SECTION 525 Bridge Decks

CMM provisions mobilized by the contract:
CMM 525.1.3 figure 525-1 ..... evaporation nomograph

525.1 Placing, Finishing, and Curing Bridge Decks

525.1.1 General

The placing, finishing, and curing of concrete bridge decks is the most critical aspect of bridge construction. Not only is it critical from the standpoint of the finished surface, since the traveling public judges a bridge by its riding qualities, but the quality and durability of the concrete are critical because bridge decks are probably subjected to more severe conditions conducive to scaling and deterioration than any other highway element. Since bridge decks are subject to becoming frosty and slippery, chemical de-icing and abrasive agents are frequently applied, which may remain in contact with portions of the bridge deck for extended periods.

Some of the measures necessary to obtain smooth riding bridge decks are setting of grades to allow for anticipated deflections, adequate falsework and supports, including banding and bracing of outside girders as needed, using adjustable screed guides, constant observation of actual deflections during the placement of the deck concrete, and the correction of any indicated deficiencies. Generally, it might be said that the same principles, methods, and skills are required to produce smooth bridge decks as are employed in constructing smooth pavements. The important difference in the two procedures is the technique of working in the limited space usually available on a bridge deck.

One of the essential ingredients of a smooth bridge deck, after the forms and screed guides are accurately set and firmly supported, is a properly proportioned, uniform concrete mix. It is impossible to get optimum results with concrete of varying consistency, since areas of stiffer concrete will finish a little higher than those placed with wetter concrete, and the wet concrete will shrink more when drying. However, a good mix is of little value unless it can be delivered to the bridge deck at an adequate and constant rate to allow uninterrupted placement and finishing of the deck surface. Another essential element is adequate equipment and manpower to place, strike-off, finish, and start curing the concrete.

525.1.2 Setting Grades

The structure plans will generally include a diagram showing the amount of deflection expected in any span due to the mass of the span itself (dead load). For non-prestressed cast in place structures, there will be an additional allowance for deflection due to future creep. Creep is the tendency for concrete under stress to deform, at a decreasing rate for a period of time, perhaps several years. The grade to which the forms, screed guides, or rails are set will depend on several considerations. As mentioned in the discussion of falsework, the grade to which the forms are built must provide sufficient camber to offset anticipated deflections due to dead load and future creep, plus an allowance for settlement or compression that will take place within the falsework.

Theoretical finished grades at the centerline and edge of slab at required intervals are supplied to the region by the structural design section. For spans utilizing steel beams or prestressed concrete members, WisDOT should determine a profile for each stringer after steel erection by taking elevations at frequent intervals. The theoretical deck grade, adjusted to allow for the anticipated dead load deflection, is then compared with the stringer profile and modified, if necessary, due to excessive camber in any stringer, to provide the minimum deck thickness and haunch as specified on the plans. After the forms, screed guides, or rails are set by the contractor to the grade established by WisDOT, they should be "sighted in" to remove any irregularities.

Attention must be paid to deflection allowances when screed rails are placed on overhangs. Falsework supports or placing of outer beams may be necessary to prevent settlement of the overhang or other areas of the deck forms.

The contractor should set the rails or tracks upon which the machine finisher operates to the required elevation. For all but the shortest spans, the screed guides or rails on which the strike-off apparatus rides should be readily adjustable, so that if excessive settlement or deflection takes place under load, appropriate adjustments can be made at once and the surface refinished to the correct grade.

Rails or tracks upon which heavy machine finishers operate should be rigid enough and supported at frequent intervals so that deflection of the rail will be minimized, and preferably the supports on one side of the bridge should not be directly opposite those on the other side.

The rails or tracks should be extended to allow the finishing machine to be run clear of the floor at both ends. Hand finishing at the ends of the bridge floor can be eliminated, and the quality of the ride improved under this procedure.

525.1.3 Prepour Preparations

1. Initial inspection

   Before placing the deck concrete, a thorough inspection of the falsework should be made, including the following:

   - Footings and the forms
   - Reinforcement
   - Finishing equipment
   - Guides or rails
   - Delivery system
   - Transit mix trucks or other mixers
   - Batch plant including admixtures, aggregates, and cement
   - Fogging and curing systems
   - Telltale devices

   Any deficiencies should be corrected before deck placement. Before scheduling the pour, a dry run of the finishing machine over the placed reinforcement bars must be made and periodic measurements of total deck thickness and clearance to the reinforcement taken and recorded. The fogging equipment must also be tried to see that it functions as intended and will not cause damage to the surface.

2. Prepour meeting.

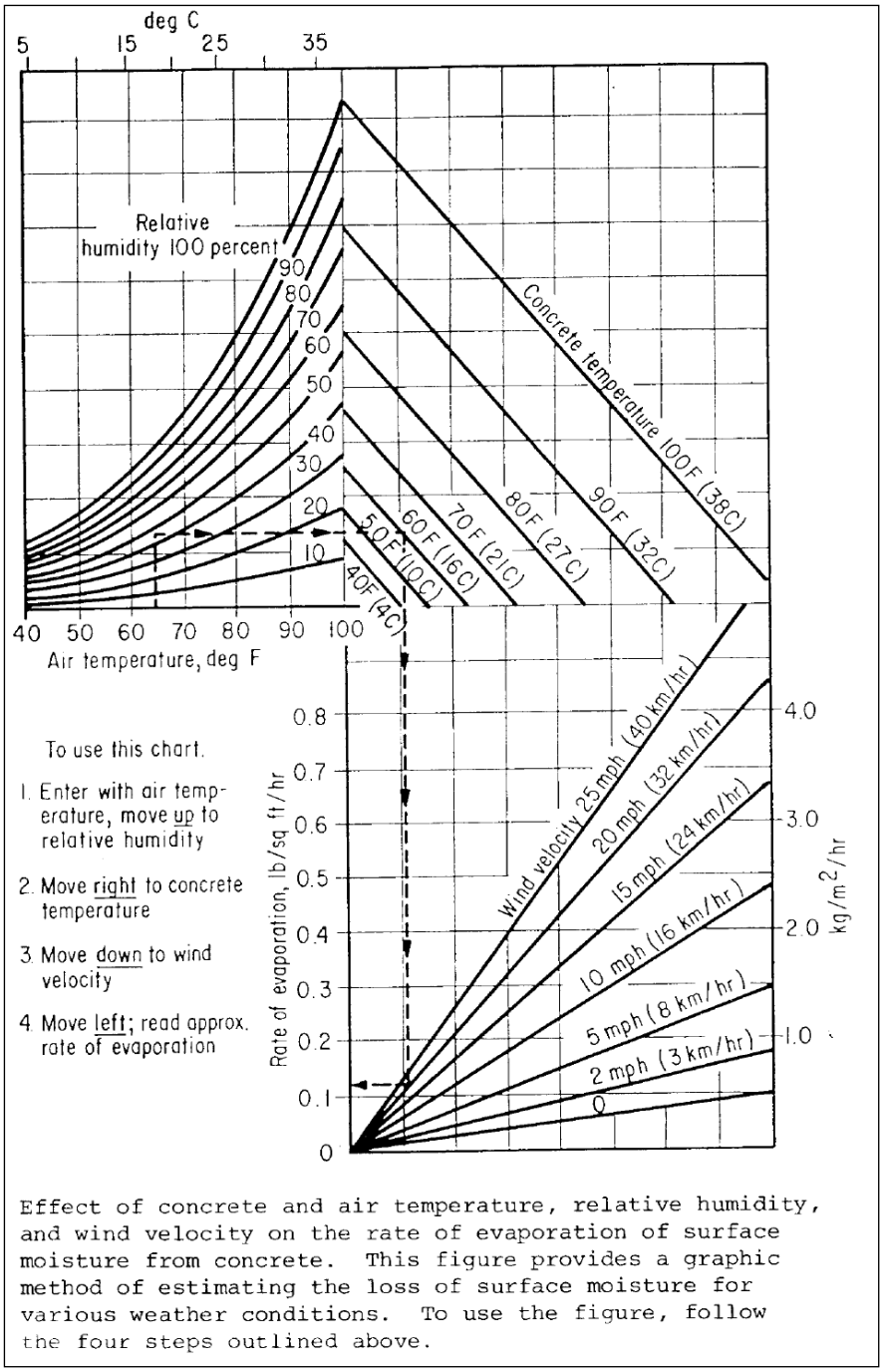
   Before every deck pour a pre-pour meeting should be held with the contractor at which time every aspect of the pour should be discussed, and any differences resolved. Items to be discussed should include:

   - Time of starting the pour
   - Anticipated weather conditions.
   - Rate of delivery of the concrete to ensure completion within a reasonable time.
   - An adequate number of approved delivery vehicles available exclusively for the pour.
   - Method of placement
   - Consolidation and finishing of the concrete
   - Number of finishers and their duties
   - Finishing tools and equipment available
   - Application of the surface texture
   - Timing of fogging and final curing
   - Emergency covering materials available in case of inclement weather.
   - Any other appropriate subjects

   Consideration should be given to delaying the pour if the rate of concrete surface moisture evaporation exceeds 0.2 lb/sq ft per hour as shown in figure 525-1 below.

The evaporation nomograph in figure 525-1 is mobilized into the contract by standard spec 501.3.8.2.2.

FIGURE 525-1 Rate of Evaporation of Surface Moisture from Concrete



Effect of concrete and air temperature, relative humidity, and wind velocity on the rate of evaporation of surface moisture from concrete. This figure provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use the figure, follow the four steps outlined above.

525.1.4 Placing Concrete

The concrete should be spread to approximate grade, then consolidated by vibration. The strike-off for the screeding equipment should be capable of striking-off low slump concrete to the desired grade and cross-section, moving forward at a uniform rate, and accomplishing its objective without requiring an excessive number of passes. It should be operated with a uniform amount of concrete ahead of the screed at all times, and for the full width of the screed. Walking in the concrete should be prohibited after the screeding operation.

Placement of concrete on the overhang should not be completed before placement of concrete on the adjacent bay or lane; otherwise the steel reinforcement on the overhang may deflect and raise the steel on the adjacent bay, reducing minimum clearance.

It is recommended that where feasible and practical, concrete placement proceeds from the lowest elevation to the highest elevation to minimize finishing problems caused by flow of rainwater or moisture from fogging into the area where finishing operations are proceeding. Also, concrete placed in longer

steel girder structures has a tendency to walk downgrade, especially if concrete placement is started at the highest elevations.

Field reviews have indicated that slump of vibrated concrete has frequently exceeded the maximum of 4 inches. Standard spec 105.3 requires that slump test results should fall substantially within the specified range and only occasionally be of borderline quality. Concrete having a uniform, proper slump is essential in obtaining a strong, durable deck, and the contractor should be required to regulate and control concrete production to ensure compliance with the slump requirements of standard spec 501.3.7.1.

Checks for deflections at form or rail supports need to be made during the deck pour. Depth of embedment and total slab depth must also be frequently checked during the placement operation, and any appropriate adjustments made in the rails or finisher screeds. The method used may be dictated to some extent by job conditions. A device for stabbing the deck for cover or thickness has been made available to each region for use in the field.

Decks that have turned out to be less than specified thickness could have easily been detected early enough by timely probing to make corrections. On the other hand, another deck pour that could have been a disaster was detected early by alert inspection and the paving rails were adjusted to make the necessary correction. It is not sufficient to assume everything will turn out all right because the dry run with the machine showed proper cover and thickness. We have numerous examples where these measurements have changed substantially without acceptable explanation. The only defense is to be constantly aware of what is happening and have a contingency plan for correcting it when something starts to go amiss. The inspector should also be constantly checking for settlement or deflection during a floor pour by sighting along the forms or rails, taking elevations of the same at frequent intervals, or by using telltale devices previously installed.

The standard specifications require that concrete in decks must be consolidated by mechanical vibration. Gang vibrators mounted on the paving machine are preferred. An adequate number of vibrators should be provided. Special care must be taken to ensure the entire deck pour is completely and uniformly vibrated to achieve thorough consolidation without over vibration of local areas. Vibration must not be applied through reinforcement to partially hardened areas of the deck. Vibrators must be capable of transmitting at least 4,500 impulses per minute to the fresh concrete. This frequency can be checked by means of a vibrating reed tachometer available through the region. The tachometer reading shown in revolutions per minute is equivalent to impulses per minute.

525.1.4.1 Evaporation Retarders

Commercial liquid evaporation retarders are only allowed with engineer approval in emergency situations such as equipment breakdowns during deck pours. If used, evaporation retarder must be applied in an even, fine mist by a hand-held pressurized sprayer. Application that results in puddling or runoff will not be allowed.

525.1.5 Finishing Concrete

Standard spec 502.3.7.8 provides that all concrete bridge floors must, unless otherwise specified, be finished by self-propelled machine finishers.

Placement of the concrete should never be allowed to progress faster than the hand finishers or machine finishers can acceptably complete the finishing of the concrete. The skill and experience of the contractor's crew will have a great effect on the final finishing operations. Where an acceptable finish has been obtained by the self-propelled finishing machine, float finishing will not be required. Float finishing, when required, should be closely observed by the inspector to detect and correct waves or dips due to faulty operation of the strike-off, failure to properly adjust screed guides, deflections of forms or screed guides, uneven consolidation of the concrete, or failure to properly meet expansion joints or construction joint headers. The screed or screeds should be so adjusted and operated as to finish the concrete to the required crown and grade and to produce a surface within specified tolerances.

Straight edging should be done while the concrete is still in a condition that corrections can be made but delayed as much as possible to take advantage of the final slumping of the concrete. The inspector should closely observe the straight edging operations by the contractor or may elect to independently check the surface with a testing straightedge. Any irregularities disclosed by the straight edging should be immediately corrected. Special attention should be paid to the finishing of gutter lines to maintain longitudinal drainage on the bridge floor. With structures on very flat grades or on the crest of vertical curves, it is sometimes necessary to warp the flow line of the gutter in order to maintain drainage to the ends of the structure or to the floor drains as the case may be. This warping can be accomplished in the outer three feet of the surface and need not be detrimental to the overall riding quality of the deck. A carpenter's or mason's level is helpful to the finishers working in these areas.

The final operation in finishing the bridge floor is the application of the surface texture. This is intended to give the floor a uniform, pleasing appearance and a skid-resistant surface. The timing of this operation must coincide with the proper degree of setting of the concrete if optimum results are to be obtained.

Decks having approach pavements with design speeds of 40 mph or greater must receive either an artificial turf drag finish or a broom finish, followed by a tined finish. The tined finish is similar to that used on rural pavements except that it is done transversely, and the depth is only about 1/8". The tining must not be applied within 1 foot of the gutters and may be applied manually. On bridge decks having skew angles of 20 degrees or greater, tining must be applied within 20 degrees of the centerline of bearing of the substructure units.

Decks having approach pavements with design speeds less than 40 mph must receive either an artificial turf drag finish or a broom finish, with no tining.

Brooms for a broomed surface should have fairly stiff, medium coarse bristles, and the pressure on the broom should be regulated to prevent tearing of the surface yet produce an acceptable skid resistant surface.

525.1.6 Curing Concrete

Curing of the concrete is extremely important in the production of strong, durable concrete. Included in the curing process is the protection of the concrete from either excessively high or low temperatures. It is very important that before the water sheen disappears from the surface of the bridge floor a fog or fine water spray be applied until the concrete is sufficiently hardened to support the curing procedure used for these surfaces. The object of fog curing is to provide the necessary concrete cure after the deck slab loses its surface moisture and before it is sufficiently hardened to allow placement of the burlap or fabric. The amount of mist and number of applications necessary may vary from bridge to bridge depending on weather, concrete consistency, and finishing methods. The engineer should review with the contractor the proposed method for applying the fog cure at the prepour meeting and before the day of the deck pour. Fogging should be accomplished by nozzle arrangements allowing the discharge of a constant uniform mist without washing of the fresh concrete. Fogging should be accomplished as a separate and distinct part of the deck curing operation.

After the concrete has sufficiently hardened the deck should be cured with a double thickness of wet burlap for not less than seven days. Keeping the deck continuously wet and covered is very important to maximize future strength and durability and minimize the potential for cracking. Decks on structures less than 100 feet in length may be cured for a period of seven days with polyethylene-coated burlap or other coated material meeting the requirements of the standard specifications. Curing with liquid membrane curing compound is not allowed on the bridge deck.

Refer to figure 525-1 above for rates of evaporation of moisture from concrete. Refer to standard spec 502.3.8 for detailed curing requirements.

525.1.7 Durability of Bridge Decks

Probably the most significant factor in the resistance of concrete to scaling is adequate air-entrainment. Many variables affect the percentage of air that a given concrete mixture will entrain. The inspector should make sufficient air tests on the concrete going into structures to ensure an air content well above the lower limit of the specification range. Later operations of placing and finishing the concrete should be closely controlled, since excessive manipulation and vibration of the concrete may decrease the air content. Research indicates a loss of 0.5% to 1.0% of air occurs at the surface of the concrete due to over vibration. Also, over vibration tends to bring the lighter, unsound aggregate particles to the surface where freeze-thaw action may cause deterioration, pop-outs, and scaling.

Another practice to be strenuously avoided in the finishing of concrete is the persisting tendency of some finishers to sprinkle water on the surface in an attempt to gain workability. The resulting high-water content in the surface mortar can result in a reduction of up to 25% in the strength of concrete at the surface and is an invitation to the development of surface scaling.

525.2 Miscellaneous

525.2.1 Set Retarding and Water Reducing Admixtures

Using retarding agents to delay the setting of concrete in bridge floors, especially in hot weather, offers the advantage of providing sufficient time for proper finishing of the concrete, including any corrections of high or low spots disclosed by the final straight edging, and generally allows using a lower water content, which is conducive to a stronger, more durable concrete.

525.2.2 Rust Stains

Rust stains may be removed from the concrete by mopping with a solution containing 1 lb of oxalic acid powder per gallon of water. After two to three hours, rinse with clear water and scrub with a stiff brush.

Rust staining of substructure concrete where reinforcing steel extends through a construction joint and will be exposed for some considerable time can be prevented by painting the steel with a thin coat of cement grout. The grout must be entirely removed before the remainder of the concrete is poured.

525.2.3 As-Built Plans

Refer to CMM 165 for requirements relating to the supplying of as-built structure detail sheets to the BOS structures development section.

525.2.4 Inventory Inspection

An inventory inspection is the inspection of a new bridge as it becomes a part of the bridge inventory. An inventory inspection could also apply where a substantial change has been made to the existing structure such as widenings, lengthenings, supplemental bents or piers, deck replacements, superstructure replacement, concrete or asphalt overlay, changing pin and hangers, or replacing or changing joints, bearings, etc. The inventory inspection required here may only have to include the changes made.

The inventory inspection is a fully documented investigation performed by persons meeting the required qualifications for inspection personnel. An analytical determination of load capacity may be required. An underwater or other specialized inspection may be part of the inventory inspection.

The purpose of this inspection is twofold:

- It will be used to determine all structure inventory and appraisal data required by the FHWA and other relevant information required by WisDOT to maintain an up-to-date bridge file.
- It will be used to determine baseline structural conditions and identify and list any existing problems or locations that may have potential problems. With this information recorded, these areas can be checked at the next inspection for a comparison to see what is developing. Aided by a prior detailed review of plans, it is during this inspection that any fracture critical members (or details) are noted for subsequent focus, and assessments are made of other conditions that may later warrant special attention.

On any new bridge or rehabilitated bridge where the construction inspection was accomplished with state funds by state forces or consultant forces, the engineer must notify the bridge maintenance supervisor and the maintaining authority that the structure is ready for an inventory inspection. This applies to either a state-maintained bridge or a local government-maintained bridge.

The inventory inspection should be accomplished after the bridgework is complete, but before the contractor leaves the job site.

All data required to update the bridge file must be submitted to the proper region. The region should submit the data to the BOS structural development section. This data should be submitted as soon as possible, preferably before the bridge is open to traffic.

Data to be submitted may include the inventory inspection, Bridge Inspection Report (form EM30), Bridge Inventory Report (short form EB575-186) and a set of bridge plans. The data required depends on the work done, plans available, if the state has a set of plans, etc.

525.2.5 Opening to Service

Refer to standard spec 502.3.10 for strength requirements for opening to service.

525.2.6 Applying Epoxy Pavement Markings to New Concrete Bridge Decks and Overlays

The question has arisen whether protective surface treatment should be removed from those areas on new concrete bridge decks and overlays where epoxy center-line and edge-line pavement markings are to be applied. The answer is yes, however the protective surface treatment must be re-applied to all areas where it has been removed in preparation for application of pavement marking. The protective surface treatment must be re-applied after the pavement marking is applied. Alternatively, the protective surface treatment can be applied to the entire surface after the pavement markings are in place.

No portion of an epoxy overlay on a bridge deck should be removed to apply pavement marking.

525.2.7 Grooving Preformed Plastic Tape on Bridge Decks

Preformed Plastic Tape placed in a grooved 120 mils slot on a bridge deck or concrete overlay will not cause structural problems, however, the protective surface treatment must be re-applied after the preformed plastic tape is applied. Alternatively, the protective surface treatment can be applied to the entire surface after the preformed plastic tape is in place.

No portion of an epoxy overlay on a bridge deck should be removed to apply preformed plastic tape.

525.3 Crack Survey and Sealing

Sealing cracks on bridge decks has great potential to extend service life of structures. Concentrated chloride solution can leach through cracks as a direct conduit all the way through decks within the first winter season. Defects in epoxy coating on embedded rebar in the vicinity of the cracks can allow

corrosion to begin immediately. To prevent chlorides from leaching into cracks, standard spec 502.3.13 requires application of low viscosity crack sealer to all cracks visible in dry weather conditions.

525.3.1 Crack Survey

The initial crack survey is performed within 7 days after the end of the required wet-cure period. The deck surface should be thoroughly dry at the time of the initial crack survey. The initial crack survey should be completed before opening the deck to public traffic. Falsework does not have to be released before the initial crack survey. Cracks to be sealed should be visible from a standing position. The initial crack survey must include the bridge deck surface only, not other items such as medians, sidewalks, or parapets.

When conducting the initial crack survey, identify the endpoints of each crack with a small, discreet mark. Use of a black felt-tip permanent marker is recommended. Please do not mark along the length of the cracks with fluorescent paint or any other marking that would prevent penetration or bond of the crack sealer or appear obnoxious to the public after the structure is open to traffic.

At the conclusion of the initial crack survey, determine the total linear footage of cracking that has been identified to be sealed. This is the upper limit of cracking for which the contractor will be responsible for sealing under the Concrete Masonry Bridges bid item.

525.3.2 Crack Sealing

The initial crack sealing should be completed at least 7 days following the end of the wet cure period at the earliest, but before opening the deck to public traffic. High pressure water-blasting should be used to clean the deck surface in the immediate vicinity of the cracks to be sealed. Do not sandblast, as this will deface the appearance of the deck.

The deck surface should be allowed to air dry for at least 48 hours before crack sealing. The sealer must be selected from the approved product list APL. It is acceptable for the sealer to be applied after only 7 days following the end of the wet cure period, which will take precedence over the longer dry curing periods recommended by the sealer manufacturers. The department recognizes the time pressure to construct and open projects quickly and is willing to forego the benefits of dry curing for 21 to 28 days as recommended by the sealer manufacturers.

Initial crack sealing is incidental to the concrete masonry bid item. However, it is recognized by the department that a majority of later cracking can be due to design and deflection influences that are beyond the control of the contractor. The department will be responsible for the cost (including traffic control) of sealing any additional cracking that develops later following the initial crack survey. The contractor should be paid for any additional crack sealing as additional work. To enhance the durability of the structure, it is recommended that wherever practicable, the department should pay for sealing any additional cracks that have developed just before final opening of the completed structure to public traffic.

In the event of a late season deck pour, when there is no opportunity to perform the crack sealing promptly due to cold or wet weather and improper curing conditions, the contractor may perform the crack sealing the following spring when weather conditions allow. Traffic control, if needed, will be paid for by the department.

525.3.3 Protective Surface Treatment

After deck crack sealing, new bridge decks must be sealed with protective surface treatment. Protective surface treatments significantly reduce the penetration of de-icing chemicals into the concrete, which reduces the rate of chemical attack on the concrete and chloride attack on the reinforcing steel and minimizes the effects of corrosion and freeze-thaw cycles.

The contractor must use products from the approved products list and apply the treatments according to manufacturer's recommendations. Application requirements can be found in standard spec 502.3.13.2.

525.4 Slab Span Bridges

Slab bridges are cambered (normally up) during construction to counteract creep of the concrete over the next several years. This camber is normally three times the dead load deflection. This camber will cause a temporary "bump" in the grade line until the creep deflection slowly takes place. This is an expected condition and part of the process in using concrete slabs. The finishing machine rails should be set to reflect this camber condition. Normally the high points will be at the mid span locations of the bridge. The bridge surface should not be ground after casting as the bump is expected and will disappear over time. If the bump is corrected when the bridge is opened there will be a depression at mid span a few years later. Any questions related to this issue should be directed to the BOS design section.