



Quick Response

BY AARON FRANKLIN, P.E., MAZEN WAHBEH, PH.D., P.E., DANIEL SPEER, P.E., AND MARTIN POHLL, P.E., S.E.

A Caltrans-led construction team was able to quickly repair a damaged Bay Area interchange following a major explosion.

THE MACARTHUR MAZE ISN'T AS FUN AS IT SOUNDS. It's a nickname for a network of major interchanges east of the San Francisco-Oakland Bay Bridge that distributes traffic to East Bay freeways. The Maze connects Oakland, Berkeley, and San Francisco via five major highways, whose combined average daily traffic is approximately 80,000 vehicles.

Earlier this year, the Maze was the site of a major accident that made national headlines. At 3:41 a.m. on April 29, 2007, a tanker truck, carrying 8,600 gallons of fuel and traveling southbound from I-80 to I-880, overturned and exploded. According to police reports, the accident occurred when the driver changed lanes and the fuel shifted from one side to the other, tipping the truck. The explosion and fire occurred on the bridge deck of southbound I-880 and beneath the connector ramp from the Bay Bridge to eastbound I-580. The heat from the free-burning gas fire caused the steel box beam bent cap at Bent MB19, as well as spans 18 and 19 on I-580, to buckle and collapse onto the I-880 connector ramp directly below. The estimated high temperatures were in excess of 1,500 °F, which caused the steel to soften and forge under its own weight. This collapse closed both the southbound I-880 and eastbound I-580 connectors, interrupting San Francisco-Oakland Bay Bridge traffic.

The collapsed portion of I-580—a total of 160 ft long and 51 ft wide—encompassed the steel girders on both sides of the bent (MB19) as well as the bent cap itself. The failed spans had six steel girders with a 45-ft-wide concrete deck. Luckily, the I-880 connector sustained less damage.

The California Department of Transportation (Caltrans) management and government officials reacted immediately and decisively to prioritize reconstruction. Within hours, senior bridge officials were meeting to set priorities, and engineers were on-site assessing damage. By the end of the first day, Governor Arnold Schwarzenegger declared a State of Emergency and procured federal support for emergency reconstruction funds.

Immediately after removal of debris and stabilization of the structure, steel and concrete samples were obtained. After testing, Caltrans engineers determined that the I-580 superstructure, which remained standing, was not heat damaged, with exceptions at the upper columns. Caltrans engineers also determined that the I-880 structure had suffered minimal damage.

Eight days later, after shoring from below and minor repairs were completed on the I-880 connector, Caltrans reopened it to traffic. As a result, the primary items of work required to replace the collapsed section were the girders, bent cap, and deck. Caltrans engineers realized that rebuilding quickly would hinge on the availability of materials and obtaining the right contractors. On the day of the accident, Caltrans officials mobilized a worldwide search to assess steel availability and fabrication capabilities. This information, gathered within two days, became a critical guide for engineers selecting the reconstruction alternatives.



Two spans of I-580 collapsed onto the I-880 connector ramp directly below.



The steel box beam bent cap spanning the I-880 connector collapsed in the estimated 1,500 °F fire.

Caltrans determined steel girders like those in the original design would be the preferred option—if the steel could be located quickly. They initially considered precast concrete girders, but decided against this idea because it would require foundation enhancement to support the additional weight.

From the time of the collapse on Sunday until the following Thursday, damage to the bridge structures was evaluated, a design was developed, and contract documents and plans were developed. To meet this schedule, designers had to make quick decisions, taking into consideration several factors. These included:

- Quick design that could be easily fabricated with currently available materials.
- Fast fabrication time to minimize structure closure.
- Shoring design of the lower structure to provide a platform for reconstructing the upper structures.
- Two different designs, with both concrete and structural steel bent caps, providing alternatives to further speed-up the reconstruction.

The engineers anticipated that the contractor would need a straightforward and simple design to complete the project in the time frame required, and made several engineering judgments during the design phase with assistance of fabrication experts, allowing delivery of a fast and safe design. The design team investigated prefabricated rolled shapes versus built-up sections; however, the required rolled shape sizes were not known to be readily available and would have required several weeks for fabrication. Hence the team decided to proceed with built-up sections. In addition, to reduce the number of stiffeners required for local buckling checks and to reduce the amount of welding required on built-up girders, the web thickness was increased. The flange plates were kept to one size only to simplify fabrication. The web depth was adjusted to ensure that the overall depth would not require adjustment of the existing bearings that were to be reused.

Constant communication played a large role in the success of this project. Daily status meetings with project managers and key Caltrans management cleared hurdles that would have caused costly delays. On the shop floor, Caltrans maintained a constant presence of quality assurance inspectors, which proved to be critical to the success of steel girder fabrication. Designer availability at all hours of the day allowed materials engineers to quickly work through

Quick Turnaround

The implementation of significant changes to typical construction contracts contributed to the MacArthur Maze project's success. Caltrans, the owner, was motivated to complete the project safely and in record time. It issued a construction contract specifying that its engineers would have only 24 hours to respond to all submittals and requests from the contractor (typical response times range from several days to several weeks, depending on the submittal type). To provide a comprehensive yet expedited review, Caltrans significantly increased the manpower of the review teams. Reducing response time to a single day clearly demonstrated Caltrans' commitment to be responsive.

Within two hours of awarding the general contract award, the steel fabricator was also determined. Caltrans immediately initiated contact to begin discussing the fabricator's first critical path item before fabrication could start: approval of welding and shop plans. Within 24 hours of contract award, Caltrans had placed a senior reviewer full-time at the fabricator to provide immediate guidance for welding and shop plans. In order for Caltrans to meet the one-day review times, Caltrans engineers directly solicited draft copies of all welding submittals. In this way, Caltrans provided the fabricator immediate feedback, often before the official copy was even submitted.

On May 10th, three days after the contract was awarded, Caltrans and the general contractor conducted a pre-welding meeting with the fabricator. During this meeting, Caltrans provided Stinger Welding with review comments on their Welding Quality Control Plan, to which the fabricator was able to respond immediately. By the end of this meeting, Caltrans officials were satisfied with the fabricator's plan; that same evening, fabrication began.

any issues that came up. On-site, Caltrans inspectors quickly elevated and addressed any issue that could potentially delay fabrication. At the height of fabrication, there were several QA inspectors covering fabrication and quality around the clock.

Another key factor to the project's success was a new Caltrans process that was recently implemented where "fit-for-purpose" decisions could be made. This process is managed by a materials engineer who is dedicated to the project and charged with seeking proposals from the fabricator and contractor, making a fit-for-purpose determination on the contractor's proposal and gathering input and concurrence from the appropriate authorities. With this process, when it is in the best interest of Caltrans to accept the contractor's proposal, a decision can be rapidly made and documented. Thanks to this new program, Caltrans was able to use material with minor deviations, but that were nonetheless acceptable to all parties.

Governor Schwarzenegger had described the Maze collapse as "the worst damage to our transportation infrastructure since the Loma Prieta Earthquake." However, in just 25 days, traffic was reopened in time for the Memorial Day weekend. In less than a month, the design and construction team was able to erect a bridge that met current stringent guidelines. MSC

Aaron Franklin is a senior engineer and Mazen Wabbeh is a senior principal with Mactec Engineering. Daniel Speer is a supervising bridge engineer and Martin Pobll is a senior bridge engineer (seismic specialist) with the California Department of Transportation.

Owner/Designer

California Department of Transportation (Caltrans)

General Contractor

C.C. Myers, Rancho Cordova, Calif.

Fabricator

Stinger Welding, Coolidge, Ariz. (AISC/NSBA Member)



Built-up sections were fabricated with thicker web plates to minimize the number of stiffeners required. Flange plates were kept constant to simplify fabrication. The bridge reopened to traffic in only 25 days.

A MESSAGE FROM THE
Executive Director



On October 31, the House Transportation and Infrastructure Committee approved legislation to authorize \$2 billion in spending for repairs and reconstruction to the most structurally unsound bridges in the U.S. The bill was drafted by committee chairman Congressman Jim Oberstar (D-MN) in response to the I-35 bridge collapse in Minnesota that killed 13 people and injured at least 140. Chairman Oberstar originally proposed a \$25 billion initiative, partially funded by a five-cent fuel tax for automobiles over three years. However, that amount has been scaled

back to \$2 billion in light of political opposition from the Senate and White House, both of which are fearful that the new tax would contribute to the highly politicized issue of growing fuel prices. The approved \$2 billion amount is a fraction of the Department of Transportation's estimate that \$65 billion is needed to address all critical bridge deficiencies.

The bill now waits to be considered and voted upon by the full House of Representatives and has yet to be introduced in the Senate.

Best Regards,
Conn Abnee
NSBA Executive Director

National Steel Bridge Alliance

One East Wacker Drive, Suite 700
Chicago, IL 60601-1802
www.nsbaweb.org
www.steelbridges.org

Conn Abnee

Executive Director
Phone: 606.724.2347
Cell: 312.804.1524
abnee@nsbaweb.org

Mike Moffitt

Director of Engineering Services
1228 S. 4th Street
St. Charles, IL 60174-4019
Phone: 630.443.8090
moffitt@nsbaweb.org

Jody Lovsness

Marketing and Membership Coordinator
11708 Jackson Road
Omaha, NE 68154
Phone: 402.758.9099
Fax: 402.778.9499
lovsness@nsbaweb.org

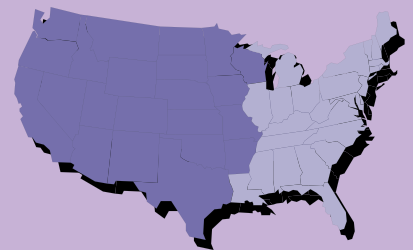
Calvin R. Schrage

Regional Director (west)
5620 Harding Drive
Lincoln, NE 68521
Phone: 402.466.1007
Fax: 402.466.1027
schrage@nsbaweb.org

William F. McEleney

Regional Director (east)
45 Pasture View Lane
Cranston, RI 02921-2732
Phone: 401.943.5660
Fax: same as phone
mceleney@nsbaweb.org

Regional Directors' Territories



Beauty and the Beast

BY DENNIS GOWINS, P.E.



In taming congestion, Orlando's Lake Underhill Bridge widening project will be beautiful—and beautifully effective.

CONGESTION CAN BE A BEAST ON ORLANDO'S STATE ROAD 408. Just ask any of the more than 150,000 daily commuters who pay a toll to use the major artery to and from downtown. Increased demand, backups at toll plazas, and a general lack of mainline capacity create 55 hours of delays per motorist annually.

To sooth the bottleneck, the Orlando-Orange County Expressway Authority has undertaken a \$450 million improvement program to widen 12 miles of S.R. 408 from Hiwassee Road to Goldenrod Road. Program improvements include the reconstruction of the Holland East and Holland West main toll plazas and the installation of express E-PASS lanes, so that customers may travel at the posted highway speed instead of creeping along. Once complete, the overhaul is expected to significantly condense commute times and increase the corridor's overall capacity by 50%. S.R. 408 will be well-positioned to handle the more than 215,000 daily commuters projected by 2025.

The final leg of the current S.R. 408 improvement program calls for widening the Lake Underhill Bridge from eight to 12 lanes, increasing the bridge's traffic capacity by 50%. The Expressway Authority, which plans, builds, maintains and operates a network of five tolled expressways in the Orlando metropolitan area, is funded completely by tolls. It has taken extra steps to respect the surrounding neighborhoods of its customers by ensuring the mile-long project will be both highly functional and highly attractive.

Beauty Comes at a Price

Lake Underhill Bridge is punctuated with two pylons with faux cable stays resembling a cable-stayed bridge. Dramatic nighttime lighting will be added to spotlight the structure, which has been dubbed Orlando's new eastern gateway. Complementing this structure to the east will be the Conway Road Bridge. This highly curved steel box girder structure will be framed by four pylons in

combination with highly landscaped planter walls.

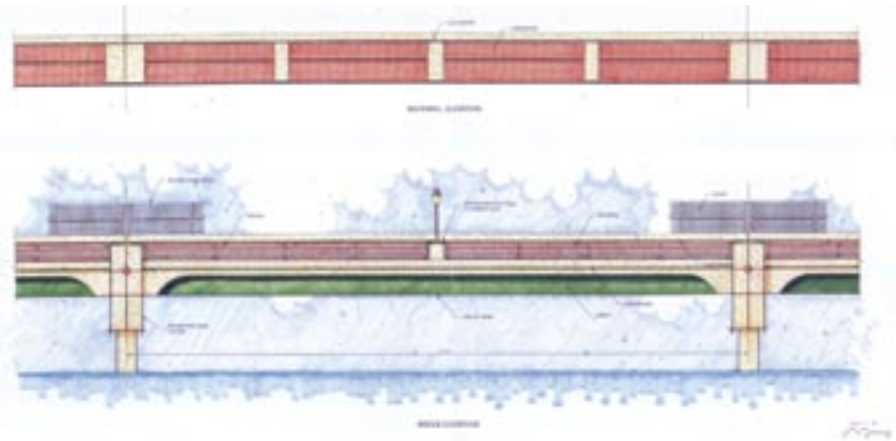
HNTB was selected as the prime consultant to provide final engineering and construction plans for the Lake Underhill widening project, which runs from Crystal Lake Drive to Conway Road. At the request of the Expressway Authority, the original design featured two "braided ramp" bridges, each more than 2,400 ft long. They were to be a combination of steel plate girders and AASHTO prestressed girders. The steel plate girders were to span the ramps below and yield a braided ramp configuration. The braiding concept was intended to eliminate traffic weaving between the Crystal Lake Drive and Conway Drive ramps.

The low bid for the project came in at \$105 million—too much, according to the Expressway Authority. It rejected the bids and directed HNTB to redesign the project without the braided ramp bridges.

Because it impacted other aspects of the adjacent projects currently under construction, completion of the Conway Road Bridge was the only milestone built into the new design. The Expressway Authority's request for a new design could have jeopardized the project's schedule, but HNTB established an aggressive one-year schedule for the redesign and hoped for a better bidding environment than the original project bid, which occurred just a few weeks after Hurricane Katrina. When the firm delivered the redesign, bidding was tight with the low bid being within 1% of the engineer's estimate.

Scrapping the initial design proved to be a very cost-effective decision for the Expressway Authority. Less than 18 months later, HNTB presented a new design with a new price tag: \$77.9 million—more than \$25 million less than the original bid. This past March, designs for the Lake Underhill widening project were completed. The project includes:

→ Expanding one mile of S.R. 408 from six to 10 lanes.



- Widening Lake Underhill Bridge to 12 lanes.
- Modifying the ramps at Crystal Lake Drive and Conway Road Interchanges.
- Widening the mainline bridges at Crystal Lake Drive and Lake Underhill Road.
- Creating a parallel 1,700-ft pedestrian bridge spanning the lake that will be the missing link in connecting a series of trails in the area.

Bids for the redesign were opened on May 8, 2007, and construction began this summer. The project is scheduled for completion in early 2010. More than 290 tons of steel will be used in the fabrication of the structure.

Putting it into Context

At least \$10 million of the project's budget will be spent on aesthetics and to preserve the fiber of the surrounding community. As such, the Expressway Authority was at liberty to incorporate design elements that might not have been considered on a tighter aesthetics budget. For example, in lieu of curved plate girders for the Conway Road Bridge, they chose curved steel box girders, which traditionally are more expensive.

The Authority also approved the additional expense of enclosing the area beneath the deck between the steel box girders to give the appearance of a single steel box. This will provide a smooth appearance to motorists traveling below.

The bridge is a highly curved two-span structure with an overall length of 270 ft. The curvature's tight 280-ft radius and spiral transitions presented a complex geometrical challenge. The use of two steel trapezoidal box girders yielded both a technical and aesthetically pleasing solution.

The Expressway Authority's decision to put the Lake Underhill project in a context-sensitive design is part of a national and

statewide trend in transportation planning. It requires the input of all stakeholders to develop a transportation facility that fits its physical setting and preserves scenic, aesthetic, historic, and environmental resources, while also improving mobility and safety.

Throughout the entire S.R. 408 widening project, the Expressway Authority has incorporated sound walls, eye-pleasing retaining walls, tiered landscaped planter walls, improved lighting, decorative bridge treatments, colored concrete, and extensive landscaping. Architects even borrowed design elements from Orlando's downtown neighborhoods. For example, the battered pylons featured at each bridge in the program reflect the battered columns found on the front porches of bungalows throughout downtown neighborhoods. Sedate colors, aesthetic wall treatments, and high-quality lighting fixtures follow the community's standards.

The Expressway Authority used the Florida Department of Transportation's Interstate 4 urban design criteria as a foundation for the S.R. 408 improvements. Criteria include:

- Placing emphasis on adjacent properties and cross streets.
- Reflecting the character of the surrounding neighborhood in the design of retaining and sound walls.
- Providing good lighting for pedestrian safety under bridges.
- Landscaping, so the focus is on the vegetation, not the walls.
- Minimizing the use of chain-link fence.

The design of the S.R. 408 expansion program also follows the vision of the Downtown Orlando Community Redevelopment Agency (CRA). As part of its Downtown Orlando 2020 Vision plan, the CRA touched on downtown gateways that announce: "You have arrived."

The Lake Underhill project is symbolic of the entire city. In planning the

At least \$10 million of the project's budget will be spent on aesthetic elements to integrate the bridges into the surrounding communities.

project, the Expressway Authority obviously thought well beyond the scope of its right-of-way. By considering the community along its corridor, the design moves far beyond asphalt and concrete to respect the people who live and work along this road, as well as those who drive on it. The entire community will benefit. **MSC**

Dennis Gowins is structures leader for HNTB Corp. and structural project manager for the State Route 408 Lake Underhill widening project.

Designer

HNTB, Orlando, Fla.

Fabricator/Detailer

PDM Bridge, Palatka, Fla. (AISC/NSBA Member)

Value Engineering Returns \$1.85 Million to Florida County

A VALUE ENGINEERING REDESIGN BY FINLEY ENGINEERING GROUP, INC., COMBINED WITH COST-EFFECTIVENESS MEASURES TAKEN BY ZEP CONSTRUCTION, will return \$1.85 million to Lee County, Fla. on the Estero Parkway Flyover project.

Finley's redesign replaces twin, cast-in-place concrete box girders with a single, four-steel box girder design. This solution provides significant economic benefits with the elimination of a large falsework support system, reduced construction time, reduced foundation design requirements, and simplified construction.

The new Estero Parkway Flyover, 561 ft long with spans of 340 ft and 221 ft and approximately 116 ft wide, will alleviate traffic on the parkway and nearby I-75 in the Estero community, which is southeast of Fort Myers. It will complement the widening of Corkscrew Road while providing a link to areas east and west of I-75. It will also provide an alternate east-west route for travelers using the Tamiami Trail and I-75.

"By using shallower steel girders, it allows for the use of smaller grades, so it won't require as much fill on each approach," said Robert Clark, Jr., president of steel fabricator Tampa Steel. "The contractor can also erect the bridge in longer sections, which means fewer obstructions in the roadway."

The redesign also calls for a staged temporary tower support scheme to optimize the efficiency of the steel section, which al-

lowed the steel bridge solution to be competitive against the initial cast-in-place concrete design.

In addition, the driving public benefits from the redesign through reduced traffic maintenance requirements. The redesign also enhances overall project safety with the elimination of falsework over the Interstate and reduces risks associated with a constrained traffic pattern through the falsework system.

The \$1.85 million refund to the county is significant because the county is responsible for funding the flyover, and in the wake of a tax cut passed down by the state, the money will help the county meet its budgetary commitments.

"We're obviously pleased," said Donald Deberry, P.E., public works operations manager for Lee County. "We always appreciate working with engineers and contractors who are willing to take a second look at projects and find ways to give the public more bang for their buck."

"We see this as a great example of what can happen with value engineering when the owner, contractor, and engineer come together to create a design that takes the contractor's strengths into account and utilizes the best material for the challenges of the project," says Craig Finley, president of Finley. "In this case, the redesign from concrete to steel had an overall positive effect on the cost, schedule, and efficiency of the bridge. With construction budgets as tight as they are, there's no room for waste in any of these areas."

MSC

A Tale of Two Yanktons

BY DAN SHARP



A new steel span over the Missouri River replaces a National Historic Register bridge to route auto traffic between South Dakota and Nebraska.

PRETTY SOON, THERE WILL BE A NEW WAY TO GET FROM NEBRASKA TO SOUTH DAKOTA—AND VICE VERSA, OF COURSE. Construction began this summer on a new, 1,590-ft, welded steel-plate girder bridge over the Missouri River between Yankton, S.D. and South Yankton, Neb. It is the first bridge over the Missouri River to be designed in-house by the Nebraska Department of Roads (NDOR).

The bridge is being constructed approximately 900 ft west of the Meridian Bridge, the current span between the two towns. The 84-year-old, two-level, steel truss bridge carries U.S. Route 81 motorists via a single lane on the top level. Northbound traffic is underneath, on a single lane originally intended for a railroad line that was never built.

Constructability was the primary concern when preliminary design began, and the added attention to that aspect resulted in a very efficient, cost-effective design. With assistance from National Steel Bridge Alliance, NDOR was able to evaluate the capabilities of fabricating shops in the surrounding states to determine the maximum length and height of girder sections to use. It was determined that the maximum-depth girder that area shops could handle

was 10 ft, and the maximum length for a girder section was 160 ft. With a six-span, haunched girder design, using 280 ft for the four interior spans and 235 ft for the two end spans, a 166-ft girder section was needed in the end span from the abutment to the first field splice. All of the other girder sections could be 130 ft, 140 ft, or 150 ft. An optional field splice in the 166-ft section was provided to reduce the section length to less than 130 ft, if the contractor chooses to use it.

The superstructure is made up of seven lines of girders spaced at 11-ft 4-in. centers. The hybrid girders, which incorporate ASTM A709 Grade HPS70W steel for the flanges and Grade 50W steel for the webs, are 10 ft deep at the piers and 6.5 ft deep at midspan. The maximum flange plate thickness used was 2 in. to take advantage of increased market competition in the supply of Grade HPS70W 2 in. thick and under. These limits helped determine the best span arrangement to use for the bridge.

Preliminary plans were sent to the steel fabricating shops for review and comment. The only comment received was that it was a very clean and efficient design and should be very competitive with any other girder option.

Common practice in Nebraska is to design both concrete and steel options for girder bridges with spans greater than 50 ft, unless site conditions or other restrictions prohibit it. In the case of the Meridian Bridge replacement, the state prepared both sets of plans and received three bids—all for the steel option; no bids were received for a concrete girder option.

Once completed, the bridge deck will provide for two traffic lanes in each direction on a 74-ft clear roadway with an 18-ft painted median. The anticipated completion date is November 2009; however, the contractor expects to finish almost a year early because of the steel design.

The old bridge, meanwhile, is on the National Historic Register and will be maintained for use as a pedestrian bridge, connecting existing and planned foot and bike trails. MSC

Dan Sharp is a bridge engineer with the Nebraska Department of Roads.

Designer

Nebraska Department of Roads

Fabricator

PDM Bridge, Eau Claire, Wisc. (AISC/NSBA Member)