



TOLL BRIDGE PROGRAM OVERSIGHT COMMITTEE

CALTRANS BAY AREA TOLL AUTHORITY CALIFORNIA TRANSPORTATION COMMISSION

Just The Facts: Welding on the Self Anchored Suspension Span

Welding and steel fabrication involved in the Self-Anchored Suspension span (SAS) took place around the world, including locations in the United States, Japan, China, Korea and the United Kingdom. Standards and rigorous inspection were common to all locations. The tower and orthotropic box girders of the SAS were fabricated at the Zhenhua Port Machinery Company (ZPMC) in Shanghai, China. ZPMC was selected for the work by the SAS prime contractor, American Bridge/Fluor (ABF). American Bridge and Fluor are contractors with international reputations for technical skill and quality. ZPMC is an internationally known steel fabricator that has fabricated massive port container cranes, bridges, offshore oil platforms and wind turbine towers. ZPMC's work for the SAS involved almost one million individual welds, miles and miles in length, and took place between late 2007 and 2011. The vast majority of this work was completed without issue.

Two specific issues were identified during fabrication that required additional attention. In both cases, these were viewed as "issues" due to a higher than average rate of "rejectable" indications identified during the quality control/quality assurance process. A "rejectable" indication means that our testing procedure, which allows us to look inside a weld, was giving us an "indication" that there might be a defect in a weld.

The first issue involved small cracks in deck panel welds and the second involved small cracks in "butt" (end to end) welds using a particular welding process – Flux Core Arc Welding.

Both issues were carefully analyzed to determine the cause, so as to allow for an improved process moving forward. The team performing this analysis included pre-eminent experts from the welding and engineering community. The result of this analysis was reviewed by the Toll Bridge Seismic Safety Peer Review Panel, a panel of technical experts considered to be at the pinnacle of their respective professions (several members have

been elected to the National Academy of Engineering, the highest recognition bestowed on engineers in the United States).

In all cases, rejectable indications in weld areas required for the performance of the structure (performance including both the 150 year life of the bridge as well as the lifeline seismic performance criteria) were removed and repaired.

The inspection for this work involved a large and talented staff. ABF and ZPMC had a team of over 200 performing quality control work, and Caltrans had a team of over 50 performing quality assurance work. ABF, ZPMC and the Department stand by the quality of the work.

Of the almost one million welds, how many were inspected?

All welds have been inspected in accordance to the contract requirements. The inspections were conducted by quality control inspectors from ABF and ZPMC and were verified by the Department of Transportation's (Caltrans or Department) quality assurance inspectors. All inspectors were certified as required by the American Welding Society (AWS).

What are the industry standards for welding and inspection?

American Welding Society D1.5 Section 6 was followed, with additional requirements set forth in the contract Special Provisions (that is to say, we did more than is required by national standards). These standards were applied at all steel fabrication facilities throughout the world. Inspection includes an array of non-destructive testing procedures (a specified combination of visual inspection, magnetic particle testing, and ultrasonic testing). Through agreement with ABF, an innovative procedure, phased array ultrasonic testing, was utilized to assess the deck panels.

What were the changes to the welding process?

Modifications to deck panel welding included additional grinding and "feathering" of tack welds.

Modifications to butt welds included:

- Use of a new welding filler
- Use of new shielding gas.

Did Caltrans simply relax its inspection standards?

No. Inspection requirements were followed in all cases and as noted in the case of the deck panel welds, new and additional testing processes were utilized through agreement with ABF. It is important to understand that, when rejectable indications are found, the level of inspection actually increases.

How were the welds repaired?

Welds were repaired by removing the affected weld metal. The area was then rewelded using an approved process. The repaired weld, and an additional two inches on either side of the repaired weld, was then inspected and tested.

How do we know the welds are safe?

The Department is known for having one of the most rigorous quality programs in the country, and detailed records exist to document this work. The Bay Bridge project added to this with a panel of top welding experts, many of which were directly involved in crafting the codes that were actually being applied to the work. Yet another layer of review was involved with the issues discussed in this fact sheet, the Peer Review Panel. Extraordinary steps were consistently taken to ensure the quality of all steel components being fabricated throughout the world. Both the welding experts and members from the Peer Review Panel directly observed the work and did not opine from a distance. All of this took place in the context of an extremely conservative and robust design that will provide the intended 150 year life (double the standard) and lifeline seismic performance of the bridge.

Who were the experts that assisted with the analysis of these issues?

David L. McQuaid, Current AWS Vice President and former Chairman of the AWS D1Committee on Structural Welding

Donald D. Rager, former Chairman of the AWS D1Committee on Structural Welding

Dr. John Barsom, former Director of the Materials Technology Division of U.S. Steel

Alan Cavendish-Tribe, Welding Engineer, Mott MacDonald Engineering Consultants

Who are the members of the Toll Bridge Seismic Safety Peer Review Panel that reviewed this analysis?

Joeseeph Nicoletti, Structural Engineer (now retired from the panel)

Dr. Frieder Seible, Structural Engineer and member of the National Academy of Engineering

Dr. John Fisher, Structural Engineer and member of the National Academy of Engineering

Dr. I.M. Idriss, Geotechnical Engineer and member of the National Academy of Engineering

Further Reading

Self-Anchored Suspension Bridge Project: Project Team Response to QA/QC Expert Panel Recommendations
<http://baybridgeinfo.org/sites/default/files/pdf/UpdatedFinal-QAQC-Rpt-2011Nov-v1.pdf>

Welding documents for the SAS can be viewed at
<http://baybridgeinfo.org/documents>

Bay Bridge Steel
<http://baybridgeinfo.org/factsheets>