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AISI Standard for Cold-Formed Steel Framing – Header Design, 2004 Edition

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AISI/COFS/HEADER-2004



**American
Iron and Steel
Institute**

AISI STANDARD

Standard for Cold-Formed Steel Framing – Header Design, 2004 Edition

Revision of AISI/COFS/HEADER-2001

Endorsed by:



Steel Framing Alliance™

DISCLAIMER

The material contained herein has been developed by the American Iron and Steel Institute Committee on Framing Standards. The Committee has made a diligent effort to present accurate, reliable, and useful information on cold-formed steel framing design and installation. 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. Specific references are included in the *Commentary*.

With anticipated improvements in understanding of the behavior of cold-formed steel framing and the continuing development of new technology, this material may eventually become dated. It is anticipated that AISI will publish updates of this material as new information becomes available, but this cannot be guaranteed.

The materials set forth herein are for general purposes only. They are not a substitute for competent professional advice. Application of this information to a specific project should be reviewed by a design professional. Indeed, in many 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 liability arising there from.

2nd Printing - April 2005

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PREFACE

The American Iron and Steel Institute (AISI) Committee on Framing Standards (COFS) has developed this *Standard for Cold-Formed Steel Framing - Header Design* [*Header Standard*] to provide technical information and specifications for designing headers made from cold-formed steel.

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 the subjects. The Committee wishes to also express their appreciation for the support and encouragement of the Steel Framing Alliance.

All terms in this *Header Standard* written in italics are defined in the AISI *Standard for Cold-Formed Steel Framing - General Provisions*.

This 2nd Printing incorporates the Errata to the Standard for Cold-Formed Steel Framing - Header Design [Errata], dated April 21, 2005.

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STANDARD FOR COLD-FORMED STEEL FRAMING – HEADER DESIGN

A. GENERAL

A1 Scope

The design and installation of cold-formed steel box and back-to-back *headers*, and double and single *L-headers* used in single-span conditions for load carrying purposes in buildings shall be in accordance with the *North American Specification for the Design of Cold-Formed Steel Structural Members* [*Specification*] and the *Standard for Cold-Formed Steel Framing-General Provisions* [*General Provisions*] except as modified by the provisions of this *Header Standard*. Alternatively *headers* are permitted to be designed solely in accordance with the *Specification*. This *Header Standard* shall not preclude the use of other materials, assemblies, structures or designs not meeting the criteria herein, when the other materials, assemblies, structures or designs demonstrate equivalent performance for the intended use to those specified in this *Header Standard*. Where there is a conflict between this *Header Standard* and other reference documents the requirements contained within the *Header Standard* shall govern.

This *Header Standard* shall include Sections A through C inclusive.

A1.1 Limitations

A1.1.1 Back-to-Back and Box Headers

The design provisions of Sections B1 and B2 of this *Header Standard* shall be limited to back-to-back and box *headers* that are installed using cold-formed steel *C-shape* sections, as shown by Figures A1.1.1-1 and A1.1.1-2.

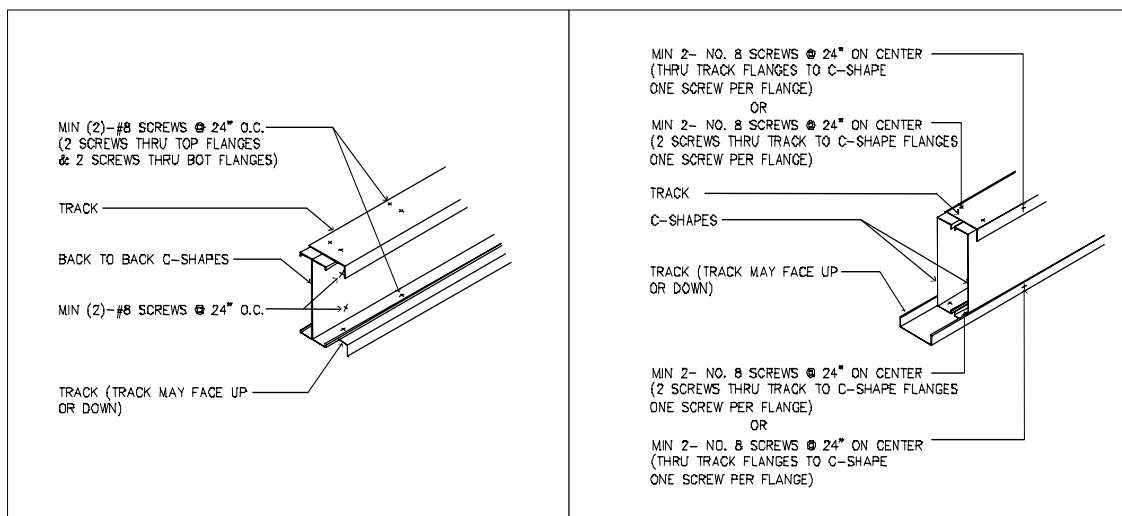


Figure A1.1.1-1 Back-to-Back Header

Figure A1.1.1-2 Box Header

A1.1.2 Double and Single L-Headers

The design provisions of Sections B3 and B4 of this *Header Standard* shall be limited to double and single L-headers that are installed using cold-formed steel angles, as shown by Figures A1.1.2-1 and A1.1.2-2 respectively, having the following limitations:

Minimum top flange width = 1.5 inches (38.1 mm)

Maximum vertical leg dimension = 10 inches (254 mm) for double L-headers

Maximum vertical leg dimension = 8 inches (203 mm) for single L-headers

Minimum base metal steel thickness = 0.033 inches (0.838 mm)

Maximum design thickness = 0.0713 inches (1.829 mm) for double L-headers

Maximum design thickness = 0.0566 inches (1.448 mm) for single L-headers

Minimum design yield strength, $F_y = 33$ ksi (230 MPa)

Maximum design yield strength, $F_y = 50$ ksi (345 MPa)

Cripple stud located at all load points

Minimum bearing length 1.5 inches (38.1 mm) at load points

Minimum wall width = 3.5 inches (88.9 mm)

Maximum span = 16'-0" (4.88 m) for double L-headers

Maximum span = 4'-0" (1.219 m) for single L-headers

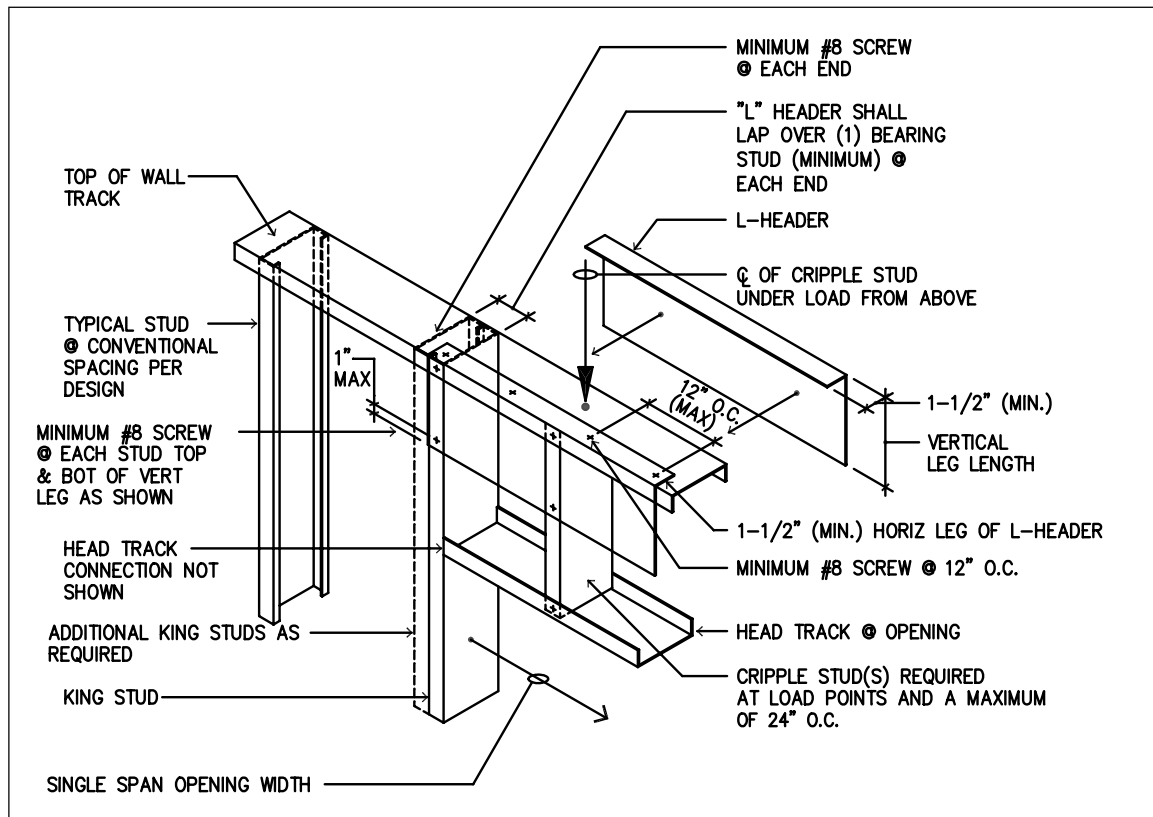


Figure A1.1.2-1 Double L-Header

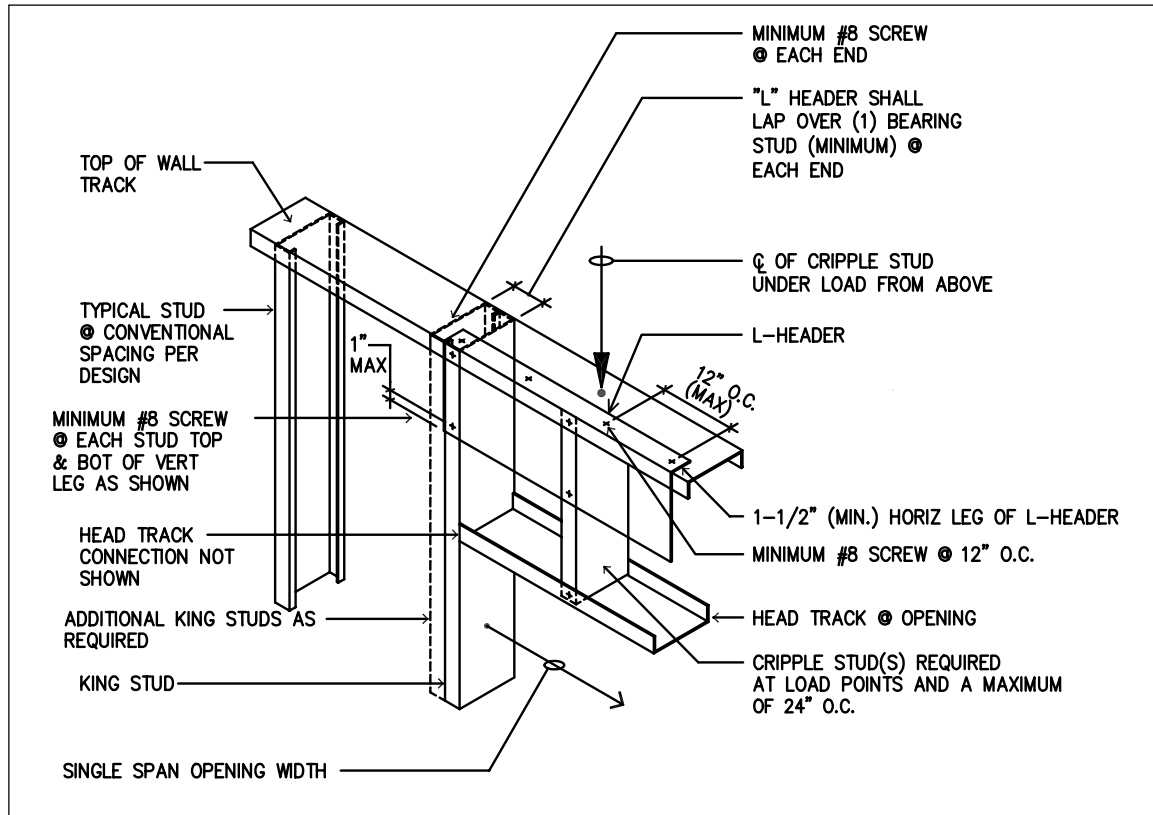


Figure A1.1.2-2 Single L-Header

A2 Loads and Load Combinations

Buildings or other structures and all parts therein shall be designed to safely support all loads that are expected to affect the structure during its life in accordance with the *applicable building code*. In the absence of an *applicable building code*, the loads, forces, and combinations of loads shall be in accordance with accepted engineering practice for the geographical area under consideration as specified by the appropriate sections of ASCE 7.

A3 Referenced Documents

The following documents are referenced in this *Header Standard*:

1. AISI, *North American Specification for the Design of Cold-Formed Steel Structural Members*, 2001 Edition with 2004 Supplement, American Iron and Steel Institute, Washington, DC.
2. AISI, *Standard for Cold-Formed Steel Framing—General Provisions*, 2004 Edition, American Iron and Steel Institute, Washington, DC.
3. ASCE 7-02, *Minimum Design Loads for Buildings and Other Structures*, American Society of Civil Engineers, Reston, VA.

B. DESIGN

B1 Back-to-Back Headers

The provisions of this section are limited to back-to-back *header* beams as defined in Section A1.1.1.

B1.1 Moment Capacity

Flexure alone shall be evaluated by using Section C3.1.1 of the *Specification*.

B1.2 Shear Capacity

Shear alone need not be considered for the design of back-to-back *header* beams that are fabricated and installed in accordance with this *Header Standard*.

B1.3 Web Crippling Capacity

Web crippling alone shall be evaluated by using Section C3.4 of the *Specification*. For back-to-back *header* beams the equations for I-sections or similar sections shall be used.

B1.4 Bending and Shear

The combination of bending and shear need not be considered for the design of back-to-back *header* beams fabricated and installed in accordance with this *Header Standard*.

B1.5 Bending and Web Crippling

Webs of back-to-back *header* beams subjected to a combination of bending and web crippling shall be designed using Section C3.5 of the *Specification*. For back-to-back *header* beams the equations for I-sections or similar sections shall be used.

B2 Box Headers

The provisions of this section are limited to box *header* beams as defined in Section A1.1.1.

B2.1 Moment Capacity

Flexure alone shall be evaluated by using Section C3.1.1 of the *Specification*.

B2.2 Shear Capacity

Shear alone need not be considered for the design of box *header* beams that are fabricated and installed in accordance with this *Header Standard*.

B2.3 Web Crippling Capacity

Web crippling capacity alone, P_n , shall be evaluated by using Section C3.4 of the *Specification*. For box *header* beams the equations for shapes having single *webs* shall be used. P_n for an interior-one-flange loading condition, with the applicable Ω or ϕ factor defined below, shall be permitted to be multiplied by α , where α accounts for the increased strength due to the *track* and is defined as follows:

α = parameter defined by equation B2.3-1 or B2.3-2

Ω = 1.80

ϕ = 0.85

When the *track* section design thickness ≥ 0.0346 in. (0.88 mm), the *track flange* width ≥ 1 in. (25.4 mm), the C-section depth ≤ 12 in. (305 mm) and the C-section design thickness ≥ 0.0346 in. (0.88 mm):

$$\alpha = 2.3 \frac{t_t}{t_c} \geq 1.0 \quad (\text{Eq. B2.3-1})$$

where:

$$t_t = 0.0346 \text{ in. (0.88 mm)}$$

$$t_c = \text{design thickness of the C-section}$$

When the above limits are not met:

$$\alpha = 1.0 \quad (\text{Eq. B2.3-2})$$

B2.4 Bending and Shear

The combination of bending and shear need not be considered for the design of box *header* beams fabricated and installed in accordance with this *Header Standard*.

B2.5 Bending and Web Crippling

For box *header* beams subjected to combined bending and web crippling, the requirements for flexure alone and web crippling alone shall also apply.

Webs of box *header* beams subjected to a combination of bending and web crippling shall be designed using either Section C3.5 of the *Specification* or the following equations:

(a) For ASD:

$$\frac{P}{P_n} + \frac{M}{M_n} \leq \frac{1.5}{\Omega} \quad (\text{Eq. B2.5-1})$$

where

P = required web crippling strength for ASD

M = required flexural strength for ASD

P_n = web crippling capacity computed by Section B2.3

Ω = 1.85

M_n is defined in the *Specification*.

(b) For LRFD:

$$\frac{P_u}{P_n} + \frac{M_u}{M_n} \leq 1.5\phi \quad (\text{Eq. B2.5-2})$$

where

P_u = required web crippling strength for LRFD

M_u = required flexural strength for LRFD

P_n = web crippling capacity computed by Section B2.3

ϕ = 0.85

M_n is defined in the *Specification*.

B3 Double L-Headers

The provisions of this section are limited to double *L-headers* as defined in Section A1.1.2.

B3.1 Moment Capacity

B3.1.1 Gravity Nominal Moment Capacity

- (a) For a double *L-header* beam having a vertical leg dimension of 8 inches (203 mm) or less, the design shall be based on the flexural capacity of the L-sections alone. The nominal gravity flexural strength, M_{ng} , shall be determined as follows:

$$M_{ng} = S_{ec} F_y \quad (\text{Eq. B3.1.1-1})$$

where

F_y = yield strength used for design

S_{ec} = elastic section modulus of the effective section calculated at $f = F_y$ in the extreme compression fibers

- (b) For a double *L-header* beam having a vertical leg dimension greater than 8 inches (203 mm), and having a span-to-vertical leg dimension ratio greater than or equal to 10, design shall be based on the flexural capacity of the L-sections alone (Eq. B3.1.1-1).
- (c) For a double *L-header* beam having a vertical leg dimension greater than 8 inches (203 mm) and having a span-to-vertical leg dimension ratio less than 10, the nominal gravity flexural strength, M_{ng} , shall be determined as follows:

$$M_{ng} = 0.9 S_{ec} F_y \quad (\text{Eq. B3.1.1-2})$$

where

F_y = yield strength used for design

S_{ec} = elastic section modulus of the effective section calculated at $f = F_y$ in the extreme compression fibers

B3.1.2 Uplift Nominal Moment Capacity

For a double *L-header* beam, the nominal uplift flexural strength, M_{nu} , shall be determined as follows:

$$M_{nu} = R M_{ng} \quad (\text{Eq. B3.1.2-1})$$

where

M_{ng} = gravity moment capacity determined by Eq. B3.1.1-1

R = uplift factor

= 0.25 for $L_h/t \leq 150$

= 0.20 for $L_h/t \geq 170$

= use linear interpolation for $150 < L_h/t < 170$

L_h = vertical leg dimension of the angle

t = base metal thickness

B3.1.3 Design Moment Capacity.

(a) For ASD, the allowable design moment shall be determined as follows:

For gravity,

$$M_a = M_{ng}/\Omega \quad (\text{Eq. B3.1.3-1})$$

$$\Omega = 1.67 \text{ for beams with } L_h \leq 8 \text{ inches (203 mm)}$$

$$\Omega = 2.26 \text{ for beams with } L_h > 8 \text{ inches (203 mm)}$$

For uplift,

$$M_a = M_{nu}/\Omega \quad (\text{Eq. B3.1.3-2})$$

$$\Omega = 2.0$$

(b) For LRFD, the design moment capacity shall be determined as follows:

For gravity,

$$M_u = \phi M_{ng} \quad (\text{Eq. B3.1.3-3})$$

$$\phi = 0.90 \text{ for beams with } L_h \leq 8 \text{ inches (203 mm)}$$

$$\phi = 0.71 \text{ for beams with } L_h > 8 \text{ inches (203 mm)}$$

For uplift,

$$M_u = \phi M_{nu} \quad (\text{Eq. B3.1.3-4})$$

$$\phi = 0.80$$

B3.2 Shear Capacity

Shear alone need not be considered for the design of *L-header* beams that are fabricated and installed in accordance with this *Header Standard*.

B3.3 Web Crippling Capacity

Web crippling alone need not be considered for the design of *L-header* beams that are fabricated and installed in accordance with this *Header Standard*.

B3.4 Bending and Shear

The combination of bending and shear need not be considered for the design of *L-header* beams fabricated and installed in accordance with this *Header Standard*.

B3.5 Bending and Web Crippling

The combination of bending and web crippling need not be considered for the design of *L-header* beams fabricated and installed in accordance with this *Header Standard*.

B4 Single L-Headers

The provisions of this section are limited to single *L-headers* as defined in Section A1.1.2.

B4.1 Moment Capacity**B4.1.1 Gravity Nominal Moment Capacity**

(a) For a single *L-header* beam having a vertical leg dimension of 6 inches (152 mm) or less, the design shall be based on the flexural capacity of the L-section alone. The nominal gravity flexural strength, M_{ng} , shall be determined as follows:

$$M_{ng} = S_{ec} F_y \quad (\text{Eq. B4.1.1-1})$$

where

F_y = yield strength used for design

S_{ec} = elastic section modulus of the effective section calculated at $f = F_y$ in the extreme compression fibers

- (b) For a single L-header beam having a vertical leg dimension greater than 6 inches (152 mm), but less than or equal to 8 inches (203 mm), the nominal gravity flexural strength, M_{ng} , shall be determined as follows:

$$M_{ng} = 0.9 S_{ec} F_y \quad (\text{Eq. B4.1.1-2})$$

where

F_y = yield strength used for design

S_{ec} = elastic section modulus of the effective section calculated at $f = F_y$ in the extreme compression fibers

B4.1.2 Uplift Nominal Moment Capacity

[Reserved]

B4.1.3 Design Moment Capacity

- (a) For ASD, the allowable design moment shall be determined as follows:

For gravity,

$$M_a = M_{ng} / \Omega \quad (\text{Eq. B4.1.3-1})$$

$$\Omega = 1.67$$

- (b) For LRFD, the design moment capacity shall be determined as follows:

For gravity,

$$M_u = \phi M_{ng} \quad (\text{Eq. B4.1.3-2})$$

$$\phi = 0.90$$

B4.2 Shear Capacity

Shear alone need not be considered for the design of L-header beams that are fabricated and installed in accordance with this *Header Standard*.

B4.3 Web Crippling Capacity

Web crippling alone need not be considered for the design of L-header beams that are fabricated and installed in accordance with this *Header Standard*.

B4.4 Bending and Shear

The combination of bending and shear need not be considered for the design of L-header beams fabricated and installed in accordance with this *Header Standard*.

B4.5 Bending and Web Crippling

The combination of bending and web crippling need not be considered for the design of L-header beams fabricated and installed in accordance with this *Header Standard*.

C. INSTALLATION

Headers shall be installed in accordance with the *General Provisions* and Figures A1.1.1-1, A1.1.1-2, A1.1.2-1 and A1.1.2-2.



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AISI STANDARD

**Commentary on the
Standard for
Cold-Formed Steel Framing –
Header Design,
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Endorsed by:



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1st Printing – December 2004

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PREFACE

This *Commentary* is intended to facilitate the use, and provide an understanding of the background, of the *AISI Standard for Cold-Formed Steel Framing – Header Design [Header Standard]*. The *Commentary* illustrates the substance and limitations of the various provisions of the *Header Standard*.

In the *Commentary*, sections, equations, figures, and tables are identified by the same notation as used in the *Header Standard*.

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COMMENTARY ON THE STANDARD FOR COLD-FORMED STEEL FRAMING – HEADER DESIGN

A. GENERAL

Box and back-to-back header beams have been commonly used in cold-formed steel framing. The geometry is fabricated using two C-shaped cold-formed steel members. Design practice for such header beams can be based on the AISI *North American Specification for the Design of Cold-Formed Steel Structural Members [Specification]* (AISI, 2004). Recent research has determined that the application of the AISI design provisions is conservative. This led to the development of an improved design methodology.

L-header beam geometries are gaining popularity in cold-formed steel framing. The geometry is fabricated using one or two L-shaped cold-formed steel members connected to a top track section. This geometry is commonly referred to as a single or double L-header because one or two angle shapes are used to create the header.

A1 Scope

A1.1.2 L-Headers

Prior to 2003, the *Header Standard* excluded single *L-headers*. The NAHB Research Center study that was completed prior to 2003 tested both single and double *L-header* beams. The tests consisted of either a single point load or a two-point load. All angles had a 1.5 inch (38.1 mm) top *flange*. The vertical leg dimensions were either 6, 8, or 10 inches (152, 203 or 254 mm). Thicknesses ranged from nominally 0.033 to 0.068 inches (0.84 to 1.73 mm). Test span lengths ranged from 36 to 192 inches (914 to 4880 mm).

An analysis of the data indicated that the behavior of the *L-headers* differed for single versus double angle geometries. Also, the single point load produced test results that differed from the two-point load. Prior to 2003, there was insufficient data to develop design guidelines for single angle *L-headers*. Thus, the data analysis did not consider data for the single angle sections nor for the single point loading.

In 2003, testing was completed at the NAHB Research Center on single *L-header* beams. The tests were similar to the previously tested double *L-header* beam tests, but *header* sizes were limited to vertical leg dimensions of 6 and 8 inches (152 or 203 mm), thicknesses ranged from nominally 0.033 to 0.054 inches (0.84 to 1.37 mm) and spans were limited to 4 feet (1.219 m). From this testing, sufficient data was provided to develop design guidelines for single *L-headers* within the range of parameters tested.

B. DESIGN

B1 & B2 Box and Back-to-Back Headers

The design methodology is based on the review and analysis of the data presented in the NAHB report *Cold-Formed Steel Back-To-Back Header Assembly Tests* (1997) and the study of Stephens (2000, 2001). The test results were evaluated and compared with the strength equations contained in the *Specification*.

Stephens and LaBoube (2000) concluded that web crippling or a combination of bending and web crippling is the primary factor in *header* beam design for the IOF (interior-one-flange) loading condition. Neither pure shear nor combined bending and shear were failure modes in the test program. The research study showed that using the *Specification* web crippling equations for shapes having single *webs* for the design of box or back-to-back *header* beams would give conservative results.

Based on additional studies conducted by Stephens (2001), a modification factor was derived that enable the computation of the interior-one-flange web crippling capacity of a box *header* assembly as defined by Figure A1.1.1-2 of the *Header Standard*. The increased web crippling capacity is attributed to the interaction of the *track* section and the C-section, thus it is imperative that the *track* section be attached with the *flanges* as shown in Figure A1.1.1-2. This interaction is quantified by the ratio of *track* thickness to C-section thickness in Eq. B2.3-1. When computing the web crippling capacity for a *header* assembly, the nominal capacity computed using the *Specification* is to be multiplied by 2 to reflect that there are two *webs* in the assembly. In addition to a modification to the pure web crippling strength, the *Header Standard* also contains an interaction equation for bending and web crippling of box *header* assemblies that differs from the *Specification*. This interaction equation is based on the research of Stephens (2001). The research of Stephens (2001) included test specimens having standard perforations. Thus, the provisions of the *Specification* are appropriate for *header* design.

If the top *track* section of a box *header* assembly is attached with the *flanges* up, as would be the case when the *header* beam is located directly above the opening and beneath the *cripple studs*, the provisions of Section B2.3 would not apply. Web crippling capacity and the combination of bending and web crippling should be evaluated by using Sections C3.4 and C3.5 of the *Specification* and the equations for shapes having single unreinforced *webs* should be used.

The procedure to calculate the vertical deflection of a box or back-to-back *header* may be accomplished by using a composite assembly calculation, which would include the two C-sections and the top and bottom *tracks*. However, to achieve full composite action using this type of calculation would require an extensive (cost prohibitive) fastener requirement between the *tracks* and the C-sections, and therefore, it is more common to use a conservative estimate of the vertical deflection based on the full moment of inertia of the two C-sections alone.

B3 Double L-Headers

The available test data (Elhadj and LaBoube, 2000 and LaBoube, 2004) indicated that the failure mode was flexure or combination of flexure and web crippling. Neither pure shear nor combined bending and shear were failure modes in the test program. The tested moment capacity, M_t , was determined and compared with the computed moment capacity as defined by Section C3.1.1(a) of the *Specification*. The nominal moment capacity was computed using the following equation:

$$M_n = S_{xc} F_y$$

where

F_y = measured yield stress

S_{xc} = elastic section modulus of the effective section computed at $f = F_y$.

The section modulus of the compression *flange* was used for all computations.

It should be noted that the flexural capacity is based on the section modulus of the compression *flange*; i.e., yielding of the shorter, horizontal leg of the angle. The inelastic reserve capacity of the longer, vertical leg is recognized and yielding in the extreme tensile fiber is not considered a limit state.

It should also be noted that when the design provisions of the *Header Standard* were developed, the elastic section modulus of the effective section was computed assuming that when the free edge of the element was in tension, Equations B2.3-3, B2.3-4 and B2.3-5 of the *Specification* would apply regardless of the magnitude of h_0/b_0 . Therefore, these assumptions are appropriate when calculating the elastic section modulus of the effective section using the *Header Standard*.

For typical L-headers having a geometry as defined by the limitations of Section 1, the performance of full-scale double L-header beam tests (Elhajj and LaBoube, 2000) and LaBoube (2004) has shown that the limit states of shear, web crippling, bending and shear, and bending and web crippling need not be considered when designing an L-header beam. This is because shear and web crippling failures were not indicated in any of the tests, and because a simplified conservative design approach is used. Web crippling is effectively prevented by the way L-headers are assembled. However, designers are cautioned that an L-header could potentially fail in shear for the combination of a very short span and a very large loading. Currently there are no limitations prescribed on minimum lengths or other factors that would prohibit shear failure in such cases. However, as a suggested procedure shear should probably be considered when the span-to-depth ratio is less than 3.

The procedure to calculate the vertical deflection of an L-header is undefined because the L-header is an indeterminate assembly consisting of two angles, *cripple studs*, and *track* sections interconnected by self-drilling screws. However, the test results indicate that the measured assembly deflections at an applied load that equaled the design load, was less than $L/240$. Further analytical work, based on test data, would be necessary in order to develop a calculation procedure to determine the deflection of L-header beams.

B3.1.1 Gravity Moment Capacity

The test results summarized by Elhajj and LaBoube (2000) and LaBoube (2004) are considered to be confirmatory tests that show the *Specification* Section C3.1.1 provides an acceptable determination of the design moment capacity. Thus, the factor of safety of 1.67 is prescribed by the *Header Standard*.

For the 10 inch (254 mm) deep L-header beams having the span to vertical leg dimension, L/L_h , greater than 10, the tested *header* sections had tested moment capacities greater than the computed moment capacity defined by *Header Standard* Eq. B3.1.1-1. However, for 10 inch (254 mm) deep beams having L/L_h ratios less than 10, the tested moment capacity was on the average ten percent less than the computed moment capacity (Elhajj and LaBoube, 2000). Thus, the application of Eq. B3.1.1-1 is questionable for full range of the 10 inch (254 mm) L-header. A review of the data

indicates that the application of Eq. B3.1.1-1 is valid for test specimens having a span to vertical leg dimension, L / L_h , of 10 or greater. For the specimens having L / L_h ratios less than 10 it is proposed that the results obtained by using Eq. B3.1.1-1 be multiplied by 0.9.

B3.1.2 Uplift Moment Capacity

A comparison of the tested to computed moment capacity ratios ranged from 0.141 to 0.309 with a mean of 0.215 (Elhadj and LaBoube, 2000). Further analysis of the tested to computed moment ratios indicated that the behavior was influenced by the ratio of L_h / t . Therefore, uplift reduction factors, R , in the *Header Standard* were developed as a function of the L_h / t ratio.

Based on the provisions of Chapter F of the *Specification*, the factor of safety was computed to be 2.0.

B4 Single L-Headers

LaBoube (2004), based on testing by the NAHB Research Center (2003), demonstrates that the design methodology for double L-headers in the 2001 *Header Standard* is acceptable for evaluating the gravity moment capacity of single L-headers, within the limitations of the test program. Uplift tests on single L-headers were not performed as part of this test program; however, Section B4.1.2 has been reserved in the *Header Standard* for this eventuality. Further, using the provisions of Chapter F1 of the *Specification*, the same Ω and ϕ factors that were prescribed in the 2001 *Header Standard* for the design of double L-headers would apply to single L-headers. As with previously tested double L-headers, neither pure shear or combined bending and shear were failure modes for the tested single L-headers. Also, web crippling and combined bending and web crippling would be precluded from occurring because of the requirement that concentrated load applications occur at cripple stud locations.

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