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ITEM V - CONCRETE CONSTRUCTION

5.01 Scope

- (a) The work covered by this item shall consist of furnishing, erecting and removing concrete forms; furnishing, proportioning and mixing concrete ingredients; and placing and finishing plain and reinforced concrete and masonry; and all other work incidental thereto as required for the proper construction of the structures shown on the plans or specified herein.
- (b) Concrete and steel reinforcement for all classes and types of construction of whatever nature or location, shall be furnished and placed in accordance with the applicable provisions of this section.

5.02 General Requirements

- (a) Concrete shall be composed of cement, fine aggregate, coarse aggregate and water proportioned and mixed to produce a plastic, workable mixture. Concrete shall be either Class A or Class B, as indicated on the plans. If the class is not otherwise indicated the Contractor shall furnish Class A concrete. In general, Class A concrete shall be reinforced concrete masonry, cast-in-place in forms for foundations, footings, piers, headwalls, tanks, walls, floors, manholes, pits, streets, sidewalks and similar structures; and Class B concrete shall be plain concrete and shall be used for pipe cradles, pipe protection, anchors, collars, massive sections and similar work.
- (b) Concrete construction shall conform to the requirements of the American Concrete Institute (ACI) Standard 304 for Measuring, Mixing, Transporting, and Placing Concrete; Standard 305 for Hot Weather concreting; Standard 308 for Curing Concrete; and Standard 309 for Consolidation of Concrete.

5.03 Materials

- (a) Cement for Class A concrete shall be Portland Cement conforming to ASTM Specification C150, Type I. Added thereto shall be Master Builders Pozzoloth and Master Builders MB-VR, comparable additives as manufactured by the W. R. Grace Co., or equal. Additives shall be placed in the cement at the mixer in accordance with recommendations of their manufacturer.
- (b) Cement for Class B concrete shall be Portland Cement conforming to ASTM Specification C150, Type I.
- (c) Other type cements, when required, will be specified in the Special Conditions.

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- (d) Fine aggregate shall be a natural siliceous and consisting of hard, durable, and uncoated particles conforming to ASTM Specification C33. It shall have a fineness modules of from 2.40 to 3.00. Fine aggregate shall be of such quality that when made into a mortar and subjected to a mortar strength test (ASTM C87), it shall develop a compressive strength at 7 and 8 days of not less than 90 percent of that developed by a mortar prepared in the same manner with the same cement and graded standard sand having a fineness modules of 2.40 ± 0.10 .
- (e) Coarse aggregate shall consist of natural washed gravel, crushed stone or crushed blast furnace slag conforming to ASTM Specification C33. It shall be graded to pass square mesh screens of the following limiting sizes:

	<u>Class A Concrete</u>	<u>Class B Concrete</u>
Minimum Screen Size	No. 4	No. 4
Maximum Screen Size	3/4 Inch	2 Inches

- (f) Water used in mixing concrete shall be fresh, clean and free from injurious amounts of oil, acid, alkali, vegetable, sewage and/or organic matter.

5.04 Material Sampling and Testing

- (a) Cement and aggregates shall be tested by a recognized testing laboratory which has been selected by the Owner. The testing laboratory shall prepare written reports of such tests which shall certify that the material covered by the report complies in all respects with these specifications. These tests and reports shall be made on each shipment of cement and on each bin or stockpile of aggregates used in the work. When aggregate is being furnished from the same source, tests subsequent to the initial tests may be suspended when specifically authorized by the Engineer. When specifically authorized by the Engineer, mill test certificates shall be submitted for cement shipments. Certified test reports and certificates shall be submitted to the Engineer in duplicate.
- (b) The Contractor shall determine the source, kind and quality of cement and aggregates to be used in the work well in advance of the scheduled start of the work, in order to permit proper sampling and testing. He shall be fully responsible for delays in the progress of the work due to delays in sampling, testing and reporting on cement or aggregates. No cement or aggregates shall be incorporated in the work prior to receipt and acceptance of certified test reports or certificates by the Engineer. The cost of sampling and testing cement aggregates will be borne by the Contractor.

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5.05 Storage of Concrete Materials

- (a) Cement shall be stored off the ground in a dry, ventilated building. Storage facilities shall be provided by and at the expense of the Contractor and accepted by the Engineer prior to the arrival of the first shipment. No cement damaged by improper storage or handling shall be used in the work.
- (b) Sand and coarse aggregates shall be stored in stock piles at selected points to provide maximum drainage and to prevent the inclusion of any foreign material during re-handling. Stock piles shall be built on planking in 2 foot layers to avoid segregation. Sizes shall be kept separate by the use of wooden bulkheads between adjacent piles.

5.06 Proportioning

- (a) Concrete ingredients shall be selected, proportioned and mixed to produce a workable, homogeneous concrete within the following limiting requirements:

MIXTURE	CONCRETE	CONCRETE
	CLASS A	CLASS B
Min. Compressive Strength (28 days) 5 consecutive specimens (lbs. per square inch)	4000	2000
Any one specimen (lbs. per square inch)	3500	1600
Volume of cement per cubic yard of concrete - minimum (bag)	6	4.5
Volume of cement per cubic yard of concrete - maximum (bag)	7	5.5
Volume of water per cubic foot of cement - maximum (gal)	6	7.5
Amount of air entrained in fresh mix - minimum (% of volume)	4	None
Amount of air entrained in fresh mix - maximum (% of volume)	7	None

- (b) The exact volumes and proportions of ingredients to be used in each cubic yard of concrete shall be predetermined by the Contractor well in advance of the start of mixing operations in order to assure conformity of the resulting concrete with the

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above specifications. Such predetermination shall be made by mixing and testing a series of trial mixes of the actual ingredients proposed to be used, the trial mixes to be computed and designed in accordance with the Portland Cement Association Bulletin ST-100, Design of Concrete Mixes. Trial mixes shall be repeated with varying proportions of ingredients until the resulting concrete meets the specified limitations. The results of such trial tests shall be reported to and accepted by the Engineer prior to the start of concrete mixing operations. Said test shall be performed by an independent certified testing laboratory.

- (c) The amount of moisture carried on the surface of the aggregate particles shall be included in calculating the water content of each mix. In all cases, however, the amount of water to be used shall be the minimum amount necessary to produce a plastic mixture of the specific strength and of the desired durability, density and workability. The slump shall be between 3 inches and 4 1/2 inches when determined in accordance with ASTM Test C143. Concrete must be workable at these slumps.
- (d) The air content of freshly mixed concrete shall be determined by the appropriate ASTM Test C231. Frequency of this test will be at the discretion of the Engineer. Any concrete shown by such measurements to contain more or less air than the specified amount shall be rejected and shall not be used in the work.
- (e) No admixtures of hardening or curative materials shall be used unless previously authorized in writing by the Engineer.

5.07 Mixing and Transporting

- (a) Concrete materials shall be measured by weight. Scales suitably designed and constructed for this purpose shall be provided. Each batch of aggregate and cement shall be weighed separately. Cement in standard packages need not be weighed. Mixing water shall be measured by volume or by weight. All measuring devices shall be checked and accepted by the Engineer prior to use.
- (b) Concrete shall be mixed in a standard type of batch mixer with a drum speed of 200 to 225 peripheral feet per minute. Mixing time shall be one minute for batches of 1 cu. yd. or less, and shall be increased 15 sec. for each additional 1/2 cu. yd. or fraction thereof. The entire batch shall be discharged before recharging.
- (c) Central mixed and transit mixed concrete may be used, providing that the quality and kind of material used and the proportioning, mixing and transportation to the forms conform to the requirements of ACI Standard 304.

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5.08 Concrete Placement

- (a) Before placing concrete, forms shall be clean and thoroughly oiled with a non staining mineral oil. Concrete shall not be placed until the forms and reinforcement have been checked and accepted by the Engineer. Unless otherwise specified, all concrete shall be placed upon clean, damp surfaces, free from water, and never upon soft mud or dry porous earth.
- (b) Chutes shall be used to place concrete only when specifically authorized by the Engineer. When permitted, metal or metal lined chutes shall have rounded bottoms, with end baffles and shall be sloped to insure continuous flow of concrete without segregation of aggregates. Tremies, bottom dump buckets, or concrete buggies shall be used whenever practical for depositing concrete.
- (c) Concrete shall be deposited as close as possible to its final position in the forms. The depositing of concrete shall be regulated so that the concrete may be effectively compacted with a minimum of lateral movement into horizontal layers approximately 12 inches in thickness. Concrete shall be worked into all corners and angles and around reinforcement and embedded fixtures in such manner as will fill all voids, prevent honey combing against the forms, and prevent segregation of coarse aggregate. This operation shall be performed by the use of spades or forks, or by other approved methods. Rakes shall not be used.
- (d) During placing operations, concrete shall not be allowed to drop freely a distance greater than 5 feet. When concrete is placed a vertical distance greater than 5 feet in narrow wall forms, metal drop chutes with top hoppers (tremies) or other acceptable placing methods shall be used.
- (e) Concrete shall be compacted with mechanical vibrating equipment supplemented by hand spading and tamping. Vibrators shall not be used to transport concrete inside the forms. Vibrating equipment shall be of the internal type and shall at all times be adequate in number of units and power of each unit to properly consolidate all concrete. Form or surface vibrators shall not be used. Internal vibrators shall maintain a frequency of vibration of not less than 3,600 per minute when submerged in the concrete. Vibrators shall not be left stationary in any position, but shall be moved continuously from point to point in a slow and steady movement. Vibration shall be held to a minimum to avoid loss of air content after concrete has been placed in the forms.
- (f) Water accumulated during placement shall be immediately removed. Under no circumstances shall concrete be placed in such accumulations.
- (g) Before depositing new concrete on or against hardened concrete, the surface of the hardened concrete shall be thoroughly roughened, cleaned, and saturated with

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water. The surface shall then be coated with grout against which the new concrete shall be placed before the grout has attained its initial set.

- (h) All top surfaces not covered by forms and which are not to be covered by additional concrete or backfill shall be carried slightly above grade and struck off by board finish.
- (i) Freshly placed concrete shall be protected from wash by rain, flowing water, mud deposits and other injurious conditions. Concrete shall not be allowed to dry out from the time it is placed until the expiration of curing period.

5.09 Curing and Protecting Concrete

- (a) All concrete shall be cured by the use of wet burlap or by a liquid membrane curing compound. Wet burlap shall be used where concrete is to be painted, topped with grout, and where concrete is to receive tile or a covering which requires an adhesive. Burlap so used shall be kept continuously wet for a period of seven (7) days, Liquid membrane curing compound shall be Sonneborn-Contech Hydroxide Resin Base Compound with fugitive red tint, Lambert Corporation No. 64-WB Compound with fugitive red tint, or approved equal. Curing compounds shall comply with ASTM Specification C309, Type 1 and AASHTO Specification M148, Type 1 and shall be applied to concrete at a rate recommended by the manufacturer.
- (b) In cold weather concrete shall be mixed and placed only when the temperature is at 40°F, or above, and rising, unless specifically authorized by the Engineer, in which event all materials shall be heated in a manner acceptable to the Engineer. In freezing weather, suitable means shall be provided for maintaining the concrete at a temperature of at least 50°F for a period of not less than 72 hours after placing, or until the concrete has thoroughly hardened. Salt, chemicals or other foreign materials shall not be mixed with the concrete for the purpose of preventing freezing. Concrete temperature shall not be allowed to exceed 90°F. during pouring operations or for 72 hours hereafter.

5.10 Finish

- (a) All permanently exposed concrete surfaces which are above water level, except slabs and precast manholes, shall have a uniform and textured surface. All form marks exposed to view shall be rubbed off with a stone.

5.11 Forms

- (a) Forms shall be of wood, steel or other authorized material. Where feasible, steel slip forms for continuous concrete placement may be used, subject to prior

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authorization by the Engineer of the materials to be used. Unless otherwise authorized, the form sheeting against permanently exposed concrete surfaces shall be either steel or plywood of the necessary strength.

- (b) Forms shall be built true to line and grade, and shall be mortar tight and sufficiently rigid to prevent displacement, or sagging between supports. Form surfaces shall be smooth and free from irregularities, dents, sags, or holes. Bolts and rods used for internal ties shall be arranged so that, when the forms are removed, no metal will be less than 1 inch from any concrete surface.
- (c) Forms shall not be removed without the authorization of the Engineer. Removal shall be accomplished in such manner as will prevent injury to the concrete. Forms shall not be removed before the expiration of the following minimum number of days after placement of concrete:

Slabs	14 days
Monolithic Pipe	7 days
Columns and Walls	2 days
Other Concrete	2 days

- (d) All exposed concrete edges shall be given a 3/4 inch chamfer unless other size chamfers are shown on the plans. Chamfers shall be formed by properly sized strips secured to the forms.

5.12 Embedded Items

- (a) Before placing concrete, all embedded items shall be firmly and securely fastened in place. They shall be thoroughly clean and free of any coating, rust, scale, oil or other foreign matter.

5.13 Reinforcement Bars

- (a) Reinforcement bars shall conform to the requirements of ASTM Specification A615 Grade 60. Bars shall be deformed in accordance with the requirements of ASTM Specification A615. Steel mesh reinforcement shall be electrically welded cold drawn mild steel fabric conforming to the requirements of ASTM Specification A185.
- (b) Prior to the placing of any steel reinforcement in the work, written evidence shall be submitted to the Engineer to the effect that such steel has been tested under and is in conformity with these specifications unless testing is specifically waived by the Engineer. Certified true copies of test and acceptance reports by a responsible testing laboratory shall be considered as evidence of compliance. Additional tests may be required by the Engineer upon the finished bars as furnished if deemed

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necessary.

- (c) Complete detailed shop drawings, bending diagrams and schedules of the steel to be used in the work shall be submitted by the Contractor to the Engineer for review prior to the fabrication of the steel. All steel which fails to meet these specifications or which has been improperly cut or bent, or which does not conform to the sizes shown on the plans shall be rejected.
- (d) On delivery to the site of the work, the steel reinforcement shall be carefully bundled, tagged and stored in such a manner that the bars for any position in the work may be readily identified. Reinforcement bars shall be protected from oil, grease, dirt and any other substance that could prevent proper bonding to the concrete.

5.14 Placing Steel

- (a) Before being placed in position, all steel reinforcement shall be thoroughly cleaned of oil, mill and rust scale and other coatings that would tend to destroy or reduce the bond. Where there has been a delay in depositing concrete after the reinforcement has been placed, it shall be re-inspected and re-cleaned, if necessary.
- (b) Reinforcement shall be accurately positioned and secured against displacement by using annealed or similar wire of not less than No. 18 gage, or suitable clips at intersections, and shall be supported by concrete or metal chairs, stays, spacers, hangers or other acceptable supports which shall have sufficient strength and stability to maintain the reinforcement in place throughout concrete operations.
- (c) The minimum distance between parallel bars shall be as shown on the plans. Bars placed parallel to a concrete face shall be embedded in the concrete so as to provide a protective coating around the bars of the following minimum thickness unless otherwise shown on the plans:

Slabs	1 inch
Floors, walkways, driveways	1 1/2 inches
Walls	2 inches
Columns (including Pier Columns)	2 inches
Footings in contact with ground	3 inches

- (d) Where splicing is necessary, the bars shall be lapped not less than 30 diameters, and splices shall be staggered. In all cases, the lapped connection shall be sufficient to transfer the stress between bars by bond and shear, and to develop the full strength of the bars. In slabs, beams and girders, no splices shall be made at points of maximum stress and in no case shall adjacent bars be spliced at the same point.

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- (e) All supports and ties shall be placed in such manner that they will not be exposed on the face of the concrete nor discolor the surface of the finished concrete. Reinforcement which has been exposed for bonding with future work shall be protected from corrosion by heavy wrappings of burlap saturated with a bituminous material.
- (f) Movement of steel reinforcement in place during concrete operations shall be prevented. Any rods which were displaced shall be restored to proper position before they are completely covered.

5.15 Joints

- (a) Construction joints and expansion and contraction joints shall be constructed only at locations shown on the plans, unless otherwise authorized by the Engineer. Concrete at all joints shall have been in place not less than 12 hours before concrete is placed on or adjacent to it. The joints shall be straight and exactly horizontal or vertical as shown on the plans. When shown on the plans, molded water stops shall be used in construction joints and expansion and contraction joints. Molded water stops shall be of rubber or polyvinyl chloride composition.
- (b) Molded rubber water stops for construction joints shall be the flat type, 6-inches in length, with a 3/4 inch bulb at each end. Molded rubber water stops for expansion and contraction joints shall be the flat type, 9-inches in length, with a 1-inch bulb at each end and a 1 1/2 inch hollow bulb in the center. Splices in rubber water stops shall be made by vulcanizing or by the use of a rubber union and rubber cement. Molded rubber water stops shall be as manufactured by A.C. Horn, W. R. Meadows, Inc., Rubber & Plastics compound Co., or equal.
- (c) Molded polyvinyl chloride water stops for construction joints shall be the flat type, 6-inches in length and 3/8 inch thick, with a 3/4 inch bulb at each end, as manufactured by A.C. Horn, or the flat type 6-inches in length and 3/8 inch thick with end and intermediate ribs, as manufactured by Vulcan Metal Products, Inc., A-H Products, Viveflex Corporation, or equal. Molded polyvinyl chloride water stops for expansion and contraction joints shall be the flat type, 9-inches in length and 3/8 inch thick, with a 1-inch bulb at each end and a 1 1/2 inch hollow bulb in the center, as manufactured by A.C. Horn, Vulcan Metal Products, Inc., A-H Products, Viveflex Corporation, or equal; or the flat type 9-inches in length and 3/8 inch thick, with an intermediate ribs and center hollow bulb as manufactured by Vulcan Metal Products, Inc., A-H Products, Viveflex Corporation, or equal. Splices in polyvinyl chloride water stops shall be made by the heat-softening process in strict accordance with the manufacturer's recommendations.
- (d) In expansion and contraction joints, premolded joint filler and cold applied joint sealing compound shall be applied in the opening on both sides of the molded

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water stop. Cold applied joint sealing compound shall be applied to the opening at the top of the molded water stop. Premolded joint filler shall be Self-Expanding Cork, Code 4324, and cold applied joint sealing compound shall be Vertiseal (light gray), a polysulfide polymer, both as manufactured by A.C. Horn, or shall be comparable products as manufactured by W.A. Meadows, Inc., Rubber & Plastics Compound Co., or equal.

5.16 Waterproofing

- (a) Waterproofing materials of the paint and/or membrane types shall be applied to concrete structures at the locations shown on the plans.
- (b) Waterproofing paint and its application shall be as shown on the plans or as specified in the Special Conditions.
- (c) Membrane type waterproofing shall consist of four coats of hot applied waterproofing pitch and three layers of No. 15 tarred felt, or one coat of cold applied setting cement and one layer of synthetic sheeting. Pitch and felt shall be as manufactured by the Barrett Division, Allied Chemical Corporation; the Flintkote Company; Johns-Manville; or equal. Cold applied cement shall be Nerva-Plast and synthetic sheeting shall be Nervastrol Seal-Pruf H-D, as manufactured by Rubber & Plastics Compound Co.; comparable materials as manufactured by Carlisle Tire & Rubber Division, Carlisle Corporation; Building Products Division, American Cyanamid Company; or equal. Membrane waterproofing shall be applied in accordance with the manufacturers' recommendations and as authorized by the Engineer.

5.17 Test Cylinders

- (a) During concrete placement operations the Contractor shall make test cylinders, generally three cylinders for each major pour or day's operations, or on large pours every 50 cubic yards of concrete poured unless additional testing is required by the Engineer on-site. The test cylinders shall be placed in a protected spot immediately after molding and kept under moist curing conditions for 24 hours, and then removed to the testing laboratory. The cost of providing cylinder molds, storing, transportation, handling, and testing the cylinders will be borne by the Contractor. Samples shall be taken and test specimens prepared in accordance with the requirements of ASTM Specification C31, and shall be tested in accordance with the requirements of ASTM Test C39. One cylinder shall be tested at 7 days and two cylinders shall be tested at 28 days for each major pour or day's operation unless otherwise authorized by the Engineer. In addition, one cylinder shall be tested at 56 days in the event that the 28-day test fails to meet the requirements of the specifications. Slump and air content tests shall be made at the time samples are taken for each set of cylinders. Test results shall be reported

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to the Engineer in writing and shall include the date and location of the pour from which the samples were taken.

5.18 Hydrostatic Testing

- (a) Concrete structures that are to contain water, sludge, or other liquids, such as settling or digestion tanks, coagulation basins, reservoirs, filter basins and similar structures shall be hydrostatically tested for leakage before backfilling, where applicable. Testing shall consist of filling each structure with water so that the Engineer can inspect and observe any leaks when the structure has been full of water from 24 to 48 hours. When practical, such tests shall be made before backfill is placed around the structure. All leaks in the structure are to be repaired in an approved manner. Patching or caulking or any other method of repair on the outside or dry side of walls will not be permitted. Damp areas or spots on permanently exposed walls, such as in filter galleries, will be considered leaks. For structures below finished grade, hydrostatic testing may be omitted when specifically authorized by the Special Conditions.

5.19 Grout

- (a) All grouts used on manhole interiors shall be "non-shrink" grouts. Grout used on manhole exteriors shall be either "non-shrink" or standard cement mortar grouts.
- (b) "Non-Shrink grouts shall be either Gilco pre-mixed Supreme nonmetallic grout as manufactured by Cormix Construction Chemicals, Dry Pack Grout "Willco Brand" by A. W. Cook Cement Products, Inc., or equal.
- (c) Acceptable range of testing requirements:

Compressive Strength (7 days)....7,000 to 9,000 PSI
Compressive Strength (28 days)....8,250 to 11,000 PSI
% Expansion.....+0.025% to +0.75%
- (d) Expansion grouts shall be used only as directed by the Engineer.
- (e) Grouts shall be mixed (if applicable) and placed in accordance with the manufacturer's current recommendations, for each specific application.
- (f) Cement mortar grouts shall be mixed and proportioned depending upon application range from plastic to flowable cement water paste.

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5.20 Unapproved and Damaged Work

- (a) On concrete work where samples failed to show proper strength or where the quality of the concrete is otherwise questionable, the Contractor may be directed to obtain cores for further testing. Such cores and tests shall be at the Owner's expense.
- (b) Unapproved or damaged work shall be satisfactorily replaced by the Contractor in accordance with the requirements of the plans and specifications. Removal and/or replacement of concrete work shall be done in the manner that will not impair the strength of the structure.