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Method for Flexural Testing of Cold-Formed Steel Hat-Shaped Beams, 2013 Edition

American Iron and Steel Institute

AISI S911-13

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AISI STANDARD

Method for Flexural Testing of Cold-Formed Steel Hat-Shaped Beams

2013 Edition

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 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 provide test methods for determining the nominal flexural strength of an open hat shaped cross-section subject to *negative bending moment*.

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 this subject.

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

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Method for Flexural Testing of Cold-Formed Steel Hat-Shaped Beams

1. Scope

1.1 This method establishes test procedures for determining the nominal flexural strength of an open hat-shaped cross-section subject to *negative bending moment*.

1.2 This test method is permitted to be used to evaluate the nominal flexural strength of hat sections with or without a discrete intermediate bracing system.

1.3 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 of this standard to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.

Commentary:
This test method can be used to establish the nominal flexural strength of a particular open hat-shaped cross-section which is subjected to local, distortional and/or overall buckling.

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:

S100-12, *North American Specification for the Design of Cold-Formed Steel Structural Members*

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

A370-12a, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*
E6-09be1, *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.

Negative Bending Moment. A moment which causes compression on the open side of the section.

Failure. A state at which the specimen will accept no additional load.

4. Symbols

a = Measured distance along beam (See Figure 1)
b = Measured distance along beam (See Figure 1)
L = Span length of the section tested, measured center-to-center of end supports (See Figure 1)

P_{ts} = *Failure* load of single span system tested
R = Support reaction
t = Nominal base steel thickness exclusive of coating
t_a = Average base steel thickness

5. Apparatus

5.1 The test method shall be generally suitable for either hydraulic or screw-operated testing machines.

5.2 The test specimen support fixtures and the testing machine ram shall have the capability of maintaining a constant loading direction throughout the test.

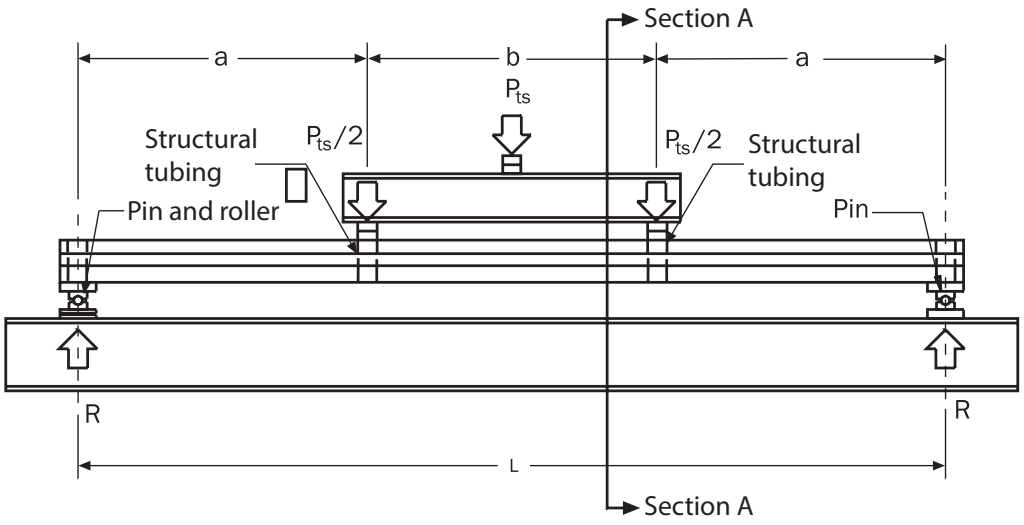

Figure 1 - Simply Supported Beam Test

5.3 The lateral support fixtures used in the test shall be installed in such a manner so as not to impede the horizontal displacement of the open side of the section, i.e., the compression flanges and the vertical deflection of the specimen.

5.4 In lieu of a test machine, the load shall be applied by either a hydraulic or a pneumatic cylinder. When a cylinder is used, a calibrated load cell shall be used to measure the applied load to within ± 2 percent.

User Note:
The testing machine should comply with the requirements of ASTM E4-10, *Standard Practices for Force Verification of Testing Machines*, wherein the rate of loading can be controlled, constant loads maintained, and the applied load can be measured accurately to within ± 2 percent.

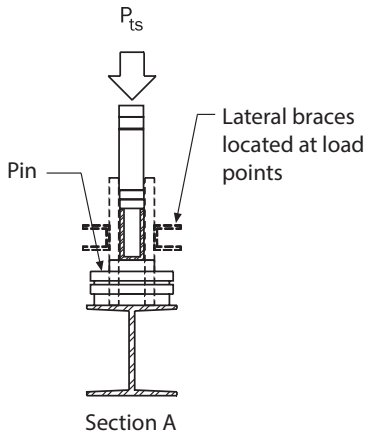

Figure 2 - Section of Simply Supported Beam Test

6. Test Unit

6.1 A test unit shall include a minimum of three identical beam specimens and a minimum of two corresponding sheet-type tensile specimens.

6.2 The specimens within a unit shall represent one type of cold-formed steel section with the same specified geometrical, physical, and chemical properties. The specimens are permitted to be taken from the same beam or from different production runs provided the source of the specimens is properly identified and recorded.

6.3 If beam specimens are taken from different production runs, at least two corresponding sheet-type specimens shall be taken and tested from each production run.

6.4 The test specimens shall be used to determine:

(1) The actual geometry of each specimen.

(2) The maximum beam test load.

6.5 The tensile test specimens shall be used to determine the yield stress, tensile strength, and percent elongation of each beam specimen in accordance with the requirements described in ASTM A370.

6.6 For each test specimen and test unit, the measured geometrical and tested mechanical properties of the individual specimens shall meet the requirements stated by the fabricator and material producer, respectively.

6.7 If the average area, thickness, or yield stress of a test unit varies by more than 20 percent from the specified-minimum value, the test unit shall be considered to be non-representative of the beam section, and further evaluations are considered to be invalid.

7. Specimens

7.1 The beam specimen shall be supported at one end by a pin condition and at the other end by a pin and roller condition. Lateral bracing at the beam specimen ends and at load points is permitted.

User Note:
It is permitted to restrain the top flange (open portion of a hat section in compression) at the load points to replicate the in-place, fabricated assembly.

7.2 The beam specimen shall be installed so as to cause compression on the open side of the hat section.

7.3 For tests including intermediate discrete point braces, the braces used in the test shall be installed in such a manner so as not to impede the lateral displacement of the compression flanges and the vertical deflection of the beam specimen.

7.4 Beam specimen length, b, as shown in Figure 1, shall enable formation of each of the local buckling, distortional buckling, or overall buckling modes, and shall be determined as follows:

(1) For local buckling determination, length b is taken as at least three times the maximum flat width of the section.

(2) For overall buckling, length b is based on the maximum in-place unbraced length of the member.

(3) For distortional buckling, length b is determined analytically or experimentally. If the length is determined analytically, b is taken as a minimum of three half-wave lengths as determined analytically by a finite strip or finite element analysis, where the half-wavelength is the one corresponding to the minimum distortional buckling. If the distortional buckling mode is not observed, the test specimen length is to be adjusted to achieve distortional buckling. If b is determined experimentally, an array of tests of differing lengths is performed until distortional buckling is observed. Length a, as shown in Figure 1, is to be chosen to achieve the desired applied bending moment, but not less than three times the depth of the beam specimen.

7.5 At the point of application of the loads, the webs of the beam specimen shall be connected by self-drilling screws to a structural tube or other element simulating the truss web in such a manner to effectively restrain lateral movement of the web (See Figure 1).

7.6 *Beam Specimen Source*. Beam test specimens shall be cut from the commercially fabricated beam product or beam test specimens shall be specially fabricated, provided care is taken not to exceed the cold work of forming expected in the commercial product. If the beam test specimen is specially fabricated, subsequent proof tests using specimens from commercially produced beams shall be required and reported.

7.7 *Tensile Specimen Source*. Longitudinal tensile specimens shall be cut from the center of the widest flat of a formed section from which the beam specimens have been taken, or the tensile specimens shall be taken from the sheet or coil material used for the fabrication of the beam specimens. The tensile specimens shall not be taken from parts of a previously tested beam.

8. Beam Test Procedure

8.1 The beam specimen shall be supported at one end by a pin condition and at the other end by a pin and roller condition. Lateral bracing at the beam specimen ends and at load points is permitted.

8.2 For tests including intermediate discrete point braces, the braces used in the test shall be installed in such a manner so as not to impede the lateral displacement of the compression flanges and the vertical deflection of the beam specimen.

8.3 A two-point load shall be applied to the system to produce a *negative bending moment* in the test specimen (See Figure 1).

8.4 Care shall be taken to center the specimen on the axis of the test machine.

8.5 The load increments applied during the test shall not exceed 10 percent of the estimated maximum test load.

8.6 The test specimen shall be loaded to *failure*, P_{ts}, and the mode of *failure* reported.

8.7 The maximum loading rate between load increments shall not exceed a corresponding applied stress of 3 ksi (21 MPa) at the extreme fiber of the gross cross-section per minute.

8.8 Deflections of the specimen are permitted to be measured during the test. When deflections are recorded, the following procedures shall be required:

(1) The deflection shall be measured to the nearest 0.001 in (0.0254 mm) at each load increment, and

(2) The load increments applied during the test shall be the same for each specimen within a test unit, with a variation not to exceed one percent.

9. Calculations

9.1 Extrapolations beyond 20 percent of the extreme parameters tested shall not be permitted.

10. Test Report

10.1 The report shall include a complete record of the sources and locations of all beams and tensile-test specimens, and shall describe whether the specimens were taken from one or several beams, or several production runs, coil stock, or other sources.

10.2 The documentation shall include all measurements taken for each beam test specimen, including: (1) cross-section dimensions, (2) uncoated sheet thickness, (3) yield stress, (4) tensile strength, (5) percent elongation, (6) applicable material specification, (7) manufacturer, (8) test setup characteristics such as lateral brace locations and bearing stiffeners, and (9) evaluation procedure used.

10.3 The determination of the selected beam span shall be fully documented with appropriate calculations.

10.4 A description of the test setup and the instrumentation used shall be included.

10.5 The report shall include the load increments, rate of loading, ultimate loads and observations made during the test for each beam tested.

10.6 The report shall include complete calculations and results.

10.7 The report shall state any visual observations recorded that are pertinent to the performance of the test specimen(s).

10.8 The report shall provide the data required (number of tests, coefficient of variation of the test load, etc.) for the determination of resistance factor, ϕ, and safety factor, Ω, in accordance with Section F1 of AISI S100.

11. Precision

The following criteria shall be used to judge the acceptability of the test results:

11.1 *Repeatability*. The individual beam test results shall be considered suspect if they differ by more than 10 percent from the mean value for a test unit with at least three specimens.

11.2 *Reproducibility*. If tests are performed at different test labs, the results of tests on beams conducted at two or more laboratories shall agree within 10 percent when adjusted for differences in cross-sectional dimensions and yield stress in order to be considered valid tests.

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