CFSEI
COLD-FORMED STEEL ENGINEERS INSTITUTE

TECHNICAL NOTE

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On Cold-Formed Steel Construction

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HEADER DESIGN

Summary: The Standard for Cold-Formed Steel Framing - Header Design (AISI S212-07) is aimed at giving design professionals the tools they need to design headers over door and window openings in buildings. AISI S212-07 (Header) reflects the appropriate design procedures for back-to-back headers, box headers, and L-headers subject to gravity loads or wind uplift loads. This Technical Note provides additional recommendations and design examples intended to augment AISI S212-07 (Header).

INTRODUCTION

The *Standard for Cold-Formed Steel Framing - Header Design* (AISI S212-07) is aimed at giving design professionals the tools they need to design headers over door and window openings in buildings. AISI S212-07 (Header) reflects the appropriate design procedures for back-to-back headers, box headers, and L-headers subject to gravity loads or wind uplift loads. The design recommendations have been heavily influenced by research at the University of Missouri-Rolla and the National Association of Home Builders.

A header is a flexural member spanning a wall opening. Therefore, the AISI S212-07 (Header) Standard establishes both design and installation requirements for: moment capacity, shear capacity, web crippling and combinations of bending and shear and bending and web crippling. AISI S212-07 (Header) does not provide design guidance for wind loads applied perpendicular to the wall, i.e. out-of-plane loads. For design guidance pertaining to out-of-plane loads and for additional example problems for gravity load applications the reader is referred to *Cold-Formed Steel Framing Design Guide* (AISI D110-07).

Three header configurations are addressed by AISI S212-07 (Header): back-to-back, box and L-headers (Figures 1A, 1B, 1C and 1D). The stipulated design provisions are founded on the design requirements of the *North American Specification for the Design of Cold-Formed Steel Structural Members* (AISI S100-07) with modifications applicable to the respective header configurations. A key aspect of the design provisions is the recognition that these headers are assemblies and thus to achieve optimum strength and economy the headers should be designed as assemblies.

BOX HEADERS

AISI S212 includes provisions for all potential strength limit states pertaining to the box-header, i.e. bending, shear, web crippling and combinations of these limit states.

Bending. The design provisions for bending alone stipulate that the moment capacity of the built-up section must be determined based on the moment capacity of the two C-sections alone. The interconnection of the track with the C-sections using a fastener spacing of 24 inches on center is inadequate to develop composite action. Thus, there is no modification to the provisions of Section C3.1.1 of AISI S100-07 (Specification).

Shear. The design provisions for shear alone stipulate that the shear capacity of the built-up section must be determined based on the shear capacity of the two C-sections alone. The interconnection of the track with the C-sections does not develop an increase in the web shear capacity. Thus, there is no modification to the provisions of Section C3.2 of AISI S100-07 (Specification).

Combined Bending and Shear. The design provisions of Section C3.3 of AISI S100-07 (Specification) are applicable to the box header.

Web Crippling. Research has shown that the interior-one-flange loading capacity of the C-sections that form the box header is favorably influenced by the track section. Therefore, to evaluate the nominal strength for the interior-one-flange web crippling strength of a box-beam header, P'_n, which is for a single, unreinforced web, represents the increase in web crippling strength for the box-header assembly:

$$P'_n = 2.3\left(\frac{t_t}{t_c}\right)P_n \geq P_n$$

Where P_n is determined by using Eq. C4.3-1 from the AISI S100 for the interior-one-flange loading condition, t_c = thickness of C-section, and t_t = thickness of top track taken as 0.0346 in. The top track thickness is stipulated as 0.0346 inches because this was the track thickness used in the research study (Stephens and LaBoube, 2003). For design, the allowable web crippling strength is $P'_a = P'_n / \Omega$ where the safety factor Ω is1.80. AISI S212 also permits LRFD.

At end supports for the end-one-flange loading, AISI S100 must be used.

Combined Bending and Web Crippling. To provide a more accurate interaction of bending and web crippling, the following interaction equation is stipulated by AISI S212:

$$\left(\frac{P}{P'_n}\right)+\left(\frac{M}{M_n}\right)\leq 1.5/\Omega$$

Where P and M are the required strengths, i.e. the unfactored or nominal load and moment. P'_n is computed by Section B2.3 of S212 and $M_n = S_{xe}$ Fy based on Section C3.1.1 of the AISI S100. Both P'_n and M_n are taken as the sum of the two C-sections that form the box header. The safety factor is 1.85. A similar interaction equation is provided by AISI S212 for LRFD.

BACK-TO-BACK HEADERS

The AISI S212-07 (Header) includes provisions for all potential limit states pertaining to the I-header, i.e. bending, shear, web crippling and combinations of these limit states.

Based on a research study by Stephens and LaBoube (2003), the design strength of an I-beam header must be computed using the provisions given in the AISI S100-07 (Specification).

Noteworthy is that the calculations for I-beam web crippling strength for the header may be taken as if the header is a built-up section even though the fastener spacing does not meet the specification definition of a built-up section. Web crippling strength alone is determined using the built-up section coefficients.

L-HEADERS

The AISI S212-07 (Header) includes provisions for all potential limit states pertaining to the L-header, i.e. bending, shear, web crippling and combinations of these limit states.

The single, double, and inverted L-headers are addressed by AISI S212. The design methodology is similar for single and double L-headers, except specific limitations are defined based on what has been tested.

PRACTICAL CONSIDERATIONS

The selection of the header geometry is generally at the discretion of the design engineer. When considering the selection of the header geometry the design engineer may want to consider the following:

For gravity loads lateral stability is an important design issue, especially for longer spans. A top of wall header will generally be more laterally stable than a top of opening header. The header is more stable because the joists or truss members being supported by the header will provide lateral support.

If a box or back-to-back header is used as a top of wall header the header may not be capable of providing adequate out-of-plane stability for the wall. Attention must be given to the top of wall detail.

For lateral stability for long spans, a box header is likely to be more stable than a back-to-back header.

For wind loads a top of opening header may be required to provide adequate stability for the window and to transfer the wind loads.

The back-to-back header is easier to inspect for the installation of the insulation.

If joists or trusses frame into the header, the back-to-back header may be more likely to share the load between the two C-sections. However, a back-to-back header may be more difficult to attach joists or trusses framing into the side.

The single and double L-header has little uplift capacity.

Use of the L-header enables all king and jack studs to be the same length.

Additional practical considerations are provided by SSMA on their website www.ssma.com, click on Tech Library.

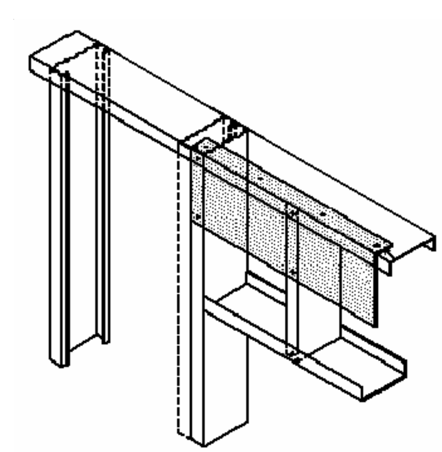

FIGURE 1A: SINGLE L-HEADER

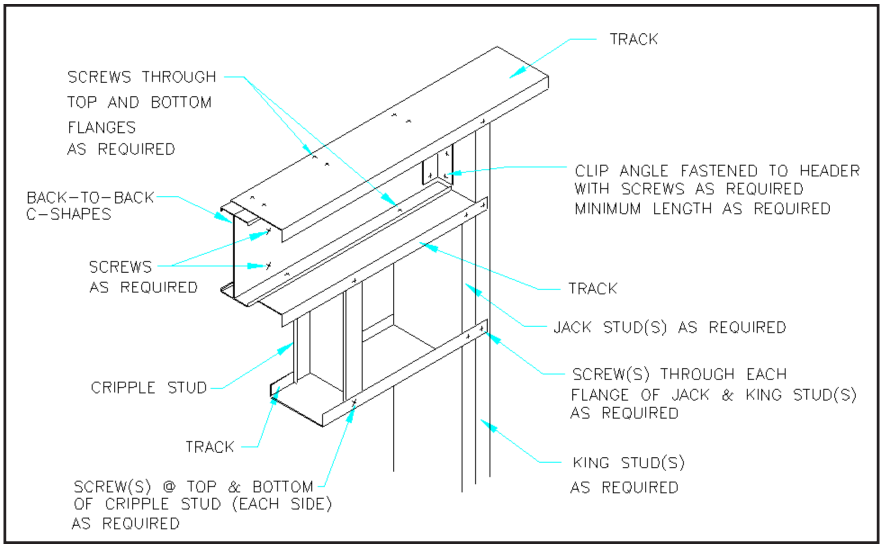

FIGURE 1B: BACK-TO-BACK HEADER

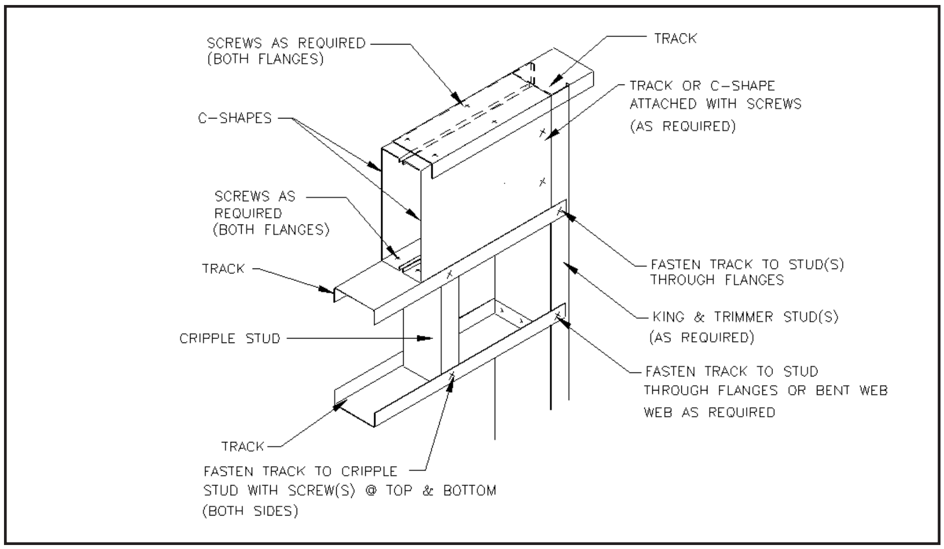

FIGURE 1C: BOX HEADER

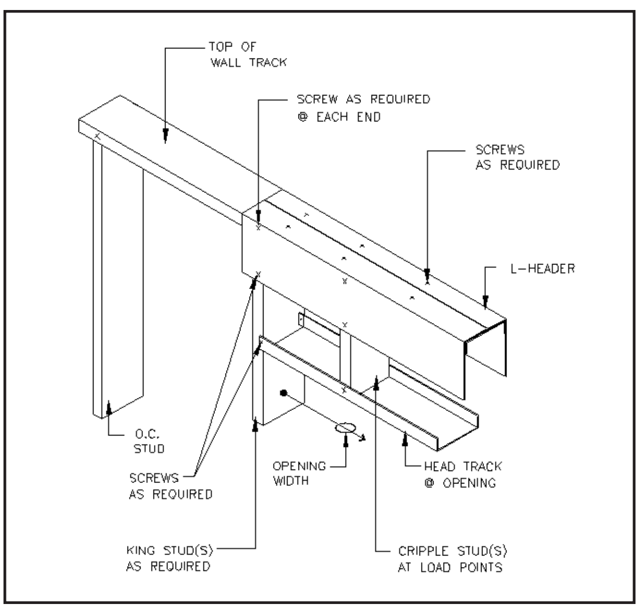

FIGURE 1D: DOUBLE L-HEADER

Example Problems

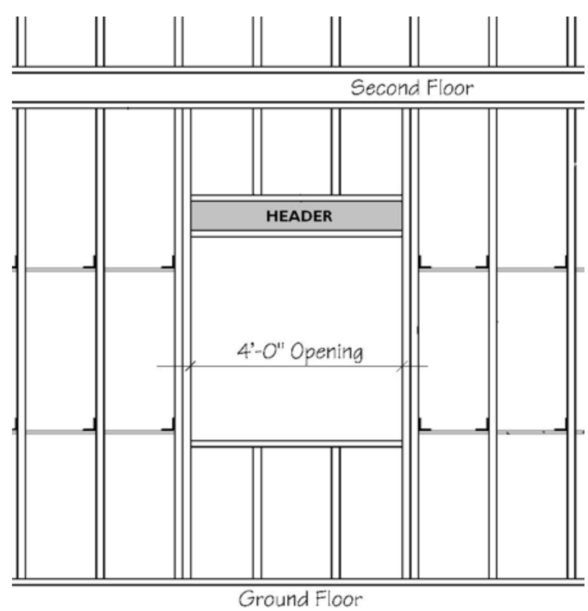

FIGURE 2: LOADBEARING OPENING ELEVATION

BOX HEADER DESIGN

Design a box header for the 4 ft window opening (Figure 2). The header is assumed to be a simple span beam supporting the two cripple studs (Figure 3). Using Allowable Strength Design size the header C-sections as follows:

1. Use the AISI Specification, S100
2. Use the Header Standard, S212

Applied forces (total on both C-sections):
Applied P = 2.79 kips
Applied M = 44.6 in.-kips

Using the AISI Specification

Try 800S162-68 (F_y = 50 ksi) for the C-sections.

Flexural Design Strength:
$M_a = S_{xe}F_y$, per Section C3.1.1 of the Specification
M_a = 99.64 in.-kips (without punchout)

Applied M = 44.6 in.-kips, flexure alone is okay

Web Crippling Design Strength:
Using AISI Specification Section C3.4 for the interior-one-flange load condition
P_a = 2.151 kips/web x 2 webs = 4.30 kips > 2.79 kips

Bending and Web Crippling:
Using AISI Specification Section C3.5with P = 2.79 kips, M = 44.6 in-kips,
P_n = 1.65 x 4.30 kips, M_n = 1.67x99.64 in-kips
Interaction Eq. C3.5.1-1 = 0.63 < 0.78

Shear Design Strength:
Using AISI Specification Section C3.2.1
V_a = 4.220 kips/web x 2 webs = 8.44 kips < 2.79 kips

<u>Conclusion</u>: 2 - 800S162-68 are okay for the header!

Try 800S162-54 (Fy = 50 ksi) for the C-sections.

Flexural Design Strength:
$M_a = S_{xe}F_y$, per Section C3.1.1 of the Specification
M_a = 73.68 in.-kips (without punchout)

Applied M = 44.6 in.-kips, flexure alone is okay

Web Crippling Design Strength:
Using AISI Specification Section C3.4
P_a = 1.40 kips/web x 2 webs = 2.80 kips > 2.79 kips

Bending and Web Crippling:
Using AISI Specification Section C3.5
Interaction Eq. C3.5.1-1 = 1.80 > 1.5, No Good!

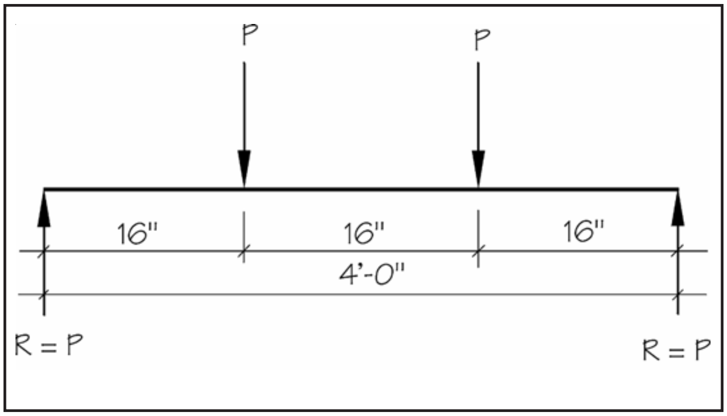

FIGURE 3: HEADER FREE BODY DIAGRAM

Using the Header Standard

Try 800S162-54 (F_y = 50 ksi) for the C-sections.

Flexural Design Strength:
Is the same as when using the AISI Specification:
M_a = 73.68 in.-kips (without punchout)

Applied M = 44.6 in.-kips, flexure alone is okay!

Web Crippling Design Strength:
Using Header Standard Section B2.3
$\alpha = 2.3\ (t_t/t_c) \geq 1.0$
$= 2.3$ (0.0346"/0.0566") = 1.41

P_n = 2.80 kips x 1.65 = 4.62 kips (two webs, where 1.65 is the safety factor per the AISI Specification Section C3.4)

$P_a' = \alpha\, P_n/\Omega$
P_a' = 1.41 (4.62 kips /1.80) = 3.62 kips (for 2 webs)
3.37 kips > 2.79 kips, Okay!

Bending and Web Crippling Design Strength:
Using Header Standard Section B2.5 and Interaction Eq. B2.5-1

$P/P_n' + M/M_n \leq 1.5/\Omega$, where Ω= 1.85
2.79/(1.41x4.62) + 44.6/(73.68 x 1.67)= 0.791 < 0.81 Okay!

Shear Design Strength:
Using AISI Specification Section C3.2.1
V_a = 2.091 kips/web x 2 webs = 4.18 kips < 2.79 kips Okay!
<u>Conclusion</u>: 2 - 800S162-54are okay for the header design!

<u>Design Summary</u>

For the above strength based design the following C-sections and track sections may be used. Neither AISI S212 nor AISI S100 provide specific design requirements for serviceability. However, the header must be designed to perform its intended function without damaging attached finish materials. Therefore, an acceptable service limit state should be considered.

C-Sections:

Using the AISI Specification:
800S162-68 or 800S162-54 with bearing stiffeners
Using the Header Design Standard:
800S162-54

Track Sections:
Although common practice is to use matching wall stud and track thicknesses, based on the design for web crippling the track section thickness may be 0.0346 inches. However, the track must be designed for the applied lateral loads in which case 0.0346 inches is the minimum thickness that may be used.

Note: The header assembly details must adhere to details illustrated by Figure 1C taken from Section A1.1.1 of the AISI S212.

BACK-TO-BACK HEADER DESIGN

Design a back-to-back header for the 4 ft window opening (Figure 2). The header is assumed to be a simple span beam supporting the two cripple studs (Figure 3). Using Allowable Strength Design size the header C-sections as follows:

3. Use the AISI Specification, S100
4. Use the Header Standard, S212

Applied forces (total on both C-sections):
Applied P = 2.79 kips
Applied M = 44.6 in.-kips

Using the AISI Specification

Try 800S162-68 (Fy = 50 ksi) for the C-sections.

Flexural Design Strength:
$M_a = S_{xe}F_y$, per Section C3.1.1 of the Specification
M_a = 99.64 in.-kips (without punchout)

Applied M = 44.6 in.-kips, flexure alone is okay!

Web Crippling Design Strength:
Use AISI Specification Section C3.4 as single unreinforced webs. Although the Specification provides web crippling design for a built-up sections, the back-to-back header does not have sufficient web connectors to qualify as a built-up section in the Specification.

P_a = 1.903 kips/web x 2 webs = 3.81 kips > 2.79 kips Okay!

Bending and Web Crippling:
Using AISI Specification Section C3..5, Equation C3.5.1-2
Interaction Eq. C3.5.1-2 = 1.340 < 1.5

Shear Design Strength:
Using AISI Specification Section C3.2.1
V_a = 4.220 kips/web x 2 webs = 8.44 kips < 2.79 kips Okay!

Conclusion: 2 - 800S162-68 are okay for the header!

Using the Header Standard

Try 800S162-54 (F_y = 50 ksi) for the C-sections.

Flexural Design Strength:
Is the same as when using the AISI Specification:
M_a = 73.68 in.-kips (without punchout)

Applied M = 44.6 in.-kips, flexure alone is okay!

Web Crippling Design Strength:

P_a = 4.67 kips for both webs (built-up section, AISI Specification Section C3.4)
4.67 kips > 2.79 kips, Okay!

Web Crippling Design Strength:
Using the Specification Section C3.5.1 and Interaction Eq. C3.5-2

$0.88P/P_n + M/M_{nxo} \leq 1.46/\Omega$ where $\Omega = 1.70$
0.88x2.79/(4.67x1.65) + 44.6/(73.68 x 1.67)= 0.681 < 0.81 Okay!

Shear Design Strength:
Using AISI Specification Section C3.2.1
V_a = 2.091 kips/web x 2 webs = 4.18 kips < 2.79 kips Okay!

Conclusion: 2 - 800S162-54 are okay for the header!

Design Summary

C-Sections:
Using the AISI Specification:
800S162-68
Using the Header Design Standard:
800S162-54

Track Sections:

Although common practice is to use matching wall stud and track thicknesses, based on the research that serves as the basis for the web crippling design methodology the track section thickness may be 0.0346 inches.

Note: The header assembly details must adhere to details illustrated by Figure 2 taken from Section A1.1.1 of the AISI S212.

L-HEADER

Design a double L-header for a door opening of 3 ft. The stud spacing is 24 in. on center. The top flange bearing length, N, is 1.625 in.

The L-header is assumed to be a simple span assembly. For a 3 ft span with studs 24 inches on center, the worst loading condition will be the cripple stud located at midspan of the L-header.

Steel properties are taken as follows for the L-header: sheet thickness ≤ 43 mil, F_y = 33 ksi; sheet thickness > 43 mil, F_y = 50 ksi.

Based on the nominal gravity load and wind load, the following summarizes the cripple stud forces that will be applied to the L-header:

Upper Floor Load: 1.2 k (gravity) and 0.69 k (uplift)
Lower Floor Load: 3.12 k (gravity) and 0.40 k (uplift)

Flexural Design Strength:

The L-header is analyzed as a simple span beam with a concentrated load applied at midspan of the 3 ft. header span.

Nominal moment, M = PL/4 is summarized as follows, where L = 3 ft. and the loads are defined above for the upper and lower floors

Floor	M Gravity (in.-kips)	M Uplift (in.-kips)
Upper	10.80	6.21
Lower	28.08	3.60

Using Section B3.1 of the header standard, $M_a = M_{ng}/\Omega$ where $M_n = S_{xc}F_y$ and S_{xc} = the elastic section modulus of the effective section calculated at $f = F_y$ in the extreme compression fibers.

Lower Floor
Double L-Header: Try 600L150-54

Gravity Allowable Strength M_a = 31.90 in.-kips > 28.08 in.-kips Okay!
Uplift Allowable Strength M_a = 0.25 x 31.90 in.-kips = 7.98 in.-kips > 6.21 in.-kips Okay!

Upper Floor
Double L-Header: Try 600L150-43

Gravity Allowable Strength M_a = 23.78 in.-kips > 10.80 in.-kips Okay!
Uplift Allowable Strength M_a = 0.25 x 23.78 in.-kips = 5.95 in.-kips < 6.21 in.-kips No Good!

Use 2-600L150-54 for both the upper and lower floor headers.

The header standard does not provide a design methodology for a single L-header subjected to a wind uplift load. Therefore only the double L-header can be used in this application.

References

1. *Standard for Cold-Formed Steel Framing - Header Design* (AISI S212-07), American Iron and Steel Institute, Washington, DC, 2007.
2. *North American Specification for the Design of Cold-Formed Steel Structural Members* (AISI S100-07), American Iron and Steel Institute, Washington, DC, 2007.
3. *Cold-Formed Steel Framing Design Guide* (AISI D110-07), American Iron and Steel Institute, Washington, DC, 2007.
4. Stephens, S.F., and LaBoube, R.A, "Web Crippling and Combined Bending and Web Crippling of Cold-Formed Steel Beam and Headers," *Thin-Walled Structures*, 41, Elsevier Ltd, 2003.

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