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QUALITY ASSURED STEEL BRIDGE FABRICATION AND ERECTION

By

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Political expediency can lead to underestimating the complexities of the modern signature structure bridge design. Accelerated construction schedules can lead to a lack of communication by otherwise well intentioned people once a contract has been let. The net result could be physical or economic failure. This can be avoided by first specifying that the steel fabricator/erector be properly certified to accomplish the work. Secondly; the owner during the duration of the contract has the responsibility of providing sufficient qualified personnel to constantly monitor the work and aid in clarifying any misunderstandings between the parties.

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1.) Introduction

In 1998 a steel plate girder bridge crossing a busy freeway was in the process of being constructed. It was a conventionally designed structure consisting of four girders abreast and four continuous spans on a 3280-foot radius of curvature with a 230-foot center span. The concrete deck was designed to act compositely with the steel girders. The curved span crossed a multilane freeway that could be closed to traffic only on Friday nights, allowing only about eight hours of traffic-free erection time per week. As the freeway carried many thousands of vehicles per day the specifications did not allow falsework to be placed on or over the freeway. The construction plans clearly showed the camber values for the steel girders. The general contractor sub-contracted the fabrication of the girders to a structural steel fabricator, who used the camber values shown on the contract plans to fabricate the girders.

The contractor submitted an erection plan, as required by the specifications that was based upon erecting the girders with his own personnel and using only a few falsework supports, on the shoulders of the freeway and near the piers that would support the completed spans. The contractor’s erection plan was approved by the owner.

On a weekend night, the contractor attempted to erect the four girders over the freeway, but the cross-framing and the splice plates did not fit. The field ironworkers made temporary repairs so that the bridge could be opened to traffic the following morning. Surveys of the top flanges of the girders indicated that all of the girders had been placed too low. Analysis showed that the camber calculations for this project were based upon the computer’s default, no-load case, as if the steel girders and concrete deck were to be constructed on continuously supported falsework. After discovery of this error, the cross-frames and splice plates were retrofitted and/or replaced, the concrete deck was placed to a recalculated camber, and the bridge was opened to traffic a few months late.

The cause apparently was a combination of a design team inexperienced in steel bridge detailing, fabrication, and construction; poor communications; and reliance upon output from a computer program that did not take into account the actual erection method. It should be noted that industry no longer relies upon the master builder who oversaw both the design and construction of a bridge, but now employs multidisciplinary teams whose member are experts in the various disciplines required to design and construct today's complex bridge structures.

What follows are suggestions from a former steel fabricator/erector and Class "A" California general contractor on how the Owner's Quality Assurance personnel can best contribute to interworking of these teams. It should be recognized that in today's market they could well be a third party.

2.) Preparation of Shop Detail Drawings.

This phase starts immediately upon award of the contract and is essential to the ordering of the specified plain material from mill suppliers and performing the required fabrication shop work upon same. These drawings are produced by the Fabricator or his agent based upon the Owner's Contract Drawings, Standard Specifications, and Special Provisions, as well as material specifications and associated industry standards referenced by the Contract, such as the American Association of State Highway and Transportation Officials (AASHTO), the American Welding Society (AWS), and the American Society for Testing and Materials (ASTM). They will define and detail fabrication procedures, materials, dimensions, tolerances and testing. These procedures include cutting, welding, drilling, punching, cleaning, and painting of structural steel. Any Owner required specific fabrication procedures deviating from the standards of AWS and ASTM should be clearly stated in the Special Provisions. The Owner's approval of the Fabricator's Shop Detail Drawings is a verification that the drawings appear to be consistent with the Contract documents. "Approval" does not relieve the Fabricator of the responsibility for the accuracy of dimensions on Shop Detail Drawings or for complete submittals satisfying applicable Contract requirements; nor does it permit deviations from the Contract without the Owner's documented consent. Our bridges are becoming longer, wider, higher, and more complex. For the sake of being spectacular some new bridges will utilize structural systems never used before; even when well intentioned and trained engineers are performing these designs there are no precedents for them to use as sensibility checks for a potential fabrication process. This is creating an environment where an inordinate number of Requests for Information (RFI's) are being generated. How can this be mitigated?

The Shop Detail Drawing Review/Approval Guidelines Responsibilities Section of the AASHTO/NSBA Steel Bridge Collaboration Document clearly states the responsibility of the Contractor/Fabricator and the Owner. They must approach the submittal, review, approval, and distribution process as a team effort in order to ensure accurate and timely construction. They must maintain open lines of communication so that problems can be quickly addressed and resolved. Verbal discussions and agreements are to be encouraged and should be quickly followed by written confirmation. Efforts should be made to expedite information and drawings transmission, including e-mail, faxes and electronic file transmission when applicable. On major projects a so-called drawing campus could be established where all parties could have in-house representation. RFI's should indicate the urgency of a reply. The Owner or his outside Designer should provide a timely response or acknowledgement (explanation, decision, request for additional information, or estimate of the time required to evaluate), usually within two business days. The Owner/Designer should definitely be receptive to considering alternate fabrication methods or configurations proposed by the Fabricator that will result in improving or equaling the expected performance, maintenance and longevity of the structure, The Contractor's acceptance of any modifications that alter the finished product must be verified before submission to the Owner.

3.) Quality Assurance and Control on the Fabrication Shop Floor.

Rather than engaging in the time-consuming and costly process of qualifying a fabricator for an individual state, it is recommended that State Departments of Transportation (DOTs) should specify that steel bridge fabrication work should be performed only by shop facilities that are properly certified as major steel bridge fabricators (CBR) by the American Institute of Steel Construction (AISC). This certification program is widely recognized for its effectiveness in assuring quality. No matter how well implemented or effective the quality management system of a fabrication firm may be, periodic verification is required. In the case of fabricator approval based upon AISC Certification, this verification is made through a comprehensive audit to stringent industry-specific performance criteria by trained auditors and industry professionals. AISC utilizes the Quality Management Company, LLC (QMC) to audit fifteen areas specific to structural steel fabrication annually and more frequently when significant changes take place at a certified firm. These audits encompass quality management system documentation and on-site operations that include, in part, contract review, document and record control, material identification, process control, inspection and testing, and training. QMC auditors look closely for a demonstrated commitment to quality by assessing non-conformances with corrective action, internal audits, and management review of the quality management system. QMC assures high standards for AISC Certifications audits: personnel are carefully selected, regular auditor training is provided (including biannual formal training workshops), and fabricators are offered a different auditor for each scheduled audit to enhance objectivity. The cost of quality management system verification provided through AISC Certification is borne by the fabrication firm. A number of independent quality research professionals have found that the waste reduction and efficiency gain associated with providing higher quality on the shop floor usually lowers production costs and delivery time.

It is recommended that all parties agree to a Quality Assurance Plan (QAP) that the Owner's Quality Assurance Inspector (QAI) should where appropriate follow, including both inspection personnel employed by the Owner and contracted inspection personnel acting as agents to the Owner. The role of the QAI will be defined and general guide lines provided for monitoring Quality Control (QC) procedures, fabrication personnel qualifications, inspection status, equipment condition, record keeping, and final acceptance of the work. Although the QAI does not perform QC work, some Quality Assurance (QA) activities may duplicate a portion of QC activity for verification. Some DOT organizations require three levels of inspection/quality activities. First the fabricator's Quality Control Inspector (QCI), second an independent QCI hired by the contractor reporting both to the contractor and DOT, and finally the Owner's QAI. This is obviously redundant and costly. What is less obvious is that when the Owner has third-party QAI the situation can break down into an adversarial win or lose game as the third-party QAI tries to demonstrate his or her worth and that the others are not adequate. The cost and schedule impacts of the win–lose third-party QAI are significant. A more economical approach would be to create an objective, cooperative win-win situation with the fabricator's inspectors and the Owner's direct hire QAI. They must all be familiar with the QAP to better understand the QC operations of the shop. The fabricator has the obligation to provide and maintain proper facilities for the owner's quality assurance staff that ensure a reasonable amount of privacy and are reasonably close to the work. Access must be provided any time fabrication is in progress to allow interaction with the fabricator's QCI to verify the effectiveness of their evaluation of the work. The QAI's must perform verification inspection after the QCI has completed inspection and testing in accordance with the QCP. The Owner's QAI should provide daily reports to the fabricator that are as concise as possible and note any problems, concerns, or failures; and then listing all items that have been accepted. This will remove any ambiguity or mystery regarding whether or not there are issues that need attention and whether fabricated items are ready for shipment. Deferring final acceptance until the time of shipment can create serious cost and schedule problems. If there are problems, concerns or communication issues between the QAI and the fabricator, the Owner needs to have competent staff available to resolve issues in a timely manner. This usually means the same day or the next day. The fabricator needs to be allowed to communicate directly with the Owner's engineer, with copies to the general contractor, so that all issues can be resolved in a timely manner. However serious problems noted at any time or stage of the fabrication must be immediately reported to the QCI. Although QA inspection may include all aspects of the fabrication, the QAI must not supersede QC, which is the responsibility of the Fabricator. If QC is not accomplishing its role, the Owner and Fabricator must determine the necessary corrections. The QAI must be well aware of the

Contract Plans and Specifications. If conflicts arise regarding their interpretation or adequacy, the QAI must immediately seek guidance from the Owner and inform the QCI of the results of their discussion. An unrealistic or too literal interpretation of the Specifications can disrupt the project and lead to potential claim notices. The scheduling of inspection and other QA functions can have a significant impact upon the project. The QAI should follow these guide lines: coordinate with the QCI for anticipated production scheduling to determine timing and staffing needs; discuss the progress of the work with appropriate fabrication personnel designated during the prefabrication conference; schedule inspections in a timely manner to facilitate the fabrication process, especially if multiple shifts are used; discuss with the Owner whether additional presence in the shop is required; document problems with scheduling inspection, including inaccurate information from fabrication personnel and production delays. All parties must have a common objective: to produce fabricated steel members meeting all contract requirements in a timely fashion with minimum repairs. The Owner and the Fabricator should work together in a cooperative spirit, and develop relationships based upon mutual respect and trust. The Fabricator should inform the QAI when information is proprietary to avoid confusion. In general, the QAI should respect the Fabricator's intellectual property and not discuss its operations with other fabricators, even if the information is not proprietary. This would include the insertion of pictures of the shop facilities and layout in its reports as they then may be viewed by other fabricators which could negate any competitive edge.

It is essential that the QAI's have experience in steel bridge fabrication in addition to being a Certified Welding Inspector (CWI) in accordance with AASHTO/AWS D1.5, Bridge Welding Code. The following minimum years of experience are recommended by AASHTO/NSBA:

Project Type	Minimum Recommended Years of Experience
Rolled beam bridges	1 year
Welded Plate Girders	2 years
Complex structures; such as trusses, arches, cable stayed and moveable bridges.	3 years
Fracture Critical (FC) members.	3 years

Inspectors who have less experience than that specified above should work under the guidance of an inspector having those qualifications. Experience in rolled beam girder inspection should not be counted towards the experience needed for plate girder, complex, or fracture critical fabrication. The QAI must ensure that approved welding procedures are followed. This includes observing the QCI periodically monitoring the current and voltage. He should be aware that voltage varies over the length of the welding leads and that welding machine gauges often cannot be trusted. Current and voltage should be verified as close to the work as possible using calibrated ampere and volt meters.

Fabricators should have approved shop drawings before beginning work, but often shop drawings are not yet approved when the Fabricator wishes to commence in order to meet the Contractor's schedule. In such cases a request may be made to proceed with the Fabricator taking responsibility for any changes. Because holding up the Fabricator may delay progress in the field, the Owner should allow the Fabricator to proceed, provided that the shop drawings have been submitted and copies provided to the QAI. When the approved drawings are provided the QAI and QCI should coordinate with the Fabricator's detailer to define any drawing revisions and verify that changes are incorporated into the work.

4.) Transport and Erect.

Steel bridge erection is the process of transporting, handling, and assembling steel bridge components, resulting in a bridge structure that meets all the geometric and structural requirements of the Contract documents. The Contractor is responsible for coordinating delivery from the fabricating plant to the jobsite and providing adequate site access. The Contractor is also responsible for preparing a shipping plan indicating support, lateral bracing, and tie-down points for primary members during transport. Complex or monumental structures may require a more detailed shipping plan to avoid excessive stress or repeated stress reversals. Care should be exercised to avoid coating damage from slings, chokers or clamps. Fastener components should be shipped in sealed watertight containers with contents clearly listed on external tags. Store fabricated material on blocking above properly drained ground and keep material clean. Primary members should be stored upright and shored or braced for stability. Support all members to prevent permanent distortion or damage.

Fasteners and machine-finished parts should be stored inside covered structures or otherwise protected from the weather. Fasteners removed from storage should be installed by the end of the work shift. Return unused fasteners to storage at the end of a work shift or otherwise protect them from the weather. Welding consumables should be stored in accordance with the AASHTO/AWS D1.5 Bridge Welding Code. Any damaged structural steel should be reported to the Owner, including a description of the damage and the Contractor's proposed disposition (repairs or replace).

While preparing the erection drawings the Erector should communicate with the Designer to ensure that no undue stress is placed upon the permanent structure by its proposed erection scheme. The in-state Professional Engineer preparing the detailed erection procedure shall be qualified by knowledge, training, and experience in steel erection and should have attended any Owner scheduled prebid and preconstruction meetings. The procedure shall address all requirements for erection of the structural steel into the final as designed configuration and satisfy all written Owner Documents prior to the start of erection. The procedure, as a minimum, shall include the following information:

a) Plan of the work area showing permanent support structures (piers and abutments), roads, railroad tracks, waterways and navigation channels, overhead and underground utilities, and other information pertinent to erection
b) Erection sequence for all members noting any temporary support conditions, such as holding crane positions, temporary supports and falsework. It should indicate specific cross frames or lateral bracing required by stability calculations. Piece marks of the erection drawings should be the same as used on the shop detail drawings
c) Primary member delivery location and orientation
d) Location of each crane for each primary member pick, showing radius and crane support (barges, mats, etc.). On navigable waterways, the configurations of the barge(s), loading sequence, stability provisions (tie downs, piles), and calculations
e) Capacity chart for each crane configuration and boom length used in the work
f) Center of gravity locations for primary members
g) Detail, weight, capacity and arrangement of all rigging for primary member picks
h) Lifting weight of primary member picks, including all rigging and pre-attached elements
i) Details of any temporary lifting devices to be bolted or welded to permanent members, including method and time (shop or field) of attachment, capacity, and method, time and responsibility for removal
j) Bolted splice assembly requirements
k) Lifting/handling procedure for any primary member defined as slender, that is lifted length divided by width greater than 85
l) Blocking details of bridge bearings to limit movement and/or rotation during the erection of a single girder
m) Design calculations to criteria established or approved by the Owner indicating the load capacity and verifying the stability of temporary supports for structure and crane(s) for each pick and release
n) Calculations to substantiate structural adequacy and stability of girders for each step of bridge assembly. Complex projects may require input from the structural designer in addition to the original design calculations such that the Contractor can confirm constructability of the structure during various erection stages. The Owner should ensure that the structural designer is available to consult with the Contractor in these cases
o) Calculations to verify adequate capacity of Contractor fabricated rigging such as lift beams, welded lugs, spreader beams and beam clamps. Submit manufacturers' certification or catalog cuts for pre-engineered devices

The Owner and Contractor should be aware that they can communicate directly with Ironworker Management Progressive Action Cooperative Trust (IMPACT) which is currently working with AISC to encourage participation by their members in the Erector Certification Program. A Qualified and Competent Erection Contractor will have knowledge, training, and experience; and will have demonstrated technical proficiency and ability to complete the work specified. The Contractor should be able to resolve common problems associated with the complexity of the proposed work. It is recommended that AISC Advanced Certified Steel Erectors certification be required for complex bridge structure types, such as suspension, cable-stayed, tied arch, cantilever truss or moveable bridges. Complex erection projects may require input from the structural designer in addition to the original design calculations such that Contractor can confirm constructability of the structure during the various erection stages. This may include construction activities that occur concurrently with steel erection, such as setting forms or concrete deck pours. The Owner should ensure that the structural designer is available to consult with the Contractor in these cases. The Contractor should coordinate activities with the Owner/Engineer, Fabricator and Erector. Special coordination requirements may be included in the Contract. These could include review and approval by other agencies for maintenance and protection of traffic, waterway navigation, school bus and emergency vehicle routes. Discuss current certification program and any pending changes. Safety measures (emergency boat and notification plans), coordination plan for regulatory agencies and other water traffic, and anticipated schedules of obstructing the navigable channel should be prepared and published.

Jobsite conditions vary on a daily basis and often are not as they were anticipated to be when the erection scheme was conceived and submitted to the Owner. Consequently the need to deviate from the approved erection procedure may arise during the course of a bridge project. It is the Contractor's responsibility to erect the steel in a safe and efficient manner and within the crane manufacturer's rated capacity for all positions. Girders shall be stabilized with falsework. Temporary bracing, and/or holding cranes will be utilized until a sufficient number of adjacent girders are erected with diaphragms and/or cross fames connected to provide the necessary lateral stability and to make the structure self-supporting. All trusses shall be erected on falsework, unless approved by the Owner. When erecting trusses on falsework it shall remain in place until all connections are completed and the truss is self-supporting. Falsework and temporary supports shall be designed to ensure that the temporary elevation of the supported steel accommodates the deflections expected to occur as the structure is completed. Removal of falsework, temporary bracing and holding cranes shall be in accordance with stability calculations provided in the erection procedure. If dead load beyond that of the steel is to be applied to the structure while temporary supports remain n place, they must have provision to be lowered or "jacked down."

As stated in the AASHTO/NSBA Steel Bridge Collaboration Erection Guide Specification primary member bolted splice connections that are made up on the ground (prior to erection) shall be 100 percent complete in the no-load condition prior to any lifting operation. For bolted splice connections fill at least 50 percent of the holes prior to crane release. The 50 percent may be either erection bolts in snug tight condition or full-size erection pins, but at least half (25 percent of all holes) shall be bolts and shall be uniformly distributed. Permanent bolts may be used as erection bolts provided that they are installed in accordance with the Specification for Structural Joints Using ASTM A325 or A490 Bolts by the Research Council on Structural Connections (RCSC) referred to hereafter as the “Bolt Specification”. No loose mill scale, dirt, metal shavings or any other foreign material that would preclude solid seating of the parts or frictional transfer of load is allowed on faying surfaces of bolted connections. The steel fabricator is normally responsible for faying surface preparation but the erector must keep them clean during erection. Pins are normally used to align holes for field bolted connections. Field reaming to facilitate fit-up will only be allowed with the Owner’s prior permission. Fully tighten all bolts in the bridge by completion of steel erection in accordance with the Bolt Specification. This should be accomplished before exposure to the elements affects their rotational capacity test characteristics. The Erector should inventory and review bolt installation with its field crews. They should all be involved in pre-installation verification which confirms not only the suitability of fastener assemblies but also the bolt crew understanding of the installation procedure that will be used (RCSC 7.1). Everyone should understand what covered and protective storage means with respect to structural fasteners. Also review both the RCSC and where appropriate FWHA Rotational Capacity testing procedures. This can go a long way toward avoiding uncertainty which can subsequently lead to arbitration testing of fastener installation.

The Owner’s representative should be physically present in sufficient and qualified force to physically observe all of the foregoing; and to verify material quality, damage repair, and conformance to plan dimensions and assembly requirements. These personnel should be physically capable of accessing high steel work and be trained in safety procedures.

Bridge field welding is not customary in many states. D1.5 is written mostly to cover shop fabricating structural steel members. The Erector should review the required Welding Procedure Specifications (WPSs) and corresponding Procedure Qualification Test Records (PQRs) where appropriated. These documents should then be placed in the hands on the individuals who will do the work. Field welding structural steel bridge members presents environmental and geometric conditions that exceed those of the shop. Rain, humidity, temperature and wind are examples of conditions that cannot be controlled in the field as they are in the shop. Difficulty in steel fit-up, physical access to the joint by the welder, and welding position are geometric constraints that can adversely affect the quality of the weld. Erectors normally do not weld joints in Fracture Critical members but they may find situations where they are instructed to weld attachments to members designated as Fracture Critical. An awareness of how to spot Fracture Critical member notations on erection drawings may prevent the need for expensive weld testing, repair or rework. However despite these challenges, experience in constructing numerous major bridges over the past fifty-plus years, particularly in California, has shown that field welding can readily be accomplished successfully by experienced Contractors. If field welding is to be properly visually inspected and nondestructive testing (NDT) performed in accordance with D1.5 the Owner should be prepared to furnish uniquely qualified QAIs with field construction experience. This experience is necessary for them to safely and efficiently access the work in progress.

5.) Example and Summary

A recent example of how lack of proper communication and adherence to proper QA led to a Contract Dispute occurred recently at an in-state fabrication facility that was engaged in fabricating a total of twenty-nine heavy wall steel pile shells for the E2/T1 footings of the new San Francisco-Oakland Bay Bridge Self Anchored Suspension Span (SAS). These piles were fabricated from flat steel plate. Individual plates were rolled into short tubular sections and welded along a longitudinal joint (long seam) by the semi-automatic submerged arc welding (SAW) process. The short tubular sections, or cans, were then joined together by the automated SAW process at the girth seams to form full-length pile sections. The SAW process is a long-established welding technology covered fully by the Provisions of AWS D1.1, 2002. It is characterized by high weld metal deposition rates, fixed or semi-fixed remotely operated equipment, and suitability to production line welding of heavy steel fabrication. At this fabricator's facility SAW is performed at fixed production stations utilizing powered manipulator booms and turning rolls operated remotely by the welding operator.

The Fabricator had a long-established practice of placing new welding operator trainees with an experienced and qualified welding operator on the shop floor to learn the SAW operation. The trainee works with the experienced operator starting with simple tasks and progresses through supervised operation of the welding station as the trainee's skill and aptitude increases. As the trainee is working with the experienced operator on permanent work, the qualified operator remains with the work and is the welding operator of record. Once the trainee becomes sufficiently proficient he or she will perform a qualification test in accordance with AWS D1.1 and contract requirements. The welding operator is permitted by contract provisions to perform work on the project without restriction after successfully completing the qualification test. It had utilized this practice on California Department of Transportation (Caltrans) projects since 1998 while fabricating piling for projects on the San Mateo-Hayward, Carquinez, Richmond-San Rafael and Benicia-Martinez Bridges as well as for the three months during the initial stages of the E2/T1 Contract. There were no significant language changes in the E2/T1 Special Provisions regarding the requirements to use qualified welding operators or the use of trainees in production welding. On these projects welding operators were trained without conflict to following Special Provisions and AWS Code:

a.) All requirements of the AWS welding codes shall apply unless specified otherwise in the Standard specifications or on the Contract Plans. Wherever the abbreviation AWS is used, it shall be equivalent to the abbreviations ANSI/AWS or ANSI/AASHTO/AWS.

b.) A system for identification and tracking of all welds, Non Destructive Testing (NDT) and any required repairs, and a procedure for the re-inspection of any repaired welds. The system shall have provisions for permanently indentifying each weld and the person who performed same; and placing all identification and tracking information on each radiograph.

c.) Documentation of all welder certifications for each weld process and position that will be used. Certifications shall list the electrodes used, test position, base metal and thickness, tests performed, and the witnessing authority. All certifications shall be within the allowable period of effectiveness.

d.) A daily production log for welding shall be kept by the QCM for each day that welding is performed. The log shall clearly indicate locations of all welds; and shall include the welder's names, amount of welding performed, any problems or deficiencies discovered, and any testing or repair work performed at each location. The daily report from each QCI shall also be included in the log.

e.) The period of effectiveness for a welder's or welding operator's qualification shall be a maximum of three years for the same weld process, welding position and weld type. A valid qualification at the beginning of work on a contract will be acceptable for the entire period of the contract, as long as the welder's work remains satisfactory.

f.) All qualification tests for welders, welding operators, and welding procedure specifications used in welding operations will be witnessed by the Engineer, or by an independent third party acceptable to the Engineer.

During the performance of these contracts all Caltrans inspection work was performed by their in-house Materials Engineering and Testing Services (METS) personnel. During the middle of the Benicia Bridge Contract State METS employees were no longer being used on Toll Bridge Contracts. Instead outside inspection firms were retained by the State and directed to furnish QAI. Welding Operators were trained without conflict to the Special Provisions and The AWS Code.

When pricing the bid item for furnishing fabricated piling to the Contractor for the SAS E2/T1 project the Fabricator relied upon the standards established for the training of Welding Operators on the aforementioned projects. However upon award of the contract and commencement of the work they were notified that these third-party inspectors objected to welding trainees coming in contact with the SAW welding equipment while in operation. Starting in December of 2005 a series of Non-Conformance Reports (NCR's) were generated by these inspectors for operation of SAW welding stations by trainees even though the qualified welding operator of record was in full control of the welding operations. With one exception where a trainee was allegedly left without supervision, the trainees were cited as unqualified welders. The fabricator objected to the position of the QAI at bi-weekly coordination meetings during December 2005 and January of 2006. The Fabricator was then compelled to alter its long-established fabrication practices and exclude trainees from production operations. Separate training-only stations were established and training was performed off-line until after the trainees passed a welding operator qualification test. However the trainee issue continued as a constant disagreement with additional NCR's written. The Fabricator filed a Notice of Potential Claim (NOPC) in June of 2007.

The simple basis of the NOPC was the action of the outside QAI interpreting contract terms that were silent on the use of trainees; and doing so in spite of long-standing precedents on Caltrans work involving trainees. In an effort to avoid additional NCR's the fabricator removed valuable production assets and manpower from its operations to be devoted exclusively to training. Due to limited training facilities the rate at which trainees became available was reduced. As a result pile production durations were extended and deliveries to the jobsite delayed. The fabricator attempted to mitigate delays by re-tooling portions of its plant. Additional testing was demanded by the outside QAI for acceptance of the work declared by them to be in non-conformance. These factors and the related higher overhead costs increased the unit cost of the work.

This claim was subsequently referred to the Disputes Resolution Board which, after review of the specifications for the referenced projects, concluded that no significant language changes were evident regarding the requirements to use qualified welder operators or regarding the use of trainees in production welding. Consequently they found that it was not unreasonable for the fabricator to assume that its traditional trainee program would be acceptable to Caltrans on the SAS E2/T1 Contract. The Board recommended reimbursement (currently estimated to be in excess of $1,000,000) for the additional costs resulting from the actions of the outside QA firm. Was the generation of this dispute due to a lack of knowledge and training and/or certification in the Steel Bridge fabrication process on the part of this particular firm or a potential make work action? Whatever the answer this resulting negative impact to the overall project completion can only be mitigated on similar future contracts by the Owner; and it is his responsibility to do so.

Special outside Inspection may not be the best way to achieve construction quality. Built-in construction quality can be achieved through quality management systems that provide both quality assurance and quality control. Inspection is quality control and by itself is insufficient for achieving construction quality. Without a quality assurance function to act upon and correct the processes that produce defects discovered by inspection, construction quality, as well as cost and schedule, suffer. Quality suffers because repair of a defect discovered during construction seldom matches what the first time quality would have provided. Outside the normal fabrication process limitations on resources and skilled workers often necessitate a less than ideal "fix" to correct a defect. Schedule is consumed in the development, approval and execution of this "fix." Usually there is an increase in overall construction cost due to wasted material and production hours, and also due to the management effort or transactional costs required to address this issue.

Finding non-conformances post-production can be costly to fix, especially if the product is a steel truss already on the jobsite. This is why it is recommended that the QAI provide daily reports to both parties stating the items that have been accepted. Second guessing at the time of shipment or even worse, at the jobsite, is extremely costly and destructive to schedules. When the differences between certification and inspection are understood they can complement each other and add measurable value to a bridge project. Unfortunately, too often they are confused and one is called upon to replace the other. You can only build quality in, you can't inspect it in. When the Owner specifies an AISC Certified Fabricator it is clear what they will receive and how it will contribute to the quality of the project. Special inspection agencies cannot be expected to replace fabricator provided Quality Assurance and Quality Control, particularly that provided by the quality management system of an approved fabricator. This is particularly true in welding where joint preparation and fit-up are important. Special inspections should be used to supplement a fabricator's quality management system rather than duplicate or replace it.

In conclusion it is recommended that the Owner rely upon an approved fabricator's effective quality management system to provide quality assurance and quality control. The Owner should clearly communicate in construction documents to the fabricator requirements for specific inspections and inspection reports. The individuals doing the work are in the best position and may be the best qualified to do it.

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Shown here on the right, Jay Murphy is a Life Member of ASCE, a Life Industry Member of SEAONC, and holds a personal California Class "A" Heavy Engineering Contractor's License. He spent thirty years working in all departments of his family-owned company and was elected president in 1970. The company ceased fabrication and erection operations in 1983. He now serves as chairperson of Dispute Resolution Boards and also consults in the area of construction claims and cost estimating.

Others shown, left to right, are Mike Foley, Chief Engineer of the Division of Bay Toll Crossings; Jim Moe, Caltrans Director; and Howard Schirmer, Regional Engineer for the AISC.

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