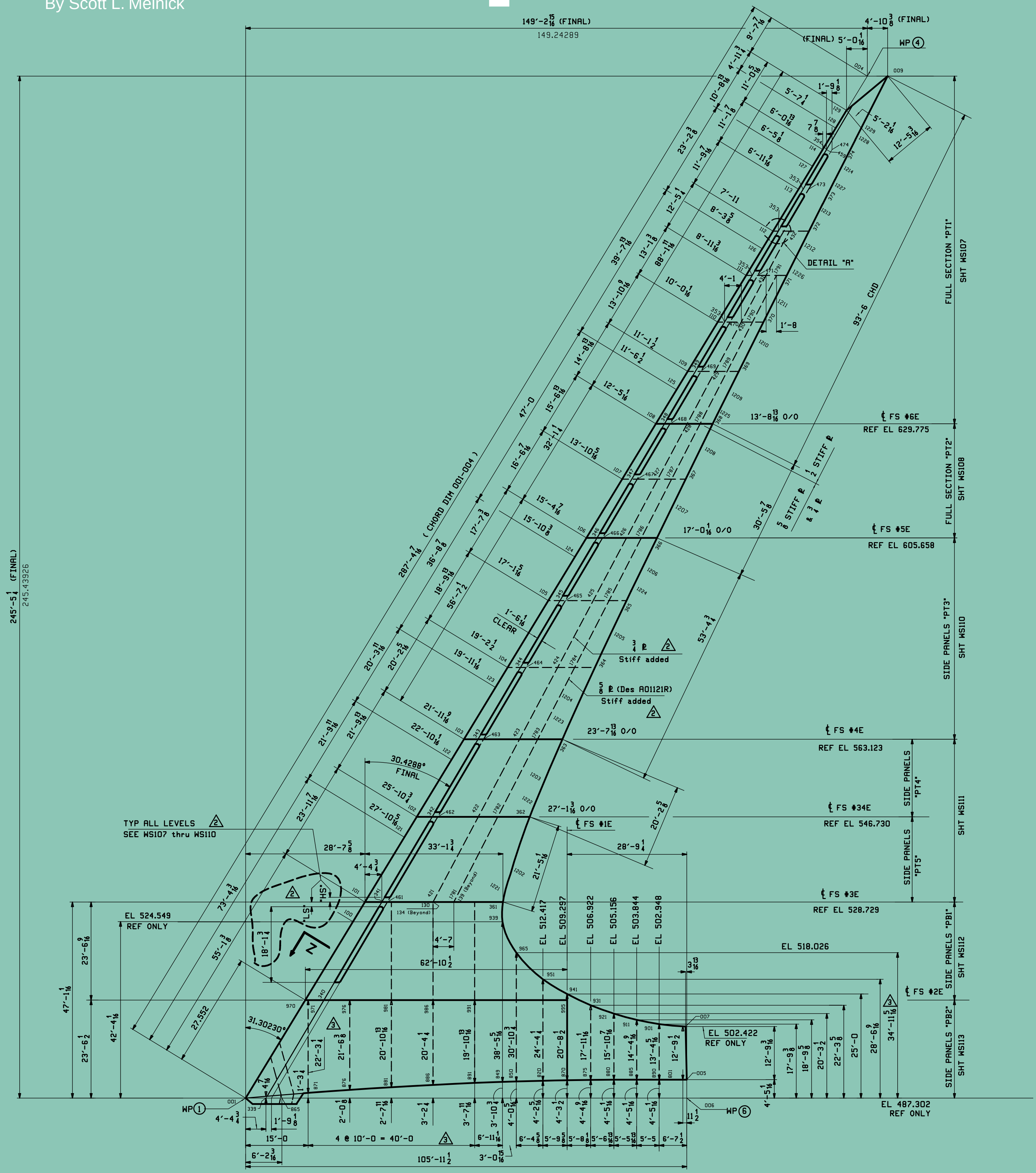
Sun Sculpture

By Scott L. Melnick



Is it a bridge or a sculpture? The Turtle Bay Sundial Bridge, designed by the world-renowned Spanish architect/engineer Santiago Calatrava is both. The first steel inclined-pylon, cable-stayed bridge in the U.S., the unusual pedestrian walkway connects the north and south structures of the Turtle Bay Exploration Park by spanning the Sacramento River in the City of Redding, CA. But in addition, the sloping pylon also is a working sundial as its shadow falls onto a large plaza at its base.

The $23.5 million bridge was paid for primarily by the McConnell Foundation, which donated the bridge to the City of Redding. The city fathers wanted a signature bridge like no other, and they turned to "starchitect" Calatrava for a unique design. The 1,600-ton bridge, which opened July 4, consists of a 300′ long by 217′ wide, single-inclined tapered pylon supporting a 722′ truss span. The triangular pylon, inclined at 42 degrees, runs in a true north-south direction. Approximately 110′ long by 75′ wide, the open base of the pylon forms a plaza with a 36-degree angle between the east and west walls.

The west face, which supports the triangular deck span, inclines two degrees to the west, while the east face is inclined toward the west at 28 degrees. The north wall is a curved warped surface connecting to the rear edge of the west and east walls. Each wall has both inner and outer faces, which are 2′-8″ apart at the base and taper to about 6″ at the top. There

The bridge deck consists of translucent glass panels with granite accents.

are both horizontal and vertical stiffener systems, as well as skewed stiffeners that line up with the cable support brackets. The entire structure is made of plate material varying from one inch at the base and reducing to 5/8" at the top.

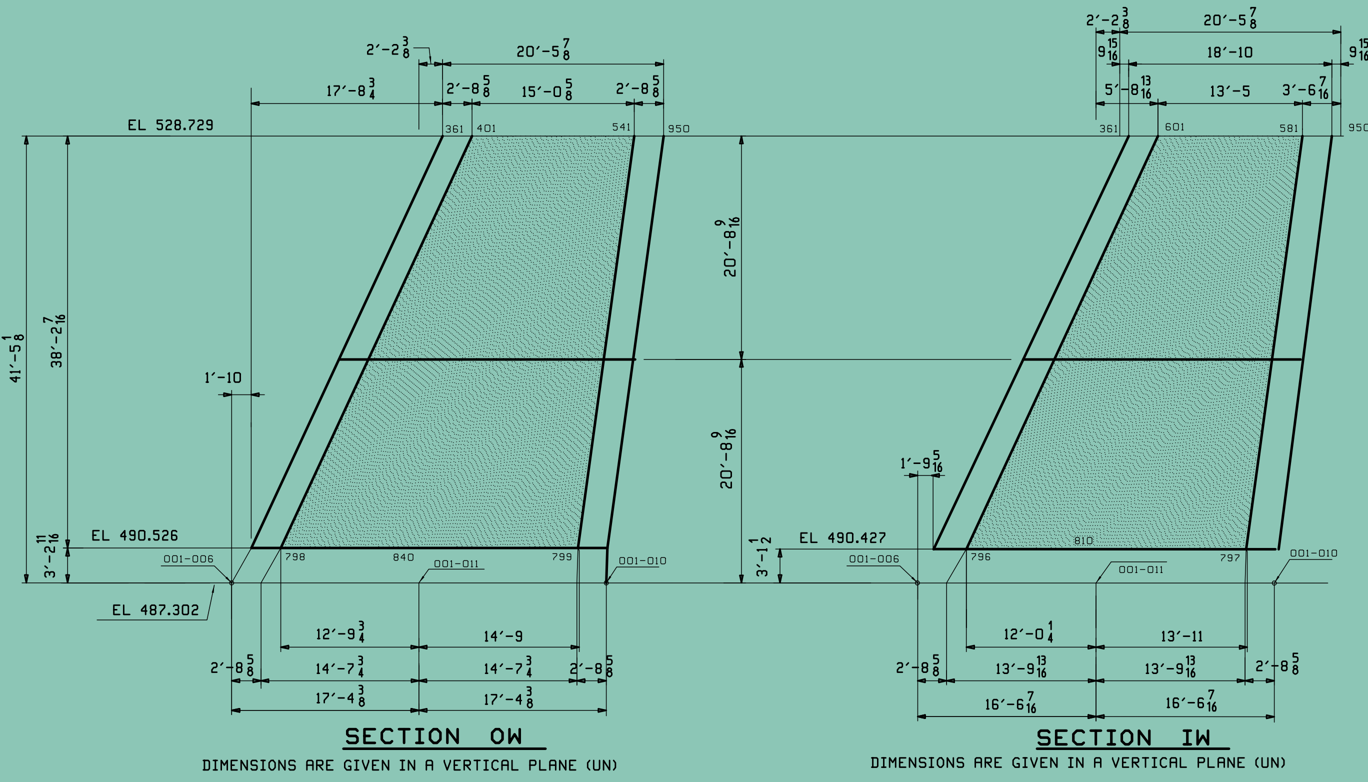
But while Calatrava created an amazing design, he also created a detailing, fabrication, and erection nightmare. Rather than providing full design drawings, the architect essentially provided beautiful renderings—and left it to the detailer, fabricator, and erector to turn the bridge into reality.

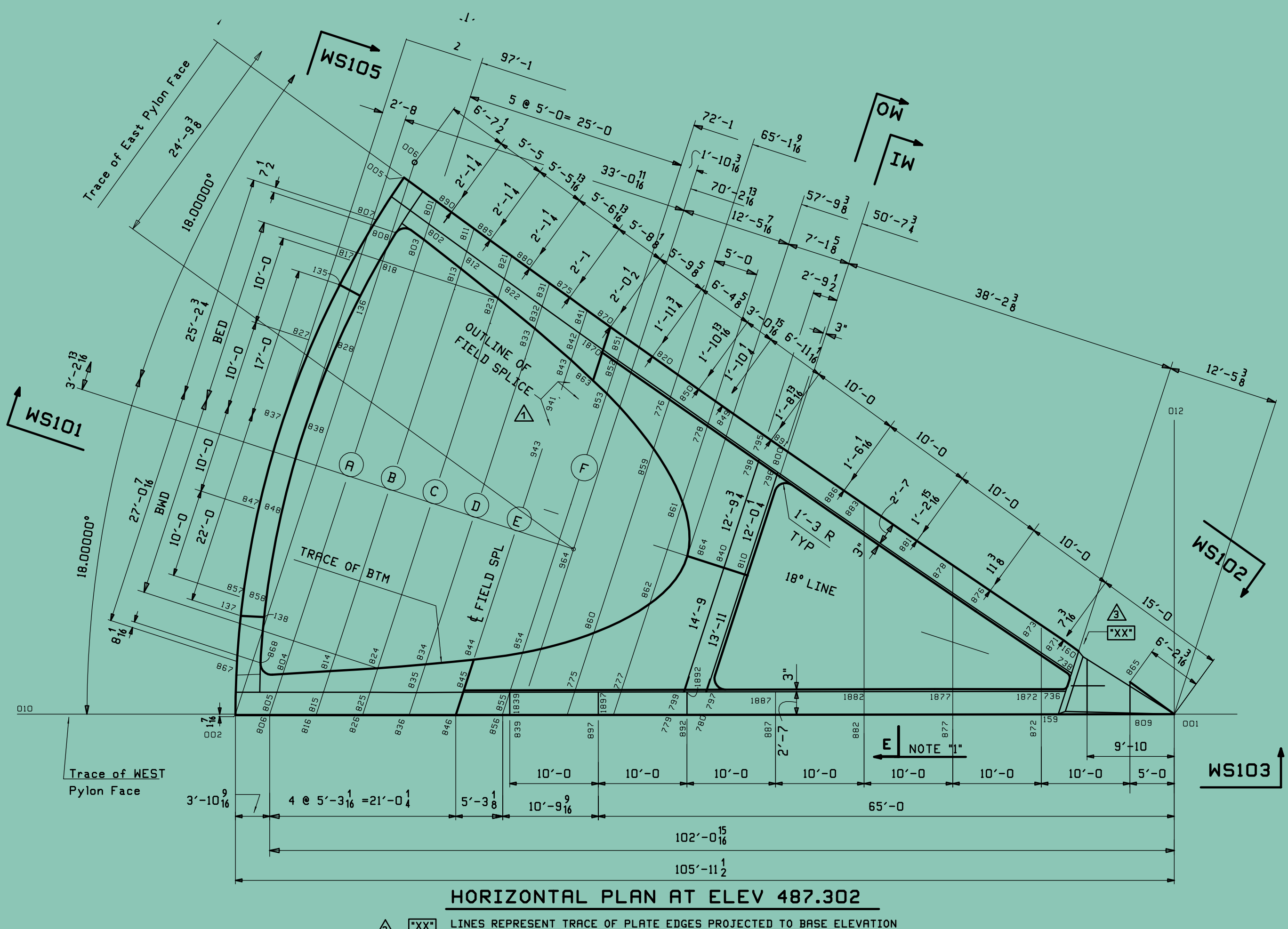
Tensor Engineering, the project's detailer, started with several conceptual architectural/engineering drawings and then developed a 3-D analytical model that defined the ends of each member in its final loaded position. Next, the 3-D coordinates were sent electronically to a specialty-engineering firm, Buckland and Taylor in Vancouver, Canada. Through extensive analysis and calculations, Buckland and Taylor determined the camber needed to adjust the final shape for the dead load of the structure and the erection stresses. Buckland then sent the camber information (in the form of 3-D vectors applied to the leading edge of the pylon) back to Tensor. Tensor used this information to write special programs, which then translated every component into a new position in space. The inclination of all three faces of the pylon and the warped surfaces resulting from the influence of the cambered shape complicated this task immensely.

More than 1,200 different plates each required 3-D calculations to determine the irregular polygon shape. Each plate edge had to be cut at a different angle to prepare for full penetration welds. Tensor also prepared fabrication procedures to show which sequence of plates would be assembled together and in what order. Additionally, they prepared several scale models and used special software showing an animated 3-D graphic model to illustrate construction sequencing and to serve as a visual aid for the steel fabrication shop.

"We had to make all the layouts and dream up all the details," explained Walter Gatti, Tensor's president. "The pylon essentially consisted of curved, warped surfaces and we had to develop three-dimensional models for just about every connection." During a two-year period, Tensor developed the layouts and details, which were then sent to Bob Morrison, a local engineer hired by the Foundation, and to Calatrava for review and approval.

"I looked at the two elevations and decided to build a simplistic cardboard model, about 16-18" high," Gatti said. "I knew each side was a flat plane, even though it was leaning in two directions, with about a 36 degree angle between the sides, so I could establish some basic work lines. From that early model we





Top: Vertical sections through the pylon showing the non-parallel sloping walls.

Bottom: Horizontal section through the pylon. The horizontal plan of the pylon changes at every elevation.

could begin to determine what the shape would be on the curved surfaces. Starting with one plane we would then create another plane that would intersect it on the other side. We then used inhouse programs to develop the series of compound curves and splines. Then we had to run a trial and error accuracy check to make sure the three sides met. It was tedious and time consuming to get the shape down pat. Complicating the problem was a double wall—with the inside wall not parallel to the outside wall. It developed into a honeycomb construction with a large number of stiffeners—all in different planes."

Further complicating the project was that the pylon faces sloped in every direction. "Of the thousands of pieces, there were only six pieces of fitting material that were identical," Gatti explained. "The fabrication shop couldn't burn anything perpendicular—everything had to be cut on an angle." Once the basic final geometric coordinates were created, the information was sent to Buckland & Taylor, which developed the three-dimensional camber information critical to final preparation of the shop drawings.

The 722′ pedestrian bridge deck system is a triangular pipe truss with a 14″ diameter bottom chord and two 11″ diameter top chords. Framed in glass panels with granite accents, the 23′-wide translucent deck will also serve as an entrance for Redding's Sacramento River Trail system. "The walkway was a fairly simple pipe truss job," Gatti said. "The only complexity is that it isn't symmetrical, which created a camber issue. It had to be cambered vertically, longitudinally as well as transversely."

The span is supported by 14 cables connected to transverse bulkheads in the deck truss and to plate brackets cantilevered from the west inclined face of the pylon. All of the steel has a three-coat paint system with a white epoxy final coat—except the stainless steel rods and pipe used for the bridge railing. The detailer prepared approximately 500 detail, erection, and design work drawings for this complexly shaped structure. Detailing began in late spring of 2000 and took almost two years to complete.

For environmental reasons, no part of the bridge touches the water in the Sacramento River. Always a route for migratory salmon, the fishery is sensitive, but has rebounded strongly in recent years as water from the Shasta Lake upstream is now being taken from lower—and colder—levels below the dam.

As with any project, the efforts of many contributed to a successful outcome. "We had a great team," noted Gatti. "Margaret Zech [McConnell Foundation], Randy Stine [Universal Structural], and Bob Elliot [Kiewit Pacific] were outstanding project managers for their respective firms." ★

Owner
City of Redding, CA

Architect
Santiago Calatrava, Zurich, Switzerland

Engineer
Calatrava Firm, Zurich, Switzerland

Steel Fabricator
Universal Structural Inc., Vancouver, WA

General Contractor
Kiewit Pacific Co., Vancouver, WA

Steel Detailer
Tensor Engineering, Indian Harbor Beach, FL
(AISC, NSBA & NISD members)