

SECTION 4 CONCRETE

- 4.01 General: The work described by this Section consists of furnishing all materials and equipment and performing all labor for the complete construction of all concrete work, including all work and appurtenances thereto, as shown or specified or both. Work shall include the installation of all sleeves, inserts, piping, hangers, anchors, frames and other items to be built into the concrete work, and all other work and appurtenances specified or required or both for proper execution of the work. All products to be built into concrete work shall be correctly positioned in the formwork. Positioning must be inspected and approved by the Engineer before concrete is placed.
- 4.02 Applicable Specifications and Quality Assurance: Concrete work shall conform to all requirements of ACI-318 *Building Code Requirements for Structural Concrete*, ACI-350 *Code Requirements for Environmental Engineering Concrete Structures* and ACI301 *Specifications for Structural Concrete*.
- 4.03 Concrete: Concrete shall be composed of cement, Class F fly ash (if required), admixtures (if required), fine aggregate, coarse aggregate and water proportioned and mixed to produce a plastic workable mix in accordance with the requirements of this Section and shall be suitable for the specific conditions of placement. Concrete shall be classified as 'A,' 'B' or 'C,' shall have normal setting characteristics (unless high early strength cement is specified); shall be used in the locations identified below and shall have 28-day compressive strengths not less than those listed below, except that concrete containing high early strength cement shall have 7-day compressive strengths not less than those listed below.
- A. Class 'A-1' concrete shall have a compressive strength of not less than 4,000-psi, and shall be used for reinforced concrete work and for unreinforced footings not thicker than 8".
 - B. Class 'A-2' concrete shall be used for slabs and walls for all water containment structures. Class 'A-2' concrete shall have a compressive strength of not less than 4,000-psi.
 - C. Class 'B' concrete shall have a compressive strength of not less than 2,500-psi, and shall be used for blocking gravity type walls and for unreinforced footings and slabs thicker than 8".
 - D. Class 'C' concrete shall have a compressive strength of not less than 1,500 psi and shall be used for concrete sub foundations, pipe envelopes and concrete backfill where required.
- 4.04 Materials:
- A. Admixture: Admixture may be added to Class 'A-1,' Class 'A-2' and Class 'B' concrete if its addition is approved by the Engineer. If approved, it shall be added in accordance with the admixture manufacturer's printed instructions. A standard dispenser shall be used to introduce the admixture into the mix, and the services of

the admixture manufacturer's representative to install and establish the operation of the dispenser shall be furnished by the Contractor.

- B. Fine Aggregate: Fine aggregate shall be natural sand having fineness modulus of no less than 2.30 and no more than 3.00. Variation in fineness modulus shall be limited to +0.20 from the average of all tests.

Aggregate shall satisfy the requirements of ASTM C33, amended to date, except that gradation shall be as follows:

<i>Sieve Size</i>	<i>Percent Passing, by Weight</i>
No. 4, Sieve	95 – 100
No. 8, Sieve	80 – 90
No. 16, Sieve	50 – 85
No. 30, Sieve	25 – 60
No. 50, Sieve	10 – 30
No. 100, Sieve	2 – 10

- C. Coarse Aggregate: Coarse aggregate shall be washed gravel or crushed stone consisting of hard, strong, durable and uncoated particles and shall contain neither vegetable matter nor soft, friable, thin and elongated particles in quantities considered deleterious by the Engineer. Coarse aggregates shall satisfy the requirements of ASTM C33, as amended to date, except that gradations shall be as follows:

<i>Sieve Size</i>	<i>Percent Passing, by Weight</i>
1-½" Sieve	100
1" Sieve	95 – 100
½" Sieve	25 – 60
No. 4, Sieve	0 – 10
No. 16, Sieve	0 – 5

- D. Cement: The cement for concrete Class 'A-1,' Class 'A-2,' Class 'B' or Class 'C' shall be Portland Cement. Bland fineness shall be less than 2,000. Cement types shall be furnished in accordance with the following:

1. Portland Cement shall conform to ASTM C150 Type II.
2. High Early Portland Cement shall conform to ASTM C150 Type III.
3. If Type II cement is not commercially available, subject to prior approval by the Engineer the Contractor may use an approved mix of Type I cement with fly ash. Fly ash, if used, shall satisfy the requirements of ASTM C618, except that loss-on-ignition shall not be more than 6%.

4. Cement shall be ACI 318-11 exposure categories F, S, P and C, and exposure category classes F2, S3, P1 and C1. Additional requirements include a maximum W/C ratio of 0.45, minimum compressive strength of 4,500 psi and total air content of 6%.
 5. Other provisions of these Specifications, except for cement, shall be applicable to such concrete.
- E. Fly Ash: Fly ash shall be Class F and conform with the requirements of ASTM C618, as amended to date, except that the loss-on-ignition shall not be more than 6%.
- F. Admixtures:
1. Concrete directly exposed to the elements and to cycles of freezing and thawing shall contain 4% (+/-1%) entrained air.
 2. Retarder shall be used when ambient air temperature of 75° F or higher is reached or expected during the day. Retarding admixtures shall conform to ASTM C-494.
 3. Crystalline Waterproofing Admixture: Class A-2 concrete in liquid containment structure walls only shall contain Xypex C-1000 admixture or approved equal for concrete work containing liquids. Xypex C-1000 admixture shall be dosed at a rate equal to 2% by the weight of Portland cement. For concrete containing fly ash the dosage rate shall be 2% by the combined weight of cement and fly ash.
 4. Type-F high-range water-reducing admixture may be added to Type A-1 and A-2 concrete for placement and consolidation. Type-F water-reducing admixture shall conform with ASTM C-494. The admixture shall be able to be "re-dosed" at the site if required, but only if the elapsed time from the time it was batched and the time the concrete is placed is less than 90 minutes. Concrete not placed at or sooner than 90 minutes from the time it was batched shall be returned to the ready mix plant.
 5. Admixture to be used shall be approved by the Engineer prior to inclusion into the mix.
- G. Water: Water shall be fresh, clean and free from injurious amount of oil and acidic, alkaline and organic materials.
- H. Forms: Forms shall be of plywood or of tongue-and-groove lumber and shall be of grade and type which will provide the concrete finish required. Forms constructed of tongue-and-groove lumber shall be lined when used to form exposed-to-view surfaces; form lining, where used, shall be tempered fiberboard not thinner than 1/8". Metal forms and other types of manufactured forms shall not be used unless their use has been approved by the Engineer. Form oil shall be non-staining mineral oil. Form ties shall be of the cone nut threaded rod or standard snap-tie type and designed so that when removed, no metal will be left closer than 1" from the finished concrete surface. The cavities left in faces of concrete work by removal of form ties shall be pointed-up with non-shrink mortar. Form ties shall have a

working strength of not less than 3,000 pounds when fully assembled and must be approved by the Engineer.

- I. Grout: Grout shall be composed of 1 part Portland Cement to 1 part sand to 2 parts of aggregate no larger than $\frac{3}{8}$ " and to those parts of water which will produce a grout having a consistency approved by the Engineer.
- J. Floor Hardener: Floor hardener shall be a silicious aggregate: Master Builders "Mastercron Aggregate," Devoe Paint Division of Cleanese Coatings Company "Hurundum," or equal.
- K. Water Stops: Water stops shall be of those configurations and types shown on the Drawings.
- L. Nonshrink Cement Based Grout: The work covered in this Specification consists of furnishing all manufactured nonshrink cement-based grout where called for on the Drawings. Grout shall be Five Star Grout as manufactured by U.S. Grout Corporation or equal. Nonshrink grout shall contain only premeasured, prepackaged materials supplied by the manufacturer. Water to be used for mixing Portland Cement manufactured grout shall be potable.
 - 1. Requirements for Nonshrink Cement-Based Grout: Manufacturer must submit certified information verifying:
 - a. Plastic Volume Change: The grout shall show no shrinkage (0.0%) and a maximum of 4.0% expansion at any time before initial set when testing according to ASTM C827.
 - b. Hardened Volume Change: The grout shall show no shrinkage (0.0%) and a maximum of 0.2% expansion on the hardened state.
 - c. Compressive Strength: All nonshrink cement-based grout shall show a minimum 28 day compressive strength of 5,000 psi at standard laboratory temperatures when tested according to ASTM C109.
 - d. Placeability: All nonshrink cement-based grouts shall be capable of a flowable consistency (124 – 145 flow) when tested according to ASTM C109. Standard nonshrink cement-based grout shall have a minimum initial set time of 60 minutes when tested according to ASTM C191.
 - e. Soundness: The grout shall contain no metallic substances, aluminum powder or other materials known to compromise long-term durability.
 - f. Technical Service: Technical service shall be made available by the manufacturer upon request of the Contractor for purposes of advising on proper procedures dealing with grout installation.
 - 2. Expansion Joint Filler: Expansion joint filler and sealer shall be as shown in the Drawings.

- M. Sand-Cement Repair Mortar: Mortar used for filling voids in concrete surfaces shall consist of not more than one part Portland cement to two and one-half parts sand by damp, loose volume.
- N. Smooth Steel Rods for Expansion Joints: ASTM A 36, smooth, round dowels shall be sawed to the length indicated; shearing of dowels will not be allowed. Dowels shall be of size, length and spacing indicated on the drawings.
- O. Supports for Reinforcing Bars: Bar supports including bolsters, chairs, spacers and other devices for slabs and mats cast on earth shall be of the height necessary to position the reinforcing bars as indicated on the drawings and shall have sand plates or other similar devices to prevent the supports from sinking into the earth grade. Materials for the manufacture of bar supports may consist of steel wire, plastic or precast concrete. Bar supports for elevated slabs and mats shall have plastic coated legs. Concrete bricks may be used to support reinforcing bars for slabs and footings for non-liquid-containment structures cast on grade. Compressive strength of bricks shall not be less than 4,000 psi.
- P. Fiber Reinforcement: High zirconia (minimum 16%) alkali-resistant glass fibers specifically designed for use with Portland cement and conforming to ASTM C1666/C1666M and Appendix F, 1/2" length typical shall be provided.

4.05 Storage: Cement and fly ash shall be stored immediately upon receipt at the jobsite in a thoroughly dry, weather tight and properly ventilated building having adequate provisions for preventing cement from absorbing moisture. Storage shall permit ease of access for inspection and permit definite identification of each shipment.

Fine and coarse aggregate shall be stored separately in a manner which will avoid the inclusion of foreign material. Stockpiles of coarse aggregate shall be built in horizontal layers in a manner which will minimize or eliminate segregation.

4.06 Sampling and Testing: Sampling and testing of aggregate, cement, and concrete cylinders shall be as specified in the "Control of Materials" section, and shall be made by an independent laboratory approved by the Engineer. Costs of all concrete testing shall be paid by the Owner. The Owner shall have access to all places where concrete materials and concrete are manufactured, stored, proportioned, mixed, placed and tested. *Modification 8.2, Standard Minimum Specification for Ready Mix Concrete* shall apply.

- A. Aggregate: The Contractor shall select the source of the concrete aggregates which he proposes to use in the work. The Contractor shall furnish suitable samples of those aggregates to the testing laboratory for testing and preparation of design mix not more than 60 days and no less than 30 days in advance of the time of proposed use.
- B. Cement: Cement which has been stored for more than 4 months after being tested shall be re-tested before use.
- C. Required Concrete Tests: Four cylinders from the same batch of concrete shall be made for each day's placing of each class of concrete of each 50 cubic yards or fraction thereof. Each cylinder shall comprise a test under the definition of this

Specification, with 1 cylinder being broken at the age of 7 days, 2 cylinders broken at the age of 28 days and 1 cylinder held in reserve.

- D. Owner's Duties in Inspection: All sampling, molding, transportation, storing, curing, preparation for breaking and testing of cylinders shall be the responsibility of the Owner and shall be performed by qualified personnel observing all requirements of ASTM C31 and ASTM C39. The Owner shall make and record slump test in connection with each sampling of concrete. The Owner shall determine the air content of the concrete delivered to the jobsite. The Owner representative shall visit the batching plant, observe and report on the compliance of procedures used therein with all provisions of this Specification and of applicable ASTM and ACI Standards, observe job conditions in the handling and placing of concrete and report any items of noncompliance with these Specifications to the Engineer.
- E. Contractor's Duties in Inspection: The Contractor shall deliver to the laboratory and Owner all materials to be used in tests required by these Specifications. The Contractor shall supply test cylinders, wheelbarrows, shovels, mixing boards, shaded work space for molding cylinders and similar equipment required by the Owner's representative for molding test cylinders. Contractor shall provide stable, insulated storage boxes equipped with thermostatically controlled heat for storage of cylinders for the first 24 hours after molding in accordance with ASTM C31. He shall keep slump cone available for use on the job at all times.
- F. Evaluation of Tests: Evaluation of test results shall be in accordance with ACI 214-65. Concrete shall be deemed satisfactory if the average of all 28 day tests representing one design strength is equal to or greater than the design strength and if the following additional conditions are met for 28 day tests.
1. No one test shall be less than 85% of the design strength.
 2. The average of any two consecutive tests shall not be less than 92.5% of the design strength.
 3. The average of any three consecutive tests shall be equal to or greater than the design strength.
 4. Not more than one test in 25 consecutive tests shall fall below the design strength.
- G. Faulty Concrete: Failure to measure up to any of the specified conditions constitutes faulty concrete. Unless otherwise directed by the Engineer, faulty concrete shall be removed and replaced with concrete as specified at no expense to the Owner.
- H. Additional Tests: Any additional tests must be approved by the Engineer prior to testing at no expense to the Owner. Load test, if permitted by the Engineer, shall be conducted in accordance with the loading criteria as required by the design of the structure as determined by the Engineer.
- I. Slump Tests: Slump tests of each concrete placement shall be made in the field with an accurately made sheet iron test cone and shall be made by the Contractor

in accordance with the procedure described in ASTM C-143. The slump of concrete to be placed in piers and wall shall not be less than 4", nor greater than 7". The slump for concrete to be placed in slabs on earth shall not be less than 1", nor greater than 4".

J. Leakage Tests: All water holding structures shall have a leakage test performed prior to acceptance. The test shall be performed in accordance with ACI 350.1-01. The testing shall conform to the following:

1. Fill structure to be tested to the normal operating liquid level. Filling rate shall not exceed 4' of water per hour and shall be at continuous uniform rate with continuous monitoring.
2. The exterior surface of the tank shall be monitored for flowing leaks. Repair any flowing leaks which occur before continuing filling.
3. The water shall be kept at the test level for at least 3 days prior to the actual test.
4. Measure the vertical distance to the water surface from a fixed point on the tank above the water surface. Record measurements at 24-hour intervals. The test shall be performed for a minimum of 3 days
5. A drop of the water surface exceeding 1/10 of 1% of the normal volume of contained liquid will be considered failing.
6. The structure will have also been considered to have failed the test if flowing or seeping water is observed, or if moisture can be transferred to a dry hand from the exterior surface.
7. Independently measure change in water volume due to evaporation and precipitation using a 24" deep white, watertight container not less than 10 square feet of surface area. Position the container to experience environmental conditions similar to the structure being tested. The volume change of the structure shall be corrected based on the water volume change in the sample container.
8. Failing tanks which exhibit no visible signs of leaking or seepage may be permitted to be immediately retested.
9. Failing tanks will be drained, repaired and retested until the tank has met the test requirements.
10. Methods for repairing concrete should be submitted as shop drawings for review by the Engineer.
11. Repairs and retesting of tanks shall be accomplished at no additional cost to the Owner.

4.07 Design Mix: Design mix for each classification of concrete to be used in the work shall be prepared and tested by the laboratory. The design mix shall be prepared, proportioned and mixed using samples of the cement, fly ash (if required), admixture (if required) and the aggregates to be used in the work. Not fewer than 4 cylinders shall be made from the design mix for each classification of concrete: 2 shall be tested at 7 days, and 2 shall be

tested at 28 days. Cylinders shall be made and tested in accordance with ASTM C-31 and C-39. If an existing design mix that was recently prepared using the same source of proposed materials is demonstrated to conform to this Specification, the Engineer may approve its use in the work.

4.08 Proportioning and Mixing: Proportioning and mixing shall be accomplished either at the jobsite or at a central mix plant. If proportioning and mixing is accomplished at the jobsite, the Contractor shall provide the equipment necessary to positively determine and control the actual amounts of ingredients entering the mix. If proportioning and mixing is accomplished at a central mix plant, the Contractor shall, through the testing laboratory, furnish a laboratory representative who shall control the proportioning and mixing of Class 'A-1' or Class 'A-2' concrete except as may be otherwise approved by the Engineer.

A. Proportioning of materials shall be accomplished in a manner which will produce a workable mixture having a slump within the required limits and having minimum water content.

1. The exact proportion of materials to be used in concrete shall be identical to that established by the design mix except that the proportions of materials shall be changed whenever, in the opinion of the Engineer, a change is necessary to obtain the required strength and the desired density for uniformity and workability. In structures intended to be watertight, good workability will be considered to be primary importance. The equipment necessary to positively determine and control the amounts of materials entering the concrete shall be furnished by the Contractor.

All materials shall be measured by weight, except for water, which may be measured by volume. One bag of Portland Cement shall be considered to weigh 94 pounds.

2. Cement and Fly Ash Content:

- a. Each cubic yard of concrete containing Type I or Type III cement shall contain not less than the following quantities of cement and fly ash.
 - Class 'A-1' or Class 'A-2': 470 pounds (5 bags) of cement and 100 pounds of Class F fly ash.
 - Class 'B': 376 pounds (4 bags) of cement and 100 pounds of Class F fly ash.
 - Class 'C': 376 pounds (4 bags) of cement; no fly ash required.
- b. Each cubic yard of concrete containing Type II cement shall contain not less than the following quantities of cement:
 - Class 'A-1' or Class 'A-2': 564 pounds (6 bags)
 - Class 'B': 470 pounds (5 bags)
 - Class 'C': 376 pounds (4 bags)

3. In calculating the total water content of mixes, the amount water borne on the surfaces of the aggregates shall in all cases be the least amount necessary to produce a plastic mix having the required strength and the desired

density, uniformity, workability and characteristics, yet being within the limits of slump.

4. The total volume of aggregates to be used in each cubic yard of concrete and proportion of fine aggregate to coarse aggregate shall be that amount necessary to produce a dense mixture having the required workability.
- B. Jobsite Mixing: Mixing, if accomplished at the jobsite, shall be accomplished with a batch mixer of approved design and of a type which will insure a uniform distribution of the ingredients. The entire contents of the drum shall be discharged before recharging. The volume of each batch shall not exceed the rated capacity of the mixer. The Contractor shall during the mixing and placing of concrete have no fewer than 2 mixers on the jobsite to maintain continuity of the placing in the event of mechanical failure of 1 of the mixers. The mixing of each batch shall continue not less than 1-½ minutes after all ingredients have been placed in the mixer. During mixing the mixer shall rotate at peripheral speed of no fewer than 200' per minute.
 - C. Central Plant Mixing: Mixing, if accomplished at a central mix plant, shall be accomplished by a plant which has had its layout, equipment and trucks approved by the Engineer. Concrete shall be mixed and transported to the jobsite in accordance with the requirements of ASTM C94. Loading tickets for Class 'A-1' or Class 'A-2' concrete shall be initialed by the laboratory representative and shall bear the time of loading. Tickets shall be handed to the inspector when the trucks arrive at the jobsite and before the load is discharged.
- 4.09 Installing Smooth Dowels in Construction Joints: Smooth steel dowels shall be smooth, straight and free of any bends or tabs that would prevent the dowels from functioning. Dowels shall be clean and free of dirt, grease, rust, or mill scale. Dowels shall be installed parallel with the surface of the slab, mat or wall and shall be installed square to the face of the joint. The half of the dowel that will be in the second concrete pour shall be lightly greased.
- 4.10 Placing: Before concrete is placed, the depth and character of the foundations, the adequacy of forms and falsework and the placing of reinforcing steel and inserts must be inspected and approved by the Engineer. Approval, however, shall not relieve the Contractor from the responsibility to produce the required work. Handling and placing of concrete and the preparation for placing concrete shall be as follows:
- A. Accumulated water and debris must be removed from excavations and from forms into which concrete is to be placed. Flow of water into those places shall be diverted into side drains or sumps and be removed without disturbing newly placed concrete. Forms, unless lined, shall be thoroughly wetted with water before concrete is placed so as to tighten the joint. Runways for buggies and wheelbarrows, if used, shall not be supported by forms. Concrete shall be conveyed in a manner which will not disturb forms.
 - B. Concrete shall be placed in daylight. Placing of concrete in a portion of the work shall not be started if that portion of the work cannot be completed during daylight unless otherwise specifically approved by the Engineer. That approval, however,

will not be given unless an adequate lighting system is provided and lighting system is approved by the Engineer.

- C. Concrete shall not be placed when the atmospheric temperature is cooler than 35°F. If, after placing concrete, the atmospheric temperature becomes cooler than 35°F, the Contractor shall enclose, heat and protect the concrete in a manner which will keep the air surrounding the fresh concrete at a temperature not cooler than 45°F for a period of 5 days after concrete is placed. In addition, all requirements specified in ACI 306.1-90 *Standard Specification for Cold Weather Concreting* shall apply. The Contractor shall assume all risk of protecting the concrete. Unsatisfactory concrete shall be rejected.
- D. When the ambient temperature is 90°F or above, special precautions shall be taken during mixing, placing and curing. In no case should the temperature of the concrete, when placed, be above 90°F. Attention shall be given to coordinating the dispatching of trucks with the rate of placement to avoid delays in delivery. When elapsed time from batching to placement is so long as to result in significant increases in mixing water demand or in slump loss, mixing in the trucks should be delayed until only sufficient time remains to accomplish mixing before the concrete is placed. On truck arrival at the jobsite, addition of water shall not be allowed other than that required to adjust the specified slump. The forms and reinforcing steel should be cooled to a temperature of not more than 90°F by spraying with fog nozzles. Admixtures for retardation shall conform to ASTM C494-17, Type B or Type D. Water curing is preferred, but prompt application of curing compound meeting ASTM C309-11 may be used. In addition, all requirements specified in ACI 305.1-06 *Specification for Hot Weather Concreting* shall apply.
- E. Concrete shall be transported from the mixer to the point of deposit with a crane-handled bottom-dump concrete bucket, concrete buggies or wheelbarrows. In the event the quality of the concrete as it reaches the forms and the method and placing thereof in the opinion of the Engineer is not satisfactory, the Contractor shall change his method of operation so as to place concrete in a manner approved by the Engineer.
- F. Concrete shall be placed in a manner which will prevent the segregation of aggregates and prevent displacing, reinforcing, coating and splattering the concrete reinforcing which is in place. Troughs, pipes, hoppers, chutes and canvas tremies shall be arranged and used in a manner which will insure the concrete is placed in the manner specified. The placing of concrete within formwork shall be regulated in a manner which will insure that the pressure within the formwork, caused by that placing, shall not exceed the design pressure of the formwork. Concrete shall be placed in continuous horizontal layers, the thickness of which in general shall not exceed 4'. Each batch and each layer shall be placed immediately following the preceding batch and layer, so there will be no "cold joints" in the work. Care shall be used to fill each part of the forms. Concrete shall be deposited as near final position as possible. After the concrete has taken its initial set, care shall be used to avoid jarring the formwork and placing strain and vibration on the ends of

projecting concrete reinforcements. If concrete must be dropped more than 5', it shall be deposited through a tremie.

1. Concrete when placed shall be compacted with mechanical internal-vibrating equipment. Compaction shall be supplemented with hand spading using a steel-splicing rod. Vibrating equipment shall not be used to transport concrete within forms. Vibrating equipment shall maintain an impulse rate of no less than 5,000 impulses per minute when submerged in concrete. No less than 1 spare vibrator shall be maintained on the jobsite as a relief. The duration of vibration shall be limited to that time necessary to satisfactorily consolidate the concrete without causing objectionable segregation. The vibrator shall not be inserted into lower layers which have begun to set.
2. Thin-section work shall be thoroughly worked with a steel rod. Faces of thin-section work shall be shaped and mortar flushed to the surface. Small diameter holes shall be drilled in formwork beneath large wall sleeves and inserts to prevent the entrapment of air beneath those sleeves and inserts when concrete is placed.

G. Concrete shall be placed and compacted in a manner which forms a dense, compact, impervious structure having smooth faces on exposed surfaces. Concrete work found to be porous, plastered and otherwise defective in the opinion of the Engineer shall be removed and replaced in whole or in part as directed by the Engineer at no additional expense to the Owner.

4.11 Joints:

A. Construction Joints: Construction joints shall be located where shown and where directed and approved by the Engineer. Placing of concrete, once started, shall continue without interruption so that the placement will be monolithic. No less than 72 hours shall elapse between casting of adjoining units unless otherwise approved by the Engineer. The Contractor shall submit to the Engineer for approval the detailed location of construction joints not shown on the Drawings but required for the execution of the work prior to the detailing of any reinforcing steel.

1. Construction joints in footings and walls required for proper execution of the work but not shown shall be located where directed by the Engineer and across regions of low shearing stress so as to least impair the strength and appearance of the work. Special provisions shall be made for joining successive units as shown and as directed by the Engineer.
2. Construction joints in slabs, required for proper execution of the work but not shown, shall be located where directed by the Engineer. Special provisions, including concrete footing for construction joints in slabs on earth, shall be made for joining successive units as shown and as directed by the Engineer.
3. Keys shall be constructed in construction joints where shown and where directed by the Engineer. Keys and water stops shall be placed in those construction joints which will be subject to water pressure.

- B. Expansion Joints: Expansion joints, when required, shall be as shown on the Drawings.
- C. Bonding: Before placing new concrete work on and against concrete work which has recently set and that which has cured, the surfaces of recently set and cured concrete work shall be thoroughly roughened and made free from all foreign matter and laitance, the forms shall be placed and tightened, and the surfaces of the recently set and cured concrete shall be slushed with grout. New concrete shall be placed before the grout has attained its initial set. Bonding shall be accomplished in a manner which will insure complete bonding. Grout 2" to 4" shall be applied to construction joints.

Bonding of new concrete work to existing hardened concrete shall be accomplished with a multi-component epoxy adhesive complying with ACI 503R and construction procedures complying with ACI 503.2.

4.12 Forms: Forms shall be constructed, braced and removed in accordance with the following:

- A. Forms shall be built to conform to the shape, lines and dimensions of the concrete work. Forms shall be set to line and grade and shall be braced, tied and secured in a manner which will withstand placing of the concrete and which will maintain shape and position. Forms shall be tight and be substantially assembled to prevent bulging and the leaking of concrete. Chamfer strips shall be placed in exterior corners of forms. Joints shall be arranged vertically or horizontally. Temporary openings shall be provided, where required, at the bottoms of wall forms and elsewhere to facilitate cleaning and inspecting. Lumber used once in forms shall have nails removed, and the surfaces in contact with concrete work shall be thoroughly cleaned before reusing the lumber for forms. Wall sleeves, inserts and openings shall be properly set in forms.
- B. Shores shall be used where necessary. If adequate foundations for shores cannot be obtained, trussed supports shall be provided. Structural members, another work which will be subject to additional loads during construction, shall be adequately shored to protect that work from distortion and damage.
- C. Forms shall not be removed until the member supported thereby has acquired sufficient strength to safely support its own weight and the load imposed on it. Tie rod clamps shall be loosened 24-hours after concrete has been placed. Standard snap ties shall be removed when forms are stripped. Care shall be taken to avoid spoiling the concrete surface. Cutting ties back from the face of the wall will not be permitted. Under normal conditions, the time elapsing before the forms may be stripped shall not be less than that shown in the following schedule.

- | | | |
|----|---|---------|
| 1. | Slabs: | 14 days |
| 2. | Columns and Pedestal: | 7 days |
| 3. | Walls and Vertical Faces Not Supporting Other Work: | 2 days |

The use of the schedule shall not relieve the Contractor from his responsibility for the safety of the structure. Wood forms shall be completely removed from all portions of the work, so no material will remain for termite infestation.

- 4.13 Finishing: Exterior concrete surfaces shall be finished to levels no less than 12" below finish grade levels. Interior concrete surfaces below grade and concrete surfaces exposed to view shall be finished. Interior of basins shall be finished to a level not less than 12" below normal water level. Concrete not exposed to view shall have rough edges tooled off. Irregularities shall be filled, pointed-up with non-shrink sand, cement, mortar, and spot finished. All imperfect concrete shall be removed to dense solid concrete and repairs made as directed by the Engineer.

When concrete has set sufficiently to permit, forms and form ties shall be carefully removed. Depressions resulting from removal of form ties and other holes and rough places shall be thoroughly wetted with water and pointed-up.

A. Walls and Vertical Surface:

1. Procedures:

- a. Surface Preparation: Grind all seams and form joints level with surrounding concrete. Patch any holes, honeycomb, tie holes, and similar imperfections with non-shrink construction grout, including bonding admixture, and allow to dry. Wall surface must have smooth level finish, approved by the Engineer's inspector, prior to beginning the finish coat.
- b. Finish Coat: Apply bonding agent in front of grout application, not allowing to dry before grout is applied. Apply thin coat of non-shrink grout mix with rubber coarse sponge. Follow sponge application with carborundum stone, rubbing grout in a circular motion not allowing the grout to dry. Before grout dries, apply a light broom finish using a soft bristle brush.

2. Products:

- a. Bonding Agent: Provide acrylic latex liquid bonding admixture compliant with ASTM C1059, Type II, non-yellowing, UV resistant as manufactured by Euclid, WR Meadows, or equal.
- b. Non-Shrink Grout: Provide non-shrink, non-staining, non-metallic cement based grout compliant with CRD C 621 and ASTM C 1107 as manufactured by Euclid, WR Meadows, or equal.

- B. Slabs on Earth: Before constructing concrete slabs on earth, all piping which will be under those slabs shall have been tested, approved and encased in Class 'C' concrete. The sub-grade shall provide a solid bearing and shall be brought to a true and even plane. Where floor drains occur, floors shall be pitched as shown on the Drawings. The concrete shall have comparatively dry consistency and shall be screeded level or to the proper grade. After compacting and vibrating the concrete, the surface shall be prepared to receive the specified finish.

- C. Wood Float Finish: All floors, walks, platforms stairs and other slab work shall have a wood float finish. After screeding to the required grade while the concrete is still green but has hardened sufficiently to bear the finisher's weight, the concrete

surface shall be floated with a wood float to a true and even plane, have no visible coarse aggregate and be sufficiently rough to prevent slipping.

- D. Floor Topping: Floor topping shall be applied where shown. Sub-base shall be wire-brushed before sub-base has hardened, shall be swept clean, shall be thoroughly wetted and shall be slushed with bonding grout. Topping shall be floated and troweled twice in a manner which will prevent the fine material from being drawn-up. Floor hardener shall be applied in strict accordance with the hardener manufacturer's printed instructions. Other type finishes shall be as shown on the Drawings.
- E. Trowel Finish: Apply trowel finish on interior slabs to receive floor coverings or where indicated on Drawings. Troweling shall follow the float finish as previously described and when the surface has sufficiently hardened. Trowel until the surface is free of trowel marks and has a uniform appearance and texture. Any defects that may project through surface coatings or coverings shall be ground smooth.
- 4.14 Curing and Protecting: Freshly placed concrete shall be protected from rain and flowing water. Concrete shall not be allowed to dry-out from the time it is placed until the expiration of the specified curing period. Methods of curing unless otherwise approved by the Engineer shall be as follows:
- A. Concrete shall be kept wet with clean water for period of 7 days after placing. Each day forms are left in place shall suffice for wetting.
- B. Curing may be accomplished by leaving forms sufficiently wet to prevent opening of joints.
- C. If formwork is removed prior to seven days following placement concrete surfaces shall be wet cured by covering the concrete with a 4-mil white polyethylene sheet. Immediately prior to installing the sheeting thoroughly wet all concrete surfaces by spraying with clean water. The sheeting shall be held close to the surface and all joints continuously taped to prevent air from getting under the sheeting. The concrete surface shall be checked once a day and concrete surfaces showing drying shall be sprayed with clean water. The sheeting may be removed after a total of 7 days have elapsed following concrete placement.
- 4.15 Imperfect and Damaged Work and Materials: Imperfect and damaged work and materials shall be satisfactorily removed. New work and new materials which are in accord with the requirements of the Drawings and Construction Specifications shall be furnished and installed at no additional expense to the Owner. Removal of imperfect and damaged work and materials and the installation of new work and materials shall be accomplished in a manner which will not impair the strength of the structure.
- 4.16 Cleaning: Upon completion of work, all forms, equipment, protective covering and rubbish resulting from the work shall be removed from the premises. Finished concrete surfaces shall be left in a condition satisfactory to the Engineer and Owner.
- 4.17 Payment: No separate payment will be made for the work under this Section except as may be specifically set forth in the Proposal. The cost of the work of this Section and all costs incidental thereto, except that work which may be specifically set forth in the Proposal, shall be included in the price bid for the items to which the work pertains.