Applying Orthotropic Deck Design to a Vertical Lift Bridge

The rarely-used orthotropic deck design provided for a 2,200-ton span that could be hauled up on cables and avoid being lifted for 90 percent of water traffic.

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The world's widest vertical lift bridge features an orthotropic deck that is as large as a football field — but it is still light enough to be raised to its full 125-foot clearance in two minutes. The new span allows ocean-going ships and barges to move smoothly through the heavily-traveled Industrial Canal in New Orleans, Louisiana. And tens of thousands of motorists can now zip across the canal daily, free of the interruptions once caused by more than 20 closings a day of the old bridge.

The deck of the new, seven-lane, $28-million Danziger Bridge is unusually large, especially for a lift bridge. The span is 108 feet wide by 320 feet long. Generally, lift spans are much less than 80 feet in width. The unusual size of the bridge presented major design challenges. The solution to these design problems consisted of:

- a lightweight steel orthotropic deck (one of only five or six in the country)
- precisely-welded architecturally-finished closed box sections for the lift towers
- a streamlined vertical guidance system that accommodates thermal dimensional changes in the steel deck

The result was a sleek bridge structure that has greatly improved canal and highway traffic and visually enhanced the New Orleans skyline (see Figure 1). The roadway profile grade at the canal is high enough so that even in the closed position it allows passage of 90 percent of the ship and barge traffic. As a result of this higher profile, the bridge only needs to be raised about five times a day.

The Orthotropic Deck as a Design Solution

To conserve weight, most highway lift bridges employ a steel open-grid deck design. This design is characterized by a rough and noisy riding surface. A solid concrete deck is one way to avoid the rough surface, but such a deck on the Danziger Bridge would have weighed 3,700 tons.

Another problem with more traditional ap-

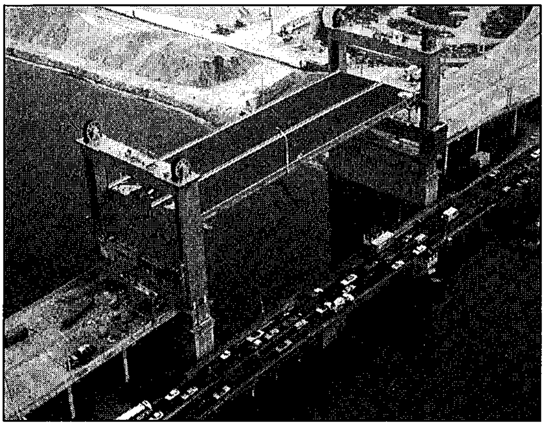

FIGURE 1. A view of the Danziger Bridge.

proaches was the visual clutter that the trusses would create over the bridge, obstructing the bridge operator's view of the canal and roadway. The Danziger Bridge's location at a particularly hard to navigate stretch of the canal made clear sight lines crucial.

Given these criteria, the design consultant considered an alternative that is seldom used because of the fabrication complexity and its comparatively high costs: a steel orthotropic deck. Developed in Europe in the 1940s, lightweight orthotropic decks have been used only a few times in the United States (two major bridges are the San Mateo Bridge in California and the Poplar Street Bridge in St. Louis, Missouri, both of which were opened in the 1960s) and never before on a lift bridge.

However, in the case of the Danziger Bridge, a careful analysis showed that the orthotropic deck system would not only be lighter and smaller, but would also be comparable in price to a two-truss design with greater lift-system requirements. The orthotropic design also offered a cleaner, more aesthetic structure. Without the clutter of the truss members, the bridge operator has a clear view of both the navigation and vehicular traffic.

Essentially, an orthotropic design uses a full deck width deck plate that functions as the top flange of the transverse floorbeams and longitudinal girders. The Danziger Bridge design used three box girders, with the bottom flange of each girder 14.25 feet below the profile grade. The deck plate on orthotropic designs is stiffened longitudinally between the girders. The Danziger Bridge design utilized 52 trapezoidal closed ribs with transverse floorbeams at 14-feet 7-inch centers. The cross section for the Danziger superstructure is shown in Figure 2. Note that the deck plate is overlain by a specialized 2.5-inch thick rubberized asphaltic wearing surface. Specially suited to orthotropic

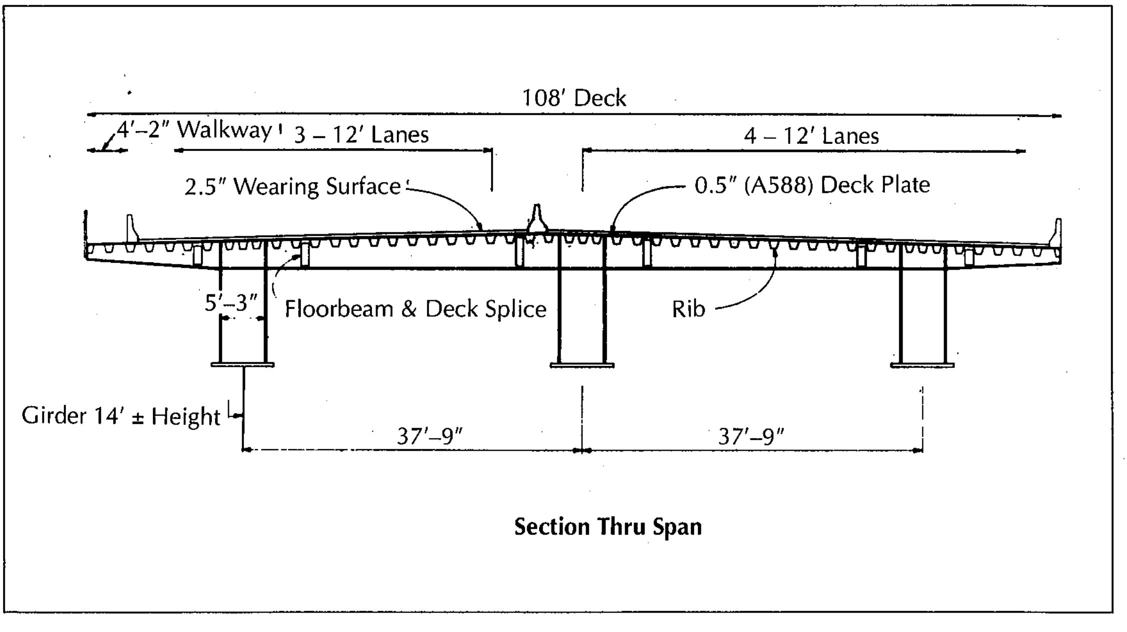

FIGURE 2. Cross-section for the Danziger Bridge superstructure.

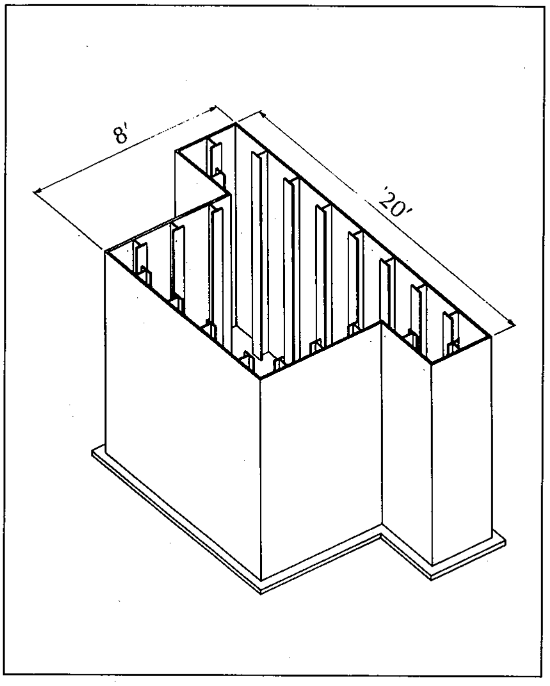

FIGURE 3. An isometric view of the tower leg.

decks, the rubberized asphalt adheres to the steel for a longer, tougher wear than most conventional bridge surfaces. The weight of the lift span is 2,200 tons, considerably lighter than a solid concrete slab deck.

Lift Tower Design

To complement the slender horizontal ribbon of the deck, the vertical towers for the Danziger Bridge were designed with welded, stiffened plate tee-shaped box columns with a rectangular box top strut. An isometric view of a tower leg is shown on Figure 3. The result is a set of towers with clean, simple lines and architectural proportions that accommodate the lift span.

The towers are 20 feet wide (longitudinally) and 139 feet tall. The tee-shape conceals the end attachments of both the lift span and the counterweight, masking the clutter of the ropes, guide tracks, balance chains and electrical guides. The counterweights, which are concrete with two encased steel trusses to support the concrete dead weight, fit into the approach span side of the tee-shaped tower. This placement minimizes the visual effect of the counterweights that are each 7.67 feet by 18.5 feet by 119.5 feet.

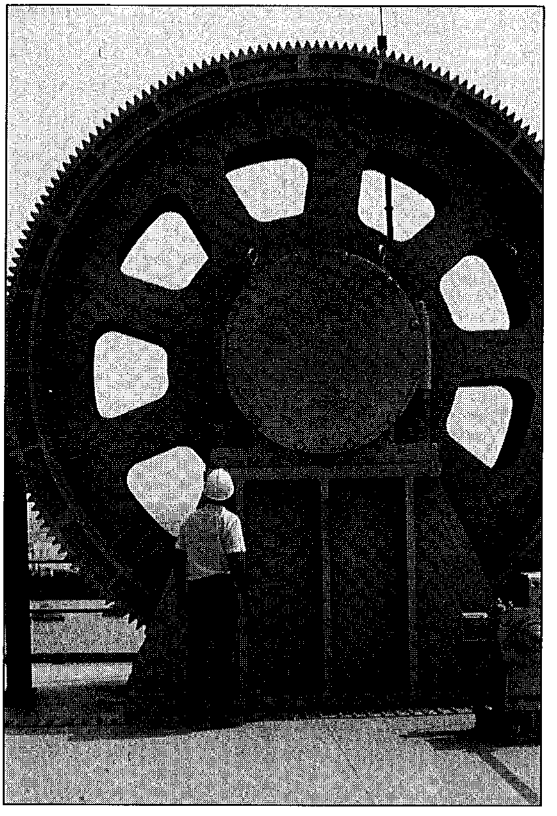

FIGURE 4. A view of one of the welded steel sheaves.

The machinery that operates the span is located on top of the tower struts, and includes two 75-horsepower electrical motors on each tower. While only one motor is required to power the span drive system, the other is provided for redundancy during motor repair or replacement.

Welded steel sheaves, 17 feet in diameter, are located on top of the towers, two per tower (see Figure 4). The span is lifted by eighty 2.5-in. diameter wire ropes (20 per sheave).

Unique Guidance System

Another concern in the design was that the great size of the Danziger Bridge span would magnify the effects of thermal dimensional changes in periods of hot or cold weather. A conventional lift system consisting of six guides would have restricted too much the ability of the bridge to expand, causing freezeups or tilting in the bridge controls. The Danziger Bridge employs only three guides, two transverse and one longitudinal, to allow more free-play of the span. The guides are mounted on the lift span faces of the tower.

Another unusual design feature is the frictionless eddy-current brakes that are on the high speed motor shafts. These units reduce the span speed to a crawl, and then conventional thruster-shoe brakes, on the slow speed shafts, stop and hold the span.

It takes less than two minutes to raise the 1,100-ton lift span the full 75 feet of travel, including locking and/or unlocking the span. The maximum rate of span travel is 0.9 feet per second.

Preventing Costly Barge Impacts

The Danziger Bridge's 313-foot horizontal canal clearance will let even the widest marine traffic pass with no threat of collision. But in the event of a collision, the piers have been designed for ship impact up to 3,000 tons. Should the lift span itself ever be damaged, the towers have been designed so that the lift span can be released from the cables to slide out horizontally for repair.

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