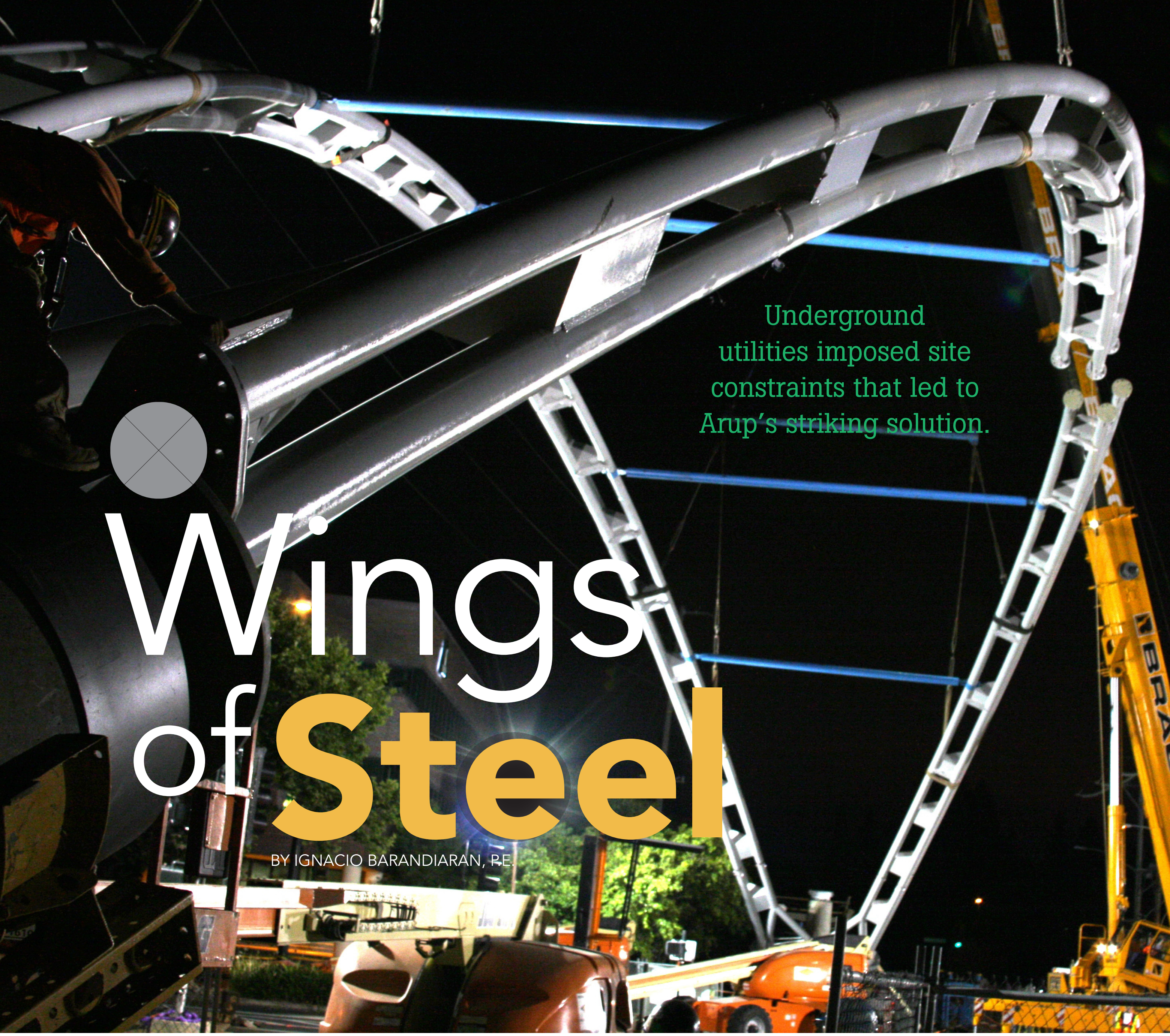


Wings of Steel

Underground utilities imposed site constraints that led to Arup's striking solution.

BY IGNACIO BARANDIARAN, P.E.

THE DESIRE FOR an iconic bridge, combined with constraints imposed by a spiderweb of underground utilities, led the designers of a new $6.8 million pedestrian and bicycle bridge to design an arched rib structure with curving members that meet at a common point to minimize substructure requirements. Adding to the complexity, the deck curves in plan, causing the arches to incline at slightly different angles. The new Robert I. Schroder bridge provides safe passage over busy Treat Boulevard in Contra Costa County to be an integral part of the Iron Horse recreational trail. The trail, formerly a railroad corridor, also serves as a right of way for several underground utilities and includes an easement for a future transit line. These constraints made foundation placement complex and were the main determinants for the design of the bridge structure.

Bridge Site

The bridge is sited within the Transit Village built around the BART Pleasant Hill/Contra Costa Centre station in Contra Costa County. This station is one of the busiest in the BART system for commuters. The surrounding development consists of high-density residential condos and apartments, extensive commercial and retail space, and high-rise garages for parking. The Transit Village and the bridge have both been developed by the Contra Costa County Redevelopment Agency, led by its director Jim Kennedy. The Contra Costa County Public Works Department was charged with managing the process for the final design, to get the project built, and to maintain it after its completion.

Parallel to the BART system is a railroad right of way called the Iron Horse Trail that by the late 1980s was no longer being used by its original owner, the Southern Pacific Railroad. Spearheaded by Robert Schroder, then mayor of nearby Walnut Creek and later a county supervisor, the county started purchasing this right of way in the 1980s. Currently the trail connects residential and commercial areas, business parks, schools, public transportation, open space and parks, regional trails, and community facilities. It runs north and south for some 30 miles in the San Francisco Bay Area.

The agency saw an opportunity to upgrade the trail in the area

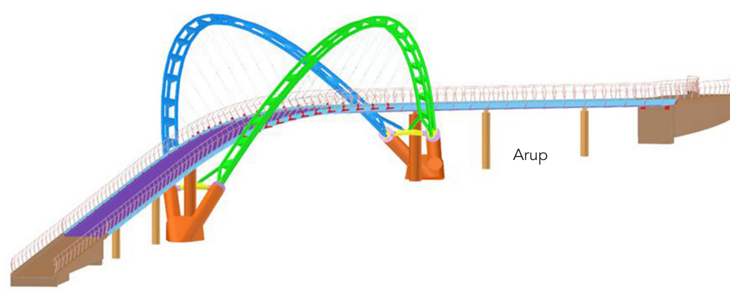
Glenn Fleming

Randy Olaes, Arup

Spectacular night lighting effects showcase the dynamic and striking design of the bridge.

The four steel arch sections suspended with two cranes and ready to be bolted together. The blue bracing shown between them was removed when all bolting was completed.

The arches meet at a common base point at each end, resulting in a narrow foundation and thus avoiding existing underground utilities. The deck curves in plan, causing the arches to incline away from the deck at slightly different angles.



Arup

Jake Wayne, Arup

The curved alignment of the deck was designed to make the bridge the backdrop to the new park.

near the BART station by adding a signature pedestrian bridge for foot and cycling traffic. The new bridge takes the trail over the heavily traveled, eight-lane Treat Boulevard.

Gaining Public Consensus

The agency selected Arup as the prime consultant for the bridge. Being conscious of the appropriate use of public funds, the agency called for a thorough community outreach program to achieve consensus on the need, exact location, and form of the bridge structure. The extensive outreach program required multiple meetings and design charettes with people and organizations that provided a representative sampling of the community.

Although a relatively small project, the bridge involved a significant amount of decision complexity given the prominence of the location and how the project could affect the neighboring stakeholders. The public meetings made a concerted effort to explain the physical constraints, cost issues, design trade-offs, and construction aspects.

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Ignacio Barandiaran, Arup

▲ Precast concrete inclined columns ready to receive the steel arches, which are bolted to the steel connections at the top of the inclined columns.

▼ The main span of the arch, with a length of 240 ft, crosses Treat Boulevard with a curving deck and independent arches inclined away from the deck.

Jake Wayne, Arup

The outreach process culminated in four buildable bridge designs for the main span's superstructure: steel cable-stayed, steel arch, steel truss, and concrete girder. Designs for the approaches were similar and the alignment was the same for all four.

Arup provided a detailed report on the design issues and the estimated cost of construction for each main span design. What followed in 2003 was a web-based preference survey of all those who participated in the outreach meetings and for the community at large. The survey requested that respondents rank the designs in order of preference from 1 to 4. More than a thousand people responded.

Through the preference survey the community ruled out the plain concrete alternative. The cable-stayed bridge was too costly. Considered to provide an appropriate balance among cost, function, and aesthetics, the arch edged out the somewhat less expensive steel truss.

Dealing with Site Constraints

Among the many constraints that are typical in the design of infrastructure projects in the public right of way, one most affected bridge design for this project: the existing underground utilities along the Iron Horse Trail. Each of the several utility owners had specific easement rights, concerns with maintenance and access, and plans for new facilities in the future. Underground utilities include a 60-in.-diameter sanitary sewer, an 84-in. storm sewer, a jet fuel line, underground power cables, a gas line, potable water mains and fiber-optic cables. A 115 kV transmission cable looms overhead. The underground utility constraints ruled out shallow spread footings that would limit their access and expansion. This required the alignment to weave its way around the utilities such that foundations of minimal width could be placed to avoid them.

In the case of the winning arch design, the solution used a pair of inclined arches coming down to a single narrow, deep foundation at each end of the main span. Vertical arches would have required two foundations and a pile cap on each end, which would have more than doubled the width and would have conflicted with utilites. For example, at the south end the arch foundation is wedged between the sanitary and storm sewer pipes. Each of the foundations consists of two, 90-ft-deep, 6-ft-diameter piles along the bridge alignment that are tied together by a narrow pile cap.

The Iron Horse Trail includes a linear park on the north side of Treat Boulevard adjacent to the bridge. A bridge straight across the roadway would have hidden the park as viewed from the adjacent street to the west of the park. The community outreach programs indicated that people wanted to avoid the park being hidden behind a bridge structure. As a result, the bridge curves in plan toward the east in an "S" shape as it approaches the north side. In this way the bridge preserves a grove of heritage oak trees, becomes an attractive backdrop for the park, and does not provide concealment for unwanted nighttime activities.

Designing the Arch Configuration

The utility constraints and lateral curve of the deck were the main drivers of the design of the bridge arches. The single deep foundation at each end meant that the arches had to incline outward and away from each other. The lat-

The top of stainless steel "projectile" fence follows the crossing points of the dual cables that support the deck, thus creating an arched shape for the fence. The higher of the two handrails is for cyclists.

eral curvature of the deck meant that the arches had to incline outward at different angles. The arch on the east side is more vertical that that on the west side.

One of the most important structural design aspects of the bridge is the lateral bracing of the arches which was placed just below the deck. This allows the full length of the arch ribs above the deck, over three-quarters of their length, having no cross-bracing connecting the two arches together. Bracing the asymmetrical outwardly inclining arches above the deck would have been awkward because of the increasing distance across from arch to arch as they incline outward. As it is, pedestrians and cyclists traversing the bridge have an open, roofless feeling. From afar the bridge resembles the wings of a butterfly.

The steel arch ribs are supported on inclined 42-in.-diameter concrete columns that follow the arch line of thrust. The length of the steel ribs from one column to the other is 240 ft. A curved steel box beam brace across the tops of the inclined concrete columns provides a stiff point to brace the steel arches below the deck. The two arches come down and bolt to the top of the columns and to the middle of the box beam.

Each arch rib consists of three 10-in.-diameter steel pipes in a triangular cross section. Steel box stiffeners connect the three pipes together at roughly 13-ft intervals so that the three pipes for each rib form a composite structural section. This choice over a more conventional single, large-diameter steel pipe had two advantages: first, smaller diameter pipes are more readily available than larger ones, and, second, the built-up arch rib has an open, more airy look that offers interesting light and shadow effects.

Connection plates welded to the underside of the stiffener boxes serve to attach a pair of cables at each of the 24 locations where the deck hangs from the arches. The cables in each pair cross each other and form a vertically elongated "X" shape as they stretch from the arches down to each side of the deck. California regulations require that pedestrian bridges have a "projectile fence" as they cross over streets and highways. This requirement posed a special challenge to the design team: how to provide for this safety feature and avoiding a "caged" feeling for the bridge users. Taking advantage of the leaning arches with an open top, the design of the projectile fence was integrated with the geometry of the arches. The fence, which is made from a woven stainless steel mesh, is complemented with a pair of low and high hand rails along the full length of the deck. This design makes the 10-ft width of the deck feel more spacious.

An important requirement for the bridge was to have adequate lighting on the deck and in the surrounding park for user safety, as well as appropriate decorative lighting. The design team developed a system of strip LED lights that is concealed in a cove integral with the deck structure, and supplemented by ground mounted fixtures to illuminate the sidewalks and the bridge superstructure.

Joe Reyes, Hanna Group

▲ The deck was designed as an integral boat-like structure in sections approximately 60 ft long that were shop fabricated and painted, then shipped to the site and field bolted.

▼ Each arch rib is built up from three 10-in.-diameter steel pipes bent to the appropriate radius and welded together with steel box stiffeners spaced at approximately 14 ft along the length of the ribs.

Joe Reyes, Hanna Group

Erecting the Bridge

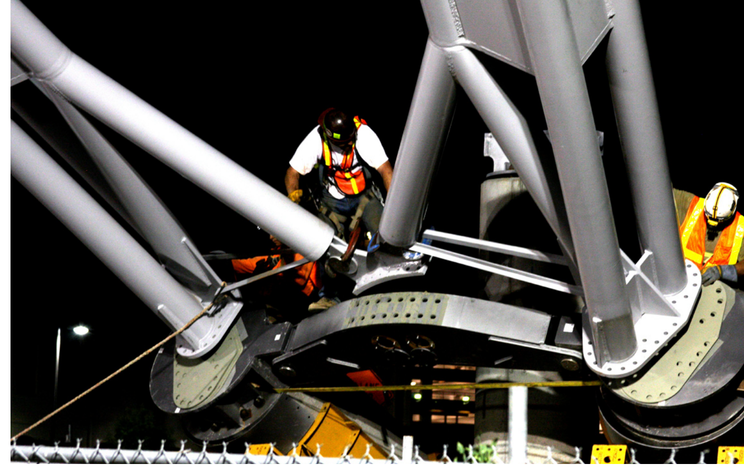
In the spring of 2009 the Contra Costa County Public Works Department received eight bids for the construction of the project and awarded the contract to Robert A. Bothman of San Jose, Calif. The winning bid of approximately $6.8 million was almost 20% below the engineer's estimate, which along with the number of bids reflected the competitive market conditions at that time.

Arup required the erection subcontractor, Adams & Smith, to develop a dimensionally accurate 3D CAD model for bridge fabrication and a detailed erection procedure. The complex geometry of the bridge ruled out reliance on conventional 2D shop drawings. Adams & Smith's chief engineer, Jeff Darby, developed the erection procedure and retained a construction engineer, OPAC, to perform a detailed structural engineering analysis of each stage of erection. The 3D CAD model was developed by Axis Steel Detailing and was required to be cross-checked with the construction engineer's own analytical model.

Adams & Smith subcontracted fabrication to Mountain States Steel, which fabricated each arch rib in two 120-ft segments for shipping to the site. Each of the four rib sections weighed approximately 20 tons. Mountain States fabricated the deck in 11 sections of various lengths weighing from 10 to 18 tons each. The design team selected splice locations in the arches and deck to maximize the sections for shop fabrication and to ensure that they could be shipped by truck. The design was such that no field welding was required.

Erection of the bridge took place over three nights in June 2010. The arch ribs arrived on site in four pieces, and were bolted together and to the inclined column supports during erection the first night using two cranes. On the following weekend night clo-

Photos this page by Glenn Fleming



Two arch sections are lifted to their final positions with temporary bracing. The were erected on the first of three weekend night closures.

Arches being lowered onto the inclined concrete column supports, prior to being bolted down.

sures erection crews used one crane to hang the deck sections from the cables and bolt them together. Additional night closures allowed for final cable tension adjustments and installation of the projectile fence.

The extensive planning work that was done initially by the design team and then by the construction team paid off. Working as a team with the owner to anticipate and resolve issues as they arose, the site work proceeded quickly and on time and on budget ready for its inauguration on October 2, 2010.

The new bridge makes the Iron Horse Trail safer at a busy thoroughfare and provides an attractive structure for the community. The urban redevelopment project at the Contra Costa Centre Transit Village now has an iconic piece of infrastructure that is both a place marker and gateway. As reporter John King of the San Francisco *Chronicle* newspaper put it in his article reviewing the bridge, "The Robert I. Schroder Overcrossing shows what an icon can be. This larger cultural role is what civic infrastructure can achieve when built with ambition and the long-term view." MSC

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Contra Costa County, Calif.

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ARUP, San Franscisco

Steel Detailer
Axis Steel Detailing, Inc., Orem, Utah
(AISC Member)

Steel Fabricator
Mountain States Steel, Lindon, Utah
(AISC Member)

Steel Erector
Adams and Smith, Lindon, Utah
(AISC Member)

Construction Management
TRC Solutions, Rancho Cordova, Calif.
The Hanna Group, San Franscisco

General Contractor
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