall be clean, sharp, natural sand free from loam, clay, lumps or other deleterious substances.

Grading - (Virginia Grade A)

One Hundred (100%) percent will pass a 3/8 inch mesh-screen.

Ninety-seven (97%) percent will pass a U.S. Standard No. 4 sieve.

A maximum of ten (10%) percent will pass a U.S. Standard No. 100 sieve.

2. Coarse aggregate shall be clean, uncoated, processed aggregate of crushed natural stone, or washed gravel either natural or crushed.

Grading - (Virginia Size 57)

One Hundred (100%) percent will pass a 1-1/2 inch mesh screen.

Ninety-five (95%) percent will pass a 1 inch mesh screen.

Forty-three (43%) percent will pass a 1/2 inch mesh screen.

A maximum of seven (7%) percent will pass a U.S. Standard No. 4 sieve.

A maximum of Three (3%) percent will pass a U.S. Standard No. 8 sieve.

- C. Concrete Classes - Two classes of concrete may be utilized in the work and are referenced as follows:

VDOT Class	Compressive Strength <u>7 day – 28 day</u>		Cement Content lbs./cu.yd. <u>Minimum</u>	Maximum Water-lbs. Water per <u>lbs. Cement</u>	Slump <u>(in.)</u>	Air Content <u>(%)</u>
A4	2,700	4,000	635	0.45	2-4	6½ + 1½
A3	1,800	3,000	588	0.49	1-5	6 + 2

Aggregates per Paragraph 29.03.B above.

Unless otherwise shown on the plans or permits, the following listing indicates the class of concrete to be used for specific

<u>Use</u>	<u>Class of Concrete (VDOT)</u>
Buttress & Anchors (pipeline)	A3
Sewer Structures	A4
Structures (precast)	A4

Mix designs shall be prepared in accordance with ACI 211 for each type of concrete required and submitted to the Engineer for approval. The adequacy of each mix design shall be verified by strength tests on a minimum of six cylinders: One tested at 3 days, two tested at 7 days, and three at 28 days, in accordance with ASTM C 39 and C 192; by slump tests in accordance with ASTM C 143; and by air content tests in accordance with ASTM C 138 Or ASTM C 173. All test results shall be submitted to the Engineer for approval a minimum of Thirty-five (35) days before concrete is placed.

- D. Admixtures - The use of admixture shall be limited to an air-entraining admixture conforming to ASTM C 260, water-reducing admixtures conforming to ASTM C 494, Type A, and water-reducing set retarders conforming to ASTM C 494, Type D. The exact formulation for each admixture shall be submitted for approval by the Engineer. Calcium chloride or other admixtures containing chloride ion are prohibited.

The use of admixtures other than those listed above, require prior approval by the Engineer.

Water-reducing and set-retarding admixtures shall be used only with the written permission of the Engineer. The Contractor shall provide test data indicating that the concrete containing the admixtures has improved workability and does not show any abnormal behavior such as premature stiffening or slump loss for at least 30 minutes after mixing has been completed, or any other abnormal differences when compared with concrete made without the admixture. Such test

data shall be based on fresh concrete from the proposed supplier, using hatching equipment proposed for use on the project.

When more than one admixture is used, each admixture shall be dispensed separately into the mix, and at different times during mixing, in accordance with the recommendation of ACI Committee 212. After system approval, no changes shall be made in hatching equipment or concrete constituents without approval of the Engineer.

- E. Water - The water used in the preparation of the concrete shall be potable. The pH of the water shall be between 4.5 and 8.5.
- F. Reinforcing Steel - Reinforcing steel bars shall be deformed bars meeting the requirements of ASTM A 615, Grade 60. All reinforcing shall be rolled with special deformations or identifying marks indicating the ASTM Specification and Grade. Bars shall be free from defects, kinks and from bends that cannot be readily and fully straightened in the field. Test certificates of the chemical and physical properties covering each shipment shall be submitted to the Engineer for approval.

All provisions of the ACI 315 Detailing Manual, SP-66 for detailing reinforced concrete structures shall be followed in the preparation of placing drawings and bar lists, and for fabrication details, bends, tolerances and the like.

- 1. Reinforcing Steel Bars shall be supplied in lengths, which will allow them to be conveniently placed in the work and to provide required lap at joints as shown. Dowels of proper length, size and shape shall be provided for tying walls, beams, floors and the like together.
 - 2. Fabrication - Bent bar reinforcement shall be cold bent to the shape shown on the plans. Unless otherwise specified or shown on the plans, bends shall be made in accordance with the requirements of the Manual of Standard Practice for Detailing Reinforced Concrete Structures (ACI 315). Truss bars for members 12 inches or less shall be fabricated to within a tolerance of 0 to minus 1/2 inch of the height shown on the plans.
- G. Welded Wipe Mesh shall conform to ASTM A185. When used in continuously reinforced pavement, wire mesh shall be deformed, furnished in flat sheets and shall conform to ASTM A497.
 - H. Forms
 - 1. Plywood - Forms for all interior exposed concrete surfaces and designed areas of exterior exposed concrete surfaces shall be constructed of plywood not less than 5/8-inch thick for straight sections and 3/8-inch thick for curved sections. Plywood shall be five-ply for 5/8-inch or thicker and three-ply for 3/8-inch, made with a waterproof glue and

manufactured especially for concrete formwork. Edges shall be square in both directions, and adjoining panels shall match in thickness, width, and length. Full-size sheets of plywood shall be used, except where otherwise required or where smaller pieces will cover an entire area. Forms shall be placed so that markings will be symmetrical. Plywood shall be thoroughly oiled on contact faces and edges with raw linseed oil or other approved form lacquer.

2. Steel - If steel forms are proposed, their type shall be submitted to the Engineer for approval; they shall not be used until such approval is secured. The forms shall be accurately constructed in modular sizes and in such minor multiple widths and lengths as will permit plates and readily distinguishable at the time bars are placed fillers to be erected to correct alignment, as required. Steel forms shall be coated before each use with a light, clear paraffin-base oil or other acceptable commercial preparation which will not discolor the concrete. Plates shall be wire brushed after each use.
 3. Form Ties - Only form ties, hangers, and clamps approved by the Engineer shall be used, and they shall be of such type that, after removal of the forms, no metal will be closer than one inch from the surface. Wire ties will not be permitted. Lugs, cones, washers, or other devices that will leave holes or depressions at the surface of the concrete greater than 7/8-inch in diameter shall not be fitted within the forms. Ties, which are to be left in place, shall be provided with swaged washers or other suitable devices to prevent seepage of moisture along the ties. The spacing of form ties hangers, and clamps shall be strictly in accordance with the manufacturer's directions, and the removable portions shall be coated with cup grease or other approved material.
- I. Water Stops and Expansion Joints: Water stops of the type and dimensions shown shall be provided at each of the locations where they are shown on the plans. Details on the water stops or expansion joints shall be submitted to the Engineer for approval.
1. Steel water stops shall consist of 1/8" x 8" steel plate, braced with cross struts to the reinforcing steel. Joints shall be lapped and continuously welded across the lap.
 2. Monel water stops shall consist of 24 gauge monel metal sheet approximately 15 inches in width formed with a V-shaped center with the edges bent to a 1/2-inch radius. All joints shall be lapped at least one (1) inch, riveted and soldered.

3. Vinyl water stops shall have a web thickness of not less than 3/8 inch, a width of approximately 9 inches and with center bulb and 1-inch diameter bulbs on each end.

36.04 EXECUTION

A. Reinforcing Steel

1. Detailing Shop Drawings - The Contractor shall submit checked detailed reinforcing steel placing drawings and bar lists to the Engineer for approval.

Wall and slab reinforcing shall not be billed in sections. Complete elevations of all walls and complete plans of all slabs shall be shown, except that when more than one wall or slab are identical only one such elevation or plan is required. These plans and elevations need not be true views of the walls or slabs shown. Every reinforcing bar in a slab shall be billed on a plan. Every reinforcing bar in a wall shall be billed on an elevation. Sections shall be taken to clarify the arrangement of the steel reinforcement. All bars shall be identified, but not billed, on such sections.

For all reinforcing bars, unless the location of a bar is clear, the location of such bar or bars shall be given by a dimension to some structural feature which shall be readily distinguishable at the time bars are placed.

The reinforcing steel placing drawings shall be complete for placing reinforcement without reference to the design drawings, including the location of support bars and chairs.

Every reinforcing steel placing drawing and bar list shall be completely checked by the Detailer and corrected before submittal for approval.

If, after reinforcing steel placing drawings and bar lists have been submitted to the Engineer for approval, a review reveals that the drawings and lists obviously have not been checked and corrected they will be returned to the Contractor for checking and correcting.

2. Delivery and Protection - Reinforcing steel shall be delivered to the work in strongly tied bundles, and each group of both bent and straight bars shall be identified with a metal tag giving the identifying number corresponding to the reinforcing steel placing drawings and bar lists. All bars shall be properly stored in an orderly manner, at least 12 inches off the ground, and kept clean and protected from the weather after delivery at the site of the work.

Reinforcing steel shall be delivered without rust other than that accumulated during transportation to the work. It shall, at all times, be fully protected from moisture, grease, dirt, mortar and concrete. Before being placed in position, it shall be thoroughly cleaned of all loose mill scale and rust and of any dirt, oil grease coatings or other material that might reduce the bond. If there is a delay in depositing concrete, the steel shall be inspected and satisfactorily cleaned immediately before the concrete is placed.

3. Installation - Bars shall be cut to required length and bent accurately before placing. Bars shall be bent in the shop unless written approval of field bending is obtained from the Engineer. If field bending is permitted, it shall be done only when the air temperature where the bending operation is performed is above 30 degrees F. No bars partially embedded in concrete shall be field bent.

Cleaning, bending and placement of reinforcement shall be in accordance with ACI 315, ACI 318 and CRSI "Recommended Practice for Placing Reinforcing Bars". Bars used for top reinforcement in slabs shall be placed to vertical tolerance of plus or minus 1/4-inch. All other reinforcement shall be placed to the tolerances given in ACI 318.

Bars shall be placed in the exact positions shown with the required spacing and shall be cross-wired securely in position at intersections to prevent displacement during the placing of the concrete. The bars shall be fastened with annealed wire of not less than 17 gauge or other approved devices. Spacing chairs of an approved shall be furnished and properly placed to support and hold reinforcing bars in position in all beams and slabs, including slabs placed directly on the subgrade or work mate. Continuous hi-chairs shall not be used for support of top bars. Top bars shall be supported by means of individual hi-chairs that have welded cross ties or circular hoops to prevent spreading of the legs. Side form spacers shall be used against vertical or sloping surfaces to maintain specified concrete cover and cross-position of rebate. All bolsters, chairs and other accessories that come in contact with forms for exposed surfaces of concrete other than architectural surfaces shall be hot-dipped galvanized after fabrication or have plastic coated legs.

Tension and compression lap splices shall conform to ACI 318 with all supplements. Splices at points of maximum tensile stress shall be avoided wherever possible. Temperature bars shall have the clear spacing shown. All bar splices shall be staggered with not more than Fifty (50%) Percent of the bars spliced in any one direction, unless otherwise shown.

On any section of the work where horizontal bars run further than the length of the forms, the form or head against which the work ends shall be

perforated at the proper places to allow the bars to project through a distance at least equal to the lap specified. The projecting ends, however, unless otherwise directed by the Engineer, shall be of different lengths so that in no place will laps in adjoining bars in the same plane occur opposite each other.

All welded splices and cadweld coupler splices shall develop at least One Hundred Twenty-five (125%) Percent of the specified yield strength of the bar in tension. Welded splices shall be made by certified welders in accordance with AWS D12.1.

All welded splices shall be approved by the Engineer prior to the work being done.

B. Formwork

1. Installation - The design and engineering of the formwork, as well as its construction shall be the responsibility of the Contractor. Forms shall be designed, detailed and constructed in accordance with ACI 347 including all tolerances except as modified herein. Beams and girder soffits shall be erected with a camber as shown or as directed by the Engineer. Where camber is not given a minimum camber of 1/4-inch per 10-foot of span shall be provided. The forms shall be sufficiently braced, shored and wedged to prevent deflection.

External angles of walls, beams, pilasters, columns and girders shall be provided with 3/4-inch bevel strips.

Forms for repeated use shall be supplied in sufficient number to ensure the required rate of progress. All forms shall be thoroughly cleaned before reuse and shall be inspected immediately before concrete is placed. Deformed, broken, or defective forms shall be removed from the work. Temporary openings shall be provided in forms at convenient locations to facilitate cleaning and inspection.

The entire inside surfaces of forms shall be oiled with a suitable form oil immediately before erection or else thoroughly wetted just prior to placing concrete. No form oil shall be permitted on the reinforcing steel.

The Contractor shall be responsible for the adequacy of all forms and for remedying any defects resulting from their use, inspection and prior approval by the Engineer notwithstanding.

2. Minimum Clearances - Forms shall be placed and held in position so that the concrete cover, as measured from the surface of the bar to the surface

of the concrete, shall be not less than the following, unless otherwise shown.

Slabs

For top and bottom bars for dry conditions:

#11 bars and smaller	1 inch
#14 and #18 bars	1½ inch

Exposed to earth, water or weather and for bottoms bearing on concrete work mat:

#5 bars and smaller	1½ inches
#6 through #18 bars	2 inches

Beams and Columns

For dry conditions:

Stirrups and ties	1½ inches
Principle reinforcement	2 inches

Exposed to water or weather

Stirrups and ties	2 inches
Principle reinforcement	2½ inches

Walls

For dry conditions:

Less than 12 inches thick	1 inch
12 inches or thicker	1½ inches

Exposed to water, weather, or in contact with ground	2 inches
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Footings

At formed sides and ends, and bottoms bearing on concrete work mat	2 inches
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At unformed sides and ends, and bottoms in contact with earth	3 inches
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Tops of footings	Same as slabs.
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C. Concrete

1. Mixing

- a. Hand mixing, on the job site, will be permitted for concrete batches not to exceed ½ cubic yard. The component materials shall be measured by placing them in a rigid container in the

volumetric proportions of 1:2:2½, cement to fine aggregate to course aggregate. Water shall be added to produce a slump not to exceed 3 inches.

- b. Transit Mixing - The concrete shall be mixed in a truck mixer. Mixing shall begin immediately after all ingredients are in the mixer and shall continue for not less than 70 nor more than 125 revolutions of the drum or blades at not less than 14 nor more than 20 revolutions per minute unless otherwise directed by the Engineer.

Maximum time between introduction of cement to the mix and discharge, hours:

	Air Temperature		
	Up to 80° F	80° - 90° F	Above 90° F
Agitator Type Haul Equipment Class A3, General Use (Retarded)	2½	2	1½
Other Classes and Usages (Retarded and Unretarded)	1½	1¼	1
Non-Agitator Type Haul Equipment – All Concrete	1	¾	½

- c. Mixing Limitations: Placement of concrete shall not be initiated when the air temperature is below 40 degree Fahrenheit in the shade, unless otherwise approved by the Engineer.

- 2. Placement - No concrete shall be placed after its initial set has occurred, and no retempered concrete shall be used under any conditions. Concreting operations shall be continuous until the section, panel, or scheduled placement is completed. Should the concreting operations be unavoidably interrupted, construction Joints shall be formed at proper locations as specified.

Concrete shall be conveyed and placed with minimum handling and by means of buckets, buggies, chutes, pumps, or other approved equipment that will prevent segregation of the ingredients. The use of chutes is subject to the approval of the Engineer. Outlets of chutes, hoppers, and conveyor belts shall be provided with suitable baffles to prevent segregation. Apparatus shall be kept clean and flushed with water before and after each run. Concrete shall be deposited in the forms as close as

possible to its final position and in no case more than 5 feet in a horizontal direction therefrom. Rehandling of concrete will not be permitted.

Concrete shall be placed in layers shallow enough so that the previous layer is still soft when the next layer is added and the two layers can be vibrated together. Each layer shall not exceed 18 inches in depth, and the elapsed time between placing successive layers shall not exceed 45 minutes.

Wall and column concrete shall be deposited through heavy duck canvas, galvanized steel, or PVC chutes equipped with suitable hopper heads. Chutes shall be of variable lengths so that the free fall of concrete shall not exceed 3 feet. Where required, illumination shall be provided inside the forms so that the concrete is visible from the deck and runways at the point of deposit. Aluminum chutes are unacceptable.

Special care shall be taken to place the concrete against the forms, particularly in angles and corners, in order to prevent voids, pockets, and rough areas and to assure continuous contact of the entire surface of reinforcing steel and inserts with the concrete. The concrete shall be rodded or spaded, if necessary, to work the coarse material away from the forms.

Freshly placed exposed concrete shall be protected against damage from the elements or other sources.

3. Vibrating - All concrete shall be consolidated by means of mechanical internal vibrators applied directly into the concrete in a vertical position.

The intensity and duration of vibration shall be sufficient to cause concrete to flow, to compact thoroughly and to embed reinforcement, pipes, conduits, and similar work completely. Vibrators shall not, however, be used to cause concrete to move more than a short distance horizontally. Vibrators shall be inserted and withdrawn at points 18 to 30 inches apart, and vibration shall be stopped immediately when a sheen of mortar first appears on the surface. The vibrating apparatus shall penetrate the previously placed layer so that the two layers shall be adequately bonded together but does not penetrate lower layers that have attained their initial set. Vibration shall be supplemented, if necessary, by forking or spading in the corners and angles of forms while the concrete is still plastic and workable.

Vibrators shall operate at a speed of not less than 4,500 cycles per minute. Each tool shall weigh approximately 15 pounds and shall be capable of producing a visible effect upon concrete mixture with a 1-inch slump for a distance of at least 18 inches from the vibrator. A sufficient number of

vibrators shall be on hand to assure that the incoming concrete can be properly compacted within 15 minutes after placing. Reserve vibrators shall be on hand when others are being serviced. No placement of any concrete shall be made with a single vibrator on hand.

4. Special Weather Considerations:

- a. Warm Weather - For placement of concrete during hot weather, the recommendations of ACI 305 shall be followed as modified herein. No concrete shall be placed if its temperature at the time of placement exceeds 90 degrees F and every effort shall be made to maintain lower temperatures. Where the temperature of the concrete being placed is consistently above 75 degrees F and a noticeable decrease in slump or an increase in mixing water demand occurs, a retarding admixture shall be used. Admixtures shall conform to the subsection entitled "Admixtures" and shall be used only with the written permission of the Engineer.

Unformed surfaces of concrete placed during hot weather shall be protected from drying by continuous moist curing for at least 24 hours. Curing shall be started as soon as the concrete has hardened sufficiently to withstand surface damage. If moist curing is not carried beyond 24 hours, the surface while damp shall be covered with a suitable heat-reflecting plastic membrane or sprayed with a white pigmented curing compound.

- b. Cold Weather - Before placement of concrete, all ice, snow and frost shall be completely removed from all surfaces to be in contact with the concrete. Concrete shall not be placed on a frozen subgrade. Surfaces to be in contact with the concrete shall be at a temperature as near as practical to that of the concrete being placed.

Set-accelerators will not be permitted for placement of concrete during cold weather.

In general, concrete placed in the fall from the time of the first frost until the mean daily temperature at the site falls below 40 degrees F shall be protected from freezing for at least 24 hours after it is placed. Concrete placed in the spring after the mean daily temperature at the site rises above 40 degrees F shall be similarly protected until the danger of freezing is past.

When mean daily temperatures at the site are generally below 40 degrees F, the temperature of the concrete as placed shall be not less than 50 degrees F except for mass concrete where the

temperature of the concrete as placed shall be not less than 45 degrees F. Heating of aggregates or mixing water or both shall be used as needed to obtain these placement temperatures. The concrete temperatures as mixed shall not be permitted to exceed the placement temperature by more than 10 degrees F for air temperatures of 0 degree to 30 degrees F nor by more than 15 degrees F for air temperatures below 0 degree F.

Concrete in place shall be maintained at a temperature of 50 degrees F by keeping forms in place, covering with insulated blankets, enclosures or combinations of these for the following minimum time intervals except that forms shall not be removed in less than the time specified in the subsection headed "Removal of Forms".

	<u>Type II Cement</u>
i) Footings and walls below grade and slabs on grade	2 days
ii) Exposed walls and columns carrying no load	3 days
iii) Exposed floor slab, beams and girders above grade and partially loaded	6 days

Exposed surfaces of new concrete shall be protected from drying out. When dry heating is used for protection against low temperatures, exposed concrete surfaces shall be covered with an approved sheet material or membrane as specified in the subsection headed "Curing". Water curing may be used if icing problems can be avoided.

Concrete shall be cured during the period of low temperature protection and for such additional time as approved by the Engineer. Curing shall conform to the requirements of the subsection headed "Curing". During periods of very cold weather, the Contractor shall continue the protection against low temperature during the extended curing period to prevent freezing of the concrete as approved by the Engineer.

Concrete, which is to be exposed to freezing temperatures, shall be permitted to undergo some drying just prior to and during the period of adjustment to ambient cold-weather conditions. When protection against low temperatures is removed, the resulting

temperature drop in any part of the concrete shall not exceed 5 degrees F per hour nor 40 degrees F for the first 24-hour period.

5. Curing - In general, the recommendations of ACI 308 shall be followed for curing concrete.
 - a. Standard Portland cement concrete surfaces normally exposed to the atmosphere shall be protected against too rapid drying by curing for a minimum period of 7 days. When daily average temperatures are below 70 degrees F, the curing period shall be extended as required in the sub-section headed "cold Weather Requirements". The curing period shall commence immediately following the placing of the concrete. Curing shall be accomplished by the water method as approved by the Engineer, unless an alternate method is approved in writing. Should there be any delay in the application of the method of curing used, the concrete shall be covered with moistened burlap held in complete contact with the surface or kept wet by continuous sprinkling.
 - b. Water Curing - Water curing shall be accomplished by the use of quilted covers wetted and applied to the concrete surface as soon as the forms have been removed, or in the case of slabs, as soon as the concrete has set up sufficiently to prevent marring of the surface. These quilted covers shall consist of an outer covering 1'3 of burlap or cotton or other approved material, and a needled, punched or sandwiched inner layer of cotton batting or other approved material, in all weighing not less than 20 ounces per square yard. The covering material shall be maintained in a thoroughly saturated condition and shall show the presence of free water between the mat and the surface of the concrete at all times throughout the curing period.
6. Joints and Bonding - Construction joints shall be made where indicated or permitted. Such joints shall be located to insure stability, strength, and water tightness. All corners shall be built monolithically, and the concrete on either side shall be continuous to points shown or as directed.

At least 2 hours must elapse after placing concrete in the walls before depositing concrete in beams, girders, or slabs supported thereon.

Horizontal keyways shall be built to permit flushing water to escape from the keyways.

Joints shall have continuous, straight, and regular keys or grooves. Exposed concrete surfaces shall be brought to a true level line at the top of

every horizontal construction joint. The exposed construction joints shall have a row of form ties located in the concrete at from 4 to 6 inches from the joint to tighten the forms for subsequent sections. Reinforcing rods shall be set to extend into subsequent sections of construction, as shown. Water stops, if required, shall have watertight splices and corner intersections and shall be of an approved type.

Concrete surfaces against which the new concrete is to be placed shall be thoroughly cleaned and wetted. Just prior to placing new concrete, horizontal surfaces and joints shall be slushed with at least 2 inches of cement grout of the same mixture as the concrete but with coarse aggregate omitted. Special care shall be used in placing and puddling concrete at vertical joints to ensure a bond with existing concrete. Vertical construction joints shall not be made in watertight construction, unless shown or permitted by the Engineer.

7. Inserts and Sleeves – Pipes, anchor bolts, sleeves, steps, castings, floor drains, cast-in reglets, dovetail anchor slots and other inserts shall be encased in concrete as shown or as directed. Special care shall be taken to place and maintain them to the proper lines and grades and to compact concrete thoroughly around them to prevent the passage of water. Insofar as possible they shall be set before placing concrete and thoroughly braced to prevent movement during the progress of the work.

All concrete walls faced with masonry shall have dovetail anchor slots spaced as shown, but not more than 24 inches apart.

8. Removal of Forms - In General, forms shall not be removed until the concrete has hardened sufficiently to support its own load safely, plus any superimposed load that might be placed thereon. The forms shall be left in place at least the minimum length of time or until the minimum strength is developed, as indicated by field-cured cylinders, as specified below.

	Minimum <u>Time</u>	Minimum <u>Strength</u>
Side forms for girders and beams	2 days	1500 psi
Walls	2 days	1500 psi
Bottom Forms of slabs:		
Under 10 feet clear span	4 days	2500 psi
10 to 20 feet clear span	7 days	2700 psi
Over 20 feet clear span	10 days	3000 psi
Bottom forms of beams and girders:		
Under 10 feet clear span	7 days	2700 psi
10 to 20 feet clear span	14 days	3000 psi
Over 20 feet clear span	21 days	3500 psi

These times shall be increased if the concrete temperature following placement is permitted to drop below 50 degrees F.

The removable portion of form ties shall be withdrawn from the concrete immediately after the forms are removed. Holes left by such ties shall be filled with grout and the surface shall be finished with a steel spatula rubbed with sackcloth. On exposed interior surfaces of buildings, where appearance is important, some white cement shall be added in the patching grout.

Care shall be taken in removing forms, wales, shoring, supports, and form ties to avoid spalling or marring the concrete. Patching as may be necessary shall be started immediately after form removal.

9. Finishes:

- a. Ordinary Surface Finish: All walls not exposed to view shall have an ordinary surface finish. Following the removal of forms, fins and irregular projections shall be removed from all exposed surfaces and from all surfaces which are to be water-proofed, surfaces which are free from cavities having a diameter or depth greater than 1/4 inch need not be filled and burlap rubbed.

Surfaces which contain cavities having a diameter or depth greater than 1/4 inch shall be cleaned, wetted, filled with mortar and burlap' rubbed. In the event of surface finish cannot be' performed immediately following the removal of the forms or before the surface of the concrete has become dry, the surface shall be kept wetted for a period of 1-3 hours, as directed by the Engineer prior to the application of the mortar.

All construction and expansion joints in the completed work shall be left free of all mortar and concrete. Joint filler shall be left exposed for its full length.

- b. Rubbed Finish: All walls exposed to view shall have a rubbed finish. After removal of forms, the rubbing of concrete shall be started as soon as its conditions will permit. Immediately before starting this work, the concrete shall be kept wetted for a minimum of three (3) hours. Sufficient time shall have elapsed before the wetting to allow the mortar used in the pointing of rod holes and defects to set thoroughly.

Surfaces to be finished shall be rubbed with a medium coarse carborundum stone, using a small amount of mortar on its face. The mortar shall be composed of cement and fine aggregate mixed

in the proportions used in the concrete being finished. Rubbing shall be continued until all form marks, projections and irregularities have been removed, all voids filled and a uniform surface obtained. The paste produced by this rubbing shall be left in place.

The final finish shall be obtained by rubbing with a fine carborundum stone and water. Rubbing shall be continued until the entire surface has a smooth texture and uniform color. After the final rubbing is completed and the surface has dried, it shall be rubbed with burlap and shall be left free from all unsound patches, paste, powder and objectionable marks.

- c. Float Finish: The surface of all concrete slabs shall, unless otherwise hereinafter specified, be given a float finish. The structural slab shall be brought to the established grade by screening. The surface shall be tested for irregularities with a straightedge. Irregularities shall be eliminated and the entire surface finished with a wood hand float or finishing machine.
 - d. Trowel Finish: All interior concrete floor slabs shall receive two steel trowelings so as to obtain a hard dense surface free from pinholes and blemishes.
10. Grouting - Grout shall be placed under equipment bases, in conjunction with the setting of anchors or dowels in holes drilled in concrete, and elsewhere as directed by the Engineer.

Grout for setting equipment bases, and similar uses shall be a flowable, prepackaged, nonshrink grout without dependence on gas expansion forces or enlargement of metal particles for its non-shrinking characteristics. There shall be no shrinkage below placement volume under ASTM C 827 and no drying shrinkage under CRD 588-76.

Grout for setting equipment bases and similar uses shall be Embeco 636 grout as made by Master Builders Company, Cleveland, Ohio; Propak as made by Profex Industries, Inc., or equal.

Grout for setting anchors, bolts, and similar uses shall be Embeco Pre-Mix 153 Grout, Protalico as made by Protex Industries, Inc., or equal.

36.05 TESTING AND INSPECTION: Slump tests, compression tests, air content determinations, or tests on individual ingredients in the concrete mixture, will be conducted. The Contractor shall furnish all necessary assistance and materials for collecting specimens including standard slump cones and wax coated cylinder molds. Normally this will not be required for thrust blocks unless problems occur.

The Contractor shall provide an independent testing laboratory to conduct tests on the concrete. The laboratory shall provide the certified results of these tests directly to the Engineer.

- A. Compression Test - During the progress of the work, concrete compressive strength tests shall be conducted. Sampling of fresh concrete shall be in accordance with ASTM C 172. Test cylinders shall be made and for the first 24 hours, cured and stored in a tightly constructed, firmly braced wooden box, constructed to maintain the temperature immediately adjacent to the specimens in a range of 60 to 80 degrees F and prevent loss of moisture from the specimens. The storage temperature shall be thermostatically controlled by means of stoves, heating cables, electric light bulbs or other approved means.

Loss of moisture shall be prevented by covering cylinders with wet burlap, damp sand or other approved means. Test cylinders cast in cardboard molds shall not be stored in contact with wet burlap, damp sand or any other material that will allow the outside surfaces of the mold to absorb water for the first 24 hours. Cylinder shall be removed from storage after 24 hours, and molds removed. After removal of molds, laboratory-cured cylinders shall be stored in a moist condition at a temperature of 65 to 75 degrees F until the time of test.

After removal of molds, field-cured cylinders shall be stored in the structure as near the point of sampling as practicable, with the same protection on all surfaces as the structure which they represent.

One strength test shall be made for each 50 cubic yards or fraction thereof for each mix design of concrete placed in any one day, except that in no case shall a given mix design be represented by less than 5 tests.

Cylinders will be tested in accordance with ASTM C 39. Each strength test will consist of three laboratory-cured and one field-cured cylinders. One laboratory-cured cylinder will be tested at 7 days. Normally two laboratory-cured cylinders and the field-cured cylinder will be tested at 28 days. If the 7-day laboratory-cured cylinder is not satisfactory, one of the remaining laboratory-cured cylinders will be tested at 7 days instead of at 28 days.

Each strength test is the average strength of two cylinders from the same sample tested at 28 days. The average of the strength tests for any portion of a structure shall be equal to or greater than the strength specified, and at least Ninety (90%) Percent of all the tests shall indicate a strength equal to or greater than the strength specified. In cases where the average of the strength tests for any portion of the structure falls below the specified requirements, the Engineer may order a change in the mix proportions or water content for the remaining portion of the work and may require the Contractor to secure test specimens of the hardened concrete represented by these cylinders. The number of test specimens required to

be taken shall be the same as the number of test cylinders specified to be made for each concrete placement. Specimens shall be secured and tested in accordance with ASTM C 42. If the specimen tests further substantiate that the concrete represented by the cylinders and specimens is below the specified strength requirements, the concrete shall be removed and replaced at the expense of the Contractor.

- B. Slump And Air Entrainment - Slump tests shall be made in accordance with ASTM C 143, at the same time cylinders are made or more frequently as directed by the Engineer. Tests to determine air content of fresh concrete shall be taken twice daily, at least 4 hours apart, in accordance with either ASTM method or with a testing device approved by the Engineer. Concrete with excessive slump or improper air content will be rejected and no additional concrete shall be delivered until the cause of the deficiency is determined and corrected.

36.06 COATINGS:

- A. Floor Hardener: All concrete floor surfaces shall have applied a non-colored Master Builders Company "Saniseal" or approved equal. Hardener to be applied in accordance with manufacturer's recommendations.
- B. Wet Well Coating: In addition to the use of stainless steel or aluminum straps and appurtenances at and below the high water elevation in the wet well, the application of one coat of Epoxy Type EP-3B followed by one coat of Epoxy Type EP-3T shall be required.

36.07 MEASUREMENT AND PAYMENT: Concrete will not be measured, but will be included in the Lump Sum bid price for the pumping station or unit price for fittings and/or pipeline.