Sliding and Rolling Bridge *Solutions*–Part 1

by Craig A. Shutt

As owners look to save costs and erect bridges faster with less interference to the traveling public, the concepts of sliding and rolling bridges transversely into place after constructing them nearby are becoming more popular. These techniques offer benefits, but they require unique considerations that can make the difference between success and failure. Both design and construction teams must understand these movement considerations.

Sliding or rolling bridges into place has become accepted by contractors due to the tighter time restrictions owners are placing on projects and their awareness of user costs for tying up either roadway access or waterways. These approaches also can help minimize environmental impact during and after construction.

In some cases, owners require this delivery method in their contract documents, necessitating designers and contractors to become familiar with the techniques as soon as they can. In these cases, clients often want to avoid employing cranes on small sites, which create economic drawbacks. On the plus side, owners don't typically provide detailed requirements for how the bridge should be moved into place. When they do, they often allow contractors to propose alternatives, ensuring the most efficient approach can be employed.

There are three typical options when considering how to move bridges into place:

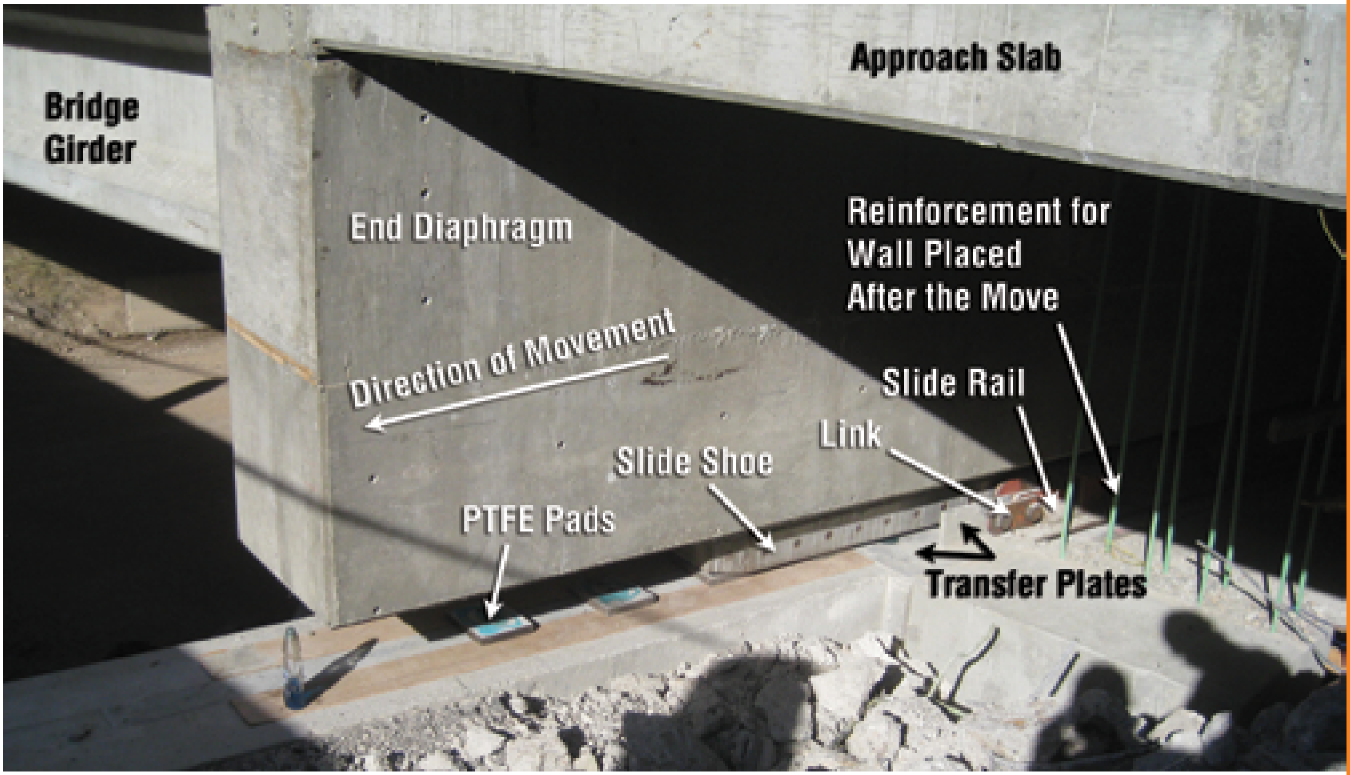
- Pushing with hydraulic jacks on rollers or pads
- Pulling with hydraulic jacks or cables on rollers or pads
- Moving with self-propelled modular transporters (SPMTs)

This article and the next in the *ASPIRE*™ accelerated bridge construction (ABC) series will deal with design issues of the first two types, sliding or rolling the components into place. These will be followed by a look at necessary activities in the field during construction. The use of SPMTs will be addressed in a subsequent article.

Define Duties

Because few companies have deep experience with these projects yet, it is critical for engineers and contractors to define each member's duties, requirements and who will be responsible for all the means and methods. Typically, the means and methods will derive from the contractor's preference, based on the method with which the contractor is most comfortable.

In creating a construction plan, the design team should develop an ABC strategy with requirements for as-builts or contingency



As used on the I-80 bridges over Echo Dam Road in Echo, Utah, the slide shoes on the bottom of the abutment wall glide across polytetrafluorethylene (PTFE) pads onto the permanent abutment. Photo: Michael Baker Jr. Inc.

ACCELERATED BRIDGE CONSTRUCTION

Jacking pockets in concrete end diaphragms are shown with the jacks. Photos: Horrock Engineers.

plans and sequencing plans for closure periods for the road. Some departments of transportation have developed ABC specifications to cover additional requirements of the contractor or design-builder when utilizing ABC moving techniques. In some cases, these special provisions can become very specific. Too restrictive of an ABC specification can limit innovation during bidding.

Concrete Solutions Available

Concrete components provide many workable solutions for ABC. Some owners or contractors discourage the use of concrete when sliding components due to the added weight. The additional weight of concrete components is normally not a problem on bridge slides. The jacks typically have more capacity than needed.

The increase in weight does impact the temporary-support structure. But in general, concrete components offer no more difficulties than other materials in construction and provide benefits in speed of delivery, better durability over the bridge's service life, and less maintenance.

Lightweight concrete can be used to mitigate the dead-load considerations, although it is not essential. Other options can optimize handling needs, including prestressing, post-tensioning, and the use of cast-in-place concrete joints.

Superstructure Design

Superstructure design of ABC bridges is generally the same as that used for conventional construction. The major difference occurs at the abutment. In the conventional bridge design, the girder loads pass directly into the abutment. When the bridge is rolled or slid, either the end diaphragms of the bridge have to be designed to support the bridge on the sliding shoes or rollers or the girders must be designed to accommodate both the sliding or rolling bearings and the permanent bearings.

Throughout the process of designing and detailing the structure, construction sequencing should remain a priority. For instance, the lower diaphragms can be unstable during girder erection in its temporary condition because the lower diaphragm is only supported vertically on the temporary supports. This produces a partial hinge. Bracing the diaphragms until all girders are set and the upper diaphragm concrete is placed eliminates this concern.

Sliding Forces

The designer should consider all the elements of the pushing or pulling system—ram, slide rail, and push blocks—when planning the process of moving the bridge into place. The pushing or pulling ram will most likely require a steel-to-steel connection, as it is the sole link allowing the structure to move. Details should allow the steel pushing or pulling block to be easily bolted on to the superstructure and then removed after the slide. Bridge skew can play a large part in the design of the pushing or pulling block.

The required force to move the bridge is a function of the weight of the superstructures and the coefficient of friction between the skid shoes and the polytetrafluorethylene (PTFE) pads over which the skid shoes slide or the rolling resistance of roller bearings. Coefficients of friction for PTFE bearings are given in the *AASHTO LRFD Bridge Design Specifications*, Chapter 14. Data are also available from product manufacturers.

Based on recent project experience, static coefficients in the range of 0.09 to 0.12 and dynamic coefficients in the range of 0.05 to 0.06 are reasonable values to consider for lubricated PTFE bearings sliding against polished stainless steel skid shoes.

The pushing or pulling mechanisms should have a capacity in excess of the calculated pushing or pulling force. Some designers recommend that the entire moving system be designed for the full capacity of the hydraulic system so the connections cannot be over-loaded by the jacking system, in case the system binds up and is not immediately detected by the operator.

Coordination early and often with the bridge-move subcontractor is highly recommended.

Push block between the hydraulic jack and the abutment must handle an axial load plus a horizontal shear without damaging the end of the diaphragm. Photo: Horrock Engineers.

Approach Slabs

In sliding- or rolling-bridge applications, moving the approach slabs along with the main span can be effective. This resolves key challenges affecting rideability of the roadway after construction and reduces closure times. Falsework and shoring can be designed to support the approach slabs during construction.

There can be dead-load deflection when casting the approach slabs on shored construction. This deflection can be handled by recognizing its impact, and the benefits in speed and ultimate road smoothness are worth the effort. Shored construction will also result in compression in the top of the slab when the shoring is removed, possibly improving its cracking resistance.

Expansion joints can be set in the approach slabs and locked into place until after the move. This allows the expansion to take place, after which the surface can be paved, if required. One team reported that this method saved critical time during the construction-launch period.

Normally, the approach slab-to-bridge connection is designed to accommodate rotation. The approach slab will need to be lifted concurrently with the bridge if the rotation on the joint during the jacking and moving process exceeds the beam limit. If the expansion joint is at the end of the approach slab, then precast concrete sleeper slabs may be needed.

Substructure Considerations

A key temporary-foundation element involves designing piles or spread footings to support the bridge in its temporary position. Pile locations can be out of line by more than 6 in., so it is critical that some tolerance is delineated for them to be welded to the slide rail-support system (which often is separate from the slide rails themselves) that will support the bridge during construction and during the move.

One easy way to accomplish this is to weld an oversized plate onto the top of the pile. The plate can then support the slide-rail supports. In most cases, the slide rails require tight vertical tolerances. Allowing for adjustments in the slide-rail elevations to ensure a smooth and level sliding surface provides the best solution.

Likewise, consideration should be given to the possibility that abutments will deflect when the bridge weight is moved into place. This typically isn't noticed in a more traditional method of construction, using cranes or launchers, because that weight is added incrementally and any deflections can be accommodated in the haunch or deck thickness. But when sliding the bridge into place, all of that significant weight is placed on the abutments at about the same time, so deflections of the permanent support from the partial and complete loading process need to be considered.

These adaptations need to be made at the design stage, as contractors must build the components to the plan dimensions to ensure the final bridge elevations match the required final profile. In some cases, when one abutment is out of line longitudinally, adjustments by the use of guide rails can be made to counteract anticipated and unanticipated movements in unguided systems.

Temporary strap tying the approach slab to the bridge deck slab. Photo: Horrock Engineers.

Some tolerance is needed to allow for minor differences in the extensions of each jack. This difference in movement will rotate the structure in plan view. Bridges have been successfully slid into place with less than a 2-in. tolerance allowance.

Construction of new substructure elements around existing elements requires consideration of stability during construction. Temporary bracing of existing substructures or top-down retaining walls (soil nails or mechanically stabilized earth) may be required to ensure stability of the system during construction. Specifications defining construction submittals or design plans for shoring of the existing bridge should be included on the plan set.

Soil nails or other bracing often are required, and their construction can make or break the schedule. Stabilizing this soil at the abutments is critical, as delays can result in all other scheduled activities being delayed as well. Significant and detailed analysis needs to be performed to ensure the temporary structures and existing spread footings, if used, will not settle once the dead loads are transferred.

This is the first in a series of articles examining different approaches to accelerated bridge construction. This report 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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