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Another Bridge Saved!

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Some head-scratching and an innovative solution saved a corroding bridge.

Virtually all cities and counties have inventories of bridges of various ages ranging from new to end of usable life. A new bridge generally requires little attention for many years, with the exception of routine inspections in accordance with National Bridge Inspection Standards. On the other hand, bridges nearing or at the end of their usable life should already be programmed and budgeted for by the jurisdiction for replacement in the near future. But what are we to do with the vast majority of bridges that lie within those extremes? Many of those bridges are carry-overs from the era when smaller trucks and agricultural equipment were used; hence the bridge was not designed for the equipment that is almost universally used today. How quickly we forget, but that era wasn't all that long ago!

Last year I shared the story of our Grand Avenue Bridge, a 1930's vintage bridge, which we successfully strengthened. As a result, it is anticipated the bridge will continue to serve a major regional industrial park for many years to come.

This article has to do with another Saline County bridge and what we did to strengthen it and extend its useful life.

Photos courtesy of Saline County

Construction of formwork for subsequent encasement of the open H-pile bents with concrete.

The bridge

The Hobbs Creek Bridge over Gypsum Creek in southeast Saline County was constructed in 1991. In terms of anticipated bridge life expectancy ("hoped for" may be more apropos), 20+ years is not that old. Built with county forces, the 130 ft long, three span (40'-50'-40') bridge was constructed with steel girders spaced at 2.27 feet on centers. A total of 12 girder lines gave the bridge a 26 ft wide travel-way. The deck itself was of no reliable assistance in bracing the girders. It consisted of 12 gage corrugated steel planks tack-welded to the girders and then covered with an asphalt milling wearing course. Diaphragms were provided but not a sufficient number to meet the lateral bracing requirements for the girders to develop their full plastic moment capacity. Steel W-section guardrail was bolted to posts welded to the outside girders—an obsolete bygone era detail. The piers were open bent H-piles (known almost everywhere to be notorious debris collectors during high stream/river flow conditions) and the abutments were H-piles with corrugated steel plank to hold back the earth-fill bridge approaches. Needless to say, the completed bridge was a source of pride to the Saline County Public Works Department and a framed photograph of the bridge graced the reception area of the County Engineer's Building almost since the day the bridge was completed.

Bad corrosion (very bad)

Over the years, corrosion of the girders became increasingly evident. Review of the successive bridge inspection reports for the last decade indicated that the corrosion was getting worse at an accelerating rate. There was much speculation as to why it was happening with this particular bridge. The possibility that there might be something in the area that was causing this to occur, even the possibility that the bridge might be acting as a

sacrificial anode for an adjacent cathodically-protected pipeline was even considered. It was decided that the corrosion was probably due to the porous asphalt milling wearing course simply allowing rain water to pass through the deck and come into contact with the unpainted girders. The millings even held water for an extended time after a rain event, slowly releasing it through the metal deck seams. What has not been figured out is why this same phenomenon doesn't occur as rapidly on other similarly-constructed bridges.

Ideas considered

It became clear that something needed to be done to the bridge before the damage progressed to the point that replacement was the only option. But what could be done? Sandblast the girders to remove the rust and then paint them without removing the deck? The closeness of adjacent girders, the fact that most of the work would have to be done from a man lift, and the large surface area which would have to be blasted due to the number and length of the girders made that option cost prohibitive. Besides, this would do nothing to provide additional lateral bracing to the girders to increase the bridge load capacity.

How about taking the deck off to provide better access to the girders for sandblasting and painting? Headed studs could then be welded to the top girder flange and a new concrete deck placed compositely with the girders, thus increasing the load capacity of the bridge by allowing the girders to develop their full plastic moment capacity. The problem was that the costs to sandblast and paint would still be high, plus the additional cost to weld headed studs on that many girders would also be high. Besides, any option to address the girder issue would still leave the open pile bents and the associated issue with trapping debris.

So if addressing the problems with the existing bridge would be high-cost, why not simply replace the bridge? It was not difficult to anticipate the reaction of elected officials and the public to my recommending replacement of a bridge that was barely 20 years old. So what could be done to address the existing corrosion issue, provide better protection of the girders from additional deterioration, laterally brace the girders to get more load capacity from them, and deal with the open steel pile bents? I admit that I struggled for a long time with those questions.

A concrete solution

I can't recall what prompted it, but I began pondering the idea of concrete encasement. Not to say that encasing an existing steel girder bridge has never been done before, but I could not find examples despite much research. What I did find were a couple of articles regarding the broader topic of W-shape steel beams and columns encased in concrete. One of the articles even dealt with Load and Resistance Factor Design of W-shapes encased in concrete. I was encouraged to find (or to be more accurate, have my belief confirmed) that there are several benefits of concrete encasement which are as follows:

1. Monolithic placement of the concrete slab and girder encasement ensures composite action between the two without the need for headed studs;
2. Concrete encased girders with monolithic slab could indeed be considered continuously braced and thus capable of developing their full plastic moment capacity.
3. So long as the corrosion was not overly deep or causing delamination of the steel and there was not significant section loss, the concrete encasement would passivate the corrosion and protect the steel girders from further deterioration.
4. Monolithic placement of the concrete slab and girder encasement provides an excellent opportunity to supplement the beam strength with additional longitudinal reinforcement in the maximum positive and negative moment regions.
5. Replacing the existing corrugated steel bridge plank and asphalt milling deck with a new concrete deck would also provide an opportunity to widen the bridge travel way by a couple of more feet and also replace the obsolete W-section guardrail with KDOT standard concrete corral rail.
6. A few relatively simple calculations showed that the existing steel beams provided more than sufficient strength to carry the formwork, equipment, and fresh concrete prior to the concrete coming to strength. Thus, the forest of falsework (and its hefty costs) typically necessary to support these construction loads would be eliminated!
7. Concrete encasement of the open H-pile bents eliminates the proclivity of that type of bent to trap floodwater debris.

Getting buy-in for a new idea

Convinced, at least in my own mind, that the concrete encasement idea had merit and was feasible, I knew that my next task was to convince others of the same thing. Quite frankly, that can sometimes be more challenging than even coming up with new ideas.

After 10 years, the team in the Engineering Division of the Saline County Road and Bridge Department is somewhat conditioned to my sometimes unconventional ideas, and they were cautiously supportive. However, contractors, as a rule, are set up for and are used to doing repetitive things they have done profitably for years.

Even if contractors concede that unusual ideas may have merit, they still fear the unknowns and simply cannot afford to get bogged down on a given project. To remain profitable, they need quick, predictable projects based on the expertise they already have. I fully understand this,

At left, *placement of formwork and supplemental reinforcing around existing steel beams in preparation for concrete placement.*
At right, *Removal of formwork after completion of concrete placement.*

but I still find it unfortunate because it is a hindrance to innovation and progress in our industry.

I was certain that the main hurdle that contractors would have is how to economically form the concrete slab and the encasement around the existing steel girders. The solution I came up with was coated void forms, also known as carton forms. We often used such forms, though not in exactly the same manner, when I was more involved in building design. They are ideal for situations where there is significant repetition of similar forming requirements and a "one-use" (i.e., disposable) forming solution is needed. In addition, void forms are more easily removed after the concrete comes to strength than other forming alternatives.

I contacted several suppliers of these forms and obtained quotes that I found to be very cost-effective for a bridge having a 3,900 square foot deck area.

Potential bidders were informed of this method of forming and were given the contact information for the suppliers. However, the engineer does not generally dictate "means and methods." Those decisions are at the discretion of the contractor.

Contract drawings and specifications were prepared and we went out for bids. Bids were opened on February 27, 2013.

Four bids were received and they varied widely. Such divergence in bids generally reflects uncertainty on the part of the various bidders with undertaking something that is out of the ordinary. However, the low bid was below the Engineer's Estimate, and was about half of what our records show is the current square foot cost of a new bridge in Saline County.

The work starts, and so does the rain

The Saline County Commission awarded a contract for this project on March 12, 2013. To accommodate harvest traffic, the road was not closed until July for construction to begin. Once construction got started, early going was good and the existing metal deck and asphalt millings, bridge railing, and guardrail were quickly removed and the east pier concrete encasement was placed. Then it rained, and high creek flows set further construction progress back until mid-August. The end of August saw the placement of the concrete encasement of the second open bent pier.

Formwork issues

Next to be tackled was the superstructure. In lieu of using the void form idea, the contractor chose to use formwork built mostly on site using dimensional lumber. Quite frankly, it seemed from my perspective that it would be expensive in terms of materials and time to go that way but, as I previously stated "means and methods" of construction are at the discretion of the contractor. I believe that the higher than anticipated cost became apparent to the contractor as well, not too long after he began fabricating the formwork. Unfortunately, this activity took longer than we all anticipated. I hasten to add that we have worked with this contractor on numerous other bridge projects and we have the utmost respect for him and all of his people. We have found them to be dedicated and principled and can always be counted on to do their best on any project, and this project was no exception.

It was the end of October before all formwork, deck reinforcement, and supplemental girder reinforcement were in place. November 1st the concrete deck and

beam encasement were placed without complication. The remainder of the month of November saw the placement of the corral rail, removal of the formwork, and placement of shot rock slope protection at the four corners of the bridge. Virtually no areas of unconsolidated ("honeycombed") concrete were observed when the formwork was stripped, which was a concern we all had due to the relatively close clearances between the formwork and the steel girders, especially the bottom flanges of those girders. The bridge was reopened to traffic on December 12, approximately five months after work began. Not a bad completion time for a 130 ft long, 30 ft wide bridge even with weather and formwork setbacks.

It worked!

The completed bridge has no load restrictions. After more than a year in service, it exhibits no visible cracking in the deck or the concrete girder encasement. In fact, no one would know that the bridge had been a bare steel girder bridge that was exhibiting premature aging if they didn't know its history. A subsequent project in the summer of 2014 placed a polymer overlay on the new concrete bridge deck to further protect the bridge from water penetration. This strengthened bridge will likely serve the community for another century!

Thoughts about trying something new

This project was a complete success from Saline County's point of view in terms of providing an innovative, economical solution to rehabilitating a rapidly deteriorating bridge. From the contractor's perspective, however, the project wasn't as profitable as I'm sure he had wished.

Frankly, we agree. Some people may think an owner gets a "steal" if a project isn't highly profitable for the contractor. That just isn't the case. The contractor must make a profit to stay in business and we need all the bridge builders we can get. In addition, innovative projects that are profitable for a contractor turn that contractor into a vocal advocate and supporter of the concept. The reasons for lack of profitability were the project schedule setback due to high creek flows shortly after initiation of construction and the cost in time and materials of the site built formwork. I still think the coated void or carton forms probably would have been less expensive and may have expedited construction and wrecking-out of the formwork after concrete curingMaybe we will find out on a similar project in the future.

I consider this prototype project as proof of concept. However, all new ideas are subject to refinement and this one is no exception. In fact, several improvements occurred to me and yet others were mentioned to me by Saline County staff and the contractor's project superintendent during and following completion of this successful project that may have simplified construction.

The finished bridge.

Saline County has many more bridges where this innovative concept could be used and I would definitely consider employing it again. However, as I stated earlier, convincing others that any new idea is feasible and has merit can sometimes be more challenging than even coming up with new ideas. If, construction of the prototype is not as profitable as the contractor expected it to be, even if that reduced profitability is due to acts of God or contractor's selection of a particular mean or method to execute the project, as I believe was the case with this particular project, the word gets around the small pool of potential bidders for future projects, and, unfortunately, will often adversely impact the whole contractor community's willingness to work with any ideas out of the norm.

State and federal agencies do offer some programs that cover the unanticipated costs associated with promoting new ideas that may hold promise for the greater highway and bridge building industry. For example, the Strategic Highway Research (SHRP) and Every Day Counts (EDC) programs were created with that being one of their objectives. Maybe coverage of some of the risk by employing one of these sort of programs will make taking on another of these projects in the future more attractive and less risky for contractors. Unfortunately, such programs generally come with so many "strings" that simply employing them can result in increased costs which can easily offset their benefits. So, one must carefully weigh whether seeking such funding will indeed be beneficial.

All this being said, innovation is true engineering and all of us in this profession owe it to those who employ us to seek better ways to do things. We must not cower in fear of trying new things and taking the road less traveled, or even blazing an entirely new road! If our thinking is good, so also will be our solutions! ■

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