SECTION 710

CONCRETE STRUCTURE CONSTRUCTION

710.1 DESCRIPTION

Construct concrete structures according to the Contract Documents.

BID ITEMS	UNITS
Concrete (*) (**) (***)	Cubic Yard
*Grade of Concrete	
**AE (air-entrained), if specified	
***Aggregate, if specified	

710.2 MATERIALS

Provide materials that comply with the applicable requirements.

Concrete	**DIVISION 400**
Asphalt Materials for Poured Joints	**DIVISION 1200**
Concrete Curing Materials	**DIVISION 1400**
Joint Sealing Compounds	**DIVISION 1500**
Type B Preformed Expansion Joint Filler	**DIVISION 1500**
Preformed Elastomeric Compression Joint Seals	**DIVISION 1500**
Bridge Number Plates	**DIVISION 1600**

710.3 CONSTRUCTION REQUIREMENTS

a. Falsework and Forms. Construct falsework and forms according to **SECTION 708**.

b. Handling and Placing Concrete. At a progress project meeting prior to placing concrete, discuss with the Engineer the method and equipment used for deck placement; include the equipment for controlling the evaporation rate and procedures used to minimize the evaporation rate.

Use a method and sequence of placing concrete approved by the Engineer. Do not place concrete until the forms and reinforcing steel have been checked and approved. Before placing concrete, clean all forms of debris. Drive all foundation piling in any one pier or abutment before concrete is poured in any footing or column of that pier or abutment.

On bridges skewed greater than 10º, place concrete on the deck forms across the deck on the same skew as the bridge, unless approved otherwise by State Bridge Office (SBO). Operate the bridge deck finishing machine on the same skew as the bridge, unless approved otherwise by the SBO.

Maintain environmental conditions on the entire bridge deck such that the evaporation rate is less than 0.2 lb/sq ft/hr. This may require placing the deck at night, in the early morning or on another day. The evaporation rate (as determined in the American Concrete Institute Manual of Concrete Practice 305R, Chapter 2) is a function of air temperature, concrete temperature, wind speed and humidity.

Just prior to and at least once per hour during placement of the concrete, the Engineer will measure and record the air temperature, concrete temperature, wind speed and humidity on the bridge deck. The Engineer will take the air temperature, wind and humidity measurements approximately 12 inches above the surface of the deck. With this information, the Engineer will determine the evaporation rate by using KDOT software or by using **FIGURE 710-1** (Figure 2.1.5 from the American Concrete Institute Manual of Concrete Practice 305R, Chapter 2).

When the evaporation rate is equal to or above 0.2 $lb/ft^2/hr$, take actions (such as cooling the concrete, installing wind breaks, sun screens etc.) to create and maintain an evaporation rate less than 0.2 $lb/ft^2/hr$ on the entire bridge deck.

Place concrete to avoid segregation of the materials and displacement of the reinforcement. Do not deposit concrete in large quantities at any point in the forms, and then run or work the concrete along the forms.

Deposit the concrete in the forms in horizontal layers. Perform the work rapidly and continuously between predetermined planes. Vibrate through each plane.

Fill each part of the form by depositing the concrete as near to the final position as possible. If the chutes for placement of concrete are on steep slopes, equip them with baffle boards or assemble in short lengths that reverse the direction of movement. Do not drop concrete in the forms a distance of more than 5 feet, unless confined by clean, smooth, closed chutes or pipes.

Work the coarse aggregate back from the forms, and around the reinforcement without displacing the bars. After initial set of the concrete, do not disturb the forms, or place any strain on the ends of projecting reinforcement.

If placing concrete by pumping, place the concrete in the pipeline to avoid contamination or separation of the concrete. Obtain sample concrete for slump and air test requirements at the discharge end of the piping.

Do not use chutes, troughs or pipes made of aluminum.

Accomplish consolidation of the concrete on all span bridges that require finishing machines by means of a mechanical device on which internal (spud or tube type) concrete vibrators of the same type and size are mounted (**subsection 154.2**). Observe special requirements for vibrators in contact with epoxy coated reinforcing steel as specified in **subsection 154.2**. Provide stand-by vibrators for emergency use to avoid delays in case of failure.

Operate the mechanical device so vibrator insertions are made on a maximum spacing of 12 inch centers over the entire deck surface. Provide a uniform time per insertion of all vibrators of 3 to 15 seconds, unless otherwise designated by the Engineer. Provide positive control of vibrators using a timed light, buzzer, automatic control or other approved method. Extract the vibrators from the concrete at a rate to avoid leaving any large voids or holes in the concrete. Do not drag the vibrators horizontally through the concrete.

Use hand held vibrators (**subsection 154.2**) in inaccessible and confined areas such as along hubguards. When required, supplement vibrating by hand spading with suitable tools to provide required consolidation.

Reconsolidate any voids left by workers.

Deposit concrete in water, only with approval from the Engineer. Do not place concrete in running water. Use forms that are reasonably watertight to hold concrete deposited under water. Increase the minimum cement factor of the class of concrete being deposited in water by 10%, obtaining approximately a 6 inch slump. Carefully deposit the concrete in place, in a compact mass, using a tremie pumped through piping, bottom-dumping bucket or other approved method that does not permit the concrete to fall through the water. Do not pump water from the inside of the foundation forms while concrete is being placed. Do not disturb the concrete after being deposited. If necessary to prevent flooding, place a seal of concrete through a closed chute or tremie, and allow it to set.

Continuously place concrete in any floor slab until complete, unless shown otherwise in the Contract Documents.

The method used for transporting concrete batches, materials or equipment over previously placed single pour (non-overlaid) floor slabs or floor units, or over units of structures of continuous design types is subject to approval by the Engineer.

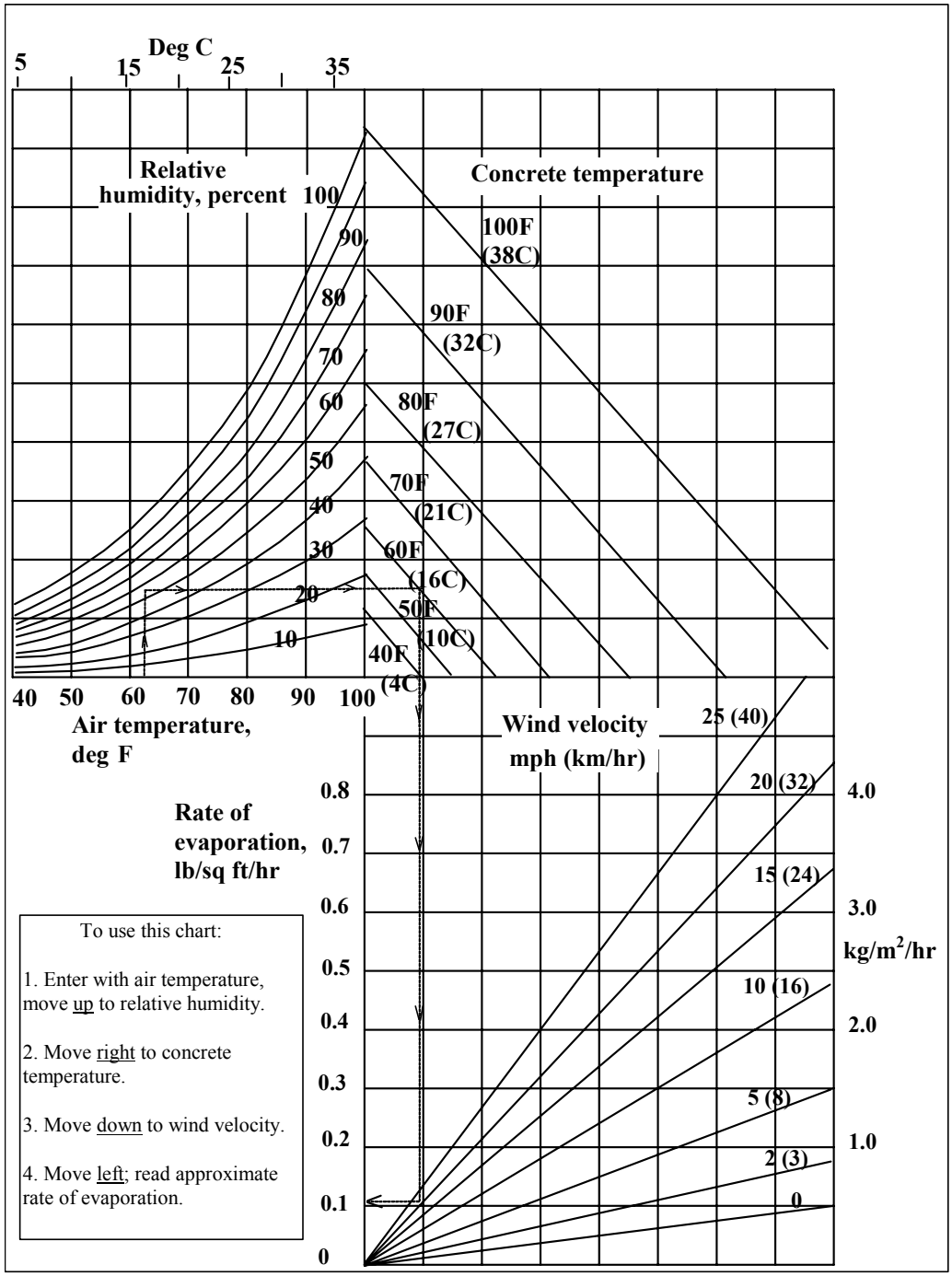
Do not operate bridge deck finishing equipment on previously placed concrete spans until:

- A minimum of 72 hours on structures that are fully supported with falsework;
- A minimum of 72 hours on structures with concrete girder spans with concrete decks; and
- A minimum of 96 hours on structures with steel girder spans with concrete decks.

The time delays begin after the day's pour has been completed.

Follow **TABLE 710-2** for load limitations after concrete placement. Prior to permitting approved traffic on the bridge deck, construct temporary bridge approaches and maintain them in a condition to prevent damage to the bridge ends.

FIGURE 710-1: STANDARD PRACTICE FOR CURING CONCRETE



Effect of concrete and air temperatures, relative humidity, and wind velocity on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use the chart, follow the four steps outlined above. When the evaporation rate exceeds 0.2 lb/ft^2/hr (1.0 kg/ m^2/hr), measures shall be taken to prevent excessive moisture loss from the surface of unhardened concrete; when the rate is less than 0.2 lb/ft^2/hr (1.0 kg/m^2/hr) such measures may be needed. When excessive moisture loss is not prevented, plastic cracking is likely to occur.

c. Construction Joints, Expansion Joints and End of Wearing Surface (EWS) Treatment. Locate the construction joints as shown in the Contract Documents. If construction joints are not shown in the Contract Documents, submit proposed locations for approval by the Engineer.

If the work of placing concrete is delayed and the concrete has taken its initial set, stop the placement, saw the nearest construction joint approved by the Engineer and remove all concrete beyond the construction joint. On post-tensioned structures construct a stepped joint as shown in the Contract Documents.

When the Contract Documents show a construction joint in the wall of the RCB 3 inches above the floor, the Contractor has the option of constructing the joint as shown on the Contract Documents, or constructing the joint level with the floor of the RCB. When the Contract Documents show a construction joint in the wall of the RFB 2 inches above the floor haunch, the Contractor has the option of constructing the joint as shown on the Contract Documents, or even with the top of the floor haunch of the RFB.

If dowels, reinforcing bars or other tie devices are not required by the Contract Documents, make a key in the construction joint. Construct keyed joints by embedding water-soaked beveled timbers of a size shown on the Contract Documents, into the soft concrete. Remove the timber when the concrete has set. When resuming work, thoroughly clean the surface of the concrete previously placed, and when required by the Engineer roughen the key with a steel tool. Before placing concrete against the keyed construction joint, thoroughly wash the surface of the keyed joint with clean water, and paint it with a thick coat of neat cement mortar.

(1) Bridges With Tied Approaches. When concrete is placed at the bridge EWS, embed 3 (½ inch by 8 inch) bolts to hold a header board for each traffic lane into the vertical surface of the EWS. Finish the surface of the EWS using an edging tool with a ¼ inch radius. Immediately after the vertical forms on the EWS are removed, protect the exposed EWS by bolting a wooden header (minimum dimension of 2 ⅝ inch by 7 ½ inch) to the exposed vertical surface of the EWS. Extend the header board the full width of the EWS, or use 1 section of header board for each lane of traffic. Shape the header board to comply with the crown of the bridge surface, and install it flush with the concrete wearing surface.

(2) Bridges Without Tied Approaches. Place the concrete for the approach slab, and at the end of the approach slab away from the EWS place bolts and attach a header board in the same manner required for bridges with tied approaches. If the Contractor needs to drive on the bridge before the approach slabs can be placed and cured construct a temporary bridge from the approach over the EWS capable of supporting the anticipated loads. Do not bend the reinforcing steel which will tie the approach slab to the EWS or damage the concrete at the EWS. The method of bridging must be approved by the Engineer.

d. Finishing. Finish all top surfaces, such as the top of retaining walls, curbs, abutments and rails, with a wooden float by tamping and floating, flushing the mortar to the surface and provide a uniform surface, free from pits or porous places. Trowel the surface producing a smooth surface, and brush lightly with a damp brush to remove the glazed surface.

Strike off bridge decks with a finishing machine, either self-propelled or manually operated by winches and approved by the Engineer. The screed on the finish machine must be self-oscillating, and operate or finish from a position either on the skew or transverse to the bridge roadway centerline.

On decks skewed greater than 10º, operate the finishing machine on the same skew as the bridge, unless approved otherwise by the SBO. Before placing concrete, position the finisher throughout the proposed placement area allowing the Engineer to verify the reinforcing steel positioning.

Irregular sections may be finished by other methods approved by the Engineer. Reinforced concrete box bridges that will be under fill may be struck off by other approved methods.

Float and straightedge the wearing surface so the finished surface is at the cross-section shown in the Contract Documents. Do not add water to the surface of concrete, unless approved by the Engineer, and when approved apply as a fog spray.

Secure a smooth riding bridge deck, correcting surface variations exceeding ⅛ inch in 10 feet by use of an approved profiling device, or other method approved by the Engineer.

Straightedge decks that are to receive an overlay leaving them with an acceptable float or machine pan finish.

Unless shown otherwise in the Contract Documents, finish decks that do not receive an overlay in this manner:

- When a tight, uniform surface is achieved, give the surface a suitable texture by transverse grooving perpendicular to the center line of the bridge with a tining float or a vibratory tining float having a single row of fins. Make the grooving approximately $^{3}/_{16}$ inch in width at ¾ inch centers, with a depth of approximately ⅛ inch.

- Achieve the desired texture while minimizing displacement of the larger aggregate particles. For bridges without drains, the transverse grooving should terminate approximately 3 feet in from the outside edge of the deck and for bridges with drains, approximately 2 feet in from gutter line at the base of the curb. Finish the area adjacent to the curbs with a light, longitudinal broom finish. Provide suitable work bridges, which do not come in contact with the wearing surface.
- Begin fogging the bridge deck immediately behind the tining float. Maintain the fogging to produce a "gloss to semi-gloss water sheen" on the surface until the curing is applied. Apply the fog over the entire placement width. Reduce fogging only if excess water accumulates on the surface.
- Produce a fog spray from nozzles that atomize the droplets and a system capable of keeping a large surface area damp without depositing excess water. Use high pressure equipment that generates a minimum of 1200 psi at 2.2 gpm, or low pressure equipment having nozzles capable of supplying a maximum flow rate of 1.6 gpm.

Obtain reasonably true and even concrete surfaces, free from stone pockets, excessive depressions or projections on the surface. Strike off with a straightedge and float the concrete in bridge seats and walls flush with the finished top surface.

As soon as the forms are removed and the concrete is ready to hone, rub the concrete surfaces that are not in an acceptable condition, or are designated in the Contract Documents to be surface finished to a smooth and uniform texture with a carborundum brick and clean water. Remove the loose material formed on the surface, due to the rubbing with a carborundum brick as soon as it dries. The finished surface shall be free from all loose material. Do not use a neat cement wash.

Give handrails, handrail posts, the deck side, and the top and end of all curbs, except curbs of structures having the top of curb below the final shoulder elevation of the road, an acceptable troweled or floated finish. This includes the back of the inside rails of side by side structures, or any rails easily viewed by the traveling public.

Remove the forms as early as possible, and perform the float finish while the concrete is still green. Use mortar during the float finish operation to fill in air and water voids and supplement the float finish. Keep surfaces requiring a rubbed finish moist before and during the rubbing. Do not use a mortar coating after the concrete has cured.

Unless otherwise provided in the Contract Documents, all reasonably true and even surfaces, obtained by use of a form lining, which are of a uniform color, free from stone pockets, honeycomb, excessive depressions or projections beyond the surface, are considered as acceptable surfaces, and a rubbed surface finish is not required.

The Engineer may require the use of a dry carborundum brick for straightening moulding lines, removing fins or requiring a rubbed surface finish on all portions of the structure that do not present an acceptable surface even though a form lining is used.

e. Curing and Protection.

(1) General. Cover concrete surfaces with wet burlap, moisture proofed burlap, liquid membrane-forming compound, white polyethylene sheeting or other impermeable material approved by the Engineer. Maintain a damp surface until the wet burlap is placed. Burlap shall be wet before placing on concrete surface. Cover the concrete surfaces immediately after finishing the concrete, and at such time that marring of the concrete shall not occur. Provide a work bridge while applying the curing materials. Maintain the curing so that moisture is always present at the concrete surface.

The minimum curing periods are shown in **TABLE 710-1**. The determination of the time requirement for curing commences after all the concrete for the placement is in place and finished. During cold weather, the specified time limits may be increased at the discretion of the Engineer, based upon the amount of protection and curing afforded the concrete.

TABLE 710-1: MINIMUM CURE TIMES AND CURING MEDIUMS		
Type of Work	**Cure Time**	**Curing Medium**
Bridge subdecks (decks with overlays)	7 days	Wet burlap covered with polyethylene sheeting
Bridge decks (full-depth decks)	7 days	Type 1-D liquid membrane forming compound (1 coat) covered with wet burlap and polyethylene sheeting
Other unformed or exposed surfaces	7 days	Wet burlap, moisture-proofed burlap, liquid membrane forming compound (2 coats), white polyethylene sheeting, or other impermeable material approved by the Engineer
Formed sides and ends of bridge wearing surfaces and bridge curbs	7 days	Forms*
Other formed surfaces	4 days	Forms*

*Formed surfaces will be considered completely cured upon the Engineer's permission to remove the forms, providing the forms have been in place for a minimum of 4 days. If forms are removed before the end of the 4 day cure period, cure the surface with an application of Type 1-D liquid membrane curing compound.

If rain falls on the newly coated concrete before the film has dried sufficiently to resist damage from the rain, or if the film is damaged by any other means, apply a new coat of the membrane to the affected portion equal in curing value to the original application.

When liquid membrane-forming compound is required, use spraying equipment capable of supplying a constant and uniform pressure to provide uniform distribution at the rates required. Agitate the liquid membrane-forming compound continuously during application. The surface must be kept wet from the time it is finished until the liquid membrane-forming compound is applied. Apply the liquid membrane-forming compound at a minimum rate per coat of 1 gallon per 200 square feet of concrete surface. Apply the first coat immediately after completion of the concrete finish just as the surface water disappears. Spray the second coat immediately after and at right angles to the first application. Give marred or otherwise disturbed applications an additional coating. Should the liquid membrane-forming compound be subjected to continuous damage, the Engineer will require wet burlap, polyethylene sheeting or other approved impermeable material to be applied at once.

When burlap is required, place and weight down the burlap so it will remain in intimate contact with the surface covered. When an impermeable sheeting material is used, lap each unit 18 inches with the adjacent unit. Place and weight down the impermeable sheeting material so it will remain in intimate contact with the surface covered. When any burlap or impermeable sheeting material becomes perforated or torn, immediately repair it, or discard and replace it with acceptable material.

(2) Bridge Decks. If the concrete surface temperature is above 90ºF, do not use polyethylene sheeting in direct sunshine during the day for the first 24 hours of the 7 day curing period. White polyethylene sheeting may be used at night to maintain the required damp condition of the burlap. When polyethylene sheeting is used over the burlap at night during the first 24 hours and the concrete surface temperature is above 90ºF, place the polyethylene sheeting a maximum of 1 hour before sunset, and remove the polyethylene sheeting within 1 hour after sunrise. After the first 24 hours, the polyethylene sheeting may be left in place continuously for the remainder of the curing period provided the burlap is kept damp.

Construction loads on the new bridge subdeck, new one-course deck or any concrete overlay are subject to the limitations in **TABLE 710-2**.

TABLE 710-2: CONCRETE LOAD LIMITATIONS ON BRIDGE DECKS		
Days after concrete is placed	**Element**	**Allowable Loads**
1*	Subdeck, one-course deck or concrete overlay	Foot traffic only.
3*	One-course deck or concrete overlay	Work to place reinforcing steel or forms for the bridge rail or barrier.
7*	Concrete overlays	Legal Loads; Heavy stationary loads with the Engineer's approval.***
10 (15)**	Subdeck, one-course deck or post-tensioned haunched slab bridges**	Light truck traffic (gross vehicle weight less than 5 tons).****
14 (21)**	Subdeck, one-course deck or post-tensioned haunched slab bridges**	Legal Loads; Heavy stationary loads with the Engineer's approval.***Overlays on new decks.
28	Bridge decks	Overloads, only with the State Bridge Engineer's approval.***

*Maintain a 7 day wet cure at all times.

** Conventional haunched slabs.

*** Submit the load information to the appropriate Engineer. Information that will be required is the weight of the material and the footprint of the load, or the axle (or truck) spacing and the width, the size of each tire (or track length and width) and their weight.

****An overlay may be placed using pumps or conveyors until legal loads are allowed on the bridge.

(3) Surfaces Requiring Rubbed Finish. Apply Type 1-D liquid membrane-forming compound immediately after the surface is completed, and while the concrete is still damp.

(4) Cold Weather Curing. If concrete is placed in cold weather, comply with **SECTION 401**.

If concrete is placed and the ambient air temperature is expected to drop below 40ºF during the curing period, provide suitable measures such as straw, additional burlap or other suitable blanketing materials or housing and artificial heat to maintain the concrete temperature between 40 and 90ºF as measured on the surface of the concrete. Keep the surface of the concrete moist by the use of an approved moisture barrier such as wet burlap or polyethylene sheeting or both. Maintain the moisture barrier in intimate contact with the concrete during the entire 7 day curing period. After the completion of the required 7 day curing period, remove the curing and protection to prevent rapid cooling of the concrete.

(5) If concrete is placed in cofferdams and subsequently flooded with ground water, the specified curing conditions are waived providing the surface of the water does not freeze.

f. Removal of Forms and Falsework. Do not remove forms and falsework without the Engineer's approval. During cold weather, the specified time limits may be increased at the discretion of the Engineer, based upon the amount of protection and curing afforded the concrete.

Do not remove forms and falsework until the minimum amount of time required for strength gain has elapsed regardless if the concrete is fully cured per **TABLE 710-1**.

If forms are removed before expiration of the cure period, maintain the cure as provided in **DIVISION 700**. Remove forms on handrails, ornamental work and other vertical surfaces that require a rubbed finish as soon as the concrete has hardened sufficiently that it shall not be damaged.

Under normal conditions, the Engineer will allow removal of forms and falsework according to **TABLE 710-3**. The determination of the time requirement for the removal of forms commences after all the concrete for the placement is in place and finished. If high early strength concrete is used, the specified time limits may be decreased as determined by the Engineer, and agreed upon before placing the concrete.

TABLE 710-3: MINIMUM STRENGTH GAIN TIME BEFORE REMOVAL OF FORMS & FALSEWORK (DAYS)

Type of Work	Span Length (feet)						
	Less than 10	10 or less	Greater than 10	10 to 20	20 + to 30	Greater than 20	Greater than 30
Cantilevered Piers - Formwork (supporting the pier beam) supported on column		7 [4]*	10 [6]*				
Column Bent Piers - Falsework supporting pier beam**	4			7 [4]*		10 [6]*	
Forms and Falsework under slabs, beams, girders, arches and brackets	4			7 [4]*	10 [6]*		15 [10]*
RCB and RFB top slabs not re-shored		7 [4]*		7 [4]*		10 [6]*	

Type of Work	Time (Days)
Walls, Wing Walls and vertical sides of sides of RCB and RFB structures Do not Backfill until 3 days after forms are removed per **SECTION 207**.	4 [3]*
Footing Supported on Piles - minimum cure before erecting forms and reinforcing steel for columns	4 [2]*
Spread Footing founded in rock – minimum before erecting forms and reinforcing steel for columns	2
Footing supported on piles - minimum cure before erecting forms and reinforcing steel for columns	4 [2]*
Columns for cantilevered piers - 1. minimum before supporting forms and reinforcing steel for the pier beam on the column. 2. minimum before placing concrete for the pier beam	4 [2]* 7 [4]*
Columns for bent piers - 1. minimum before erecting formwork and reinforcing steel for the pier beam 2. minimum before placing concrete for the pier beam	2 4 [2]*
Drilled shafts - minimum before erecting forms and reinforcing steel for the columns	2

*Contractors may reduce the time required before form removal to the number of days shown in brackets, provided the concrete is shown to have attained a minimum strength of 75% of the specified f'_c. To accomplish this, prepare the necessary cylinders, obtain the services of an approved laboratory to break them at the appropriate time and provide a report to the Engineer. Field cure the cylinders alongside and under the same curing conditions, as the concrete they represent.
**Do not set girders or beams on the pier beams until the falsework under the pier beams is removed.

Reshoring of RCB and RFB (classified as culverts or bridges) top slab will be permitted if the Contractor uses traveling forms or to reduce the minimum time shown in **TABLE 710-2**. At the Preconstruction Conference, submit calculations, sealed by a Professional Engineer, to the Engineer that show that the concrete tensile stress is below $0.23 \sqrt{f'_c}$ (ksi) and the shoring has sufficient capacity.

In determining the time for the removal of forms, give consideration to the location and character of the structure, weather and other conditions influencing the setting of concrete. If forms are removed before expiration of the cure period, maintain the cure as provided in **DIVISION 700**.

For additional requirements regarding forms and falsework, see **SECTION 708**.

g. Bridge Number Marking. When designated in the Contract Documents, place bridge numbers on bridges by the use of plates recessed in the concrete during construction, using plates constructed as shown in the Contract Documents. The date placed on the plates is the year in which the structure is completed.

710.4 MEASUREMENT AND PAYMENT

The Engineer will measure the various grades of concrete placed in the structure by the cubic yard. No deductions are made for reinforcing steel and pile heads extending into the concrete.

Payment for the various grades of "Concrete" at the contract unit prices is full compensation for the specified work.