Sliding and Rolling Bridge *Solutions*–Part 3

by Craig A. Shutt

Construction of falsework for the new bridge begins on the right side. All photos: Hilman Rollers.

Construction of widened substructure begins on the left side.

The deck is ready for casting concrete.

The old bridge has been removed and the new bridge is ready to be moved into place.

The new bridge is in its final location.

Sliding and rolling bridges into place offers key benefits to owners, designers, and contractors. As a result, more bridges are being designed and built using these techniques. This series of articles looks at some of the key considerations when using these approaches to construct bridges.

The first two parts of this series examined key design considerations that impact construction. This part addresses construction considerations.

Pads

Pads are a simple, low-cost solution. They offer significant directional flexibility, as the direction of movement is not tied to the orientation of the pads. Pads also allow the use of an unguided system that will not bind if ends of the bridge move at different rates.

Normally, the superstructure is lifted prior to the slide, to allow the skid shoes and bearings to be cleaned and to apply a non-petroleum-based synthetic grease onto the sliding surface. Continuous lubrication of the pads is critical during the slide, especially to overcome the initial inertia and achieve the breakaway force.

Fortunately, many types of inexpensive lubrication can be used. A variety of biodegradable lubricants are available that won't damage the pads. A popular option is dish soap, readily available from any mass-merchant store, but it dries quickly if left for any time. One contractor uses bananas as lubricant. Whatever is readily available, inexpensive, and has been found to be effective can be put into service for this need.

Skid shoes should be braced during construction to maintain a level slide surface. Normally, the sliding surface of the shoe consists of polished stainless steel. There are many ways to construct skid shoes. One method uses concrete-filled steel shapes using steel as thin as ¼ in. Other methods use steel box or I-sections with the base plate at least ¾ in. thick. Thinner shoes can deflect or warp during construction, creating an uneven sliding surface. Beveled ends should be used to ease sliding over the pads and limit friction.

Rollers

Rollers are more costly than pads but have a longer service life. They are often used on bridge projects with larger load requirements. When properly sized, the slide resistance is more predictable and requires less force to start and stop the bridge. Undersized rollers can dimple the slide surface, which can significantly increase the starting force.

Rollers are almost always guided with troughs or channels that align the rollers during the move. Roller-guide surfaces can be flush or approximately 2 to 3 in. wider than the rollers to allow room as the jacks push or pull the bridge. These channels must be kept clean and clear at all times to ensure no obstructions for the rollers.

Rollers were used between the end diaphragms and the temporary substructure on the I-205 Redland Road overpass in Oregon.

Contractors using rollers must fully understand the tolerance issues, know the requirements to achieve the breakaway force, and monitor when to reduce the force once the bridge begins moving. These calculations must be precise, as any deviation can bind up the system and require time-consuming adjustment.

Push-Pull Options

The decision to use jacks to pull or push the bridge will depend on a variety of specific factors, including terrain, bridge design, and contractor preference. Typically, the deciding factor is the contractor's preference given the specifics of the bridge under construction.

When pushing a bridge, temporary abutments are used with self-setting jacks. When pulling the bridge, the mechanism relies on cables attached to an electric drum, strand, or

Tension rods are anchored at the abutment to create a reaction point. Note the bracket to accommodate the skew of the bridge.

This before and after view shows how the abutment was changed once the bridge was moved into place. Note the channel guide rail and tension rods.

threaded bars. Anchor points are needed to secure the jacks. Often, the jacks are anchored to the existing bridge beyond the replacement bridge being pulled into place.

In either format, it is critical that the movement is monitored to ensure the jacks move at the same rate. Uneven movement often occurs due to differences in friction regardless of how careful the system is designed. Early correction of uneven movement minimizes the potential for binding or final misalignment.

Monitoring is especially important on bridges moved without guides. Without guides, the structure will move back and forth as rams will most likely be hydraulically connected and not using a displacement-based control. Achieving a final alignment within the specified tolerance can be time consuming, especially when inadequate monitoring allows significant racking or rotation to occur.

Jacks

When pushing the bridge, restroke jacks are used, with no stroke length greater than 30 in. Longer strokes take too long and can create bending in the jack piston. A push range of 6 to 18 in. is recommended.

Typically, the jack features a home rail with pins, with the piston pushing to advance the bridge, after which the pins are advanced (or a second set of pins are inserted) at about 6-in. increments. Double-acting rams can retract quickly, moving the bridge at a faster rate. Pressure in the system may not always be proportional to the jacking force because of friction in the jack.

A trial-and-error approach, along with the use of a measuring stick along the rails, will best determine how far the bridge can be moved at once. If one side moves farther, however, adjustments must be made quickly. Workers should be assigned to each corner to watch the longitudinal and lateral movement carefully.

A simple measuring system is needed to monitor bridge movement at both abutments.

Terrain

It is best to move the bridge on a horizontal surface, irrespective of any slope in the terrain. A complete evaluation of soil conditions is critical to ensure adequate support during the move, especially under the launching rails.

Typically, it is more advantageous to move the bridge uphill if a level surface cannot be provided, as it makes it easier to control movement. Moving downhill requires a launch mechanism that includes heavy-duty brakes or a restraining system to restrain movement when gravity tries to take over.

In all cases, a test run will help assess any concerns. This should include actually moving the bridge, even if only by a few inches.

Key Stages

The initial lifting of the structure to place the slide system can be the controlling load case for the shoring system. Next, the initial movement creates the largest horizontal force demand and the maximum transverse force in the shoring system. During the slide, transitioning from the temporary support to the final support can cause differential deflections between the supports. This stage maximizes the vertical-load demand on the connection element. The final stage places the bridge on the permanent bearings.

Typically, permanent bearings are thicker than pads and shorter than rollers. After the bridge is aligned in its final position, it is jacked up, the slide system is removed, and permanent bearings are placed. Shim plates can be used to correct any elevation discrepancies in the bearing surface on the permanent abutment or variation in the bottom of the substructure elevations.

Other Considerations

Integral diaphragms and shoes provide a robust section and minimize differential deflection between girder lines. Normal cross-frames provide a more flexible system and can reduce the impacts of differential deflection in the slide supports.

Use of two slide supports increases the load per support but minimizes the variation in load due to an uneven slide surface. Three or more slide supports reduce the average load per support, but it also can concentrate the load onto a single support if the system is stiff and the slide surface has a high point.

Often, pads are reused in a slide as the bridge transitions over them. At the final move into the bridge's permanent position, new pads are placed and left in place. They are locked in with shear keys after the bridge is positioned. Detailing gaps between the skid shoes can allow temporary and final bearings to be switched during the final push.

Deck cracking due to lateral moves is rare. The deck is vulnerable during the initial or final jacking, but the loads are similar to those encountered in a normal bearing-replacement project. The deck can also be stressed when a high point is encountered by the rollers or slide shoes during the move. Bridges using a flexible cross-bracing system are more vulnerable.

No matter how well thought out the process and how high the quality, these projects should always have contingency plans. These plans typically include backup power for the rams, backup rams themselves, additional bearings, redundant load paths, and other accessory parts.

As contractors and engineers become more experienced with this type of construction, some of these requirements will become second nature. That will not reduce their importance. A strategy must be developed to ensure the owner receives an acceptable as-built bridge. The contractor's team must be diligent about every aspect of the project to ensure its success. A

This is the third in a series of articles examining approaches to accelerated bridge construction as it applies to slide-in 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, formerly chief bridge engineer at Burns & McDonnell.

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