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Weldability of Higher Grades of Reinforcing Steel

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MANUFACTURING & MATERIALS JOINING INNOVATION CENTER

Background and Motivation

- Higher-strength reinforcing steel is increasingly used in seismic, bridge, and infrastructure applications. It can reduce bar congestion, lower construction costs, and improve structural efficiency.
- The current version of AWS D1.4 does not include provisions for ASTM A706 Grade 80 and Grade 100 reinforcing steel.
- Results from OSU weldability testing will inform the upcoming AWS D1.4 revision, providing fabricators and engineers with code support to prevent Hydrogen-Induced Cracking (HIC).

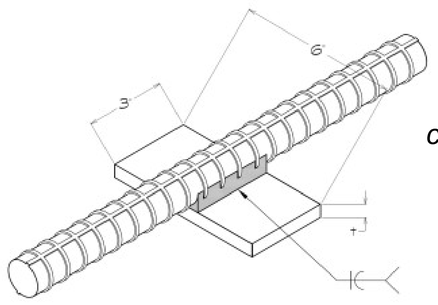
Table 7.2
Minimum Preheat and Interpass Temperatures[a, b] (see 7.2.1)

Carbon Equivalent (C.E.) Range, %[c,d]	Size of Steel Reinforcing Bar	SMAW with Low-Hydrogen Electrodes, GMAW, FCAW, or GTAW — Minimum Temperature °F	°C
Up to 0.40	Up to 11 [36] inclusive	none[e]	none[e]
	14 and 18 [43 and 57]	50	10
Over 0.40 to 0.45 inclusive	Up to 11 [36] inclusive	none[e]	none[e]
	14 and 18 [43 and 57]	50	10
Over 0.45 to 0.55 inclusive	Up to 6 [19] inclusive	none[e]	none[e]
	7 to 11 [22 to 36]	50	10
	14 to 18 [43 to 57]	200	90

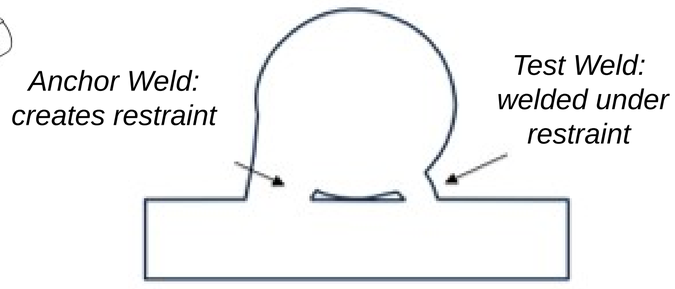
Objective

- Perform a series of self-restrained HIC weldability tests on bar sizes #6, #11, and #14 with both Micro-Alloyed (MA) and Quench and Self-Tempered (QST) strengthening mechanisms.
- Specimens will have a flare-bevel on either side. The first weld acts as the anchor, and the second (on the opposite side) is the test weld.
- Test the validity of the current minimum preheat temperature specified by AWS D1.4.
- If preheat is found to be insufficient, subsequent specimens will be tested with an increase of 50°F increments until specimens are free of HIC.

Specimen Geometry



HIC Test Geometry



Cross-Section

Approach/Procedure

Color coded ASTM A706 Bars

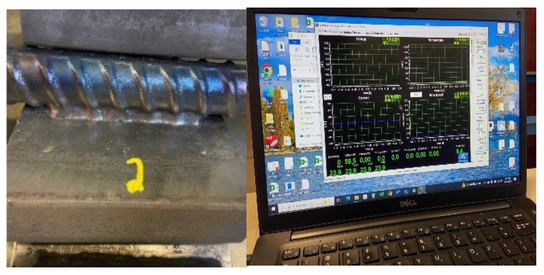
Remove Mill Scale

Preheat Before Anchor Weld

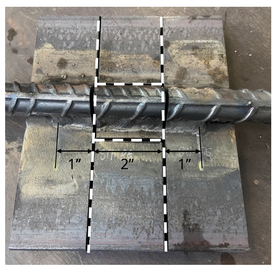
Tack and Complete Anchor Weld

Preheat Before Test Weld

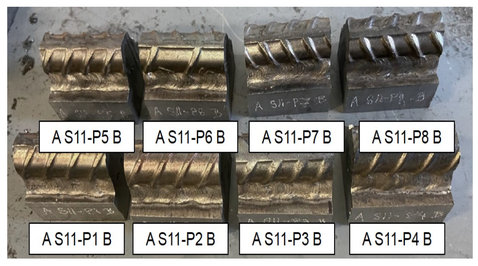
Complete Test Weld While Recording Live Data



After 48-hr Delay, Section Specimen

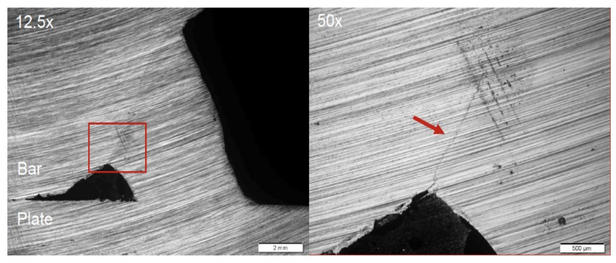


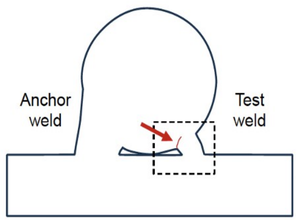
Engrave Specimen ID Numbers



Grind/Polish Cross-Sections

Inspect Cross-Sections for HIC using Light Optical Microscopy





Results/Conclusions

- Critical preheat was determined using a method developed by Graville, 1995.
- The higher of the two critical preheats was rounded up to the nearest 50°F to be used in a future revision of AWS D1.4.
- In many cases, the minimum preheat temperature needed to prevent HIC in Grade 80 and Grade 100 was higher than the values currently listed in Table 7.2 of AWS D1.4.
- **Future Work:** Investigate the cause of the differences in critical preheat between Micro-Alloyed (MA) and Quench and Self-Tempered (QST) bars.

Bar Strength	Bar Type	Bar Size	Critical Preheat	Combined MA & QST
Grade 80	MA	#6	32°F	50°F
	QST		39°F	
	MA	#11	157°F	250°F
	QST		213°F	
	MA	#14	268°F	300°F
Grade 100	MA	#6	95°F	100°F
	MA	#11	277°F	300°F
	QST		177°F	
	MA	#14	318°F	350°F

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