

## ITEM 420

### CONCRETE STRUCTURES

420.1 Description. These specifications shall govern for the construction of culverts, retaining walls, abutments, bents, piers, girders, slabs and all other structures involving the use of concrete.

All concrete structures shall be constructed in accordance with the design requirements and the details shown on the plans; in conformity with the pertinent provisions of the items contracted for and the incidental items referred to; and in conformity with the requirements herein set forth.

420.2 General Requirements. Before starting work, the contractor shall inform the Engineer fully as to the methods of construction he proposes to follow and as to the amount and character of equipment he proposes to use; the adequacy of which shall be subject to the approval of the Engineer. Concurrence on the part of the Engineer in any proposed construction methods and approval of equipment, shall not relieve the contractor of the responsibility for the safety or correctness of his methods or the adequacy of his equipment or from carrying out the work in full accordance with his contract.

420.3 Materials. All concrete shall conform to the provisions of the Items "Concrete" or "Lightweight Concrete for Structures," whichever is applicable, as may be indicated on the plans. The class of concrete for each unit shall be as shown on the plans.

Preformed expansion joint materials shall meet the requirements of ASTM D994 or ASTM D1751, as well as the Item 438, "Preformed Joint Seal".

Poured joints shall be asphalt that is homogeneous, shall be free from water and shall not foam when heated to 392° F. It shall conform to the following requirements:

Flash point (open cup), not less than	200°C (392°F)
Softening point (ring and ball method)	65°C to 110°C (149°F to 230°F)
Penetration at 0°C (32°F), 200 gms., 60 sec., not less than	10
Penetration at 25° C. (77° F.), 100 gms., 5 sec.	30 to 50
Penetration at 46° C. (115° F.), 50 gms., 5 sec., not more than	110
Loss on heating at 163° C. (325° F.), 50 gms., 5 hrs., not more than	1.0%
Penetration at 25° C. (77° F.), 100 gms., 5 sec., of residue after heating at 163° C. (325° F.), as compared with penetration of asphalt before heating, not less than	60.0%

Ductility @ 25° C. (77° F.), not less than 3.0 cm.	3.0 cm
Proportion of bitumen soluble in carbon tetrachloride, not less than	99.0%
Total bitumen (soluble in carbon disulfide), not less than	99.0%

All other materials such as reinforcing steel and structural steel shall conform to the requirements of the pertinent specifications.

420.4 General Construction Requirements. Before constructing forms and falsework for concrete superstructure spans over twenty (20) feet in length; form and falsework plans shall be submitted to the Engineer for review and approval. Similar plans shall be submitted for other units of the structure if requested by the Engineer. The plans shall be prepared on standard sheets twenty-four (24) inches by thirty-six (36) inches overall size and shall be sufficiently complete to show all essential details of the proposed forms, falsework, and bracing for same. In general, not over six sets of such plans will be required.

Concurrence on the part of the Engineer in any proposed construction methods, approval of equipment, or approval of form and falsework plans shall not be considered as relieving the Contractor of the responsibility for the safety or correctness of his methods and adequacy of his equipment, or from carrying out the work in full accordance with the contract.

Unless otherwise provided, the following requirements shall govern for the time sequence in which construction operations may be carried on and for the opening of completed structures to traffic.

Steel I-beams or forms and falsework for superstructures shall not be erected on concrete substructures until the concrete in the substructures has cured at least four (4) curing days. Concrete for concrete slab or girder spans or concrete slabs on steel I-beam spans shall not be placed until the substructure has cured at least seven (7) curing days.

Steel trusses or plate girders to be erected from the ground on approved falsework may be erected when the substructure has cured four (4) curing days, but the falsework shall not be removed until the substructure has cured at least seven (7) curing days. Erection by means of a traveling crane on the span will not be permitted until the substructure has cured at least seven (7) curing days.

Forms for walls or columns shall not be erected on concrete footings until the concrete in the footing has cured at least two (2) curing days. Concrete may be placed in the wall or column as soon as the forms and reinforcing steel placement is approved.

The use of completed portions of a structure as the site for mixing operations or for storage of materials will not be permitted until the particular portion of the structure has aged at least ten curing days.

A curing day shall be as defined in the Section "Removal of Forms and Falsework". In continued cold weather the construction operations may be authorized at the end of a period of calendar days equal to twice the number of curing days specified above.

For bridges and direct traffic culverts, construction traffic and traveling public permitted in accordance with the following:

- A. Authorization for light construction traffic not to exceed a three-quarter ton truck may be given after last slab of concrete has been in place at least 14 days.
- B. Authorization for normal construction traffic, when necessary, and to traveling public may be given after last slab of concrete has been in place 30 days.

Forms or screed supports for bridges may be attached to I-beams or girders by welding.

420.5 Foundations. Excavation for foundations shall be made in accordance with the requirements of pertinent specifications.

Caissons shall be constructed of the materials and to the dimensions and details shown on the plans. Forms for concrete caissons may be of wood or metal meeting the specified requirements. The operation of sinking will be permitted to proceed immediately after form removal.

Where necessary, falsework shall be provided to support the caisson during the construction and lowering period. Such falsework shall be of the strength required to support the caisson in combination with the forces of wind, water currents and drift.

Concrete foundation seals, if required, shall be of the thickness shown on the plans. The seals shall be Class D Concrete and shall be placed in accordance with the requirements herein for concrete placed in water. The completed seal shall not be higher or lower than the plan grade or the grade established by the Engineer, by more than one-sixteenth (1/16) times the least inside caisson, cofferdam, or dredge well dimension at such grade.

The seal shall be allowed to set for at least thirty-six (36) hours before the caisson or cofferdam is dewatered. After dewatering, the top of seal shall be cleaned off, all or other soft material readily loosened with a pick shall be removed, and all high spots which exceed the above limitation shall be cut off and removed.

Foundation piling shall be cut off square at the elevation shown on plans. A tolerance of not more than two (2) inches above or below established cut-off grade will be permitted.

420.6 Drains. Weep hole drains shall be installed in abutments and retaining walls, and roadway drains or scuppers shall be installed in the roadway slabs in accordance with the details shown on the plans.

420.7 Expansion Joints and Devices. Expansion joints and devices to provide for expansion and contraction shall be constructed where and as indicated on the plans.

Unless otherwise provided on the plans, the bridge seat under the expansion ends of concrete slab spans and slab and girder spans shall be given a steel trowel finish, and the surfaces of substructure and spans and girders shall be separated by layers of roofing felt or a combination of roofing felt and sheet metal. Before installation, the contact areas of such roofing felt or sheet metal shall be coated with graphite grease.

Layers of roofing felt or sheet metal shall be carefully placed so that concrete or mortar will not be worked around or under the material.

All joints constructed, to be left open or filled with poured joint material, shall be constructed using forms adaptable to loosening or early removal. In order to avoid jamming such forms by the expansion action of the spans and the consequent likelihood of injury to the adjacent concrete, these forms shall be removed or loosened as soon as practicable after the concrete has attained its final set. A provision for loosening the forms to permit free expansion of the span without the necessity for full removal is preferred.

Armored joints shall be carefully constructed in order to avoid defective anchorage of the steel and to avoid porous or honeycombed concrete adjacent to same.

When premolded joint material is to be used in vertical joints of roadway and sidewalk slabs, the tops of such joints shall be adequately sealed with asphalt of the quality specified for poured joint materials. To accomplish this sealing, the top two (2) inch depth of the joint shall be constructed open or the premolded material shall be plowed out and the space filled with liquid asphalt.

Premolded material, if specified, shall be used in expansion or contraction joints in abutment walls, wing walls and retaining walls. Metal flashing strips for the prevention of water seepage through wall joints shall be provided and installed in accordance with the plan provisions.

Premolded materials, wherever used, shall be anchored to the concrete on one side of the joint by means of copper wire not lighter than No. 12 B. & S. gauge. Such anchorage shall be sufficient to preclude the tendency of the material to fall out of the joint.

Careful workmanship shall be exercised in the construction of all joints to insure that the concrete sections are completely separated by an open joint or by the joint materials and to insure that the joints will be true to the outline indicated. Immediately after the removal of forms and again where necessary after surface finishing, all projecting concrete shall be removed along the exposed edges of premolded materials in order to secure full effectiveness of the expansion joint.

Where roofing felt or premolded material is specified for horizontal joints, the material shall, if practicable, extend two (2) inches beyond the form for the top member. The projecting portions shall be subsequently trimmed to the face of the member after the forms are removed.

420.8 Construction Joints. The joint formed by placing plastic concrete in direct contact with concrete that has attained its initial set shall be deemed a construction joint. When concrete in a structure or a portion of a structure is specified to be placed monolithic, the term monolithic shall be interpreted to mean that the manner and sequence of concrete placing shall be such that construction joints will not be created.

Construction joints shall be of the type, location and spacing shown on the plans. Additional joints shall not be provided, without written authorization from the Engineer. Any additional construction joints shall have details equivalent to those shown on the plans for joints in similar locations.

Unless otherwise provided, construction joints shall be square and normal to the forms. Bulkheads shall be provided in the forms for all joints except horizontal joints.

The top surface of a concrete placement which terminates at a horizontal construction joint shall have the surface cement film removed and shall be thoroughly roughened as soon as practicable after the concrete has attained initial set. The surface at bulkheads shall be roughened as soon as the bulkhead forms are removed.

Before joining plastic concrete to concrete that has already set, the surface of the concrete in place shall be thoroughly cleaned up of all loose materials, , dirt or foreign matter; shall be washed and scrubbed clean with stiff brooms and thoroughly drenched with water until saturated, and shall be kept wet until the plastic concrete has been placed. Immediately prior to the placing of additional concrete, all forms shall be drawn tight against the concrete in place, and the surface of the concrete in place shall be flushed with a coating of grout mixed in the proportions of one part of cement to two parts of sand.

If shown on the plans, construction joints, shall be provided with concrete keyways, reinforcing steel dowels, and/or metal flashing strips. The method

of forming keys in keyed joints shall be such as to permit the easy removal of forms without chipping, breaking, or damaging the concrete in any manner.

420.9

Falsework. All falsework shall be designed and constructed so that no excessive settlement or deformation will occur, and so that the necessary rigidity will be provided. Details of falsework construction shall be subject to review and approval by the Engineer in accordance with the provisions of Section "General Construction Requirements".

For calculating the loads on falsework, a weight of one hundred and fifty (150) pounds per cubic foot shall be assumed for concrete, and a live load allowance of fifty (50) pounds per square foot of horizontal surface of the form work shall be included. The maximum stresses shall not exceed one hundred and twenty-five (125) per cent of the allowable stresses used for the design of the structure.

All timber used in falsework centering shall be sound, in good condition, and free from defects which will impair its strength.

Steel members shall be of adequate strength and of such shape as to be suitable for the purpose intended.

Timber piling may be of any species of wood which will withstand driving satisfactorily and which will adequately support the superimposed load.

Where sills or timber grillages are used to support falsework columns, unless founded on, shale or other hard materials, shall be placed in excavated pits and backfilled to prevent the softening of the supporting material by drip from the forms or by rains that may occur during the construction process. Sills or grillages shall be of ample size to support the superimposed load without settlement.

Falsework which cannot be founded on a satisfactory spread footing shall be supported on piling which shall be driven to a bearing capacity sufficient to support the superimposed load without settlement. The safe bearing capacity of piling shall be determined by the formula specified elsewhere.

In general, each falsework bent shall be capped transversely at the proper elevation by a cap of adequate size. If desired by the Contractor, however, a short cap section forming a T-head may be substituted at the top of each pile or column in order to permit the removal of portions of the forms without disturbing the falsework. Caps shall be securely fastened to each pile or column in the bent and shall be set at the proper elevation to produce, in conjunction with the use of approved hardwood wedges or jacks, permanent camber indicated on the plans or specified, plus a construction camber covering allowance for deformation of the forms and falsework. The use of wedges to compensate for incorrectly cut bearing surfaces will not be permitted. Each falsework bent shall be securely braced to adjacent bents by

bracing material of ample size to provide the stiffness required. The bracing shall be securely spiked or bolted to each pile or column it may cross.

420.10

Forms. Forms shall be built mortar-tight and of material sufficient in strength to prevent bulging between supports and shall be set and maintained to the lines designated until the concrete is sufficiently hardened to permit form removal. During the elapsed time between the building of the forms and the placing of the concrete, the forms shall be maintained in a manner to eliminate warping and shrinking. All details of form construction shall be subject to the approval of the Engineer, and permission to place concrete will not be given until all of such work is complete to his satisfaction.

Forms shall be designed for the pressure exerted by a liquid weighing one hundred and fifty (150) pounds per cubic foot. The rate of placing the concrete shall be taken into consideration in determining the depth of the equivalent liquid. An additional live load of fifty (50) pounds per square foot shall be allowed on horizontal surfaces. The maximum stresses shall not exceed one hundred and twenty-five (125) per cent of the allowable stresses used for the design of the structures.

If, at any stage of the work, the forms show signs of bulging or sagging, that portion of the concrete causing such condition shall be immediately removed, if necessary, and the forms shall be reset and securely braced against further movement.

Lumber for forms shall be properly seasoned and of good quality. It shall be free from loose or unsound knots, knot holes, twists, shakes, decay, and other imperfections which would affect its strength or impair the finished surface of the concrete. The lumber used for facing or sheathing shall be finished on at least one side and two edges and shall be sized to uniform thickness.

The use of nominal two (2) inch lumber, as a minimum thickness, will be required for forms for the bottoms of all superstructure girders except that in case of special forming of girders, as for curved-bottom girders where facing boards are transverse to beam, the Engineer may permit the use of one (1) inch lumber. Nominal one (1) inch thickness lumber will be permitted for general use on other portions of the structure if backed by a sufficient number of studs and wales.

Timber forms for exposed concrete surfaces which are required to be surface finished in accordance with these specifications shall be face lined with an approved type of form lining material such as masonite or plywood. If desired by the Contractor, facing for such surfaces may be constructed of three-fourth (3/4) inch thick plywood backed by adequate studs and wales, and in this case form lining will not be required.

Forms or form lumber to be re-used shall be maintained clean and in good condition as to accuracy, shape, strength, rigidity, tightness, and smoothness of surface. Any lumber which is split, warped, bulged, marred, or has defects

that may produce work inferior to that resulting from using new material, shall not be re-used.

Studs shall not be less than two (2) inches by four (4) inches nominal section and shall be spaced center to center not more than twenty (20) times the actual thickness of the facing lumber. Wherever practicable, studs shall be capped at the top with a plate of not less than two (2) inches by six (6) inches nominal size, carefully selected as to straightness. All joints in plates shall be scabbed at least four (4) feet each way to provide continuity.

Wales shall be spaced at such intervals as to hold forms securely to the designated lines. All wales shall be scabbed at least four (4) feet on each side of joints to provide continuity. A row of wales shall be placed within six (6) inches of the bottom of each placement.

Forms shall be rigidly braced to prevent movement while placing the

All face form material shall be fastened to all studs and shall have true horizontal and vertical joints. Facing material on horizontal and other surfaces shall be placed with parallel and square joints.

Molding specified for chamfer strips or other uses shall be made of redwood, cypress or pine materials of such grade that will not split when nailed and which can be maintained to a true line without warping. The molding shall be mill cut and dressed on all faces. Unless otherwise provided, forms shall be filleted at all sharp corners and edges with triangular chamfer strips. The strips shall be three-fourths (3/4) inch measured on the sides.

Forms for railings shall be constructed to standards equivalent to first class mill work. All moldings, panel work, and bevel strips shall be straight and true with neatly mitered joints and of such design that the finished work shall be true, sharp and clean cut.

All forms shall be so constructed as to permit removal without damage to the concrete. Particular and special care must be exercised in framing forms for copings, offsets, and railing so that there will be no damage to or marring of the concrete when the forms are removed. If desired by the Contractor, the forms may be given a slight draft to permit ease of removal.

Metal form ties of an approved type shall be used to hold forms in place. Such ties shall be of a type especially designed for use in connection with concrete work, and they shall have provision to permit ease of removal of the metal as hereinafter specified. The use of wire form ties will not be permitted except for minor or special form areas where the use of rigid type metal ties would be impracticable.

All metal appliances used inside of forms to hold them in correct alignment shall be removed to a depth of at least one-half (1/2) inch from the surface of the concrete and shall be so constructed that the metal may be removed without undue injury to the surface by chipping or spalling. Such devices,

when removed, shall leave a smooth opening in the concrete surface. Burning off of rods, bolts, or ties will not be permitted.

Metal ties shall be held in place by devices attached to wales. Each device shall be capable of developing the strength of the tie.

Pipe spreaders will not be permitted.

Metal and wooden spreaders which are separate from the forms shall be entirely removed as the concrete is being placed.

Where wire ties are used, all wires, upon removal of the forms, shall be cut back at least one-half (1/2) inch from the face of the concrete with a sharp chisel or nippers.

All cavities produced by the removal of metal ties shall be carefully cleaned and completely filled with re-tempered sand cement mortar mixed in proportion of one to three, and the concrete shall be left smooth and even.

Whenever practicable, forms shall be erected complete before the reinforcement is placed.

For narrow walls and other locations where access to the bottom of the forms is not readily attainable otherwise, adequate clean-out openings shall be provided.

At the time of placing concrete, the forms shall be clean and entirely free from all chips, dirt, sawdust, and other extraneous matter.

The facing of all forms shall be treated with oil before concrete is placed. In hot weather, both sides of face forms may be required to be treated with oil to prevent warping and to secure tight joints. The oil must be applied before the reinforcement is placed. The oil used for this purpose shall be a light clear oil which will not discolor or otherwise injuriously affect the concrete surface.

In general, all forms shall be thoroughly wetted before the concrete is placed therein.

The foregoing specifications for forms, regarding design, mortar-tightness, filleted corners, beveled projections, bracing, alignment, removal, re-use, oiling and wetting shall apply with equal force to all forms, except that metal forms will not require lining unless noted on the plans.

The metal used for forms shall be of such thickness that the forms will remain true to shape. All bolt and rivet heads on the facing sides shall be countersunk. Clamps, pins, or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms which do not present a smooth surface or line up properly shall not be used. Special care shall be exercised to keep metal free from rust, grease, or other foreign material such as will tend to discolor the concrete.

420.11 Placing Reinforcement. Reinforcement in concrete structures shall be carefully and accurately placed and rigidly supported as provided in the Item 440, "Reinforcing Steel".

420.12 Placing Concrete, General. The Contractor shall give the Engineer sufficient advance notice before starting to place concrete in any unit of the structure to permit the inspection of forms, the reinforcing steel placement, and preparations for casting. Unless authorized by the Engineer, no concrete shall be placed in any structure until prior to the completion of the formwork and the placement of the reinforcement. No concrete shall be placed before the completion of all adjacent pile driving or other operations which might prove detrimental to the concrete.

Whenever it is necessary to continue the mixing, placing, and finishing of concrete after the daylight hours, the site of the work shall be brilliantly lighted so that all operations are plainly visible. In general, however, concrete placing shall be so regulated as to permit finishing operations to be completed in the daylight hours.

The Engineer reserves the right to order postponement of the placing operations when, in his opinion, impending weather conditions may result in rainfall or low temperatures which will impair the quality of the finished work. In case rainfall should occur after placing operations are started, the Contractor shall provide ample covering to protect the work. In case of drop in temperature, the provisions set forth in the Section "Placing Concrete in Cold Weather" shall be applied.

The sequence of placing concrete shall be as provided on the plans or in the specifications. The operation of depositing and compacting the concrete shall be conducted so as to form a compact, dense, impervious mass of uniform texture which shall show smooth faces on all surfaces. The placing shall be so regulated that the pressures caused by the plastic concrete shall not exceed the loads used in the design of forms.

The method and manner of placing shall be such as to avoid the possibility of segregation or separation of the aggregate or the displacement of the reinforcement. Concrete shall not have a free fall of more than three (3) feet except in the case of thin walls such as culvert walls.

Spattering on forms or reinforcement bars shall be prevented if the concrete so spattered will dry or harden before being incorporated in the mass. Any hardened concrete splatter ahead of the plastic concrete shall be removed.

Each part of the forms shall be filled by depositing concrete directly as near its final position as possible. The coarse aggregate shall be worked back from the face and the concrete forced under and around the reinforcement bars without displacing them. Depositing large quantities at one point in the forms and running or working it along the forms will not be allowed.

After the concrete has taken initial set, the forms shall not be jarred or any strain placed on projecting reinforcement.

Chutes, troughs, conveyors or pipes used as aids in placing concrete shall be arranged and used so that the ingredients of the concrete will not be separated. When steep slopes are necessary, the chutes shall be equipped with baffle boards or be made in short lengths that reverse the direction of movement. Open troughs and chutes shall extend, if necessary, down inside the forms or through holes left in the forms, or the ends of such chutes shall terminate in vertical downspouts. All chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete by a thorough flushing with water before and after each placement. Water used for flushing shall be discharged clear of the concrete in place. The use of chutes in excess of thirty-five (35) feet total length for conveying concrete will not be permitted except by specific authorization from the Engineer.

Where the Contractor's operations involve the placing of concrete from above, that is, directly into an excavated area or through the completed forms, particularly in the case of abutments, piers, columns, retaining walls, and deep girders, and excepting thin walls such as culvert walls less than 12-inches, all concrete so placed shall be deposited through a vertical sheet metal or other approved pipe not less than six (6) inches nor more than ten (10) inches in diameter. The pipe shall be made in sections so that the outlet may be adjusted to proper heights during placing operations.

Concrete shall be placed in continuous horizontal layers approximately 12-inches in thickness. Not more than one hour shall elapse between the placing of successive layers of concrete in any portion of the structure included in a continuous placement. The Contractor shall avoid unauthorized construction joints by placing required portions of abutments, pier walls or superstructures in one continuous operation. Laitance or foreign matter of any kind shall not be permitted to accumulate inside the forms. Openings in forms necessary for removal of shall be provided.

All concrete shall be well compacted and the mortar flushed to the surface of the forms by continuous working with concrete spading implements or mechanical vibrators of an approved type. Vibrators of the type which operate by attachment to forms or reinforcement will not be permitted. The vibrators shall be applied to the concrete immediately after deposit and shall be moved throughout the mass, thoroughly working the concrete around the reinforcement, embedded fixtures, and into the corners and angles of the forms until it has been reduced to a plastic mass. The mechanical vibrator shall not be operated so that it will penetrate or disturb layers placed previously which have become partially set or hardened. The vibration shall be of sufficient duration to accomplish thorough compaction and complete embedment of reinforcement and fixtures but shall not be done to an extent

that will cause segregation. Vibration shall be supplemented by hand spading if necessary to insure the flushing of mortar to the surface of all forms.

Holes for anchor bolts in piers, abutments, bents, or pedestals may be drilled or may be formed by the insertion of oiled wooden plugs or metal sleeves in the plastic concrete. The plugs or sleeves shall be withdrawn after the concrete has set. When the holes are formed, they shall be of such diameter to permit horizontal adjustment of the bolts. The bolts shall be carefully set in mortar. In lieu of the above methods of placing, anchor bolts may be set to exact locations in the concrete when it is placed.

The placing of concrete for floor slabs of I-beam spans, girder spans, or truss spans preferably shall be done from a mixing plant located off the structure. If the mixer plant is to be located on the structure, it shall not be placed on a section of the roadway slab which has not aged for at least ten (10) curing days. Carting or wheeling concrete batches on a completed concrete floor slab will not be permitted until the slab has aged at least four (4) curing days. If carts are used, the carts shall be wheeled on timber planking so that the loads and impact will be distributed over the slab. Carts shall be equipped with pneumatic tires. Curing operations shall not be interrupted for the purpose of wheeling concrete over finished slabs.

Stockpiling of concrete aggregate or cement on bridge floors will be permitted only when authorized by the Engineer, and, when permitted, the stock piles shall be uniformly distributed and shall be limited to not over two (2) feet maximum depth. The storing of reinforcing or structural steel on completed roadway slabs shall generally be avoided, and, when permitted, such storage shall be limited to quantities and distribution that will not induce excessive stresses.

420.13 Placing Concrete In Cold Weather. No concrete shall be placed when the atmospheric temperature is at or below 40° F. (taken in the shade away from artificial heat) unless permission to do so is given in writing by the Engineer. When such permission is given or in cases where the temperature drops below 40° F. after the concreting operations have been started, the Contractor shall furnish sufficient canvas and framework or other type of housing to enclose and protect the structure in such way that the air around the forms and fresh concrete can be kept at a temperature not less than 50° F. for a period of five days after the concrete is placed. Sufficient heating apparatus such as stoves, or steam equipment and fuel to furnish all required heat shall be supplied. The treatment of mixing water and aggregates used in mixing concrete shall be as specified in "Concrete". The placing of concrete in cold weather, shall conform to the requirements of ACI306.

It is understood that the Contractor is responsible for the protection of concrete placed under any and all weather conditions. Permission given by the Engineer to place concrete during freezing weather will in no way relieve the Contractor of the responsibility for satisfactory results. Should concrete

placed under such conditions prove unsatisfactory, it shall be removed and replaced at the expense of the Contractor.

420.14 Placing Concrete in Hot Weather. Unless otherwise directed by the Engineer, when the temperature of the air is above 85° F., an approved retarding agent will be required in all concrete or direct traffic culverts. An approved retarding agent will be required in all cased drilled shafts, regardless of temperature.

420.15 Placing Concrete In Water. Concrete shall be deposited in water only when specified on the plans or with the permission of the Engineer. The forms, cofferdams, or caissons shall be sufficiently tight to prevent any water current passing through the space in which the concrete is being deposited. Pumping will not be permitted while the concrete is being placed, nor until it has set for at least thirty-six (36) hours.

The concrete shall be carefully placed in a compact mass by means of a tremie, closed bottom-dump bucket or other approved method that does not permit the concrete to fall through the water. The concrete shall not be disturbed after being deposited. Depositing shall be regulated to maintain an approximately horizontal surface at all times.

When a tremie is used, it shall consist of a tube having a diameter of not more than ten (10) inches, constructed in sections having water-tight connections. The means of supporting the tremie shall permit the movement of the discharge end over the entire top surface of the work and shall permit the tremie to be rapidly lowered when necessary to choke off or retard the flow. The number of times it is necessary to shift the location of the tremie, for any continuous placement of concrete, shall be held to a minimum.

During the placing of concrete, the tremie tube shall be kept full to the bottom of the hopper. When a batch is dumped into the hopper, the tremie shall be slightly raised, but not out of the concrete at the bottom, until the batch discharges to the level of the bottom of the hopper. The flow shall then be stopped by lowering the tremie. The placing operations shall be continuous until the work is complete.

When concrete is placed by means of a bottom-dump bucket, the bucket shall have a capacity of not less than one-half (1/2) cubic yard. The bucket shall be lowered gradually and carefully until it rests upon the concrete already placed. It shall then be raised, very slowly, during the upward travel, the intent being to maintain, as nearly as possible, still water at the point of discharge and to avoid agitating the mixture.

420.16 Placing Concrete in Slab Spans. Concrete in slab spans shall be placed in longitudinal strips. Placing preferably shall be started at a point in the center of the span adjacent to one curb and the longitudinal strip thus started shall be completed by depositing concrete uniformly in both directions toward the ends of the span. The width of longitudinal strips shall be such that the

concrete in any strip will not take its initial set before the adjacent strip is placed. The concrete in the curbs shall be placed in proper sequence to be monolithic with the adjacent longitudinal strip of the slab.

The forms for the bottom surface of the slab shall be maintained true to the required vertical alignment during the placing of concrete in the span. For convenience in checking the vertical alignment, an approved system of "tell-tales" shall be installed and maintained by the Contractor. The "tell-tales" shall be attached to the form and shall provide a convenient means of matchmarking with reference to points set on stakes or other suitable reference points set independent of the forms and falsework for the span being placed.

On completion of the filling of the curb forms, the curbs shall be brought to the correct camber and alignment, and then they shall be struck off and float finished.

As soon as concrete is placed in a longitudinal section of the slab of a width necessary to permit finishing operations, the slab shall be finished in accordance with the requirements of "Finish of Roadway Slabs".

420.17

Placing Concrete in Deck Girders Spans. Unless otherwise provided, the girders, slab and curbs of deck girder spans shall be placed in one continuous operation. Concrete shall be placed in longitudinal sections. Placing preferably shall commence with a section adjacent to one curb, and successive sections continuing across the roadway shall follow. The width of each longitudinal section shall be governed by the size of the mixing apparatus and shall be such that each successive section shall be placed before the adjacent completed section shall have attained its initial set. The placing of concrete in curbs shall be in the proper sequence to be monolithic with the adjacent slab or girder section. Except for spans on a grade of one and one-half (1.5) per cent or more, concreting in each longitudinal section preferably shall be started at the middle of the span and shall be continued in both directions to the ends of the span. For spans on a grade of one and one-half (1.5) per cent or more, concreting shall be commenced at the low end of the span. The filling of the girder stems ahead of placing the concrete in the slab will be permitted provided the slab is placed not later than one hour after the filling of the girder stem.

During the operations of placing concrete in the span, the bottoms of the girders and overhanging slabs shall be maintained true to required vertical alignment. For convenience in checking the vertical alignment, the Contractor shall attach to the form of each girder an approved system of "tell-tales" which shall provide a means of matchmarking for reference to established grades fixed on stakes or other suitable reference points set independent of the forms and falsework for the span being placed. Care shall be exercised to assure that the "tell-tales" system is not altered or destroyed after the matchmarking is done.

On completion of the filling of the curb forms, the curbs shall be brought to the correct camber and alignment, and then shall be struck off and float finished.

The surface of the floor slab shall be finished as provided in Section, "Finish of Roadway Slabs". The finishing shall be done as soon as possible after the placing of concrete is completed in a section of slab of sufficient width to permit finishing operations.

420.18 Placing Concrete In Floors on Steel Spans. Before concrete floor slabs are placed on steel truss spans, the falsework under the span shall be released and the span swung free on its supports. The floor slab shall be placed symmetrically about the centerline of the span beginning at the center and working simultaneously toward each end, or beginning at the ends and working simultaneously toward the center. Where construction joints are provided at each panel point of the truss, variations from the above sequence will be permitted to the extent of one unsymmetrical panel; that is, concreting will be permitted in a panel on one side of the centerline of span provided that the corresponding panel on the opposite side of the centerline shall be the next panel placed.

Placing of the slab in each panel and the placing of the slab on steel I-beam spans shall be in accordance with the provisions of Section

Concrete placed around steel shapes shall be deposited on one side of the shape and shall be spaded or vibrated until it flushed up over the bottom flange on the opposite side of the member, after which, it may be placed on both sides to completion.

On completion of the filling of the curb forms, the curbs shall be brought to the correct camber and alignment, and they shall then be struck off and float finished as described in Section "Treatment and Finishing of Horizontal Surfaces Except Roadway Slabs".

The surface of the floor slab shall be finished as provided in Section, "Finish of Roadway Slabs". The finishing shall be done as soon as possible after the placing of concrete is completed in a section of slab of sufficient width to permit finishing operations.

420.19 Placing Concrete in Box Culverts. In general, the base slab, curtain walls, lower haunches, and the bottom portion of the sidewalls up to a height approximately one inch above the haunches, or sidewalls to a height approximately four (4) inches above the base slab when no haunch is provided, shall be placed as a monolith. The top surface of the base slab and the top surface of the top slabs which do not carry direct traffic shall be accurately finished by hand floating methods before the concrete has attained its initial set. Before concrete is placed in the sidewalls, the footing area joining the walls shall be thoroughly cleaned of all shavings, sticks, sawdust, or other extraneous material.

In the construction of box culverts less than four (4) feet in clear height, the sidewalls and top slab generally shall be placed monolithic. When box culverts are greater than four (4) feet in clear height, a construction joint may, if shown on the plans, be provided between the sidewalls and the top slab. In case no joint is provided, an interval of not less than one (1) hour or more than two (2) hours shall elapse between the placing of concrete in the walls, and concrete in the haunches and top slab, such interval to allow for shrinkage in the wall concrete. Curbs and haunches at tops of walls shall be placed monolithic with the top slab.

The tops of culvert slabs which are intended to carry direct traffic shall be finished and surface tested in accordance with the provisions for finishing roadway slabs.

420.20 Placing Concrete in Foundations of Structures. Concrete shall not be placed in footings until the depth and character of the foundation has been inspected by the Engineer and permission has been given to proceed.

The placing of concrete bases above seal courses will be permitted after the caissons or cofferdams are free from water and the seal course cleaned. Any necessary pumping or bailing during the concreting operations shall be done from a suitable sump located outside the forms.

All temporary wales or braces on the inside of cofferdams or caissons shall be constructed or adjusted as the work proceeds, so that construction joints in bases or shaft, in addition to those shown on the plans, will not be necessary.

Concrete in deep foundations shall be placed in a manner that will avoid separation of the aggregates or displacement of the reinforcement. Suitable chutes or vertical pipes shall be provided.

When footings can be placed in dry foundation pits without the use of cofferdams or caissons, forms may be omitted, if desired by the Contractor and approved by the Engineer, and the entire excavation filled with concrete to the elevation of the top of footing. Where this procedure is followed, no measurement for payment will be made for concrete placed outside of the footing dimensions shown on the plans.

Concrete in columns shall be placed monolithically unless otherwise provided. Unless a construction joint is provided at the top of columns, an interval of not less than one hour or more than two (2) hours shall elapse between the placing of concrete in columns and the placing of concrete above the top of columns. Such interval is intended to allow for shrinkage of the column concrete.

420.21 Treatment and Finishing of Horizontal Surfaces, Except Roadway Slabs. All upper surfaces not covered by forms, such as tops of railing posts, railings, caps, curbs, parapets, copings, bridge seats, and sidewalk areas shall be completed by placing excess material in the forms and removing or striking

off such excess with a wooden template forcing the coarse aggregate below the mortar surface. The use of mortar topping for surfaces under this classification will not be permitted.

After the concrete has been struck off as described above, the surface shall be thoroughly worked and floated with a wooden, canvas, or cork float. After floating and before the finish has set, all surfaces, except sidewalks so finished, shall be lightly striped with a fine brush, to remove the surface cement film, leaving a fine grained, smooth but sanded texture. That portion of curbs or parapets which is to be the seat for concrete rail posts or webs of concrete railings shall be roughened in an approved manner.

420.22

Finish of Roadway Slabs. As soon as concrete placing operations have been completed for a longitudinal roadway slab section of sufficient width to permit finishing operations, the concrete shall be approximately leveled and then struck off, screeded and tamped by a longitudinal screed. The screed shall be of a design adaptable for the purpose intended. It shall have provisions for adjustment to the desired camber and be sufficiently rigid to hold true to shape during use.

The first strike-off operation shall leave the concrete surface at an elevation above grade so that, when consolidation and finishing operations are completed, the slab will be at the exact grade elevation shown on the plans with proper allowance for finished camber as hereinafter provided. The tamping and screeding operations shall be continued until the concrete is properly consolidated and surface voids eliminated. The surface shall then be brought to a smooth true alignment by means of longitudinal screeding, floating, belting, and/or other methods approved by the Engineer. Spans over forty (40) feet in length may be screeded in two or more sections if suitable intermediate templates are installed. Unless otherwise provided, the templates shall be of such design as to permit early removal in order to avoid construction joints and to permit satisfactory finishing at and adjacent to the site of the template.

After the finishing operations are completed and while the concrete is still plastic, the surface shall be straight edged by the Contractor, using a standard ten (10) foot metal straightedge. Any deviations from the face of the straightedge greater than those prescribed under the following surface test shall be corrected before the concrete has attained its initial set. The final belting of the slab shall be done after this straight edging is completed.

After the concrete has attained its final set, the roadway surface shall be tested again with a standard ten (10) foot metal straightedge for irregularities, and the surface shall be corrected, if necessary, to conform to the following:

The straightedge shall be placed parallel to the centerline of the road so as to bridge any depression and tough high spots. Ordinates measured from the face of the straightedge to the surface of the slab shall not exceed one-

sixteenth (1/16) inch per foot from the nearest point of contact and the maximum ordinate shall not be greater than one-eighth (1/8) inch. The surface shall be corrected by grinding off the high spots as may be required in order to conform to these limits.

In the case of concrete slab or girder spans, the floor shall be finished so as to provide a camber sufficient to off-set the dead load deflection of the span; other spans shall be so finished if directed by the Engineer. Unless otherwise shown on the plans, the camber at the center of the span shall be made one-eighth (1/8) inch for each ten (10) feet of span length with a maximum camber of one-half (1/2) inch. When camber is provided, the ordinate to the straightedge may be as much as three-sixteenths (3/16) inch at the end of the straightedge but shall not exceed one-sixteenth (1/16) inch under its center.

420.23

Curing Concrete. Careful attention shall be given by the Contractor to the proper curing of all concrete in the structure. The Contractor, at his option, may elect to use other curing methods outlined in the Item, "Concrete". If cotton mats are used, all upper surfaces not formed, except roadway and side walk slabs, shall be covered by cotton mats immediately following the floating operations and shall be kept thoroughly wet for a period of four (4) curing days after the concrete is placed. All formed surfaces requiring a surface finish shall be covered with wet cotton mats immediately after the forms are removed and shall be kept covered and wet until the concrete has aged at least four (4) curing days. Intermission will be permitted as needed to allow the surfaces to be finished. The mats shall be held in direct contact with the concrete. Water used for curing shall be free from injurious amounts of oil, acid, alkali, salt, or other deleterious substances.

When forms are removed from concrete caissons in less than four (4) curing days and when the sinking operations do not immediately follow the form removal, the caissons shall be cured by being covered with wet cotton mats which shall remain in place until the caissons have aged at least four (4) curing days.

Immediately following the finishing operations, concrete roadway and sidewalk slabs shall be covered with wet cotton mats or with a temporary covering of canvas or burlap. The temporary covering will be required in all cases where the size of span, size of mats, or other factors are such that the mats cannot be placed immediately following the finishing operation without marring the finish of the slab.

The canvas or burlap covering material shall weigh not less than ten (10) ounces per square yard, and the sections shall be placed with a lap at the edges of at least eight (8) inches. The material shall be saturated with water previous to placing and shall be kept saturated as long as it remains in place. Care shall be exercised in the placing of the cover material in order that the concrete surface shall not be disturbed.

When a temporary covering is used, it shall remain in place only until the slab has sufficiently hardened that a cotton mat covering can be substituted without disturbing or marring the finish of the slab. Cotton mats shall be thoroughly saturated before placing and shall be maintained in a saturated condition for a period of at least eight (8) curing days after the concrete is placed.

Ponding, instead of cotton mat covering may be used for curing roadway, sidewalk slabs, and top slabs of culverts. In addition, membrane curing as specified in the Item 526, "Membrane Curing", may also be used, where appropriate.

420.24

Removal of Forms and Falsework. Except as hereinafter provided, forms for surfaces required to be finished shall be removed when the concrete has aged not less than one-half (1/2) nor more than two (2) curing days after the concrete is placed. In order to facilitate slab finishing, forms for inside curb faces on roadway slabs may be removed in not less than three (3) hours if the concrete has set sufficiently to permit form removal without damage to the curbs.

Forms and falsework for the portions of structures which do not require surface finish may be removed when the concrete has aged for the minimum number of curing days set forth in the following table:

Forms and falsework under slabs or girders having span lengths of 10 feet and less	7 Days
Forms and falsework under slabs or girders having span lengths over 10 feet and less than 17 feet	7 Days plus one day for each foot of span over 10 feet
Forms and falsework under slabs or girders having spans over 17 feet in length	14 Days
Forms and falsework under caps or tie beams of framed bents	4 Days
Forms under caps of pile bents	4 Days
Forms & falsework under webwalls of piers	7 Days
Forms for walls, columns & sides of beams	4 Days
Forms for concrete caissons	2 Days

The term "curing day" will be interpreted as any calendar day on which the temperature is above 50° F. for at least nineteen (19) hours. Colder days may be counted if satisfactory provision is made to maintain the air temperature adjacent to the concrete constantly above 50° F. throughout the entire day. In continued cold weather, when artificial heat is not provided, the Engineer may permit the removal of forms and falsework at the end of a period of calendar days equal to twice the number of curing days stated in the above table. Test specimens may be made, at the option of the Engineer, for the purpose of determining a satisfactory time of form and falsework removal in cold weather. When tests made on specimens cured under like conditions to the curing of the structure indicate that strengths equivalent to the seven-day strengths as given in the Item, "Concrete" have been attained, the forms and falsework may be removed. In no event shall this removal be done in less time than the curing periods given in the above table.

Forms for the portions of slabs that cantilever more than one foot beyond the outside beams shall not be removed in less than four curing days, nor shall falsework under girders and bent caps for framed bents be removed in less than the minimum time specified regardless of requirements for surface finish. The above provisions relative to form removal shall apply only to forms or parts of forms which are so constructed as to permit removal without disturbing forms or falsework which are required to be left in place for a longer period on other portions of the structures.

420.25 Defective Work. Any defective work discovered after the forms have been removed shall be repaired immediately. If the surface of the concrete is bulged, uneven, or shows excess honeycombing or form marks, which defects, in the opinion of the Engineer, cannot be repaired satisfactorily, the entire section shall be removed and replaced. In repairing honeycombed areas, all loose material shall be removed before the repair work is started. No extra compensation will be allowed for the extra work or materials involved in repairing or replacing defective concrete.

420.26 Finishing Exposed Surfaces. All railing, curbs, the underside of overhanging slabs, the outside and bottom of exterior girders or fascia beams, and all portions of piers, columns, bents, abutments, retaining walls and culverts, which are exposed to view after backfill and roadway embankments are placed shall be surface finished. The area inside of culvert barrels including both sidewalls and the underside of the top slab for a distance equal to one-third (1/3) the clear height but not less than eighteen (18) inches shall be considered as exposed to view. The remaining surface inside of culvert barrels, the underside of roadway slabs between exterior girders or beams, the sides and bottoms of interior superstructure girders and bottoms of slab spans will not be required to be surface finished unless such surfaces are not true or have porous spots or honeycombed areas. In case these defects occur, the areas shall be given a first surface rubbing.

The operation of surface finishing shall be in accordance with the following provisions:

As soon as forms are removed, all necessary pointing shall be done. When the pointing has set sufficient to permit it, all surfaces requiring surface finish shall be wet with a brush and given a first surface rubbing with a No. 16 Carborundum Stone or an abrasive of equal quality. The rubbing shall be continued sufficiently to bring the surface to a paste, to remove all form marks and projections, and to produce a smooth dense surface without pits or irregularities. The use of cement to form a surface paste will not be permitted. The material which has been ground to a paste in this process shall be carefully spread or brushed uniformly over the surface and allowed to take a reset.

In general chamfered corners shall not be rubbed in the first surface rubbing.

During the process of conditioning the completed structure for final acceptance, the surfaces of the entire structure requiring finish shall be cleaned free from drip marks and discolorations and shall be given a final finish rubbing with a No. 30 Carborundum Stone or an abrasive of equal quality. On completion of this rubbing, the surface shall be neatly striped with a brush, and the mortar on the surface shall be allowed to take a reset. The surface shall then be washed down with clean water. The entire structure shall be left with a clean, neat, and uniform appearing finish and shall be uniform in color.

The surfaces of concrete roadway and sidewalk slabs shall be finished by floating, screeding, and belting as provided in Section, "Finish of Roadway Slabs".

420.27 Special Surface Finishes. When so specified, special surface finishes shall be employed for ornamental panels, copings, and like construction. In general, the method and manner of performing this work will be fully provided for in the plans or special provisions to these specifications.

In case of special finishes, the Contractor will be required to prepare test or sample panels showing the method and manner of finish. The choice and selection of the aggregate and other features affecting the work shall be approved by the Engineer before any further work is done.

420.28 Measurement and Payment. No direct compensation will be made for "Concrete Structures". Measurement and payment for quantities of concrete, railing, piling, excavation and other proposal items, which constitute the completed and accepted structure will be made in accordance with the provisions of the pertinent specifications.

END OF ITEM 420