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

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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.
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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Santa Clara University

Fernando Sesma
California Expanded Metal Products

Peter Tian
Berridge Manufacturing

Tim Waite
Simpson Strong-Tie

Rahim Zadeh
Marino\Ware

HEADER DESIGN TASK GROUP

Roger LaBoube, Chairman
University of Missouri-Rolla

Jay Larson, Secretary
American Iron and Steel Institute

Nader Elhajj
NAHB Research Center

Jeff Ellis
Simpson Strong-Tie

Steve Fox
Canadian Sheet Steel Building Institute

Greg Ralph
Dietrich Industries

Reynaud Serrette
Santa Clara University
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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.
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
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.

A3Referenced Documents

The following documents are referenced in this Header Standard:

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

Web crippling alone shall be evaluated by 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 $\Omega$ or $\phi$ factor defined below, shall be permitted to be multiplied by $\alpha$, where $\alpha$ accounts for the increased strength due to the track and is defined as follows:

$$\alpha = \text{parameter defined by equation B2.3-1 or B2.3-2}$$

$$\Omega = 1.80$$

$$\phi = 0.85$$
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):

\[
\alpha = 2.3 \frac{t_c}{t} \geq 1.0 \quad (Eq. B2.3-1)
\]

where:

\[ t_c = 0.0346 \text{ in. (0.88 mm)} \]
\[ t = \text{design thickness of the C-section} \]

When the above limits are not met:

\[ \alpha = 1.0 \quad (Eq. B2.3-2) \]

**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:

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

where

\[ P = \text{required web crippling strength for ASD} \]
\[ M = \text{required flexural strength for ASD} \]
\[ P_n = \text{web crippling capacity computed by Section B2.3} \]
\[ \Omega = 1.85 \]
\[ M_n \text{ is defined in the Specification.} \]

(b) For LRFD:

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

where

\[ P_u = \text{required web crippling strength for LRFD} \]
\[ M_u = \text{required flexural strength for LRFD} \]
\[ P_n = \text{web crippling capacity computed by Section B2.3} \]
\[ \phi = 0.85 \]
\[ M_n \text{ is defined in the Specification.} \]
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:

\[
M_{ng} = S_{ec} F_y
\]

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:

\[
M_{ng} = 0.9 S_{ec} F_y
\]

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:

\[
M_{nu} = R M_{ng}
\]

where

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

\( R \) = uplift factor

\begin{align*}
&= 0.25 \text{ for } L_h/t \leq 150 \\
&= 0.20 \text{ for } L_h/t \geq 170 \\
&= \text{ use linear interpolation for } 150 < L_h/t < 170
\end{align*}

\( L_h \) = 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,
\[ M_a = \frac{M_{ng}}{\Omega} \]  
\[ \Omega = 1.67 \text{ for beams with } L_h \leq 8 \text{ inches (203 mm)} \]
\[ \Omega = 2.26 \text{ for beams with } L_h > 8 \text{ inches (203 mm)} \]
For uplift,
\[ M_u = \frac{M_{nu}}{\Omega} \]  
\[ \Omega = 2.0 \]

(b) For LRFD, the design moment capacity shall be determined as follows:
For gravity,
\[ M_u = \phi M_{ng} \]  
\[ \phi = 0.90 \text{ for beams with } L_h \leq 8 \text{ inches (203 mm)} \]
\[ \phi = 0.71 \text{ for beams with } L_h > 8 \text{ inches (203 mm)} \]
For uplift,
\[ M_u = \phi M_{nu} \]  
\[ \phi = 0.80 \]

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:
\[ M_{ng} = S_{ec} F_y \]  
\textit{(Eq. B4.1.1-1)}

where

\begin{align*}
F_y & = \text{yield strength used for design} \\
S_{ec} & = \text{elastic section modulus of the effective section calculated at } f = F_y \text{ in the extreme compression fibers}
\end{align*}

(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:

\[ M_{ng} = 0.9 S_{ec} F_y \]  
\textit{(Eq. B4.1.1-2)}

where

\begin{align*}
F_y & = \text{yield strength used for design} \\
S_{ec} & = \text{elastic section modulus of the effective section calculated at } f = F_y \text{ in the extreme compression fibers}
\end{align*}

**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,

\[ M_a = M_{ng}/\Omega \]  
\textit{(Eq. B4.1.3-1)}

\[ \Omega = 1.67 \]

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

For gravity,

\[ M_u = \phi M_{ng} \]  
\textit{(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 \textit{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 \textit{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 \textit{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 \textit{Header Standard}.
C. INSTALLATION

Commentary on the Standard for Cold-Formed Steel Framing – Header Design, 2004 Edition
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 this Commentary.

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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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Fernando Sesma  California Expanded Metal Products
Peter Tian  Berridge Manufacturing
Tim Waite  Simpson Strong-Tie
Rahim Zadeh  Marino\Ware

HEADER DESIGN TASK GROUP

Roger LaBoube, Chairman  University of Missouri-Rolla
Jay Larson, Secretary  American Iron and Steel Institute
Nader Elhajj  NAHB Research Center
Jeff Ellis  Simpson Strong-Tie
Steve Fox  Canadian Sheet Steel Building Institute
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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 (Elhajj 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:
Mn = Sxc Fy

where

Fy = measured yield stress
Sxc = elastic section modulus of the effective section computed at f = Fy.

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 h0/b0. 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/ Lh, 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/ Lh 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 (Elhajj 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 $\Omega$ and $\varphi$ 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.
REFERENCES


