Specifying Impact Toughness of Steel Plates for End Plate Connections in Seismic Lateral Resisting Frames

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Introduction

Structures designed to the *Steel Structures Standard*, NZS 3404, are required to be able to resist collapse under a maximum considered earthquake as directed by the Loadings Standard, NZS 1170.5. Brittle systems are not permitted.

The nature of steel material is that it always contains some imperfections, albeit of very small size. When subject to tensile stress these imperfections (similar to very small cracks) tend to open. If the steel is insufficiently tough, the 'crack' propagates rapidly, without plastic deformation, and failure may result. This is called 'brittle fracture', and is of particular concern because of the sudden nature of failure. The toughness of the steel, and its ability to resist this behaviour, decreases as the temperature decreases. In addition, the toughness required, at any given temperature, increases with the thickness of the material.

A convenient measure of toughness is the Charpy V-notch impact test. This test measures the impact energy (in Joules) required to break a small, notched specimen by a single impact blow from a pendulum. The tests are carried out with the specimens at specified (low) temperatures, and the steel material standards specify the required minimum impact energy values for different grades.

The current impact provisions in NZS 3404 were developed at a time when steels used in construction were of Australasian origin made in modern steelmaking plants that are continuous cast/control rolled steels and are fully killed with the addition of Aluminium and/or Silicon. There was an expectation that all steel would meet impact values of 27J at 0 Degrees C if tested.

Today steel may be sourced from non-Australasian steel making plants which may have very much lower charpy impact performance. These steel supplied as a non-impact grade of steel may not meet the 27 J at 0 Degrees C expectation on which the *Steel Structures Standard,* NZS 3404, was developed.

It is therefore important any steel that may develop inelastic action under earthquake induced deformations are specified as an impact grade to ensure a guaranteed minimum toughness to prevent brittle fracture behaviour.

The following describe the minimum impact toughness requirements for the end plate in moment end plate connections of beams to columns in a moment resisting seismic frame and the availability of impact grade steel plate.

Moment End Plate Connections

Beams in moment resisting seismic frames are sometimes connected with moment end plate connections to columns. See figure 1. The end plates are considered to be secondary type seismic members and the material requirements for a category 3 seismic member apply for seismic category 1,2 and 3 moment resisting seismic frames. For a seismic member category 3 the impact toughness requirement for a standard v-notch specimen from the end plates is 27 J at 0 Degrees C. Therefore steel type 2 and 5 to NZS 3404 must be specified.

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The toughness requirements of end plates for category 1, 2 and 3 moment resisting seismic frames should also extend to category 4 'elastic' seismic frames. The performance of the moment resisting seismic frame is dependent on ensuring the brittle behaviour within the connection is avoided and that the assumed toughness of the steel by the *Steel Structures Standard* is achieved.

There will be applications in cold external environments or cold stores where more stringent impact toughness must be specified.

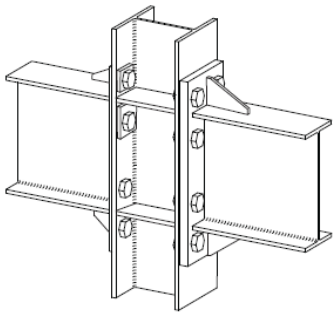

Figure 1: Example of Moment End Plate Connection

Other Seismic End Plate Connections
This guidance presented in this article would also be applicable for baseplate and other types of plate connections in seismic load resisting systems.

Impact Grade Plate Availability
The designer should consider the availability of impact grade plate. New Zealand made impact grade plate available to AS/NZS 3678:2011 is given in Table 1. Currently seismic grade (S0) plate is only available as G300S0 to AN/NZS 3678:2011 and only made in New Zealand. Larger size imported impact grade plate supplied to AS/NZS 3678:2011 are available.

Impact grade imported plate can also be supplied to alternate JIS and BS EN plate standards recognized and referenced from the *Steel Structures Standard*, NZS 3404.

Table 1: New Zealand Made Impact Grade Plates to AS/NZS 3678:2011

Impact Grade	Thickness (mm)	Width (mm)	Length (mm)
G250L0, G250L15 G300L0, G300L15, G300S0 G350L0, G350L15	10, 12	1220	2400
		1520	3600, 7200
	16, 20, 25, 32, 40, 50[1]	1220	2400, 7200
		1520	3600, 7200

1) 50mm thickness not available for G300S0

Conclusion
The *Steel Structures Standard*, NZS 3404, does not permit brittle type behaviour and assumes a minimum toughness of steel. As a result the end plates on moment end plate connections of moment resisting seismic frames must be specified to an impact grade to achieve a minimum of 27 Joules 0 Degrees C for a standard v-notch specimen. Plate supplied to AS/NZS 3678 must be as minimum an L0 grade. Greater impact toughness requirements are required for applications in cold external environments or cold stores.

References

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, 2007

New Zealand Steel, Structural Engineering + Fabrication Steel Grades, 2013

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