AISI S909-17

American Iron and Steel Institute

AISI STANDARD

Test Standard for Determining the Web Crippling Strength of Cold-Formed Steel Flexural Members

2017 Edition

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Approved by
the AISI Committee on Specifications for the Design of
Cold-Formed Steel Structural Members

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.

The materials set forth herein are for general information only. They are not a substitute for competent professional advice. Application of this information to a specific project should be reviewed by a registered professional engineer. Indeed, in most jurisdictions, such review is required by law. Anyone making use of the information set forth herein does so at their own risk and assumes any and all resulting liability arising therefrom.

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PREFACE

The American Iron and Steel Institute Committee on Specifications developed this Standard to establish procedures for conducting tests to determine the web crippling strength of cold-formed steel flexural 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.

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

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AISI S909-17
TEST STANDARD FOR
DETERMINING THE WEB CRIPPLING STRENGTH OF
COLD-FORMED STEEL FLEXURAL MEMBERS

1. Scope

1.1 This Standard establishes procedures for conducting tests to determine the nominal web crippling strength [resistance] of cold-formed steel flexural members.

1.2 This Standard describes the procedure for determining the following web crippling strengths:

Interior One-Flange Loading (*IOF*) (Figure 1)
End One-Flange Loading (*EOF*) (Figure 2)
Interior Two-Flange Loading (*ITF*) (Figure 3)
End Two-Flange Loading (*ETF*) (Figure 4)

1.3 The Standard is applicable to single-web, multiple-web and built-up web sections. See Figures 5, 6 and 7, respectively.

1.4 This Standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.

Commentary:
This Standard was developed based on the research report by LaBoube and Schuster (2002), "Standard Test Method for Determining the Web Crippling Strength of Cold-Formed Steel Members," published by the American Iron and Steel Institute.

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*

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

A370-16, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

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

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

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 or ASTM E6 shall have the ordinary accepted meaning for the context for which they are intended.

Interior One-Flange Loading and Reaction (IOF). A condition where the distance from the edge of the bearing to the end of the member is greater than 1.5h, and the clear distance between the bearing edges of adjacent opposite concentrated loads or reactions is equal to or greater than 1.5h (See Figure 1).

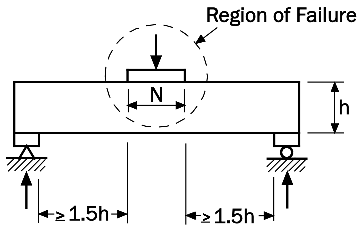

Figure 1 – Interior One-Flange Loading (IOF)

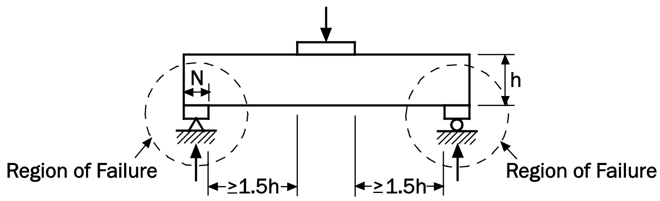

Figure 2 – End One-Flange Loading (EOF)

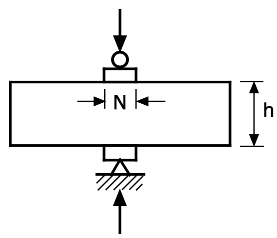

Figure 3 – Interior Two-Flange Loading (ITF)

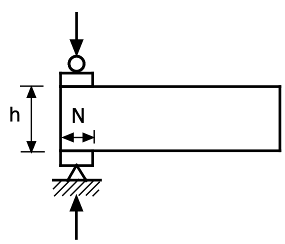

Figure 4 – End Two-Flange Loading (ETF)

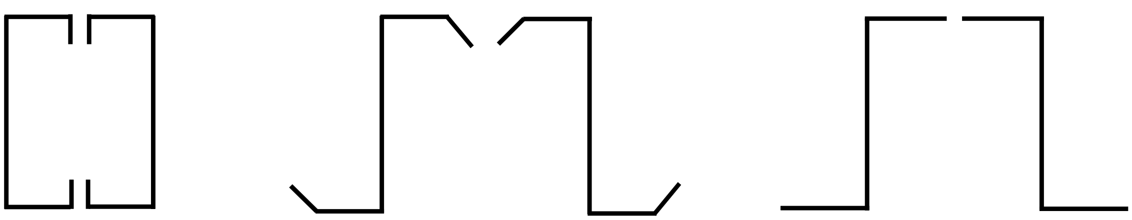

Figure 5 – Single-Web Cross-Sections

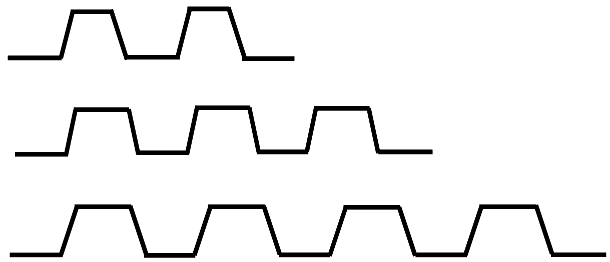

Figure 6 – Multi-Web Cross-Sections

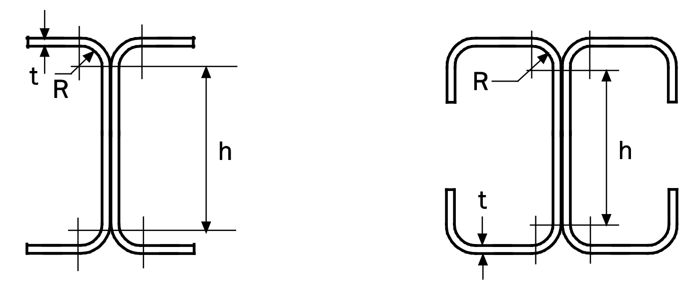

Figure 7 – Built-Up Cross-Sections

End One-Flange Loading and Reaction (EOF). A condition where the distance from the edge of the bearing to the end of the member is equal to or less than 1.5h, and the clear distance between the bearing edges of adjacent opposite concentrated loads or reactions is equal to or greater than 1.5h (See Figure 2).

Interior Two-Flange Loading (ITF). A condition where the distance from the edge of the bearing to the end of the member is greater than 1.5h, except as otherwise noted, and the clear distance between the bearing edges of adjacent opposite concentrated loads or reactions is equal to or less than 1.5h (See Figure 3).

End Two-Flange Loading (ETF). A condition where the distance from the edge of the bearing to the end of the member is equal to or less than 1.5h, and the clear distance between the bearing edges of adjacent opposite concentrated loads or reactions is equal to or less than 1.5h (See Figure 4).

4. Symbols

h = Depth of flat portion of web element measured along plane of web
L_{min} = Minimum length of test specimen
N = Length of bearing
t = Web thickness
R = Inside bend radius
θ = Angle between plane of web and plane of bearing surface

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 in this Standard shall include U.S. customary units (force in kips and length in inches) and SI units (force in Newtons and length in millimeters) in accordance with IEEE/ASTM-SI10.

6. Measurement Precision

6.1 Loads shall be recorded to a precision of ±1 percent of the 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 rests should be conducted on a testing machine that complies with the requirements of ASTM E4-16, *Standard Practices for Force Verification of Testing Machines*.

7. Test Fixture

7.1 In lieu of using a test machine, the load is permitted to be applied by a hydraulic or pneumatic cylinder.

> **User Note:**
> The test method is generally suitable for either hydraulic or screw-operated testing machines.

8. Test Specimen

8.1 The test specimen shall be both laterally and torsionally stable. Thus, for a geometry that does not permit the application of the load through the shear center (e.g., a C-shape), or for a geometry having oblique principal axes (e.g. Z-shape), the test specimen shall consist of two opposed sections as shown in Figure 5. Alternatively, the shapes are permitted to be positioned to represent in-place conditions with appropriate lateral stability provided (e.g., C-shapes facing the same direction with the flanges attached by sheathing).

8.2 When evaluating the nominal web crippling strength [resistance] of a specific single-web cross-section, the test specimen as described in Section 8.1 shall be constructed with two cross-sections of like geometry, dimensions, and material properties. For consideration of a specific structural condition, the in-place condition shall be simulated by the test specimen (e.g., a lapped section at the interior support).

8.3 The cold-formed steel shapes shall be interconnected using rigid connecting elements, (e.g. L3/4×3/4×1/8 in inches and L20×20×3 in mm), to form the box shape. Connecting elements of equivalent stiffness are permitted (e.g., sheathing). The width of the connecting elements shall not be so large that they influence the web crippling deformation.

8.4 The rigid connecting elements shall be connected to the top flange of the cold-formed steel shape using screws or bolts. It is permitted to attach the rigid connecting elements to the bottom flange as well.

> **User Note:**
> A self-drilling screw is commonly used.

8.5 When using rigid connecting elements, they shall be located at approximately the 1/4 and 3/4 points along the longitudinal axis of the box shape.

8.6 For built-up shapes (e.g., back-to-back C-shapes or nested Z-shapes), the fastener type and pattern used to fabricate the shape shall replicate the in-place condition.

8.7 For sections that may experience a spreading of their webs when under loads, such as a hat section, the open side of the cross-section is permitted to be laterally restrained by rigid elements as defined in Sections 8.3 and 8.4 assuming in-place conditions are reflected.

8.8 The length of the test specimen shall be defined based on the loading condition and the in-place conditions. Conservatively, it is permitted to use the following minimum specimen lengths:

IOF Loading: L_{min} = 3.0 h + bearing plate lengths (See Figure 1)
EOF Loading: L_{min} = 3.0 h + bearing plate lengths (See Figure 2)
ITF Loading: L_{min} = 3.0 h (See Figure 3)
ETF Loading: L_{min} = 3.0 h (See Figure 4)

where h = depth of the flat portion of the web measured along the plane of the web.

User Note:
For *ITF* loading, L_{min} = 3.0 h provides a conservative web crippling strength. Based on in-place conditions, it is permitted to use a longer length; for example, L = 5.0 h. However, longer lengths for *IOF* and *EOF* loading are not recommended since they may result in premature failure resulting from combined bending and web crippling. Accordingly, the flexural capacity of the specimen needs to be controlled at the mid-span to ensure flexural failure will not occur prior to the web crippling failure at the ends or the mid-span throughout the test. It is also recommended to consider combined bending and shear in accordance with Section H2 of AISI S100 when designing the specimen.

8.9 The length of the bearing plate, N, shall replicate in-place conditions.

8.10 The cold-formed steel shape shall be connected to its support member replicating in-place conditions. For conservative results, it is permitted to omit the support connection.

8.11 For conservative results, a simply supported condition is permitted. Alternatively, the support condition shall replicate the in-place conditions (e.g., C-shapes nested into a track section).

8.12 It is permitted to use the test specimen configuration and bracing that replicate the in-place conditions.

9. Test Procedure

9.1 A test series shall consider each steel grade and cross-section geometry.

9.2 A test series shall consist of no fewer than three tests for each unique cross-section geometry and steel grade. The safety factor or resistance factor used in design shall be computed in accordance with Section K2.1 of AISI S100.

9.3 The mechanical properties of the sheet steel shall be determined in accordance with ASTM A370. The coupons shall be taken from flat sheet cut from the coil used to fabricate the cold-formed steel shapes, or from the web element of the shape. Coupons shall be taken from areas where cold-working stresses will not affect the results.

9.4 The test specimen shall be loaded at a uniform rate between 0.03 and 0.10 in. (0.76 to 2.54 mm) per minute until failure, and the mode of failure shall be noted. Failure shall be considered as at the point at which the specimen will accept no further load. For those members or assemblies that fail in a progressive manner (e.g., a mechanism whereby there is an initial web crippling failure followed by a change in the specimen configuration and then continued increase in load-carrying capacity), the failure load is permitted to be taken as the first local maxima in the load deflection curve.

10. Data Evaluation

10.1 The measured failure load per web at the location of failure shall be computed using measured values, common methods of statics or other structural analysis methods as required.

11. Test Report

11.1 The objectives and purposes of the test series shall be stated at the outset of the report so that the necessary test results such as the failure load and the mode of failure are identified.

11.2 The types of tests, the testing organization, the supervising engineer, and the dates on which the tests were conducted shall be included in the documentation.

11.3 The test specimen shall be fully documented, including:

(a) The measured dimensions, mechanical properties and identification data of each specimen.

User Note:
This data would include material thickness, yield stress, percent elongation, cross-section dimensions, length of bearing plate(s), specimen length, support conditions, manufacturer, and any other distinguishing characteristics.

(b) Location of additional stiffeners,
(c) Location of lateral braces,
(d) Location and size of connecting elements, and
(e) Type and size of fasteners used.

11.4 The report shall include the type of testing machine, loading increments, and supports. If a hydraulic cylinder and load cell are used, they shall be described. The last date of calibration for the test machine or load cell shall be recorded.

11.5 The report shall include a description summarizing the test program results including the specimen type, span length, failure loads for the test series, representative load-deflection curves, and supporting calculations.

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