



Quick Response

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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.

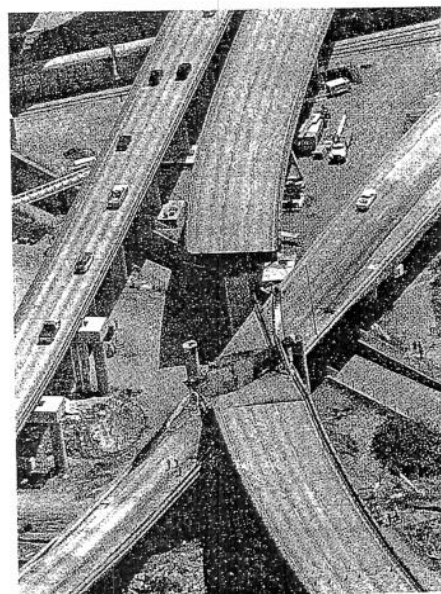
The California Department of Transportation (Caltrans) management and government officials reacted immediately and decisively to prioritize reconstruction. Within hours, senior bridge officials were meeting to set priorities, and engineers were on-site assessing damage. By the end of the first day, Governor 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.

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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 ma-

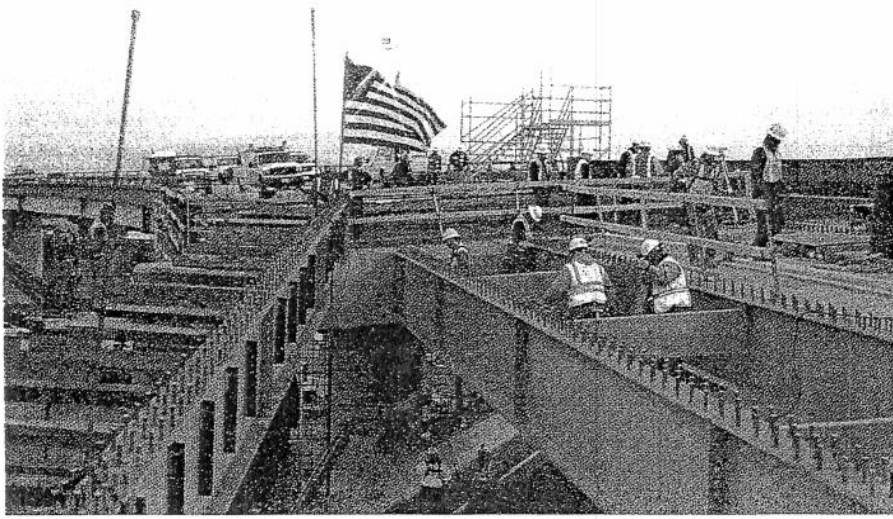
Quick Turnaround

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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.



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.

materials engineers to quickly work through 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

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Owner/Designer

California Department of Transportation (Caltrans)

General Contractor

C.C. Myers, Rancho Cordova, Calif.

Fabricator

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