Casting Box Girder Segments

Following basic casting yard procedures will assure quality concrete bridge segments

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Producing bridge segments in a casting yard away from the bridge construction site is a major advantage of segmental concrete bridges. The casting yard brings factory-controlled production techniques, efficiency, quality control, and time savings to bridge construction. Fabricating bridge segments in a separate area also removes casting operations from the construction critical path and reduces the overall construction time.

Regardless of the project location or size, a contractor's casting yard for bridge segments has several essential features. These include delivery and storage areas, a concrete batch plant, a rebar cage assembly area, one or more casting cells, steam curing facilities, geometric control stations, and segment storage and handling facilities. The size of the yard depends on the size of the job and the required rate of segment production. A typical production rate is four or five segments per five-day work week.

Forming Systems

Two methods of segment casting are available to the contractor. Long-line or short-line forms can be used depending on the area available for the casting yard and the geometry of the bridge spans.

In long-line casting, all segments are cast on a soffit the full length of the cantilever (or half-length if the cantilever is symmetrical). All geometric control is accomplished while constructing the soffit, greatly simplifying control during segment production. A full soffit constructed for the long-line method, however, requires a large area, and the soffit might only be used once because it is difficult to accommodate variations for different bridge spans.

With short-line casting beds the form is stationary while the individual segments move from the casting position to the match-casting position to storage. Advantages of short-line casting are much smaller space requirements, centralized production, adaptability to variations in bridge geometry, and the ability to reuse the forms many times. Casting bridge segments using a short-line bed requires accurate placement of the match-casting segment and post-casting geometry observations. Precise surveying skills and equipment are needed to measure elevations and alignments within 0.001-foot tolerances.

Match casting is a type of casting method where a new segment's fresh concrete is cast against the hardened concrete of a previously produced segment . Both short-line and long-line casting operations can use match casting. By casting against the hardened surface of the previous segment, the joint is almost invisible when the segments are reassembled during erection of the bridge. A bond breaker (usually chemical compounds or a mixture of wax, soap, and talcum powder) applied to the hardened concrete surface ensures that the segments will separate.

Regardless of the forming system used in the casting yard, follow basic recommended practices to produce quality concrete segments and achieve desired production rates. These basic practices apply to both long-line and short-line casting methods.

Rebar Cages and Post-tensioning Ducts and Hardware

To increase segment production rates, some contractors prefabricate rebar cages with post-tensioning ducts and hardware already installed. Custom jigs and templates are typically used to facilitate initial assembly. Final adjustments made in the casting cell account for movement during transport or slight variations in shape, reinforcement, or post-tensioning requirements.

During fabrication, avoid conflicts between the rebar and the post-tensioning ducts and hardware. Proper alignment of the post-tensioning ducts is more important than rebar location. Position post-tensioning ducts correctly, then make local adjustments to the rebar as needed. When using epoxy-coated rebar, avoid damaging the coating. Shop drawings should show details of the post-tensioning hardware system, ducts, reinforcing bars, and any special construction details.

A combination of chairs, spacer bars, and tie wire is recommended to maintain post-tensioning ducts at the correct elevation and secure them to the reinforcing steel. Using tie wire alone may cause deformation of the rebar cage unless braced by local transverse rebar. In densely reinforced anchor zones, place and consolidate the concrete properly to eliminate honeycombing.

Placing Concrete

Follow good concrete placement practice to ensure a quality product. Before placing concrete, be sure forms are thoroughly cleaned, all joints are tight and sealed, and post-tensioning ducts are aligned and secure. The forms should be lightly oiled for easier stripping and the face of the match-cast segment coated with a suitable bond breaker.

Use skips, chutes, or pumps to deliver concrete without letting it fall a great distance. This prevents concrete segregation, damage to post-tensioning ducts, and rebar displacement. Though concrete delivery should be as continuous as possible, short waits are occasionally necessary, especially after placing the bottom slab and web-corner concrete. A short interval allows the concrete to set up enough to support the weight of the rest of the web concrete without creating cold joints. Retarding admixtures are often used to help simplify the operation.

Thoroughly consolidate the concrete using internal vibrators. Vibrators should be pushed into the concrete no more than about 2 feet and should be withdrawn slowly from the same location. Moving the vibrator sideways in the concrete or trying to move concrete with the vibrator can lead to poor consolidation and honeycombing. Avoid contact between the vibrator and rebar or post-tensioning ducts, which can cause damage or displacement .

Be sure the concrete is thoroughly compacted, especially in awkward areas such as corners, spirals, and heavily reinforced anchor zones.

Placement Sequence

A good placement procedure should prevent the concrete placed in the bottom of the web from spilling into the bottom slab. Movement of the web concrete can easily displace rebar and post-tensioning ducts and can pull concrete away from the heavily reinforced bottom anchors or the web itself. A proper sequence will minimize flow of the concrete after it has been placed.

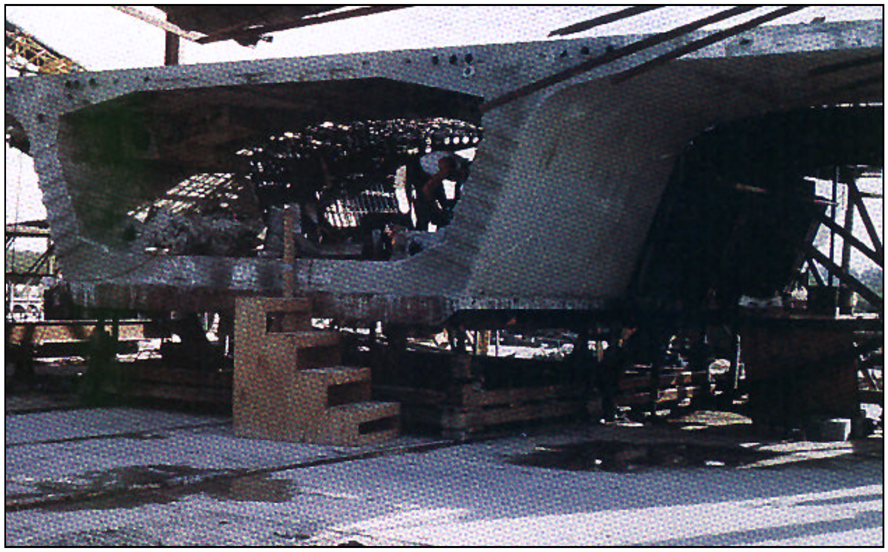

Figure 1. **Match casting against the hardened surface of the previous segment leaves an almost invisible joint when the segments are assembled.**

Place the first concrete in the middle portion of the bottom slab, leaving about 6 to 12 inches clear of the side forms at the bottom of the webs. Deliver bottom slab concrete through a trap in the top slab soffit or through the bulkhead end. Next, place concrete in the webs and consolidate it around the bottom corners to complete the bottom slab. Continue placing concrete in the webs, working up to the top slab. Finally, place the concrete in the top slab, working from the center and outside edges toward the webs.

Finishing and Curing

A high-quality finish of the top surface is essential in superstructure segments where it also functions as the riding surface. The only opportunity to achieve a smooth surface is during the casting operation. Grinding rough surfaces after construction reduces concrete cover and adds time and expense to the project.

Mechanical finishing equipment provides a smooth riding surface if used properly by trained and experienced operators. Be sure to fill in depressions and remove high areas to achieve a very uniform, dense, and level surface. Both rolling and vibratory screeds work well to produce a smooth finish.

Mechanical screeding should be followed by a straight edge used to check and correct any low and high areas (Figure 2). The straight edge also produces an accurate, level surface across the top of the segment from the bulkhead to the match-cast segment. If hand finishing the surface, ensure a level surface by using a strong, straight screed that extends from the top of the bulkhead to the top of the match-cast segment.

To achieve typical production rates, the curing process in the casting cell cannot be longer than from the completion of the casting in the evening to the start of survey and stripping the next morning. Curing procedures depend on the concrete mix and the environmental conditions after casting. Common practice is to cover the segment with tarpaulins and apply steam to maintain a controlled temperature and humidity. Other successful methods include wet burlap, curing blankets, and fog sprays.

Although curing procedures may

differ, the segment must remain in favorable curing conditions, such as under wet burlap, after stripping the form.

Striking Forms

Removing segment forms begins after the concrete has reached specified strength, typically 2500 psi in compression. At this strength it is usually possible to ease off the side forms, remove the core form, and pull back the match-cast segment (if the top slab is self-supporting). The segment can also be moved on its pallet, but not lifted. If the segment reinforcement cannot carry the weight of the unsupported top slab at 2500 psi, transverse post-tensioning must be stressed in full or in part. This requires a higher concrete strength, usually 4000 psi. Traditionally, quality-control cylinders have been broken to verify the concrete strength for these intermediate operations.

Remove the forms carefully since the concrete is more susceptible to spalling and other damage at an early age. Most casting cell forms are removable in whole pieces. Delay removing special blockout forms for as long as possible to avoid damaging blockout edges.

Striking and pulling back the match-cast segment should be done with particular care. If the bond breaker has not been properly applied, portions of either segment can break off. Shear keys are especially vulnerable. The stripping crew also needs to examine and understand the movement mechanism. Do not "lift" the newly cast segment by loosening jacks and tilting the pallet. This motion can easily damage the shear keys. The same rule applies when pulling the new segment away from the bulkhead.

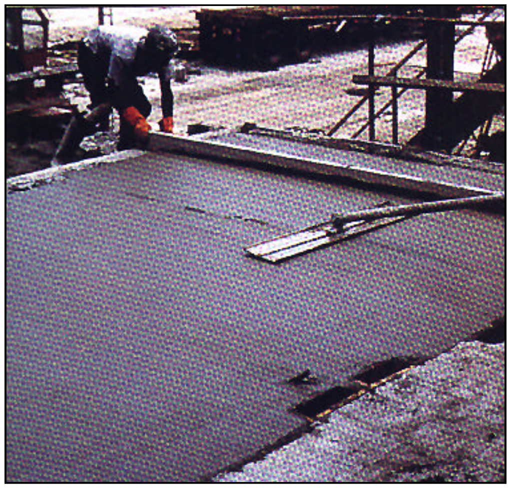

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Figure 2. **A high-quality finish of the top surface is essential in superstructure segments where it is also the riding surface.**

Understanding basic segment casting techniques reduces costs and delays associated with lack of understanding of critical procedures and over-emphasis of noncritical items. Following these basic procedures in the production of bridge segments will increase quality assurance for the entire construction team.

Editor's Note

The material for this article is excerpted from the *Guide to the Construction of Segmental Bridges* commissioned by the Florida Department of Transportation to HDR Engineering Inc.

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PUBLICATION # C950068