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Test Standard for Determining the Distortional Buckling Strength of Cold-Formed Steel Hat-Shaped Compression Members, 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

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 provide test methods for determining the distortional buckling strength of cold-formed steel hat shaped compression 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 S910-17
TEST STANDARD FOR DETERMINING THE DISTORTIONAL BUCKLING STRENGTH OF COLD-FORMED STEEL HAT-SHAPED COMPRESSION MEMBERS

1. Scope

1.1 This Standard establishes procedures for determining the nominal distortional buckling strength [resistance] of cold-formed steel compression members with a hat-shaped cross-section.

1.2 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 to use.

Commentary:

Distortional buckling involves both rotation of the compression element as well as translation of the compression element about fold lines. Distortional buckling reduces the axial load-carrying capacity that would otherwise be limited by general yielding, local buckling, or overall column buckling. AISI S100 can be used to determine the column buckling strength limited by general yielding, local, distortional, and overall buckling. AISI S902 can be used to determine the column capacity for local buckling.

Reference:

S902-17, *Test Standard for Determining the Effective Area of Cold-Formed Steel Compression Members*

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

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.

4. Symbols

F_y = Minimum specified design yield stress of compression member

F_{yi} = Individual yield stresses used to compute F_{ya}

F_{ya} = Average yield stress of the sheet steel for a given test unit

L = Required test specimen length

P_u = Test load at which compression member failure occurs

P_{ua} = Average of test loads P_u
ϕ = Resistance factor
Ω = Safety factor

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

7. Test Fixture

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

8. Test Unit

8.1 A test unit shall include a minimum of three nominally identical compression member specimens and a minimum of two corresponding sheet-type tensile specimens.

8.2 The compression member specimens within a unit shall represent one type of cold-formed steel section with the nominally identical specified geometrical and mechanical properties. The specimens are permitted to be taken from the same column or from different production runs provided the source of the specimens is properly identified and recorded.

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

8.4 The compression member specimens shall be used to determine:

(1) The actual geometry of each specimen, and

(2) The nominal distortional buckling strength [resistance] of the compression member.

8.5 The tensile test specimens shall be used to determine the yield stress of each compression member specimen according to the requirements described in ASTM A370.

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

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

9. Test Set-Up

The compression member specimens shall meet length and end-flatness requirements as follows:

9.1 *Compression Member Length*. The required compression member length shall be defined in accordance with Section 9.1.1.

User Note:
The length requirements of the compression member test specimen, L, are that it is: (1) short enough to minimize overall column buckling effects, and (2) long enough to minimize the end effects during loading.

9.1.1 The length, L, is to be determined analytically or experimentally. If analytical determination of the test specimen length is used, the length is to be based on the minimum distortional buckling wavelength as determined by a finite strip or other appropriate finite element analysis. The specimen length with consideration of distortional buckling shall be at least four half-wavelengths and shall be tested between flat ends. If the distortional buckling mode is not observed experimentally, the specimen length shall be adjusted to achieve the distortional buckling mode. If experimental determination of the test specimen length is used, the test specimen length shall be based on an array of tests of differing specimen lengths until the distortional buckling mode is observed or it is shown that distortional buckling is not a controlling limit state.

9.2 *Compression Member End Surface Preparation*. The end planes of the test specimens shall be carefully cut and milled to a flatness tolerance of plus or minus 0.002 in. (0.0508 mm).

9.3 *Compression Member Specimen Source*. Test specimens shall be cut from the commercially fabricated product or shall be specially fabricated, provided care is taken not to exceed the cold work of forming expected in the commercial product. If the specimen is specially fabricated, subsequent proof tests using specimens from commercially produced compression member shall be required and reported.

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

10. Test Procedure

10.1 Care shall be taken to center the specimen on the axis of the test machine to ensure that the applied load is uniformly distributed over the specimen end surfaces. The compression member ends shall rest on flat steel plates, or on a spherical surface with a point contact, or on pins in mutually perpendicular directions, such that the resultant of the axial load is applied through the centroid of the gross section.

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

10.3 The maximum loading rate between load increments shall not exceed a corresponding applied stress rate of 3 ksi (21 MPa) of gross cross-sectional area per minute.

104 The test specimen shall be loaded to failure and the mode of failure shall be noted. Failure is the point at which the specimen will accept no additional load.

11. Data Evaluation

11.1 For a given test unit, all individual test loads, P_u, derived from the tests shall be used to calculate the average test load, P_{ua}. Similarly, all individual yield stresses, F_{yi}, derived from the tensile tests of the same unit shall be used to calculate the average yield stress of the same test unit, F_{ya}.

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

12. Test Report

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

12.2 The documentation shall include all measurements taken for each compression member test specimen, including: (1) cross-section dimensions, (2) uncoated sheet thickness, (3) yield stress, (4) tensile strength, (5) percent elongation, (6) manufacturer, (7) end preparation, and (8) test and evaluation procedure used.

12.3 The determination of the selected compression member length shall be fully documented with appropriate calculations.

12.4 A description of the test setup and the instrumentation used to measure lateral displacements and axial shortening (if measured) shall be included.

12.5 The report shall include the load increments, rate of loading, test loads and any observations made during the test for each compression member tested.

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

12.7 The report shall provide the data required (number of tests, coefficient of variation of test loads, etc.) to determine the resistance factor, ϕ, and safety factor, Ω, in accordance with Section K2.1 of AISI S100.

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