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On Opposite Coasts

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This rendering shows the MIC-MIA bridge, which will provide access to Miami International Airport's rental car facility.

The redesign of the Estero Parkway Flyover project replaces twin, cast-in-place concrete box girders with with a design using four steel box girders.

Two Florida bridges—on either side of the state—will deliver multiple benefits to their owners and users, thanks to value engineering redesign.

LOCATED ON OPPOSITE COASTS OF FLORIDA, TWO CURRENT BRIDGE PROJECTS WILL SERVE VASTLY DIFFERENT PURPOSES.

The Estero Parkway Flyover, near Fort Myers on Florida's west coast, will ease traffic congestion on the parkway and offer travelers an alternate east-west route on the Tamiami Trail and I-75. The Miami Intermodal Center Terminal Access Roadway Project—nicknamed MIC-MIA—will provide access to a rental car facility as part of a major upgrade of Miami International Airport.

But both projects have one thing in common (besides being in Florida): they were both initially designed to use concrete for the superstructure. Both were redesigned in steel by Finley Engineering Group in a value engineering process. And both will now be built faster and will save their respective owners approximately $2.5 million combined.

Out of the Comfort Zone

Tampa Steel is the steel fabricator on both the Estero and the MIC-MIA projects. Robert "Bob" Clark, Jr., the company's president, says that most bridge superstructures are designed in concrete because many bridge engineers are more comfortable and experienced with concrete than they are with steel. "Most colleges teach concrete design in their core courses, whereas steel design is an elective in advanced courses. So many engineers choose concrete because of an absence of knowledge about steel."

Not every project benefits from a conversion to steel from concrete, of course. And despite what some may think, the savings aren't strictly linked to the material costs of the former versus the latter. Donald Deberry, P.E., public works operations manager for Lee County, notes that the recent cost fluctuation for all kinds of construction materials underscores the need for good, solid engineering design, because chasing material prices is a losing game.

"It might look like you're saving money when you evaluate price during development of the project or the bridge development report," he says. "But later, when you actually go to buy it, you might find that you would have been better off using something else because of price fluctuations in the materials market."

On both the Estero and MIC-MIA projects, three factors other than material price dictated that steel was the better choice:

Site conditions. The original design for the MIC-MIA project called for a cast-in-place concrete-on-falsework section combined with concrete U-beam superstructure to make up the 584-ft-long bridge. As designed, the construction would have been excessively complicated and labor-intensive. The value engineering redesign included only one superstructure type. And by converting the superstructure to steel, the redesign eliminated the need for falsework, greatly simplifying construction and minimizing the impact on ongoing operations and construction projects at the rental car facility.

According to one of the subcontractors working on the FDOT MIC-MIA project, the original design would have required substantially more temporary shoring towers on the site, thereby impeding the principal access to the site. As such, the shift to steel box girders significantly reduced the amount of shoring required.

The Estero site had similar site restrictions—and design solutions. The redesign replaces twin, cast-in-place concrete box girders with a single bridge using four steel box girders.

This eliminates a large falsework support system, reduces foundation design requirements, and simplifies construction. The overall result is a shorter time frame to complete the bridge, an obvious benefit to the traveling public.

Falsework in the original design would have also more significantly affected a design-build project to widen I-75, which runs beneath the bridge site. It would have created more safety hazards for motorists, and the falsework erection and cast-in-place pours would have slowed traffic far more often than will occur with the placement of steel girders on the superstructure.

Contractor means and methods. Value engineering redesigns are often driven by the preferences and experiences of the contractor chosen for the work. Some contractors are simply better with one material than the other.

Contractors also prefer designs that are not overly complex and that allow them to make money on the job. On both the MIC-MIA and the Estero projects, elimination of the falsework reduced the complexity and the amount of labor that would be required to complete the work. Particularly in a construction climate where qualified workers have been difficult to find, this is a welcome change for the contractors.

Material cost did play some role in the Estero project. Jovan Zepcevski, president of Estero contractor Zep Construction, says steel prices were relatively high during the initial design period, but that they eventually receded enough to make steel the clearly better choice during the value engineering portion of the project.

The less complex construction process will also help the contractors meet their schedules. For example, in the case of the Estero project, Zep must finish the job in less than two years. For the Miami project, completing the structure quickly alleviates coordination issues associated with large, integrated construction projects.

Owner requirements. Lee County will pay a minimum of $1.85 million less for the redesigned Estero Parkway Flyover than it budgeted under the original design. The county coffers may get even more back, as the contractor and the county will split any additional savings.

The redesigns saved money in a number of ways. On the Estero project, the conversion to steel resulted in a reduced superstructure depth. This shortened the required approach embankment height, so the project won't need as much fill on each approach. A reduction of about 4 ft in the fill height at the beginning and end of the bridge, tapered over the length of the nearly 700-ft-long approach embankments, means massive savings in mechanically stabilized earth (MSE) fill.

In both projects, the change to steel reduced the number of piles required, and in the case of the MIC-MIA project, one of the piers could be eliminated. Because the steel boxes produce a lighter superstructure, the redesign resulted in a more efficient substructure design, meaning that fewer piles were necessary. In the Estero project, the number of 24-in. precast piles dropped from 130 to 76. On the MIC-MIA, the redesign increased the precast piles from 18 in. to 24 in., but reduced the number of piles from 163 to 60.

A New Perspective

An important lesson to take away from both projects is that value engineering provides the opportunity for a new look at a project by involving the contractor. That new look may very well uncover a better way to build the bridge—as it did in these two cases. Taking the opportunity to look at a project, with the engineer and contractor both contributing ideas on how to best accomplish the project's objectives, can add *better*, *faster*, and *less costly* to the overall project accomplishments. By incorporating a value engineering redesign, the project team is loudly and clearly stating that the client's needs are paramount. MSC

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*For more on the Estero Parkway Flyover project, see December 2007's Steel Bridge News, available online at **www.modernsteel.com/archives**.*

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KC Crossing

Construction is scheduled to start this spring on the $245 million KCICON (Interstate Connections 29/35) Project in Kansas City. This is the second of three design-build projects being undertaken by the Missouri Department of Transportation (MoDOT).

Paseo Corridor Constructors, a joint venture partnership of Clarkson Construction, Massman Construction, and Kiewit Construction, will lead construction efforts. Design is being handled by Parsons Transportation Group and TranSystems. PDM Bridge (AISC/NSBA Member) is the steel fabricator for the project.

The project will reconstruct/rehabilitate a four-mile section of Interstate 29/35 leading into downtown Kansas City. Along with highway widening and interchange reconstruction work, the project will replace the existing Paseo Bridge over the Missouri River with the Christopher S. Bond Bridge, a 124-ft-wide, 1,676-ft-long cable-stay structure.

The cables will stretch across a 550-ft main span and 451-ft side span, with a single composite steel plate girder span connecting to the structure's south end and a multi-girder span arrangement on the north end.

A closed, delta-shaped pylon extending 250 ft above the roadway surface will anchor the 40 parallel strand cable stays, creating a unified focal point for the structure and a gateway experience for those driving across it.

To encourage the creation of an aesthetically pleasing bridge, representatives of a community advisory group were given 20 points with which to score the two design-build proposals. This marked the first time a state transportation agency has allocated selection points to community members. MSC

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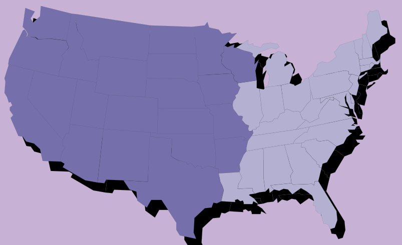
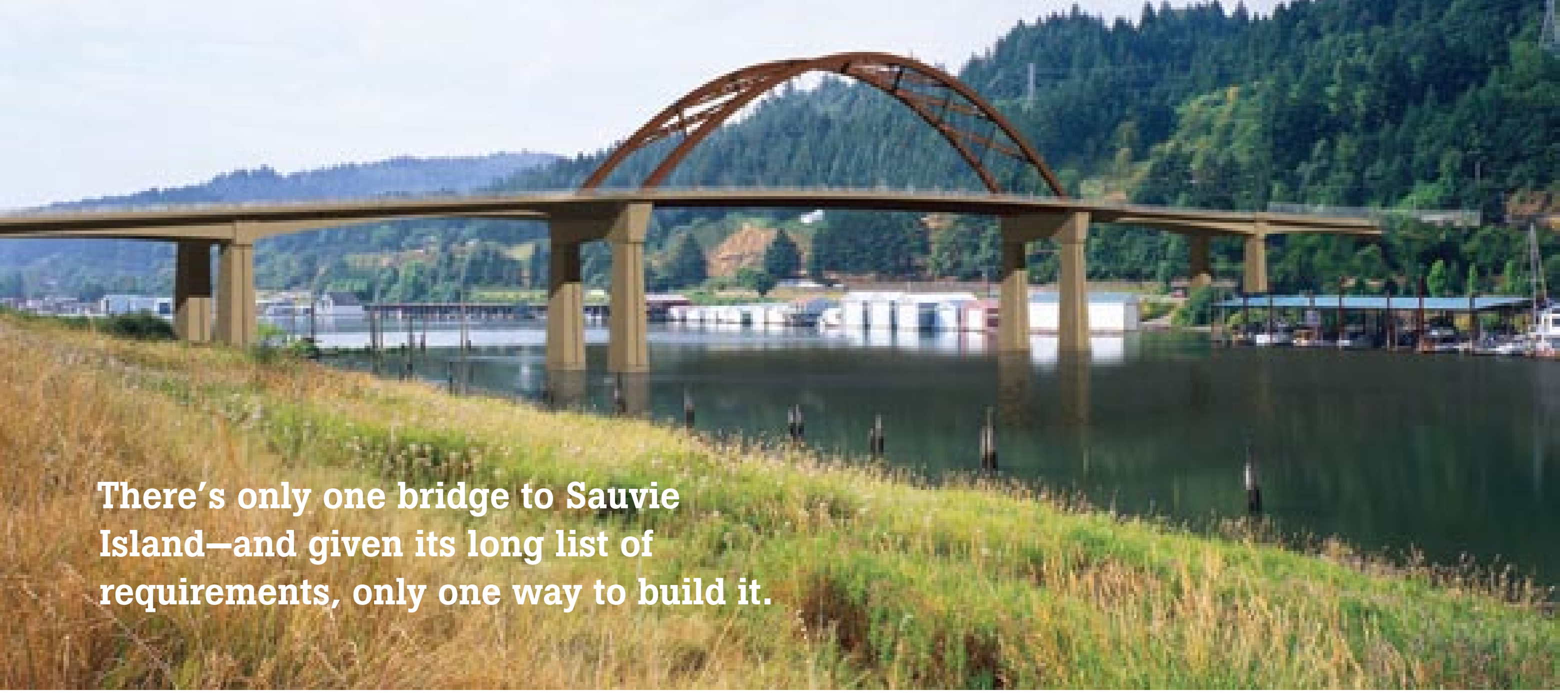


Limited Access

BY KIP COULTER, P.E., AND KENT CORDTZ, P.E., S.E.



There's only one bridge to Sauvie Island—and given its long list of requirements, only one way to build it.

Photo simulation of the five-span replacement bridge. (Courtesy 2L2 Architects/Planners LLC)

THE IDEA OF "A TOUGH ACT TO FOLLOW" isn't limited to the entertainment business. In the construction world, for example, such a situation might come up in the form of having to replace a structure that's eligible for listing on the National Register of Historic Places—while also having to pay homage to it.

Such is the case with the Sauvie Island Bridge in Oregon. Located approximately 10 miles northwest of downtown Portland, the bridge provides the only vehicular access to Sauvie Island, a largely agricultural 24,000-acre island bounded by the Columbia River, the Willamette River, and Multnomah Channel.

The original 1,198-ft long bridge, constructed in 1950, featured 14 spans. It was constructed using concrete girder and steel deck truss approach spans, and featured a steel through truss over the main navigation span. Despite its historical significance, the bridge required emergency structural repairs and was eventually classified as functionally obsolete and structurally deficient—and slated for replacement.

Considering Configurations

Led by project owner Multnomah County and with the active participation of the public and various stakeholders, viable alternative configurations for the replacement bridge and its approaches were developed to meet the following key criteria:

- The State Historic Preservation Office (SHPO) required that a portion of the replacement structure be above the bridge deck (i.e., a through truss or arch) in order to memorialize the historic existing through-truss bridge.
- The main bridge span was required to clear a 175-ft-wide by 52.5-ft-high navigation envelope (above the 100-year high-water scenario).
- The maximum grade on the bridge and its approaches was limited to 6%.
- The bridge must be constructed without falsework in the channel, and with minimal disruption to navigation.
- Life cycle costs, environmental impacts, construction duration, aesthetics—and, of course, budget—were important considerations.

A total of 21 structure alternatives were initially identified, and a multi-step process was employed to screen these down to the options that best met all project criteria. The approach grade constraints, coupled with the required vertical navigational clearance, quickly led to the conclusion that a structure with a very shallow floor system was required; this would also support the SHPO requirement for a through structure. A half through-steel arch with a 425-ft center span and twin 155-ft side spans was initially preferred for the main span, but rising construction costs forced the team to consider other similar but less costly alternatives.

Steel Tied-Arch

The team ultimately selected a 5-span, 1,177-ft-long replacement bridge featuring a 365-ft Grade 50W weathering steel tied-arch main span. The tied-arch and its unique radial cable pattern satisfied the stakeholders' desire for an aesthetically pleasing bridge while meeting the stated project and site constraints. The graceful steel tied-arch span reduces the number of piers in the channel, permits an increased navigation opening, meets vertical clearance requirements, and could readily be constructed without requiring temporary falsework.

Haunched post-tensioned concrete box-girder approach spans, constructed on falsework, complement the slender tied-arch main


David Evans and Associates, Inc.

Than hanger cables are 2.5-in.-diameter galvanized structural strand. The cast-steel sockets for the lower strand connections use molten zinc to fuse the strands into a conical "basket," locking in the cable tension.

span, and are reminiscent of the existing concrete approach spans.

Tied-arch bridges employ tension-tie girders in the plane of each arch to resist all arch thrust forces; no horizontal thrust forces are transmitted externally from the arch span to the supporting piers. The tie girders also support the transverse floor beams that carry the roadway deck structure, and resist local bending moments and deflections resulting from dead loads and moving live loads. Since complete fracture of either of the two tension tie girders could result in structure collapse, these important main members are considered to be fracture-critical. The fracture-critical nature of the main tie girders was addressed by detailing the tie girders as fully bolted members without any welding. The tie girders are built-up steel box sections consisting of web and flange plates connected by bolted corner angles. This provides for internal redundancy, as a fracture in one plate cannot propagate to the entire cross-section and lead to collapse. The bolted built-up tie girder was designed for the loss of a single web or flange plate using a special LRFD Extreme Event load combination.

The arch ribs consist of welded box sections with internal diaphragms at the hanger locations. The depth of the ribs were dictated by the minimum access openings through the diaphragms required by Multnomah County, to facilitate internal access for periodic inspection.

Hanger Cables

The hanger cables consist of 2.5-in.-diameter galvanized structural strand, per ASTM A586. Non-adjustable cast steel open-strand sockets are provided at the upper connection to the arch rib. Cable tensioning is performed at the open bridge sockets provided at the lower connection to the tie girder. Zinc spelter sockets are employed to attach the structural strand to the anchor sockets. This method of attaching structural strand cables to cast steel sockets has been in use for many years, and employs molten zinc to permanently join the individual wires of the structural strand to a conical "basket" in the cast steel socket. The resulting hanger cable assemblies provide a dependable and internally redundant tension member.

Bridge hanger cable assemblies, and the hanger plates to which they are attached, are designed with a minimum factor of safety of 4.0 for breaking strength versus unfactored dead load plus live load and impact. Bridge hanger cable assemblies are also designed for the loss or replacement of any one cable under traffic, with a minimum factor of safety of 3.0.

The unique radial cable pattern is not as structurally efficient or as stiff as a traditional vertical cable pattern or a crossed-cable pattern, but it was selected during the public involvement process primarily on aesthetic value. In other recent tied-arch projects, a crossed-cable pattern has been found to be most effective in stiffening the entire structural system and minimizing differential live load deflections, particularly when the live load is placed at the one-quarter point of the arch span.

An iterative process was employed to develop the most efficient arch shape, as the cable forces, arch rib and tie girder moments, and deflections are extremely sensitive to the arch-rib geometry with this unique cable pattern. The final shape of the arch differs somewhat from the classic shape of a uniformly loaded arch, and also from the common approximation of that shape by a second-order parabola.

Floor System

The floor system consists of longitudinal stringers supported by transverse floor beams. Due to vertical clearance requirements over the navigation channel and roadway approach grade restrictions, the top of the stringers and floor beams coincide. This results in the least structure depth and the lowest roadway profile. The stringers are composite wide-flange sections with moment connections at the floor beams. The floor beams are composite welded plate girders with moment connections to the tie girder that occur at each hanger cable node.

Erection Schemes

A significant challenge of the project was to develop a feasible means of erecting such a large steel structure. To attract the maximum number of bidders, the tied-arch span was designed to be erected by either of two methods. The first method was cantilever erection using temporary towers and stay cables, with material delivery and erection by barges. The towers would be located on the piers adjacent to the channel, with backstays anchored to the approach spans. The second method was to assemble the tied-arch and floor system off-site, deliver it to the site on barges, and erect it on the piers. Both methods were presented in the plans as suggested erection schemes only; the contractor was responsible for performing the final erection engineering for his chosen scheme. The contractor selected the float-in erection method, because it allowed for concurrent construction of the approaches and main span, as well as a savings in schedule.

Fabrication and Erection

The steel fabricator employed a progressive shop-assembly technique to complete final fit-up of all major steel members. The components were then dismantled and shipped to the Port of Portland dock on the Willamette River, approximately eight miles from the project site, where the final assembly was completed. The tie girder and floor system were assembled to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The tied arches and floor system were assembled eight miles from the bridge site and delivered to the site on barges.

the correct cambered geometry on timber blocking supported on the dock, followed by arch assembly from temporary shoring towers supported on the tie girder. Temporary compression struts between the arch and tie girder were installed to stiffen the structure during load-out and erection. Following steel assembly, the hanger cables were installed and tensioned to the specified initial tension.

The 365-ft arch structure was raised on the barge at the assembly dock, and the bridge span was eventually floated the eight miles to the project site. Once at the site, the span was carefully lowered and guided onto temporary bearing pedestals at its final vertical and horizontal location.

When completed this year, the new Sauvie Island Bridge will include 1,250 tons of steel and will provide the required capacity to support the heavy vehicles operated by the island's agricultural and industrial businesses, while also providing for safe bicycle, pedestrian, and truck use. And the chosen steel tied-arch meets the project's stringent engineering and permitting requirements while also satisfying the aesthetic and historical desires of the stakeholders. MSC

Kent Cordtz is the bridge discipline director for David Evans and Associates, Inc. and is the Engineer of Record for the Sauvie Island Bridge. Kip Coulter is the bridge discipline leader for the Denver office of David Evans and Associates, Inc. and is the tied-arch design leader for the project.

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