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Test Method for Distortional Buckling of Cold-Formed Steel Hat-Shaped Compression Members, 2013 Edition

American Iron and Steel Institute

AISI S910-13

American
Iron and Steel
Institute

AISI STANDARD

Test Method for Distortional Buckling of Cold-Formed Steel Hat-Shaped Compression Members

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 (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 with a hat shaped cross-section..

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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Test Method for Distortional Buckling of Cold-Formed Steel Hat-Shaped Compression Members

1. Scope

1.1 This test method establishes procedures for determining the distortional buckling strength of cold-formed steel hat-shaped 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. The Direct Strength Design included in Appendix A of AISI S100 provides an alternative design approach for determining member strengths. AISI S902 can be used to determine the column capacity for local 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*
S902-13, *Stub-Column Test Method for Effective Area of Cold-Formed Steel Columns*

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

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 column material
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 column load at which failure occurs

P_{ua} = Average test column load

ϕ = Resistance factor

Ω = Safety factor

5. Apparatus

5.1 In lieu of a test machine, load is permitted to 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 tests should be conducted on a testing machine that complies with the requirements of ASTM E4-10, *Standard Practices for Force Verification of Testing Machines*.

6. Test Unit

6.1 A test unit shall include a minimum of three nominally identical column 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 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.

6.3 If column 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 column test specimens shall be used to determine:

(1) The actual geometry of each specimen, and
(2) The nominal distortional buckling strength of a column.

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

6.6 For each test specimen and test unit, the measured geometrical and tested physical properties of the individual specimen shall meet the requirements stated by the fabricator and the 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 respective nominal or specified-minimum value, the test unit shall be considered to be non-representative of the column section, and further evaluations are considered to be invalid.

7. Specimens

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

7.1 *Column Length*. The required column length shall be defined in accordance with Section 7.1.1.

User Note:
The length requirements of the column 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.

7.1.1 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.

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

7.3 Column Specimen Source. Column test specimens shall be cut from the commercially fabricated column 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 columns shall be required and reported.

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

8. Column Test Procedure

8.1 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 column 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.

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

8.3 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.

8.4 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.

9. Calculations

9.1 For a given test unit, all individual test loads, P_u, derived from the column 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}.

9.2 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 column and tensile-test specimens and shall describe whether the specimens were taken from one or several columns, one or several production runs, coil stock, or other sources.

10.2 The documentation shall include all measurements taken for each column 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.

10.3 The determination of the selected column length shall be fully documented with appropriate calculations.

10.4 A description of the test setup and the instrumentation used to measure lateral displacements and axial shortening shall be included.

10.5 The report shall include the load increments, rate of loading, test loads and any observations made during the test for each column 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 describe any known deviations from this test method.

10.9 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 F1 of AISI S100.

11. Precision

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

11.1 Repeatability. Individual column test results shall be excluded if they differ by more than 10 percent from the mean value for a test unit when tested with a minimum of three specimens.

11.2 Reproducibility. The results of tests on columns conducted at two or more laboratories are to 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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