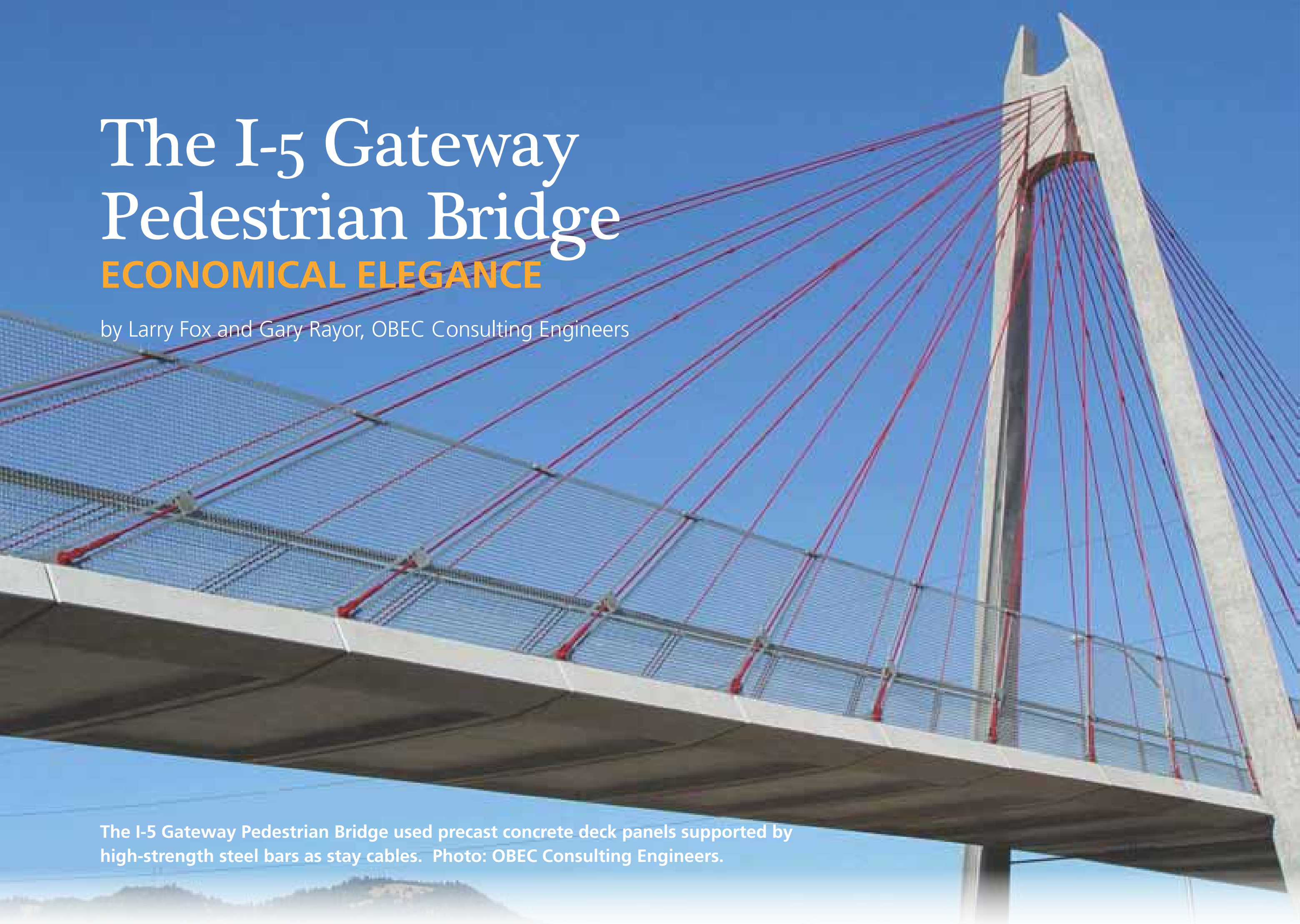
The I-5 Gateway Pedestrian Bridge

ECONOMICAL ELEGANCE

by Larry Fox and Gary Rayor, OBEC Consulting Engineers



The I-5 Gateway Pedestrian Bridge used precast concrete deck panels supported by high-strength steel bars as stay cables. Photo: OBEC Consulting Engineers.

When the Oregon Department of Transportation (ODOT) undertook a major interchange improvement at I-5 and Beltline Highway in Lane County, Ore., the project also required pedestrian and bicycle mobility improvements. A number of structure types could have effectively spanned the interstate highway that separates the cities of Eugene and Springfield. However, this major improvement project stood out as an opportunity to provide the communities with a noteworthy landmark structure.

The design team collaborated to develop an iconic cable-stayed pedestrian bridge located immediately south of the improved highway interchange. The cable-stayed bridge type helped the designers deliver a sleek structure that was both rapidly constructable and extremely economical. OBEC Consulting Engineers and Jiri Strasky have successfully demonstrated the feasibility of this cable-supported bridge type on three other signature pedestrian bridges in the area. Adding the highly visible I-5 Gateway Pedestrian Bridge to the local bike and pedestrian system supported a unified theme and extended the area's already unique and inspiring biking and walking experience across the highway.

The minimal and functional design is a direct result of the team's belief that a bridge is a sculpture; that the public appreciates and intrinsically recognizes elegance and simplicity of form as the essence of good design. As such, the bridge itself becomes public art.

The team accomplished the efficient bridge design by drawing upon the experience gained during several long-span cable bridge projects in western Oregon. The team's broad experience

profile

I-5 GATEWAY PEDESTRIAN BRIDGE / EUGENE AND SPRINGFIELD, OREGON

BRIDGE DESIGN ENGINEERS: OBEC Consulting Engineers, Eugene, Ore., and Jiri Strasky, consulting engineer, Greenbrae, Calif.

PRIME CONTRACTOR: Mowat Construction Company, Woodinville, Wash.

CONCRETE SUPPLIER AND PRECASTER: Knife River Corporation, Harrisburg, Ore., a PCI-certified producer

POST-TENSIONING CONTRACTOR: Schwager Davis, San Jose, Calif.

BRIDGE DESCRIPTION: 503-ft-long, 14-ft-wide cable-stayed pedestrian bridge with 103-ft-long main spans using precast concrete deck panels, precast concrete central tower, and 30-ft-long concrete approach spans with similar bridge concepts improved the design of the I-5 Gateway Pedestrian Bridge and showcased the versatility inherent in the fundamental deck system. The project also demonstrated how precast concrete segmental construction allows for rapid and safe bridge erection over a busy interstate highway without traffic interruption.

Alternative Selection

Three types of bridges were evaluated: a conventional precast, prestressed concrete box girder, strut-stayed, and cable-stayed. The cable-stayed bridge was the most cost-effective solution when considering the intrinsic aesthetic appeal it offered with only a small cost premium over the prestressed concrete girder alternative. As a refinement in the predesign study, the design team also considered both steel and concrete central "A-shaped" tower construction and found that concrete further reduced the cost of the bridge. ODOT ultimately selected the cable-stayed alternative, making it the first cable-stayed bridge in the state's inventory.

Bridge Design

The I-5 Gateway Pedestrian Bridge includes many unique details and innovations. The use of cable-supported precast concrete structural elements has resulted in high levels of cost-efficiency in the final structure. The background and development of the general bridge concepts used in this project demonstrate the versatility of cable-supported segmental precast concrete deck panels.

The bridge is 503 ft long with a pedestrian deck width of 14 ft. The two main spans of the bridge over the highway are 103 ft long. Ninety-two feet of each span comprise precast panels. The panels are typically 10 ft in length except for one panel in each span at the tower that is 12 ft long. The concrete used in the panels had a compressive strength of 5800 psi. The rest of the bridge beyond the area of precast panels consists of approximately 30-ft-long cast-in-place approach spans. Sixty-three feet of the cast-in-place concrete at both ends of the bridge are post-tensioned to the panels to form a 310-ft-long continuous section.

In order to eliminate the need for shoring within the highway clearance area, the deck panels are externally supported on stay cables as the bridge is erected outward from the central tower using a balanced cantilever method. The precast concrete deck panels also serve as the form for a composite cast-in-place concrete topping slab that is placed on the precast panels, making the entire bridge continuous. The topping strength was specified to be 4350 psi. The mix contained silica fume to reduce permeability and improve corrosion protection for the deck reinforcement. The cast-in-place approach spans were cast with the same mix used for the topping and some were cast at the same time the topping was placed.

The topping slab contains continuity reinforcement and full-length longitudinal post-tensioning that accomplishes several goals:

- provides capacity for asymmetrical live load bending
- enhances superstructure stiffness for improved user vibration comfort
- prestresses the panel closure joints
- precompresses the entire deck section against shrinkage and temperature cracking for increased longevity

The bridge contains no deck joints from end to end, further minimizing maintenance.

View of the main spans with spiral stairway. Photo: OBEC Consulting Engineers.

CABLE-STAYED, 503-FT-LONG PEDESTRIAN BRIDGE WITH MAIN SPANS OF PRECAST CONCRETE, END SPANS OF CAST-IN-PLACE CONCRETE, AND A PRECAST CONCRETE CENTRAL TOWER / OREGON DEPARTMENT OF TRANSPORTATION, OWNER

STRUCTURAL COMPONENTS: 18 precast concrete panels, precast concrete tower, cast-in-place concrete deck approach spans, and substructure, galvanized and painted steel stay cables, mechanically stabilized earth (MSE) walls

BRIDGE CONSTRUCTION COST: $2,035,000, including bridge bid items and mobilization ($290/ft^2)

AWARDS: *2010 Portland Cement Association Concrete Bridge Award for excellence in design and construction*

One Deck System, Many Bridge Types

The Eugene and Springfield area of Oregon has a number of long-span, cable-supported pedestrian and special use bridges designed by the OBEC/Strasky team, which is unusual for a community of this size. The design team has delivered innovative bridges using technology similar to the I-5 Gateway Pedestrian Bridge to the City of Eugene, ODOT, and the Wildish Companies. These bridges embody economical elegance by building on the previous work of Dr. Strasky in the Czech Republic prior to the fall of the Iron Curtain, when bridges had to be built with minimal materials.

The stay cables consist of galvanized and painted high-strength steel bars, connected with tapered architectural couplers to achieve the required length. The bar-type stays use simple threaded connections at the tower and deck using standard American Institute of Steel Construction clevises. The use of galvanized and painted bars represents an improvement over the more standard multiple wire bridge rope stay cables, as they vastly reduce the surface area subject to corrosion, simplify connections, and improve stiffness. Each stay cable is also readily adjusted using paired cargo jacks at a structural turnbuckle located on the stay. The turnbuckles are located at the same elevation as the bridge railing to improve aesthetics and provide easy access.

The other major elements of the bridge include cast-in-place concrete approach spans, a spiral stairway, and approach embankments supported by mechanically-stabilized earth retaining walls. The I-5 Gateway Pedestrian Bridge is similar to other economical and elegant bridges designed by this team through its innovative use of precast concrete, cable-supported main spans, slender profiles, pleasing aesthetics, and economy.

The bridge was bid in 2006, and construction was completed in early 2009.

Construction

The plans allowed for either on-site or off-site precasting of the "A-shaped" tower legs and the contractor elected to precast the legs on-site. This was done in the median of the highway with the entire tower laid out horizontally adjacent to the tower foundation to provide direct geometry control of the final assembly. The one-piece central tower was then set with a 350-ton-capacity hydraulic crane into a temporary erection tower to provide stability against overturning during erection of the superstructure. The tower legs are triangular in cross section. They have a width parallel to the bridge of 42 in. and a perpendicular depth of 36 in. at the base of the tower and taper to 28 in. wide by 24 in. deep at the top. The top of the tower stands 73 ft above the roadway and 54 ft above the deck. The concrete strength specified for the tower was 5800 psi.

The temporary tower was designed by the contractor's engineer based on design criteria shown on the plans. The criteria required the tower to resist the imbalance in the main spans during deck panel placement, aerodynamic wind loading from passing trucks, and normal horizontal wind loading. This allowed the main span deck panels to be erected without the use of any stabilizing falsework within the highway clearance envelope. The deck panels were placed during three night shifts with temporary lane closures. Erection required only a light crane to set the panels on alternate sides of the tower and connect them to the stays with easily adjusted connections. Panel erection could be terminated at any location at the end of each night shift. When work was completed each night, a temporary support was placed under the last deck panel for added stability, provided it did not conflict with active freeway lanes. All lanes of traffic on the busy interstate stayed open during daylight hours.

The deck reinforcement and full-length deck post-tensioning were installed after final grading of the panels by adjusting the stay cables to their calculated length prior to adding the remaining dead load. The next step of construction was casting the concrete topping slab within the post-tensioned portion of the bridge, post-tension the deck, and then cast the remainder of the approach spans, spiral stairway, and appurtenances. Finally, the protective fencing and railings were installed to complete the bridge.

Location of the pedestrian bridge in context of the Beltline Interchange Improvement Project. Photo: Oregon Department of Transportation.

Precast concrete tower at high point during erection. Photo: OBEC Consulting Engineers.

Conclusion

The design team's intent was to provide ODOT, the construction contractors, and the communities of Eugene and Springfield with an iconic pedestrian bridge that met all parties' needs by designing a structure that was easy to understand, constructable, economical, easily maintained, and elegant. They achieved these goals with a combination of innovative cable-stay technology and straightforward bridge construction techniques, including the use of precast concrete elements, segmental erection, and simple, effective cable support systems, and erection techniques.

Larry Fox is vice president and chief engineer and Gary Rayor is principal engineer, both with OBEC Consulting Engineers in Eugene, Ore.

For more information on this or other projects, visit www.aspirebridge.org.

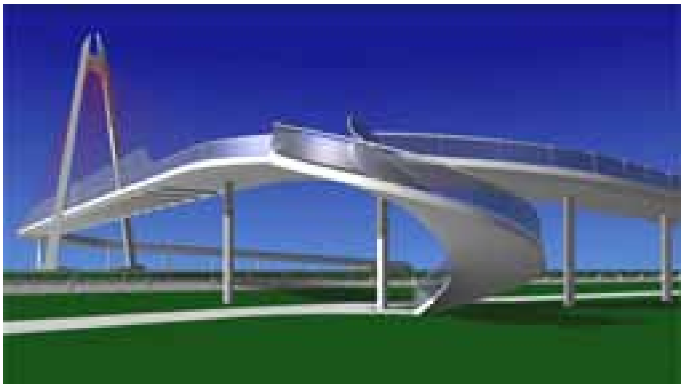


Image of the bridge and spiral stairway from structural modeling. Photo: Dr. Jiri Strasky.

Daytime traffic under balanced cantilever main spans. Photo: OBEC Consulting Engineers.

The nighttime erection of precast concrete deck panels. Photo: OBEC Consulting Engineers.

Detail of stay connection to deck and integration of rail and fencing. Photo: OBEC Consulting Engineers.

Elevation view of pedestrian bridge over I-5. Photo: OBEC Consulting Engineers.

Delta Ponds Pedestrian Bridge currently under construction for City of Eugene, Ore. Photo: OBEC Consulting Engineers.

DeFazio (Willamette River) pedestrian bridge. Photo: OBEC Consulting Engineers.