



AISI S907-17



**American
Iron and Steel
Institute**

AISI STANDARD

Test Standard for Determining the Strength and Stiffness of Cold-Formed Steel Diaphragms by the Cantilever Test Method

2017 Edition



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The material contained herein has been developed by the American Iron and Steel Institute (AISI) Committee on Specifications for the Design of Cold-Formed Steel Structural Members. The organization and the Committee have made a diligent effort to present accurate, reliable, and useful information on testing of cold-formed steel members, components or structures. The Committee acknowledges and is grateful for the contributions of the numerous researchers, engineers, and others who have contributed to the body of knowledge on the subject. With anticipated improvements in understanding of the behavior of cold-formed steel and the continuing development of new technology, this material will become dated. It is anticipated that future editions of this test procedure will update this material as new information becomes available, but this cannot be guaranteed.

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PREFACE

The American Iron and Steel Institute Committee on Specifications has developed this Standard to provide requirements for static and cyclic testing of floor, roof and wall *diaphragm* assemblies. This standard applies to framed cold-formed *steel panel* floor, roof and wall *diaphragm* construction.

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

Commentary and User Notes are non-mandatory and copyrightable portions of this Standard.

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AISI S907-17
TEST STANDARD FOR DETERMINING THE STRENGTH AND
STIFFNESS OF COLD-FORMED STEEL DIAPHRAGMS
BY THE CANTILEVER TEST METHOD

1. Scope

This Standard applies to framed cold-formed *steel panel* floor, roof and wall *diaphragm* construction and provides requirements for static and cyclic testing of floor, roof and wall *diaphragm* assemblies.

1.1 Static Testing. Static testing to develop *in-plane* nominal shear strength and shear stiffness for floor, roof and wall *diaphragm* assemblies with *steel panels* shall be performed in accordance with Section 9.1 and with the following conditions and requirements:

1.1.1 Tests shall be conducted using the cantilever test frame.

User Note:

An alternative test method using a simple span test frame is given in ASTM E455-16.

1.1.2 Framing members supporting the cold-formed *steel panels* are permitted to be steel, concrete, wood, or a combination of materials representative of the intended end use.

1.1.3 Fills such as *structural concrete*, cellular concrete, or *insulating concrete* are permitted to be placed over the steel deck panels. Insulation is permitted to be placed between the *steel panels* and the support framing or over the top of *steel panels*.

1.1.4 Tests are permitted to be run in the horizontal or vertical orientation.

1.1.5 Tests are permitted as follows:

- (1) To determine *in-plane diaphragm* shear strength and shear stiffness or flexibility values for a *single diaphragm system* in a specific condition; and
- (2) To develop, modify or verify the application of an analytical model for *in-plane diaphragm* shear strength and shear stiffness or flexibility.

1.2 Cyclic Testing. Cyclic testing to develop load-displacement data and hysteresis loops for floor, roof and wall *diaphragm* assemblies with *steel panels* shall be performed in accordance with Section 9.2.

1.3 This Standard consists of Sections 1 through 13 inclusive.

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:

AISI S100-16, *North American Specification for the Design of Cold-Formed Steel Structural Members*

AISI S310-16, *North American Standard for the Design of Profiled Steel Diaphragm Panels*

- b. ASTM International (ASTM), West Conshohocken, PA:

ASTM A370-14, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM C31/C31M-10, *Standard Test Practice for Making and Curing Concrete Test Specimens in the Field*

ASTM C33/33M-16e1, *Standard Specification for Concrete Aggregates*

ASTM C39/C39M-12, *Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens*

ASTM C330/330M-14, *Standard Specification for Lightweight Aggregates for Structural Concrete*

ASTM C332-09, *Standard Specification for Lightweight Aggregates for Insulating Concrete*

ASTM C495/C495M-12, *Standard Test Method for Compressive Strength of Lightweight Insulating Concrete*

ASTM C869/C869M-11(2016), *Standard Specification for Foaming Agents Used in Making Preformed Foam for Cellular Concrete*

ASTM E6-15, *Standard Terminology Relating to Methods of Mechanical Testing*

IEEE/ASTM SI10-10, *American National Standard for Metric Practice*

c. American Welding Society (AWS), Miami, FL:

AWS D1.1/D1.1M-2015, *Structural Welding Code - Steel*

AWS D1.3/D1.3M-2008, *Structural Welding Code - Sheet Steel*

3. Terminology

Where the following terms appear in this Standard, they shall have the meaning as defined herein. Terms not defined in Section 3 of this Standard, AISI S100, ASTM A370 or ASTM E6 shall have the ordinary accepted meaning for the context for which they are intended.

Aspect Ratio. Ratio of length to depth (a/b) of test assembly.

Base Steel Thickness. The thickness of bare steel exclusive of all coatings.

Bare Frame. Steel, wood, concrete, or a combination of materials support members assembled to form the test frame of the *diaphragm* without *steel panels* installed onto the frame.

Cellular Deck. Composite or partially composite built-up deck formed by fastening either a flat steel sheet or a *fluted panel* beneath and to another *fluted panel*.

Composite Deck. Fluted or *cellular deck* that combines with *structural concrete* fill to form a slab with the steel deck as reinforcement. The fluted deck has embossments, interlocking profile geometry, or other horizontal shear connection devices to develop a mechanical bond between the deck and concrete so the slab compositely resists vertical and *diaphragm* shear loads.

Configuration. A specific arrangement of panel geometry, thickness, mechanical properties, span(s), and attachments that is unique to a *test assembly*.

Diaphragm. Roof, floor, or other horizontal or nearly horizontal membrane or bracing system that transfers *in-plane* forces to the lateral force resisting system.

Fluted Panel. Product formed from steel coils into profiles having single or a repeating pattern such that top and bottom flanges are connected by webs.

Form Deck. Fluted or cellular deck that chemically bonds with structural concrete or insulating concrete fill to form a slab that resists diaphragm shear loads. The deck resists the concrete dead load prior to development of compressive strength. Reinforcement is required in structural concrete to resist slab flexure.

In-Plane. Orientation of loads that are applied in line with the plane in which the steel panels are installed.

Insulating Concrete. A mixture of Portland cement, cellular or expanded mineral concrete aggregate, and water that forms a relatively lightweight concrete.

Out-of-Plane. Orientation of loads applied normal to the surface of the plane in which the steel panels are installed.

Power-Actuated Fastener (PAF). Hardened steel fastener driven through deck or panels into supports using either powder cartridges or compressed gas as the driving energy source.

Sidelap Connection. Connections that attach adjacent panels to each other along the panel edges between the support members.

Single Diaphragm System. A diaphragm system having a specific configuration with one set of profile, thickness, mechanical properties, span, support fastener and sidelap connection types and patterns, support type and thickness, fill type and thickness when applicable, and edge detail.

Standing Rib Sidelap Connection (Top Sidelap Connection). A connection formed by a vertical sheet leg (edge stiffener of deck) inside an overlapping sheet hem, or by vertical legs back-to-back.

Steel Panel. A sheet of steel cold-formed into fluted panel or cellular deck with specified width and variable length.

Structural Concrete. A mixture of Portland or other hydraulic cement, fine aggregate, coarse aggregate and water.

Structural Fastener. A fastener attaching one or more steel sheets to the support member.

Test Assembly. Steel panels installed and connected to a bare frame to form the diaphragm test assembly.

Top Arc Seam Sidelap Weld. Arc seam weld applied at the top of a standing rib sidelap connection.

Top Overlapping Sidelap Connection. Welded, screwed, mechanically formed or crimped connection located at or near the top of an overlapping sidelap.

Wall Diaphragm. A wall, bearing or non-bearing, designed to resist forces acting in the plane of the wall (commonly referred to as a “vertical diaphragm” or “shear wall”).

4. Symbols

The following notations shall apply to this standard:

- a = Length of diaphragm test frame (See Figures 1 through 3)
- b = Depth of diaphragm test frame and dimension parallel with load P (See Figures 1 through 3)
- d_c = Average concrete cover depth over top of the deck measured at supports
- F = Shear flexibility of diaphragm web as determined from test measurements (flexibility factor)

F_u	= Tensile strength of steel
G'	= Shear stiffness of the <i>diaphragm</i> web as determined from test measurements
L_v	= Span of <i>steel panels</i> between supports with fasteners
P	= Applied load to test frame
P_d	= Load of P at which the <i>diaphragm</i> stiffness is determined = $0.4P_{\max}$
P_{fd}	= Load of P from testing of the <i>bare frame</i> at the deflection equal to the deflection for load of $P_d = 0.4P_{\max}$ for stiffness
P_{fn}	= Load of P from testing of the <i>bare frame</i> at the deflection equal to the deflection for load $P_{\max}$ for strength
$P_{\max}$	= Maximum applied load of P to test frame
P_n	= Load of P for determining nominal shear strength [resistance], S_n
S_n	= Nominal shear strength [resistance] of the <i>diaphragm</i> per unit length
t	= <i>Base steel thickness</i> of steel deck element of <i>diaphragm</i> web
Δ	= Reference displacement
Δ_d	= Net shear deflection of <i>diaphragm</i> at load $P_d = 0.4P_{\max}$
Δ_i	= Net shear deflection of <i>diaphragm</i> at any load level
Δ_u	= Displacement corresponding to ultimate load of average of a minimum of two static tests of <i>test assembly</i> run in accordance with Section 9.1
$\Delta_{1,2}$	= Diagonal displacement measured at points 1 or 2 (See Figure 2)
$\Delta_{1,2,3,4}$	= Orthogonal displacement measured at points 1, 2, 3 or 4 (See Figure 3)

5. Units of Symbols and Terms

Any compatible system of measurement units is permitted to be used in this Standard, except where explicitly stated otherwise. The unit systems considered shall include U.S. customary units (force in kips and length in inches) and SI units in IEEE/ASTM SI10 (force in Newtons and length in millimeters).

6. Measurement Precision

Precision in measurements shall be in accordance with this section.

6.1 The accuracy of the recorded loads shall be within ± 1 percent of full range of the measuring device.

User Note:

The capacity (range) of the load-measuring device should be appropriate to the expected maximum tested load. The use of a measuring device with a calibrated capacity greatly exceeding the anticipated load is inappropriate. A target ratio of the load-measuring device capacity to specimen strength of no greater than three is recommended.

The tests should be conducted on a testing machine that complies with the requirements of ASTM E4-16, *Standard Practices for Force Verification of Testing Machines*.

6.2 Displacements shall be recorded to a precision of 0.01 in. (0.25 mm).

7. Test Assembly

The *test assembly* shall consist of a rectangular test frame upon which the *steel panels* are placed and fastened using connections spaced as intended for end use. The *test assembly* is

permitted to have intermediate framing members to support the *steel panels*. All *steel panels* of the *test assembly* shall be full-width, except for parallel edge sheets which are permitted to be partial-width sheets, and shall use the same grade of steel, thickness, details, methods of construction, and connections as intended for end use. It is permitted to fasten partial-width panels to develop the strength of full-width panels.

7.1 Components of Test Assembly. The components of the test assembly shall meet the requirements of this section:

7.1.1 Steel Panels. The *steel panels* shall be installed perpendicular to the load beam(s) as shown in Figures 1 through 3 or parallel to the load beam(s). All of the panels in a *test assembly* shall be produced from the same coil of steel. The end lap splice, as illustrated in Figure 1, is optional, but shall be included in the test program if end lap performance is a test program parameter.

User Note:

It is permitted to apply test results for butted or continuous sheets to lapped construction.

It is permitted to connect the *steel panel's* parallel edges to the support framing members, as required, to ensure the failure mechanism of the test occurs in the field of the *diaphragm*. To test an edge detail parallel with the *steel panel* span or an end detail perpendicular to the *steel panel* span, it is permitted to provide enough connections elsewhere to ensure the failures occur at the desired locations. The same *configuration* shall be tested without the end detail to isolate the contribution of the end detail, unless the end detail contribution can be determined analytically.

7.1.2 Test Frame Support Members. The test frame members that support the *steel panels* are permitted to be steel, concrete, wood, or a combination of materials representative of intended end use. The intermediate support beams shall be installed consistent with the intended construction.

User Notes:

- a. The failure mechanism and flexibility of *steel panel* connections to the test frame support members should be representative of the intended end use.
- b. The test frame member sizes need not be the same size as those for the intended end use.

7.2 Cantilever Test Assembly. The cantilever test consists of the rectangular *test assembly* with load applied along one side of the test frame, and supports provided at the opposite side of the test frame. See Figures 1 through 3 for illustrations.

The *test assembly* size shall not be less than five (5) full-width *steel panels* and shall have an *aspect ratio* (see Figures 1 through 3) between 0.6 and 1.67. When the intended end use of the *diaphragm* is outside these limits, it is permitted for the *test assembly* size to be less than five (5) full-width *steel panels* and have an *aspect ratio* outside the 0.6 to 1.67 limits.

8. Number of Diaphragm Tests

8.1 Tests for Single Diaphragm System. To determine the strength and the stiffness of a single *diaphragm* assembly from testing, the minimum number of tests shall be in accordance with Section K2.1.1(a) of AISI S100.

User Note:

AISI S100 Section K2.1.1(a) requires a minimum of three (3) tests, with additional tests required based on the deviation from the average.