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Upgrading the Welding Module in the B.Eng Programme at the University of Technology, Jamaica (UTech)

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Abstract
A case study of the collapsed welded structure of the walkway at the post of Ramsgate in the United Kingdom in 1996 is used to bolster the paradigm shift in welding education that is needed to straddle the scientific and technological developments of the last decade.

Furthermore, the paper describes changes in the welding module in the B.Eng (Mechanical) programme offered in the School of Engineering, at the University of Technology, Jamaica. The paper gives an account of the collaborative initiatives between UTech, Jamaica and the Welding Institute in developing the curriculum and testing.

Keywords

Welding Programme, The Welding Institute, Welding Procedures, Welding Processes

1. Introduction

Welding and Joining has developed continuously over the past century and over much of that time has been the preferred process for the fabrication of steel structures including pressure vessels, bridges and building frames. Over the last 50-60 years extensive research and development has resulted in an increased understanding or the knowledge required to produce satisfactory welded structures and the ability to fabricate such structures. [1,2]

However, failures still occur in welded structures of all types. Minor failures do not get reported but a significant number of failures result in significant financial losses and, even more significantly, injury and death.

A major cause of failures lies in the view of many engineers that welding is a manual craft and is not an engineering discipline. Many educational courses leading to the qualification of engineers pay little, if any, attention to the significance of welding. Most design courses in engineering education ignore welding and joining. In a small island state such as Jamaica, engineers are consistently called upon to be multifaceted in their approach to solving engineering problems. Therefore an infusing of welding as a science is included at the undergraduate stage.

2. The Ramsgate Walkway Disaster

It is possible to identify many of the problems that can occur due to the lack of perspective that many engineers have about welded fabrication.

In 1996 a walkway collapsed in the Port of Ramsgate after only a very short time in the service [3]. The result was six (6) deaths and seven (7) serious injuries in addition to lengthy delays in port services.

The walkway connected the passenger terminal building to ferries to allow embarkation and disembarkation of passengers and their luggage; it was movable to allow ferries to connect to the dockside. The main structure was built from steel sections and clad with 6mm thick steel plate. The steel was conventional carbon manganese steel with a carbon content below 0.24%. This steel is readily weldable provided that suitable precautions (hydrogen controlled consumables, application of preheat and post weld heat treatment) are applied during fabrication. Where the walk connected to the terminal building, medium carbon (circa 0.4%C) steel rods were welded to the walkway to allow for wear and load variations during service. Steel with this carbon content is recognized as presenting difficulties during fusion welding and suitable precautions are essential.

The design, fabrication and erection of the walkway was carried out by a Western European company with a good reputation. The company quoted the appropriate standards and codes of practice and the design, fabrication and inspection were approved by an international approval organization.

So, what went wrong? At the design stage, the hardening effect of the weld thermal cycle was not considered. In particular, the hardenability of medium carbon steel was ignored, which led to embrittlement and hydrogen induced cold cracking. In addition, the variable loading on the walkway, which could, and did, lead to fatigue failure was not identified so that many partial penetration welds were included in the design. Finally, the need for careful inspection and non-destructive testing to identify and rectify potentially dangerous weld defects was not appreciated, so that the walkway was put into service with defects that could, and did, lead to fatigue failure and collapse.

After the collapse, investigations showed that the failure occurred by fatigue of a cracked welded joint between a medium carbon steel rod and the main frame.

A commission of enquiry identified problems of defective design, fabrication and inspection that had occurred. It appeared that no one involved in design, fabrication and inspection of the walkway identified the potential problems although a competent engineer or metallurgical engineer would have expressed concern immediately.

3. Requirements Of Background Knowledge For Engineers

The basic problem for engineers involved in the design and fabrication of welded steel structures is the range rather than the depth of knowledge required. This section attempts to identify that range of knowledge.

3.1 Material Selection

There is a large number of steels produced and used in welded fabrication. These steels may have ferritic, pearlitic, martensitic or austenitic structures; they also exhibit a range of responses to the thermal cycle involved during welding. A steel will always be selected for a given structure based on the service requirements. However, it is equally important that the steel properties required can be maintained during and after fabrication.

3.1.1 Design

The design of a structure to be fabricated by welding requires the assurance that the metallurgical properties of the steel selected can be maintained during the service life. Depending on the service required from the structure, attention may have to be given to the static and dynamic loading of the structure, service temperature, ease of fabrication and ability to inspect the structure both during fabrication and subsequent service life. Additionally, service conditions have to be considered and effect of stress fluctuations (fatigue) and temperature variations (brittle fracture and creep) allowed.

3.1.2 Welding processes

A basic knowledge is required of the welding process. In arc welding the process applies a thermal cycling of the steel and melting and resolidification in the fusion zone, generally with the addition of additional steel from the welding arc. The arc atmosphere may not be completely inert so that the thermal cycle may result in some chemical changes in the weld composition.

3.1.3 *Welding procedures*

The welding procedure is at least as important as the welding process in controlling the properties of the welded joint. The use of preheat is essential in many situations, especially with thick sections, whilst multi-run welds can significantly improve weld metal structures and reduce the size of the heat affected zone. Post weld heat treatment may be essential to ensure that the required properties are obtained in the welded joints.

3.1.4 Inspection and quality assurance

Weld defects can cause failures in welded structures both during fabrication and during service life. It is therefore essential that the structure can be inspected by one or more of the available non-destructive testing techniques. This requirement may impose restriction on the design and during fabrication because of the need for inspection.

3.1.5 Inspection during service

It is also essential that the design and fabrication of any structure allow for in-service inspection. In many cases an annual inspection is required for insurance purposes. In particular, the design must allow adequate access for inspectors and non-destructive testing equipment.

4. The Synergistic Welding and Joining Technology Course – TWI/UTech

From the foregoing, it is clear that the formation of an engineer would be improved if engineering curriculum was so designed to encompass the points raised. To this end, the University of Technology, Jamaica (UTech), School of Engineering is the only University outside of the United Kingdom to have collaborate with the Welding Institute, United Kingdom) to offer a course (within the undergraduate engineering programme), that will lead to the Welding Institute Certificate for students who are successful in the examination. [4]

The following benefits are realized from this collaboration:

1. A Lincoln Electric, UK, Prize of £500 is given to the student with the best Welding and Joining examination results;
2. Promote Welding as a key industrial technology governing reliability and safety of many products;
3. Promote the importance of welding technology in Jamaica, construction codes and manufacturing standards;
4. Engineers to understand welding processes, selection of materials, design for welding, fabrication, service performance and quality management;
5. The Welding Institute, with the support from UK industry assist with course material;

6. Students who are successful at examination will be given free membership of the Welding and Joining Society for one year and will receive a bimonthly journal. In addition, Graduate Membership of the Welding Institute to all those who complete the course and graduate.
7. The Welding Institute will award a Certificate to students who complete the course successfully.
8. The Certificate will demonstrate an understanding of welding potential employers and will be a valuable addition to an Engineering degree.

The first set of students took the Welding Institute examination in 2005 where 75% of the students were successful.

5. Conclusion

A scientific and technological approach in the training/education of welding is essential to reduce the number of failures in welded structures and thus eliminate injuries to personnel and significant financial losses. A paradigm shift is necessary in the education and training of engineers to include welding and joining design courses.
The basic introductory welding module covered the general knowledge discussed in Section 3 of this paper, which takes some 20-30 hours.

The aim of this course is not to produce specialist welding engineers but to enable all engineers to be able to identify potential problems at all stages of design, fabrication and use of welded structures. Once such a problem has been identified, specialist engineers could be asked to propose any necessary modifications in procedure.

References

'Industry Leaders Look into the Future,' Welding Journal, Vol. 73 (6): 49-59, June 1994.

Cary, H.B., 'The Importance of Being a Welder' Welding Journal, 73 (10): 56-67, October 1994.

Apps, R. L, Crossland, B. Evans, C and Fenn, Killer consequences of Detective Welds, TWI Bulletin, March/April 2002.

Collaboration between TWI and UTech, letter of June 2005.

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