



Oct 26th

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Recommended Citation

Sputo, Thomas and Turner, Jennifer, "A Design Guide for Bracing Cold-formed Steel Structures" (2006). *International Specialty Conference on Cold-Formed Steel Structures*. 5.

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A Design Guide for Bracing Cold-Formed Steel Structures

Thomas Sputo¹ and Jennifer Turner²

Abstract

In response to confusion on the part of practicing structural engineers regarding the proper design of bracing for cold-formed steel structures and structural elements, the Structural Engineering Institute of the American Society of Civil Engineers funded the development of a design guide on this topic; *Bracing Cold-Formed Steel Structures: A Design Guide* (Sputo and Turner 2006). This guide introduces the engineer to the current state-of-the-art for bracing cold-formed steel elements and systems, provides relevant design examples, and provides references for further study.

Introduction

For many practicing structural engineers, the design of bracing for cold-formed steel structures is seen as a daunting task. In response to confusion on the part of practicing structural engineers regarding the design of this bracing, the Structural Engineering Institute of the American Society of Civil Engineers funded the development of a design guide on this topic; *Bracing Cold-Formed Steel Structures: A Design Guide* (Sputo and Turner 2006). This guide (Figure 1) introduces the engineer to the current state-of-the-art for bracing cold-formed steel elements and systems, provides relevant design examples, and lists references for further study.

The goal of this guide is to remove some of the perceived mystery by providing readily useful information for bracing cold-formed steel structures. This guide

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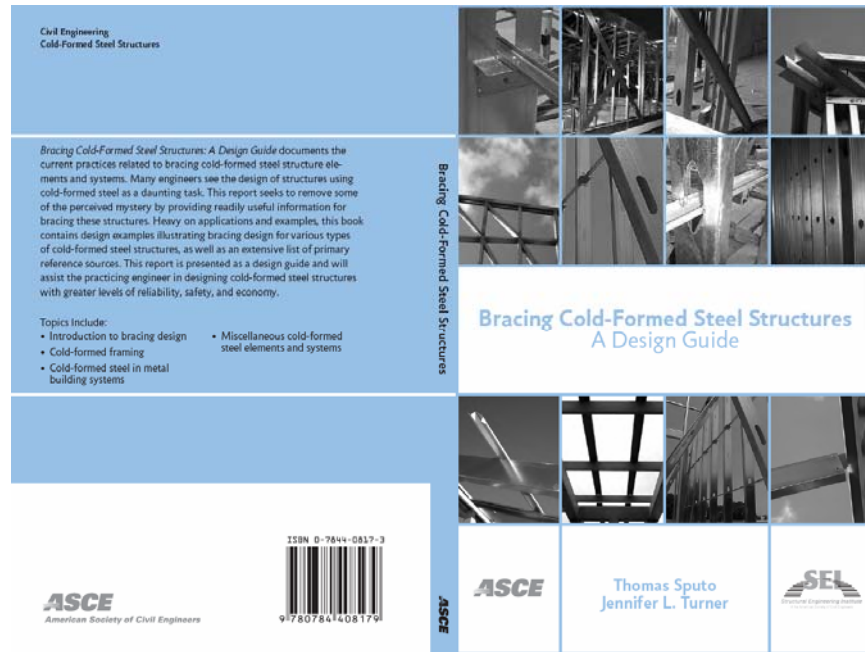


Figure 1. Cover of *Bracing Cold-Formed Steel Structures: A Design Guide* (Sputo and Turner, 2006)

is not written as a highly technical research report, it is instead presented as a design guide, written by practicing structural engineers for other practicing structural engineers. Only enough theory is presented to allow the reader to understand the basis for the methods presented. The emphasis is placed on understanding the function and design of the bracing itself.

The guide documents in a concise manner the current practices related to bracing cold-formed steel structural elements and systems. Currently this information is fragmented and sometimes not readily accessible to the practicing engineer. The guide provides summaries of cold-formed steel bracing practices and design examples with references to sources of additional information. This will enable the practicing engineer to readily access this information, resulting in cold-formed steel structures with greater levels of reliability, safety, and economy.

The contents of the guide are as follows:

Chapter 1 – Introduction to Bracing Design

A general information section is provided to discuss the means and methods for properly proportioning bracing. To further understand the differences in bracing, bracing is discussed by categories of function, by performance criteria, and by method of interaction between braced points.

A detailed explanation of different bracing models is used to describe the derivations of bracing equations. Basic bracing models (Figures 2 and 3) were used to model a perfectly straight, plumb, and elastic member and an out-of-straight member.

To conclude the chapter the differences between hot rolled and cold-formed, including multiple members and systemic sweep (Figure 4) are discussed to help the designer who is more familiar with hot rolled steel to clearly understand the importance of bracing in cold-formed steel structures.

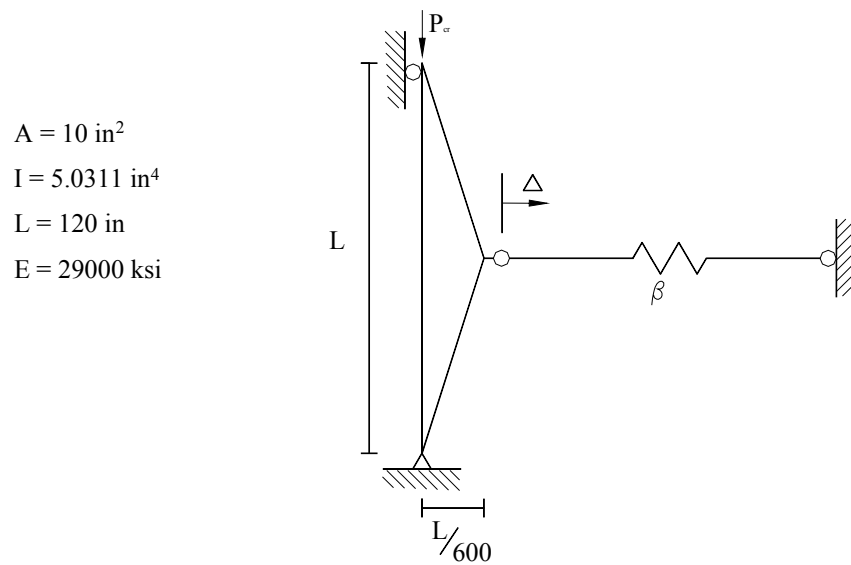


Figure 2. Imperfect Column Model (Sputo and Turner, 2006)

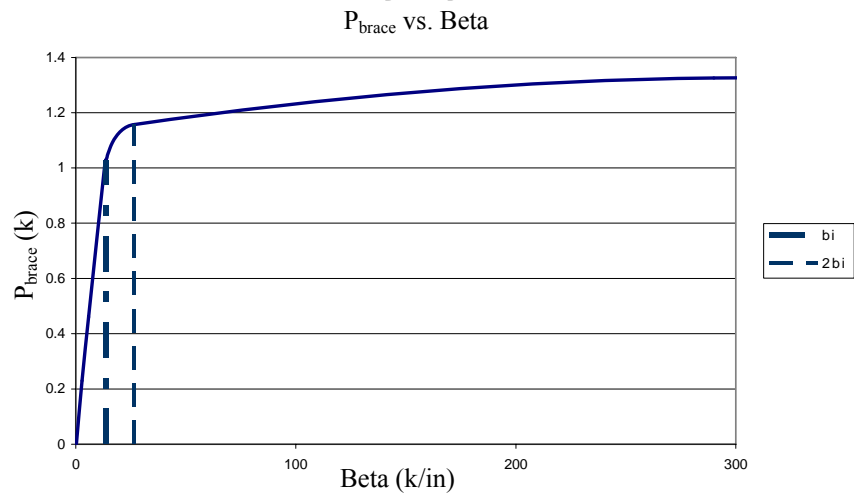


Figure 3. Relationship Between P_{brace} vs β (Sputo and Turner, 2006)

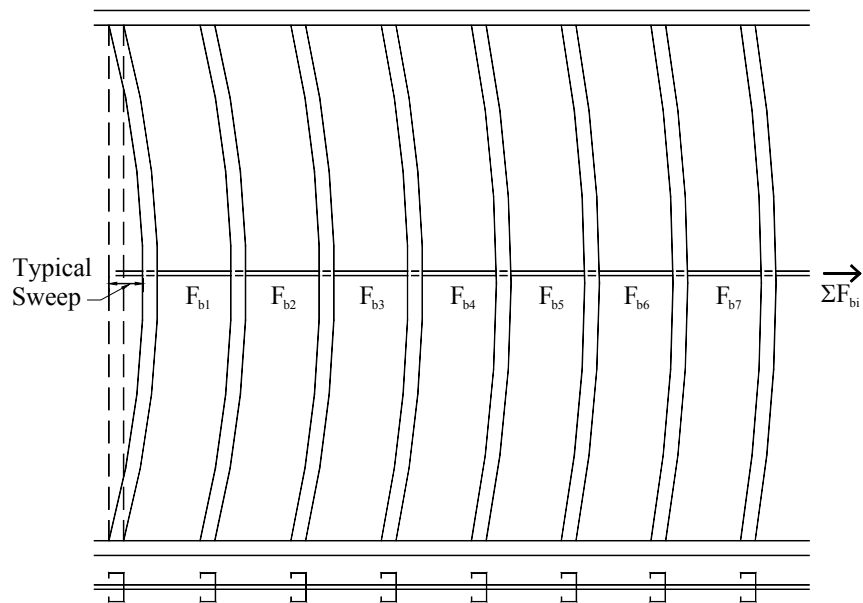


Figure 4. Systemic Sweep in Wall Studs (Sputo and Turner, 2006)

Chapter 2 – Cold Formed Steel Framing

Cold-formed steel members and assemblies utilized primarily in the construction of load bearing walls, curtain walls, and trusses are typically referred to as “cold-formed framing.” The design of these members is generally governed by the *North American Specification for the Design of Cold-Formed Steel Structural Members* (AISI 2004). Although the need for bracing is envisioned by this document, except for limited situations this document is silent as to the actual design provisions for bracing.

Chapter 2 of this Monograph discusses sheathing braced designs, mechanically braced studs (Figure 5), floor and roof joists, truss bracing, and shearwall (Figures 6 and 7) and roof diaphragms.

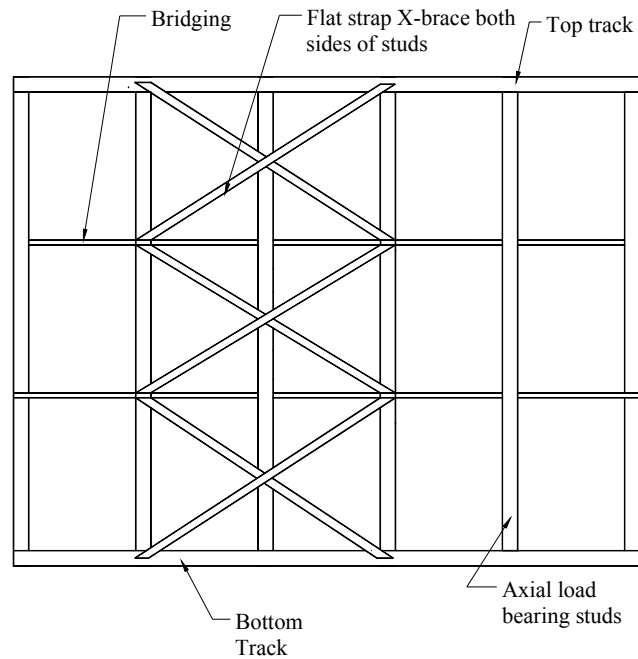


Figure 5. Bracing for Axial Load Bearing Studs (Sputo and Turner, 2006)

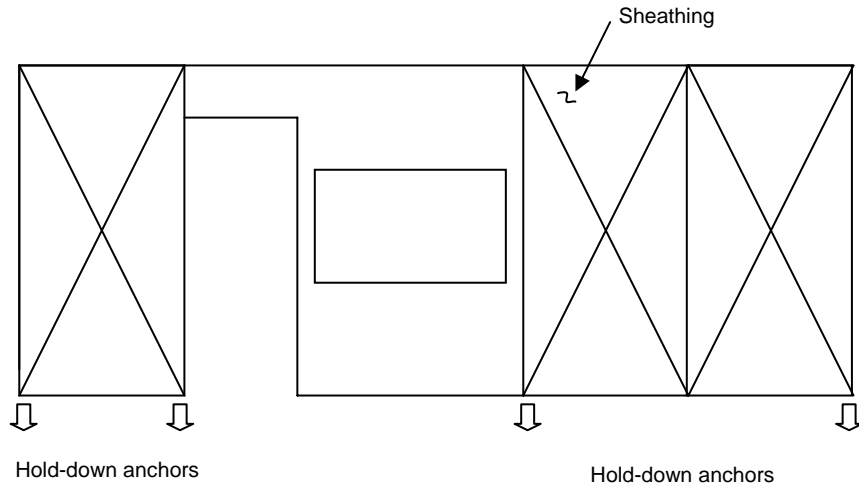


Figure 6. Type I (Solid) Shearwall (Sputo and Turner, 2006)

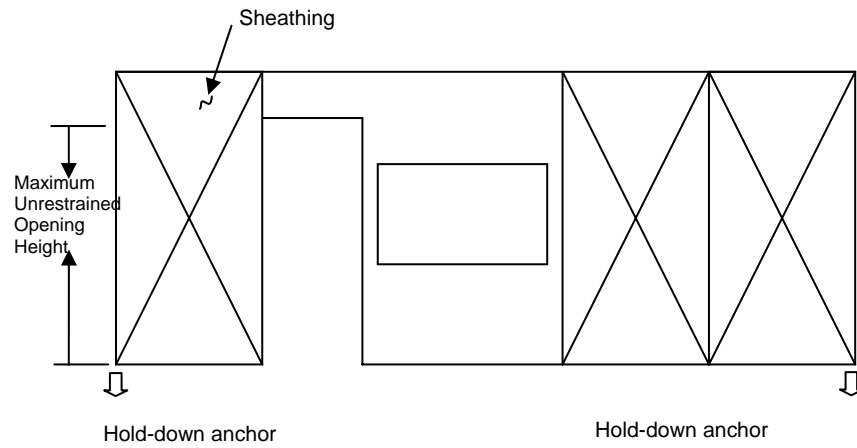


Figure 7. Type II (Perforated) Shearwall (Sputo and Turner, 2006)
Chapter 3 - Cold-Formed Steel in Metal Building Systems

Cold-formed steel members and assemblies are major components of most metal building systems (also referred to as pre-engineered metal buildings). Cold-formed steel elements are typically composed of secondary framing (purlins and girts), wall and roof sheathing, and often in the endwall framing. Occasionally cold-formed steel members are found in the primary framing of short span buildings.

The most commonly used sections are C and Z sections, typically with equal, parallel flanges, however sections with nonparallel and unequal flanges are sometimes used for eave struts and strut-purlins (Figure 8). The design of these members is governed by the *North American Specification for the Design of Cold-Formed Steel Structural Members* (AISI 2004). The *Specification* provides design requirements for several common bracing applications found in metal buildings. Although most consulting engineers will not design these elements, occasionally they will be tasked with modifying existing metal building systems, therefore having a working understanding of the bracing requirements for the cold-formed steel components is useful.

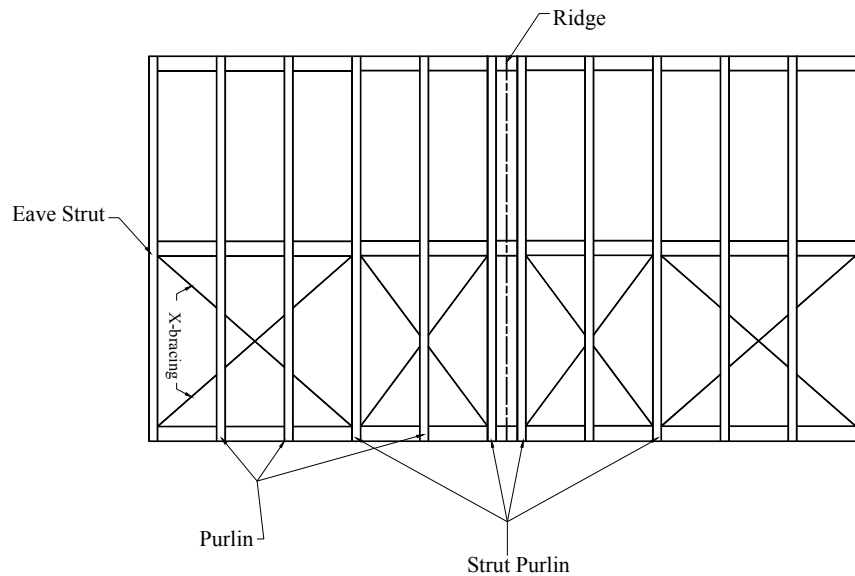


Figure 8. Roof Framing with Strut-Purlins Indicated (Sputo and Turner, 2006)
Chapter 4 - Miscellaneous Cold-Formed Steel Elements and Systems

Industrial rack systems and cold-formed steel diaphragms are structural elements and systems that structural engineers may encounter at some point in their careers. While industrial racks are somewhat specialized in their design and not usually designed by the typical consulting engineer, steel diaphragms are utilized as bracing elements in many steel structures, both hot-rolled and cold-formed.

Chapter 5 – Summary

A summary of design practices is provided.

Appendix A – Unit Conversions

A unit conversion table was placed in Appendix A to allow the user to convert from US Customary units used in the guide to SI units.

Appendix B – Design Examples

Ten design examples are provided to assist the design engineer in designing many of the different bracing systems referred to in the guide.

1. Face Mounted Strap for Mechanically Braced Axially Loaded Studs (ASD)
2. Through-the-Punchout Bridging Design for Mechanically Braced Curtain-wall Studs (ASD)
3. Through-the-Punchout Bridging Design for Axially Loaded Studs (ASD)
4. Shearwall Design (Type I)
5. Shearwall Design (Type II)
6. Drag Strut and Truss Blocking Design
7. Construction Bracing for Cold-Formed Steel Roof Truss
8. Anchorage Forces in Roof Purlin System
9. Tension Flange of Roof Purlin Braced by Sheathing
10. Purlin with One Flange Fastened to Sheathing – Strut – Purlin

Appendix C - *Lateral Bracing of Columns and Beams* by George Winter (Winter 1958)

Lateral Bracing of Columns and Beams by George Winter (1958) was included in this guide for easy reference. This paper is used as the basis for many bracing provisions in modern design codes.

Appendix D – Industry Organizations

Several industry organizations are listed as sources of additional information.

Appendix E - References

Appendix E is a list of the references referred to in the guide.

Conclusion

The guide discusses current industry practice for bracing of cold-formed steel structural members and structural assemblies within the framework of providing practical design guidance to practicing engineers. Hopefully this guide will assist the practicing engineer to develop an appreciation of bracing design.

Appendix. – References

- American Iron and Steel Institute (AISI). (2004). *North American Specification for the Design of Cold-Formed Steel Structural Members 2001 Edition with Supplement 2004 (AISI/COFS/NASPEC 2004) and Commentary (AISI/COFS/NASPEC 2004)*, Washington DC.
- Sputo, T. and Turner, J. (2006) *Bracing Cold-Formed Steel Structures: A Design Guide*, ASCE, Reston, VA.
- Winter, G. (1958). “Lateral Bracing of Columns and Beams.” *Journal of the Structural Division*, ASCE, Vol. 84, No. ST2, March, 1561-1 – 1561-22.

