THE API GATEWAY PROJECT

Bridging Borders

By Brad Mielke, S.E., P.E., Chad Harden, P.E. and Sowmya Somnath, P.E.

The Aggregate Product, Inc. (API) Gateway Project is the first permanent conveyor system designed to span the United States-Mexico Border. Almost a quarter of a mile in length, the elevated, prefabricated steel truss conveyor transports aggregate materials (rock, sand and gravel) from Mexicali, Mexico over land and the All-American Canal to Calexico, California for the processing of hot mix asphalt and concrete for distribution to the Imperial Valley. The system includes a rotating, 190-foot cable-stayed swing bridge that spans the canal. The design system addresses environmental concerns, reducing consumption associated with traditional truck transport. Unique challenges encountered during the design and construction process included a high seismicity site with liquefiable soils, security concerns given the proximity to the U.S.-Mexico border, multinational collaboration between U.S. and Mexican agencies, and coordination between multiple design firms.

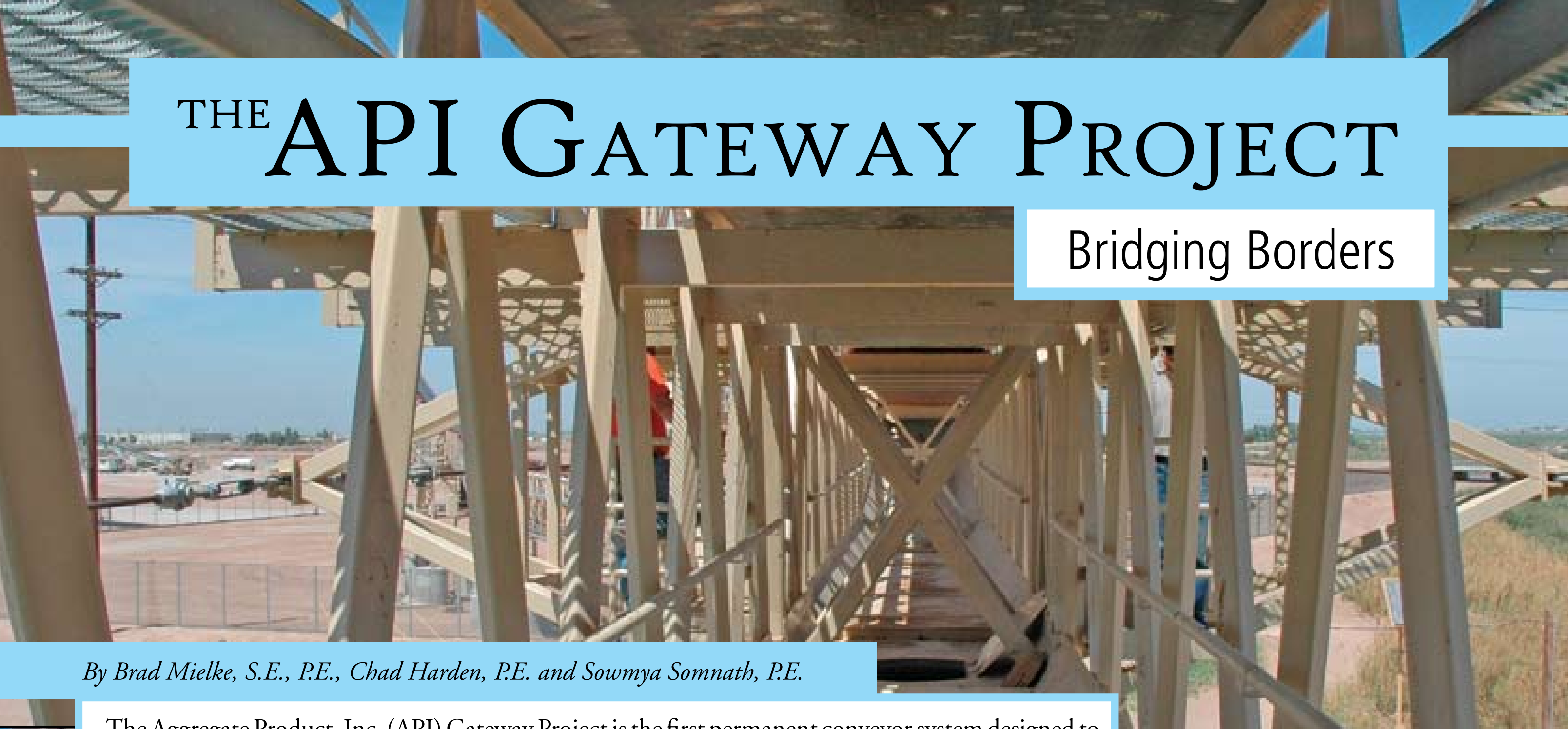

Figure 1: Interior view of the conveyor truss. The material is transported on a continuous belt (above). The outriggers for horizontal cables are visible beyond.

The project received the Finalist Project Award in the 2007 Excellence in Structural Engineering Awards by the National Council of Structural Engineers Associations (NCSEA), and a Merit Award in the 2008 Engineering Excellence Awards by the Consulting Engineers and Land Surveyors of California (CELSOC).

RBF Consulting served as the structural engineering consultant for Aggregate Products, Inc., provided structural design of the conveyor system and supports, and coordinated work among the design team, manufacturer, and contractors through construction. E.F. Marsh Engineering Co. (MARCO Conveyors) provided mechanical and electrical design, and shop drawings. GS Lyon Consultants, Inc., provided geotechnical recommendations, and Grenier Engineering, Inc. (Tucson, AZ), provided the foundation design.

Security

The project's location and design required multi-national consent from U.S. and Mexican agencies, complicating the permitting process and driving several design features.

A steel-framed observation and operations tower supports one end of the conveyor truss and, with video cameras mounted to the tower, provides continuous surveillance over a large area for United States Border Patrol (USBP) security. The swing bridge concept was developed to prevent unlawful access across the canal at the border. Large diameter steel monopole supports for the system provide a climbing deterrent to meet the security needs of the USBP.

Superstructure Design

The site is located less than ½ mile from the Imperial Fault, in an area of liquefiable soils. The peak ground acceleration for the site is estimated at 1.10g, for 10% exceedence in 50 years. Structural design considered the California Building Code near source seismic loading as well as material, walkway and moving loads. The horizontal and vertical alignment included constraints of boundaries, easements, maintenance roads and power lines. The trusses, as

Figure 2: Typical support columns are 3-foot diameter steel pipe sections. A base plate leveling detail allows monopoles to be realigned on the anchor bolts if seismic settlement occurs.

shown in *Figure 1 (see page 35)*, are made of efficient, hollow round and square steel sections, reducing the amount of steel and concrete required to support the system. The hollow 3-foot diameter steel monopole columns, shown in *Figure 2 (see page 35),* provide ductile, flexible support for the trusses under seismic loads. All structural members and connections are designed to AISC steel design requirements.

Figure 3: View of the conveyor belt system and control tower, looking south from the head end (U.S. side). The view shows the swing bridge conveyor belt system in the "Working" position.

The unique single mast swing bridge, shown in *Figure 3*, is positioned and operated from the U.S. side of the canal, and allows the conveyor system to span the waterway during operation. When not in operation, the bridge rotates parallel to the canal, preventing access across the border. Docking support mechanisms provide vertical and lateral support at the bridge's cantilevered end while in the stowed and working position. As shown in *Figure 4*, the bridge design uses 1-inch diameter vertical cables suspended from the truss tower, balancing cantilevered spans and minimizing stresses and deflections of the lightweight truss framework. A series of 1-⅜-inch diameter horizontal cables limit side-sway deflections and stresses from wind and seismic loads. Outriggers located at the 7-foot diameter monopole support for the swing bridge, shown in *Figure 4*, support the horizontal cables. *Figure 5* shows a typical, vertical cable-to-truss connection.

The bridge configuration was carefully designed considering the unbalanced loading of material and moving loads. By adjusting cantilevered spans and using vertical cables, the amount of structural steel required was minimized. Several loading conditions along with varying support arrangements, modeled with RISA 3D, were considered in the design of the interacting truss and cable system.

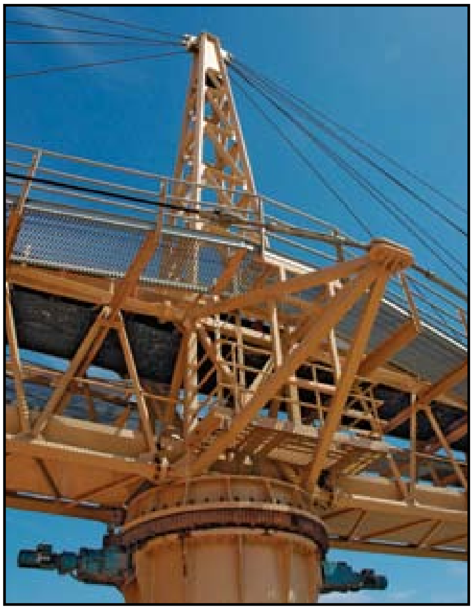

Figure 4: The swing bridge is supported by a single 7-foot diameter monopole.

Superstructure: Sustainable Elements

Approximately ⅓ of the conveyor system trusses were recycled from another location, and connections were retrofitted to resist higher local seismic loading demands. Another phase of the API Gateway Project is currently being constructed consisting of retrofitted hot mix asphalt production plant structures from Pleasanton, California, offering further sustainability of natural resources.

Figure 5: Typical vertical cable-to-truss connection.

Foundation Design

The steel columns and the bridge supports, except for the main pivot, sit on 5½-foot diameter circular concrete pedestals that range in height from 4 to 9 feet tall, supported by shallow spread footings. Overturning governed the design of the concrete spread footings, due to the relatively low axial loads and high lateral moments. Highly corrosive soils present at site mandated the use of Type V cement and greater concrete cover over reinforcing steel than normally required by code.

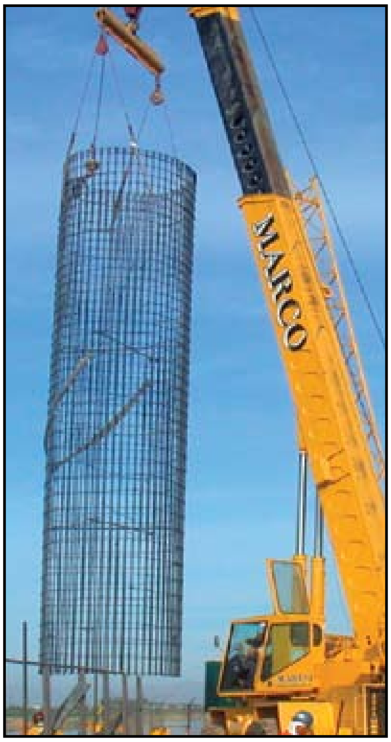

Figure 6: Installation of Drilled Shaft Reinforcing Cage for Bridge Pivot.

In order to accommodate settlement due to seismic events, the base plates for all the supports, except for the main pivot shaft, do not bear directly upon the concrete pedestals. A 3-inch gap between the underside of the base plate and the pedestal allows for vertical adjustment of the support after a seismic event. ASTM F1554 Grade 105 anchor bolts, located in a circular layout for each pedestal, were designed both as traditional anchor bolts and "mini-columns," considering combined compression and shear. The anchor bolts for the pedestals ranged in length from 5 to 9 feet, and were extended through the pedestal and a minimum of 1 foot into the footings.

This system was tested in March, 2007, during an earthquake of M3.9 located four miles from the project site; the structure shifted slightly and the base plate and anchor bolts were adjusted as planned. The main pivot support did not require this base plate leveling detail, as its drilled shaft base is set in a non-liquefying strata.

The bridge pivot is supported by a 10-foot diameter, 40-foot deep drilled reinforced concrete shaft. Installation of the drilled shaft reinforcing cage is shown in *Figure 6*. The main pivot has thirty-six,

Figure 7: Drilled Shaft Support for Bridge Pivot.

2-inch diameter anchor bolts that are 6 feet long (*Figure 7*). Due to the proximity of the pivot support relative to the canal, the top 10 feet of soil at the shaft was not considered to provide any lateral soil support. The foundation of the pivot is located within 5 feet of the canal, which delivers about 3.1 million acre-feet of irrigation water to the Imperial Valley, California each year. A polymer mixed with water was used to stabilize the hole during shaft drilling, displaced by concrete pumped in from the bottom of the shaft.

At the head end of the conveyor belt system, on the U.S. side, the truss inclines to 70 feet above ground where the transported aggregate is deposited in a stockpile. The head end is supported by two steel columns on two pedestals and a combined spread footing, as shown in *Figure 8*. The design of this footing and pedestals involved the additional challenge of accounting for potential lateral earth loads from the adjacent stockpile bearing against the columns and pedestal.

Summary

The electrically powered, lightweight conveyor system significantly reduces transportation resources and noise and air pollution, and incorporates sustainable elements. The entire conveyor system and production facility provide vital resources for the Imperial Valley by pioneering a resourceful and conscientious design.

The conveyor system was constructed in a total of 12 weeks, not including shop fabrication, due in part to an unusually quick design approval process through numerous agencies.

John Corcoran of API claimed achievement for the project citing, "The success of this unique project was a team effort involving the expertise of structural engineers in cooperation with steel fabricators, contractors, and several U.S. and Mexican agencies…through creative structural designs which help the project deliver materials to the area in an efficient, clean and responsible manner."▪

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Figure 8: Elevation view of the conveyor belt system "Head End." The truss system inclines to 70 feet above grade to stockpile material.

Acknowledgments

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