Bracing Cold-Formed Steel Structures
A Design Guide

ASCE

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Preface

For many practicing structural engineers, the design of structures using cold-formed steel is seen as a daunting task. The goal of this report is to remove some of the perceived mystery by providing readily useful information for bracing cold-formed steel structures. This report 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.

Bracing is one key to good structural design. Whether we as engineers acknowledge the fact or not, the underlying basis of steel design, for both hot-rolled and cold-formed steel structures, is the control of instability. Although little can be done to control local instabilities in a cross section, global instability of a member or an entire structure can be controlled by the proper design and implementation of adequate bracing. While structural engineers have long understood the need to provide adequate bracing, the 3rd edition of the American Institute of Steel Construction *Load and Resistance Factor Design Specification for Structural Steel Buildings* (AISC 1999) only recently included design requirements for the bracing itself. The applicable specification for cold-formed steel, the American Iron and Steel Institute *North American Specification for the Design of Cold-Formed Steel Structural Members, 2001 Edition with Supplement 2004* (AISI 2004c), however, provides little in the way of general provisions.

This report 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. This report 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.

Fortunately, over the past decade, professional and industry organizations, including the Light Gauge Steel Engineers Association (LGSEA), the Steel Stud Manufacturers Association (SSMA), and the American Iron and Steel Institute (AISI) among others, have made available design publications and computer software that make design less onerous for the typical practicing engineer in consulting practice. This report makes ready reference to many of these readily available sources of information, and the reader is encouraged to study these primary sources of information in greater depth.

The authors of this report gratefully acknowledge the assistance of the members of the ASCE-SEI Committee on Cold-Formed Steel in preparing this report. Many other individuals also contributed ideas that are included in this report. Their help was likewise invaluable. Several organizations, including the American Iron and Steel Institute, the Steel Framing Alliance, the Steel Stud Manufacturers Association, and the Light Gauge Steel Engineers Association likewise contributed their expertise. The cooperation of the Department of Civil and Coastal Engineering at the University of Florida, where the first author is a part-time lecturer and the second author was a graduate student while this report was being written, is also acknowledged.

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The authors hope that this report will contribute in some small way to the furtherance of the structural engineering professions goal of creating safer, more economical structures.

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Chapter 1. Introduction to Bracing Design

1.1 General Information

While structural engineers have designed bracing elements into their structures for centuries, it is only over the past fifty years that a developing awareness of the means and methods for properly proportioning that bracing has developed. Winter (1958) published what is considered by many to be the seminal paper on bracing theory. Derivatives from that paper have formed the basis for most current theories, guidelines, and specification provisions for the design of bracing elements in current structural and cold-formed steel practices.

The 1999 *Load and Resistance Factor Design Specification for Structural Steel Buildings* (AISC 1999) was the first North American steel design specification to provide comprehensive general design provisions for the strength and stiffness requirements for bracing elements. The current cold-formed steel design specification, the *North American Specification for the Design of Cold-Formed Steel Members* (AISI 2004c) contains design requirements for several specific cold-formed steel assemblies, as have previous American Iron and Steel Institute Specifications (AISI 1986, 1991, 1996), and Canadian Standards Association S136 Specification (CSA 1994). Whereas the 1999 AISC-LRFD specification currently provides general guidance which may be utilized in nearly any situation encountered by a practicing design engineer, the AISI and CSA specifications only provide guidance which is limited to specific situations, leaving the designer to their own resources for bracing situations and conditions not specifically covered by these specifications.

When a designer of a cold-formed steel structure or element determines that bracing is appropriate or required for a particular application, but the applicable design specification is silent as to how to proportion that bracing, how are they to proceed? Current design practice has adapted to this void, utilizing designs developed from first principles of mechanics, modifications of existing procedures for similar hot-rolled or cold-formed steel assemblies, or past experience, "engineering common sense", or empiricism.

This monograph seeks to look at current North American practice related to the design of bracing for cold-formed steel elements and structures; to report on the methods of implementation of existing specification requirements; and to report on how current practice has filled the void where specific specification guidance is lacking.

1.2 Categorization of Bracing

Braces may be categorized by function, by performance criteria, or by method of interaction between braced points. These categories exist for defining usage of the brace system, however, they are not mutually exclusive. A brace may perform multiple functions under multiple loading situations, or even under a single load condition.

1.2.1 Function: Stability, Strength, and Serviceability

For purposes of determining required strength and stiffness, braces may be categorized relative to the function that the brace serves in the structure. The function of a single brace may change under different loading conditions, and a single brace may serve multiple purposes.

1.2.1.1 Stability

Stability bracing serves to ensure the stability, or resistance to buckling, of an individual member or the entire structure. When applied to an individual member, this bracing is typically designed to ensure that a particular member buckles in a higher buckling "mode." For instance, a functioning mid-point brace in an elastic column will serve to reduce the unbraced length by 50%, thereby increasing the buckling resistance by 400%. An example of this type of bracing in cold-formed steel structures is weak-axis longitudinal bracing of axially loaded steel studs by either flat straps on the stud flanges (Figure 1-1), or cold-rolled channels through the stud webs (Figure 1-2), or continuous sheathing attached to the stud flanges.

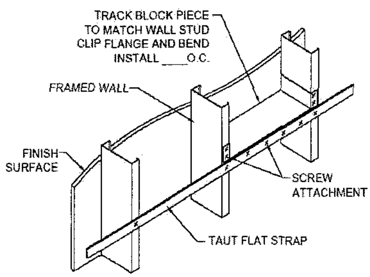

Figure 1-1 Single Flat Strap with Bracing (SSMA 2000a)

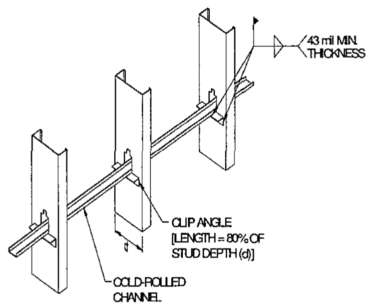

Figure 1-2 Cold-Rolled Channel with Clip Angle (SSMA 2000a)

Stability bracing can also provide for the global stability of the entire structure. The longitudinal forces that develop in the aforementioned stud bracing must be resolved out of the structure to ensure that the entire line of studs does not buckle laterally as an entire unit. These forces may be resolved using X-Bracing straps (Figure 1-3) or sheathed shearwalls.

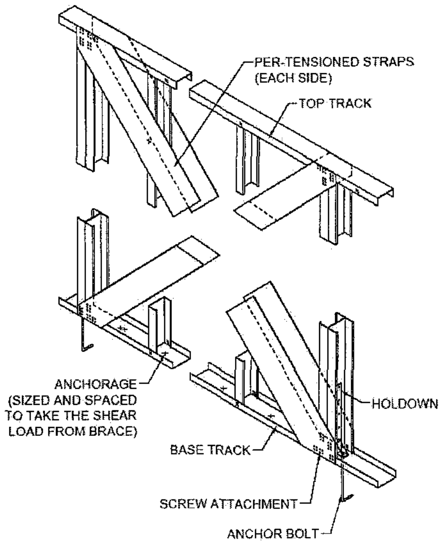

Figure 1-3 Shearwall X- Bracing (SSMA 2000a)

1.2.1.2 Strength

Whereas stability bracing is designed to resist the effects of forces that develop internal to a structure, strength bracing exists to resist the effects of externally applied forces, such as lateral load effects due to wind and seismic events. Man-made causes of lateral loads include equipment impact and non-symmetric or eccentric loading. Shearwalls in steel stud bearing walls are one example of strength bracing required to resist lateral loads due to wind or earthquake. Another example is metal building roof purlin bracing (Figure 1-4) which is designed to resist anchorage forces which develop in roof systems. Both examples will be discussed further in Chapters 2 and 3.