The Future of Forms

Ask the Experts: Perspectives on Forms for Concrete Bridge Construction

by Monica Schultes

Concrete bridge design and construction have seen the effects of optimized girder shapes, accelerated bridge construction, the introduction of new strand and concrete materials, and an increase in the number and size of prefabricated elements. All of these topics either affect, or can be affected by, concrete form manufacturing companies. To gain insights on how formwork and its use can impact the efficiency and safety of a bridge project, and how new influences in the bridge market can have an effect on bridge forms, *ASPIRE*® submitted a list of questions to a panel of experts from Helser Industries, PERI USA, and Hamilton Form Company for their perspectives. The following is an edited version of their responses about recent and future changes and challenges related to formwork in bridge construction.

Q What have been the biggest changes in bridge formwork over the last 10 years and what do you anticipate in the next 10 years?

A **HELSER:** The biggest changes have been larger span requirements and therefore taller girders with heavier strand loading. We expect more of the same in the years to come, especially with the onset of more advanced materials.

PERI: Looking back on cast-in-place (CIP) concrete bridges, there hasn't been much change in formwork solutions. Unlike other areas of the concrete construction industry, the bridge segment has not been on the cutting edge of technological advancements. From our perspective, construction timelines have been reduced and environmental concerns have increased. As a result, we are seeing more concrete elements such as columns and caps convert to precast concrete. With accelerated schedules, that trend to prefabrication appears to be here to stay.

HAMILTON: Bridge beams are getting taller; as an example, we built a form for a 15-ft-deep haunched girder. This trend drives higher hydrostatic and uplift forces for the forms. Additionally, adding taller sections to existing product families has precasters looking to split forms and other adjustable features to create more shapes from the same base form. Precasters are also focusing more on production efficiency, asking for rolling forms and other solutions that help them to set up quickly or reduce the time to strip and get ready for the next concrete placement.

What challenges or opportunities do you see in the future? How will issues such as transportation funding, labor shortages, and regulations affect our industry?

HELSER: The nation has a huge opportunity to improve aging bridges while simultaneously boosting the economy for years to come. We just need to come together on a large-scale infrastructure bill and start getting ahead of things.

PERI: With labor shortages across the board, we manufacture solutions that are easy to use in the field to make concrete construction work simpler, faster, and safer. As the industry turns to less-skilled labor, it is critical to improve on those concepts.

The Veleno Bridge replacement in Zapata County, Tex., near the Mexican border, is a 16-span bridge made up of precast concrete girders, deck panels, and pier caps. A reverse radius soffit and curved blockouts were used for rounded pier cap features that create architectural interest while preventing birds from nesting under the bridge. Photo: Hamilton Form.

We also continue to expand our digital capabilities, investing in 3-D [three-dimensional] design technology. 3-D printed structures are a disruptive technology to our business. In Germany, PERI has used this technology in the residential market, and we plan to continue to develop it in the United States for multiple uses. We definitely see it being widely adopted in the future. Separately, 3-D printed formwork has potential for some architectural finishes, and we will continue to monitor how that technology evolves.

HAMILTON: As labor markets get tighter, we are looking for more ways to help our customers by treating forming as part of an integrated production system that combines the setup, heating, tarping, and related activities in a more efficient manner. We are experiencing our own challenges finding skilled workers. As we look to automate and mechanize our processes, we want to bring those ideas to our forming solutions.

Another long-term challenge to our business is new materials and manufacturing processes. 3-D printing of forms is currently replacing complex wood forms for architectural specialty shapes. We recently built a hybrid 3-D printed shape combined with a steel form and will adapt as it becomes more commonplace. It will be a while, though, before a 3-D printed bridge girder mold competes with a long-line steel-form production system for standard DOT [department of transportation] shapes.

What would you like industry professionals to know about formwork? What should engineers and designers know about forms to improve their designs and foster innovation?

HELSER: The best designs are those that find the right marriage between financial reality and innovative design. Too often, the expert opinion of the precaster or their form builder is asked too late in the design phase. What might have been a good design idea structurally can become cost prohibitive from a production standpoint and either halted completely or get caught in cycles of project-delaying redesign.

PERI: Industry and DOT professionals should become more familiar with the capabilities and limitations of formwork options and how varying form geometries may lead to either increased or decreased inefficiencies in productivity on the jobsite.

HAMILTON: Whether bridge engineer or industry consultant, there is sometimes confusion regarding what is and what isn't achievable with new forms. There is usually a way to achieve new and complex shapes. Some common mistakes in specs are the absence of adequate draft to lift pieces out of forms. We try to collaborate with customers on large projects and we want to get involved early to add value to the project. Formwork is often overlooked as to how critical it is to the success of bridge projects.

What common mistakes do you see in plans and specifications regarding formwork?

HELSER: The most common mistake made by designers is forgetting to think about forming requirements and the added production labor that certain design features cause for a precaster.

PERI: Keep an open mind to new technologies. It is easy to reuse drawings and specs from an old project, but that is one reason why there hasn't been much forward momentum on the CIP side. For instance, we have seen specs that require a steel face finish, but there might be other, more modern options that can achieve similar results.

Regional specifications are tied to means and methods. For example, California falsework requirements make it hard for contractors to use modular systems or more competitive solutions. We would suggest opening up the specs to allow for innovation.

HAMILTON: Engineers and designers need to know any limitations on shaping steel. We also like to be involved with how to optimize precast concrete production. We have worked with a wide variety of precasters and can bring that experience to bear on new challenges.

Can you comment on form modifications or ways that existing forms could be modified to change the section?

HELSER: While any form can be modified to adjust its profile, the quality of the final product may dictate a new form. For instance, narrowing a web on

With the trend toward longer bridges, prestressed concrete must span farther while keeping superstructure depth to a minimum. For long-span precast concrete spliced-girder bridges, the optimum solution is often a haunched girder system using a form like this one. Photo: Helser Industries.

Crews cycle column formwork for piers for the Sargent Bridge replacement in Matagorda, Tex. PERI developed a custom form allowing concrete to be pumped in from the bottom to achieve a single-phase concrete placement on these hollow columns. Photo: Greg Folkins Photography.

a girder while maintaining flange widths can be achieved by adding on pans to the side forms. It will get the job done but, depending on if it is an adjustable-height form using risers, the quantity of individual pans coupled with the need to bounce back and forth between web thicknesses may make it more cost effective to purchase a separate form.

PERI: For design-build projects, we actively collaborate with the team to help them with cost-effective use of the forms. How they cycle them around the jobsite in the most effective manner saves costs for the owner. This is especially true for large projects where the contractor has input in the early stages regarding how to site-cast concrete bridge elements.

HAMILTON: Oftentimes, customers want to make their forms more versatile and want to use fillers instead of investing in a new form. While the precaster knows what is best for their production capabilities, we can make recommendations regarding form modifications. There is a point of diminishing returns on the amount of flexibility and the amount of modifications you can accommodate, even on a new form. At some point, it may make sense to have two dedicated forms rather than a universally flexible form because it doesn't save money over time.

The Impact of Ultra-High-Performance Concrete

Touted as a material that will revolutionize the concrete industry, ultra-high-performance concrete (UHPC) is a relatively unknown quantity when it comes to new shapes, forms, and sizes.

Do you think that UHPC will be a game changer for the bridge construction industry? If so, will the higher fluid pressures add a premium cost to the forming systems?

HELSER: While UHPC may very well be a game changer for the industry, the fluid pressures are in reality very similar to a highly vibrated traditional concrete mixture. All Helser forms are designed for high vibration or a fully liquefied mixture, and are therefore fully capable of supporting the onset of UHPC with no additional cost.

PERI: We haven't run into UHPC in the bridge market yet. The biggest thing that UHPC will mean for us is potentially higher pressures. We would have to help the contractors really button up the formwork for a single vertical placement that can handle the hydrostatic pressure on the bottom of the form. PERI continues to explore technologies that can measure these pressures in real time, helping to support UHPC projects by eliminating the need to design to full liquid head pressure.

HAMILTON: We are participating in the PCI research and development project on UHPC. We helped with the formwork for a few of the volunteer precasters, but since we already design our forms to the full hydrostatic pressure, we don't anticipate it to be any different from SCC [self-consolidating concrete] to UHPC mixtures.

Do UHPC forms require special sealing systems because the fresh material "runs like water"?

HELSER: History has already driven all the required forming technology to support UHPC girders. Any time you combine a high-architectural-quality requirement with a structural member, the form is required to prevent slurry leakage while being heavily vibrated to remove entrapped air, which causes a full liquid head similar to UHPC pressures. Some existing forms that weren't originally designed to that level may require some additional gasketing at the soffit and headers, but structural integrity is not an issue. It may require more care by the end user of the formwork in the way of daily cleaning and maintenance of the forms to ensure proper closure.

HAMILTON: Penetrations will not be a problem from a stress standpoint. As far as keeping leakages under control, there will be some details to resolve, but nothing too difficult to accommodate.

To better utilize the advantages of UHPC, designers are looking at 0.70-in.-diameter prestressing strand and other girder shapes, like the Florida I-beam, which can have 17 strands in the bottom row. Can beam bed pallets be redesigned to be self-stressing for the bottom row of seventeen 0.70-in.-diameter strands? That would help producers avoid major in-ground bulkhead expenditures.

HELSER: The onset of higher compressive strengths and larger spans has already pushed the boundaries of many existing abutment structures. Helser has already helped customers combat this by adding a self-stressing soffit with a low-profile stress head to pick up the lower rows of strand while allowing the upper rows to pass over to the existing abutment. While there are certainly limitations to every structure, we should be able to do the same for much of what UHPC brings.

HAMILTON: Larger strand does put more stress on the bulkheads. However, it is just a question of designing to accommodate it. When we went up from 0.5-in.-diameter strand, it was a similar evolution. Self-stressing soffit is one strategy, and others will develop to fill the need.

Conclusion

Form lengths have grown, tensioning capacities have increased, and the use of automation and equipment to improve productivity continues to evolve. Form companies have grown and changed to help advance the concrete bridge construction industry.

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