Heat Input Limits of Welding Consumables for Earthquake Resisting Structures

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Introduction

The Steel Structures Standard, NZS 3404, references the AS/NZS 1554 suite of standards for compliance of welding consumables. NZS 3404 includes additional requirements limiting the heat input in the deposited weld metal for welds subject to earthquake loads or effects. This article discusses the background to these requirements, identifies welding processes restricted by the heat input limits and how to qualify welding process that are restricted by the heat input limits.

AS/NZS 1554 Welding Procedure Requirements

A fundamental requirement of AS/NZS 1554.1 Welding of Steel Structures is that the welding procedure (that is the weld preparation, the welding consumables and the welding parameters) must be qualified before welding of the structure commences.

Welding procedure specifications control the welding variables that determine the mechanical properties of the welded joint. The tensile strength, elongation and Charpy V-Notch (CVN) toughness are dependent on a variety of factors, including the cooling rate experienced during the welding cycle. As cooling rates are increased, the yield and tensile strength of the weld deposit typically increases, but the elongation usually decreases. Conversely, slower cooling rates result in lower strength deposits with greater elongation. Charpy V-notch toughness values are typically optimal at an intermediate cooling rate, and significant changes in cooling rate (both increases and decreases) will often result in lower CVN values.

Cooling rates are a function of several variables, including heat input. High heat input levels result in slower cooling rates, whereas low heat input levels increase cooling rates. Heat input is dependent on the welding current, the arc voltage and the travel speed. Welding procedures specify a limited range for each of these parameters resulting in a low and high limit for the heat input.

Welding consumables shall be matched with the steel type in compliance with Table 4.6.1(A), AS/NZS 1554.1 and used within the arc energy limits specified by the manufacturer. Section 4.6.1, AS/NZS 1554.1 does have restrictions on heat input depending on the grading of welding consumables (e.g. S, M, SM, T and TM) in order to ensure that the required CVN values of the deposited weld metal will be achieved at a specify test temperature. AS/NZS 1554.1 does not specify any limits on heat input for the steel types.

NZS 3404 Heat Input Limits in the Deposited Weld Metal

NZS 3404 limits heat input to 2.5 kJ/mm for seismic welds. This approach is largely based on the requirement that the weld and base metal need to have sufficient ductility and toughness to allow for

the necessary redistribution of internal forces and strains introduced during a seismic event, thereby preventing cyclic brittle fracture. Figure 1 shows an example of a brittle type fracture.

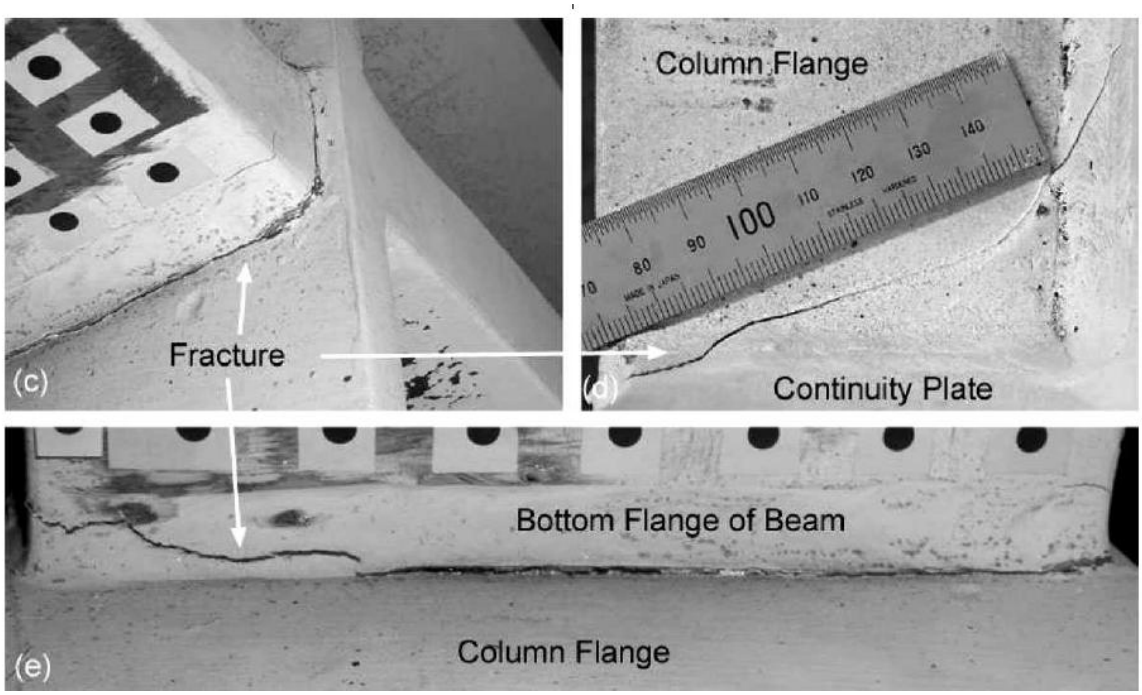

Figure 1 Brittle-type facture of a column to beam connection following large scale seismic testing (HERA/NZWC Report R8-28)

Welding Processes Restricted and How to Qualify

Limiting heat input to 2.5 kJ/mm may impose a constraint on the deployment of high productivity welding processes such as submerged arc welding (SAW). SAW is typically used for welding of railway bridge sections subject to the fracture control plan (FCP) to NZS 3404.1:2009. The FCP calls for the above limit on heat input. If the heat input exceeds 2.5 kJ/mm, CVN testing becomes a qualification requirement.

To verify that the minimum absorbed energy in the HAZ of the joint complies with that specified for the base material, it is recommended that CVN tests are carried out in accordance with AS 1544.2 and AS 2205.7.1. The V-notch should be placed in the HAZ of the welded joint.

The absorbed energy of a minimum of 3 tests must conform to the limits given in the applicable materials standard (e.g. Table 10 of AS/NZS 3678). If prequalified welding consumables are used according to AS/NZS 1554.1, CVN testing of the weld metal is usually not required. Otherwise CVN values of the weld metal test shall comply with the Table 4.6.2, AS/NZS 1554 Part 1 or 5.

According to NZS 3404.1, welding procedures shall be approved by the Design Engineer or his/her representative. Therefore the fabricator should discuss and confirm the testing requirements with the Design Engineer before qualifying welding procedures.

While welding procedures are essential quality control tools that must be used by welders, they should be integrated in a framework of the quality management system for welding fabrication such as AS/NZS ISO 3834 that addresses wider issues such as material traceability, inspection and competency of personnel involved in welding.

Application of this standard in conjunction with NZS 3404.1 and AS/NZS 1554.1 is seen as the key element to ensure reliability of structural steelwork in New Zealand's seismic environment.

Conclusion

The Steel Structures Standard, NZS 3404, has limits on the heat input in the deposited weld metal for welds subject to earthquake loads or effects. Limiting the heat input is an approach to ensuring that the weld and base metal have sufficient ductility and toughness to allow for the necessary redistribution of internal forces and strains introduced during a seismic event to prevent cyclic brittle fracture. Limiting the heat input may pose a constraint on the deployment for high productivity welding processes such as submerged arc welding. In this instance further qualification of the welding process is required. For further assistance contact HERA's New Zealand Welding Centre.

References

SA/SNZ, Structural Steel Welding-Welding of Steel Structures, AS/NZS 1554.1, Standards Australia / Standards New Zealand, Sydney /Wellington, 2011

SNZ, Steel Structures Standard (Incorporating Amendments 1 and 2), NZS 3404:1997 Part 1 and 2, Standards New Zealand, Wellington, 2007

SNZ, Steel Structures Standard Part 1: Materials, fabrication, and construction, NZS 3404:Part 1:2009, Standards New Zealand, Wellington, 2009