Welding Consumables and Design of Welds

Author: *Kevin Cowie[a], Alan McClintock[b]*
Affiliation: *a. Steel Construction New Zealand Inc.*
b. New Zealand Heavy Engineering Research Association Inc.
Date: *28th February2014*
Ref.: *WEL1002*

Key Words
Welding Consumables, Design of Welds

Introduction

The *Steel Structures Standard*, NZS 3404, references the AS/NZS 1554 suite of standards for compliance of welding consumables. New editions of the AS/NZS 1554 suite of welding Standards have recently been published and these refer to newly published editions of the AS/NZS Standards for welding consumables. Over the last few years, Australia and New Zealand have adopted the harmonized ISO welding consumable classification system. These changes in welding consumable classification system impact on structural engineers designing fillet welds and partial penetration butt welds.

Design of Welds in NZS 3404

The design capacity of a full penetration butt weld is specified in Clause 9.7.2.7 of NZS 3404 to be taken as equal to the nominal capacity of the weaker part of the parts joined, multiplied by the appropriate capacity factor for butt welds given in Table 3.3(1) of NZS 3404. This is based on the assumption that the welding procedure was qualified in accordance with AS/NZS 1554.1 or AS/NZS 1554.5 as applicable. The butt weld must be made using a welding consumable which will produce butt tensile test specimens in accordance with AS 2205.2.1 for which the minimum strength is not less than the corresponding values for the parent material. Hence, for butt welds, the structural engineer specifying the weld does not need to be concerned with what is specified in the welding consumable Standards.

However, the design capacity of fillet welds in Clause 9.7.3.10 of NZS 3404 is based on the nominal tensile strength of the weld metal, which is derived from the strength of the welding consumables specified in the relevant New Zealand Standards. Clause 9.7.2.7 specifies that the design capacity of incomplete-penetration butt welds shall be that for a fillet weld of the same design throat thickness so it also is related to the tensile strength of the welding consumable.

Table 9.7.3.10(1) of NZS 3404 specified the nominal tensile strength of the weld metal as either 410 or 480 MPa as shown in the extract below. As can be seen, reference is made in this Table to a number of Standards for welding consumables, which reflected those in use at the time these editions of NZS 3404 were published.

Table 1 Nominal tensile strength of weld metal (f_{uw}) (Table 9.7.3.10(1) NZS 3404)

Manual metal arc electrode (AS/NZS 1553.1)	**Submerged arc (AS 1858.1) Flux cored arc (AS 2203) Gas metal arc (AS/NZS 2717.1)**	**Nominal tensile strength of weld metal (f_{uw})** (see Note 2) **MPa**
E41XX	W40X (see Note 1)	410
E48XX	W50X	480

NOTE:

(1) Not included in AS/NZS 2717.1
(2) The increased design capacity available from weld metals with a nominal tensile strength exceeding that given herein may be used provided that failure at the interface between the weld and the parent metal is precluded.

New Classification System for Welding Consumables

Welding electrodes and rods are classified according to the mechanical properties of the weld metal they produce. New Zealand and Australia have adopted the harmonised ISO welding consumables classification system that brings together two seemingly incompatible systems in common usage:

(a) System A used in Europe where consumables are classified predominantly by yield strength and the temperature at which 47 J minimum impact energy is guaranteed.
(b) System B used extensively around the Pacific Rim and North America where consumables are classified by tensile strength and the temperature at which 27 J minimum impact energy is guaranteed.

New Zealand and Australia have generally followed System B practice using a tensile strength based classification system with local variations including a 47 J minimum impact energy requirement at the temperature of test as the basis for its consumable classification requirements.

The new classification system is dependent on the welding process. There are now a number of different electrode designations involved for each process. Table 2 shows the nearest equivalent designations for manual metal arc. The nominal tensile strength of electrodes has also changed. The previous values of 410 and 480 MPa for the nominal tensile strength have been increased to 430 (extra 4.9%) and 490 MPa (extra 2%) respectively under the ISO system B classification system.

Table 2 Equivalent designations for Manual metal arc

Old Designation		New AS/NZS ISO Designation (AS/NZS 4855)			
AS/NZS 1553.1	Nominal Tensile Strength MPa	System A	Nominal Tensile Strength MPa	System B	Nominal Tensile Strength MPa
E41XX	410	A-E35	440	B-E43XX	430
		A-E38	470		
E48XX	480	A-E42	500	B-E49XX	490
		A-E46	530		

How to Specify

Structural engineers will have to clearly identify on the structural drawings and in the specification both the weld size, the weld category and the nominal tensile strength of the weld metal. Nominating the nominal tensile strength, f_{uw}, in lieu of weld metal designation is more workable from a design and specification perspective as the new designation method is dependent on the welding process which is in the realm of the fabricator and is determined after the design.

It should be noted that published weld load capacity data such as the Australian Steel Institute Design Capacity Tables (ASI, 2009) will now give conservative results.

To promote standardised parameters previously noted by SCNZ it may seem reasonable to standardise f_{uw} to 490 MPa which is reasonable close to the previous standardised 480 MPa.

In the case of welding consumables classified to System B it can be difficult to identify impact properties of the deposited weld metal. It is therefore recommended to specify a Ship's Classification Society Grade in addition to tensile properties; for example Ship's Classification Society Grade 3 approval is required for some seismic applications as set out in NZS 3404.1:2009 Clause 3.2.3.2

"Welding consumables for earthquake resisting structures
For welds subject to earthquake loads or effects, the following shall apply:
(a) The welding consumables shall have a Ships' Classification Societies Grade 3 approval as shown in Table 4.6.1(A) of AS/NZS 1554.1:2004, as required for Steel Type 2S for Grade 300 steel, Steel Type 5S for Grade 350 steel and Steel Type 7C for Grade 450 steel;"

Conclusion

The long-established AS and NZS standards for welding consumables have now been superceded by the harmonized ISO welding consumable classification system. The new classification system will impact structural engineers designing fillet welds and partial penetration butt welds. How welds are specified on drawings and specifications will require modifications and this will include identifying the nominal tensile strength of the weld metal.

References

ASI, Design capacity tables for structural steel, vol. 1: Open sections, Australian Steel Institute, 2009

SA, Carbon steel electrodes, cored (for arc welding), AS 2203-1981, Standards Australia, Sydney, 1981

SA, Electrodes and fluxes for submerged-arc welding - Carbon steels and carbon-manganese steels, AS 1858.1-2003, Standards Australia, Sydney, 2003

SA/SNZ, Covered electrodes for welding - Low carbon steel electrodes for manual metal-arc welding of carbon steels and carbon-manganese steels, AS/NZS 1553.1:1995, Standards Australia / Standards New Zealand, Sydney/Wellington, 1995

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

SA/SNZ, Welding - Electrodes - Gas metal arc - Ferritic steel electrodes, AS/NZS 2717.1:1996, Standards Australia / Standards New Zealand, Sydney/Wellington, 1996

SA/SNZ, Welding consumables – Covered electrodes for manual metal arc welding of non-alloy and fine grain steels – Classification, AS/NZS 4855:2007, Standards Australia / Standards New Zealand, Sydney/Wellington, 2007

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