Economical Bridge Rehabilitation Using Composites

A 60-year-old truss bridge was rehabilitated using fiber reinforced polymer (FRP) composites for the structural deck. The innovation was the adoption of a "rehab lite" strategy instead of the traditional "re-build in kind" rehabilitation usually considered. The strategy restricts the project scope to only those tasks necessary to relieve the problem at hand. Objectives were met by painting the bridge and replacing a heavy concrete deck and numerous asphalt overlays with a lightweight FRP deck. This reduced the dead load by 80% and almost doubled the live load carrying capacity of the bridge: HS12 to HS23 (to a level higher than the original design!). A 14-ton weight restriction was able to be removed and the bridge reopened to all legal loads. This took care of the economic detriment that the posting was causing and did it well before a capital project, that typically would have taken five years, would have been completed. The cost of the rehabilitation ($876,000) was much less than that of the next best alternative which was a complete bridge replacement ($2.34M). This "maintenance" strategy also dramatically reduced project development time and construction duration.

The 140' Warren truss bridge carrying New York State's Route 367 over Bentley Creek in Chemung County was built in 1940. It found new life October 1999 after the installation of a 13 ½" thick, E-glass reinforced vinyl ester resin deck weighing 32 pounds per square foot (psf). This was possible despite the fact that the structural steel had suffered some section loss and corresponding loss of strength. The rejuvenation resulted almost entirely from the removal of 265 tons of dead load; no extraordinary measures were needed to strengthen the bridge. The deck is a structural element engineered to span 14' between floor beams, bypassing the deteriorated stringers which had been governing the bridge load rating. The deck itself rates much higher than the bridge. It meets a L/800 deflection requirement with an inventory load rating of HS85 (154 tons). Load tests indicate that the actual capacity of the deck is even greater than these analytical ratings. Though the complete project took longer, the actual deck replacement operation was completed in less than 30 days. A shortened construction time reduces noise and air pollution and energy use. It also increases safety of workers and the traveling public by limiting exposure. Because of the projected long service life, it also means that we can "stay out" for a longer period of time, accruing the above benefits even further.

According to FHWA statistics, there are 93,076 weight-restricted bridges in the country. There are approximately 19,000 steel trusses which are particularly well suited to this type of project. Even if sufficient funds were available for replacing all of the nation's deficient bridges, the low initial cost and the low life cycle cost may make it fiscally imprudent to do so, now that there is this new "lite" alternative available to us.

FHWA recognizes this as the first application of composites technology for a truss bridge deck on a state highway system. Because of lack of precedent, there many innovations that needed to be developed:

1. *A haunch for each floor beam was uniquely precast to support the deck.* This placed the deck at the proper elevation, provided a new load path directly from the deck to the floor beams, raised it above the obsolete steel stringers, and delivered a 2% (1/4"/') cross slope - an improvement over the original 1% (1/8"/') crown.
2. By *installing a deck equal to the "existing" thickness* of the deck and asphalt overlays, approach work could almost be eliminated. Historically, profile changes can add over 50% to the cost of a bridge project.
3. The 25' x 141' deck was replaced using *six discrete deck panels.* The modular construction simplified installation and reduced field time.
4. A *field splice system* was designed to transfer shear and moment between panels. The joints devised rely on FRP cover plates and structural adhesives. The watertight deck protects the steel floor system from the weather.
5. A particularly vulnerable detail of trusses is the lower chord at the panel points. To protect this and extend the life of the truss, prefabricated and field trimmed *FRP "filler panels",* were installed between the sidewalk and the truss.
6. A *FRP curb* provided to control drainage, was pre-installed on each deck panel to eliminate a construction step in the field.
7. The existing sidewalk was replaced with a lightweight, prefabricated, composite section. The *sidewalk panels* were easy to install and accounted for 32 tons of weight savings. Unique tie down clips were devised to eliminate the need for penetrating the composite materials with fasteners.

This project directly led to the development of a specification for the purchase of future FRP decks in New York.

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