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Test Standard for Determining the Fastener-Sheathing Rotational Stiffness of Sheathed Cold-Formed Steel Assemblies, 2017 Edition

American Iron and Steel Institute

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AISI STANDARD

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Approved by

the AISI Committee on Specifications for the Design of

Cold-Formed Steel Structural Members

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PREFACE

The American Iron and Steel Institute Committee on Specifications developed this Standard to determine the rotational restraint (k_ϕ) supplied by sheathing, fastened to cold-formed steel members.

The Committee acknowledges and is grateful for the contribution of the numerous engineers, researchers, producers and others who have contributed to the body of knowledge on this subject.

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AISI S918-17
TEST STANDARD FOR DETERMINING THE FASTENER-SHEATHING ROTATIONAL STIFFNESS OF SHEATHED COLD-FORMED STEEL ASSEMBLIES

1. Scope

This Standard shall apply for the determination of the rotational restraint (k_{ϕ}) supplied by sheathing, fastened to cold-formed steel members. This Standard consists of Sections 1 through 10 inclusive.

Commentary:
This test standard is conceptually related to AISI S901; however, the specifics of the test and instrumentation are modified for the use intended here. When a cold-formed steel member is connected to sheathing, the sheathing can provide beneficial rotational restraint of the member (stud, joist, etc.). One direct mechanism for developing such rotational restraint is a combination of bearing between the flange and sheathing, and pull-through resistance at a fastener location, as the member rotates. This mechanical combination may be idealized as a rotational restraint at the fastener location. This rotational restraint provides the primary bracing restraint against distortional buckling. See Schafer et al. (2010) for a complete discussion.

Reference:

Schafer, B. W., L. C. M. Vieira Jr., R. H. Sangree, and Y. Guan (2010), “Rotational Restraint and Distortional Buckling in Cold-Formed Steel Framing Systems,” *Revista Sul-Americana de Engenharia Estrutural* (South American Journal of Structural Engineering), *Special Issue on Cold-Formed Steel Structures*, 7 (1) 71-90.

2. Referenced Documents

The following documents or portions thereof are referenced within this Standard and shall be considered as part of the requirements of this document.

a. American Iron and Steel Institute (AISI), Washington, DC:

S100-16, *North American Specification for the Design of Cold-Formed Steel Structural Members*
S240-15, *North American Standard for Cold-Formed Steel Structural Framing*

b. ASTM International (ASTM), West Conshohoken, PA:

A370-14, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*
ASTM E6-09be1, *Standard Terminology Relating to Methods of Mechanical Testing*
IEEE/ASTM SI10-10, *American National Standard for Metric Practice*

3. Terminology

Terms not defined in AISI S100 or AISI S240 shall have the ordinary accepted meaning for the context for which they are intended.

4. Symbols

s_f = Fastener spacing

h_o = Out-to-out depth of member
k_ϕ = Rotational stiffness of sheathing-fastener to cold-formed steel member
$\bar{k}_\phi$ = Sheathing-fastener rotational stiffness per unit length
$\bar{k}_{\phi c}$ = Fastener rotational stiffness per unit length
$\bar{k}_{\phi w}$ = Sheathing rotational stiffness per unit length
L = Length (height) of sheathing from fixed end to fastener location
$\bar{M}$ = Rotational moment caused by P per unit width, w
P = Vertical force applied at a distance, h_o, from member-sheathing connection
P_u = Maximum test load
t = Thickness of cold-formed steel member
t_w = Thickness of sheathing
w = Width of the test specimen
Δ_v = Vertical displacement at face of flange where load, P, is applied
Δ_h = Horizontal displacement of sheathing at fastener location
θ = Rotation of cold-formed steel member due to vertical displacement
θ_c = Net rotation of cold-formed steel member
θ_w = Rotation of cold-formed steel member due to horizontal displacement

5. Precision

5.1 Loads shall be recorded to a precision of 1 percent of the maximum load during application of test loads.

5.2 Deflections shall be recorded to a precision of 0.001 in. (0.025 mm).

6. Test Fixture

6.1 The test consists of a cantilevered piece of sheathing fastened to a horizontally oriented member (i.e., joist, stud, etc.). An example test setup is provided in Figure 1.

6.2 The actuator that supplies the force to the end of the member shall be free to translate.

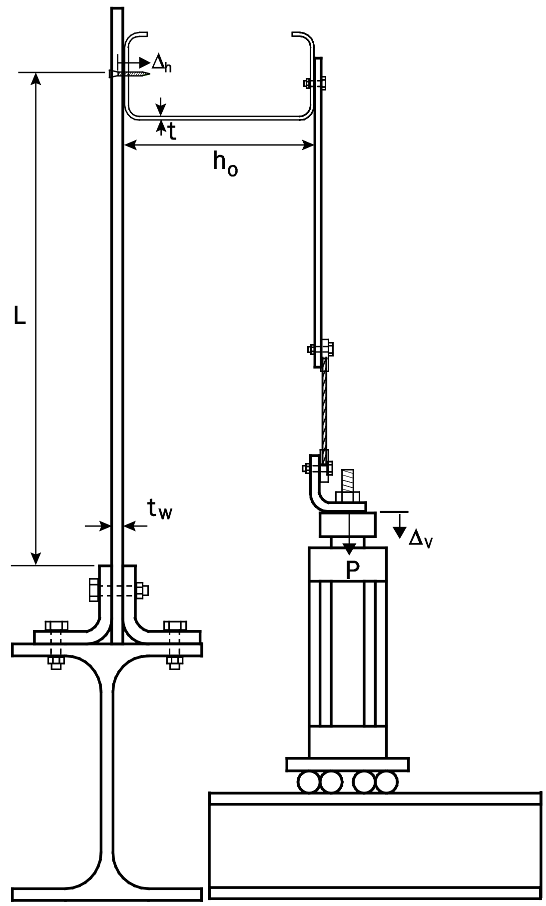


Figure 1 Side View of Cantilever Specimen

7. Test Specimen

The test specimen consists of the cold-formed steel member (joist, stud, etc.), fasteners, and sheathing.

7.1 The cold-formed steel member shall be representative of its intended end use. The member length shall be at least four times the fastener spacing.

7.2 The fasteners shall be representative of their intended end use. Sheathing screws are driven to the proper depth appropriate for the head style used: bugle, wafer and flat head screws shall be driven flush with the surface of the sheathing; pan head, round head, and hex washer head screws shall be driven with the bottom of the head flush with the sheathing. At least three fasteners shall be used per test. Fastener spacing shall match that in the intended end use.

7.3 The sheathing shall be representative of its intended end use. The sheathing width shall match the cold-formed steel member length. The sheathing length, L, shall be at least equal to 1/2 the end use spacing between cold-formed steel members, but not less than 12 in. (305 mm).

8. Test Procedure

8.1 The test shall be conducted under pseudo-static monotonic load until a maximum (failure) load is reached. A loading rate of 0.2 in./min (5.1 mm/min) shall be applied unless it takes greater than 30 minutes to reach maximum load, in which case a faster load rate may be applied, but not faster than a rate that reaches maximum load in less than 5 minutes.

8.2 Displacement shall be measured in the test specimen. Actuator displacement (from the actuator internal LVDT) is permitted for use as the vertical displacement, Δ_v. If the rotational stiffness is to be separated into fastener and sheathing components (as utilized in AISI S240), then the horizontal displacement, Δ_h, must also be recorded.

9. Data Evaluation

9.1 The rotational stiffness of the fastener-sheathing system, k_ϕ, is determined at 40% of the ultimate strength (i.e., maximum load or P_u) of the specimen. Specifically, $P = 0.4P_u$ and Δ_v and Δ_h shall be determined at $0.4P_u$.

(a) Rotational stiffness if separation between fastener and sheathing is not needed:

$$k_\phi = (\bar{k}_\phi)(s_f) \quad (1)$$

$$\bar{k}_\phi = \bar{M}/\theta \quad (2)$$

$$\bar{M} = (P/w)h_o \quad (3)$$

$$\theta = \tan^{-1}(\Delta_v/h_o) \quad (4)$$

(b) Rotational stiffness if separation between fastener and sheathing is desired:

(i) Fastener rotational stiffness:

$$k_{\phi c} = (\bar{k}_{\phi c})(s_f) \quad (5)$$

$$\bar{k}_{\phi c} = \bar{M}/\theta_c = \bar{M}/(\theta - \theta_w) \quad (6)$$

$$\theta_w = 2\Delta_h/L \quad (7)$$

(ii) Sheathing rotational stiffness:

$$k_{\phi w} = \bar{k}_{\phi w} s_f \quad (8)$$

$$\bar{k}_{\phi w} = \bar{M}/\theta_w = \bar{M}/(2\Delta_h/L) \quad (9)$$

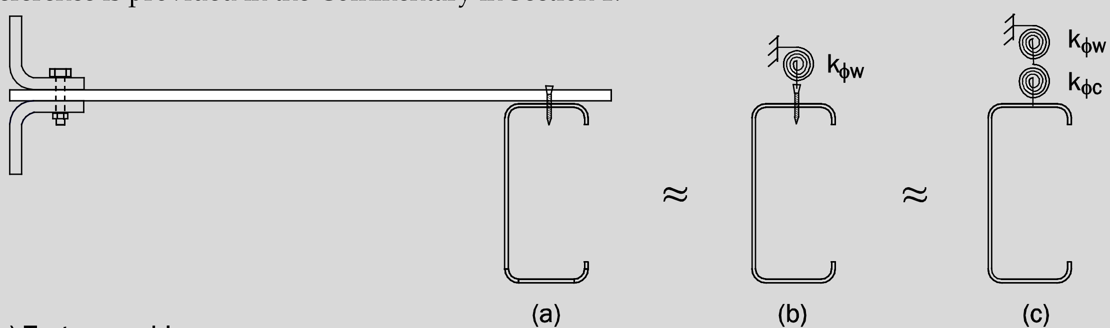
(iii) Total (sheathing and fastener) rotational stiffness:

$$k_\phi = \bar{k}_\phi s_f \quad (10)$$

$$\bar{k}_\phi = 1/[(1/\bar{k}_{\phi c}) + (1/\bar{k}_{\phi w})] \quad (11)$$

Commentary:
Separation of the rotational stiffness into fastener and sheathing stiffness is conceptually summarized in Figure C-1. In existing testing (Schafer et al., 2010[1]), the total rotational stiffness was found to be highly variable due principally to large variations in the sheathing properties; however, fastener rotational stiffness was found to be more repeatable. Both fastener and sheathing rotational stiffness are utilized in AISI framing standards, and may be replaced by the experimental values developed here.

[1]Reference is provided in the Commentary in Section 1.



(a) Test assembly
(b) Replacing sheathing with a spring (with stiffness $k_{\phi w}$)
(c) Replacing both sheathing and fastener with springs (with stiffnesses $k_{\phi w}$ and $k_{\phi c}$)

Figure C-1 Separation of Rotational Stiffness Into Fastener and Sheathing Components

9.2 The data evaluation shall be consistent with AISI S100, Section K2.1, that is: "Evaluation of the test results shall be made on the basis of the average value of test data resulting from tests of not fewer than three identical specimens, provided the deviation of any individual test result from the average value obtained from all tests does not exceed ±15 percent. If such deviation from the average value exceeds 15 percent, more tests of the same kind shall be made until the deviation of any individual test result from the average value obtained from all tests does not exceed ±15 percent, or until at least three additional tests have been made. No test result shall be eliminated unless a rationale for its exclusion can be given." For this criteria, the evaluation of consistency shall be made on the rotational stiffness, k_{ϕ}, $k_{\phi c}$, and/or $k_{\phi w}$, and the maximum number of tests is permitted to be limited to 6.

10. Report

10.1 The test report shall include a description of the tested specimens, including a drawing detailing all pertinent dimensions.

10.2 The test report shall include the measured physical properties consistent with the limitations outlined in Section 7. Conditioning of the sheathing shall be documented.

Commentary:
The major item for documenting the sheathing conditioning is the relative humidity and moisture content, as it can potentially affect the performance of the sheathing material.

10.3 The test report shall include a detailed drawing of the test setup depicting locations and directions of load application, and locations of displacement instrumentation and their point of reference. Additionally, photographs shall supplement the detailed drawings of the test setup.

10.4 The test report shall include load-versus-displacement values and curves, as plotted directly or as reprinted from data acquisition systems.

10.5 The stiffness determined at 40% of the maximum load ($\bar{k}_\phi$) shall also be drawn on the moment-versus-rotation curves. Values of $\bar{k}_\phi$ shall be provided for all tested specimens.

10.6 The test report shall include individual and average maximum test load values observed (i.e., P_u); description of the nature, type and location of failure exhibited by each specimen tested; and a description of the general behavior of the test fixture during load application. Additionally, photographs shall supplement the description of the failure mode(s).

10.7 The test report shall include a description of the test method and loading procedure used, rate of loading, or rate of motion of the crosshead movement.

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