Sliding and Rolling Bridge *Solutions*–Part 2

by Craig A. Shutt

Sliding and rolling bridges into place after assembling them nearby has gained adherents as efficient construction techniques for saving time and costs and minimizing traffic disruption. Owners, designers, and contractors are quickly learning as much as possible about these new concepts so they are ready to discuss options when opportunities arise. This series of articles looks at some of the key considerations when using these approaches to bridge construction.

Part 1 of this series considered key design considerations, including allocating duties among the construction team, superstructure and substructure concerns, and evaluating sliding forces.

This article considers falsework and related design issues. The next article will review necessary field activities during construction. The use of self-propelled modular transporters will be addressed in a subsequent article.

Falsework Design

The design for temporary falsework depends on the application, but in any form it represents a key element to ensuring the structure is safely fabricated offline and out of the critical path, allowing for accelerated bridge construction (ABC). Building falsework next to the existing bridge location allows assembly of the new components to be completed while other key elements of the construction also are underway (such as piers and abutments).

Extensive falsework and shoring requirements must be considered when sliding or rolling bridge superstructure systems into place. The falsework's constructability is critical to ensure the falsework provides the various functions required to build the bridge components and then move them into place. This means every aspect must be detailed in the shop drawings to ensure the falsework is built to perform as the specifications require.

The temporary shoring and permanent abutment must be checked for large temporary lateral forces during launching. However, if a problem arises (such as excessive settlement) during the transfer of the bridge from the falsework to its permanent support, the shoring system has to be able to accommodate and possibly support greater lateral construction loads.

For most projects, settlement of the falsework as it carries the load (during launching) of the bridge doesn't become an issue. The falsework will deflect slightly but not enough to be a concern. Even so, it is preferable to consider and evaluate this possibility to ensure the falsework is sufficiently rigid.

If the falsework does deflect too much, it will be necessary to jack up the bridge once it reaches its final landing point or transfer point if using the permanent structure to support the slide rails. A counter concern is that there can be difficulties if the falsework is too high as well.

On the West Mesquite Interchange at I-15 in Mesquite, Nev., hydraulic jacks were used to push the bridge into place. All photos: Jackie Borman, HDR.

In some cases with push/pull jacks, contractors have investigated the use of the falsework as an anchor point. This generally has not been done, as the falsework needs to be kept as light (and therefore economical) as possible. It is better to push against or pull toward something more rigid (that will ultimately act as a component of the permanent system), such as the abutments.

In some cases where space is limited, these lateral bridge-supporting devices can be built on the other side of the existing bridge from the new bridge, allowing that old bridge superstructure to be pulled out of the way and the new bridge to be moved into place behind it.

Sliding Forces

With a static coefficient of friction of 0.12, the required force to slide a 1.3-million-lb concrete superstructure is 156 kips (1,300,000 lb × 0.12/1000). This can easily be achieved with two 100-kip jacks, which are readily available.

Although a concrete bridge typically weighs about 50% more than a steel bridge, and thus a higher force is needed to move the bridge, the associated equipment and costs are not directly proportional—that is, the cost to rent the hoses, pumps, gauges, and a set of two 100-kip jacks is comparable to renting a complete system with two 60-kip jacks.

Transfer to Permanent Supports

Moving the structure from the sliding shoes to the permanent bearings is a critical step in construction that must be considered very carefully. In many cases, the bridge will be transferred from the sliding rails onto jacks and then lowered onto new permanent bearings. In some cases, the bearings under the beams can remain in place during the transfer. In any case, the bearings and guide rails should be horizontal to avoid moving the bridge uphill or downhill. Depending on

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Teflon pads on rails assisted in sliding the approach slab and bridge into place on the West Mesquite Interchange at I-15 in Mesquite, Nev.

how the beams are oriented, there may need to be either grout pads or shim plates between the bearings and the beams.

It's critical to understand how the bridge will react to the shift from its temporary position to its permanent one to be certain that the shift won't create undesirable stresses. The design must account for these stresses in its temporary position as well as in its permanent location. These details become extremely important during the move, whereas they are not as critical in other types of construction.

For instance, a skew in a bridge results in the diaphragm face not being perpendicular to the abutment. This requires a transfer plate or push block between the hydraulic jack and the abutment that can handle an axial load plus a horizontal shear without damaging the end of the diaphragm. Confinement reinforcement in the diaphragm at the connection point may be needed.

Design Considerations

Design elements need to be coordinated at every stage with the construction means and methods. The engineer coordinates the move with the heavy-mover subcontractor early in the design process. The engineer must understand what equipment the contractor will be using and how it will support and load the bridge during the move and in its permanent location. Different design approaches are required to make sure that these things happen and to ensure factors such as bending over the supports and deck cracking are considered. Design details, that in other forms of construction are insignificant or can be dealt with in the field, become critical when moving a bridge into place.

Wind-speed limitations, for instance, need to be worked out with the contractor in advance so a maximum is set beyond which the construction will not go forward. This typically is set at about 15 mph, but it will be up to the contractor to determine what can be tolerated by the equipment and comply with this limit.

Overall view of the approach slab and end diaphragm of the north half of the West Mesquite Interchange at I-15 sliding into place by a hydraulic jacking system.

At every step of the process, engineers must account for the numerous stresses and how they vary during the moving process. Likewise, the contractor needs to be diligent about the quality of construction and building the bridge exactly to the plans. Small field changes can alter the load path of the entire structure due to the complexities of the movements being handled.

The contractor's specialty engineer needs to be closely focused on any field design changes that occur to ensure they are accounted for in the loading in each phase. Each part, starting with the skid shoes or roller troughs, has to be aligned with absolute precision to ensure the bridge movement can proceed easily once it starts and that the system does not bind up.

For that reason, it is wise to build redundancy into the movement-system hardware wherever possible. Adding lateral connections will only result in a minor increase in costs, but it can resolve problems that may arise. It's critical to consider every risk and worst-case scenario to decide how it will be handled. The value of extra anchor bolts in these push/pull systems versus the problems with a failed connection provides low-cost insurance, even if it ultimately proves to be unnecessary.

The key to a successful project using slide-in or roll-in construction is to think through every step: designing falsework to handle movement and transfer loads; stresses during moving, lifting, and setting the beams into their permanent place; and the like. Every factor and every possible concern must be considered against what impact it will have on every other portion of the bridge. To ensure success, the engineer, contractor, and the heavy lifting sub-contractor must work through every contingency and create a plan that will handle each possibility that could possibly arise—and be imaginative in considering what those options could be.

This is the second in a series of articles examining different approaches to accelerated bridge construction. This article was produced from interviews with Hugh Boyle, chief engineer at H. Boyle Engineering; Mike Dobry, principal structures engineer, Larry Reasch, vice president and manager of the structures department and Derek Stonebraker, structures engineer, at Horrock Engineers; R. Craig Finley Jr., founder and managing partner at Finley Engineering Group; and Steve Hague, chief bridge engineer at Burns & McDonnell.

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