San Francisco-Oakland Bay Bridge

Self-Anchored Suspension Bridge Project

Project Team Response to QA/QC Expert Panel Recommendations

November 2011 (updated)
March 2011 (original)

Prepared by
The Self-Anchored Suspension Bridge Project Team:

UPDATED FINAL
11/03/11
San Francisco-Oakland Bay Bridge

Self-Anchored Suspension Bridge Project

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The Self-Anchored Suspension Bridge Project Team:

PREPARED BY
California Department of Transportation
Tony Anziano
Brian Maroney
Ken Terpstra
Peter Siegenthaler
Bill Casey
Ade Akinsanya

Consultants
Mazen Wahbeh, Alta Vista Solutions, Inc.
Karen Wang, HNTB Corporation

American Bridge / Fluor Enterprises, Inc., A Joint Venture
Brian Petersen
Peter van der Waart van Gulik
Bob Kick
Kevin Smith
Thomas Nilsson
Steve Lawton

CONTRIBUTORS
California Department of Transportation
Keith Hoffman
Gary Thomas

Consultants
Marwan Nader, T.Y. Lin International
Ted Hall, Bay Area Management Consultants

Bay Area Toll Authority
Peter Lee

California Transportation Commission
Stephen Maller
Dina Noel
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1.0 EXECUTIVE SUMMARY

The Self-Anchored Suspension (SAS) segment of the San Francisco-Oakland Bay Bridge East Spans Seismic Safety Project is advancing with the ongoing erection of the SAS Orthotropic Box Girders (OBG) as visual testaments to its progress. The SAS segment is part of the overall Toll Bridge Program under the direction of the Toll Bridge Program Oversight Committee (TBPOC). The construction contract is administered by the California Department of Transportation (Caltrans). The Prime Contractor is American Bridge / Fluor Enterprises, Inc., A Joint Venture (ABFJV).

The SAS steel OBGs and East End anchorages are being fabricated at Shanghai Zhenhui Heavy Industry Company, LTD. (ZPMC) in Shanghai, China under a contract with ABFJV. Twenty-two of the twenty-eight OBG lifts have been erected as of early March 2011. The remaining six OBG lifts are expected to ship from ZPMC in May and July of 2011.

As is the case in all real-world fabrication-construction projects, fabrication is expected to require inspection and some rework. The rework is required to repair rejectable flaws. This document responds to the QA/QC Expert Panel (Panel) recommendations stated in a November 2010 draft report. A main focus to these recommendations is aimed to reduce and effectively eliminate the number of transverse linear indications (TLIs) related to, in part, an excess hydrogen contaminant problem present in the performance of certain welding processes and their environments.

Significant and continued expertise and effort have been dedicated to Quality Control (Contractor) and Quality Assurance (Owner) resources to employ the requirements of the Contract Documents to identify and repair rejectable transverse crack-like indications. In some cases, contract changes have been made (i.e. implementation of the new FCAW welding process), and may be made in the future to continually improve the quality of the work and expedite the schedule.

Continual efforts to reduce transverse crack-like indications have been on-going since initial discovery in November 2009. To further expand these efforts to the more challenging fabrication of the East End of the SAS, the Project Team solicited the services of the Panel. At the end of a weeklong QA/QC Steel Fabrication meeting conducted in November 2010 at ZPMC, a draft report by the Panel was generated and distributed. This draft report reemphasized earlier welding procedure recommendations made in November 2009 and provided additional recommendations on weld inspection testing and welding procedures and processes. Recommendations can be organized into two categories:
1) Recommendations for evaluation of welding previously performed (OBG Lifts 1-11); and
2) Recommendations for welding to be performed in future work (East End, OBG Lifts 12-14).

A well-qualified and complex problem-focused team (Project Team) was assembled to directly and effectively address all elements of the Panel's recommendations regarding transverse crack-like indications, while advancing the OBG fabrication work to its completion, and provide status reporting to the Toll Bridge Seismic Safety Peer Review Panel (TBSSPRP) and the TBPOC. Weekly videoconferences were held between the Project Team members in China and Oakland to maximize communications and effectively document progress and consensus. Monthly meetings with the Project Team and Panel have also been established to provide opportunity for interaction and updates on progress focused towards
the development of a document formally addressing and responding to the recommendations stated in the November 2010 draft report.

Through these efforts, the Project Team, along with the Panel, has clarified the intent of the recommendations from which practical and reasonable consensus has been achieved on both the evaluation and the actions to be taken on the completed welds (Lifts 1 thru 11 and Crossbeams 1 thru 16) and future welds (Lifts 12 thru 14 and Crossbeams 17 thru 19). Tremendous effort has been directed to identify weld types and processes that were thought to potentially contribute to the TLIs caused by excess hydrogen contamination in order to eliminate this problem in future welds. Based upon Non-Destructive Examination (NDE) data provided from welds placed after November 30, 2010, the Project Team and the Panel concluded that TLIs caused by excess hydrogen have been effectively eliminated by implementation of multiple enhancements to the welding procedures.

The November 2010 draft report conservatively placed all weld types into a broad set of welds of interest, requiring detailed evaluation for all future (East End, Lifts 12 thru 14) welds. However, after a thorough technical evaluation by the Project Team and subsequent consensus from the Panel, it was determined that only a relatively small and select subset of welds was of further interest. The criteria in defining the welds of interest included type of weld, welding procedure used to perform the weld, welding wire, welds subjected to tensile stresses during the service life of the bridge, and weld inspection criteria. In certain cases, additional inspection has been directed either by the Contractor or the Owner. In all cases, the fabrication of the East End meets or exceeds the requirements of the Contract Documents.

The majority of the SAS OBG fabrication (Lifts 1 thru 11) has been completed, and as stated previously, has been erected in the field after undergoing the rigorous inspection as required in the Contract Documents. In the early stages of the efforts to address the Panel’s recommendation regarding OBG Lifts 1 thru 11 (Ref. Additional Recommendation From The Panel #6), many welds were thought to be welds of interest prior to all of the supplemental and detailed inspection and bridge analysis data being fully organized and evaluated together. With such information made available, it was determined that the vast majority of the welds in OBG Lifts 1 thru 11 are not welds of interest. The weld inspection data for the relatively small set of welds identified as welds of interest provided in this response document indicates inspection percentages ranging from 50 to near 100%, exceeding contract NDE requirements. Such high percentages of weld inspection using inspection methods required in the Contract Documents and the American Welding Society D1.5 Bridge Welding Code can confidently detect systemic hydrogen generated TLIs. In all cases, detected rejectable indications, including TLIs, were removed and welds repaired as required by the Contract Documents. After review of all data, it has been demonstrated that the investigated welds have in general been of high quality with very low rejection and repair percentages due in large part to the highly automated welding process at ZPMC.

Final evaluation results of the OBG steel fabrication, as summarized within this response, clearly confirms that any necessary follow-up actions taken were well-founded and were based on proper technical information and contract administrative procedures. After extensive investigation, review, and consideration, the steel fabrication of the OBGs is advancing and is being completed in compliance with the Contract Documents, including the American Welding Society D1.5 Bridge Welding Code.
2.0 INTRODUCTION

Project Background
The Self-Anchored Suspension (SAS) segment of the San Francisco-Oakland Bay Bridge East Spans Seismic Safety Project consists of twenty-eight steel Orthotropic Box Girder (OBG) lifts and nineteen crossbeams spanning 605 meters of total length. Fabrication of these steel pieces commenced in late 2007 at Shanghai Zhenhua Heavy Industry Company, LTD. (ZPMC) in Shanghai, China under a contract with American Bridge / Fluor Enterprises, Inc. (ABFJV).

Main Focus on Quality Efforts and Issue Resolution
Continual efforts to reduce transverse crack-like indications have been on-going since initial discovery in early 2008 and additional discovery in mid-2009. Through a series of destructive tests and evaluations performed in November 2009, an initial assessment of potential excess hydrogen being a root cause was made. While all rejectable crack-like indications were removed and welds repaired in compliance with the Contract Documents, the following improvements were implemented:

- Modified Welding Procedures were put into effect in a November 2009 report that was prepared by consultants to Caltrans and ABFJV;
- Amended UT Procedures were developed to address transverse linear crack-like indications;
- Over-checks of non-destructive testing were performed by ABFJV QC in addition to non-destructive testing performed ZPMC QC.

The QA/QC Expert Panel (Panel)
To further expand the ongoing efforts to improve quality and place additional emphasis on the more challenging fabrication of the East End of the SAS, the Project Team solicited the services of subject matter expert consultants that are already associated with the project through either ABFJV or Caltrans or Bay Area Toll Authority. Those third party consultants were Mr. Don Rager (Chair of the American Welding Society Code Committee for Structural Steel Welding), Mr. David McQuaid (Chair of the American Welding Society Code Committee for Bridge Steel Welding), Dr. John Barsom (Fracture Mechanics Specialist and Metallurgist) and Mr. Alan Cavendish-Tribe (Professional Welding Engineer). This group of four formed the QA/QC Expert Panel who was tasked to work collaboratively with the Project Team in the requested assessment of quality within the ongoing OBG steel fabrication in China.

The steel fabrication and erection of the OBGs, at the time of the QA/QC Expert Panel Visit and development of their November 2010 Draft Report, was as follows: (Reference Exhibit 2.0 below)

**OBG Lifts 1 through 11, Crossbeams (CB) 1 through 16**
- OBG Lifts 1 through 9 and Crossbeams (CB) 1 through 12 were completed, shipped and erected;
- OBG Lift 10 and CB 13 and 14 were shipped on November 15, 2010;
- OBG Lift 11 and CB 15 and 16 were 92% complete in fabrication.

**East End, OBG Lifts 12 through 14 and CBs 17 through 19**
- OBG Lift 12 and CB 17 were 83% complete in fabrication;
- OBG Lifts 13 and 14 and CBs 18 and 19 were 62% complete in fabrication;
- OBG Lifts 13 and 14 and CBs 18 and 19 had completed their parts fabrication and had commenced segment and crossbeam assembly in which the major and more complicated welding was to be performed.
**Section 2.0 Introduction**

**Exhibit 2.0: OBG Segment Fabrication Status as of November 19, 2010**

Information obtained from Castrans' Weekly China Fabrication Status from 11/19/10

The initial draft report was issued by the Panel at the conclusion of the meetings conducted during the week of November 15, 2010. The Project Team's response is based on the November 2010 draft report, Revision 9, issued on January 12, 2011.

**Project Team Response**

The Project Team, as a special assignment, formed a task group to address, react and respond to the Panel's recommendations. Proactive measures such as the following were implemented within two weeks from receipt of the report:

1. Weekly videoconferences were held between the Project Team members in China and Oakland to maximize communications and effectively document progress and consensus.

2. Monthly meetings with the Project Team and Panel have also been established to provide opportunity for interaction and updates on progress focused towards the development of a document formally addressing and responding to the recommendations stated in the November 2010 draft report.

3. Extensive “live” (prepared real-time during the meeting) meeting minutes were concurred by all attendees and provided in organized matrices for all weekly and monthly meetings. (Ref. Appendices B and C)
Through the weekly and monthly meetings, the Project Team addressed the following major topics in the process of clarifying and responding to the Panel's recommendations (Ref. Section 3.0):

1. Clarification of the welds of interest. (Ref. Additional Recommendations From The Panel #1 and #2)

2. Welding Process – Implementation of a new FCAW welding process, includes revisions to gas mixture and delivery system, additional focus on controls of preheat, continual evaluation of the new FCAW welding process results focusing on findings of any apparent hydrogen-related TLIs, verification of fracture critical requirements for certain weld repairs are met. (Ref. Previously Presented Recommendation #1 and #2, Additional Recommendations From the Panel #3)

3. Welder Performance – Engaged the Panel in discussions with ZPMC QC on welder performance incentive and disciplinary programs. (Ref. Additional Recommendations From The Panel #4)

4. Inspection – Collected and organized weld inspection mapping for welds of interest and reviewed and evaluated data (Ref. Additional Recommendations From the Panel #6 and #7); confirmed that the CWI process was meeting or exceeding contract requirements. (Ref. Additional Recommendations From The Panel #5)

5. Tension/Compression Mapping – Presented summary of tension/compression mapping to explain in a more visual and more graphical form stress magnitude and range, stress direction and stress location in the efforts to obtain the welds of interest. (Ref. Additional Recommendations From The Panel #6)
3.0 PROJECT TEAM RESPONSE TO QA/QC EXPERT PANEL RECOMMENDATIONS

Section 3.0 includes all ten of the QA/QC Expert Panel recommendations as stated in the "SAS Steel Fabrication Expert Panel Review of Orthotropic Deck Fabrication in China report", revision 9, dated November 2010, and issued January 12, 2011 (Ref. Appendix I). Following each recommendation are the SAS Project Team's responses as discussed and recorded during the weekly and monthly QA/QC meetings for the period of November 2010 through March 2011. Refer to Appendix B and C for meeting note references.
PREVIOUSLY PRESENTED RECOMMENDATION #1:

Follow the ‘Welding Procedure Requirements for New Welds,’ [October 2009] that was developed by ABFJV/Caltrans and issued under a covering ABFJV letter dated November 9, 2009.

PROJECT TEAM RESPONSE:

a. Some elements of the “Welding Procedure Requirements for New Welds,” dated October 2009, were already included in the Contract Documents which incorporate the AWS D1.5 Bridge Welding Code. Other elements were deemed to be means and methods that were at the discretion of the Contractor to implement. Refer to Appendix J for the delineation between contract items and means and methods.

b. An alternative means and methods, through the implementation of the new FCAW Welding Process has demonstrated that welds can be placed consistently free of rejectable transverse indications. This implementation was made effective in welds of Lifts 12, 13, and 14 placed after November 29, 2010. Refer to Project Team’s Response in “Previously Presented Recommendation #2” for more detailed information. (Ref. 12/10/11 Meeting Notes)
PREVIOUSLY PRESENTED RECOMMENDATION #2:
Implement the use of ESAB FCAW Electrodes and Ar – CO₂ Mix Shielding Gas per CCO164 dated September 21, 2010, for all FCAW welding [see Appendix C and D]. The Panel recommends implementation by November 30, 2010.

PROJECT TEAM RESPONSE:

a. ABFJV/ZPMC completely implemented the use of the new welding process using ESAB FCAW wire and Ar – CO₂ Mix Shielding Gas per CCO 164 as of November 29, 2010, in line with ABFJV letter AFC-ZPM-LTR-000648. (Ref. 12/10/10 Meeting Notes)

b. The Panel is satisfied with the implementation of the use of the new welding process based on the data received to date. The combination of wire/shielding gas and other recommended process changes in the new welding process effectively eliminated the effects of excess hydrogen in the welds. (Ref. 1/10/11 Meeting Notes)

c. The data presented to the Panel during the February 17th meeting led to the conclusion that the new welding process eliminated the hydrogen-related transverse indications. (Ref. 2/17/11 Meeting Notes)

d. ABFJV/ZPMC arranged with ESAB to provide representatives at ZPMC’s site for proper implementation and training of welders using the new welding process, starting December 8, 2010.

e. ABF/METS met with Linde (shielding gas supplier) to review the Ar–CO₂ Mix Shielding Gas mixture and delivery system and to discuss the method to eliminate contamination. Prior to switching to the manifold piping system, ZPMC is to perform pressure test of piping system to verify no leaks. When in use, Linde is to perform every other week check on the AR and CO₂ mixture concentration test of manifold cylinder packs system. In the interim, before switching over to the manifold system, ZPMC used bottled gas. To date, ZPMC continues to use bottled gas and has not yet switched to the manifold gas system. It is likely that ZPMC will not use the manifold system for the duration of the project. (Ref. 2/17/11 Meeting Notes)
ADDITIONAL RECOMMENDATIONS FROM THE PANEL #1

In addition to conformance with ABFJV letter dated November 9, 2009, the ‘Welding Procedure Requirements for New Welds’ procedure is to apply to ALL remaining SMAW, FCAW and SAW welds.

PROJECT TEAM RESPONSE:

a. The Project Team did not apply the ‘Welding Procedure Requirements for New Welds’ procedure to ALL remaining SMAW, FCAW and SAW welds. ABFJV had performed an investigation into the welding processes that included review of inspection records and extensive overchecks of the welding which revealed the hydrogen induced cracking problem was solely in the 100% FCAW welds, therefore, measures were put into place for FCAW welds only. The group clarified that the focus set of welds are the welds made with 100% FCAW filler metals only including PJP, CJP and fillet welds. (Ref. 1/10/11 Meeting Notes)

b. During the January 12, 2011 meeting, the Panel further confirmed the Project Team’s statement that the transverse indications are of concern only in welds made with 100% FCAW. All such indications, when discovered in existing welds, were repaired. Crack-like indications were not detected when using the new FCAW welding process. (Ref. 1/12/11 Meeting Notes)

c. During the February 17, 2011 meeting, it was further clarified with and confirmed by the Panel that the welds of interest are those formed using the old 100% FCAW welding process in locations throughout the bridge that are expected to experience cyclic tension under service load conditions. (Ref. 2/17/11 Meeting Notes)
ADDITIONAL RECOMMENDATION FROM THE PANEL #2:
Conformance with ABFJIV letter dated November 9, 2009, the 'Welding Procedure Requirements for New Welds' procedure is to apply to all welds not just to the skin plate welds.

PROJECT TEAM RESPONSE:

a. The focus set of welds is: ALL internal and skin plate welds made with the old 100% FCAW welding process and includes PJP, CJP and fillets. (Ref. 1/10/11 Meeting Notes)

b. During the February 17, 2011 meeting, it was further clarified with and confirmed by the Panel that the welds of interest are those formed using the old 100% FCAW welding process in locations throughout the bridge that are expected to experience cyclic tension under service load conditions. (Ref. 2/17/11 Meeting Notes)
ADDITIONAL RECOMMENDATION FROM THE PANEL #3:
Verify that the Fracture Critical Requirements of Clause 12 of the AWS D1.5 Bridge Welding Code are enforced if more than two (2) weld repairs are made in the same location.

PROJECT TEAM RESPONSE:
  a. ABFJV and Caltrans have implemented this through the preapproved Critical Weld Repair (CWR) templates since November 2009 and all weld repairs if more than two (2) weld repairs are made in the same location in Lifts 13 and 14. (Ref. 12/22/10 Meeting Notes)
ADDITIONAL RECOMMENDATIONS FROM THE PANEL #4:
Remove from the project welders who consistently make welds with rejectable discontinuities as determined by ABFJV.

PROJECT TEAM RESPONSE:

a. Currently, ZPMC has 2 separate programs for their welders' evaluation: disciplinary and incentive programs. (Ref. 1/10/11 Meeting Notes)

b. The Panel commented that welder performance depends on several factors including weld position, weld location, as well as other factors. Therefore, the decision to remove a welder is to be made at the project level based on welder statistics, performance and management evaluations. (Ref. 1/10/11 Meeting Notes)
ADDITIONAL RECOMMENDATION FROM THE PANEL #5:
An ABFJV CWI shall be available during all welding checking compliance at intervals no greater than 30 minutes.

PROJECT TEAM RESPONSE:

a. ABFJV described how the Certified Weld Inspectors (CWI) are being utilized during the welding activities. METS (Caltrans QA) confirmed that the 30 minute interval was being properly implemented and there are no problems with CWI coverage. The Panel is satisfied. (Ref. 1/11/11 Meeting Notes)
ADDITIONAL RECOMMENDATION FROM THE PANEL #6:
The performance of structural members in Lifts 1 through 12 that are determined to be subjected to
tensile stresses should be investigated once the maximum and cyclic tensile stress magnitudes are
determined.

PROJECT TEAM RESPONSE:

a. Item 6 of the Additional Recommendations from the Panel only applies to 100% CJP FCAW
skin welds made with the old welding process for Lifts 1 through 11. (Ref. 02/23/11
Meeting Notes)

b. The Project Team collected and organized cyclic tensile stress information for Lifts 1 through
12. (Ref. Tables in Appendix G), (Ref. 01/10/11, 01/26/11, 02/09/11, 02/17/11, 02/23/11,
03/02/11 and 03/09/11 Meeting Notes)

c. The tension mapping was developed to explain in a more visual and graphical form stress
magnitude and range, stress direction and stress location. This detailed information does
not represent a change in design, engineering and construction documents. (Ref. Appendix
G for OBG-Crossbeam Tension Mapping), (Ref. 03/09/11 Meeting Notes).

d. Weld type and inspection data were collected and organized for Lifts 1 through 12 and
Crossbeams 1 through 16. (Ref. Exhibits 4.1 and 4.2 in Appendix E), (Ref. 01/10/11,
01/26/11, 02/09/11, 02/17/11, 02/23/11, 03/02/11 and 03/09/11 Meeting Notes)

e. For OBG Lifts 1 through 11, CJP welds produced with the old 100% FCAW welding process
were inspected to varying percentages using either UT Scanning Pattern D or E in
accordance with the Contract Documents. (Ref. NDT Exhibit 4.0 and 4.1 in Appendix E)

- Longitudinal welds (longitudinal to the direction of the bridge) for Lifts 1 through 11,
  are in compression and are therefore not of interest.

- Transverse welds (transverse to the direction of the bridge) for Lifts 1 through 11,
  bottom portions of the bridge carry tension. These welds have received and passed
  contract and code required inspection and all indications determined to be
  rejectable were repaired. (Ref. 01/12/11 Meeting Notes)

f. Crossbeam 1-16: The bottom corner welds made with the old 100% FCAW welding process
received 100% inspection using either UT Scanning Pattern D or E. These are the only 100%
FCAW welds in these crossbeams that are subjected to tensile stresses. ABFJV provided the
NDT results for these welds and the Project Team agrees that there is no evidence to
support a systemic hydrogen problem in these welds. (Ref. Exhibit 4.2 in Appendix E) (Ref.
03/09/11 Meeting Notes)
ADDITIONAL RECOMMENDATIONS FROM THE PANEL #7:
All external skin CJP welds shall be ground flush and UT inspected using Scanning Pattern D with +6 dB above Class B acceptance criteria [acceptance criteria in Table 6.3 – UT Acceptance / Rejection Criteria – Tensile Stress in addition to the standard UT requirements of the AWS D1.5 Code [see Appendix E].

PROJECT TEAM RESPONSE:

a. The focus set of welds within this guideline are welds that are 100% FCAW, performed using the old welding procedure and the shielding gas delivery system, in locations that are expected to experience cyclic tension under service load conditions. (Ref. 02/17/11 Meeting Notes)

b. The recommendation is specific to OBG Lifts 12, 13 and 14 and Crossbeams 17, 18 and 19.

c. For Lift 12, skin plates, all FCAW CJP welds made with the old 100% FCAW welding process have been or will be 100% inspected using UT Scanning Pattern D with +6 dB above Class B acceptance criteria (with the exception of the lower corner assembly weld, in the 2n and 2s location which is 100% inspected using UT Scanning Pattern E). Per Design Joint Venture (DIV), the state of stress in these welds in Lift 12 is primarily in compression and it may vary due to variations in the dead load moment and transverse moment (Ref. 03/09/11 Meeting Notes). The Scanning Pattern E performed on this lower corner assembly weld is acceptable. ABFJV QC has reviewed the weld inspection data for these welds and has determined there is no concern. Caltrans (CT) QA reviewed their records and also have no concern. Note that CT performed 100% UT E or D scan. (Ref. 02/17/11 and 03/09/11 Meeting Notes)

Exhibit 3.0: Typical OBG Cross Section Showing Longitudinal Weld Locations on the External Skin Plate

d. For Lift 13 and 14 skin plates, CJP welds made with the old 100% FCAW welding process have received or will receive 100% inspection using UT Scanning Pattern D with +6 dB above Class B acceptance criteria, exceeding the Contract Document requirements. (Ref. 02/17/11 Meeting Notes)

e. For Crossbeam 17, 18 and 19, 100% FCAW CJP bottom corner welds made with the old welding process have received or will receive 100% inspection using UT Scanning Pattern D with +6dB above Class B acceptance criteria, exceeding the Contract Document requirements. (Ref. 02/17/11 and 03/09/11 Meeting Notes)

f. Any rejectable discontinuities found have been or will be properly repaired, reinspected, and cleared per Critical Weld Repair (CWR) template.
Section 3.0 Project Team Response

g. During the February 17th meeting, the Panel commented that they acknowledge the Project Team has correctly applied the Code and Contract Documents and has extended these requirements to the appropriate alternative UT methods as the Code allows. (Ref. Notes from 02/17/11 Meeting)
ADDITIONAL RECOMMENDATION FROM THE PANEL #8:
The Engineer may relax the UT Acceptance / Rejection Criteria to the standard requirements of the
AWS D1.5 Code - if it can be demonstrated that rejectable transverse crack-like indications are no
longer occurring.

PROJECT TEAM RESPONSE:
   a. Even though the results have shown that the Project Team could relax this requirement, the
      parties have agreed to continue with the modified UT procedure so that there is consistency
      throughout the project. Consequently this recommendation was removed during the
      December 10, 2010 meeting between the Panel and the Project Team. (Ref. 12/10/10
      Meeting Notes)
4.0 CONCLUSION

The Project Team provides this document as the formal response to the QA/QC Expert Panel recommendations stated in its November 2010 draft report and is one of the many continual efforts in supporting the quality and schedule of the Orthotropic Box Girder (OBG) fabrication. A main focus to these recommendations is aimed to reduce and effectively eliminate the number of transverse linear indications (TLIs) related to an excess hydrogen contaminant problem present in the performance of certain welding processes and their environments. Through this response, the Project Team has demonstrated that hydrogen-related TLIs have been effectively eliminated. Further, the Project Team has thoughtfully considered and responded successfully through investigation, action, and documentation to each of the recommendations made by the Panel.

The fabrication of the OBGs for the Self-Anchored Suspension segment of the San Francisco-Oakland Bay Bridge is advancing on schedule for a final shipping date from ZPMC, in July 2011. The fabricated work is in compliance with the Contract Documents, including the American Welding Society D1.5 Bridge Welding Code.
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California Department of Transportation and
American Bridge / Fluor Enterprises, Inc., A Joint Venture
375 Burma Road
Oakland, California 94607

March 29, 2011

Dear Ladies and Gentlemen:

Project: San Francisco Oakland Bay SAS Bridge Superstructure
Subject: Statement by the QA/QC Fabrication Expert Panel

In response to the Expert Panel’s recommendations made in November 2010, the Project Team has embraced the concerns and taken action as a result. The Expert Panel has read the response report issued by the Project Team in March 2011 and agrees with the commentary which has been supported by both corrective actions and data collected throughout the investigation.

The Expert Panel was formed in November 2010 and tasked to work collaboratively with the Project Team in the requested assessment of quality within the Orthotropic Box Girder (OBG) steel fabrication in China. An initial draft report was issued by the Expert Panel upon completion of the mid-November 2010 meetings held in China. The initial draft was debated during the course of the following weeks with the “SAS Steel Fabrication Expert Panel Review of Orthotropic Deck Fabrication in China report”, revision 9, dated November 2010, and issued January 12, 2011. Due to the limited information available during the first meeting of the Expert Panel, the resulting recommendations were broad in scope. Subsequently, as more data was provided by the Project Team and presented in an organized format, the Panel’s direction became more focused.

Based on the results of the combined efforts of the Project Team and the Expert Panel, the following observations are made:

- Modifications made to the FCAW welding process to mitigate transverse cracking in weld metal, presented in November 2009, have been adopted with successful results.

- QA/QC inspection requirements stated in the Contract Documents have been satisfied. The implemented UT inspection criteria exceed the AWS D1.5 Bridge Welding Code requirements and provide a high level of confidence in the weld quality for the entire Orthotropic Box Girder (OBG) and Cross Beams. This has been confirmed in statements made by ABFJV Foreign QC Manager and the Department’s QA Manager that the fabrication has been performed in compliance with the Contract Documents.
Appendix A

- The Expert Panel believes that the Project Team has demonstrated that hydrogen-related transverse linear indications (TLI) have been effectively eliminated. No hydrogen-related TLI have been detected by non-destructive examination since the new FCAW welding process was fully implemented.

The Expert Panel commends and thanks the Project Team for their willingness to tackle the complex task and provide us with the information necessary to make an objective analysis and resultant conclusions.

Sincerely,

QA/QC Fabrication Expert Panel:

[Signatures]

Dr. J. Barsom

Mr. D. McQuaid, P.E.

Mr. A. Cavendish-Tribe, CEng., FWeldI.

Mr. D. Rager, P.E.
Minutes from the Joint Meeting with the Toll Bridge Program Oversight Committee (TBPOC) - Toll Bridge Seismic Safety Peer Review Panel (TBSSPRP) - QA/QC Expert Consultants
FINAL – Dated 4/25/11 – (rev-1)

Meeting Date: April 7, 2011

Topic of Discussion: QA/QC for the Fabrication in China

Attendees:
TBPOC: Steve Heminger, Andre Boutros, Cindy McKim (phone)
PMT: Andy Fremier, Stephen Maller, Tony Anziano
TBSSPRP: Joe Nicolleti, John Fisher, I. M. Idriss
QA/QC Expert Consultants: David McQuaid, Don Rager, John Barsom, Alan Cavendish-Tribe
Others: Dina Noel, Peter Lee, Jason Weinstein, Brian Maroney, Ken Terpstra, Bill Casey, Mazen Wahbeh, Jon Tapping, Ade Akinsanya, Peter Siegenthaler, Francisco Carpio, Karen Wang, Steve Lawton, Thomas Nilsson, Brian Petersen, Peter van der Waart, Marwan Nader, Rick Land

1. Brian Maroney presented the following slide presentation summarizing the conclusions drawn from the SAS Project Team’s response to the QA/QC Expert Panel Recommendations (November 2010).
   • Slide 1: Conclusions

   Conclusions

   1. The fabricated work of the OBG is in compliance with the contract documents, including the American Welding Society D1.5 Bridge Welding Code.

   2. The project team, with guidance from the QC-QA experts, has effectively eliminated transverse linear indications (TLIs) related to an excess hydrogen problem that was present in certain welding processes and their environment.

   3. All welds were inspected following the contract documents and if necessary, repaired following the contract documents.

   Brian Maroney displayed hardcopies of the Contract Plans, Special Provisions, Standard Specifications and AWS D1.5 Bridge Welding Code. He emphasized that the bridge was constructed and inspected in accordance with the above mentioned documents.
Slide 2: Focusing in on the "Welds of Interest"

- Slide 3: If QA Finds a Significant Problem, What Actions Follow

If QA Finds a Significant Problem
What Action Follow

Contract Document Requires:
1) First Inspect
2) If Significant Rejection is Required,
   a) Increase % Inspected by 10%
   b) If Significant Rejection Continues,
      2,0,1) Increase % Inspection to 100%

The above information was referenced from the Contract Special Provisions Section 10-1.59 which states:

"If unacceptable discontinuities are found in a joint with a specified percentage of testing of NDT less than 100%, including RT examination of butt weld repairs, the repairs shall be completed and then re-examined by the same NDT method along with an additional 50mm at each end of the weld repair, for a minimum total additional length of 100mm for the repair re-examination. Two additional previously untested segments, each at least 10% of the total weld length, on each side of the repair, for a total additional length of 20%, shall be tested with the same NDT method. If additional unacceptable discontinuities are found as a result of this testing, then 100% of the remaining
untested portion of the weld shall be tested with the same NDT method. All weld repairs shall be
tested with the same NDT method that located the original defect.”

- Slide 4: Consisted of photos of the technology used for the non-destructive testing (i.e. Ultrasonic Testing and Magnetic Particle Testing) of the welds placed during fabrication

2. QA/QC Expert Panel Comments:
- Provided a brief overview of the QA/QC Panel’s role and involvement since November 2010

3. Seismic Safety Peer Review Panel Comments:
- Seismic Safety Peer Review Panel was kept abreast of this matter by Brian Maroney throughout the process.
- The “Project Team Response Report to QA/QC Expert Panel Recommendations” is a complex document to initially understand. However, the Project Team met with the SSPRP on April 6th and covered the material with the group thoroughly and answered all questions raised.
- It was noted that the SSPRP supports the following excerpt of the Executive Summary from the Project Team’s Response and suggested that these sentences be emphasized in bold type:
- “In all cases, detected rejectable indications, including TLIs, were removed and welds repaired as required by the Contract Documents. After review of all data, it has been demonstrated that the investigated welds have in general been of high quality with very low rejection (and repair) percentages due in large part to the highly automated welding process at ZPMC.”
- It was noted that the steel fabrication of this bridge has been inspected to the highest level of inspection of any bridge.

4. Toll Bridge Program Oversight Committee Comments:
- (Andre Boutros) - Caltrans and the QA/QC Panel support the welds as they meet and at most times exceed the Contract Specifications. The question was asked to the SSPRP and the QA/QC Panel if these welds were good. Both parties responded that the welds were good.
- (Steve Heminger) - Do we have bridge welds that we expect more than normal maintenance in the future? The SSPRP responded that the welds on the bridge were built and tested to and beyond the requirements in the Welding Code and therefore the State can expect superior performance from the welds.
- (Steve Heminger) - Looking backwards, did you feel pressure of making these conclusions knowing that you may have to go back and repair welds at the job site? The Panel responded no. They were confident with the completed work leaving China. Also, the code is very distinct on what to do for critical weld
repaired. The completed and accepted fabricated work is in compliance with the Contract Documents and to the AWS D1.5 Bridge Welding Code.

- (Steve Heminger) - In regard to the tension members in #6 of the Panel's recommendations and the Panel's Statement Letter, is the Panel satisfied? The Panel responded that back in November 2010, the tension/compression question came up to understand the bridge. That info was provided. However, to determine the structural performance of the bridge is beyond the group's role, it is the role of the Engineer of Record. The fabricator's role is to provide a quality weld. Marwan Nader (Design JV) clarified that the Contract Documents clearly stated which members are in tension. However, all tension and compression welds were inspected to the tension criteria in the AWS D1.5 Bridge Welding Code.

- (Steve Heminger) - Was it the Panel's preference that these recommendations were to be implemented sooner? The Panel responded that typically it is the intent that once a recommendation report is submitted, implementation or a response follows. Brian Petersen responded that ABEJV has implemented the recommendations over time. Many of the recommendations were already built into the Contract Documents. Others were adopted over time. ABFJV did not at any point compromise quality but continued the effort to improve quality over time.

- (Steve Heminger) - Will ZPMC use this new welding process in future jobs? ABEJV responded that ZPMC has accepted the process and they are now seeing the benefits. Production graphs shared by ZPMC are showing low rejection rates with this new welding process.

- (Steve Heminger) - Why is the tower not included in the discussion? The group responded that China did not have the same challenges with the tower welds. ZPMC aggressively approached the tower fabrication. In addition, tower welds are in compression and therefore are not considered an issue.

5. Summary Comments-
   - The TBSSPRP has reviewed the conditions and information associated with the welding that came into question following the Nov 2010 QA/QC draft report as well as documented data formally organized by the Project Team. The TBSSPRP has specifically interacted with both the QA/QC experts and the Project Team.
   - The TBSSPRP supports the QA/QC expert consultants' and the Project Team's conclusions that the SFO88 SAS OBG welds are in compliance with the Contract Documents, including the AWS D1.5 Bridge Welding Code and therefore can be expected to perform well.

6. Closing Comments:
   - The PMT and TBPOC expressed their gratitude and appreciation to the team for their efforts.

7. Smith Emery Technology Demonstration-
   Smith Emery came in to present to the TBPOC and TBSSPRP Members the physical demonstration of the technology used for inspection of the welds. It was noted that if there was a systemic hydrogen problem, it would be detected.
1. Introductions - All

2. Status of Action Items from the Draft Report Guideline Discussion
   - Status of TLI's with new FCAW weld process – Steve Lawton
     Refer to the attachments.
     Steve Lawton walked the group through the data of the recent welds.
     It was reported that there were no new hydrogen-related TLI’s discovered to date.
     (ACTION) Add the following footnote: It was noted that the “TLI” terminology is defined as any indication
     as detected by the project specific D-scan procedure regardless of orientation in the weld.
     (ACTION) ABF to continue with the data gathering of the UT results for the new FCAW weld process and to
     provide a final update of the data once all welds are complete and accepted.
     (ACTION) Steve Lawton to provide information on the 3G weld position for week 16 (reference page 11 of
     24). Provide call out note on the graph.

   - Recent NCRs – T-Joint
     It was noted that QA found longitudinal indications located at the toe of the weld by MT inspection after
     ZPMC/ABFJV QC inspected and accepted the weld. By contract, Contractor is required to perform 25-
     100% MT inspection depending on the specific area. It was noted that some of the indications found by
     QA were not in the areas that were previously inspected by ZPMC/ABFJV QC.
     (ACTION) As a corrective action, ZPMC/ABFJV QC will perform 100% MT inspection on all T-Joint (CJP, PJP,
     Fillets) welds performed in trial assembly and segment assembly.
     (Panel Comment) The entire QC/QA process is working very well and resulting in a quality product.

   - Project Team Response Report (and supplemental)
     (ACTION) Karen to prepare the Final Project Team Response Report to include the following:
     - Incorporate SSPRP comments
     - Supplement- Meeting documentation from April 7, June 8/9, August meetings
     - Supplement- Meeting materials distributed (weld inspection data) from June 2011 and August 2011
       meetings

   - Closing SAS Steel Fabrication Expert Panel Meeting – 9am, August 25, 2011 at ABF Conference Room, Pier
     7
     o Draft Agenda
       1. Review of Status of TLI’s with new FCAW weld process
       2. Closing Statements from QC, QA and QA/QC Panel
       3. Bridge Tour
California Department of Transportation and
American Bridge / Fluor Enterprises, Inc., A Joint Venture
375 Burma Road
Oakland, California  94607

November 3, 2011

Dear Ladies and Gentlemen:

**Project:**    San Francisco Oakland Bay SAS Bridge Superstructure  
**Subject:**    Closing Statement by the QA/QC Fabrication Expert Panel

We, the QA/QC Expert Panel, have reviewed all data for welds of interest through November 3, 2011. It is our understanding that the steel orthotropic box girder (OBG) fabrication welding is complete and no further relevant weld data is expected.

The final submittal of welding data confirms the validity of our recommendations. Full implementation of these recommendations achieved the expected weld quality acceptance rate. Additionally, the project team’s effort to implement the recommendations of the Panel has achieved positive results on the quality of fabrication and accelerated the delivery of the OBG to the erection site.


Sincerely,

QA/QC Fabrication Expert Panel:

[Signatures]

Dr. J. Barsom

Mr. A. Cavendish-Tribe, CEng., FWeldI.

Mr. D. McQuaid, P.E.

Mr. D. Rager, P.E.
SAS Steel Fabrication Monthly Review Meeting
Location: Oakland
Draft Notes – 11/3/11

1. Introductions –All

2. Goals/Objectives


   Steve Lawton (QC Manager) presented the supplemental data to the group, including the QA/QC Expert Panel, and concluded that all rejectable indications were repaired.

   Mazen Wahbeh (Department Lead QA) concurred with the data presented and the conclusions drawn from the data.

   The Panel has reviewed the supplemental weld data to the March 31, 2011 Report and accepts the presented information and agrees with the conclusions drawn from the data.

   (ACTION) Add a cloud note to page 6 of 16 of Appendix K
   “It should be recognized that the weld data (between May 9, 2011 and June 3, 2011) included more difficult work among which include confined area, weld position, and access to the location.”

   (ACTION) Show the Appendix K graphs to have the same scales as in Appendix D.

   (ACTION) In Appendix K, pages 1-5, revise the 3rd to the last column to read “length of discontinuities” to match the wording of Appendix D.

   (ACTION) In Appendices E and L, all pages, Exhibit 4.2 and 4.2S1, change sub-column titles to:
   • “Rejected TLJ Indications”
   • “Rejected Non-TLJ Indications”

   Adjust legend in the footnotes to be consistent with the above edits.

   (ACTION) In Appendix D, page 1 of 13, Reference pg 2-4 Row, change “defect” to indication. (Perform search and replace word for entire document)

   (ACTION) Remove the color background from all tables on Exhibits 3.1 and 3.1S1

   (ACTION) Final report to show final changes without revision triangles.

4. Review of Changes to March 31, 2011 Project Team Report
   (ACTION) Final November 3, 2011 Report will incorporate all changes discussed and agreed to in today’s 11/3/11 QA/QC meeting. Final report will not show revision triangles.

   • Meeting Notes - QA/QC Expert Panel Final Statements
   • Draft of Final Statement Letter from Panel QA/QC Panel provided a signed final statement letter that will be inserted in the November 3, 2011 Final Project Team Report.

   (ACTION) Final November 3, 2011 Report will be distributed to the group by November 11, 2011.

6. Thank You/Closing
   This meeting successfully completes the assessment of quality of the SFOBB SAS OBG steel fabrication by the QA/QC Expert Panel and Project Team. No further meetings are needed.