Eastern Counties Branch of the Welding Institute

Event: Lecture

Subject: Lessons from Catastrophic Weld Failures.

By: Dr Geoff Booth CEng FWeldI

Venue: TWI, Granta Park, Great Abington CB21 6AL

Date: Wednesday 16 March 2016

Report by: J Weston, Hedges, Lodge Road, Walberswick, Suffolk IP18 6UP Tel: 01502 722584, Email: weston559@btinternet.com

---

Welding is an enabling technology that is fundamental to many economically vital and visually exciting structures such as bridges, ships and offshore structures. Society expects these structures to perform safely for many years. The consequences of these structural failures can be devastating. In his presentation Geoff reviewed catastrophic failures in a number of structures describing the main engineering reasons for the failure. He outlined the lessons that have been used to develop current engineering design practice.

Geoff commenced his presentation by defining an engineering structure as one that *carries loads or contains pressure and fulfils specified requirements for a defined lifetime.*

Examples of such structures included: the QEII bridge, 2012 Olympic Stadium, fixed offshore jacket structures, floating platforms, pipe lines, and wind towers. He noted that *Engineering is a very old profession* by giving as examples Stonehenge and the Giza Pyramids built about 4500 years ago.

We then viewed examples of structural failures which occurred as the industrial revolution progressed: a railway axle failure (1842), a boiler explosion (1850), the paddle steamer Sultana (1865) and the Tay Bridge Disaster (1879).
From these the lessons were:

- Know and understand all the expected loads and service conditions
- Know and understand the behaviour of materials under all load and expected service conditions

There had been considerable loss of life with many of these early failures but it was not until the Grover Shoe Factory in Massachusetts was levelled (1905) by a boiler failure with the loss of some 58 killed and 150 injured, many women and children, that the US government felt that something must be done. A guidance note pamphlet was produced initially which over the years has led to the comprehensive ASME Boiler & Pressure Vessel Code.

In general modern standards embrace two approaches;

Rule based, i.e. the design follows very specific requirements
Goal based, i.e. must demonstrate clearly that the design is equivalent or superior to the rules.

Geoff then described experimental test work, using hydrostatic pressure testing and resonant fatigue testing, which gave rise to the lesson: *Confirm design by experiment as far as is practicable*

Geoff then described several failures, including the Kings Street bridge (Australia), the MV Kurdistan (off Nova Scotia), a gas pipeline in California and a mooring buoy failure in the North Sea). These all had weld related causes aggravated by material properties and elements of the design. Hence another lesson:

- *Use appropriate design approaches for all welded joints*
- *Ensure any repair welds are also considered.*

Welded joints present design challenges because they:

- involve a geometric stress raiser
- contain imperfections or flaws
- may have weld metal and heat affected zones properties that are inferior to parent material
- are associated with complex residual stresses due to non uniform heating and cooling
- sometimes may be overlooked – repair welds or simple attachments

In his last example Geoff outlined issues related to flaws in node joints for BPs Forties Field platform. It was discovered that there was some lack of root penetration in the highly restrained single sided brace to chord welds. In attempting repair, lamellar tearing occurred. Now what?

A thorough engineering assessment showed that lack of fusion presented no threat to the integrity of the structure so that the root penetration flaws could be accepted without repair. The result was that the platform was delivered on time, and savings to BP - £50m. The platform is still functioning satisfactorily some forty years later.

The final Lesson was:

Nothing is perfect
This includes welds
and People

This brief summary barely touches on the depth of knowledge Geoff imparted to his appreciative audience. The pictures, diagrams and video clips reinforced his words and all went away with a list of significant lessons., Thanks you Geoff.