01 Apr 2018

Test Standard for Determining the Effective Area of Cold-Formed Steel Compression Members, 2017 Edition

American Iron and Steel Institute

AISI S902-17

American Iron and Steel Institute

AISI STANDARD

Test Standard for Determining the Effective Area of Cold-Formed Steel Compression Members

2017 Edition

AISI S902-17

American Iron and Steel Institute

AISI STANDARD

Test Standard for Determining the Effective Area of Cold-Formed Steel Compression Members

2017 Edition

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

1st Printing – April 2018

Produced by American Iron and Steel Institute

PREFACE

The American Iron and Steel Institute Committee on Specifications developed this Standard to provide test methods for determining the effective cross-sectional area of cold-formed steel 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.

Commentary and user notes are non-mandatory and copyrightable portions of this Standard.

This page is intentionally left blank.

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

R. B. Haws, *Chairman*	Nucor Buildings Group
S. R. Fox, *Vice-Chairman*	Canadian Sheet Steel Building Institute
H. H. Chen, *Secretary*	American Iron and Steel Institute
D. Allen	Super Stud Building Products
P. Bodwell	Verco Decking, Inc.
R. L. Brockenbrough	R. L. Brockenbrough and Associates
J. Buckholt	Computerized Structural Design
J. K. Crews	Unarco Material Handling, Inc.
L. R. Daudet	Simpson Strong-Tie
R. S. Douglas	National Council of Structural Engineers Associations
W. S. Easterling	Virginia Polytechnic Institute and State University
D. Fulton	Triangle Fastener Corporation
R. S. Glauz	RSG Software, Inc.
P. S. Green	Bechtel Power Corporation
W. B. Hall	University of Illinois
G. J. Hancock	University of Sydney
A. J. Harrold	BlueScope Buildings North America
L. Kruth	American Institute of Steel Construction
R. L. Madsen	Supreme Steel Framing System Association
J. A. Mattingly	Consultant
W. McRoy	ICC Evaluation Service, Inc.
C. Moen	NBM Technologies, Inc.
J. R. U. Mujagic	Structural Engineering Consultant
N. A. Rahman	The Steel Network, Inc.
G. Ralph	ClarkDietrich Building Systems
V. E. Sagan	Metal Building Manufacturers Association
T. Samiappan	OMG, Inc.
A. Sarawit	Simpson Gumpetz & Heger
B. W. Schafer	Johns Hopkins University
K. Schroeder	Devco Engineering Inc.
T. Sputo	Steel Deck Institute
R. Ziemian	Structural Stability Research Council

Subcommittee 6 – Test-Based Design

L. R. Daudet, *Chairman*	Simpson Strong-Tie
H. H. Chen, *Secretary*	American Iron and Steel Institute
R. S. Douglas	National Council of Structural Engineers Associations
D. Fox	TOTAL JOIST By ISPAN Systems
S. R. Fox	Canadian Sheet Steel Building Institute
W. Gould	ICC Evaluation Service, Inc.
P. S. Green	Bechtel Power Corporation
W. B. Hall	University of Illinois
R. B. Haws	Nucor Buildings Group
R. L. Madsen	Supreme Steel Framing System Association
J. R. Martin	Verco Decking, Inc.
C. Moen	NBM Technologies, Inc.
J.R.U. Mujagic	Structural Engineering Consultant
T. M. Murray	Consultant
K. Peterman	University of Massachusetts Amherst
N. A. Rahman	The Steel Network, Inc.
G. Ralph	ClarkDietrich Building Systems
V. E. Sagan	Metal Building Manufacturers Association
T. Samiappan	OMG, Inc.
B. W. Schafer	Johns Hopkins University
M. Schmeida	Gypsum Association
R. Schuster	Consultant
F. Sesma	California Expanded Metal Products
M. Speicher	NIST Engineering Laboratory
T. Sputo	Steel Deck Institute
C. Yu	University of North Texas

AISI S902-17

TEST STANDARD FOR DETERMINING THE EFFECTIVE AREA OF COLD-FORMED STEEL COMPRESSION MEMBERS

1. Scope

1.1 This Standard provides methods to determine the effective cross-sectional area of cold-formed steel compression members.

1.2 This Standard provides requirements for testing, and equations to determine the effective area of a cold-formed steel compression member section at ultimate load, A_{euN}, and the load- or stress-dependent effective area, A_e.

1.3 The Standard provides a means to observe, measure, and account for *local buckling* deformations when the appearance of a compression member section under stress must be determined.

1.4 The determination of A_e is conducted by either of the following methods:

(1) The basic method provided in Sections 5 through 11, or

(2) An alternative method provided in Appendix A.

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.

Elements. Straight or curved portions of the cross-section of a compression member or *stub-column*.

Local Buckling. The *local buckling* mode of a flat *element* of a compression member cross-section, which influences the overall column-buckling behavior.

Overall Buckling. Buckling of a compression member as a function of its overall length.

Stub-Column. An axial compression member of the same cross-section and material as the compression member for which the strength needs to be determined, but short enough to preclude *overall* column *buckling*, if possible.

4. Symbols

A = Gross cross-sectional area of a compression member without holes or perforation, or the minimum cross-sectional area of a compression member with holes or perforation

A_a = Average of all gross cross-sectional areas of the *stub-columns* without holes or perforations in a test unit, or the average minimum cross-sectional areas of the *stub-columns* with holes or perforations in a test unit

A_e = Effective cross-sectional area of a *stub-column* at a load less than the ultimate test load, or the effective area of a full-length compression member

A_{ei} = Effective cross-sectional area of a *stub-column* at load P_i

A_{eu} = Effective cross-sectional area of a *stub-column* at ultimate load

A_{eua} = Average effective cross-sectional area of a test unit of *stub-columns* at the ultimate axial load

A_{euN} = Nominal effective cross-sectional area at ultimate load adjusted to the nominal thickness and the minimum specified yield stress

A_{eu1} = Effective cross-sectional area of a *stub-column* with parameters of Test Unit 1 at ultimate load

A_{eu2} = Effective cross-sectional area of a *stub-column* with parameters of Test Unit 2 at ultimate load

A_N = Nominal gross cross-sectional area of a *stub-column*

A_1 = Minimum gross cross-sectional area of a *stub-column* with parameters of Test Unit 1 at ultimate load

A_2 = Minimum gross cross-sectional area of a *stub-column* with parameters of Test Unit 2 at ultimate load

D = Axial shortening of a *stub-column* at load P

D_i = Axial shortening of a *stub-column* at load P_i

D_u = Axial shortening of a *stub-column* at load P_u

f = Average axial stress assumed to be uniformly distributed over the effective cross-sectional area, A_e

f_i = Average axial stress assumed to be uniformly distributed over the effective cross-sectional area, A_{ei} at load P_i

f_o = Average axial stress assumed to be uniformly distributed over the effective cross-sectional area, A_e, above which the section is not fully effective

F_n = Nominal compressive stress, assumed to be uniformly distributed over the effective cross-section of a compression member as calculated from Chapter E of AISI S100, at which flexural, torsional, torsional-flexural, distortional, or *local buckling*, and/or yielding, can occur

F_u = Tensile strength, assumed to be uniformly distributed, at which local failure occurs in a tested *stub-column*

F_y = Minimum specified elastic limit or yield stress of compression member or *stub-column* material

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

F_{yi} = Individual elastic limit or yield stress of the sheet-steel specimens in a test unit

F_{yN} = Minimum specified elastic limit or yield stress of compression member or *stub-column* material

i = Load-displacement reading number for a particular *stub-column* test (load displacement D_i at load P_i)

j = Total number of load-displacement readings taken for a particular *stub-column* test

L = Length of the *stub-column* test specimen

L_p = Pitch of a repeating pattern of perforations along the longitudinal compression member axis

n = Ratio of the effective cross-sectional area at the ultimate load to the full cross-sectional area, A_{eu}/A

P = Applied axial compression force (compression member load)

P_i = Applied load at load increment i

P_N = Nominal failure load of a compression member

P_u = Ultimate *stub-column* load at which local failure occurs

P_{ua} = Average of all ultimate *stub-column* loads within a test unit

r = Minimum radius of gyration of the cross-sectional area, A

t = Nominal base-steel thickness exclusive of coating

t_a = Average of all base-steel thicknesses within a test unit, exclusive of coating

t_N = Nominal base-steel thickness within a test unit, exclusive of coating

W = Greatest overall width of the cross-section, including corner(s)

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 Linear displacement devices for measuring lateral displacements shall have a 0.001 in. (0.0254 mm) least-reading capability.

6.2 Measuring devices for determination of the actual geometry of a test specimen shall have a 0.001 in. (0.0254 mm) least-reading capability.

6.3 If axial shortening is recorded, the measuring device shall have a 0.0001 in. (0.00254 mm) least-reading capability.

6.4 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*.

7. Test Unit

7.1 A test unit shall include a minimum of three identical *stub-column* specimens and a minimum of two corresponding sheet-type tensile specimens.

7.2 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 compression member or from different production runs, provided the source of the specimens is properly identified and recorded.

7.3 If *stub-column* specimens are taken from different production runs, at least two corresponding sheet-type specimens shall be taken and tested from each production run.

7.4 The *stub-column* test specimens shall be used to determine:

(1) The actual geometry of each specimen

(2) The ultimate *stub-column* test load

(3) Axial shortening at each load level if the alternative test-evaluation method described in Appendix A is used

(4) Lateral displacements of the specimen at locations of interest (if desired).

7.5 The tensile test specimens shall be used to define the yield stress of each *stub-column* specimen in accordance with the requirements of ASTM A370.

7.6 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.

7.7 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 evaluation of the effective area shall be considered to be invalid.

8. Test Specimen

The *stub-column* specimens shall meet length and end-flatness requirements as follows, depending on whether unconnected or welded endplates are used.

8.1 *Stub-Column* Length. The length requirements of the *stub-column* test specimen, L, as shown in Figures 1 and 2, shall be as follows: (1) short enough to eliminate overall compression member buckling effects, and (2) sufficiently long to minimize the end effects during loading, which means that its center portion be representative of the repetitive hole pattern in the full compression member.

8.1.1 To eliminate overall column-buckling effects, the *stub-column* length shall not exceed 20 times the minimum radius of gyration, r, of the cross-section, A, except where necessary to meet the requirements of Sections 8.1.2 through 8.1.5.

8.1.2 For unperforated compression members (Figure 1a), the *stub-column* length shall not be less than three times the greatest overall width of the cross-section, W.

8.1.3 For perforated compression members in which the pitch (gage length) of the perforation pattern, L_p, for a single hole or a group of holes, is smaller than, or equal to, the greatest overall width, W, of the cross-section (Figures 1b and 1g); or for a single hole pattern with a gage length larger than the greatest overall width (Figure 1c), the specimen length shall not be less than three times the greatest overall width of the cross-section, W. For widely spaced hole patterns (Figure 1c), the significant hole or hole pattern shall be located at or near the mid-length of the *stub-column*.

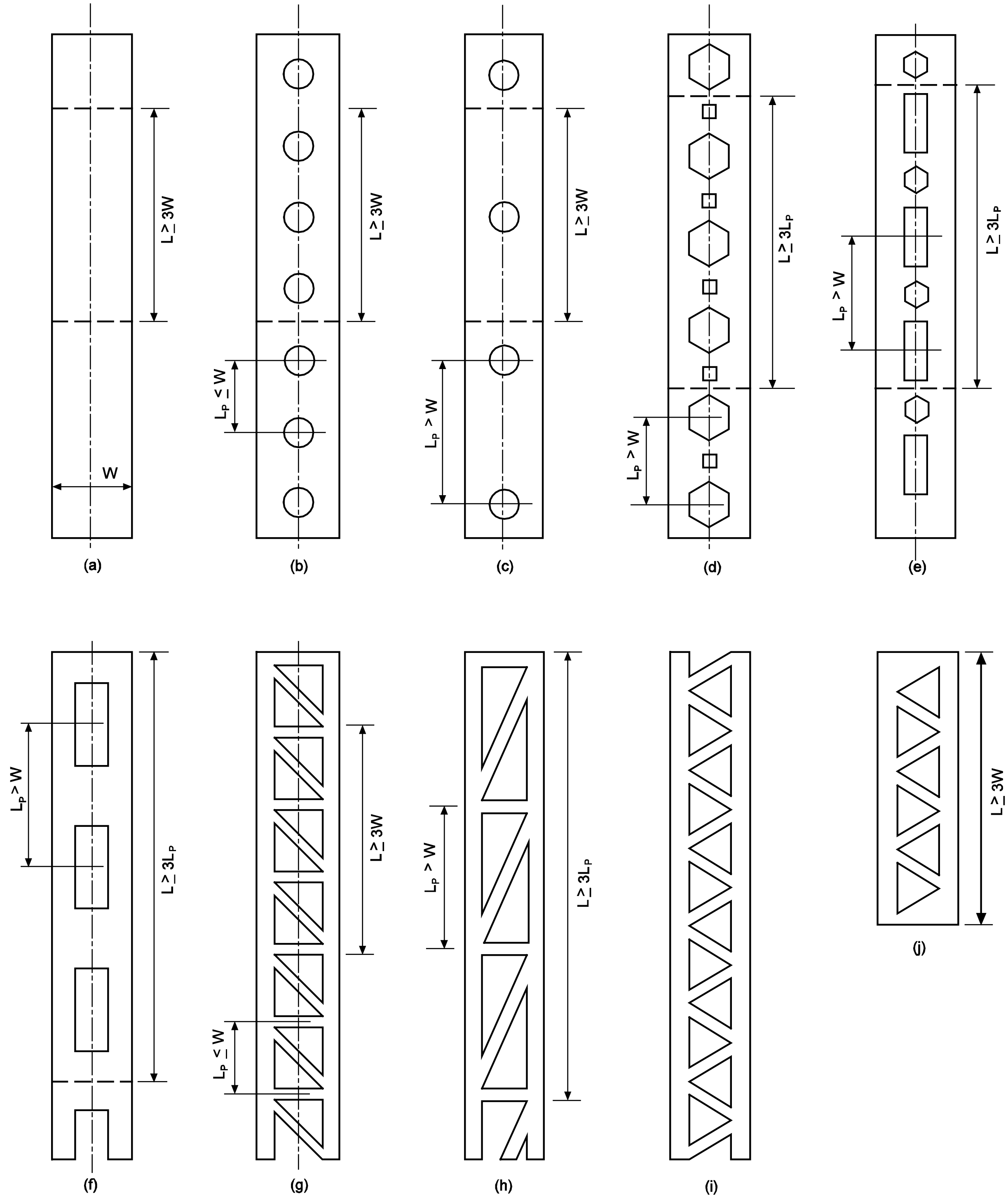

Figure 1 – Hypothetical Perforation Patterns and Suggested Stub-Column Lengths

NOTES: (1) Perforations shown are in a flat portion of a member with width W
(2) L = Length of *stub-column*
(3) L_p = Pitch length of perforation pattern

8.1.4 For perforated compression members in which the pitch of the perforation pattern, L_p, is greater than the widest side, W, of the cross-section (Figures 1d, 1e, 1f, and 1h), the specimen length shall not be less than three times the pitch of the perforation pattern.

8.1.5 For perforated sections in which the specimen end planes must pass through the normal perforation pattern (Figure 1i), a special section (Figure 1j) is permitted to be fabricated to obtain full cross-sectional surfaces at the specimen ends.

8.2 *Stub-Column* End Surface Preparation. The end planes of the *stub-column* test specimens shall be carefully cut to a flatness tolerance of plus or minus 0.002 in. (0.0508 mm). When the required flatness can be achieved, welding of the *stub-column* ends to the endplates shall not be required. However, when this flatness cannot be achieved, steel endplates shall be continuously welded to both ends of the specimen so that there is no gap between the ends of the *stub-column* and the endplates.

8.3 *Stub-column* Specimen Source. *Stub-column* test specimens are permitted to be cut from the commercially fabricated compression member product. Alternatively, *stub-columns* are permitted to be specially fabricated provided care is taken not to exceed the cold work of forming expected in the commercial product; however, subsequent proof tests using specimens from commercially produced compression members shall be considered.

8.4 Tensile Specimen Source. Longitudinal tensile specimens shall be cut from the center of the widest flat of a formed section from which the *stub-column* specimens have been taken. If perforations are large and frequent in all flats of the formed section, the tensile specimens are permitted to be taken from the sheet or coil material used for the fabrication of the *stub-column* specimens. The tensile specimens shall not be taken from parts of a previously tested *stub-column*.

8.5 Endplate Requirements. Steel endplates shall be at least 0.5 in. (12.7 mm) thick and have a flatness tolerance of plus or minus 0.0002 in. (0.00508 mm).

9. Test Procedure

9.1 To ensure that the applied load is uniformly distributed over the specimen end surfaces, the specimen shall be centered on the axis of the test machine.

9.1.1 Steel endplates shall be used to transfer the test loads uniformly into the *stub-columns* (Figure 2).

9.1.2 A 0.5 in. (12.7 mm) thick layer of grout, similar to gypsum-based concrete capping compound used for fast setting, shall be placed between the *stub-column* endplates and the machine heads to facilitate aligning the test specimen (Figure 2).

9.2 When an axial compression load is applied to the test specimen as a result of grout expansion during curing, or if a small preload is purposely applied to ensure proper contact between the *stub-column* endplates and the machine heads, the load shall be treated as part of the applied test load.

9.3 The load increments applied during the test shall not exceed 10 percent of the estimated ultimate test load.

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

9.5 When axial shortening values are recorded, the following procedures shall be required:

(1) The change in the vertical distance between the inside surfaces of the endplates (Figure 2) shall be measured to the nearest 0.0001 in. (0.00254 mm) at each load increment for each specimen.

(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.

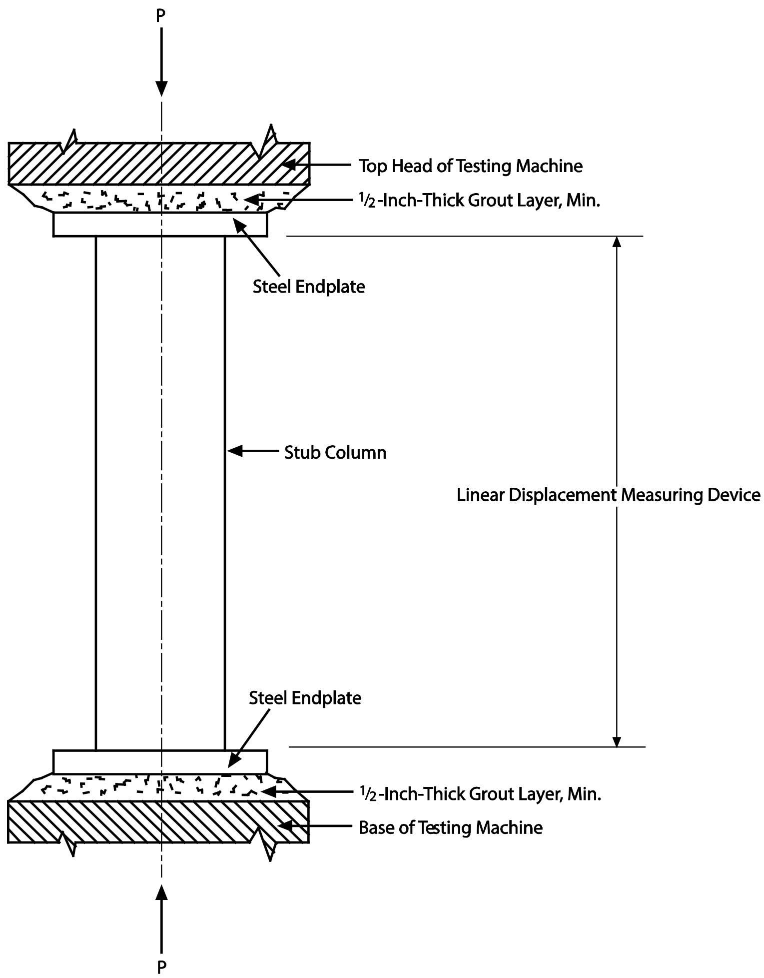

Figure 2 – Test Setup

10. Data Evaluation

10.1 For a given test unit, all individual ultimate loads, P_u, derived from the *stub-column* tests shall be used to calculate the average ultimate 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}.

10.2 The effective areas A_{eua}, A_{euN}, and A_e shall be calculated as specified in Sections 10.3 through 10.6; however, the final value of these effective areas shall not exceed that of the minimum gross cross-sectional area, A.

10.3 For tests in which the length of the *stub-column* does not exceed 20 times the minimum radius of gyration of the cross-section, r, the average effective area at the ultimate load, A_{eua}, for a given test unit shall be determined as follows:

$$A_{eua} = P_{ua}/F_{ya} \tag{1}$$

10.4 For tests in which the length of the *stub-column* exceeds 20 times the minimum radius of gyration of the cross-section, the average effective area at the ultimate load shall be determined by iteration of the following equations:

$$A_{eua} = A_a - \left(A_a - \frac{P_{ua}}{F_n}\right)\left(\frac{F_n}{F_{ya}}\right)^n \tag{2}$$

where A_a = average minimum area of the *stub-columns* in the test unit, and F_n = flexural or torsional-flexural buckling stress derived from Section E2 of the *Specification* with K = 0.5 (using the average cross-sectional properties of the test unit). The exponent, n, shall be determined as follows:

$$n = A_{eua}/A_a \tag{3}$$

The exponent, n, is permitted to be obtained using the following iteration process until n is converged:

(a) Assuming an initial value for n equal to or less than 1.0,

(b) Calculate A_{eua} using Equation (2),

(c) Obtain the new n value from Equation (3).

A converged A_{eua} for one specific test unit shall be expected by repeating the above process.

10.5 The value of A_{eua} for a specific test unit shall be adjusted to A_{euN}, which is the effective cross-sectional area of a compression member at ultimate load with a nominal cross-section of A_N and a specified minimum yield stress of F_{yN}. The adjustment shall be performed in accordance with Section 10.5.1, Section 10.5.2, or Section 10.5.3.

10.5.1 If the average area of the *stub-columns* in the test unit, A_a, or the average base steel thickness, t_a, are different from the nominal area or thickness, respectively, the effective cross-sectional area at ultimate load shall be calculated as follows:

$$A_{euN} = A_{eua}\left(\frac{A_N}{A_a}\right) \tag{4}$$

or

$$A_{euN} = A_{eua}\left(\frac{t_N}{a_a}\right) \tag{5}$$

10.5.2 If the average yield stress of all *stub-columns* in a test unit, F_{ya}, is different from the nominal yield stress, F_y, the effective cross-sectional area at ultimate load shall be the lower of the two values calculated as follows:

$$A_{euN} = A_N\left[1 - \left(1 - \frac{A_{eua}}{A_N}\right)\left(\frac{F_{yN}}{F_{ya}}\right)\right] \tag{6}$$

or

$$A_{euN} = A_{eua}\left(\frac{F_{ya}}{F_{yN}}\right)^{0.4} \tag{7}$$

10.5.3 If the average area and the minimum specified yield stress are different from the nominal values of a test unit, A_{euN} derived from the equation (4) or (5) shall be used as A_{eua} in the equations (6) and (7), which will lead to an acceptable value of A_{euN}.

10.6 The effective area at any working stress level, A_e, is permitted to be determined as follows:

$$A_e = A_N - (A_N - A_{euN})\left(\frac{f}{F_{yN}}\right)^n \tag{8}$$

10.7 For a series of sections, such as in a parameter study during which only one parameter (thickness, depth, width, yield stress, etc.) is changed, interpolations between test units, or extrapolations beyond test units, are permitted as described in Appendix B.

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

11. Test Report

11.1 The report shall include a complete record of the sources and locations of all *stub-column* 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.

11.2 The report shall include all measurements taken for each *stub-column* test specimen, including: (1) cross-section dimensions, (2) uncoated sheet thickness, (3) longitudinal yield stress, (4) end preparation procedure, (5) applicable material specification, and (6) test and evaluation procedure used.

11.3 The determination of the selected *stub-column* length shall be fully documented with appropriate calculations.

11.4 A description of the test setup—including the endplates, the grout layer used for alignment, and the instrumentation used to measure lateral displacements and axial shortening—shall be included.

11.5 The report shall include the load increments, rate of loading, and intermediate and ultimate loads for each *stub-column* tested.

11.6 The report shall include complete calculations and results of the effective area, A_{euN}, for each test unit and calculations of A_e, if requested.

This page is intentionally left blank.

Appendix A
Use of Axial Shortening Measurements in Design

A-1 Axial shortening measurements as part of thin-walled cold-formed steel *stub-column* tests are permitted to be used as an alternative method of determining the effective area of a compression member, A_e, at a certain design load or stress.

A-2 The calculations by this method shall be made separately for each *stub-column* specimen within a test unit. This shall result in a total of j calculations as a result of a total of j load-displacement tests for each test unit.

A-3 For a given specimen, the effective area at ultimate load, A_{eu}, shall be calculated from Section 10.3 or 10.4, letting $A_{eua} = A_{eu}$, $A_a = A$, $F_{ya} = F_y$, and $P_{ua} = P_u$.

A-3.1 Calculations at each load-displacement reading, i, shall be conducted in accordance with the procedure specified in this section; however, at zero load, the effective area, A_e, shall be equal to the minimum cross-sectional area, A. This provides results for the effective area at each load point:

(1) Starting with the lowest load-displacement reading, the effective area, A_i, and the assumed uniformly distributed stress, f_i, shall be calculated for each reading, i, from:

$$A_{ei} = \frac{P_i D_u}{F_y D_i} \tag{AA-1}$$

and

$$f_i = \frac{F_y D_i}{D_u} \tag{AA-2}$$

where D_i and D_u are the axial shortening at loads P_i and P_u, respectively.

(2) If A_{ei} calculated is greater than A, A_{ei} shall be set equal to A.

(3) If A_{ei} calculated is less than A, A_{ei} shall be as calculated, and f_o, the stress above which the section is not fully effective, shall be set equal to f_{i-1}, as calculated for the previous load-displacement reading.

A.3.2 For specimens within a test unit, the lowest A_{ei} values shall be used for further evaluations.

A-4 For any load that causes a stress f higher than f_o, an exponential equation is permitted to be developed as follows:

$$A_e = A\left[1-\left(1-\frac{A_{eu}}{A}\right)\left(\frac{f-f_o}{F_y-f_o}\right)^b\right] \tag{AA-3}$$

where

$$b = \frac{\sum_{i=1}^{j}(X_i)(Y_i) - (a)\sum_{i=1}^{j}(X_i)}{\sum_{i=1}^{j}(X_i)^2} \quad \text{(AA-4)}$$

and

$$X_i = \ln\left(\frac{f_i - f_o}{F_y - f_o}\right) \quad \text{(AA-5)}$$

$$Y_i = \ln\left(1 - \frac{A_{ei}}{A}\right) \quad \text{(AA-6)}$$

$$a = \ln\left(1 - \frac{A_{eu}}{A}\right) \quad \text{(AA-7)}$$

and ln designates the natural logarithm.

A-5 If the effective areas for a section with specified dimensions and minimum yield stress are desired which are different from the tested specimens, the A_{eu} and A_{ei} values calculated under Section A-3 shall be normalized to the specified parameters in accordance with Section 10.5 before the curve-fitting procedure of Section A-4 is employed. The variables A, A_{eu}, and F_y shall be changed to A_N, A_{euN}, and F_{yN}.

A-6 All calculations pertaining to this procedure shall be included in the report, as discussed in Section 11.

Appendix B
Parametric Studies

B-1 For parametric studies intended to develop the effective area for a series of sections with the same basic cross-section (either C, U, H, or any other shape) and the same hole pattern, but with one or more changing parameters, the required number of test units is permitted to be less than the sum of all sections with different geometries and yield stresses.

B-1.1 For a series of sections with three different values for one parameter only (dimension or nominal yield stress), at least two test units shall be chosen to include the minimum and the maximum values of the changing parameter. For the third value, A_{eu} is permitted to be interpolated in accordance with Section B-2.

B-1.2 If more than three different values for one parameter are included in a series of sections, additional units with intermediate values shall be tested such that the ratio of the changing values in adjacent units is not greater than 1.5 or is less than 0.67. For intermediate values of the changing parameter, A_{eu} is permitted to be interpolated according to Section B-2.

B-1.3 For a series of sections with the same basic cross-section that includes different values for several parameters (dimensions and/or yield stress), an appropriate factorial of test units shall be established by the responsible professional engineer in accordance with the guidelines for changes in an individual parameter, and in compliance with responsible code authorities. Interpolations and extrapolations are permitted to be made as mutually agreeable, following the general guidelines set forth in Section B-2 for changes of one parameter only.

B-1.4 For a section that falls outside a series of tested members with the same basic cross-section, A_{eu} is permitted to be extrapolated provided the changing parameter does not exceed a value of 20 percent below or above the respective minimum or maximum values tested in the series.

B-2 Interpolations and extrapolations are permitted as part of a parametric study, and as defined under B-1.

B-2.1 For a section with a thickness different from the thicknesses tested, but with identical overall nominal cross-sectional dimensions and minimum specified yield stress, A_{eu} for a thickness t and an area A is permitted to be calculated provided t does not exceed the limits described under Section B-1.2 and B-1.4. Under these conditions, A_{eu} is permitted to be determined by interpolation or extrapolation from the results of the nearest two test units with thicknesses t_1 and t_2, respectively.

$$A_{eu} = A\left[\frac{A_{eu1}}{A_1} + \left(\frac{A_{eu2}}{A_2} - \frac{A_{eu1}}{A_1}\right)\left(\frac{t_1 - t}{t_1 - t_2}\right)\right] \qquad \text{(AB-1)}$$

where A_1 and A_2 are the minimum gross cross-sectional areas, and A_{ue1} and A_{eu2} are the nominal effective cross-sectional areas for Test Units 1 and 2, respectively.

B-2.2 For a section with a yield stress different from the yield stresses tested, but with identical cross-sectional dimensions, A_{eu} for a yield stress F_y is permitted to be calculated provided F_y does not exceed the limits described under Section B-1.2 and B-1.4. Under these conditions, A_{eu} is permitted to be determined by interpolation or extrapolation from the results of the nearest two test units with yield stresses F_{y1} and F_{y2}, and with effective areas A_{eu1} and A_{eu2}, respectively.

$$A_{eu} = A\left[\frac{A_{eu1}}{A_1} + \left(\frac{A_{eu2}}{A_2} - \frac{A_{eu1}}{A_1}\right)\left(\frac{F_{y1} - F_y}{F_{y1} - F_{y2}}\right)\right] \quad \text{(AB-2)}$$

AISI S902-17-C

Commentary on Test Standard for Determining the Effective Area of Cold-Formed Steel Compression members

The effective area is used to determine the nominal axial strength of cold-formed compression member sections in accordance with AISI S100, *North American Specification for the Design of Cold-Formed Steel Structural Members*, hereafter referred as AISI S100.

The effective area is a variable section property of compression members. It reflects the effects of *local buckling* in relatively thin area *elements* caused by axial stresses, or loads. When the axial load is zero, the effective area is equal to the gross cross-sectional area; however, when an axial load is applied, the effective area may be less than the gross area. In such a case, the effective area will reduce with increasing load.

Local buckling reduces the axial load-carrying capacity that would otherwise be limited only by general yielding or overall compression member buckling. The amount of the reduction depends on the width-to-thickness ratio of the flat elements of the compression member cross-section, the yield stress of the steel sheet from which the compression member is formed, and the size and frequency of holes or hole patterns, if present.

Research information can be found in Reference 1 on the determination of the effective cross-sectional area of cold-formed steel compression members and the consideration of the effects of *local buckling* and residual stresses on solid or perforated compression members that have holes (or hole patterns) in the flat and/or curved *elements* of the cross-section.

The effective area, A_{euN}, of a cold-formed steel compression member section at ultimate load and the load- or stress-dependent effective area, A_e, are used in AISI S100 to determine the ultimate and less-than-ultimate compression member strengths. The ultimate compression member strength, P_N, is the product of the minimum specified yield stress, F_{yN}, or the buckling stress, F_n, and the corresponding effective cross-sectional area at that stress, A_{euN}. At an applied compression member strength of P less than P_N, the corresponding effective cross-sectional area is A_e.

An inherent assumption of the test method is that true *stub-column* behavior (which considers *local buckling* effects only) is achieved when overall column-buckling effects are eliminated. For this condition, the ultimate test load on a *stub-column*, P_u, equals the product of the effective cross-sectional area at ultimate load, A_{eu}, times the stress that causes *local buckling*, or times the yield stress of the virgin steel sheet. In case *overall buckling* cannot be avoided because of geometrical constraints, the critical column-buckling stress must be used.

The following two approaches are provided in the Standard for determining the effective area, A_e:

(1) The basic, more simple and conservative method:

This method is embodied in the main part of this document and is based on the measured test loads of *stub-columns* and their measured and tested physical and mechanical properties.

(2) An alternative and less conservative method provided in Appendix A.

This method is based on the shortening of *stub-columns* which occurs during testing. Also, this evaluation method requires more calculations. The results of this method lead to more accurate results for A_e, and to higher allowable axial loads at lower-than-ultimate stress levels. The evaluation procedure for this method is described in Appendix A.

References

T. Pekoz (1986), "Development of a Unified Approach to the Design of Cold-Formed Steel Members," Committee of Sheet Steel Producers, American Iron and Steel Institute, 1986

.

American Iron and Steel Institute

25 Massachusetts Avenue NW
Suite 800
Washington, DC 20001
www.steel.org

The New Steel

American Iron and Steel Institute
25 Massachusetts Avenue NW
Suite 800
Washington, DC 20001
www.steel.org

The New Steel

AISI S902-17E