

SECTION 03300**CAST-IN-PLACE CONCRETE STRUCTURES****03300.01 GENERAL****A. Description**

Cast-in-place concrete structures shall include the construction of Portland cement concrete structures to the lines and dimensions and at the locations shown on the Plans and in accordance with the Contract Documents.

B. Related Work Included Elsewhere

1. General excavation; Section 02220.
2. Excavation support; Section 02400.
3. Dewatering; Section 02512.

C. Quality Assurance

1. General
 - a. The Engineer will inspect all materials before and/or after installation to ensure compliance with the Contract Documents. When specific tests of materials are called for in the referenced standards and specifications, the Engineer has the option of requiring that any or all these tests be performed for materials furnished for a specific Project. When testing is required, it will be specified herein or in the "Special Provisions".
 - b. The Engineer will conduct normal concrete job control tests, i.e. slump and air content, on the plastic concrete and will prepare test cylinders in accordance with Section 03310.01.
 - c. For the purpose of determining the time when falsework, forms, etc. may be removed, backfill made, and when loads may be applied to structures, an adequate number of test specimens shall be made in addition to the number required to check the quality of the concrete being produced.
 - d. Design mixes to produce concrete of proper workability, durability, compressive strength, maximum density, and minimum shrinkage and permeability.
 - e. Design mixes to have a minimum water-cement ratio, the largest permissible maximum size specified coarse aggregate, and an optimum percentage of fine aggregate.

- f. Use maximum size of coarse aggregate in accordance with ACI Committee 613 Report, Recommended Practice for Selecting Proportions for Concrete.
2. Durability
 - a. For durability purposes, use a water-cement ratio in accordance with either ACI Committee Report 613, Table 4 as determined by the type of structure and exposure conditions, or 0.50 by weight whichever is the lesser.
 3. Workability
 - a. Use approved chemical or air-entraining admixtures, or suitable combinations thereof to improve workability, as well as to reduce water and cement contents, and minimize shrinkage and permeability of concrete, provided that these admixtures do not adversely affect other required properties of concrete.
 4. Strength
 - a. Design the mix for each class and type of concrete of a specified compressive strength based on the required overdesign factor according to ASTM C94, and assuming a coefficient of variation equal to 15. Unless otherwise shown, working stress method of design will apply to structures.
 - b. For working stress method of design, each class of concrete shall be designed so that not more than 20 percent of the compressive strength tests will have values less than the specified compressive strength, and the average of six consecutive strength test will be equal to or greater than the specified compressive strength.
 5. Method of Proportioning
 - a. For proportioning mixes use methods as described in ACI Report 613.
 - b. Vary mixing water content as specified in ACI Report 613, Table 3.
 - c. Do not vary the proportions of the ingredients of the approved mixes without the written approval of the Engineer.
 6. Inspection

The Contractor shall provide all facilities as are reasonably required for the safe and convenient conduct of the Engineer's inspection procedures.
 7. Tolerances for Formed Surfaces

Formed surfaces shall be true to the lines and dimensions shown on the Contract Documents to the tolerances listed herein:

 - a. Variation from plumb:

- 1) In the lines and surfaces of columns, piers, walls, and in arises:
- | | |
|-------------------------------|----------|
| In any 10 foot of length | 1/4 inch |
| Maximum for the entire length | 1 inch |
- 2) For exposed corner columns, control-joint grooves, and other conspicuous lines:
- | | |
|-------------------------------|----------|
| In any 20-foot length | 1/4 inch |
| Maximum for the entire length | 1/2 inch |
- b. Variation from the level or from the grades specified in the Contract Documents:
- 1) In slab soffits, ceiling, beam soffits, and in arises, measured before removal of supporting shores:
- | | |
|-------------------------------------|----------|
| In any 10 foot of length | 1/4 inch |
| In any bay or in any 20-foot length | 3/8 inch |
| Maximum for the entire length | 3/4 inch |
- 2) In exposed lintels, sills, parapets, horizontal grooves, and other conspicuous lines:
- | | |
|-------------------------------|----------|
| In any bay or 20-foot length | 1/4 inch |
| Maximum for the entire length | 1/2 inch |
- c. Variation of the linear structure lines from established position in plan and related position of columns, walls, and partitions:
- | | |
|-------------------------------|----------|
| In any bay | 1/2 inch |
| In any 20 foot of length | 1/2 inch |
| Maximum for the entire length | 1 inch |
- d. Variation in the sizes and location of sleeves, floor openings, and wall openings: $\pm 1/4$ inch
- e. Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls:
- | | |
|-------|----------|
| Minus | 1/4 inch |
| Plus | 1/2 inch |
- f. Footings*
- 1) Variations in dimensions in plan:
- | | |
|-------|----------|
| Minus | 1/2 inch |
| Plus | 2 inches |

- | | | |
|----|--|----------|
| 2) | Misplacement or eccentricity: | |
| | 2% of the footing width in the direction of misplacement but not more than | 2 inches |
| 3) | Thickness: | |
| | Decrease in specified thickness | 5% |
| | Increase in specified thickness | No limit |

g. Variation in steps:

- | | | |
|----|------------------------|-----------------|
| 1) | In a flight of stairs: | |
| | Rise | $\pm 1/8$ inch |
| | Tread | $\pm 1/4$ inch |
| 2) | In consecutive steps: | |
| | Rise | $\pm 1/16$ inch |
| | Tread | $\pm 1/8$ inch |

*Tolerances apply to concrete dimensions only, not to positioning of vertical reinforcing steel, dowels, or embedded items.

8. Defective Work

Porous areas, open or porous construction joints, and honeycombed concrete indicate that all of the requirements for mixing, placing, and handling have not been complied with and shall be considered as sufficient cause for rejection of the members of the structure thus affected. Defective work exposed upon removal of forms shall be entirely removed or repaired within 48 hours after forms have been removed.

No repaired area will be accepted unless:

- a. the structural requirements have not been impaired by reducing the net section of compression members;
- b. the bond between the steel and concrete has not been reduced;
- c. the areas shall be finished so as to blend in every respect with the texture, contour, and color of the surrounding concrete.

If the above limitations cannot be satisfied, the members or unit involved shall be removed and satisfactorily replaced entirely at the Contractor's expense.

Defective areas shall be cut out to such depth that all voids, honeycombed, or any other defect are entirely removed. The edges of the material remaining in place shall be cut perpendicular to the finished surface to the full depth of the material removed but not less than 1 inch.

If the removal of defective concrete affects the structural requirements as above defined, the member likewise shall be removed and replaced.

The area to be repaired and a space at least 6 inches wide entirely surrounding it shall be wetted to prevent absorption of water from the patching mortar. The patch shall be made with mortar; the mix of which shall be predetermined by making trial batches to secure a mix matching the color and texture of surrounding concrete. In order to facilitate color matching, the Contractor shall obtain a quantity of Portland cement from his concrete supplier that shall be used to mix the patching mortar. The amount of water used in mixing the mortar shall be as little as is consistent with the requirement of handling and placing. The mortar shall then be put aside for 1 hour during which time it shall be mixed with a trowel to prevent setting. No additional water shall be added to the mix. The mortar shall be thoroughly compacted in place and screeded off so as to leave the patch slightly higher than the surrounding surface. It shall then be left undisturbed for a period of 1 to 2 hours to permit initial shrinkage before being finally finished. The patch shall be finished in such a manner as to match the adjoining surface. On surfaces where unlined forms have been used, the final finish shall be obtained with straightedge spanning the patch and held parallel to the direction of the form marks. After the patches have set sufficiently so that the surface will not be damaged, curing and protection of concrete shall proceed as required for the original concrete section.

D. Submittals

1. Shop Drawings

Shop drawings shall be submitted as specified in the "General Provisions" for the following materials and shall include the following information: preformed expansion joint material, joint sealers, curing materials, form release compounds, and waterstops: general product information, chemical composition, and dimensional information where appropriate.

2. Samples

Membrane-forming curing compound: Two one-pint samples, each type.

3. Design Mixes

- a. At least 30 days prior to the start of placing concrete, submit design mixes for each class and type of concrete, indicating that the concrete ingredients and proportions will result in a concrete mix meeting the requirements specified.
- b. Include for each class and type of concrete as many mix designs as there are combinations of different ingredients, or type of ingredients, anticipated to cover the requirements of the contract work.
- c. Compression test cylinders from all footings, walls and slabs shall be made at the Contractor's expense by an independent testing laboratory approved by the Engineer and tested in accordance with the ACI Code and "Method of Test for

Compressive Strength of Molded Concrete Cylinders (ASTM C39)". One set of cylinders will

- d. be required for the first 5 cubic yards and one set for each 25 cubic yards thereafter for each day's pour.
 - e. Furnish two (2) copies of each report to the Engineer and one copy to local government building department and structural engineer. Concrete which does not meet the Specifications will be required to be removed and replaced at the Contractor's expense or may be subjected to a load test, also at Contractor's expense.
 - f. Establish the mix designs and have them tested through the laboratory.
 - g. Submit cylinder test results for the various mix designs showing compressive strength at 2, 7, and 28 days.
4. Proposed methods for controlling concrete temperature.
5. Certificate of Compliance
- a. Certificates of compliance shall be submitted in accordance with the "General Provisions" for all waterstop, joint filler, preformed joint fillers, form release compounds, paraffin wax, and Portland cement concrete curing materials stating that the material furnished is in accordance with, and meets the test requirements specified in Section 03300.02.
 - b. Ingredients
 - 1) Submit with the mix design, laboratory test reports and mill or manufacturer's certificates attesting to the conformance of ingredients with these specifications. Use ingredients in the design mix which are representative samples of the materials to be used in the contract work.
 - 2) In case the source, brand or characteristic properties of the ingredients need to be varied during the term of the contract, submit revised laboratory mix report, in conformance with the above procedures.
 - c. Batch Tickets

Submit a delivery ticket from the concrete supplier with each batch delivered to the site setting forth the following information. Submit certificate to the Engineer before unloading at the site.

 - 1) Name of Supplier
 - 2) Name of batching plant and location

- 3) Serial number of ticket
- 4) Date
- 5) Truck Number
- 6) Specific job designation (contract number and location)
- 7) The volume of concrete (cubic yards)
- 8) Specific class and type of concrete (in conformance with the specification requirements)
- 9) Time loaded
- 10) Type and brand of cement
- 11) Weight of cement
- 12) Maximum size of aggregates
- 13) Weights of coarse and fine aggregates, respectively
- 14) Maximum amount of water to be added and amount of water added at the site, if any.
- 15) Kind and amount of admixtures

E. Product Delivery, Storage And Handling

1. Aggregates

- a. Transport and stockpile aggregates according to their sources and gradations. Handle in a manner which will prevent segregation and loss of fines or contamination with earth or foreign materials.
- b. If aggregates show segregation or the different grades become mixed, rescreen before placing in the proportioning bins.
- c. Do not use aggregates from different sources or of different gradations alternatively. Mix only to obtain different gradations.
- d. Do not transfer aggregates directly from trucks, railroad cars or barges to the proportioning bins when the moisture content is such that it will affect the accuracy of the proportioning of the concrete mixture. In such case, stockpile aggregate until the excess moisture drains off.

2. Packaged Cement

- a. Deliver to the project site in original sealed packages labeled with the weight, name of the manufacturer, brand, and type specified.
- b. Store packages in a water-tight building.
- c. Do not use cement which has been reclaimed by cleaning bags.
- d. Do not use cement which has been damaged by exposure or overstocking.
- e. Do not deliver packages varying more than three percent from the specified weight.

- f. Packaged cement will be subject to test at any time.
3. Bulk Cement
 - a. Store bulk cement separately from other cement and protect from deterioration from exposure to moisture and intrusion of foreign matter.
4. Provide facilities to maintain separation of cement meeting the requirements of these specifications from other cement.
5. Provide in cement manufacturer's plant, facilities for sampling of cement at the weighing hopper or in the feed line immediately before entering the hopper.
6. Do not use different brands of cement, or the same brand of cement from different sources without approval.

03300.02 MATERIALS

A. Materials Furnished by the County

1. The County will not furnish any materials for cast-in-place concrete.
2. The Contractor may purchase water from the County's potable water system in accordance with current County policies and procedures. The Contractor shall contact the Bureau of Utilities, Meter Section, for requirements.

B. Contractor's Options

The Contractor may furnish higher strength concrete than specified.

C. Detailed Material Requirements

1. Portland Cement Concrete

Portland cement concrete shall be the mix number called for in the Contract Documents and shall be in accordance with the requirements of Section 03310.03.

2. Concrete Reinforcement

Concrete reinforcement shall be the size and type specified and shall be in accordance with the requirements of Section 03200.03.

3. Joint Fillers

The hot applied material shall be in accordance with ASTM D6690. Manufacturers' recommendations regarding pouring temperature will be used when testing this material. If a range of temperatures is recommended, the mid point will be used as the pour point. The cold applied type shall be in accordance with ASTM D5893.

4. Preformed Joint Fillers

The cork type shall meet the requirements of AASHTO M 153. The bituminous fiber type shall be in accordance with AASHTO M 213 with the bitumen content determined by MSMT 408.

5. Roofing Paper

Roofing paper to be used in expansion joints shall be composed of roofing felt saturated and coated on both sides with an asphaltic material. It shall not weigh less than 39.8 pounds per 100 square feet and shall not crack when bent 90 degrees over a 1/2 inch radius at room temperature.

6. Waterstops

Waterstops shall be made of rubber or polyvinyl chloride. The rubber type may be of natural rubber, synthetic rubber, or a suitable combination of natural and suitable synthetic rubber. The polyvinyl chloride shall contain at least 90% virgin polyvinyl chloride. The remaining 10% may include one or more monomers copolymerized with vinyl chloride or consist of other resins mechanically blended with polyvinyl.

The waterstop shall be of the shape and dimensions shown on the Plans. The cross section shall be uniform along the length and transversely symmetrical so that the thickness at any given distance from either edge of the waterstop shall be uniform. The waterstop shall be dense, homogeneous, and free from holes and other imperfections.

The waterstop shall meet the following requirements:

Tensile Strength, ASTM D 412, psi min.	2000
Elongation at Break, ASTM D 412, % min.	300
Hardness, Rubber, Type A Durometer, ASTM D 2240	55 ± 5
Hardness, PVC, Type A Durometer, ASTM D 2240	75 ± 5

7. Form Release Compounds

Form release compounds shall effectively prevent the bonding of the concrete to the forms. The form release compounds shall not cause discoloration of the concrete nor adversely affect the quality or rate of hardening at the interface of the forms. The compounds will be tested in accordance with MSMT 503.

The flash point of the material shall not be less than 100°F when tested in accordance with AASHTO T 73.

8. Paraffin Wax

Paraffin wax for use as a bond breaker for concrete shall be water clear. The flash point shall not be less than 380°F when tested in accordance with ASTM D 92.

9. Portland Cement Concrete Curing Materials

Curing materials shall be burlap cloth, sheet materials, or liquid membrane-forming compounds.

a. Burlap

Burlap cloth shall be made from jute or kenaf and shall be in accordance with AASHTO M 182, Class 1, 2, or 3.

b. Burlap Polyethylene Sheeting

Sheet material shall be in accordance with AASHTO M 171 except that tensile strength and elongation requirements are waived. White burlap polyethylene sheeting shall give a finished product weight of not less than 10 ounces per square yard.

c. Liquid Membrane

Liquid membrane-forming compounds shall be in accordance with AASHTO M 148.

Field control testing of the white pigmented curing compounds will be on the basis of weight per gallon. The samples shall not deviate more than plus or minus 0.3 pounds per gallon from the original source sample.

10. Vapor barrier

a. Building paper shall be Sisal-Kraft building paper, conforming to requirements ASTM C171.

b. Polyethylene sheeting shall be 0.006 inch thick, conforming to requirements of ASTM D 2103.

03300.03 EXECUTION

A. General

1. Concrete shall be mixed as specified in Section 03310. Concrete shall be delivered to the site in accordance with ASTM C 94.
2. The Contractor will be required to use concrete equipment of sufficient capacity to complete any unit or section of masonry between construction joints, as indicated on Plans, in one continuous operation consistent with placement operations as approved by the Engineer.

3. Hand mixing may be permitted with written approval of the Engineer for small volumes of concrete. However, its intended use is for small, isolated areas where structural integrity is not critical.
4. Before placing any concrete, the Contractor shall install all sleeves, anchors, frames, fittings, pipes, conduits, or other special devices called for in the Contract Documents. No concrete shall be placed until this work has been approved by the Engineer. The Contractor shall ascertain that all material to be installed in the concrete by other trades has been placed prior to pouring any concrete. Any concrete poured without prior provisions having been made for inclusion of the indicated inserts and materials will be subject to rejection by the Engineer and/or correction at the Contractor's expense.

B. Forms

Forms for concrete work shall be mortar tight.

1. Design Criteria

Design of the forms shall be the Contractor's responsibility. Forms shall be designed for strength and deflection to resist all loads and pressure of wet concrete. The design shall provide for rate of pour, effect of vibration, and use of retarders, etc. In addition, horizontal surfaces shall have applied to them a live load of 50 pounds per square foot. This load is to be used in the design of the forms for strength only and is not to be used in computing deflections. However, in the design of forms for horizontal slabs, in no case shall this loading be less than a total of 120 pounds per square foot. (This does not apply to form joists, form wales, etc.) No form member or support thereof shall have a deflection in excess of 1/240 of its span length, and in no case shall said deflection exceed 1/4 inch. An exception is deflection of form surfaces for concrete floor slabs where such concrete is supported by beams, stringers, or girders, which may be 1/180 of the span length but not in excess of 1/2 inch. In steel forms that remain in place, camber shall not be used to compensate for deflection in excess of the foregoing limits. The design spans of the form sheets shall be the clear span of the form plus 2 inches measured parallel to the form flutes.

2. Concrete and Form Unit Weights

All buckets, buggies, finishing machines, etc. shall be removed from the forms before concrete attains its initial set. The concrete shall be assumed to weight 150 pounds per cubic foot unless lightweight concrete is specified. The lumber in the forms shall be assumed to weigh 60 pounds per cubic foot. When forms are composed of material other than lumber, the unit weight shall be in accordance with the AASHTO specifications.

3. Plywood Forms

The strength of plywood (without backing) shall be calculated on the basis of the grain of the face plies running parallel to its span, and it shall be so installed. When the plywood is against backing, the strength of the plywood will be neglected; and the backing must carry the entire load. In cases where the plywood form panels are to be reused, the actual span length of the plywood shall be 2 inches less than the computed maximum allowable span. The unit stresses to be used shall be as subsequently described.

4. Forms at Construction Joints and Corners

At construction joints in concrete, ties or bolts shall be provided 3 to 6 inches from each side of the joint for tightening the forms against the hardened concrete (first pour) immediately prior to placing fresh concrete. At joints where forms have been removed and reconstructed, the form surface shall extend over the concrete already in place; and the forms shall be drawn tightly against the previously placed concrete immediately prior to placing the fresh concrete. Where forms have been extended, the forms shall be retightened against the concrete already in place immediately before placing fresh concrete.

Forms shall be filleted at all sharp corners, except when otherwise indicated on the Plans and shall be given a bevel or draft in the case of all projections, such as girders, copings, etc., sufficient to ensure easy removal.

5. Bracing and Maintenance

Special attention shall be paid to bracing; and where the forms appear to be insufficiently braced or unsatisfactorily built, either before or during the placing of concrete, the Engineer will order work stopped until the defects have been corrected. All forms shall be so maintained as to eliminate the formation of joints due to the shrinkage of lumber. All forms shall be set and maintained true to the line designated until the concrete is sufficiently hardened. For narrow walls where access to the bottom of the forms is not readily attainable otherwise, provide temporary openings at the base of column forms, wall forms, and at such other locations as may be necessary to clean out all chips, dirt, sawdust, or other extraneous material immediately prior to placing concrete. Existing forms may be extended after the concrete in said forms have been in place for at least 12 hours, provided such form extension can be done without any damage to the previously placed concrete.

Unit stresses for forms, form supports, falsework, and bracing shall not exceed the AASHTO Specification except as modified hereafter:

- a. Bending in Timber - Unit stresses stipulated in AASHTO for timber may be increased by 1/3 with a maximum value of 1800 psi.
- b. Horizontal Shear (Timber) - Horizontal shear for beams up to 6 inches in depth shall not exceed 200 psi. Form beams more than 6 inches in depth;

the horizontal shear shall not exceed 150 psi. The method for calculating horizontal shear shall be in accordance with AASHTO specifications.

- c. Compression Perpendicular to Grain (Timber) - Unit stresses stipulated in the latest edition of the AASHTO specifications for treated timber may be increased by 25%.
- d. Compression Parallel to Grain (Timber) - Unit stresses stipulated in the latest edition of the AASHTO specifications for treated timber may be increased by 25%.
- e. Timber Columns - Use values from formulas in AASHTO specifications increased by 25% except for long columns when no increase in value will be allowed.
- f. Moduli of Elasticity - Same as stipulated in AASHTO specifications.
- g. Structural Steel Members - The unit stresses developed in structural steel members of formwork or falsework shall not exceed the values stipulated in the AASHTO specifications for the appropriate steel grade, except that the axial allowable tension in the net section may be increased to 24,000 psi maximum, and tension in bolts at root of thread may be increased to 16,000 psi maximum (provided deflections are satisfactory). The 24,000 psi does not apply to the tension flange in beams.
- h. Steel Forms which Remain in Place - The unit working stress in the steel sheet and supporting members shall be not more than 0.725 of the specified minimum yield strength of the material furnished but shall not exceed 36,000 psi. Physical design properties shall be computed in accordance with requirements of the latest published edition of the American Iron and Steel Institute Specification for the Design of Cold Formed Steel Structural Members. The deflection limitations specified in Paragraph of this Article shall also apply to structural steel members.

6. Forms Scaffolds and Platforms

Form scaffolds or working platforms shall be designed and constructed as an integral part of the form supports. Details of these scaffolds or platforms shall be shown on Shop Drawings for forms submitted for review and acceptance. Separate design calculations shall be furnished with the Shop Drawing submission.

Design shall meet the minimum requirements for component parts as determined under Construction Safety and Health Standards for all projects, except that guardrail height shall be approximately 42 inches high and supports for the scaffolds or working platforms shall be designed to support all dead loads and an applied live load of 75 pounds per square foot of horizontal surface.

7. Form Supports

In addition to all other loads, the design of the form supports, etc., if they are to be used to support the concrete finishing equipment, must also recognize these additional loadings.

8. Forms for Unexposed Surfaces

Forms for unexposed surfaces (such as concrete surfaces in contact with earth) may be composed of sheathing lumber not over 8 inches wide and surfaced four sides to a uniform thickness of at least the minimum dimension approved on the form plans. All sheathing studs and bracing shall be of sound lumber, free from defects and loose knots. Studs and wales shall be straight and true and surfaced on two edges to uniform width. The inside face of the forms shall be of sufficiently smooth construction that the resulting concrete surfaces will be accurately formed and coincident with the required dimensions.

9. Forms for Exposed Surfaces

Forms for surfaces of concrete work exposed to weather or view (such as walls, retaining walls, inside surfaces of culvert barrels, etc.) shall be either lined or unlined forms as described in the following sections.

10. Lined Forms for Exposed Surfaces

The contact surface of lined forms for surfaces exposed to weather or view shall be approved composition board or sanded plywood, especially manufactured for concrete formwork. All studs shall be surfaced two edges to a uniform width and shall be of a grade of lumber that is solid, straight and free from defects that might impair its strength. The backing for form lining shall be constructed of a good grade of form lumber that is solid, straight, and free from defects that might impair its strength but need not be of quality used for contact forms for unexposed surfaces. All sheathing for form backing shall be surfaced two sides to a uniform thickness of at least the minimum dimension approved on the form plans. Form sheathing shall be built solidly, securely nailed to studs and so spaced as to prevent any bulging of the lining.

All lining shall be used in pieces as wide as is practicable. Where horizontal rustication occurs, horizontal joints in the lining shall be made behind a rustication strip. Otherwise, horizontal joints in the lining shall be placed at the same respective elevations in all portions of the structure. Where vertical rustication occurs, vertical joints in lining shall be made behind a rustication strip. Otherwise, vertical joints must be kept to a minimum and shall be placed to make a uniform pattern. Joints in lining and backing shall not occur at the same place and abutting edges of adjacent sheets shall be nailed to the same board. All joints shall be butted tight together and sealed with an approved crack filler as the lining is nailed in place. The lining shall be nailed to the backing beginning at one end of a sheet and work uniformly across it to prevent buckling. Three penny blue shingle nails or similar nails with thin, flat heads shall be used to attach the lining material to the

backing. The nails shall not be farther apart than 8 inches along the edges, and there shall be at least one nail for each square foot of surface.

11. Unlined Forms for Exposed Surfaces

Unlined forms in contact with surfaces exposed to weather or view shall be constructed of 5-ply, sanded plywood of approved thickness. Plywood shall be made with a waterproof glue and shall be especially manufactured for concrete formwork. All studs and wales shall be surfaced two edges to a uniform width.

Full size sheets of plywood shall be used except where smaller pieces will cover an entire area. All horizontal and vertical joints shall be backed solidly to prevent leakage, and the edges of abutting sheets shall be nailed to the same stud or blocking with sixpenny box nails, not farther apart than 8 inches. Where rustication occurs, horizontal joints in the plywood shall be made behind the rustication strips. Where no rustication strips are used, joints shall be made at the same respective elevations in all portions of the structure. Where vertical rustication occurs, vertical joints in lining shall be made behind a rustication strip. Otherwise, vertical joints must be kept to a minimum and shall be butted tight together and sealed with an approved crack filler as the plywood is nailed in place.

12. Removable Steel Forms

Removable steel forms shall meet all requirements of these Specifications for forms except as otherwise noted herein.

Forms for barrels of reinforced concrete box culverts shall be steel forms or forms having wood or composition wood panel sheathing set in metal frames. The minimum thickness of steel in forms for box culverts shall be 10 gage. Surfaces of box culvert and rigid frame wingwalls and headwalls exposed to view must be wood formed.

13. Release Agents

All forms shall be treated with a form release compound or saturated with water immediately before placing concrete. In case forms have been erected for sometime and have become dry so that joints have opened, then the forms shall be thoroughly soaked until the joints are closed.

14. Form Removal

All forms for concrete work shall be removed and disposed of by the Contractor after formwork requirements have been complied with, except those that are designated to remain in place.

Forms for pipe endwalls may be removed after the concrete has been in place for a period of 24 hours unless it is necessary to protect the concrete against cold weather, in which case the forms shall remain in place for the entire protection period.

Forms for vertical surfaces shall remain in place for a period of 48 hours. If, however, forms are removed before the concrete is 7 days old, the vertical surfaces shall be immediately covered with curing material and the concrete kept wet and so covered until the concrete is 7 days old. Horizontal form, and falsework, carrying loads shall remain in place for a minimum of 7 days and until the concrete has attained a compressive strength of 3000 psi. Internal bulkheads used for forming construction joints, contraction joints, expansion joints, etc. may be removed after the concrete has been in place for 24 hours, if it is necessary to do so for the continuance of the work without interruption.

Method of form removal likely to cause overstressing of the concrete shall not be used. Forms and their support shall not be removed without the approval of the Engineer. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight.

15. Reuse of Forms and Falsework Material

Plywood and lining material may be reused provided that the surfaces and edges are in a satisfactory condition and provided that they are cleaned off and sandpapered with the proper grade sandpapers and coated with form release compound.

Forms and falsework material reused shall be maintained at all times in good condition as to accuracy of shape, strength, rigidity, mortar tightness, and smoothness of surface. Any warped or bulged lumber or plywood will be rejected. Unsatisfactory form and falsework materials shall not be used and, if condemned, shall be removed immediately from the work.

16. Form Ties

Only non-removable form ties approved by the Engineer shall be used. Form ties for water or sewage containing structures shall have a washer attached in the center of the wall to act as a water seal. Ties shall be adjustable in length and of such type as to leave no metal closer than 2 inches from the surface. They shall not be fitted with any lugs, cones, washers, or other device to act as a spreader within the form, or for any other purpose that will leave a hole larger than 7/8 inch in diameter or a depression back of the exposed surface of the concrete. If approved by the Engineer, flat ties with 2 inch break back and rubber or plastic elongated cones may be used in removable steel forms for barrels of box culverts. Elongated rubber or plastic cones shall not be used as spreaders within the form.

Tie rod clamps shall remain in place until forms are to be removed as specified elsewhere and until the concrete has hardened sufficiently to permit the tie rods to be removed without damaging the concrete. Care shall be exercised to avoid spalling the concrete on the exposed surface. Cutting ties back from the face of the wall will not be permitted. All voids left in the concrete after the exposed form ties are removed shall be completely filled with non-shrink mortar and the surface finished as specified.

17. Form Support Brackets or Devices

Steel brackets or other devices attached to previously poured concrete for supporting forms may be used provided all parts are satisfactory to the Engineer for size, strength, and material. No metal of an insert, threader, or anchor, etc. that remains in place in the concrete shall be within 2 inches of the surface. The concrete supporting the brackets or other devices shall be cured and shall have attained a minimum compressive strength of 3000 psi before the brackets or other devices are attached. All voids left in the concrete after brackets or other devices are removed shall not be greater than 2 inches in diameter and shall be completely filled with non-shrink mortar and the surface finished as specified.

C. Concreting

Before placing concrete, all sawdust, chips, and other construction debris and extraneous matter shall be removed from interior of forms. No struts, stays, and braces, serving temporarily to hold the forms in correct shape and alignment, pending the placing of concrete at their locations, will be permitted.

All concrete shall be placed in the dry, unless plans and/or "Special Provisions" require the placement of tremie concrete.

1. Footings

Spread footing faces shall be placed against plumb, undisturbed material or forms unless shown otherwise on the Plans. If faces of completed and/or proposed excavated footing areas are disturbed during the excavation activities in the area, the footings will be extended to bear on undisturbed faces, at the Contractor's expense.

2. Piles

All material forced upward by the driving of the piling shall be removed prior to placing the concrete. This removal will not be a pay item and shall be done by hand labor unless the pile spacing, or use of special equipment will permit this removal without damaging the placed piling. This requirement will be waived in the case of tremie seals if the minimum thickness of footing concrete, pile embedment, and the required sealing capacity of the tremie concrete can be maintained. Any special requirements other than those contained in these Specifications for the tremie type of design will be shown on the Plans.

3. Temperature Controls

Concrete shall not be placed when the air temperature in the shade and away from artificial heat is below 40° or 50°F and falling without the written permission of the Engineer. Concrete shall at no time be mixed at a temperature of less than 50°F nor more than 90°F. If the temperature is below 50°F then one or more of the

following methods shall be used to obtain the required temperature all as approved by the Engineer.

- a. When the method of heated mixing water is used, the water shall not be above 170°F when introduced into the mix.
- b. When the method of heated aggregates is used, aggregates containing frozen lumps shall be independently heated; and no materials containing frozen lumps, ice, or snow shall be allowed to enter the mixer. Aggregates may be heated by steam coils or other dry heat but not by discharging live steam or hot water into them. Heating by means of a flamethrower or any direct flame will not be permitted.

When the ambient air temperature is below 40°F, the temperature of the air in contact with the reinforcement shall be raised to 40°F prior to placing concrete. When the ambient air temperature is above 90°F and the reinforcement is exposed to the direct rays of the sun, the reinforcement shall be cooled by means of water spray prior to placing concrete.

When abnormal wind and/or storms are forecast locally by the U.S. Weather Bureau, concrete shall not be placed during the period covered by the forecast.

4. Foundation Design

As previously stated, foundations of structures are subject to Engineer's approval before pouring concrete. The Contractor shall be solely responsible for any reinforcing steel fabricated prior to approval of foundations. If bearing material varies from that assumed in design, footings may be lowered, raised, deepened, subfoundations placed or piles used, or a combination of these methods used to best obtain bearing. If planned footings are changed vertically, reinforcing steel shall be revised as required. Selected backfill will be allowed as subfoundation for box culvert barrels, headwalls, and miscellaneous structures. If Mix No. 1 concrete is used, it need not be vibrated, shall be unreinforced, and the usual curing and cold weather requirements will be reduced to 3 days.

Concrete shall be placed to avoid segregation of the material and the displacement of the reinforcement. The use of troughs or chutes, for conveying concrete more than 15 feet from the mixer to the forms will not be permitted. Belt conveyors or concrete pumps shall be used where there is more than 15 feet to point of discharge.

Open troughs and chutes shall be of metal or metal lined. Where steep slopes are required, the chutes shall be equipped with baffles or be in short length that reverses the direction of movement.

All chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run. Water used for flushing shall be discharged clear of the structure and such that it does not enter an existing

water course. Chutes, troughs, pipes, etc. in contact with concrete shall not be aluminum.

Where placing operations would involve dropping the concrete more than 5 feet, the concrete shall be deposited through sheet metal, canvas, or other approved tube. The use of aluminum hoppers or tubes will not be permitted. The lower ends shall be kept as close as possible to the newly placed concrete and not more than 3 feet above it. All tubes, metal, canvas, or other shall have a minimum diameter of 8 inches unless otherwise approved by the Engineer. An exception to this placing requirement is permitted for the filling with concrete of cast-in-place piles. In this case, tubes or chutes are not required unless specifically called for by the Contract Documents. The shells or casings shall be filled from a hopper with spout applied directly to the top of the pile shell.

After initial set of the concrete, the forms shall not be jarred; and no strain shall be placed on the ends of the reinforcing bars that project outside the face of concrete.

Concrete, during and immediately after depositing, shall be thoroughly compacted. The compaction shall be done by mechanical vibration complying with requirements stated elsewhere in this section.

Concrete shall be placed in horizontal layers not more than 12 inches deep except as hereinafter provided. When less than the complete area of a layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and compacted before the preceding layer has taken initial set to prevent injury to the green concrete and avoid separation or joints between the layers. Each layer shall be compacted so as to avoid the formation of a cold joint with a preceding layer that has not taken initial set.

When the placing of concrete is temporarily discontinued, the concrete, after becoming firm enough to retain its form, shall be cleaned of laitance and other objectionable material to a sufficient depth to expose sound concrete.

Immediately following the discontinuance of placing concrete, all accumulations of mortar splashed upon the reinforcing steel and the surfaces of forms shall be removed. Dried mortar chips and dust shall not be puddled into the unset concrete. If the accumulations are not removed prior to the concrete becoming set, care shall be exercised not to injure or break the concrete-steel-bond at and near the surface of the concrete while cleaning the reinforcing steel.

5. Rate of Concreting

Concrete in beams and girders shall be deposited uniformly for the full length of the beam or girder and brought up evenly in horizontal layers. Each of which shall not be over 3 feet high.

Concrete in slab spans shall be placed in one continuous operation and in one layer for each span, unless otherwise provided.

Concrete shall not be mounded on concrete slab forms but in placing shall be distributed over an area to a depth not exceeding the depth of the planned slab thickness plus 6 inches before spreading, compacting, finishing, etc.

Concrete in columns, walls, etc. shall be placed in one continuous operation, unless otherwise directed. The concrete shall be allowed to set at least 12 hours before any concrete is placed above them.

Where walls, piers, columns, struts, posts, etc. allow horizontal construction joints, succeeding lifts shall not be poured until the lower pour has been allowed to set for 12 hours.

6. Pneumatic Placing

Pneumatic placing of concrete will be permitted only if specified in the "Special Provisions" or if authorized by the Engineer in writing. The equipment shall be so arranged that no vibrations result that might damage freshly placed concrete.

Where concrete is conveyed and placed by pneumatic means, the equipment shall be suitable in kind and adequate in capacity for the work. The machine shall be located as close as practicable to the place of deposit. The position of the discharge end of the line shall not be more than 10 feet from the point of deposit. The discharge lines shall be horizontal or inclined upwards from the machine. No parts of the equipment in contact with the concrete mix or the discharge line are to be made of aluminum.

At the conclusion of placement, the entire equipment shall be thoroughly cleaned.

7. Pumping

Placement of concrete by pumping will be permitted only if specified in the "Special Provisions" or if authorized by the Engineer in writing. The equipment shall be so arranged that no vibrations result which might damage freshly placed concrete.

Where concrete is conveyed and placed by mechanically applied pressure, the equipment shall be suitable in kind and adequate in capacity for the work. The operation of the pump shall be such that a continuous stream of concrete without air pockets is produced. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients. No parts of pump or the discharge line are to be made of aluminum.

At the conclusion of placement, the entire equipment shall be thoroughly cleaned.

8. Use of Conveyors

Concrete may be moved from the mixer to its final position by use of conveyors. Conveyors shall be in sections, and concrete shall be deposited from one conveyor

belt onto the next through a hopper. No individual section of the conveyor train shall rise more than 30 degrees from the horizontal. The belt travel speed shall not exceed 900 feet per minute for concrete slumps at 2 inches, and this speed shall be decreased for slumps exceeding 2 inches. Polyethylene or some other acceptable cover shall be placed under the conveyor line to contain any spillage from the belts.

9. Cofferdams

Where cofferdams are used, separate forms shall be constructed within the cofferdams except where footing concrete is to be placed against a base of undisturbed material and where the cofferdam is to remain in place and act as the concrete form. The water level in the space between the form and cofferdam shall be kept below the bottom elevation of all fresh concrete for 12 hours.

10. Concrete Exposed to Saline Water

When concrete is exposed to saline water, the water content shall be carefully controlled and so regulated as to produce concrete of maximum impermeability. In placing concrete, care shall be exercised to avoid the formation of stone pockets; and the concrete shall be thoroughly consolidated. After forms are removed, the concrete surface shall be left undisturbed.

The range of possible disintegration of the concrete from an elevation below that of extreme low tide to an elevation above that of extreme high tide will be determined by the Engineer; and except with his special permission, no construction joints will be located within this range. In the determination of this range, due consideration shall be given to wave action, ice formation and other conditions affecting the extreme limits of possible deterioration and disintegration.

Concrete which is to be in contact with saline water within the tide range and below said tide range shall in all cases be deposited in the dry. In no case shall saline water be allowed to come in direct contact with the concrete until it has been permitted to harden as required by the following table unless directed otherwise in writing by the Engineer.

Saline Content of Water by Weight in Parts per Thousand	Saline Water Shall not Contact Concrete until Following Time in Days has Elapsed after Initial set
0 to 10	0
10 + to 15	7
15 + to 20	14
20 + to 25	21
over 25	30

Unless otherwise noted, such concrete shall be wet cured for at least seven days while being maintained at a temperature of 50°F or above.

11. Construction Joints

Construction joints shall be kept to a minimum and will be permitted only where shown on the Plans or authorized by the Engineer in writing.

In order to bond successive courses, suitable keys shall be formed at the top of the lift where construction joints are permitted and at other levels where work is interrupted. These keys shall be as indicated on the Plans. At horizontal construction joints, the pour shall be allowed to set for about 12 hours before placing concrete above same.

After concrete has been placed and before it has hardened, all laitance and foreign material shall be removed from the surface. Before placing fresh concrete adjacent to hardened concrete, the surface of the hardened concrete shall be cleaned thoroughly of any remaining laitance or foreign material, scrubbed with wire brooms and clean water, and thoroughly drenched with water until saturated. It shall be kept saturated until the new concrete is placed.

Unless otherwise specified, the top surface of the concrete shall be leveled whenever a pour of concrete is stopped; and to ensure a level, straight joint on exposed face, a strip of sheathing shall be attached to the form at the exposed face where the joint occurs. The concrete shall be carried not more than 1/2 inch above the underside of this strip. About 1 hour after concrete is placed, the strip shall be removed; and any irregularities in the joint line shall be leveled off with a wood float (use steel trowel at exposed face of joint). All laitance shall be removed. To avoid visible joints at chamfers, the top surface of the concrete shall be steel troweled adjacent to the chamfer using the top surface of the chamfer strip as a guide.

Where a feather edge might be produced at a construction joint, as in the sloped top surface of a wingwall, and inset form shall be used to produce a blocked-in addition to the preceding layer which shall produce an edge thickness of concrete of not less than 6 inches in the succeeding layer.

12. Consolidation

All concrete shall be internally vibrated unless herein noted otherwise.

In addition of the internal vibration, certain specified vertical, inclined, or special faces which are exposed to weather or to view shall be externally vibrated when required by the Engineer.

Vibration shall be in accordance with the following requirements:

- a. All concrete shall be deposited in the forms in its final position and shall be placed in layers of uniform thickness. All concrete shall be consolidated by vibratory methods, except concrete deposited in water or unless otherwise specified.

Vibration shall be internal and applied directly to the concrete, except when the use of other methods is authorized by the Engineer or provided herein.

The Engineer will be the final judge as to which sections are unsuited for internal vibration.

External vibration applied to the concrete through the forms may be required on certain sections such as those which are very thin, very heavily reinforced, or otherwise crowded with material other than concrete, or where form surfaces are sharply including or battered. External vibration may be used alone or in conjunction with internal vibration when necessary to secure dense surfaces. The Engineer will determine when and where external vibration must be used.

The Contractor shall provide a sufficient number of vibrators to properly consolidate each batch immediately after it is placed in the forms and before the next batch is delivered, without delaying such delivery. The vibration shall be of sufficient intensity and duration to thoroughly consolidate the concrete, but it shall not be continued to such an extent as to cause segregation. Vibration shall not be continued at any one point to the extent that any localized areas of grout are formed.

Vibration shall be applied at points uniformly spaced not further apart than twice the radius over which the vibration is visibly effective.

Vibration shall not be used to transport concrete in the forms or to make it flow in the forms over distances so great as to cause segregation. Vibration shall not be applied directly or through the reinforcement or forms to sections or layer of concrete which have hardened to such a degree that the concrete ceases to be plastic under vibration.

Vibration shall be supplemented by such spading, along form surfaces, in corners, and at locations impossible to reach with the vibrators, as is necessary to ensure smooth surfaces and dense concrete.

The provisions of this section shall apply to precast concrete cribbing and other precast members or units, except that if approved by the Engineer the manufacturer's methods of vibrating may be used.

- b. Internal vibrators shall be of a type and design approved by the Engineer. They shall be capable of transmitting vibration to the concrete at frequencies of not less than 4500 impulses per minute. The intensity of application shall be such as to visibly affect a mass of concrete of 1-inch slumps over a radius of at least 18 inches.

Internal vibration shall be applied directly to the concrete at the point of deposit and in the area of freshly deposited concrete. Vibrators shall be inserted in and withdrawn from the concrete slowly. Internal vibrators shall be manipulated to thoroughly work the concrete around the reinforcement and imbedded fixtures and into the corners and angles of the forms.

- c. When external vibration is required, the vibrators shall be power operated equipment of the size and frequency approved by the Engineer.

External vibrators shall be clamped to or applied against the forms and operated to produce concrete free from honeycomb and having a dense surface free from pockets and entrapped air bubbles. They shall be applied to a level below the top of the concrete being deposited but not so low as to disturb concrete which has partially set. Every precaution shall be taken to avoid damage to or misalignment of the forms.

D. Concrete Surface

1. General

Concrete surfaces shall be finished in accordance with one of the following designations. Unless otherwise specified, all concrete work shall have an "Grout Finish" for vertical surfaces and "Troweled Finish" for horizontal surfaces. Strict compliance with the Specifications and the intent pertaining to finished surfaces will be enforced. Any concrete structure or concrete work that exhibits surfaces with defective finish will not be accepted until finishing has been completed in accordance with the Specifications. All concrete surfaces shall be finished within 24 hours after the forms are removed. If the concrete surfaces are not finished as specified within the time limit mentioned, all other work shall be suspended until the concrete surfaces required to be finished are completed.

<u>Application</u>	<u>Finished Designation</u>
<u>Structures</u>	
For all concrete surfaces not exposed to public view and not to be waterproofed	Rough Form Finish
For all concrete wall surfaces exposed to public view	Grout Finish
Upper horizontal surfaces	
Headwalls, wing walls, retaining walls, inlet head pieces	Troweled Finish
Tops of Footings	Float Finish
Horizontal construction joints	Left Rough
<u>Slabs & Miscellaneous Paving</u>	Floated Finish
<u>Incidental Works</u>	
Sidewalks, curb, combination curb and gutter, concrete paving, safety curb, median paving	Broom or Belt Finish

Tops of culvert slabs, culvert invert slabs, concrete ditch paving	Floated Finish
Exterior platforms, steps, landings, and pedestrian ramps	Nonslip Finish
Surfaces intended to receive bonded cementitious application	Scratched Finish

2. Rough Form Finish

Immediately following the removal of forms, all fins and irregular projections shall be removed from all surfaces except from those that are not to be exposed or not to be waterproofed. On all surfaces, the cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges, and other defects shall be thoroughly cleaned and, after having been kept saturated with water for a period of not less than 3 hours, shall be carefully pointed and trued with a mortar of cement and fine aggregate mixed in proportions used in the grade of the concrete being finished. Any excess mortar at the surface of the concrete due to filling form tie holes shall be struck off flush with a cloth. The mortar patches shall be cured as specified under Curing. All construction and expansion joints in the completed work shall be left carefully tooled and free of all mortar and concrete. The joint filler shall be left exposed for its length with clean and true edges.

The resulting surfaces shall be true and uniform. All surfaces which cannot be repaired to the satisfaction of the Engineer shall be finished as specified in Paragraph 03300.03 D.3.

3. Grout Finish

All fins, projections, etc. shall be removed to the satisfaction of, and by means approved by, the Engineer (stone, chipping hammer, sandblasting, etc.). No cleaning operations shall be undertaken until all contiguous surfaces to be cleaned are completed and accepted. Cleaning as the work progresses will not be permitted. The surface of the concrete shall then be saturated with water and kept wet for at least 2 hours. Proceeding by sections, a grout mix of 1 part Portland cement and 1 1/2 parts fine sand with sufficient water to produce a grout having the consistency of the thick paint shall be thoroughly rubbed onto the surface using burlap pads or cork floats completely filling all voids, pits, and irregularities. While the grout is still plastic, remove all unnecessary grout by working the surface with a rubber float or burlap. After this grout has dried sufficiently so that it will not smear, the surface shall be wiped off with dry, clean burlap so as to leave a clean uniform surface. This surface shall then be cured as required, except that only colorless liquid curing compound will be permitted for this method.

4. Scratched Finish

After the concrete has been placed, consolidated, struck off, and leveled, the surface shall be roughened with stiff brushes or rakes before final set.

5. Floated Finish

After the concrete has been placed, consolidated, struck off, and leveled, the concrete shall not be worked further until ready for floating. Floating with a hand float or with a bladed power trowel equipped with float shoes, or with a powered disc float shall begin when the water sheen has disappeared and when the surface has stiffened sufficiently to permit the operation. During or after the first floating, planeness of surface shall be checked with a 10 ft straightedge applied at not less than two different angles. All high spots shall be cut down and all low spots filled during this procedure to produce a smooth surface. The slab shall then be refloated immediately to a uniform sandy texture.

6. Troweled Finish

The surface shall first be float-finished. It shall next be power troweled, and finally hand troweled. The first troweling after power floating shall produce a smooth surface which is relatively free of defects, but which may still show some trowel marks. Additional trowelings shall be done by hand after the surface has hardened sufficiently. The final troweling shall be done when a ringing sound is produced as the trowel is moved over the surface. The surface shall be thoroughly consolidated by the hand troweling operations. The finished surface shall be essentially free of trowel marks, uniform in texture, and appearance and to a smooth plane.

7. Broom or Belt Finish

Immediately after the concrete has received a float finish, it shall be given a coarse transverse scored texture by drawing a broom or burlap belt across the surface.

8. "Dry shake" Finish

If a "dry shake" application of a selected metallic or mineral aggregate is specified, the aggregate, selected or acceptable to the Engineer, shall be blended with Portland cement in the proportions recommended by the manufacturer of the aggregate. The surface shall be given a float finish. Approximately two-thirds of the blended material for required coverage shall be applied to the surface by a method that ensures even coverage without segregation. Floating shall begin immediately after application of the first "dry shake". After this material has been embedded by floating, the remainder of the blended material shall be applied to the surface at the right angles to the previous application. The second application shall be heavier in any areas not sufficiently covered by the first application. A second floating shall follow immediately. After the selected material has been embedded by the two floatings, the operation shall be completed with a broomed, floated, or troweled finish, as designated in the Contract Documents.

9. Nonslip Finish

Where the Contract Documents require a nonslip finish, the surface shall be given a "dry shake" application, as specified above, of crushed ceramically bonded aluminum oxide or other specified selected abrasive particles. The rate of application of such material shall be not less than 25 pounds per 100 square feet.

10. Exposed Aggregate Finish

Immediately after the surface of the concrete has been leveled, and surface water has disappeared, aggregate of color and size (usually 3/8 to 5/8 inch) selected by the Engineer shall be spread uniformly over the surface to provide complete coverage to the depth of a single stone.

The spread of selected aggregate shall be embedded into the surface by light tamping and the surface shall be floated until the embedded stone is fully coated with mortar and the surface has been brought to a true plane. Exposure of the aggregate shall start after the matrix has hardened sufficiently to prevent dislodgement of the aggregate. Water, in abundant quantities but without force, shall be allowed to flow over the surface of the concrete while the matrix encasing the selected aggregate is uniformly exposed but not dislodged.

An acceptable chemical retarder sprayed onto the freshly floated surface may be used to extend the working time for exposure of aggregate.

E. Curing

Provisions shall be made for curing all concrete. Curing shall start as soon as concrete has set sufficiently so that curing applications will not damage the surfaces. Curing will also be required while protecting concrete against cold weather.

The following are methods to be used for curing:

1. All units of structures which will be below water in the completed structure, i.e. bottom slabs of culverts, footings, struts, etc., may be gradually flooded after the concrete is 12 hours old provided the water meets all specification requirements for curing water. The temperature of this water must be maintained at a temperature of 50°F or above for the specified curing time.
2. Two layers of burlaps shall be used. Successive strips of each layer shall be overlapped a minimum of 6 inches. The second layer shall be placed not less than 45 degrees to the first layer; or the 6 inches overlap of the second layer may be placed midway (one-half width) of the first layer. The layers of burlap shall be kept thoroughly saturated with curing water for the full time specified for curing.
3. When curing concrete structural slabs, etc., burlap-polyethylene mats or white polyethylene sheets may be used atop the wet burlap on unobstructed flat and reasonably level surfaces.

The burlap-polyethylene mats or white polyethylene sheets shall be placed only on unobstructed flat and reasonably level surfaces. They will not be permitted on vertical surfaces, such as walls, columns, abutments, etc.

Adjacent mats or sheets shall be lapped no less than 1 foot. The ends shall be brought down around the sides of the concrete being cured and securely fastened to the satisfaction of the Engineer to make an airtight seal that will be unaffected by wind.

The burlap-polyethylene mats must be placed on no less than one layer of wet burlap with the burlap side of the mat facing down. White polyethylene sheets, if used, must be placed on no less than two layers of wet burlap.

The burlap-polyethylene mats or white polyethylene sheets must remain in place for the same length of time as required for burlap mats. These protective coverings need not be wetted down; however, the covered burlap or cotton mats must be kept wet for the time interval required by the Specifications.

4. The material for liquid membrane-forming compounds shall have a fugitive dye or be white pigmented. The materials shall be thoroughly agitated before use and applied by sprayers.
5. The burlap must be thoroughly saturated just prior to placement. The requirement for keeping the concrete surfaces saturated at all times during the curing period, regardless of the covering, will be strictly enforced. This saturation of the surfaces must be employed even in areas where there is no ready water supply. The contractor must furnish, at his expense, sufficient water to satisfy this requirement.

All vertical surfaces may be cured by leaving forms in place for 7 days. If forms are removed after 48 hours, then the remainder of the 7 days of cure shall be by method 3.

Immediately after the finishing operation for sidewalks and culvert top slabs, the areas of future construction joints shall be covered with two layers of wet burlap which shall extend 6 inches outside the joint area. The finished concrete surface shall then be sprayed with a liquid compound as specified in curing method 4. The material shall be applied uniformly at the rate of 150 to 200 square feet per gallon, one half applied in a longitudinal direction and the second half in a transverse direction. After 1 day or as soon as the concrete may be walked upon without damage, the concrete shall be cured using method 2 or 3 for the remainder of the 7-day curing period.

All other horizontal surfaces shall be cured using either method 2 or 3 for a period of 7 days.

Cover tops and other horizontal surfaces of endwalls, and headwalls with burlap; and cover vertical surfaces of same after removal of forms with burlap mats and keep concrete, forms, mats, and/or burlap wet for 3 days.

F. Cold Weather Protection

When the air temperature in the shade and away from artificial heat drops to 40°F or lower at the time of placing or at any time within the number of days specified below for protection, concrete shall be protected and heated after it has been placed. Protection and heating shall be as follows:

1. Ordinary concrete shall be protected and kept continuously at a temperature not less than 50°F for at least 7 days following placement.
2. In no case shall concrete be heated to more than 100°F. At the end of the heating period, the concrete surfaces shall be cooled to the temperature of the outside air by slowly reducing the artificial heat at a uniform rate until the temperature of the outside air is reached within a 24 hour period.

The Contractor shall have available enough tarpaulins, insulating devices, and/or other suitable materials to enclose or protect all portions of the concrete requiring protection. As much as possible of the aforesaid devices and materials shall be installed before placing the concrete, and the remainder shall be installed as rapidly as possible to keep exposure to cold weather to a minimum. Where heating is required, the spaces to be heated shall be completely enclosed and the temperature therein kept at required levels using approved heaters.

Insulated devices (wrappings), if proposed for use, shall be first submitted to the Engineer for approval; and if acceptable, they may be used, provided that satisfactory protective performances under prior usage can be verified. Where the insulating devices are in tight contact with forms of concrete surfaces, satisfactory instruments and usage thereof shall be devised and placed in operation to prove to the Engineer that required temperatures are being maintained under the insulators.

All structure concrete requiring cold weather protection and having curing periods less than the cold weather protection period shall be cured for the full cold weather protection period.

The Contractor shall provide a sufficient number of maximum minimum recording thermometers to record the temperatures in each concrete pour undergoing cold weather protection.

The responsibility for defective concrete by reason of heating or lack of heating, or any other hazards incidental to cold weather concreting, shall remain with the Contractor; and such defective concrete shall be replaced by him at his sole expense.

Concrete in place shall be protected to minimize drying and absorption of heat when and as directed by the Engineer.

G. Underpinning

Where structures are extended, widened, or repaired, it is frequently found that the foundations of the old structure are not in solid or full area bearing on their intended foundations. Frequently, foundations of the extended or new parts are at a lower elevation

than the former foundations. These conditions usually led to the necessity of underpinning the old structure, which operation shall consist of the restoring or lowering of the old foundations with concrete masonry. The concrete masonry shall be Mix No. 6. Excavation and the underpinning operations shall be done in part section, so as not to remove more than 10% of the supporting area under the old foundation at one time. The concrete shall be mixed to a stiff consistency (slump not to exceed 1 1/2 inch). The underpinning masonry shall usually be applied by hand, well inserted, pushed, rodded, or tapped into position. Where specified, underpinning masonry shall be installed by pneumatic or pumping processes. The usual curing and cold weather requirements will be deleted for underpinning masonry with other provisions for curing and protection improvised on the job as may be directed.

H. Prevention and Removal of Stains on Concrete

The Contractor shall prevent rust of unpainted structural steel, staining by bituminous materials, or any other substance from discoloring any portion of the concrete. The Contractor, therefore, shall devise and use construction procedures or methods that prevent staining of any of the concrete. If, however, any portion of the concrete is stained, the Contractor shall remove such stains and restore the concrete to its original color without damage to the concrete all at his expense and as approved by the Engineer. No chemical solvents will be allowed unless previously approved by the Engineer.

03300.04 METHOD OF MEASUREMENT

Measurement for cast-in-place concrete of the mix number specified will be made on a unit area or volume, or a lump sum per structure basis. In establishing the breakdown between footing concrete and substructure concrete, the divisions line shall be the top of footing regardless of where the construction joint occurs.

A. Unit Price

Measurement for cast-in-place concrete, when a unit price is provided for in the Proposal, will be made on an area or volume basis for the actual amount of concrete satisfactorily placed and accepted.

B. Lump Sum

Measurement for cast-in-place concrete, when a lump sum price or prices per structure are provided for on the Proposal Form, will be made on the basis of a lump sum for all concrete included in the Project or on the basis of the number of structures satisfactorily placed and accepted.

03300.05 BASIS OF PAYMENT

A. General

1. Payments will be made at the unit and/or lump sum prices bid. The prices shall include all materials, forms, reinforcing steel, curing materials, sealing, caulking,

and dampproof or waterproofing, and all necessary equipment, tools, labor, and work incidental thereto in accordance with the Contract Documents.

2. Unless otherwise specified, payment for footing and subfoundation concrete will be made on a unit price basis.
3. Payment will be made for contingent items when ordered by the Engineer. Payment will be specified in Section 02951, 02952, 02953, 02954, 02955, 02956, and 02957.

B. Unit Price

Payment for cast-in-place concrete will be made at the price bid per cubic yard for the various mix numbers specified.

C. Lump Sum

1. Payment for cast-in-place concrete will be made at the lump sum price bid for all concrete on the Project, or for all concrete in each structure or structural unit as indicated in the Proposal.
2. To provide for unforeseen changes in planned dimensions affecting concrete on a lump sum basis, the Proposal may include an item(s) for contingent concrete. This item(s) shall be used only upon written direction of the Engineer and applies only to referenced structure(s). If necessary, changes in the planned dimensions result in an enlargement, then the pertinent lump sum price shall be increased by an amount obtained from the product of the increase in volume times the unit price bid per cubic yard on the pertinent contingent concrete item. Should, however, the necessary changes result in a smaller structure than planned, then the pertinent lump sum price shall be reduced by an amount obtained from the product of the reduction in volume times the unit price bid per cubic yard on the pertinent contingent concrete item. The unit price bid on the pertinent contingent concrete item shall include cost of all concrete, reinforcing steel, expansion material, dampproofing, membrane waterproofing, formwork, incidental materials, etc. and work required to complete the structure(s) as revised.

END OF SECTION