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Abstract

The North American Specification for the Design of Cold-Formed Steel Structural Members does not provide specific design guidance for sheet-to-sheet top arc seam welds in shear. A collaborative industry study has developed design guidance for both strength and stiffness of the connection to facilitate analytical evaluation of floor and roof diaphragm assemblies and wall assemblies. The test program was performed per AISI S905 and addressed material ductility, weld length, sheet thickness and the distribution of the force being transferred by the weld connection.

Introduction

Top arc seam sidelap welds has commonly been used to attach the edges of standing seam steel roof and floor deck panels, particularly those used for diaphragms. The top arc seam sidelap connection is formed by a vertical sheet leg (edge stiffener of deck) inside an overlapping sheet hem, or by two vertical sheet legs back-to-back. Top arc seam welds have been referenced in some historical diaphragm design standards as part of a system without defining the strength of individual connections. Similarly, AWS D1.3 has shown the weld as a possible variation of an arc seam weld, without clear provisions to determine weld strength. The paper summarizes the research presented in the S. B. Barnes Associates (Nunna and Pinkham, 2012; Nunna, et al., 2012) reports. This research was undertaken by a number of interested manufacturers of steel deck panels to develop design provisions for the top arc seam sidelap welds.

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Test Program

The tests included typical weld spacing of approximately 12 in. o.c. and this established the strength of the welds with the stated limits. All testing was performed on joints with a vertical sheet leg inside an overlapping sheet hem configuration, but the behavior of connections with back-to-back vertical sheet legs is assumed to be similar.

Testing was performed in general accordance with AISI S905 (AISI, 2008), with the specimen dimensions in S905 Table 2 as required to address the described deck edge configuration.

The range of test parameters was selected to encompass the typical industry applications:

- 31.9 ksi $\leq F_y \leq$ 105 ksi
- 48.0 ksi $\leq F_u \leq$ 107 ksi
- $1.01 \leq F_u/F_{sy} \leq 1.50$
- 0.0297" $\leq t \leq$ 0.0652"
- ¾" $\leq h_{st} \leq$ 1-1/4"
- $F_{xx} \geq$ 60 ksi
- 1.0" $\leq L_w \leq$ 2-1/2"

The testing was performed by Kleinfelder West, Inc (2011). Both load and deflection measurements were recorded for each test. Figures 2 and 3 show the test setup and instrumentation. Complete details regarding the Kleinfelder test program and test results may be found in Nunna and Pinkham (2012).

As required by AISI S905, a minimum required three tests were performed for each specimen geometry, material strength and top arc seam weld length, L_w.

All specimens were loaded to failure. Figure 4 illustrates a typical tearing failure of deck.

Evaluation of Test Data

A total of 63 tests were performed that encompassed the range of test parameters. Figure 5 illustrates the correlation of the test data with the following proposed design equation.

$$P_n = [4.0(F_u/F_{sy})-1.52](t/L_w)^{0.33}L_w t F_u \qquad (1)$$

where,

P_n = Nominal shear strength [resistance] of top arc seam sidelap connection; F_u = Minimum tensile strength of connected sheets; F_{sy} = Minimum yield stress of connected sheets; t = Sheet thickness exclusive of coating; L_w = Total length of top arc seam sidelap connection.

The reliability of Eq. 1 was evaluated in accordance with AISI S100 (2007a) and Commentary (2007b). The mean value for P_{test}/P_n was computed to be 1.00 and the corresponding coefficient of variation of the test results was 0.130 which yielded the following:

$\Omega = 2.60$ (ASD)

$\Phi = 0.60$ (LRFD)

$\Phi = 0.55$ (LSD)

Conclusion

The North American Specification for the Design of Cold-Formed Steel Structural Members does not provide specific design guidance for sheet-to-sheet top arc seam welds in shear. A collaborative industry study has developed design guidance for both strength and stiffness of the connection to facilitate analytical evaluation of floor and roof diaphragm assemblies and wall assemblies.

Acknowledgements

The authors acknowledge the collective contribution of test material and financial support, technical guidance, and peer review of the group charged to complete this task. We particularly remember the many contributions of the late Clarkson Pinkham in this area of study.

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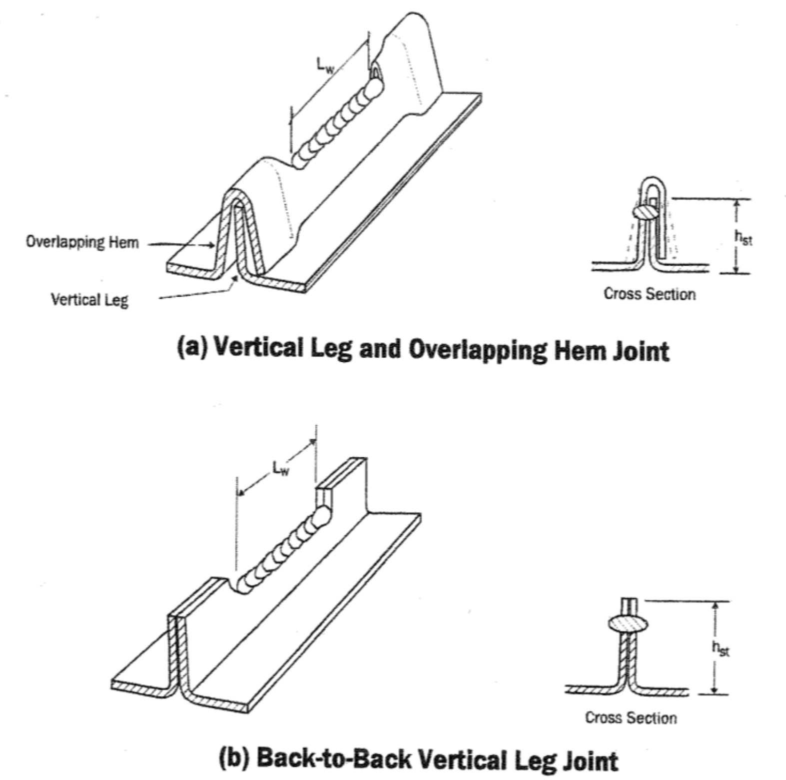

Figure 1 Typical Arc Seam Weld Configuration

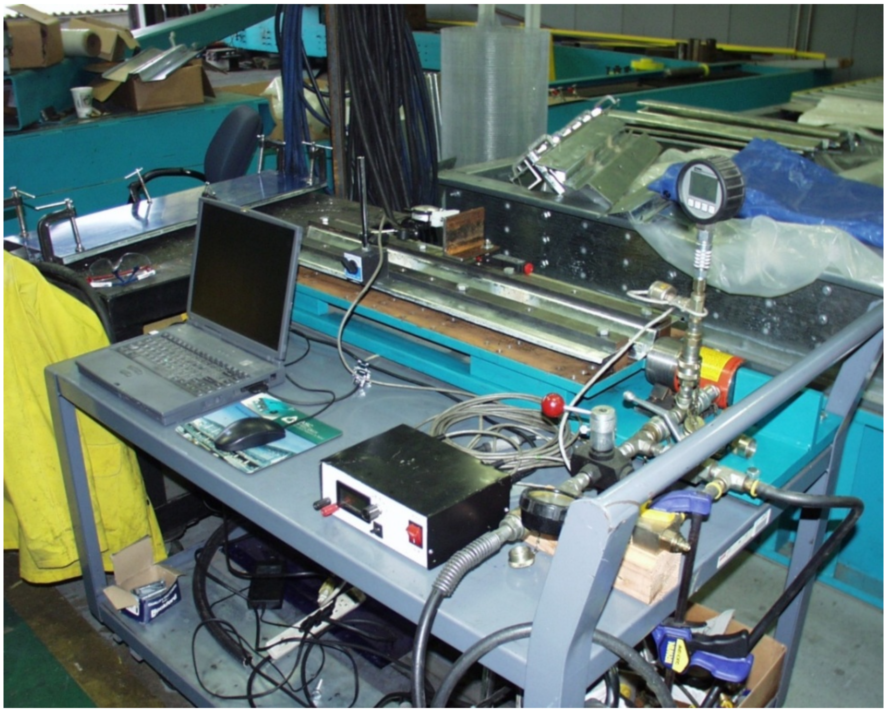

Figure 2 Test Setup

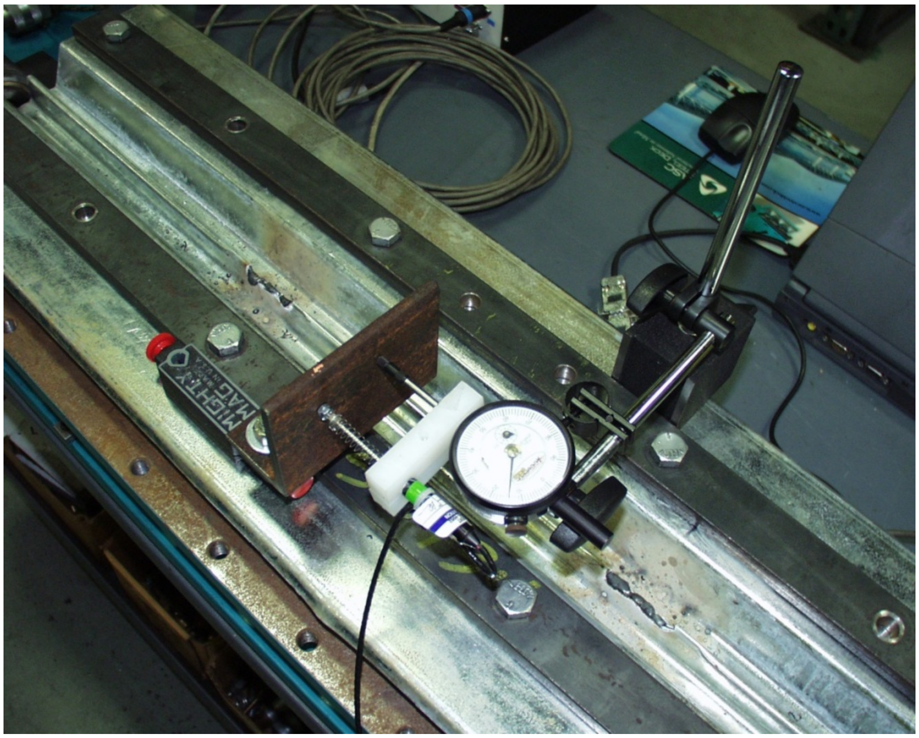

Figure 3 Deflection Instrumentation

Figure 4 Typical top seam weld failure (shearing of male leg parallel to weldment)

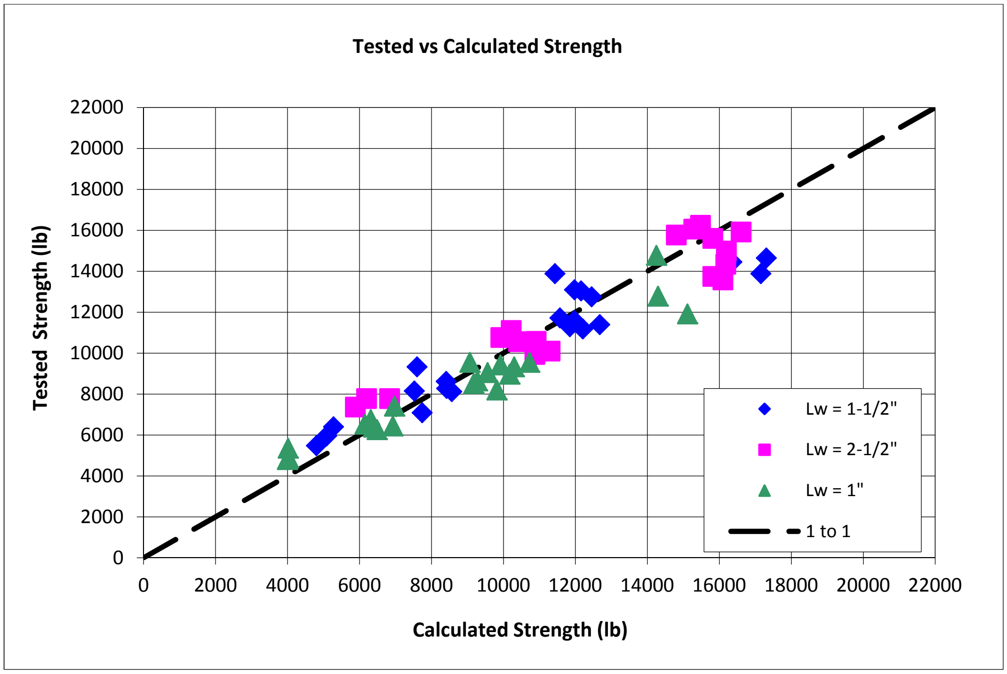

Figure 5 Comparison of test to calculated strength using Eq. 1