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Project title:

Optimization of welding technology of high strength S690 steel and development of smart welding monitoring and quality control system

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Project outline:

As there is an increasing application of high strength steel in high rise buildings and bridge structures nowadays, welding has gained more and more attention because it is one of the most important connection. A standardized procedure and technology of welding of high strength steel is needed in order to control the quality of welded section by limiting the mechanical property reduction of heat affected zone (HAZ), which is the precondition of structure safety. A completed welder qualification test system together with development of welding monitoring system will be an effective tool to achieve good quality of welding. Developing the former standardized procedure and system will help to lay a foundation for applying high strength steel in the future.

1. S690QL base metal, welded section material test and microstructure assessment

（1） A series of assessment of mechanical properties of high strength steel used in bridge arch in Tseung Kwan O Cross Bay Link (CBL) project is needed. For steel in 20/40/50/60/70mm thickness, following test shown in Table 1 will be conducted:

Table 1. S690QLbase metal material test (pcs)

Thickness (mm)	Tensile test	Bending test	Impact test
20	3	3	15
40	6	3	15
50	6	3	15
60	9	3	15
70	9	3	15

（2） Material properties of welded sections with various heat input and thickness

For steel plate with 50/60/70mm in thickness, butt joint welding will be conducted with various heat input. Specimen and Tensile tests will be conducted according to BS EN ISO 6892-1:2016 Metallic Materials - Tensile testing to evaluate the influence of various heat energy input onto welded sections' material properties. A testing program is shown in Table 2

Table 2. Test program for welded sections

Thickness (mm)	Heat input (kJ/mm)	Dimension of tensile test	Hardness test	SEM
50	2.4 3.5 5.0	25×25	Y Y Y	Y Y Y
70	2.4 3.5 5.0	25×25	Y Y Y	Y Y Y

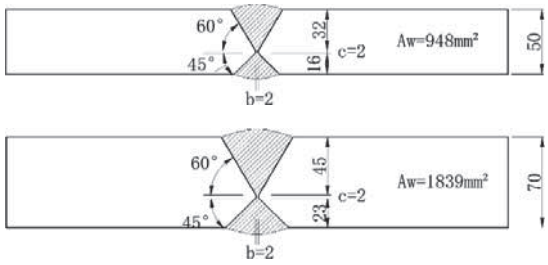

Figure 1.1 Dimensions of weld joints

2. Residual stress analysis of welded box section

   A box section column fabricated with 50mm thick S690 plate will be welded according to the same procedures with CBL bridge arch. The joint detail is shown in figure2.1. Sectioning method will be used here to measure the residual stress distribution.

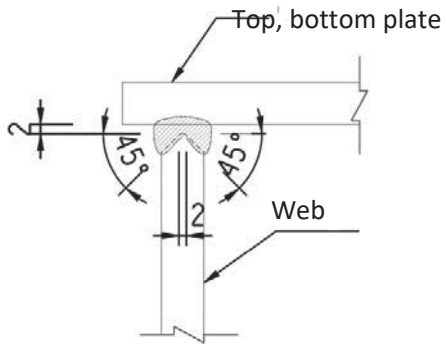

Figure 2.1 Box section welding detail

Procedures of sectioning method is shown in Figure 2.2. The center part with a length of 0.4m is taken for residual stress measurement. Take the right web plate for an example: alone the vertical direction, take slices with 25mm in height with a 50mm interval, then slice the specimen alone the thickness direction into thirds for residual stress measurement issue.

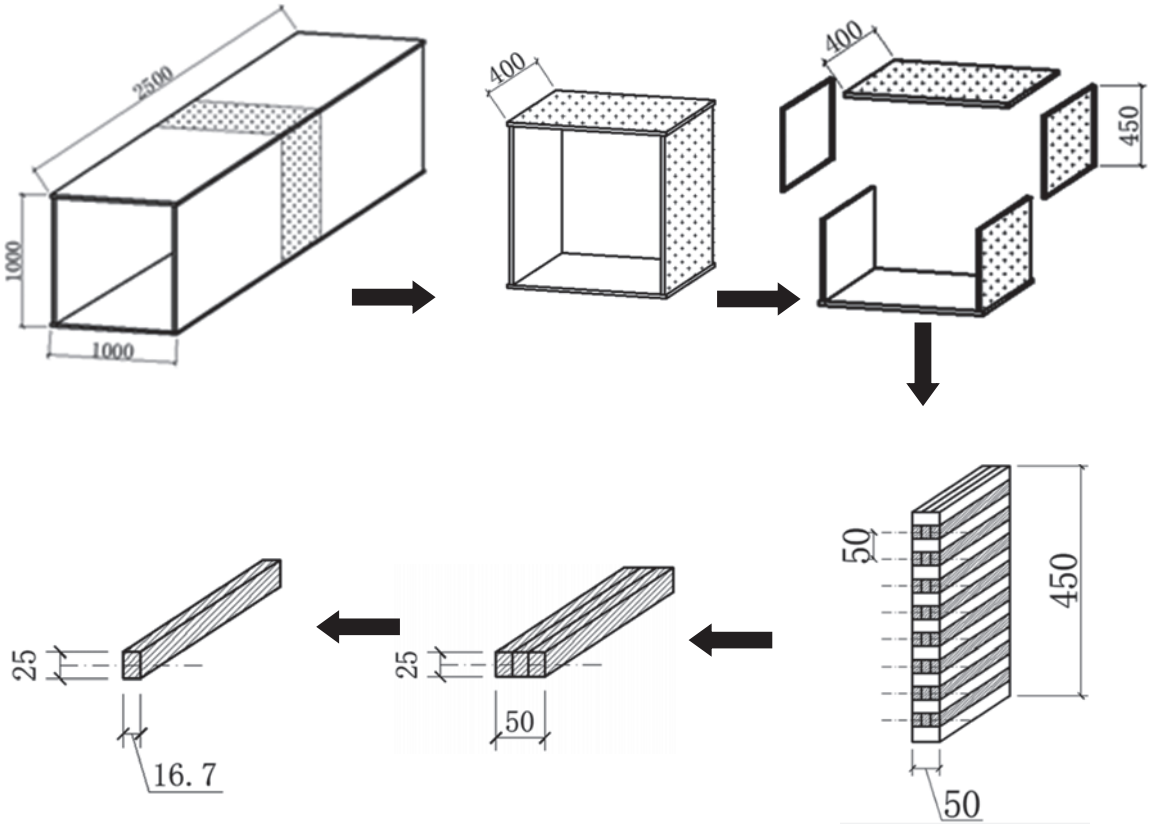

Figure 2.2 Sectioning method (Unit: mm)

3. Development of real-time welding monitoring system

Background:

In the process of steel welding, the monitoring of the welding parameters such as travelling speed, change of weld pool, the current and voltage in welding process serves as important reference for improving the accuracy of welding, the quality of welding, and the fabrication efficiency.

By using the computer vision inspection method, drawbacks of artificial monitoring can be made up and a comprehensive monitoring and recording of the welding process can be achieved. A special facial guard will be designed with a high dynamic range (HDR) micro camera installed outside and a liquid-crystal display (LCD) installed on the inside of the facial guard. In this way, parameters such as welding speed, weld line can be captured by HDR camera and displayed on the LCD screen together with current and voltage. With this information in real time, the welder can make a judgment of welding quality without the need to observe the welding process directly. At the same time, these videos and parameters can be recorded for subsequent viewing and be uploaded to the cloud storage for analysis by artificial intelligence.

- Facial guard with HDR micro camera
- Real time high efficiency computer
- Cloud storage for artificial intelligence analysis