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FIELD WELDING FOR BRIDGE REHABILITATION

by

James K. Merrill

Law Engineering Co.

Atlanta, Ga.

I. INTRO

~Different than new construction
~Designer needs to communicate with contractor, welding engineer

II. MATERIAL I.D.

~Review records - with ok, w/o test
~If w/o - select chemical sample locations of test
  - review for welding metallurgy
~If weldable, select physical sample locations
  - Mech. Testing
~ASTM Classification
~Conclude if prequalified procedures are possible

III. ESTABLISHING WELDING PROCEDURE

~Contractor's Process - portability, access, environment
~Review drawings for joint design
~Develop procedure
~The procedure may or may not be prequalified

IV. ANTICIPATE PROBLEMS

~With process - electrode size, storage, shielding gas
~Restrictions - site, geometry, joint access
~Solutions

V. NDT

~Purpose detect interval defects, structural integrity
~Tests - UT vs. RT, MT vs. PT
~Visual

VI. CONCLUSIONS

I. INTRODUCTION

Bridge rehabilitation presents very challenging and difficult engineering problems. Typically, bridges scheduled for rehabilitation are old structures with long service lives, often well past the original design life. These structures often suffer from neglect, and are in hostile, aggressive environments. The result is a structure that has severe corrosion damage and is detrimentally effected in many ways, and often very severely.

The same field conditions that cause the deterioration create many difficulties during welding for rehabilitation. Wind, rain, tides, access restrictions, and corrosion products all combine to make successful field welding extremely difficult to achieve. These difficulties are not normally present for bridge shop fabrication. The design codes and specifications do not lend themselves to directly apply to rehabilitation projects. AWS and AASHTO outline requirements that can be extremely challenging to comply with during rehabilitation; however, most requirements can be met, if the rehabilitation team of designer, contractor and welding engineer are willing to work together in a creative fashion.

The first stage in a successful rehabilitation is a conscientious, thorough design, utilizing a detailed existing bridge condition survey. The designer must then clearly communicate his intent with drawings and specifications. The drawings must be accurate since the existing materials and dimensions can greatly effect the contractors work.

During the preparation of his contract documents, the designer should at least make preliminary contact with the contractor and welding engineer. This contact can include reviewing rehabilitation and repair ideas or procedures to make sure that the final contract documents comply with the codes and specifications. The purpose of this paper is to review the steps and processes where the designer and welding engineer work together. This team approach is absolutely necessary to achieve a design that complies with the AWS D1.1 Structural Welding Code and AASHTO, allows use of standard welding equipment and processes, and can allow for applicable nondestructive testing (hereafter referred to as NDT) of the completed weldments.

II. MATERIAL IDENTIFICATION

The welding procedures and the welding processes utilized in the rehabilitation of bridges will be directly affected by the material utilized in the fabrication of the structure. A problem that is often encountered in rehabilitation projects is the loss or absence of records pertaining to the structure. Often the only means of material identification is by chemical and mechanical testing.

To perform the tests required to identify the material, chemical and mechanical test samples must be procured from the structure. The location for the removal of suitable samples must be determined by the structural engineer. This will ensure that the samples were not removed from an area that would be injurous to the integrity of the structure.

Testing for chemical content will typically lead to an ASTM specification to which the tolerances of the chemistry will match the findings of the chemical analysis. The material classification is then further supported by mechanical testing. The mechanical test results are compared to the mechanical requirements outlined in the ASTM specification.

The primary hope in performing this testing is that the material will test to be one of the prequalified materials listed in Section 9 of the AWS D1.1 Structural Welding Code. If the tests indicate that it is one of the materials listed, then the welding procedure may be written as a prequalified welding procedure. This will considerably reduce the amount of testing and lead time needed to have qualified welding procedures. This will, of course, lead to fewer delays and lower cost to the contractors involved in welding.

If bridge documents are available then they need to be reviewed to determine their accuracy. If there is any question as to the material type, it is recommended that the above procedures be utilized to prevent future field welding problems. It is also recommended that a thorough investigation be performed to be certain that the structure is homogenous in material type. This may be very important for older structures, constructed when there was not as high a quality control on steel manufacturing as there is today.

III. WELDING PROCEDURE

The development of a welding procedure can take two very different approaches, as outlined by AWS D1.1 and AASHTO, i.e. prequalified or non-prequalified. The preferred approach is a prequalified procedure. To have a prequalified procedure, it must meet a certain criteria outlined in AWS D1.1 Structural Welding Code and/or as notified by AASHTO. The joint welding procedure requirements will be found in Sections 2, 3, 4, 5, and 9 for bridges and Section 7 for stud welding in code editions later than 1980.

It is of particular importance that the design engineer be familiar with Section 2 of these codes. If the designer does not specify a joint that is prequalified, of course, it will be impossible for the welding contractor to meet the requirements of a prequalified welding procedure. This is an unfortunate situation, particularly when all of the other elements that go into the procedure meet the prequalification requirements. If the design engineer will consult with the welding engineer in the early stages of design, this unfortunate situation can be avoided.

If all the material and joint requirements meet the criteria of AWS D1.1 and/or as modified by AASHTO, it then becomes the responsibility of the welding contractor to tailor his procedures around the limitation of variables set forth in the various sections of these codes. At this point it is essential that the contractor choose a process that will be suitable to the field conditions that will be encountered. For example: fully automatic submerged arc welding (S.A.W.) would probably be a poor choice for field implementation in the highly restricted hostile environment of the underside of a bascule bridge. Whereas the portability and versatility of shielded metal arc welding (S.M.A.W.) would make it a very good choice in the same situation.

The choice of a particular process must be made with all the various components that go into that process in mind. If the contractor chooses S.M.A.W., then he must also realize that low hydrogen electrodes must be utilized when welding on a bridge. This also means that he must provide appropriate storage facilities as outlined in Section 4 of AWS D1.1. However, if he were to choose gas metal arc welding (G.M.A.W.) then low hydrogen electrodes or storage would not be a problem. This would present a very different set of problems. Getting equipment to the weld joint, joint root accesses due to gas cup interference, the wind blowing shielding gas from the weld pool, and the possibility of not being able to obtain the proper filler metal transfer i.e. shortcut, globular, or spray. Therefore, a little preplanning will prevent possible serious and expensive problems when performing the field welding.

There is the possibility of coming into the situation of having a material that is not considered prequalified This can present a problem, particularly for the inexperienced contractor. This is where a little homework and preparation can really pay off. The steps required for performing a procedure qualification are outlined in AWS D1.1 Structural Welding Code and/or as modified by AASHTO.

There is one major obstacle that must be overcome in preparing to perform a procedure qualification, "where do I get the material to perform the test?" This is where preplanning may really pay dividends. In most bridge rehabilitation projects, some steel will need to be removed in order to replace existing members. Therefore, if the contractor will go ahead and put in place jacking steel so that existing members can be removed safely, the steel that was removed may be used to perform the procedure qualification.

The contractor will need to complete a welding procedure specification before doing any welding on the test coupon. It is recommended that the welding engineer be active in participating in either the writing of the welding procedure specification or at the very least, a review before any welding is performed. This will help in the prevention of costly delays. Also, remember material to perform these tests may be difficult to come by. Therefore, it is imperative that no material is wasted because of a poorly written or documented welding procedure.

If the steps outlined in the codes are followed, procedure qualification can be performed with little difficulty and minimal expense. The key to successful procedure qualification is in preplanning.

IV. ANTICIPATE PROBLEMS

During design and initial material testing, the designer and welding engineer usually develop a feel for the project "weak points". These are areas of the project that, based on experience, may be difficult to achieve acceptable welding. A good designer is cognizant of these weak points as they develop. These weak points can include performing the actual joint preparation, the welding process and restrictions around the point of welding. It is important for the designer to ask himself the question, "Can this be performed in field conditions?"

Joint preparation and fit-up is essential to develop a sound weld, however this can be difficult to achieve in a field situation. With the corrosion of some members, very little "clean, white metal" may exist. Hopefully the designer has anticipated this situation in the drawings, using information gathered during the condition survey. Further, joint preparation is difficult with existing members since the member cannot be moved to gain equipment access for beveling and grinding. However, code acceptable fit-up is possible in almost all cases.

Once preparation and fit-up is completed, welding begins. There are a host of site conditions that are detrimental to field welding. Depending on the contractor's process, wind can blow shielding gas from the intended area, stick electrodes may be too large for adequate penetration, low hydrogen electrodes are typically a poor penetrating electrode, GMAW or FCAW equipment may not fit into restricted areas. These are just a few of many examples where poorly engineered welding procedures could produce internal defects or prevent sound welding practices.

A pre-construction conference specifically to discuss welding is often a major step in reducing and anticipating these problems. With the designer, welding foremen and welding engineers together, all three parts of the team can constructively discuss anticipated problems and together in a positive atmosphere develop creative solutions to seemingly difficult problems.

V. NON-DESTRUCTIVE TESTING (NDT)

The purpose of non-destructive testing (NDT) is to detect internal weld defects and to determine the integrity of the deposited weld. The designer is responsible for specifying the NDT methods utilized on the project, and their specific application locations. However, when specifying the methods, the designer should consult with the welding engineer so that the code and AASHTO requirements are fulfilled, and NDT methods are not incorrectly specified.

During all phases of repair, fit-up, and welding, a full-time CWI inspector should be present at the site. This inspector plays a key role, assuring that the welding procedures are correctly applied. He can also provide up-to-date technical information to the designer or welding engineer as the project progresses.

After welding, NDT is performed. Of the four test procedures outlined by AWS, ultrasonic testing (UT) and dye penetrant (PT) are usually the most practical test methods for field utilization. UT can detect subsurface defects in full penetration groove welds, while PT is used to identify surface defects in fillet welds. Used correctly by qualified personnel in conjunction with full-time inspection, code quality weldments can be readily achieved.

Normally radiographic testing (RT) and magnetic particle testing (MT) are not performed in the type of conditions encountered on in-place bridges. RT involves the use of radioactive materials that emit gamma radiation. During RT, this radiation can require the barricading of waterways and nearby streets, and temporary evacuation of the site during <u>each</u> test. Thus RT must be carefully considered before it is specified. MT requires the use of large electrical current and very fine dry powder. Due to water proximity, high humidity and wind, and poor weld surfaces, MT is generally not performed for safety and usefulness limitations.

VI. CONCLUSIONS

From material identification to nondestructive testing, field rehabilitation presents challenging, but surmountable problems. The key to the prevention of costly and embarrassing delays is the cooperation and communication of all the rehabilitation team members. Some forethought and planning will allow the project to run smoothly and efficiently. The entire system can and will break down if key players do not function in a responsible and timely manner. If the concepts discussed in this paper are utilized, the field welding will be brought to a workable and understandable level.