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Designing Cold-Formed Steel Using the Direct Strength Method

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Abstract

The Direct Strength Method is an entirely new design method for cold-formed steel. Adopted in 2004 as Appendix 1 to the *North American Specification for the Design of Cold-Formed Steel Structural Members*, this paper introduces the Direct Strength Method and details some of the features of a new AISI Design Guide for this Method. The intent of this paper and the Guide is to provide engineers with practical guidance in the application of this new design method. The Direct Strength Method does not rely on effective width, nor require iteration for the determination of member design strength. Instead, the engineer must determine the elastic buckling load in local, distortional, and global buckling. This information along with the load that causes first yield are then employed in a series of simple equations to "directly" provide the strength prediction. The primary complication with the method lies in determining the elastic local, distortional, and global buckling loads; once these values are determined application of the method is straightforward. Computational tools, such as the freely available open source program CUFSM, can provide the elastic buckling loads that the Direct Strength Method requires. This paper will highlight some of the features of the new Direct Strength Method Design Guide, including design examples, tutorial materials, beam and column charts, and discussion of the finer points and details that could trip up the conscientious engineer when first using the method in design.

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Introduction

The Direct Strength Method is a new design procedure for cold-formed steel member design. The method was formally adopted in 2004 as Appendix 1 to the North American Specification for the Design of Cold-Formed Steel Structural Members (AISI 2004). The Direct Strength Method does not use effective width, nor require iteration for determining effective properties, instead the method uses member elastic buckling solutions based on gross properties to determine the member strength in three key limit states: global buckling, local buckling (including interaction with global buckling), and distortional buckling.

The key documents and tools necessary for the application of the Direct Strength Method are summarized in Figure 1, they include: (a) The North American Specification for the Design of Cold-Formed Steel Structural Members (AISI 2001) also known as the main Specification, (b) the 2004 Supplement to the main Specification (AISI 2004), (c) the Direct Strength Method (DSM) Design Guide (AISI 2006), and the finite strip software CUFSM (Schafer 2006).

(a) AISI (2001) (b) AISI (2004) (c) AISI (2006) (d) Schafer (2006)

Figure 1 Key documents and tools needed for the Direct Strenth Method

The Direct Strength Method provisions are straightforward, for example, column design was excerpted from AISI (2004) and is provided in Figure 2 – in one page. The key information that the engineer must provide is the elastic buckling loads in global (P_{cre}), local ($P_{cr\ell}$), and distortional (P_{crd}) buckling, these, along with the squash load (P_y), provide the strength. The easiest means for finding the elastic buckling loads is the use of the freely available, open source, software, CUFSM, (www.ce.jhu.edu/bschafer/cufsm, Schafer and Ádány 2006). However, CUFSM is not required for the Direct Strength Method as (1) closed-formed solutions are provided for standard shapes in the DSM Design Guide, and (2) other software packages are available that provide the same solution.[2]

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[2] CFS (www.rsgsoftware.com), Thin-wall (www.civil.usyd.edu.au/case/thinwall. php), or SSS (www.appliedscienceint.com) which incorporates CUFSM v2.6.

1.2.1 Column Design

The nominal axial strength, P_n, is the minimum of P_{ne}, $P_{n\ell}$ and P_{nd} as given below. For columns meeting the geometric and material criteria of Section 1.1.1.1, Ω_c and ϕ_c are as follows:

For all other columns, Ω and ϕ of Section A1.1(b) apply.

USA and Mexico		Canada
Ω_c (ASD)	ϕ_c (LRFD)	ϕ_c (LSD)
1.80	0.85	0.80

1.2.1.1 Flexural, Torsional, or Torsional-Flexural Buckling

The nominal axial strength, P_{ne}, for flexural, … or torsional- flexural buckling is

$$\text{for } \lambda_c \le 1.5 \quad P_{ne} = \left(0.658^{\lambda_c^2}\right)P_y \qquad (Eq.\ 1.2.1\text{-}1)$$

$$\text{for } \lambda_c > 1.5 \quad P_{ne} = \left(\frac{0.877}{\lambda_c^2}\right)P_y \qquad (Eq.\ 1.2.1\text{-}2)$$

where $\lambda_c = \sqrt{P_y/P_{cre}}$ (*Eq*. 1.2.1-3)

$P_y = A_gF_y$ (*Eq*. 1.2.1-4)

P_{cre}= Minimum of the critical elastic column buckling load in flexural, torsional, or torsional-flexural buckling …

1.2.1.2 Local Buckling

The nominal axial strength, $P_{n\ell}$, for local buckling is

$$\text{for } \lambda_\ell \le 0.776 \quad P_{n\ell} = P_{ne} \qquad (Eq.\ 1.2.1\text{-}5)$$

$$\text{for } \lambda_\ell > 0.776 \quad P_{n\ell} = \left[1 - 0.15\left(\frac{P_{cr\ell}}{P_{ne}}\right)^{0.4}\right]\left(\frac{P_{cr\ell}}{P_{ne}}\right)^{0.4} P_{ne} \qquad (Eq.\ 1.2.1\text{-}6)$$

where $\lambda_\ell = \sqrt{P_{ne}/P_{cr\ell}}$ (*Eq*. 1.2.1-7)

$P_{cr\ell}$ = Critical elastic local column buckling load …

P_{ne} is defined in Section 1.2.1.1.

1.2.1.3 Distortional Buckling

The nominal axial strength, P_{nd}, for distortional buckling is

$$\text{for } \lambda_d \le 0.561 \quad P_{nd} = P_y \qquad (Eq.\ 1.2.1\text{-}8)$$

$$\text{for } \lambda_d > 0.561 \quad P_{nd} = \left(1 - 0.25\left(\frac{P_{crd}}{P_y}\right)^{0.6}\right)\left(\frac{P_{crd}}{P_y}\right)^{0.6} P_y \qquad (Eq.\ 1.2.1\text{-}9)$$

where $\lambda_d = \sqrt{P_y/P_{crd}}$ (*Eq*. 1.2.1-10)

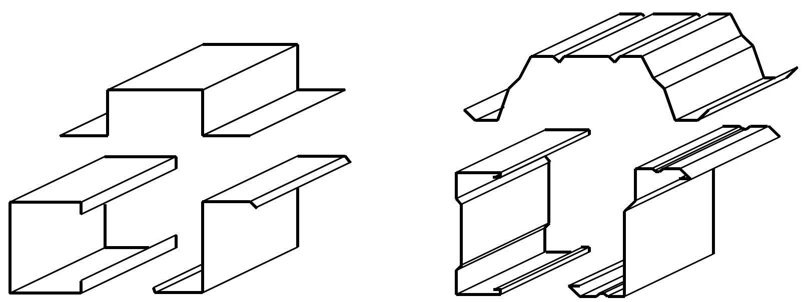
P_{crd} =Critical elastic distortional column buckling load …

P_y is given in Eq. 1.2.1-4.

Figure 2 Direct Strength Method for Columns (excerpt from AISI 2004)

Why use DSM (Appendix 1 AISI 2004) instead of the main Specification?

The design of optimized cold-formed steel shapes is often completed more easily with the Direct Strength Method than with the main Specification. As Figure 3 indicates, DSM provides a design method for complex shapes that requires no more effort than for normal shapes, while the main Specification can be difficult, or even worse, simply inapplicable in such situations.



(a) conventional shapes

	design effort
main *Specification*	medium
DSM (Appendix 1)	medium

(b) optimized shapes

	design effort
main *Specification*	**high** or NA*
DSM (Appendix 1)	medium

*NA = not applicable or no design rules

Figure 3 Design of cold-formed steel shapes main Specification and DSM

A number of practical advantages exits for the use of DSM: no effective width calculations, no iterations required, and DSM uses gross cross-sectional properties. Elastic buckling analysis performed on the computer (e.g., by CUFSM) is directly integrated into DSM. This provides a general method of designing cold-formed steel members and creates the potential for much broader extensions than the traditional Specification methods, that rely on closed-form solutions with limited applicability.

More theoretical advantages of the DSM approach include: an explicit design method for distortional buckling of beams and columns, DSM includes interaction of elements (i.e., equilibrium and compatibility between the flange and web is maintained in the elastic buckling prediction), and DSM explores and includes all stability limit states. Philosophical advantages to the DSM approach: encourages cross-section optimization, provides a solid basis for rational analysis extensions, potential for much wider applicability and scope, and engineering focus is on correct determination of elastic buckling behavior, instead of on correct determination of empirical effective widths.

Limitations of DSM: practical and theoretical

Of course, numerous limitations of DSM (as implemented in AISI 2004) exist as well, not the least of which is that the method has only been formally developed for the determination of axial (P_n) and bending (M_n) strengths to date. Other limitations of DSM include: no shear provisions, no web crippling provisions, no provisions for members with holes, limited number/geometry of pre-qualified members, and no provisions for strength increase due to cold-work of forming. Existing shear and web crippling provisions may be used when applicable. Otherwise, rational analysis or testing are a possible recourse. Members with holes are discussed in the DSM Design Guide, and this is a topic of current research. Pre-qualified members are discussed extensively in the Guide.

Practical limitations of the DSM approach also exist: DSM is overly conservative if very slender elements are used, shift in the neutral axis is ignored, and DSM is an empirical method calibrated only to work for cross-sections previously investigated. DSM performs an elastic buckling analysis for the entire cross-section, not for the elements in isolation. If a small portion of the cross-section (a very slender element) initiates buckling for the cross-section, DSM will predict a low strength for the entire member. The effective width approach of the main Specification will only predict low strength for the offending element, but allow the rest of the elements making up the cross-section to carry load (i.e., the main Specification ignores inter-element equilibrium and compatibility in the buckling solution). The DSM approach can be overly conservative in such cases; however, members with one very slender element are inefficient and prone to serviceability problems, the addition of folded longitudinal stiffeners in the offending element will improve the strength, and the DSM strength prediction, significantly. Shift in the neutral axis occurs when very slender elements are in compression in a cross-section. DSM conservatively accounts for such elements as described above, as such, ignoring the small shift has proven successful. The DSM strength equations are empirical, in much the same manner as the effective width equation, or the column curves; however, the range of cross-sections investigated is quite broad.

DSM Design Guide

In an effort to expand the use of the Direct Strength Method a Design Guide (AISI 2006) was recently completed. The subsequent sections of this paper detail this Guide and provide the interested engineer with further information on the application of DSM. The Guide covers the following areas: elastic buckling, overcoming difficulties with elastic buckling determination in the finite strip method, beam design, column design, beam-column design, product development and nearly 100 pages of design examples.

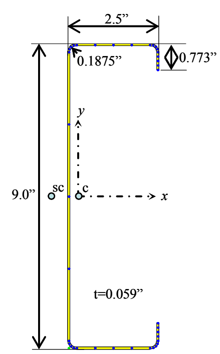
Member Elastic Buckling

Solution Methods

The Guide discusses and provides references to a variety of solution methods for elastic buckling of cold-formed steel members including the finite element method, the finite strip method, and closed-form hand solutions[3], but the focus is on the finite strip method. Typical results from a finite strip analysis are shown in Figure 5. From finite strip analyses local, distortional, and global buckling of a beam and/or column may be identified.

Finite Strip Method Examples

A number of examples are presented in the Guide, including those of the AISI (2002) Design Manual plus additional examples selected to highlight the use of the Direct Strength Method for more complicated and optimized cross-sections. For each example the following is provided: (1) references to the AISI (2002) Design Manual example problems (as appropriate), (2) basic cross-section information and confirmation of finite strip model geometry, and (3) elastic buckling analysis by the finite strip method (CUFSM) and notes on analysis. Models of the following cross-sections were generated: C-section with lips, C-section with lips *modified*, C-section without lips (track section), C-section without lips (track section) *modified*, Z-section with lips, Z-section with lips *modified*, Equal leg angle with lips, Equal leg angle, Hat section, Wall panel section, Rack post section, and a Sigma section.



C-section with lips (9CS2.5x059)

	Formula*	FSM model	
A =	0.881	0.880	in.^{2}
I_x =	10.3	10.285	in.^{4}
x_c =	0.612	0.610	in.
I_y =	0.698	0.695	in.^{4}
m =	1.048	1.036	in.
x_o =	-1.660	-1.646	in.
J =	0.00102	0.00102	in.^{4}
C_w =	11.9	11.1	in.^{6}

* given in the AISI Design Manual (2002)

Figure 4 Example of C-section used for elastic buckling and design analysis (Figure 4 in the DSM Design Guide AISI 2006)

[3] closed-formed hand solutions for elastic buckling loads are provided for standard sections through a series of design examples in the Guide. However, many of the formulae are laborious and computational methods, such as CUFSM, are recommended.

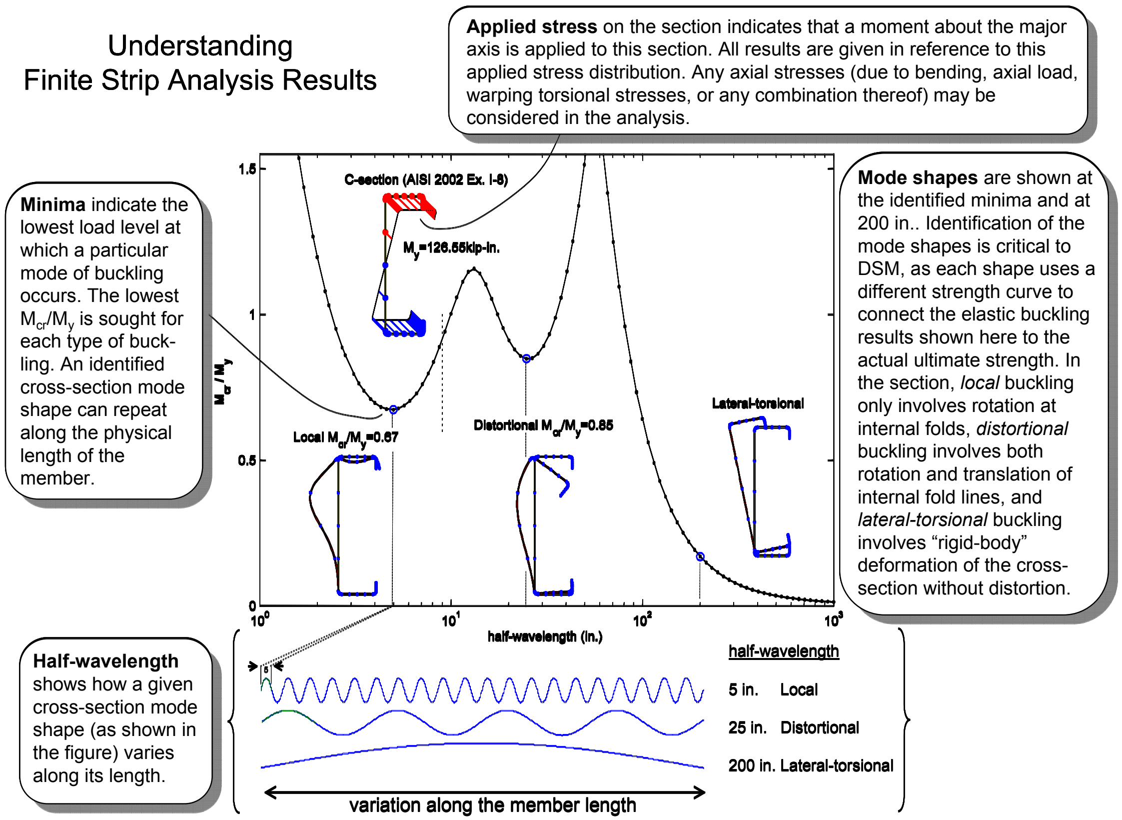


Figure 5 Understanding finite strip analysis results (Figure 2 DSM Design Guide AISI 2006)

Finite Strip Method Details and Difficulties

The Design Guide provides a complete discussion of the details associated with application of the finite strip method, and the difficulties encountered as well. Topics covered include the following:

- Indistinct local mode
- Indistinct distortional mode
- Multiple local or distortional modes (stiffeners)
- Global modes at short unbraced lengths
- Global modes with different bracing conditions
- Influence of moment gradient
- Partially restrained modes
- Boundary conditions for repeated members
- Members with holes
- Boundary conditions at the supports not pinned
- Built-up cross-sections

Each of the above listed topics is covered thoroughly with the Guide and includes narrative, figures, and practical advice for engineers modeling cold-formed steel members in a variety of design and development applications.

For example, multiple local or distortional modes often occur when small stiffeners are added to the cross-section as illustrated in Figure 6. The introduction of small stiffeners into the flats of sections can greatly enhance the elastic local buckling behavior of the section as illustrated. This improvement comes with some increased complication, but the Direct Strength Method has been shown to accurately provide the predicted strength of such optimized sections. This topic is fully explored in the Guide.

Another example of interest is the change in the elastic buckling behavior when external restraining elements are included in the model. For example, if rotational restraint is modeled as attached to the compression flange of a Z-section in bending the distortional buckling mode is retarded greatly, as shown in Figure 7. Given the recently adopted main Specification procedures for distortional buckling the ability to directly add restraint into a model is in some sense a complication, but in reality a definite advantage of the Direct Strength Method approach to strength. Even for those not using the Direct Strength Method, M_{crd}, is now required in the main Specification and finite strip method solutions are allowed.

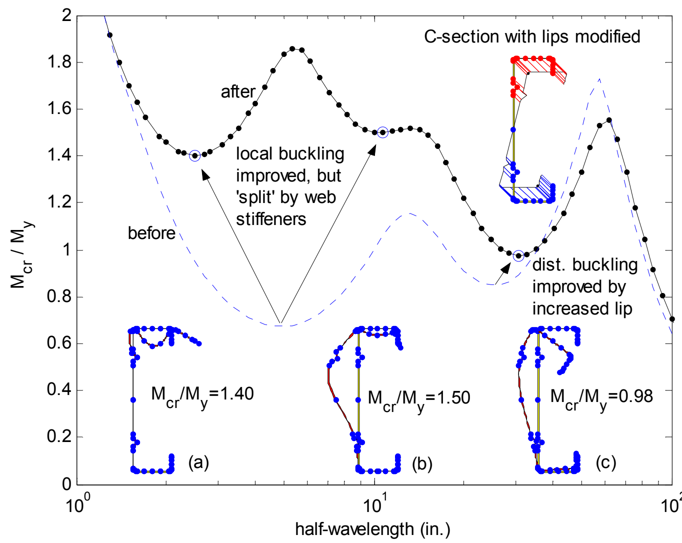


Figure 6 Example of modified/optimized C-section
(Figure 30 of the DSM Design Guide AISI 2006)

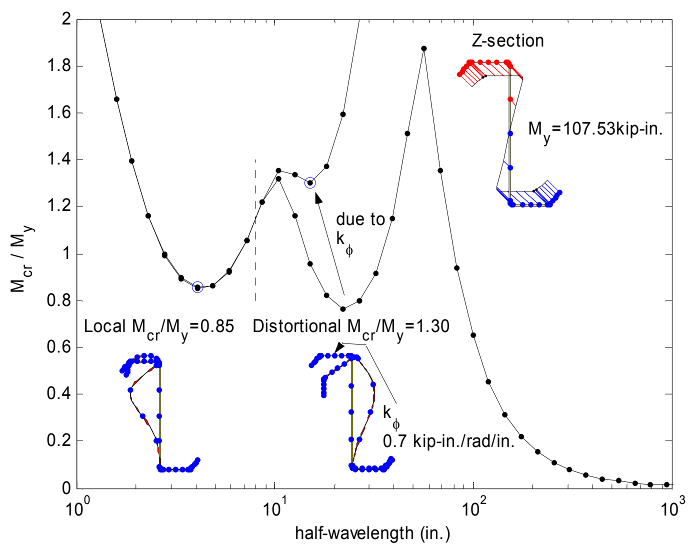


Figure 7 Example of impact of adding rotational restraint to the flange
(Figure 33 of the DSM Design Guide 2006)

Design Examples

The heart of the DSM Design Guide is a series of example problems. A typical page from the design examples is annotated, and provided in Figure 8. Each set of example problems is focused on a particular cross-section. For example, for a C-section with lips (a stud section) the following examples are provided:

C-section with lips
Flexural strength for a fully braced member (AISI 2002 Example I-8)
Flexural strength for L=56.2 in. (AISI 2002 Example II-1)
Effective moment of inertia (AISI 2002 Example I-8)
Compressive strength for a continuously braced column (AISI 2002, I-8)
Compressive strength at Fn=37.25 ksi (AISI 2002 Example III-1)
Beam-column design strength (AISI 2002 Example III-1)

The flexural strength for a fully braced member is similar in concept to determining the effective section for a member at yield. The examples cover strength as well as serviceability (deflection) determinations using the Direct Strength Method. Application of the Direct Strength Method to beam-columns is also illustrated. In addition, reference is provided to the AISI (2002) Design Manual (noted in parentheses above) where similar calculations are performed using the conventional effective width methods of the main Specification.

The design examples in the Guide span nearly 100 pages and cover a variety of cross-sections and situations, including:

- a C-section with web stiffeners added, including strong axis flexural strength and compressive strength with different bracing conditions,
- an SSMA track section, including strong and weak-axis flexural strength, compressive strength, and beam-column strength,
- a track section with flange stiffeners added, including flexural strength and compressive strength,
- a Z-section purlin, including flexural and compressive strength for different bracing conditions,
- a Z-section purlin with stiffeners added and lip length modified, including flexural and compressive strength,
- an equal leg angle with lips, including flexural strength, compressive strength, and compressive strength explicitly including eccentricity,
- an equal leg angle, including flexural and compressive strength,
- a hat section, including flexural strength, compressive strength for different bracing conditions, and beam-column allowable strength,

Typical example from the DSM Design Guide

Problem Assumptions

Provided examples

For each cross-section a number of different beam, column, and beam-column examples are provided.

Elastic Buckling

Elastic buckling results are the key to DSM. For this bending example, $M_{cr\ell}$ and M_{crd} are found from the finite strip analysis which is shown in thumbnail to the right, the same analysis is also fully examined in Chapter 3 of the Guide.

Global buckling check

The beam is assumed to be fully laterally braced, thus the global buckling strength is simply the moment at first yield, M_y.

Local buckling check

The Direct Strength expressions are used to provide the strength in local buckling ($M_{n\ell}$) including interaction with global buckling strength (M_{ne}) as shown at right.

Distortional buckling check

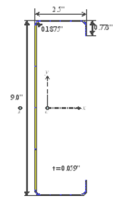
The Direct Strength expressions for distortional buckling are given to the right. Note that interaction with global buckling (M_{ne}) is not included for distortional buckling.

Nominal strength

M_n is the minimum of three individual strength checks. Conversion of nominal strength to allowable design strength (ASD) or design strength (LRFD) requires application of the appropriate safety and resistance factors which are discussed in the examples.

8.1 C-section with lips

Given:
a. Steel: F_y = 55 ksi
b. Section 9CS2.5x059 as shown to the right
c. Finite strip analysis results (Section 3.2.1)
Required:
1. Bending capacity for fully braced member
2. Bending capacity at L=56.2 in. (AISI 2002 Example II-1)
3. Effective moment of inertia
4. Compression capacity for a fully braced member
5. Compression capacity at a uniform compressive stress of 37.25 ksi (AISI 2002 Example III-1)
6. Beam-column design (AISI 2002 Example III-1)



8.1-1 Computation of bending capacity for a fully braced member (AISI 2002 Example I-8)

Determination of the bending capacity for a fully braced member is equivalent to determining the effective section modulus at yield in the main *Specification.* see AISI (2002) example I-8.

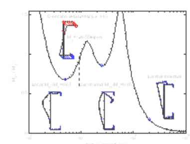
Finite strip analysis of 9CS2.5x059 in pure bending as summarized in Example 3.2.1

Inputs from the finite strip analysis include:

$M_y := 126.55 \cdot kip \cdot in$

$M_{crl} := 0.67 \cdot M_y$ $\quad M_{crl} = 85\, kip \cdot in$

$M_{crd} := 0.85 \cdot M_y$ $\quad M_{crd} = 108\, kip \cdot in$



per DSM 1.2.2, M_n is the minimum of M_{ne}, M_{nl}, M_{nd}. For a fully braced member lateral-torsional buckling will not occur and thus $M_{ne} = M_y$. M_{nl} and M_{nd} must still be checked.

$M_{ne} := M_y$ $\quad M_{ne} = 127\, kip \cdot in$ (fully braced)

Equation numbers refer to the relevant parts of DSM (Appendix 1 AISI 2004)

Local buckling check per DSM 1.2.2.2

$\lambda_l := \sqrt{\dfrac{M_{ne}}{M_{crl}}}$ $\quad \lambda_l = 1.22$ (subscript "l" = "ℓ") (Eq. 1.2.2-7)

$$M_{nl} := \begin{cases} M_{ne} & \text{if } \lambda_l \le 0.776 \\ \left[1 - 0.15 \cdot \left(\dfrac{M_{crl}}{M_{ne}} \right)^{0.4} \right] \left(\dfrac{M_{crl}}{M_{ne}} \right)^{0.4} \cdot M_{ne} & \text{if } \lambda_l > 0.776 \end{cases}$$

(Eq. 1.2.2-5)
(Eq. 1.2.2-6)

$M_{nl} = 94\, kip \cdot in$

Distortional buckling check per DSM 1.2.2.3

$\lambda_d := \sqrt{\dfrac{M_y}{M_{crd}}}$ $\quad \lambda_d = 1.08$ (Eq. 1.2.2-10)

$$M_{nd} := \begin{cases} M_y & \text{if } \lambda_d \le 0.673 \\ \left[1 - 0.22 \cdot \left(\dfrac{M_{crd}}{M_y} \right)^{0.5} \right] \left(\dfrac{M_{crd}}{M_y} \right)^{0.5} \cdot M_y & \text{if } \lambda_d > 0.673 \end{cases}$$

(Eq. 1.2.2-8)
(Eq. 1.2.2-9)

$M_{nd} = 93\, kip \cdot in$

Predicted bending capacity per 1.3

$M_n := \min((M_{ne}\ M_{nl}\ M_{nd}))$ $\quad M_n = 93\, kip \cdot in$

The geometry of this section falls within the "pre-qualified" beams of DSM 1.1.1.2 and the higher ϕ and lower Ω of DSM Section 1.2.2 may therefore be used.

LRFD: $\phi_b := 0.9$ $\quad \phi_b \cdot M_n = 84\, kip \cdot in$

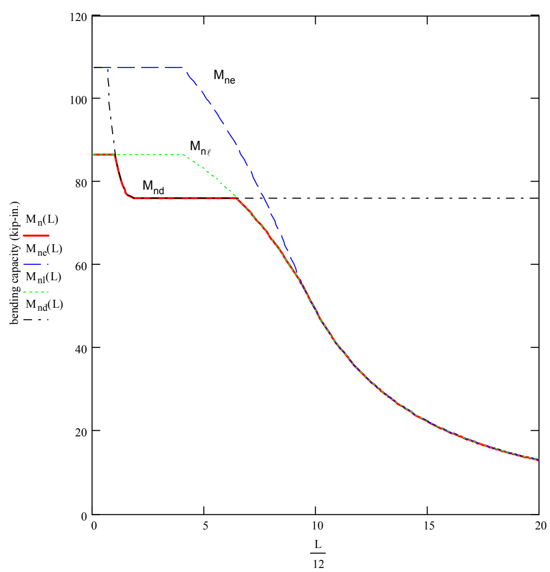
ASD: $\Omega_b := 1.67$ $\quad \dfrac{M_n}{\Omega_b} = 56\, kip \cdot in$

Figure 8 Annotated example of DSM Design Guide example problems

- a wall panel section, including flexural strength for intermediate and end panels with the top flange in compression and flexural strength for bottom flange in compression,
- a rack post section, including flexural and compressive strength, and
- a sigma section, including flexural and compressive strength.

Beam and Column Charts

The DSM Design Guide provide complete details for development of beam span tables or charts and column height tables or charts using the Direct Strength Method. An example beam chart is provided in Figure 9. In this example one can see how the local buckling strength, $M_{n\ell}$, is a reduction below the global buckling strength, M_{ne}. The point where $M_{n\ell}$ and M_{ne} merge (approximately 9 ft) indicates that local buckling no longer provides a reduction in the strength of this beam – in the main Specification this occurs when the stress used to determine the effective section (F_n) is low enough that the section is fully effective at that stress. Further, the impact of distortional buckling on intermediate length beams is clearly shown.



(c) M_n for Z-section with lips

Figure 9 Example beam chart for a Z-section
(Figure 37(c) of the DSM Design Guide AISI 2006)

Beam-column Design

Main Specification Methodology

As described in the Guide conventional beam-column design follows the basic methodology of the main Specification, and is a simple extension of the Direct Strength Method. The basic interaction equation, in ASD format, is as follows:

$$\frac{\Omega_c P}{P_n} + \frac{\Omega_b C_{mx} M_x}{M_{nx}\alpha_x} + \frac{\Omega_b C_{my} M_y}{M_{ny}\alpha_y} \leq 1.0$$

where: P_n and M_n are determined from the Direct Strength Method. The first-order required strengths (demands) are P, M_x and M_y, as determined from conventional linear elastic analysis. C_m is the moment gradient factor, of which, the method for determination is addressed in the main Specification and is unchanged. Finally, α, the moment amplification factor is $1\text{-}\Omega_c P/P_E$. P_E is the elastic buckling load of the cross-section about the same axis as the primary bending moment, i.e., for strong axis moment M_x, global buckling load P_E is P_{Ex}. Global buckling loads may be determined from main Specification equations or directly from a finite strip analysis.

Future methods for beam-column design

The advantage of the Direct Strength Method is that the stability of the entire cross-section under a given axial load (P) or bending moment (M) is investigated. Local, distortional, and global buckling of the column or beam is explored. It is natural to extend this idea to the stability of the cross-section under any given P and M combination. Where, now, the three buckling modes: local, distortional, and global buckling are explored under the actual P and M combination of interest, instead of separately for P and separately for M. Such an analysis can lead to far different behavior than typically assumed in the interaction equation approach used in the main Specification.

The fundamental difference between the interaction equations and a more thorough stability analysis can be understood by answering a simple question: *for all cross-sections does the maximum axial capacity exist when the load is concentric*? The interaction equation approach says, yes, any additional moment caused by a load away from the centroid will reduce the nominal strength of the cross-section. While a conservative answer, it is not always correct. If moving the axial load causes the relative compressive demand on a weak part of the cross-section to be relieved the cross-section strength will benefit from this. Interaction diagrams make some sense for determining when a simple cross-section yields, but stability, this is another matter. A design example previewing this new approach to beam-column design is provided in the Guide.

Product Development

Cold-formed steel is a versatile, easily formed material – it is one objective of DSM and the DSM Guide to help manufacturers take better advantage of the potential in cold-formed steel for creating optimal cross-section shapes. Final optimization and bringing a product to market has as much, if not more, to do with manufacturing, constructability, and other practical matters as strength; however, DSM provides a way to quantitatively focus on the strength improvements available to cold-formed steel designers/manufacturers.

One particularly important matter with regard to strength is the application of resistance or safety factors for newly developed members. For a newly developed cross-section, not covered by the main Specification provisions, two basic avenues exist for strength prediction, as outlined in main Specification Section A1.1(b): (a) determine the strength by testing and find ϕ via Chapter F of the Spec., or (b) determine the strength by rational analysis and use the blanket ϕ=0.80 (Ω=2.0) provided in A1.1. As Figure 10 shows although ϕ=0.8 may be a rather low resistance factor it may take a large number of tests (and relatively low scatter) to do better than this value.

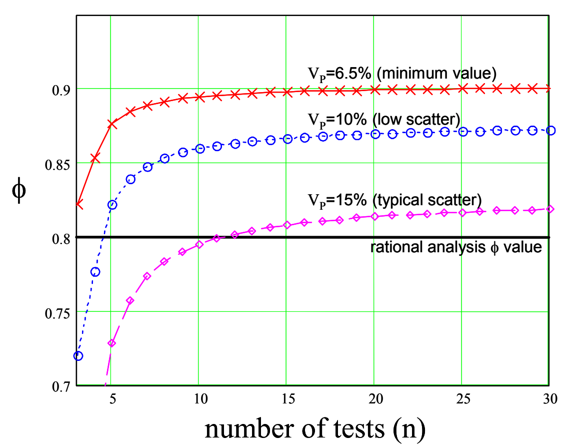


Figure 10 Comparison of rational analysis ϕ with main Specification Chapter F methodology (Figure 40 from the DSM Design Guide AISI 2006)

Beyond using the blanket rational analysis resistance or safety factors, formal methods for pre-qualifying a new cross-section and using improved resistance factors have not yet been formalized. However, the DSM Guide provides specific guidance on how to take advantage of the testing that has already been performed in approximating the reliability of a new product.

Conclusions

The Direct Strength Method (DSM) is a new method for the design of cold-formed steel members. The approach employs member elastic buckling solutions to directly provide the member strength in global, local (with global interaction), and distortional buckling. DSM does not employ effective width, and instead uses gross properties, also DSM requires no iteration in determination of the strength. The method was formally adopted for beams and columns in 2004 as Appendix 1 of the North American Specification for the Design of Cold-Formed Steel Structural Members.

Recently a DSM Design Guide has been completed. The objective of the Guide is to aid engineers interested in applying DSM to their own designs, or in developing new products that take advantage of the flexibility of DSM. Key aspects of the new Guide are reviewed here, including: detailed explanation of member elastic buckling solutions using the finite strip method, a brief summary of the topics covered in the design examples (which span nearly 100 pages of the Guide), a review of methods for developing beam and column charts, as well as beam-column design, and how to use DSM in product development.

Acknowledgments

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