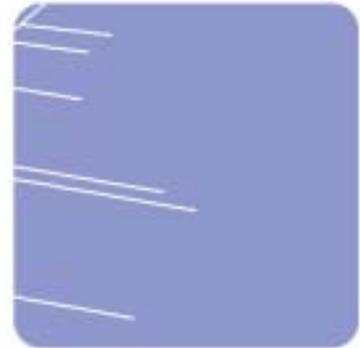
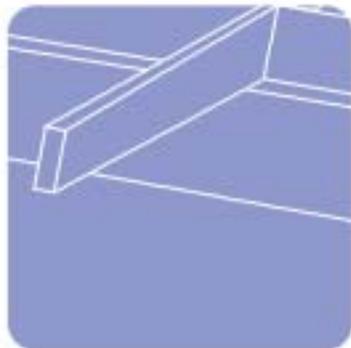
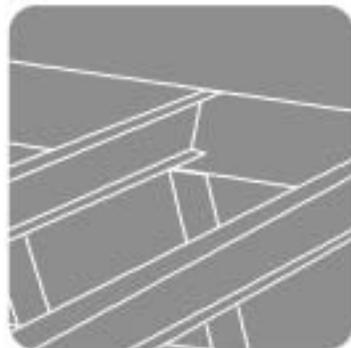




Hybrid Wood and Steel Details- Builder's Guide



PATH (Partnership for Advancing Technology in Housing) is a private/public effort to develop, demonstrate, and gain widespread market acceptance for the "Next Generation" of American housing. Through the use of new or innovative technologies, the goal of PATH is to improve quality, durability, environmental efficiency, and affordability of tomorrow's homes.

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Hybrid Wood and Steel Details- Builder's Guide

Prepared for:

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Office of Policy Development and Research
Washington, D.C.**

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The NAHB Research Center, the U.S. Department of Housing and Urban Development (HUD), and the Steel Framing Alliance have worked cooperatively to introduce cold-formed steel framing into the residential construction market and to provide builders and homeowners with a cost-effective alternative construction material. To this end, the above organizations have addressed several barriers to the widespread use of cold-formed steel framing. However, one remaining barrier is the lack of hybrid construction details giving builders the option of using steel or wood as appropriate.

In response, HUD and the Steel Framing Alliance commissioned the NAHB Research Center to review existing details and develop a comprehensive list of hybrid wood and steel connection details. Details lacking engineering data were tested and the results incorporated into this Builder's Guide.

By providing builders and framers with the necessary tools to construct hybrid wood and steel homes economically, HUD enhances housing affordability and quality through competition from new methods and materials.



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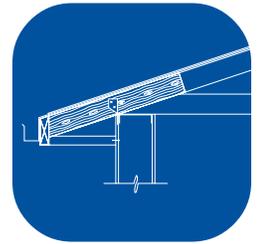
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Executive Summary

Cold-formed steel has been widely used in commercial buildings, especially in non-load-bearing (partitions) and curtain wall applications. In both commercial and residential construction, cold-formed steel sections are increasingly finding use as primary structural members, such as beams, floor joists, roof trusses, and load-bearing walls.

Despite the availability of cold-formed steel framing, some basic barriers still impede the material's adoption in the residential market. In particular, the building industry is generally reluctant to adopt alternative building methods and materials unless they exhibit clear quality or performance advantages. Therefore, builders tend to use alternative materials where they make the most sense. Currently, there is no single document that builders can use to construct hybrid cold-formed steel and wood homes. The available information and details for steel and wood hybrid structures are dispersed and not readily accessible to builders.

This report shows existing hybrid details and presents new details that are needed for builders who choose to use steel in a wood-framed building or wood in a steel-framed building.

This document starts by providing an introduction to cold-formed steel framing construction methods and fastening techniques. It then provides a comprehensive list of details with tables and engineering data where required and available.



1 Introduction

With increasing demands for improvements in standards of construction quality, comfort, and performance in housing, the residential construction market in the United States is constantly looking for new and improved methods for constructing residential buildings. Certain components of cold-formed steel framing can be considered among today's new and improved construction methods.

Cold-formed steel framing has been gaining popularity in certain regions of the country, especially after the introduction of the *Prescriptive Method* [1], the standardization of steel members, and the adoption of steel provisions in the *CABO One- and Two-Family Dwelling Code* [2] and the *International Residential Code* [3]. Building codes and industry literature, however, contain provisions and guidance for wood-to-wood and steel-to-steel connections. Lack of hybrid connection details hinders the efforts of home builders who are trying to transition from conventional framing materials to hybrid uses of wood and steel. Integrating wood and steel and developing needed connection details will further expand the use of steel in the residential market, thus enabling builders to choose their preferred material.

The materials set forth herein are for general information only. They are not a substitute for competent professional assistance. Application of the information to a specific project or setting should be reviewed by a qualified individual. The authors believe that the information contained in this publication substantially represents industry practice and related scientific and technical information, but the information is not intended to represent the official position of any organization or to restrict or exclude any other construction or design technique.

This report focuses on residential construction; however, most details can be used in light commercial applications, as the two markets possess similar characteristics.

Note that references made to other publications are in brackets [] throughout the body of this publication. All references can be found in Chapter 6.



2 General

2.1 Purpose

The purpose of this document is to provide connection details and prescriptive tables (when available) for the connection of cold-formed steel framing members and assemblies to wood framing members and assemblies.

2.2 Approach

The connection details and prescriptive tables were primarily derived from the American Iron and Steel Institute's (ANSI) *Prescriptive Method* [1], the ASCE *Minimum Design Loads for Buildings and other Structures* [4], and building code provisions.

The details and provisions contained in this publication are intended to represent sound engineering and construction practice, taking into account the need for practical and affordable construction techniques for residential buildings. This publication is not intended to restrict the use of either sound engineering judgment or exact engineering analysis of specific applications.

2.3 Scope

The provisions of this publication apply to the construction of detached one- and two-family dwellings, townhouses, and other attached single-family dwellings in compliance with the general limitations of Table 2.1. The limitations are intended to define the appropriate use of this publication for most one- and two-family dwellings.

The provisions of this document can be used for framing elements or components that meet the applicability limits of Table 2.1 but located in buildings that do not meet all the requirements of Table 2.1 provided that the nonconforming limits do not impact such framing element or component.

The provisions of this document can also be extended to buildings and components of buildings that do not meet the applicability of Table 2.1 and for other types of buildings (other than residential buildings) provided that each provision is carefully reviewed by competent individual(s) to ensure its applicability.

Using cold-formed steel and wood components with other construction materials in a single structure shall be in accordance with the applicable building code requirements for that material, the general limitations of Table 2.1, and the relevant provisions of this publication. An approved design shall be required for applications that do not meet the limitations of Table 2.1.



Table 2.1–Applicability Limits

ATTRIBUTE	MAXIMUM LIMITATIONS
General	
Building Dimensions	40 feet (12.2 m) maximum width ¹ 60 feet (18 m) maximum length ²
Number of Stories	2 stories above grade with a basement
Basic Wind Speed (3-second gust)	Up to 130 mph (209 km/hr) ³
Wind Exposure	Exposure C (open terrain) Exposures A/B (suburban/wooded)
Ground Snow Load	70 psf (3.4 kPa)
Seismic Design Category	A, B, C, D ₁ , and D ₂ (seismic zones 0, 1, 2, 3, and 4)
Floors	
Floor Dead Load	10 psf (0.48 kPa)
First-Floor Live Load	40 psf (1.9 kPa)
Second-Floor Live Load (sleeping rooms)	30 psf (1.4 kPa)
Cantilever	24 inches (610 mm) maximum
Walls	
Wall Dead Load	10 psf (0.48 kPa)
Structural Wall Height	10 feet (3 m)
Roofs	
Roof and Ceiling Dead Load	12 psf (0.58 kPa)
Ground Snow Load	70 psf (3.4 kPa)
Roof Live Load	16 psf (0.77 kPa) minimum
Ceiling Dead Load	5 psf (0.24 kPa)
Roof Slope (pitch)	3:12 to 12:12
Rake Overhang	12 inches (305 mm)
Soffit Overhang	24 inches (610 mm)
Attic Live Load (for attics with limited storage)	20 psf (0.96 kPa)
Attic Live Load (for attics without storage)	10 psf (0.48 kPa)

For SI: 1 inch = 25.4 mm, 1 psf = 47.88 Pa, 1 mph = 1.609 km/hr = 0.447 m/sec, 1 foot = 0.3 m.

¹Building width is in the direction of horizontal framing members supported by the wall studs.

²Building length is in the direction perpendicular to floor joists, ceiling joists, or roof trusses.

³To convert to fastest-mile wind speed, refer to Table 2.2.

Table 2.2–Equivalent Basic Wind Speeds (mph)¹

Fastest mile	70	75	80	85	90	100	110
3-second gust	85	90	100	105	110	120	130

For SI: 1 mph = 1.609 km/hr = 0.447 m/sec.

¹Linear interpolation is permitted.



3.1 Cold-Formed Steel Framing

Light steel framing is now used successfully for housing in many countries (such as Canada, Australia, Japan, Korea, and the United States). In the United States approximately 1 percent of new housing starts are cold-formed steel (CFS) [5]. CFS is also used for applications such as fire separation walls within hot rolled steel-framed apartment and commercial buildings.

CFS framing is a term commonly used to refer to cold-formed steel members with minimum uncoated thicknesses ranging from 0.033 to 0.118 inches (0.84 to 3.00 mm) that are produced by press braking or roll forming. These members may be wall studs, track, floor joists, roof rafters,

bridging channels, furring channels, or related accessories (see Figure 3.1). Also included are nonstructural drywall studs that have a steel thickness ranging from 0.018 to 0.033 inches (0.46 to 0.84 mm). CFS construction can use individual steel components or prefabricated panels that are assembled on site by using self-tapping screws to create a whole building structure.

The Steel Framing Alliance, in cooperation with HUD and the NAHB Research Center, has standardized the residential steel framing members and produced a prescriptive approach to residential cold-formed steel framing [1]. This prescriptive approach was later adopted by U.S. building codes, including the 1995 CABO *One- and Two-Family Dwelling Code* [2], the 1998 *International One and Two Family Dwelling Code* [6], and the *International Residential Code* (2000 IRC) [3].

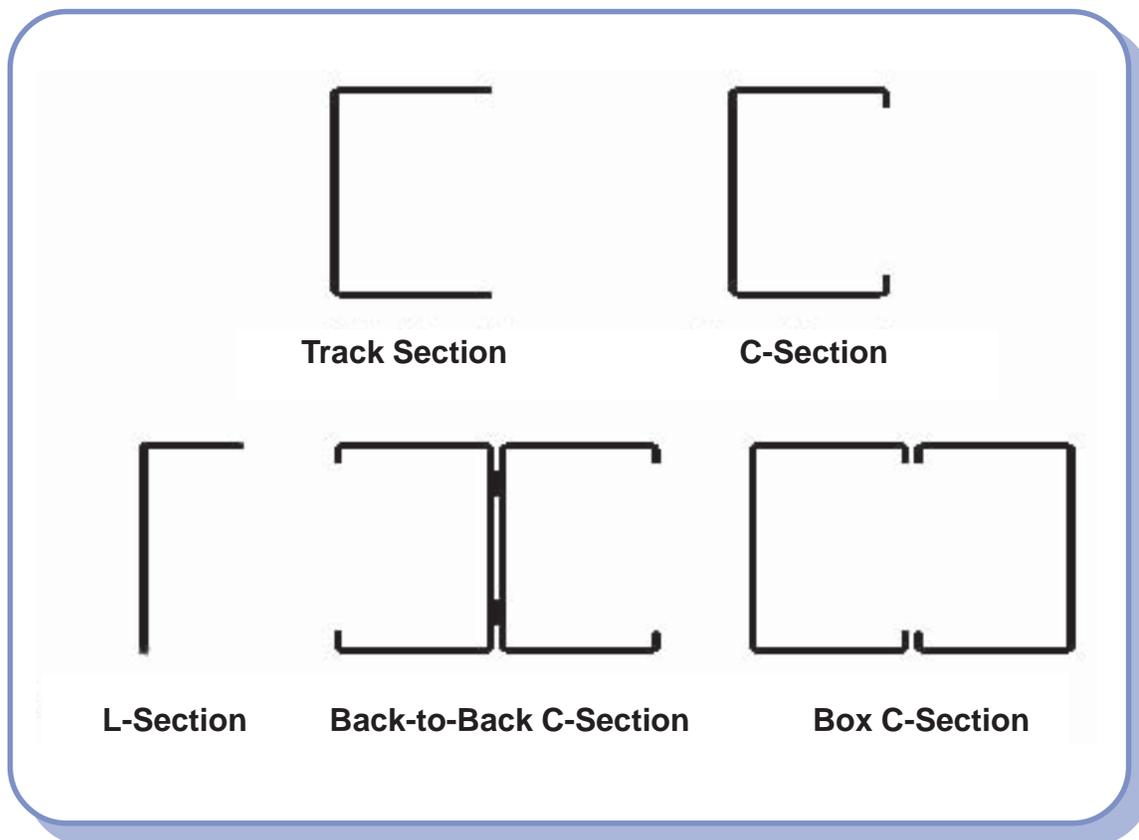
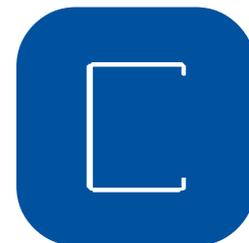


Figure 3.1—Typical Cold-Formed Steel Sections



3 Materials

3.1.1 Member Designation

The *Standard for Cold-Formed Steel Framing—General Provisions* [7] is the standard designator for identifying cold-formed steel framing members. The intent of the provisions was to overcome the varied designation approaches produced by individual manufacturers. In addition, the designation is used to identify not only a specific steel framing member but also to identify the section properties of that same member.

The use of the gauge number when ordering or specifying sheet steel thickness is an obsolete concept. Table 3.1 provides the correlation between the gauge number and the new mil designation thickness. Figures 3.2, 3.3, and 3.4 illustrate the use of the designation system. Table 3.2 provides correlations between the nominal member size that is typically used by builders and the designation system adopted by the steel industry.

Table 3.1—Correlation between Gauge Number and Mil Designation

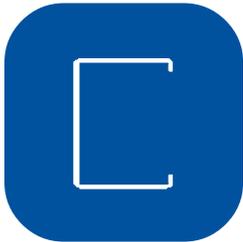
Designation (mils)	Minimum Uncoated Thickness (inch)	Design Thickness (inch)	Reference Gauge Number	Application	Color Code (painted on ends)
18	0.018	0.0188	25	Nonstructural	None
27	0.027	0.0283	22		Black
30	0.030	0.0931	20	Nonstructural	Pink
33	0.033	0.0346	20	Structural	White
43	0.043	0.0451	18		Yellow
54	0.054	0.0566	16		Green
68	0.068	0.0713	14		Orange
97	0.097	0.1017	12		Red
118	0.118	0.1242	10		

For SI: 1 inch = 25.4 mm.

Table 3.2—Correlation between Nominal Member Size and Member Designation

Nominal Member Size	Member Designation				
	20 Gauge	18 Gauge	16 Gauge	14 Gauge	12 Gauge
2x4	350S162-33	350S162-43	350S162-54	350S162-68	350S162-97
2x6	550S162-33	550S162-43	550S162-54	550S162-68	550S162-97
2x8	800S162-33	800S162-43	800S162-54	800S162-68	800S162-97
2x10	1000S162-33	1000S162-43	1000S162-54	1000S162-68	1000S162-97
2x12	1200S162-33	1200S162-43	1200S162-54	1200S162-68	1200S162-97

For SI: 1 inch = 25.4 mm.



3 Materials



Figure 3.2—Standard Designation Illustration—Stud

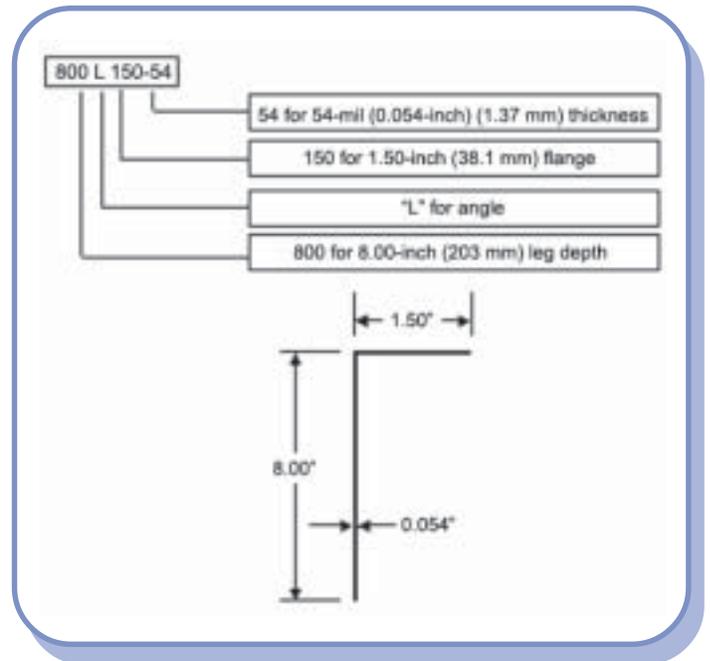


Figure 3.3—Standard Designation Illustration—Angle

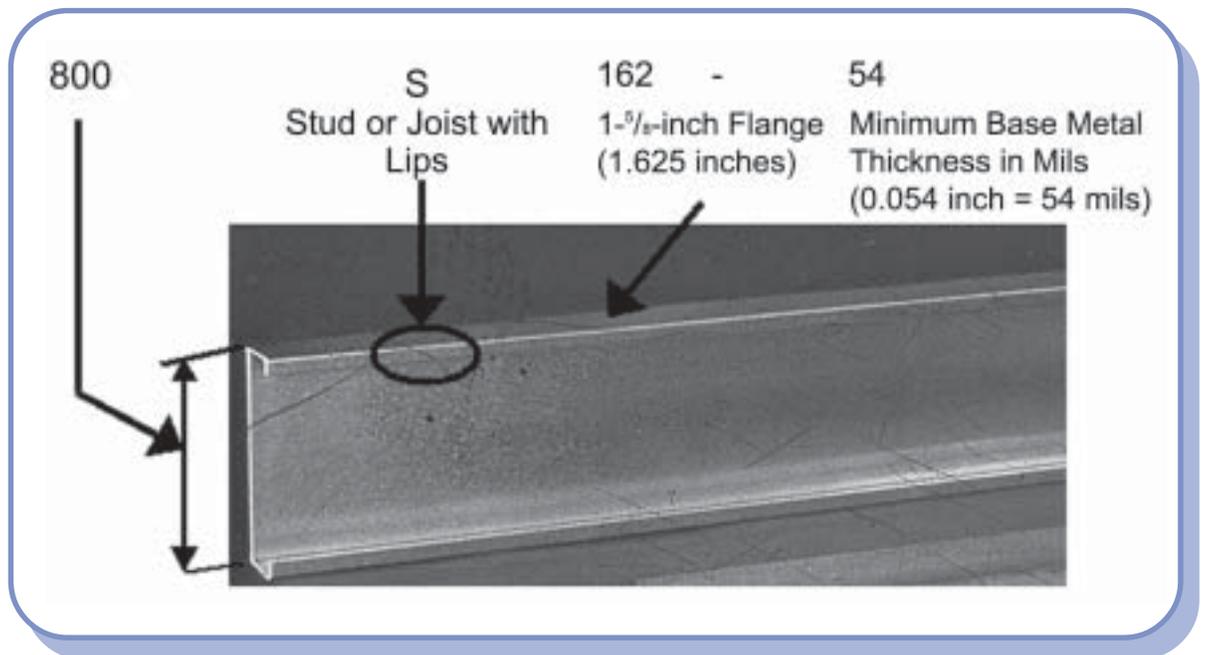
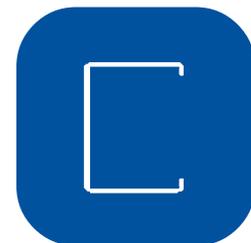


Figure 3.4—Standard Designation Illustration—Joist



3 Materials

3.1.2 Corrosion Protection

Homeowners expect their homes to last for a lifetime or longer. Therefore, it is critical that framing materials have the proper protection to provide expected longevity. With steel, the proper protection comes in the form of galvanizing. Galvanizing is the process whereby steel is immersed into a bath of molten zinc to form a zinc coating.

Before being rolled into coils, steel sheets are generally sent through a hot-dipped galvanizing process that applies a metallic zinc coating to protect the steel from rust. Therefore, coated steel is designed not to rust while on the construction job site, during construction, or after construction. A protective barrier (i.e., zinc) on the surface that does not allow moisture to contact the steel prevents corrosion of steel framing members. Zinc galvanizing protects the steel by acting as a sacrificial coating and provides long-term integrity against rusting. If steel is scratched, dented, cut, or punched, the coating will continue to protect the exposed area sacrificially. The zinc expands across the exposed steel and reseals the protective barrier.

The galvanizing process can apply a number of different coatings that vary in appearance and coating thickness. Three different types of coatings are commercially available for cold-formed steel:

Galvanized. This is the standard process of continuous coating with pure zinc. The finished coating provides good corrosion resistance and excellent sacrificial protection.

Galfan. This coating contains aluminum in addition to zinc. It has an improved corrosion resistance compared with galvanized coatings.

Galvalume. This coating contains a higher percentage of aluminum as well as silicone added to zinc. It provides superior corrosion resistance compared with galvanized coatings.

The degree of corrosion protection is measured by the coating weight (ounces per square foot) or the thickness (mils or microns) of the coating. A G60 coating, for example, has a total weight of 0.60 oz./ft.² (0.00002 mg/cm²) (both sides) and a 0.51 mil (0.013 mm) nominal thickness per side.

The minimum metallic coating for cold-formed steel members must comply with ASTM A1003 [8]. ASTM A1003 minimum coating designations assume normal exposure

conditions that are best defined as having the framing members enclosed within a building envelope or wall assembly within a controlled environment. When severe exposure conditions are probable, as in the case of industrial atmospheres, arid regions, or marine atmospheres, consideration should be given to specifying a heavier coating.

For additional guidance on corrosion protection, refer to the following publications:

Durability of Cold-Formed Steel Framing Members [9].

Galvanizing for Corrosion Protection—A Specifier’s Guide [10].

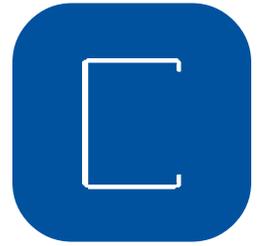
Corrosion Protection for Metal Connectors in Coastal Areas [11].

Direct contact with dissimilar metals (such as copper, brass, and so forth) should be avoided in order to prevent corrosion. To prevent corrosion, builders should use either non-conductive non-corrosive grommets at web penetrations or non-metallic brackets (a.k.a. isolators) fastened to hold the dissimilar metal building products (such as piping) away from the steel framing.

Builders should be careful in placing steel in wet or damp building materials. The potential for the materials to absorb water during the building’s life may accelerate corrosion. Table 3.3 provides the minimum corrosion protection of steel members subjected to normal exposure.

Table 3.3—Corrosion Protection

Framing Application	Coating Weight
Structural	G40
Nonstructural	G60



3 Materials

Cold-Formed Steel Contact with Wood

Metallic coated steel does not react with dry wood. Dry pressure-treated lumber is also not corrosive to zinc, and no special requirements are needed to fasten steel to wood framing. Galvanized nails and screws have been successfully used to join wood and steel for years.

3.1.3 Web Holes, Cutting, Splicing, and Patching

Web holes may also be referred to as “punchouts,” “utility holes,” “perforations,” and “web penetrations.” In structural framing members, web holes are typically 1.5 inches (38 mm) wide x 4 inches (102 mm) long and are located on the centerline of the web and are generally spaced at 24 inches (610 mm) on-center.

Coping, cutting, or notching of flanges and edge stiffeners (lips) is not permitted for load-bearing members without an approved design. Structural members may be spliced; however, splicing of studs and joists is not a common practice and is not recommended. If a structural member requires splicing, the splice connection must be installed in accordance with an approved design. Splicing of tracks is permitted. Nonconforming holes are typically patched by applying a steel plate, track, or stud section to the patch and then fastened with No. 8 screws at 1 inch (25.4 mm) on-center.

Cutting or notching of flanges and lips of structural steel members shall not be permitted without an approved design. Splicing of structural members shall not be performed without an approved design.

3.1.4 In-Line Framing

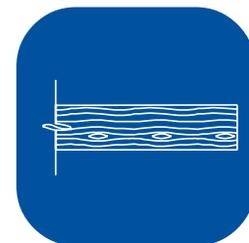
In-line framing is the preferred and most commonly used framing method. The advantage of in-line framing is that it provides a direct load path for transfer of loads from roof members all the way to the foundations. If in-line framing is not possible in structural walls, a load distribution member, such as a double wood top plate or a structural steel track, may be required for the load transfer.

Load distribution members, such as steel headers or double wood top plates, shall be used when in-line framing is not possible in structural walls.

3.1.5 Resources

There are numerous resources available from various steel industry, government, and user organizations. A few selected organizations are listed below with their web addresses:

- Steel Framing Alliance (www.steel framing alliance.com)
- Light-Gauge Steel Engineers Association (www.lgsea.com)
- Steel Stud Manufacturer's Association (www.ssma.com)
- International Iron and Steel Institute (www.worldsteel.org)
- American Iron and Steel Institute (www.steel.com)
- Partnership for Advancing Technology in Housing (www.pathnet.org)
- NAHB Research Center Toolbase Hotline (www.toolbase.org)



3 Materials

3.2 Wood Framing

Wood has been used for centuries as a building material, especially for home construction. It is the most commonly used material in the housing market in the United States. Framing members used in houses are harvested and milled from millions of available acres of forestland spread across North America. Wood is divided into two main categories—hardwood and softwood—and several subcategories and grades depending on the wood species characteristics, intended use, and the method of processing the lumber. Hardwood comes from deciduous trees (e.g., oak, maple, hickory, and so forth) while softwood comes from conifers (e.g., pine, spruce, fir, and so forth).

More than 90 percent of dimensional lumber used in North America comes from four commercial softwood species groups: Spruce-Pine-Fir, Douglas Fir-Larch, Hem-Fir, and Southern Pine. Species groups or combinations are an assemblage of species of wood that have common characteristics. Table 3.4 shows the abbreviations used for these common species groups and the lumber grade stamps. This section focuses almost exclusively on these softwood species groups because they account for a large proportion of construction applications in the United States. It also focuses on newer engineered wood products because of the products’ growing importance and use as “value-added” substitutes for traditional lumber (i.e., “solid sawn” lumber).

Table 3.4—Major Wood Species Combinations

Major Species Combinations	Canadian	U.S.
Spruce-Pine-Fir	S-P-F	S-P-F [S]
Douglas Fir-Larch	D.Fir-L [N]	D.Fir-L
Hem-Fir	Hem-Fir [N]	Hem-Fir
Southern Pine	-	SYP

This section provides an overview of the following topics related to wood framing:

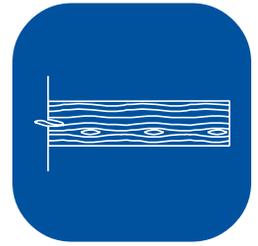
- Basic Characteristics of Wood and Lumber (Section 3.2.1)
- Lumber Applications and Sizes (Section 3.2.2)
- Grading of Lumber (Section 3.2.3)
- Engineered Wood Products (Section 3.2.4)

For an in-depth treatment of these and other topics regarding lumber products and their use, the reader is referred to the following limited selection of resources:

- *Wood Engineering Handbook* [12]
(Download: <http://www.fpl.fs.fed.us/documnts/FPLGTR/fplgtr113/fplgtr113.htm>)
- *National Design Specification (NDS) for Wood Construction* [13]
(Download: <http://www.awc.org/HelpOutreach/eCourses/STD103/NDS2001/>)
- *Residential Structural Design Guide* [14]
(Download: <http://www.huduser.org/publications/destech/residential.html>)
- *Metal Plate Connected Wood Truss Handbook* [15]
(<http://www.woodtruss.com/>)

In addition, numerous resources are available from various wood industry, government, and user organizations. A few selected organizations are listed below with their Web addresses:

- USDA Forest Products Laboratory
(www.usda-fpl.gov)
- American Wood Council
(www.awc.org)
- American Forest and Paper Association
(www.afandpa.org)
- APA—The Engineered Wood Association
(www.apawood.org)
- Wood Truss Council of America
(www.wtca.org)



3 Materials

3.2.1 Basic Characteristics of Wood and Lumber

Wood is a natural material. Therefore, its properties and behavior are as varied as the number of species, growth conditions, and other factors governing the physical characteristics of a tree (i.e., wood) or lumber (i.e., solid sawn members made from a tree). For this reason, the wood industry places much attention on managing the material's natural variability in the processing of solid sawn lumber and other wood products for a variety of end uses. The process starts with a growth management and harvesting strategy for forests that include privately and publicly held lands and resources. It ends with the final assignment of a "grade" to a milled (i.e., solid sawn) piece of lumber in accordance with various standards and practices that provide some degree of uniformity and consistency in appearance and structural properties as realized by the end user (i.e., builders and designers).

The main characteristics of an individual piece of lumber that determine its properties and behavior in end use include:

- Species
- Density
- Natural features

Species and density of wood are the primary attributes that distinguish one piece of lumber from another. For example, a given species will determine the physiological characteristics and range of wood density that can be expected for a given tree or piece of lumber. Density is important because it is strongly correlated with the strength properties of lumber. However, other factors can override this general correlation, such as knots (i.e., locations where tree limbs tie into the main stem or trunk of the tree). The overriding factors are broadly classified as natural features or "defects" in comparison to a "perfect" piece of lumber (i.e., one that is straight-grained and clear of knots). Therefore, visual grading rules for assignment of lumber structural properties are keyed to categorizing degrees of defects relative to their impact on the performance of a piece of lumber.

Wood is a plant material (i.e., cellulose) and its properties and behavior are closely tied to moisture. Therefore, moisture is also considered in the processing and end use of lumber. For example, wood shrinks and swells with changing moisture content. As a result, a piece of lumber can experience warping and splitting as it dries. In general,

lumber strength and dimensional stability depends on moisture content. For this reason, structural-use lumber is required to have a maximum moisture content of about 19 percent (i.e., cured by air drying), above this amount of moisture, decay is possible (i.e., fungal growth may be supported). In addition, given that lumber generally dries to less than 12 percent moisture content when used inside a building, excessive shrinkage can occur, causing movement of parts of a building as the lumber equilibrates to its new environment. To prevent excessive shrinkage, lumber is frequently specified as kiln-dried (i.e., designated as KD on a grade stamp) to a lower moisture content such as 15 percent or less.

3.2.2 Lumber Applications and Sizes

Lumber is divided into three main size categories based on differences in intended application:

Boards	1 to 1 ½ inches thick 2 inches and wider
Dimension Lumber	2 to 4 inches thick 2 inches wide
Timbers	5 inches and thicker 5 inches and wider

Boards are the thinnest lumber size category and are generally used for nonstructural applications such as shelving or furring. The use of boards for applications such as floor, roof, and wall sheathing has practically disappeared from practice due to the introduction and widespread adoption of wood structural panel products (e.g., plywood) in the 1950s.

Dimension lumber is commonly used for residential and light commercial framing (i.e., conventional light frame wood construction). For example, a 2x4 wood stud (wall framing), a 2x10 wood joist (floor framing), and a 2x6 rafter or 2x4 wood truss (roof framing) are all typical applications of dimension lumber. Timbers are used where larger beams or columns are required to resist heavier loads (e.g., timber frame construction, timber bridges, and so forth).

Table 3.5 provides nominal sizes of structural lumber according to intended application categories. Grades of lumber for the different categories are also shown and are discussed in the next section.

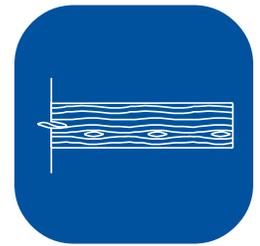


Table 3.5—Lumber Dimensions and Typical Grades by Application

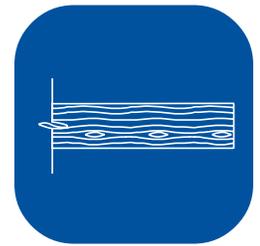
Application	Typical Grades	Nominal Dimensions		Examples
		Thickness	Width	
Light Framing	Construction Standard Utility	2 to 4 inches	2 to 4 inches	2x4, 4x4
Structural Light Framing	Select Structural 1 2 So forth	2 to 4 inches	2 to 4 inches	2x4, 4x4
Structural Joist and Plank	Select Structural 1 2 So forth	2 to 4 inches	5 inches and wider	2x6, 2x12
Stud	Stud	2 to 4 inches	2 to 6 inches	2x4, 2x6 (lengths limited to 10 feet and shorter)
Beams and Stringers	Select Structural 1 2 So forth	5 inches and thicker	More than 2 inches greater than thickness	6x10, 12x16
Posts and Timbers	Select Structural 1 2 So forth	5 inches and thicker	Not more than 2 inches greater than thickness	6x6, 6x18

For SI: 1 inch = 25.4 mm.

Lumber is generally sized according to thickness, as in the case of rough sawn lumber, or in specific widths, thicknesses, and/or lengths, as in the case of dimensional lumber. The two most commonly sizing methods are described below:

Dimension Lumber. This measuring method is probably the method most commonly recognized by the average person. Measurements of dimensional lumber refer to the “nominal” thickness and width of the lumber, which varies in nominal two-inch increments (i.e., 2 inches, 4 inches, 6 inches, and so forth). The length is an actual or minimum dimension and varies in two-foot

increments (e.g., 8 feet, 10 feet, and so forth). The nominal thickness and width dimensions are not a true measurement of the lumber thickness or width. The true measurement of a 2x4, for example, is actually about 1.5 inches by 3.5 inches (thickness by width). When the board is first rough sawn from the log, it is a true 2x4, but the drying (i.e., shrinkage) and surface finishing (i.e., planing) processes reduce it to a targeted finished actual size of 1.5 inches by 3.5 inches. However, nominal widths over 6 inches refer to actual sizes $\frac{3}{4}$ inch less than the nominal dimension. Actual thickness of dimension lumber is always $\frac{1}{2}$ inch less than the nominal dimension.



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“Quarters” Sizing Method. In the case of rough sawn lumber, the “quarters” sizing method is usually used by mills that sell rough lumber for woodworking purposes. The “quarters” method refers only to the thickness of the wood; widths and lengths vary depending on the log from which the wood is cut. Generally, a woodworker planes the boards to the desired thickness and most likely rips the boards and glues them into joined panels to achieve the desired width. Rough sawn lumber comes in “true” thicknesses as reflected by the “quarters” size. Lumber sized according to “quarters” reflects a piece of lumber’s number of quarters of an inch of thickness. To figure the thickness of a board referenced in “quarters” sizes, simply divide the second number (4) into the first number. The second number (4) means “quarters of an inch”, or “quarters.” So, a “4/4” board is four quarters, or 1 inch thick; an “8/4” board is eight quarters, or 2 inches thick; a “10/4” board is 10 quarters, or 2 1/2 inches thick; and so forth.

stress rating) of a member or other indirect electronic sensing processes are also used and have the benefit of reducing the variability of the grading process, allowing more precise assignment of structural properties. The grading process for softwood lumber is discussed in this section. Hardwood lumber is typically used for finish and furniture applications (e.g., cabinets and flooring), and its grading method is based primarily on appearance, which is not discussed in this section.

In the NDS [13], over 50 different species or species groups of wood (mostly softwoods) have published design values based on grade and size categories of lumber. Considering that some species groups include 16 or more individual species, the task of grading lumber from the many species (coupled with the variability of the material) is complex and requires careful management. Figure 3.5 shows a simplified representation of wood member classification by species group, size, and grade for visually stress-rated lumber classification.

In Figure 3.5, the first step is to organize the many different species into groups with common properties. This step requires careful statistical treatment of data on wood properties obtained from continual samples of materials from various mills across the country. The process of determining the grouping of species is also the same process by which design property values are assigned to the individual grade categories at the bottom of Figure 3.5.

3.2.3 Lumber Grades

Because visual grading of lumber is itself partly a natural process (i.e., relying on visual observation of pieces of lumber on a manufacturing line), statistical sampling and testing of “in-grade” lumber is used to determine lumber properties (i.e., design stress values) for grade classes within various species or groups of species. Alternative grading methods that rely on “proof loading” (i.e., machine

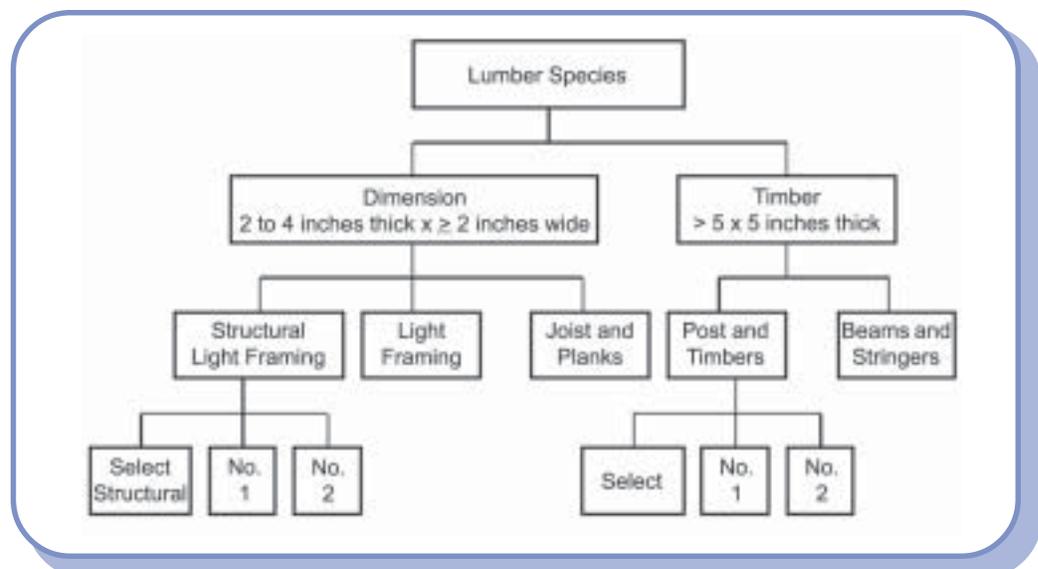
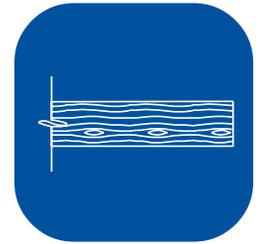


Figure 3.5–Lumber Classification



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The daunting task of administering the lumber grading process is the responsibility of many different organizations and grading associations that generally have some allegiance to a particular species or species group of wood. Several of the organizations are listed below:

- Northeastern Lumber Manufacturers Association (NELMA)
- Northwood Softwood Lumber Bureau (NSLB)
- Redwood Inspection Service (RIS)
- Southern Pine Inspection Bureau (SPIB)
- West Coast Lumber Inspection Bureau (WCLIB)
- Western Wood Products Association (WWPA)
- National Lumber Grades Authority (NLGA)
- California Redwood Association (CRA)

Softwood lumber in the United States is most typically graded according to the guidelines of the American Softwood Lumber Standard PS 20-70 [16], established by the U.S. Department of Commerce. Canadian softwood lumber imported into the United States is graded by inspection agencies in Canada that also adhere to the American Softwood Lumber Standard. Softwood lumber intended for general construction purposes may be subdivided into three categories as shown in Table 3.6.

Softwood lumber has traditionally been graded by visual inspection. The grade of a given piece of lumber is based on visual observation of characteristics such as slope of grain and the location of knots. Most softwood lumber is assigned

either an appearance grade or a structural grade based on visual review by a lumber grader who is an integral part of the lumber manufacturing process. Lumber graders are trained to assign a strength grade to lumber based on appearance criteria such as the presence of wane (bark remnant on the outer edge); the presence, size, and location of knots; the slope of the grain relative to the long axis; and several others. Table 3.7 shows a sample of a few of the criteria used to assess grade for a 2x4 as structural light framing or structural joist and plank.

Dimension lumber is generally grade stamped about 24 inches (600mm) from one end of each piece so that the stamp will be clearly visible during construction. (Specialty items such as lumber manufactured for millwork or for decorative purposes are seldom marked.) The stamp is applied to indicate the assigned grade, the mill of origin, the green or dry moisture content at time of manufacture, the species or species group, the grading authority with jurisdiction over the mill of origin, and applicable grading standards (see Figure 3.6).

Table 3.8 shows some common grades of dimensional lumber.

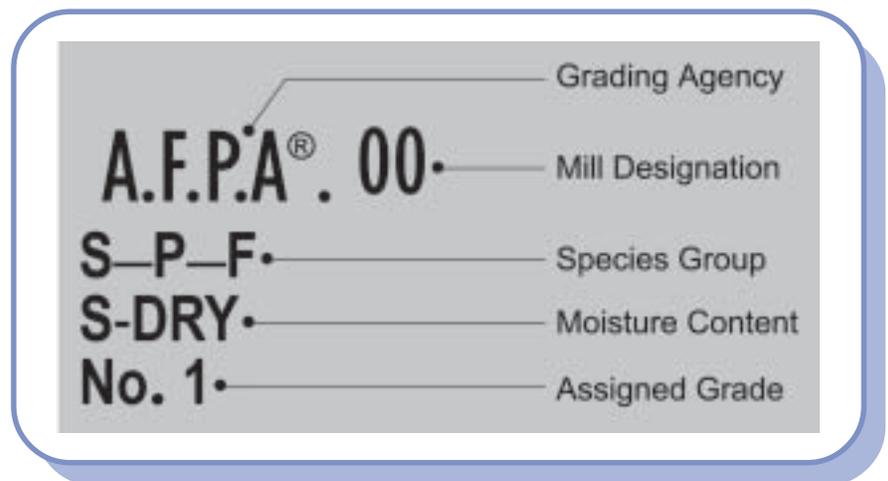
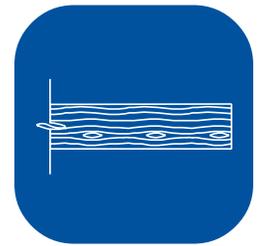


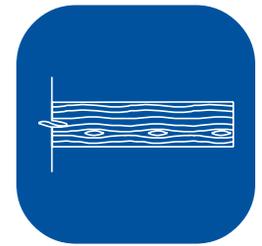
Figure 3.6–Dimension Lumber Stamp Grade



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Table 3.6—Construction Lumber Categories (Softwood)

Construction Lumber Category	Description
Stress-Graded Lumber	<ul style="list-style-type: none"> The structural integrity of the wood is the primary requirement in the grading process.
	<ul style="list-style-type: none"> The category includes most softwood lumber that is nominally 2 to 4 inches thick, referred to as “dimension” lumber. Examples include posts, beams, decking, studs, rafters, joists, timbers, and other structural lumber.
	<ul style="list-style-type: none"> Stress ratings may be determined either visually or mechanically to derive working values for properties such as bending stress and modulus of elasticity (E).
	<ul style="list-style-type: none"> Dimension stock is carried in nominal 2-, 4-, 6-, 8-, 10-, and 12-inch widths and 8- to 18-foot lengths in multiples of 2 feet.
Non-Stress-Graded Lumber	<ul style="list-style-type: none"> The structural integrity of the wood is the primary requirement in the grading process. Pieces are graded primarily for serviceability but appearance is also considered, especially in the higher grades.
	<ul style="list-style-type: none"> Imperfections such as knots and knotholes are allowed to become larger and more frequent as the grade drops.
	<ul style="list-style-type: none"> The primary product is boards that are less than 2 inches in nominal thickness and 2 inches or more in nominal width.
	<ul style="list-style-type: none"> The standard 3/4-inch-thick board found in retail lumberyards is an example familiar to most woodworkers.
	<ul style="list-style-type: none"> Common nominal widths are 2, 3, 4, 6, 8, 10, and 12 inches. Lengths are usually from 6 to 18 feet in increments of 2 feet.
	<ul style="list-style-type: none"> In descending order of quality, the grades are No. 1 (Construction), No. 2 (Standard), No. 3 (Utility), No. 4, and No. 5. The first three grades are most commonly available in retail lumberyards.
Appearance Lumber	<ul style="list-style-type: none"> The appearance or visual quality of a piece of lumber is most important, and structural integrity is of secondary importance.
	<ul style="list-style-type: none"> Boards in this category will be of most use to the woodworker interested in making high-quality softwood furniture with a natural finish.
	<ul style="list-style-type: none"> The group includes most softwood lumber used for trim, siding, shingles, flooring, casing, base, stepping, and paneling.
	<ul style="list-style-type: none"> The highest grade of appearance lumber is Finish. It is subdivided into grades composed of letters or combinations of letters (B&BTR, C, D) or names such as Superior or Prime, depending on the grading agency. The next level down is Selects, which has grade designations composed of numbers, letters, and names of combinations (B&BTR, C Select, D Select).



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Table 3.7—Criteria Used in Grading Dimension Lumber

Lumber Grade	Description
Clear	<ul style="list-style-type: none"> • Free of knots and imperfections; furniture-grade lumber. • Probably dried to 6 to 8 percent humidity range. Most stable in humid conditions. • Decidedly more expensive than No. 1 grade.
Select or Select Structural	<ul style="list-style-type: none"> • High-quality wood; broken down into No. 1, No. 2, and No. 3 or A, B, C, and D; lower grades have more knots.
No. 1 Common	<ul style="list-style-type: none"> • Fewer knots, usually small. • Few imperfections. • Dried to a range of less than 19 percent humidity. • Stronger than No. 2 grade. • Slightly more expensive.
No. 2 Common	<ul style="list-style-type: none"> • Has tight knots and no major blemishes. • Minor imperfections. • Dried to a range of less than 19 percent humidity. • Stable in areas of normal ranges of humidity. Good for shelving.
No. 3 Common	<ul style="list-style-type: none"> • Some knots may be loose; often blemished or damaged.
Construction or Standard	<ul style="list-style-type: none"> • Good strength; used for general framing.
Utility	<ul style="list-style-type: none"> • Economy grade used for rough framing.

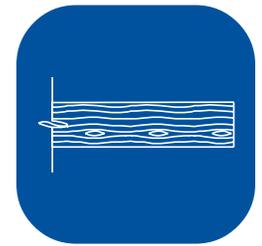
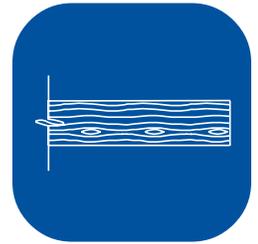


Table 3.8—Lumber Grades

Lumber Grade	Description	
Common Lumber		
No. 1 (Construction)	Moderate-sized tight knots. Paints well. Used for siding, cornice, shelving, paneling, and some furniture.	
No. 2 (Standard)	Knots larger and more numerous. Paints fair. Similar uses as No. 1.	
No. 3 (Utility)	Splits and knotholes present. Does not take paint well. Used for crates, sheathing, subflooring, and small furniture parts.	
No. 4 (Economy)	Numerous splits and knotholes. Large waste areas. Does not take paint well. Used for sheathing, subflooring, and concrete formwork.	
No. 5 (Economy)	Larger waste areas and coarser defects. Unpaintable. Applications are similar to No. 5.	
Select Appearance Lumber Grades		
A Select	No knots, splits, or other visible defects. Used for fine furniture, exposed cabinetry, trim, and flooring.	
B Select	A few small defects but nearly perfect. Used for fine furniture, exposed cabinetry, trim, and flooring.	
C Select	Small tight knots. May be nearly perfect on one side. Used for most furniture, shelving, some trim, and flooring.	
D Select	More numerous "pin" knots and other small blemishes. May be used for some furniture, shelving, some trim, and flooring.	
Dimension Lumber Grades		
2"x4" and Wider	2"x4"	Posts, Timber, Beams, and So Forth
Select Structural	Standard and Better (STD&BTR)	Select Structural
No. 1	Utility and Better (UTIL&BTR)	No. 1 Structural (Douglas Fir)
No. 2	STUD (10-foot maximum)	No. 1 SR (Southern Pine)
No. 3		No. 2 SR (Southern Pine)
No. 2&BTR		
No. 3&BTR		

For SI: 1 inch = 25.4 mm.



3.2.4 Engineered Wood Products

Engineered wood products are steadily increasing in popularity and are manufactured from wood fiber and glue (see Figure 3.7). They are considered a “value-added” product because they improve the efficient use of wood resources and address problems associated with the variability of lumber. They tend to be more stable (resist twisting or cupping) and can be produced in sizes much longer and wider than solid wood. Unlike dimensional lumber, which is a commodity, many engineered wood products are proprietary.

Wood Structural Panels (WSPs)

Wood structural panels dominate the wood frame construction market when it comes to sheathing for floors, walls, and roofs. However, competition with other wall sheathing products (i.e., hardboard and foam insulation) is strong. Wood structural panels include plywood and oriented strand board (OSB), which typically come in 4-foot by 8-foot (1.2 x 2.4 m) panels with thicknesses typically ranging from $\frac{3}{8}$ inch to $\frac{3}{4}$ inch (9.5 to 19 mm) for structural framing applications. Like dimension lumber, these products are usually manufactured and labeled according to voluntary standards administered by the U.S. Department of Commerce (i.e., USDOC PS-1 [17] and PS-2 standards [18]).

Wood I-Joists

Wood I-joists are engineered wood products with either flanges of solid wood or one of the manufactured engineered wood products (such as LVL) on the top and bottom of, and glued to, a vertical web of either plywood or OSB. Wood I-joists are typically used for floor joists and rafters and are available in long lengths for long spans. This product duplicates the flexural efficiency of the steel I-beam.

The wood I-joist is a lightweight, dimensionally stable, long-span secondary framing component that is predictable in performance, manufactured to close tolerances, easily transported to a site, and easily trimmed and installed by a carpentry crew. As a result, wood I-joists are now used on more than one-third of the floor area in new residential construction.

Finger-Jointed Lumber

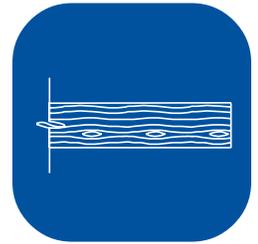
Finger-jointed lumber is dimensional lumber made up of short pieces where the ends are machined in a finger profile and glued together. Finger-jointed lumber has been in production for more than 20 years and is widely accepted throughout North America. The finger-jointing process adds environmental benefits to the lumber manufacturing process by salvaging short lengths from low-quality lumber to make long lengths of higher-grade lumber. Machining of the fingers and mixing and curing of the adhesive are required to meet strict tolerances. Finger-jointed lumber may be used interchangeably with regular lumber such as joists, studs, or rafters.

Laminated-Veneer Lumber (LVL)

Laminated-veneer lumber (LVL) is an engineered wood product produced by layering dried and graded wood veneers with waterproof adhesive into blocks of material known as billets. Cured in a heated press, LVL is typically available in various thicknesses and widths and is easily worked in the field with conventional construction tools. LVL is also known as structural composite lumber (SCL). LVL is a solid, highly predictable, and uniform engineered wood product that is sawn to consistent sizes and is virtually free from warping and splitting. LVL is used primarily as structural framing for residential and commercial construction. It is typically designed for use as floor and roof beams, headers, valley rafters, scaffold planking, and the flange material for prefabricated wood I-joists. It is well suited to applications where open web steel joists and light steel beams might otherwise be considered.



Figure 3.7–Engineered Wood Products



Glue-Laminated Lumber (Glulam)

Glulam (glue-laminated timber) is a stress-rated engineered wood product comprised of wood laminations, or “lams,” that are bonded together with strong, waterproof adhesives. Glulam components can be a variety of species, and individual “lams” are typically two inches or less in thickness. The products are made by stacking, gluing, and clamping layers of dimensional lumber (with the better grades efficiently placed at the top and bottom of the beam). For example, four layers of 2x4s (laid flat) produce a glulam with a width of 3 1/2 inches and a height of 6 inches. The result is a structural member substantially stronger than a single wood member of the same size because defects in the individual members are unlikely to line up at one cross-section of the glulam member (this principle is common to most engineered wood products). Laminated timber beams (glulams) are typically used for large spans and heavy loads. Some examples of typical nominal and actual sizes are shown below:

Nominal Sizes: 4x10, 4x12, 6x10, 6x12

Actual Sizes: 3 1/2x9, 3 1/2x12, 5 1/2x9, 5 1/2x12

Laminated-Strand Lumber (LSL)

Laminated-strand lumber is an engineered lumber product made with a network of hardwood strands laminated together with a waterproof adhesive to form a single, solid stable component. Timberstrand™ is the trade name for LSL and is typically used for rim board and framing lumber such as studs.

LSL is produced from a number of different species and grades, although species and grade are not mixed in a given member. As a result, the bending strength and stiffness of these products are determined by their composition, and clear product identification is essential to match specification requirements. Given that the finished appearance may not be as appealing as an exposed member, concealed and industrial applications are favored.

Parallel-Strand Lumber (PSL)

Parallel-strand lumber is an engineered lumber product in which veneers are cut into small strips, dried, sprayed with adhesives, and then formed into billets and cured. PSLs are high-strength products with the trade name of Parallam™. The product is uniform throughout the cross-section and is resawn from the manufactured billet to an array of sizes. The varied profiles accommodate several applications, including 1 3/4-inch wide (45 mm) plies that serve as built-up headers in much the same way as does LVL. Wider widths, 2 1/2 inches, 5 1/4 inches, and 7 inches (65mm, 133mm, and 178mm), are well suited to longer-span beams and headers.

3.2.5 In-Line Framing

In-line framing is the preferred and most commonly used framing method for stick framed construction. The advantage of in-line framing is that it provides a direct load path for transfer of loads from roof members all the way to the foundations. Where in-line framing is not possible for structural walls, a double wood top plate is typically used to transfer the loads. Other load distribution members can also be used in lieu of the double wood top plate.



4 Fasteners

4.1 Introduction

The fastening of wood and steel members is typically accomplished with nails and/or screws. This chapter provides a brief description of the different fasteners used for each material and the recommended fasteners to be used to fasten the two materials together.

4.2 Steel Fastening Methods

Cold-formed steel framing members can be fastened by using any of the following fastening methods:

- Screws
- Powder-Actuated Fasteners
- Clinches
- Pneumatically Driven Pins
- Welds
- Bolts
- Rivets
- Adhesives

4.2.1 Screws

Screws are the most common fasteners used in framing cold-formed steel members (see Figure 4.1). Self-drilling, tapping screws are the most prevalent fastener. Screws are typically applied with a positive-clutch electric screw gun. Clamps (such as locking C clamps) are essential to the steel framer; they hold the steel members together during fastening.

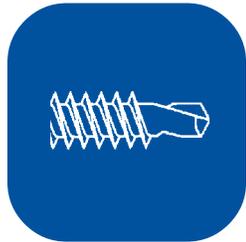
Screws are available in sizes ranging from No. 6 to No. 14, with No. 6 to No. 10 the most common. Lengths typically vary from 1/2 inch (12.7 mm) to as much as 3 inches (76 mm) depending on the application. Screws are generally 3/8 inch (9.5 mm) to 1/2 inch (12.7 mm) longer than the thickness of the connected materials so that a minimum of three threads extends beyond the connected material. For effective drilling, it is important that the drill point be as long as the material thickness to be fastened. The correct fastener type and length of each application should be selected by consulting the screw manufacturer’s specifications and catalogs.



Figure 4.1–Screws

Screw Point Type

1. Self-drilling tapping screws (see Figure 4.2) are externally threaded fasteners with the ability to drill their own hole and form or cut their own internal mating threads into which they are driven without deforming their own thread and without breaking during assembly. Self-drilling screws are high-strength, one-piece, one-side-installation fasteners. They are typically used with 33-mil (0.8 mm) steel or thicker. They are also used when fastening two or more pieces of steel of any thickness. Self-drilling point styles are listed as No. 2, No. 3, No. 4, and No. 5. The higher the number, the thicker is the material the screw is designed to drill. The self-drilling point style requires more consideration due to the variety of thicknesses and possibility that multiple layers must be joined.
2. Self-piercing tapping screws (see Figure 4.3) are externally threaded fasteners with the ability to self-pierce metallic material, form a sleeve by extruding metallic material, and “tap” their own mating threads when driven. Self-piercing screws are high-strength, one-piece, one-side-installation fasteners with sharp point angles. The self-piercing point style is recommended for connections of 33-mil (0.84 mm) steel thickness and less.



4 Fasteners

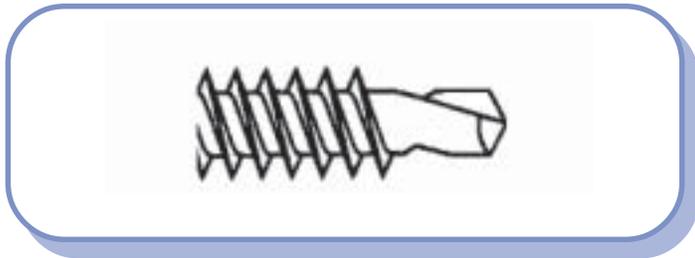


Figure 4.2–Self-Drilling Tapping Screw

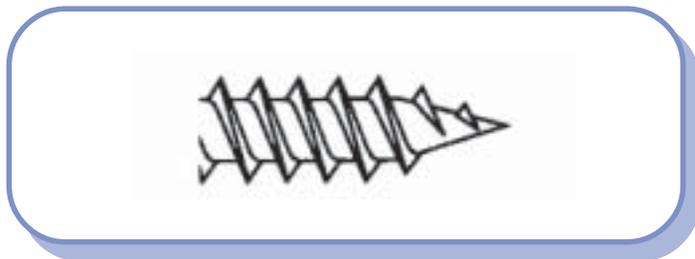


Figure 4.3–Self-Piercing Screw

Table 4.1–Screw Body Diameter

Screw Number Designation	Nominal Diameter, d, (inch)
6	0.1380
7	0.1510
8	0.1640
10	0.1900
12	0.2160
¼	0.2500

For SI: 1 inch = 25.4 mm.

Screw Body Diameter

The body diameter of a screw is related to the nominal screw size as shown in Table 4.1. Most connections are made with a No. 8 screw, except when attaching gypsum wallboard, when a No. 6 screw is typically used.

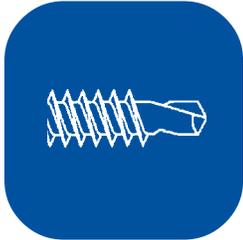
Screw Length

The length of the screw is measured from the bearing surface of the head to the end of the point as shown in Figure 4.4. For example, the length of a flat or countersunk head is measured from the top of the head to the end of the point. A pan head screw length is measured from under the head (bearing surface) to the end of the point.

The length of self-drilling screws may require special consideration since some designs have an unthreaded pilot section or reamer with wings between the threads and the drill point (see Figure 4.5). These features may be necessary for certain applications such as applying wood sheathing to a steel floor joist. The long pilot point or reamer is required to allow the screw to drill through the material before engaging the threads. If the threads engage before the pilot hole is drilled completely, a gap may result in the connection. The result can be a squeaky floor or “screw-pops” through certain finishes.

Threads

Self-piercing and self-drilling screws (see Figures 4.2 and 4.3) intended for cold-formed steel applications generally have a coarse thread (e.g., 10-16x⁵/₈ HWH SD would indicate a 10 diameter, 16 threads per inch, ⁵/₈-inch (16 mm) length, hex washer head, self-drilling screw). Many self-drilling screws have fine threads for use in thicker steel. Manufacturer's recommendations should be followed.



4 Fasteners

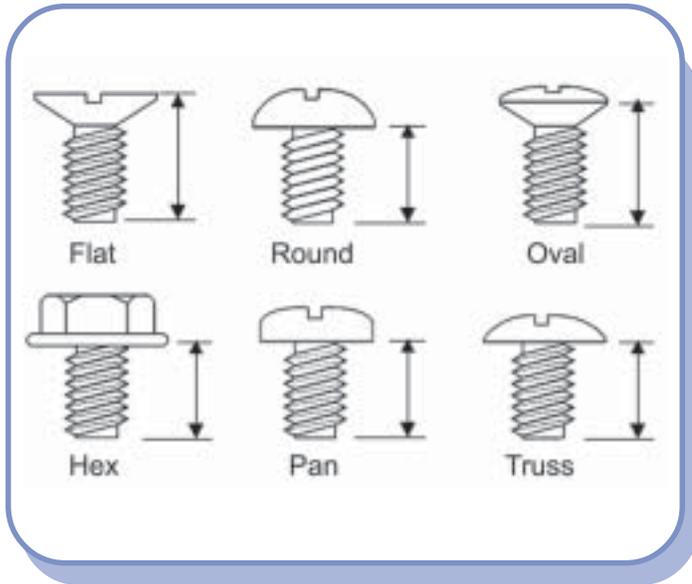


Figure 4.4–Screw Length Measurement

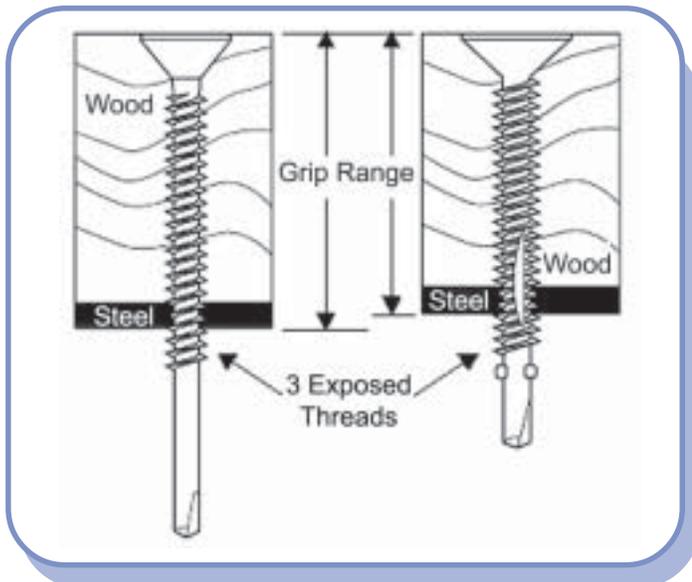


Figure 4.5–Screw Grip Range

Head Styles

Common head styles include flat, oval, wafer, truss, modified truss, hex washer head, pan, bugle, round washer, and pancake (see Figure 4.6). Specialty features may also be on the head, one of which is cutting nibs under the head of a flat head design. Cutting nibs are designed to aid in countersinking the flat head design in dense materials. The drive system may be a phillips, square, or other proprietary design. The specified style may be determined by application, preference, and availability. However, hex head screws are typically used for heavier structural connections, round washer screws for general framing connections, low-profile heads for surfaces to be finished with gypsum board, and bugle head screws for attaching sheathing products.

Screw Body

The body of the screw includes the threads and any designed special features. Special features may include a shank slot, which is a section cut out of the shank for chips of material to have a place to escape, thereby relieving driving torque. The shank slot is located directly above the drill point of the screw.

Drive Types

Drive types are usually determined by availability and preference. Figure 4.7 shows common drive types.

Screw Requirements

For all connections, screws should extend through the steel a minimum of three exposed threads as shown in Figures 4.8 and 4.9. Screws should penetrate individual components of a connection without causing permanent separation between the components. Screws should be installed in a manner such that the threads and holes are not stripped.



4 Fasteners

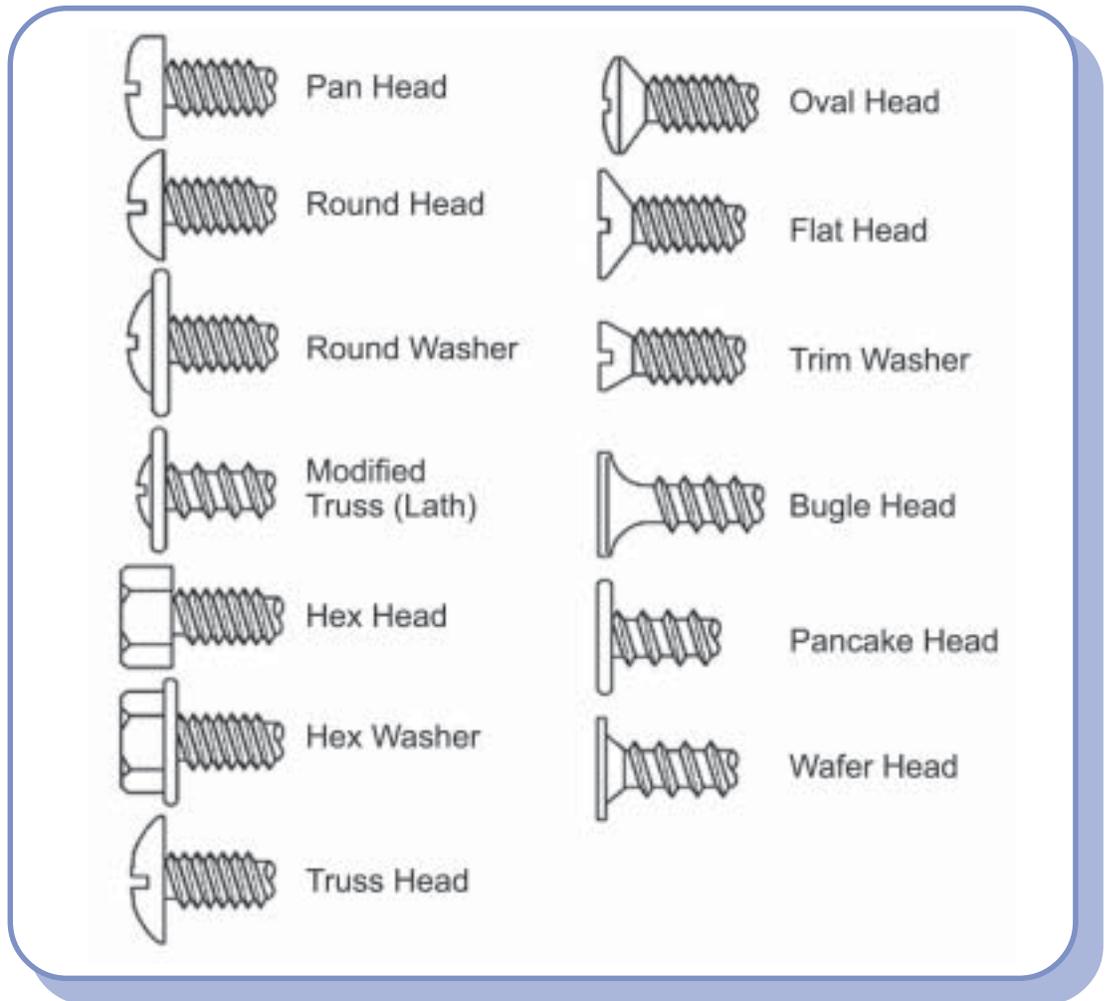


Figure 4.6–
Screw Head Types

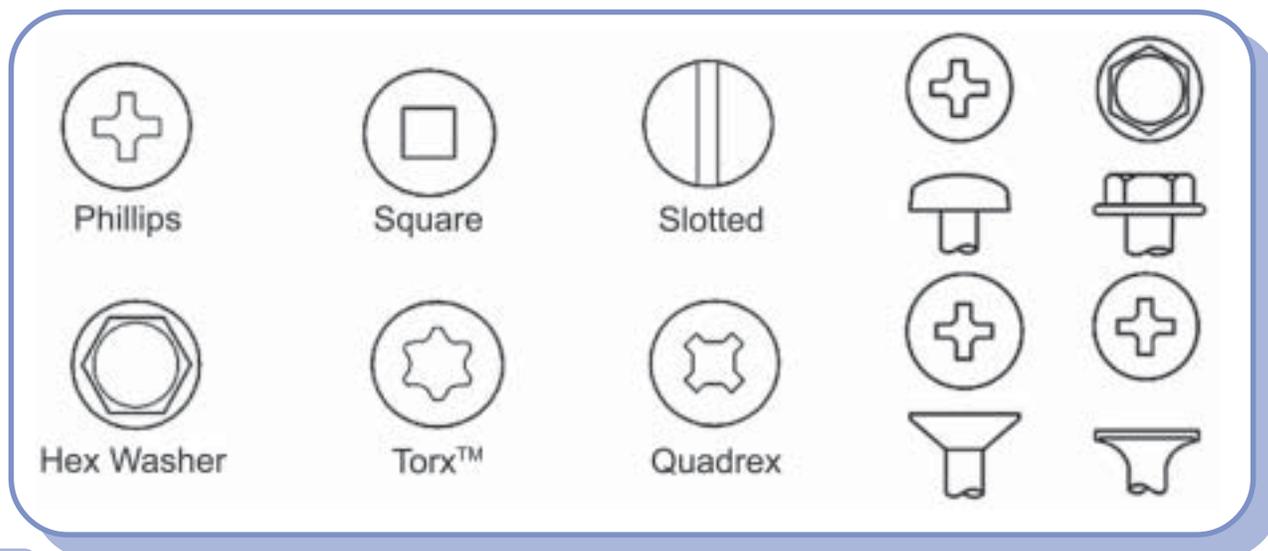


Figure 4.7–
Screw Drive
Types



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Drill Capacity

Drill capacity is defined as the total thickness the screw is designed to drill. If a fastener is chosen with a drill point that is too large, the result may be a stripped connection. If the drill point is too small, the screw may fracture and break.

The drive type and head style are typically related to

individual preference but may be a consideration for each application. An example of a misapplication is the use of a hex washer head in a framing connection. If drywall is specified as the finish material, the hex washer head will cause a bulge in the drywall finish.

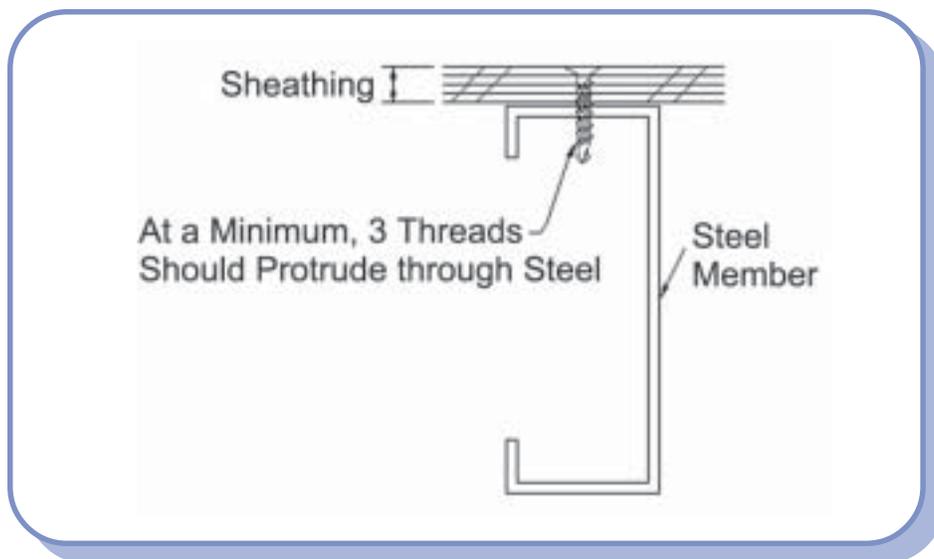


Figure 4.8—Fastening Sheathing to Steel

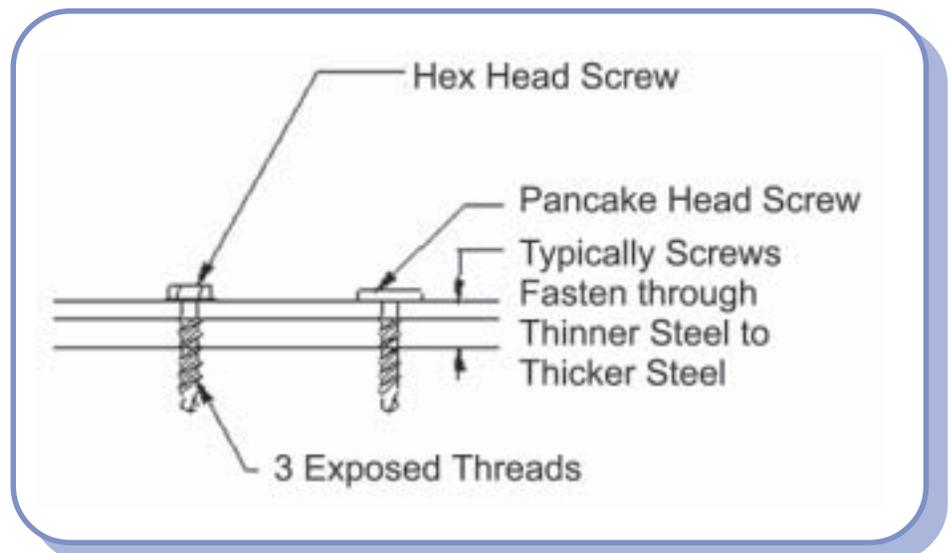
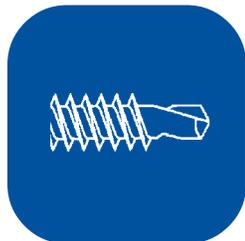


Figure 4.9—Fastening Steel to Steel



4 Fasteners

Design Values

Screw capacity is determined in accordance with the AISI Design Specification. Tables 4.2a and 4.2b provide a

summary of the design capacities (shear and pullout) for screws that are typically used in residential and light commercial applications.

Table 4.2a—Allowable Loads for Screw Connections (Pa)^{1,2,3,4}
33 ksi Steel with a 3.0 Safety Factor

Material		Steel Strength		#6 Screw		#8 Screw		#10 Screw		#12 Screw	
Thickness (mil)	Design Thickness ⁵ (inch)	F _u (ksi)	F _y (ksi)	DIA. = 0.138		DIA. = 0.164		DIA. = 0.190		DIA. = 0.216	
				SHEAR	PULLOUT	SHEAR	PULLOUT	SHEAR	PULLOUT	SHEAR	PULLOUT
				(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)
18	0.0188	45	33	60	33	66	39				
27	0.0283	45	33	111	50	121	59				
30	0.0312	45	33	129	55	141	65	151	76		
33	0.0346	45	33	151	61	164	72	177	84	190	97
43	0.0451	45	33	224	79	244	94	263	109	280	124
54	0.0566	45	33			344	118	370	137	394	156
68	0.0713	45	33					523	173	557	196
97	0.1017	45	33							902	284

For SI: 1 inch = 25.4 mm, 1 lb. = 4.448 N.

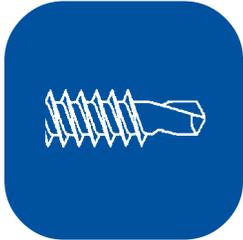
¹Screw allowable loads are based on the 1996 AISI Specification [19].

²Values include a 3.0 factor of safety.

³The nominal strength of the screw must be at least 3.75 times the allowable loads.

⁴When connecting materials of different steel thicknesses or tensile strength (F_u), the lowest applicable values should be used.

⁵Minimum thickness represents 95 percent of the design thickness and is the minimum acceptable thickness delivered to the job site.



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Table 4.2b–Allowable Loads for Screw Connections (Pa)^{1,2,3,4}
50 ksi Steel with a 3.0 Safety Factor

Material				#6 Screw		#8 Screw		#10 Screw		#12 Screw	
Thickness (mil)	Design Thickness ⁵ (inch)	Steel Strength		DIA. = 0.138		DIA. = 0.164		DIA. = 0.190		DIA. = 0.216	
				SHEAR	PULLOUT	SHEAR	PULLOUT	SHEAR	PULLOUT	SHEAR	PULLOUT
		F _u (ksi)	F _y (ksi)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)
18	0.0188	65	50	87	48	95	57				
27	0.0283	65	50	161	72	175	85				
30	0.0312	65	50	186	79	203	94	219	109		
33	0.0312	65	50	218	88	237	105	255	121	274	140
43	0.0346	65	50	324	115	353	136	380	158	408	182
54	0.0451	65	50			496	171	534	198	573	228
68	0.0566	65	50					755	249	811	288
97	0.0713	65	50							1303	410

For SI: 1 inch = 25.4 mm, 1 lb. = 4.448 N.

¹Screw allowable loads are based on the 1996 AISI Specification [19].

²Values include a 3.0 factor of safety.

³The nominal strength of the screw must be at least 3.75 times the allowable loads.

⁴When connecting materials of different steel thicknesses or tensile strength (F_u), the lowest applicable values should be used.

⁵Minimum thickness represents 95 percent of the design thickness and is the minimum acceptable thickness delivered to the job site.

Screw Designation

Screws are typically designated by their diameter, thread, head style, point type, and length as shown in Figure 4.10.

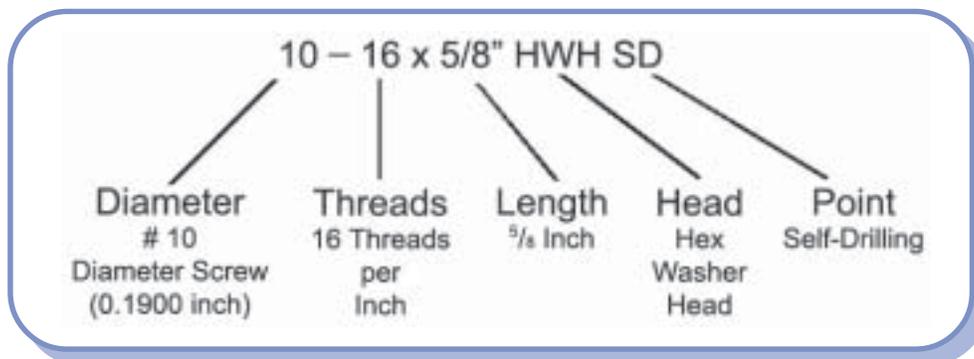


Figure 4.10–Typical Screw Designation



4 Fasteners

4.2.2 Pneumatically Driven Pins

Pneumatic pins and nails are designed with spiral grooves or knurls on the nail shaft to penetrate the steel (see Figure 4.11). As with wood framing, drive pins and nails are used with air guns. Wood sheathing (such as subflooring) can be fastened to steel members with drive pins. Care should be taken to follow manufacturer's recommendations to avoid problems such as squeaky floors. Additional guidance on pneumatically driven pins is provided in the Light Gauge Steel Engineers Association Tech Note *Pneumatically Driven Pins for Wood Based Panel Attachment* [20].

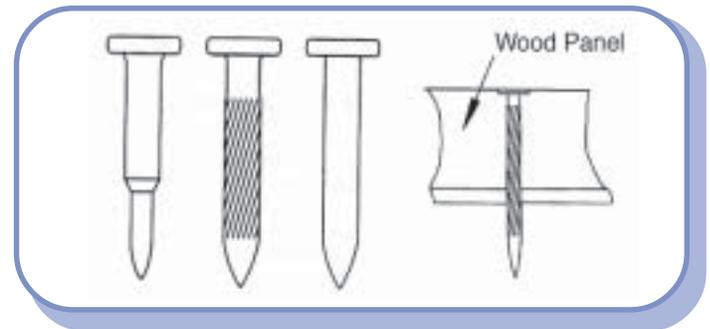


Figure 4.11–Pneumatically Driven Pins

4.2.3 Bolts

Bolts are typically used to anchor cold-formed steel members to foundations. The most common anchors used in steel construction are anchor bolts, mudsill anchors, anchor straps, mushroom spikes, and powder-actuated anchors. Washers and nuts should be properly installed and tightened where required. Bolts connecting CFS to concrete shall have boltholes spaced a minimum of three bolt diameters on-center. The distance from the center of the bolthole to the edge of the connecting member shall not be less than one and one-half bolt diameters.

- **Mudsill Anchors.** Anchors that fit in the bottom track to hold the wall down, usually available from specialty fastener companies, such as Simpson Strong-Tie®, or fabricated in the field.
- **Anchor Straps.** Steel straps that are embedded in the slab and bend up to attach to the wall studs.
- **Mushroom Spikes.** Expansion bolts that expand in predrilled concrete holes, typically used to hold down bottom track or rim joists.
- **Powder-Actuated Fasteners.** Pins fired by a special gun to hold the bottom track down to the foundation.

4.2.4 Welds

Welds are not common in residential steel construction but are used in light commercial and mid-rise construction. Field welding of thin steel members (less than 43 mil in thickness) is not recommended. Factory welds are common because they are usually performed in a controlled environment. Welded areas (see Figure 4.12) must be treated with a corrosion-resistant coating, such as a zinc-rich paint, to maintain acceptable durability of the welded connection. Additional guidance on welding of cold-formed steel members is provided in the Light Gauge Steel Engineers Association Tech Note *Welding Cold-Formed Steel* [21].

Welded areas shall be treated with zinc-enriched paint or other approved treatment to retain the corrosion resistance of the welded area.



4 Fasteners



Figure 4.12–Welding of Cold-Formed Steel Framing

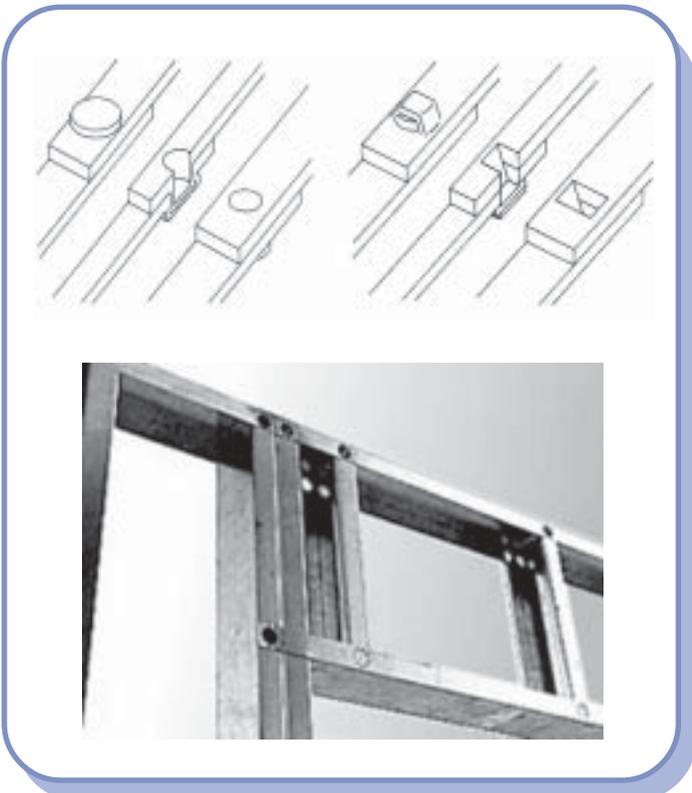


Figure 4.13–Clinches

4.2.5 Clinches

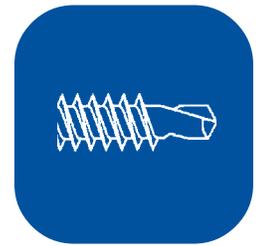
Clinching is a method of joining two pieces of sheet metal by pressing them together into a die that forms a connection similar to a rivet. This technology, although not new, has only recently been used for attaching residential steel framing members. Clinched connections are especially popular in factory settings and panelized construction. Figure 4.13 illustrates some clinched joints that are currently available.

The majority of clinched connections are made with pneumatic or hydraulic tools, although manual clinchers are available. A clincher makes a connection by driving a punch into a die through overlapping material. When the material is forced to the bottom of the die, the die begins to mushroom and then expands to allow full development of the connection. When the punch reaches its final position, it is withdrawn and the die returns to its original shape. The result is a connection similar to that of a rivet. The strength of a clinched connection is approximately the same as that of a self-drilling screw. The clinching process does not harm the galvanized coating on framing members. Many of the currently available clinching tools are limited to use in a warehouse/factory environment. It is usually difficult to loosen connections when necessary. Clinching equipment is currently not widely available.

Additional guidance on clinching of cold-formed steel members is provided in the Light Gauge Steel Engineers Association Tech Note *Clinched (Integral) Fastening of Cold-Formed Steel* [22].

4.2.6 Adhesives

The use of adhesive in residential and light commercial cold-formed steel structural application is not common. Adhesives are primarily used in factory settings and panelized construction. Adhesives are also used between floor joists and floor sheathing and between wall studs and wall covering.



4 Fasteners

4.2.7 Powder-Actuated Fasteners

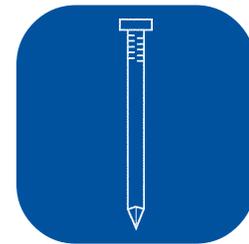
Powder-actuated fastener systems consist of specially designed fasteners, installation tools, and powder loads that are designed to function in combination to provide optimum performance. Powder-actuated fasteners need to be used with precision and accuracy to ensure proper application. The use of powder-actuated fastening systems in the construction industry permits significant speed of installation, which results in considerable cost savings. The systems also provide the contractor with the ability to fasten into concrete, masonry, and structural steel without predrilling holes. For most applications, this eliminates time-

Always ask for an evaluation report or an approved design if you are considering using a proprietary fastening system or method.

consuming layout or hole spotting, resulting in faster installation and reduced costs. In addition, powder-actuated fastening systems are completely portable and are ideal for locations that are difficult to access. Today, powder-actuated fastening technology has become the standard method of attachment for many applications in the construction industry.

4.2.8 Rivets

Currently, the use of rivets in residential and light commercial cold-formed steel framing is not common.



4.3 Wood Fastening Methods

Dimension lumber framing members can be connected together or to a variety of materials by using any of the following fastening methods:

- Nails
- Pneumatically Driven Nails
- Screws
- Bolts
- Specialty Connection Hardware
- Lag Screws
- Adhesives

In addition, a variety of specialty metal connectors (i.e., joist hangers and strapping) are available for dimension lumber and timber framing. For heavy timber construction, commonly used connections include bolts, drift pins, lag screws, shear plates and rings (used in combination with bolts), and timber rivets. Finally, the metal truss plate (a flat metal plate with preformed teeth) is instrumental to the process of making and designing efficient wood trusses manufactured from dimension lumber. This section presents some basic descriptions and technical information on the above fasteners.

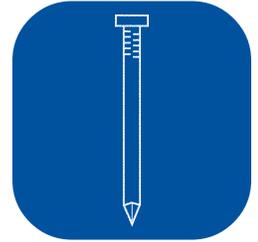
4.3.1 Nails

Several characteristics distinguish one nail from another. Figure 4.14 depicts important nail features for a few types of nails that are essential to woodframe design and construction. This section discusses some of a nail's characteristics relative to structural design; for additional information the reader is referred to *Standard Terminology of Nails for Use with Wood and Wood-Base Materials* (ASTM F547) and *Standard Specification for Driven Fasteners: Nails, Spikes, and Staples* (ASTM F 1667) [23][24].

The most common nail types used in residential wood construction follow:

- **Common nails** are bright, plain-shank nails with a flat head and diamond point. The diameter of a common nail is greater than that of sinkers and box nails of the same length. Common nails are used primarily for rough framing.
- **Sinker nails** are bright or coated slender nails with a sinker head and diamond point. The diameter of the head is smaller than that of a common nail with the same designation. Sinker nails are used primarily for rough framing and applications where lumber splitting may be a concern.
- **Box nails** are bright, coated, or galvanized nails with a flat head and diamond point. They are made of lighter-gauge wire than common nails and sinkers and are commonly used for toe nailing and many other light framing connections where lumber splitting is a concern.
- **Cooler nails** are generally similar to the nails above, but with slightly thinner shanks. They are commonly supplied with ring shanks (i.e., annular threads) as a drywall nail.
- **Power-driven nails** (and staples) are produced by a variety of manufacturers for several types of power-driven fasteners. Pneumatic-driven nails and staples are the most popular power-driven fasteners in residential wood construction. Nails are available in a variety of diameters, lengths, and head styles. The shanks are generally cement-coated (or adhesive) and are available with deformed shanks for added capacity. Staples are also available in a variety of wire diameters, crown widths, and leg lengths. Refer to NER-272 for additional information and design data [25].

Nail lengths and weights are denoted by the **penny weight**, which is indicated by **d**. Given the standardization of common nails, sinkers, and cooler nails, the penny weight also denotes a nail's head and shank diameter. For other nail types, sizes are based on the nail's length and diameter. Table 4.3 arrays dimensions for the nails discussed above. Nail length and diameter are important factors in determining the strength of nailed connections in wood framing. The steel yield strength of the nail may also be important for certain shear connections, yet such information is rarely available for a "standard" lot of nails.


 Table 4.3—Nail Types, Sizes, and Dimensions¹

Type of Nail	Nominal Size (penny weight, d)	Length (inches)	Diameter (inches)
Common	6 d	2	0.113
	8 d	2 1/2	0.131
	10 d	3	0.148
	12 d	3 1/4	0.148
	16 d	3 1/2	0.162
	20 d	4	0.192
Box	6 d	2	0.099
	8 d	2 1/2	0.113
	10 d	3	0.128
	12 d	3 1/4	0.128
	16 d	3 1/2	0.135
Sinker	6 d	1 7/8	0.092
	8 d	2 3/8	0.113
	10 d	2 7/8	0.120
	12 d	3 1/8	0.135
	16 d	3 1/4	0.148
Pneumatic²	6 d	1 7/8 to 2	0.092 to 0.113
	8 d	2 3/8 to 2 1/2	0.092 to 0.131
	10 d	3	0.120 to 0.148
	12 d	3 1/4	0.120 to 0.131
	16 d	3 1/2	0.131 to 0.162
	20 d	4	0.131
Cooler	4 d	1 3/8	0.067
	5 d	1 5/8	0.080
	6 d	1 7/8	0.092

For SI: 1 inch = 25.4 mm.

¹Based on ASTM F 1667.

²Based on a survey of pneumatic fastener manufacturer data and NER-272 [25].

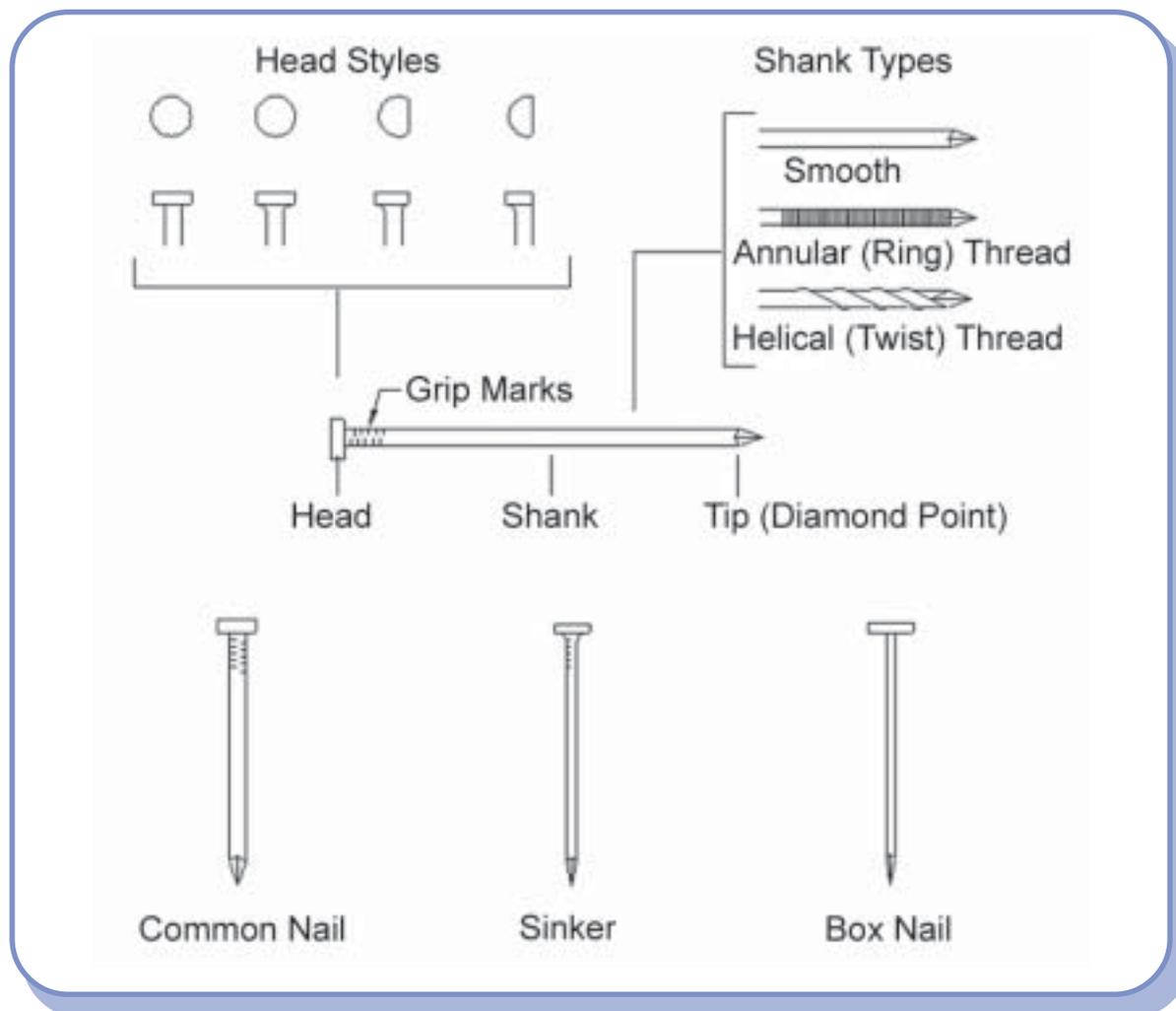
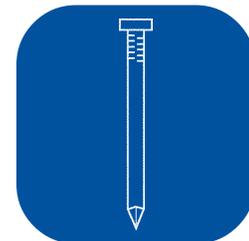
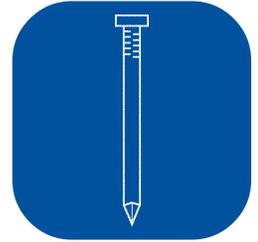


Figure 4.14—Elements of a Nail and Nail Types

There are many types of **nail heads**, although three types are most commonly used in residential wood framing.

- The **flat nail head** is the most common head. It is flat and circular, and its top and bearing surfaces are parallel but with slightly rounded edges.
- The **sinker nail head** is slightly smaller in diameter than the flat nail head. It also has a flat top surface; however, the bearing surface of the nail head is angled, allowing the head to be slightly countersunk.
- **Pneumatic nail heads** are available in the above types; however, other head types such as a half-round or D-shaped heads are also common.

The **shank**, as illustrated in Figure 4.14, is the main body of a nail. It extends from the head of the nail to the point. It may be plain or deformed. A plain shank is considered a “smooth” shank, but it may have “grip marks” resulting from the manufacturing process. A deformed shank is most often either threaded or fluted to provide additional withdrawal or pullout resistance. Threads are annular (i.e., ring shank), helical, or longitudinal deformations rolled onto the shank, creating ridges and depressions. Flutes are helical or vertical deformations rolled onto the shank. Threaded nails are most often used to connect wood to wood while fluted nails are used to connect wood to concrete (i.e., sill plate to concrete slab or furring strip to concrete or masonry). Shank diameter and surface condition both affect a nail’s capacity.



The **nail tip**, as illustrated in Figure 4.14, is the end of the shank—usually tapered—that is formed during manufacturing to expedite nail driving into a given material. Among the many types of nail points, the **diamond point** is most commonly used in residential wood construction. The diamond point is a symmetrical point with four approximately equal beveled sides that form a pyramid shape.

A **cut point** used for concrete cut nails describes a blunt point. The point type can affect nail drivability, lumber splitting, and strength characteristics.

The **material** used to manufacture nails may be steel, stainless steel, heat-treated steel, aluminum, or copper, although the most commonly used materials are steel, stainless steel, and heat-treated steel. **Steel** nails are typically formed from basic steel wire. **Stainless steel** nails are often recommended in exposed construction near the coast or for certain applications such as cedar siding to prevent staining. Stainless steel nails are also recommended for permanent wood foundations. **Heat-treated** steel includes annealed, case-hardened, or hardened nails that can be driven into particularly hard materials such as extremely dense wood or concrete.

Various nail **coatings** provide corrosion resistance, increased pullout resistance, or ease of driving. Some of the more common coatings in residential wood construction are described below.

- **Bright.** Uncoated and clean nail surface.
- **Cement-coated.** Coated with a heat-sensitive cement that prevents corrosion during storage and improves withdrawal strength depending on the moisture and density of the lumber and other factors.
- **Galvanized.** Coated with zinc by barrel-tumbling, dipping, electroplating, flaking, or hot-dipping to provide a corrosion-resistant coating during storage and after installation for either performance or appearance. The coating thickness increases the diameter of the nail and improves withdrawal and shear strength.

4.3.2 Pneumatically Driven Nails

Nails for nail guns and pneumatic tools come in two forms:

- Some manufacturers clip the nail head to form clips with the nail shanks side by side, allowing more nails per clip and reducing the frequency of reloading.
- Other manufacturers use plastic to hold the individual nails far enough apart to allow for full heads.

Nails made for pneumatic tools are not all the same. Nails produced by one manufacturer may not fit another manufacturer's tool. Pneumatic nails are typically collated or arranged into strips or rolls with the nails joined by plastic or paper strips or fine wire. Collated nails are available in a variety of metals such as copper, galvanized, or steel and are identified or classified by their head shape, shank type, and length.

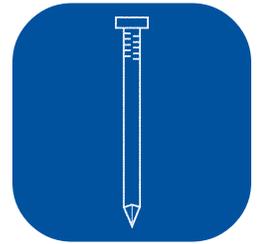
4.3.3 Screws

Although screws are widely used in the residential wood construction market, their use is not as common as nails. Screws are mostly used to fasten floor sheathing to wood joists and gypsum board to wall studs. Unlike screws used for steel-framed members, wood screws are coarse threads and do not have a drill point. Table 4.4 summarizes traditional wood screws.

4.3.4 Bolts

Bolts are often used for “heavy” connections and to secure wood to other materials such as steel or concrete. Bolts are typically used to anchor wood members to foundations, ledger plates to wall framing, or in wood decks. In many construction applications, however, special power-driven fasteners are used in place of bolts. Refer to Figure 4.15 for an illustration of some typical bolt types and connections for residential use.

In residential wood construction, bolted connections are typically limited to wood-to-concrete connections unless a home is constructed in a high-hazard wind or seismic area and hold-down brackets are required to transfer shear wall overturning forces. Foundation bolts, typically embedded in concrete or grouted masonry, are commonly referred to as **anchor bolts**, **J-bolts**, or **mud-sill anchors**. Another type of bolt sometimes used in residential construction is the

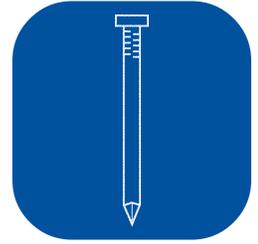


4 Fasteners

Table 4.4—Wood Screws

Gauge		2	3	4	5	6	7	8	9	10	12	14	
Head-Bore Size (inch)		11/64	13/64	13/64	1/4	9/32	5/16	11/32	23/64	25/64	7/16	1/2	
Pilot-Hole Size (inch)	Hardwood	1/16	1/16	5/64	5/64	3/32	7/64	7/64	1/8	1/8	9/64	5/32	
	Softwood	1/16	1/16	1/16	1/16	5/64	3/32	3/32	7/64	7/64	1/8	9/64	
Square-Drive Bit Size		#0			#1			#2			#3		
Phillips-Head Point Size		#1			#2						#3		
Available Lengths (inch)													
1/4		↓	↓	↓									
3/8			↓	↓	↓								
1/2		↓	↓	↓	↓								
5/8			↓	↓	↓	↓	↓						
3/4				↓	↓	↓	↓	↓					
1						↓	↓	↓	↓	↓			
1 1/8							↓	↓	↓	↓	↓		
1 1/4								↓	↓	↓	↓		
1 3/8									↓	↓	↓	↓	
1 1/2								↓	↓	↓	↓	↓	
1 5/8									↓	↓	↓	↓	
1 3/4										↓	↓	↓	
2											↓	↓	
2 1/4												↓	
2 1/2												↓	
2 3/4												↓	

For SI: 1 inch = 25.4 mm.



structural bolt, which connects wood to steel or wood to wood. Low-strength ASTM A307 bolts are commonly used in residential construction as opposed to high-strength ASTM A325 bolts, which are more common in commercial applications. Bolt diameters in residential construction generally range from $\frac{1}{4}$ to $\frac{3}{4}$ inch (6 to 13 mm), although $\frac{1}{2}$ - to $\frac{5}{8}$ -inch-diameter (13 to 16 mm) bolts are most common, particularly for connecting a 2x wood sill to grouted masonry or concrete.

Bolts, unlike nails, are installed in predrilled holes. If holes are too small, the possibility of splitting the wood member increases during installation of the bolt. If bored too large, the bolt holes encourage nonuniform dowel (bolt) bearing stresses and slippage of the joint when loaded. NDS Section 8.1 [13] specifies that bolt holes should range from $\frac{1}{32}$ to $\frac{1}{16}$ inch (0.8 to 1.6 mm) larger than the bolt diameter to prevent splitting and to ensure reasonably uniform dowel bearing stresses.

4.3.5 Specialty Connection Hardware

Many manufacturers fabricate specialty connection hardware. The load capacity of a specialty connector is usually provided in the manufacturer's product catalogue. Thus, the designer can select a standard connector based on the design load determined for a particular joint or connection. However, the designer should carefully consider the type of fastener to be used with the connector; sometimes a manufacturer requires or offers proprietary nails, screws, or other devices. It is also recommended that the designer verify the safety factor and strength adjustments used by the manufacturer. In some cases, as with nailed and bolted connections in the NDS, the basis is a serviceability limit state (i.e., slip or deformation) and not ultimate capacity.

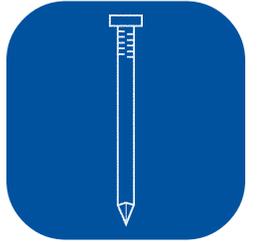
A few examples of specialty connection hardware are illustrated in Figure 4.16 and discussed below.

- **Sill anchors** are used in lieu of foundation anchor bolts. Many configurations are available in addition to the one shown in Figure 4.16.
- **Joist hangers** are used to attach single or several joists to the side of girders or header joists.

- **Rafter clips** and **roof tie-downs** are straps or brackets that connect roof framing members to wall framing to resist roof uplift loads associated with high-wind conditions.
- **Hold-down brackets** are brackets that are bolted, nailed, or screwed to wall studs or posts and anchored to the construction below (i.e., concrete, masonry, or wood) to "hold down" the end of a member or assembly (i.e., shear wall).
- **Strap ties** are prepunched straps or coils of strapping that are used for a variety of connections to transfer tension loads.
- **Splice plates** or **shear plates** are flat plates with prepunched holes for fasteners to transfer shear or tension forces across a joint.
- **Epoxy-set anchors** are anchor bolts that are drilled and installed with epoxy adhesives into concrete after the concrete has cured and sometimes after the framing is complete so that the required anchor location is obvious.

4.3.6 Lag Screws

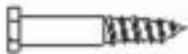
Lag screws are available in the same diameter range as bolts; the principal difference between the two types of connectors is that a lag screw has screw threads that taper to a point. The threaded portion of the lag screw anchors itself in the main member that receives the tip. Lag screws (often called lag bolts) function as bolts in joints where the main member is too thick to be economically penetrated by regular bolts. They are also used when one face of the member is not accessible for a "through-bolt." Holes for lag screws must be carefully drilled to one diameter and depth for the shank of the lag screw and to a smaller diameter for the threaded portion. Lag screws in residential applications are generally small in diameter and may be used to attach garage door tracks to wood framing, steel angles to wood framing supporting brick veneer over wall openings, various brackets or steel members to wood, and wood ledgers to wall framing.



Carriage Bolt



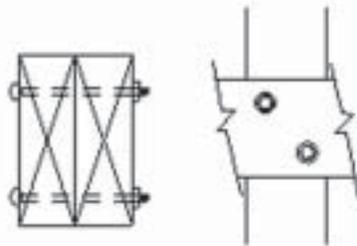
Anchor Bolt (J-Bolt)



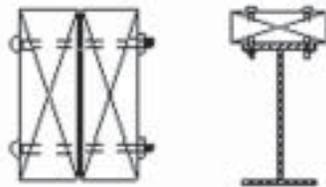
Lag Bolt



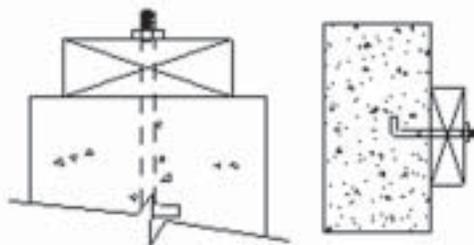
Hex Head (Machine) Bolt



Wood-to-Wood Connections

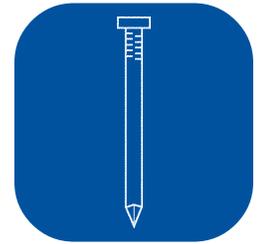


Wood-to-Metal Connections



Wood-to-Concrete Connections

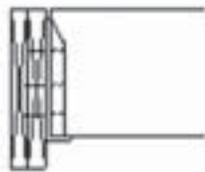
Figure 4.15–Bolt and Connection Types



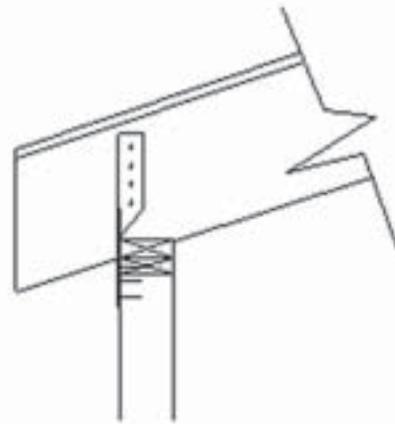
4 Fasteners



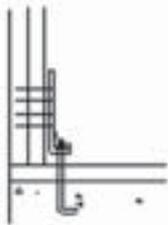
Sill Anchor



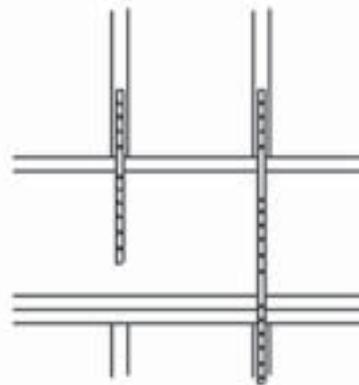
Joist Hanger



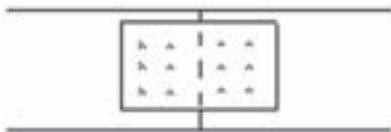
Rafter Clip (Roof Tie-Down)



Hold-Down Bracket



Straps



Splice/Shear Plate



Epoxy Anchor

Figure 4.16–Specialty Connector Hardware



4 Fasteners

4.3.7 Adhesives

The use of adhesive as a structural connection in wood structural applications is not common. Adhesives are primarily used in factory settings and panelized construction (such as in manufactured homes). Adhesives are also used between floor joists and floor sheathing and between wall studs and wall covering.

4.4 Wood-to-Steel Fasteners

4.4.1 Wood Structural Sheathing to Steel Connections

Wood structural sheathing (such as plywood or OSB) is typically fastened to steel framing (i.e., studs or joists) with minimum No. 8 self-drilling tapping screws. Screws connecting structural sheathing to steel members should have a minimum head diameter of 0.292 inch (7 mm) with countersunk heads. The screws should be installed with a minimum edge distance of $\frac{3}{8}$ inch (9 mm). The screw size is based on the steel thickness as specified in Table 4.5 and screw point style as shown in Figure 4.17. A pilot point self-drilling tapping screw is a specially designed screw used to attach plywood to steel joists. The screw has threads that start approximately $\frac{3}{4}$ inch (19 mm) up from the drill point to ensure that the spinning screw goes through the plywood and does not climb the drive. Instead, the screw penetrates the steel, and the screw threads engage in the metal for a tight fit.

No. 8 self-drilling screws with pilot points are generally used on plywood floors fastened to steel joists. Self-drilling screws with bugle heads are designed to countersink slightly in finishing material without crushing the material or tearing the surface or in the plywood sheathing. Bugle head screws leave a flat, smooth surface for easy finishing. Wafer head screws have larger heads than flat head screws and are typically used to connect soft materials to steel joists. Flat head screws are designed to countersink and sit flush without causing wood floors or finishes to splinter or split.

Table 4.5—Suggested Screw Sizes for Steel-to-Steel and Structural Floor Sheathing-to-Steel Connections

Screw Size	Point Style ¹ (inches)	Total Thickness of Steel ² (inches)
6	2	0.036 – 0.100
8	2	0.036 – 0.100
10	2	0.090 – 0.110
12	2	0.050 – 0.140
14	2	0.060 – 0.120
18	2	0.060 – 0.120
8	3	0.100 – 0.140
10	3	0.110 – 0.175
12	3	0.090 – 0.210
14	3	0.110 – 0.250
12	4	0.175 – 0.250
$\frac{1}{4}$	4	0.175 – 0.250
12	4 $\frac{1}{2}$	0.145 – 0.312
12	5	0.250 – 0.500
$\frac{1}{4}$	5	0.250 – 0.500

For SI: 1 inch = 25.4 mm.

¹ For screw point style, refer to Figure 4.19.

² The combined thickness of all connected steel members.

Table 4.6 provides ultimate lateral and withdrawal loads for sheet metal screws connecting plywood to cold-formed steel. Figure 4.18 illustrates the wood sheathing to steel connection.



4 Fasteners

Table 4.6—Plywood to 54 Mil (14 Gauge) Cold-Formed Steel Connection Capacity Using Sheet Metal Screws¹

Plywood Thickness (inch)	Ultimate Lateral Load (lb.)				Average Ultimate Withdrawal Load (lb.)			
	Screw Size							
	#8	#10	#12	#14	#8	#10	#12	#14
1/4	360	380	400	410	130	150	170	180
1/2	700	890	900	920	350	470	500	520
3/4	700	950	1300	1390	660	680	800	900

Values are reproduced from APA Technical Note E830C [26].

For SI: 1 inch = 25.4 mm, 1 lb. = 4.448 N.

¹Values are based on plywood panels of all-Group 1 construction. For plywood panels of other species groups, the values in this table should be adjusted per Table 4.7.

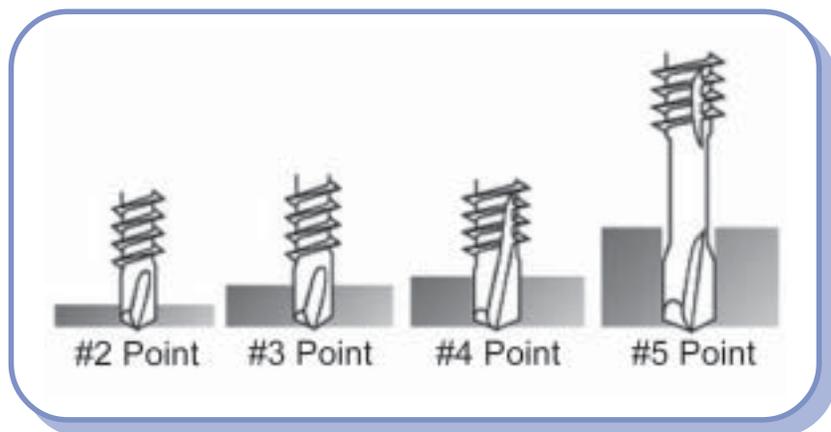


Figure 4.17—Screw Point Style

Table 4.7—Load Adjustments for Screws into Plywood for Species Group Noted^{1,2}

	Plywood Group		
	All-Group 1	All-Group 2	All-Group 3,4, and 5
Lateral	100%	78%	78%
Withdrawal	100%	60%	47%

¹Adjustments based on the species groups for plywood shown in Voluntary Product Standard PS1 [17] and the equations in U.S. Agricultural Handbook No. 72 [27].

²Face, back, and core veneer must be of the same species group. When species group is unknown, assume all-Group 4.



4 Fasteners

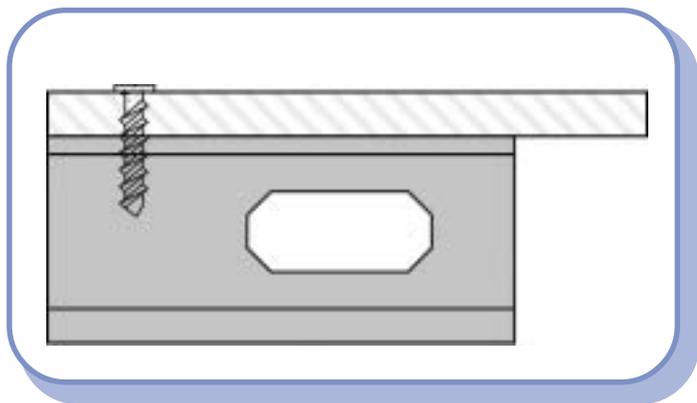


Figure 4.18–Wood Sheathing to Steel Connection

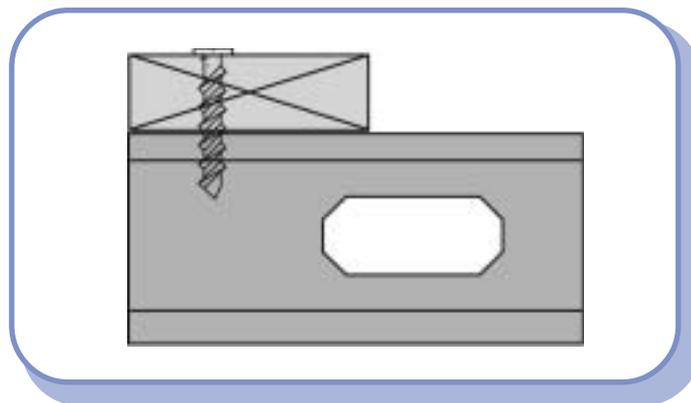


Figure 4.19–Wood to Steel Connection

4.4.2 Wood Structural Members to Steel Connections

Wood structural members (such as top plates) are typically fastened to steel members by using either screws or common nails. Nails are typically used where tension or pullout forces are nonexistent or negligible. Screws can be either self-piercing or self-drilling depending on the thickness of the steel. Refer to Table 4.8 for wood to steel connection capacity. Refer to table 4.9 for fastener type. Figure 4.19 illustrates the wood to steel connection.

Table 4.8–Fastener Capacity for Wood to Steel Connection

Substrate	Fastener	Allowable Loads (lb.)		Nominal Loads (lb.)	
		Shear	Withdrawal	Shear	Withdrawal
OSB only	10D Nail ¹	92	24	331	120
	#8 Screw ²	115	59	414	295
	#10 Screw ³	173	61	623	305
OSB and 33 mil Steel	10D Nail ¹	107	42	385	210
	#8 Screw ⁴	107	106	385	530
OSB and 54 mil Steel	10D Nail ¹	126	65	454	325
	#8 Screw ⁴	128	206	461	1030

For SI: 1 inch = 25.4 mm, 1lb = 4.448N.

¹0.131" x 3.25" pneumatic nail.

²#8 x 3" self tapping, flat head.

³#10 x 3" self tapping, flat head.

⁴#8 x 3" self drilling, bugle head.



4 Fasteners

Table 4.9—Fasteners for Hybrid Connections

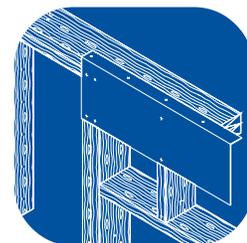
Application	Fastener Type
Wood trim over single layer gypsum board to 20 to 25 gauge (33 - 18 mil) steel studs or runners	No. 6 or 7 x 1" Trim head sharp point screws
Wood trim over double layer gypsum board to 20 to 25 gauge (33 - 18 mil) steel studs or runners	No. 6 or 7 x 2 1/4" Trim head sharp point screws
Wood trim over single layer gypsum board to 20 to 25 gauge (33 - 18 mil) steel studs or runners	No. 6 or 7 x 1 5/8" Trim head self drilling screws
Wood trim over single layer gypsum board to 14 to 20 gauge (68 - 33 mil) steel studs or runners	No. 6, 7, or 8 x 2 1/4" Trim head self drilling screws
Wooden cabinets through single layer gypsum board to steel studs	1 5/8" Oval head screws
Wooden cabinets through double layers gypsum board to steel studs	2 1/4" to 3 3/4" Oval head screws
3/8" to 3/4" Plywood to steel joists	1 15/16" Self tapping bugle head pilot point screws
Plywood or wood to 16 to 20 gauge (54 - 33 mil) steel	Flat head pilot point self drilling screws
Plywood to 12 to 16 gauge (97 - 54 mil) steel	Thin wafer head winged self drilling screws Flat head winged self drilling screws
20 gauge (33 mil) or thinner metal studs to OSB or plywood	No. 8 x 1" long Pancake head wood screw with a No. 2 Phillips head or 8 x 1", 1/4" Hex head wood grip
18 gauge (43 mil) or thicker metal studs to wood	Drill a pilot hole in the steel and use wood screws

For SI: 1 inch = 25.4 mm.

4.5 Steel-to-Wood Fasteners

4.5.1 Steel Structural Members to Wood Connections

Steel structural members (such as L-headers) are typically fastened to wood members by using either screws or pneumatic nails. Nails are usually used when pullout or tension forces are negligible or not present. When screws are used, they must be coarse thread screws. Refer to table 4.9 for fastener type. Refer to Tables 4.10 through 4.12 for steel to wood connection capacity. Figure 4.20 illustrates a steel to wood connection.



4 Fasteners

Table 4.10–Screw Capacity–Metal to Plywood Connections¹

Depth of Threaded Penetration (inch)	Ultimate Lateral Load (lb.)					
	Wood Screws			Sheet Metal Screws		
	#8	#10	#12	#8	#10	#12
1/2	415	500	590	465	565	670
5/8	-	-	-	500	600	705
3/4	-	-	-	590	655	715

Values are reproduced from APA Technical Note E830C [26].

For SI: 1 inch = 25.4 mm, 1 lb. = 4.448 N.

¹Values are based on 3/16" steel plate. For thinner plates, the values should be reduced.

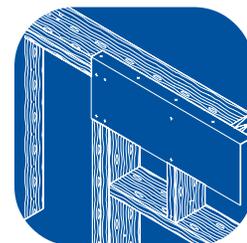
Table 4.11–Metal to Plywood Connection–Wood and Sheet Metal Screws¹

Depth of Threaded Penetration (inch)	Average Ultimate Withdrawal Load (lb.)				
	Screw Size				
	#6	#8	#10	#12	#14
3/8	150	180	205	-	-
1/2	200	240	275	315	-
5/8	250	295	345	390	-
3/4	300	355	415	470	-
1	-	-	-	625	775
1-1/8	-	-	-	705	875
2-1/4	-	-	-	-	-

Values are reproduced from APA Technical Note E830C [26].

For SI: 1 inch = 25.4 mm, 1 lb. = 4.448 N.

¹Values are based on 3/16" steel plate. For thinner plates, the values should be reduced.



4 Fasteners

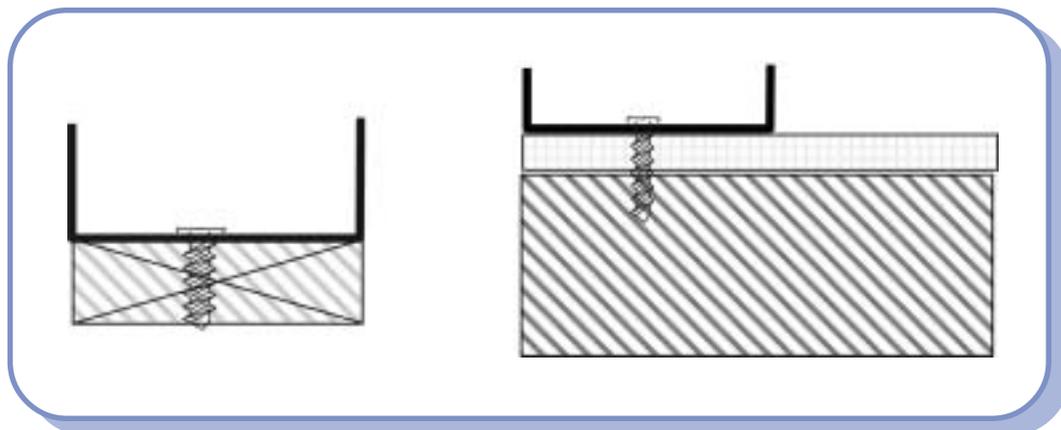


Figure 4.20–Steel to Wood Connection

Table 4.12–Fastener Capacity for Steel to Wood Connection

Steel Thickness	Substrate	Fastener Type	Allowable Loads (lb.)		Nominal Loads (lb.)	
			Shear ⁶	Withdrawal ⁶	Shear ⁶	Withdrawal ⁶
33 mil	OSB	10D Nail ¹	74	15	266	75
		#8 Screw ²	137	70	493	350
	OSB and 2x SPF	10D Nail ¹	185	80	666	400
		#8 Screw ³	172	63	619	315
54 mil	OSB	#8 Screw ⁴	151	66	544	330
	OSB and 2x SPF	#10 Screw ⁵	389	202	1400	1010

For SI: 1 inch = 25.4 mm, 1lb = 4.448N.

¹0.131" x 3.25" pneumatic nail.

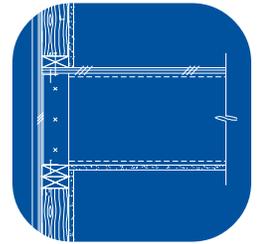
²#8 x 1.5" self-piercing, wafer head screw.

³#8 x 3" self-piercing, wafer head screw.

⁴#8 x 1-5/8" self-drilling, wafer head screw.

⁵Self-drilling, pan head screw.

⁶Values shown are based on SPF lumber with moisture content of 19% or less.



5 Hybrid Connection Details

5.1 Introduction

The details in this chapter are broken down into four sections:

- Floor Details (F)
- Walls Details (W)
- Roofs Details (R)
- Miscellaneous Details (M)

Each section contains details for connecting wood to steel and steel to wood (such as steel floor joists to wood walls or wood floor joists to steel walls). Common nails are used where possible; however, screws may be required for some connections if so specified.

This document does not include readily available span tables (such as for steel and wood floor joists). Instead, it presents span tables only for structural components that are not provided elsewhere.

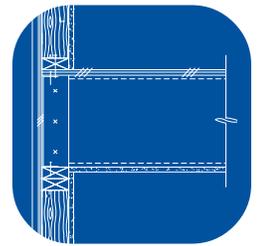
5.2 Floor Details

Steel and wood floor construction typically follow the conventional construction method. The reference documents that are commonly used for floor construction (spans, details, fasteners, and so forth) are:

- *Standard for Cold-Formed Steel Framing— Prescriptive Method for One- and Two-Family Dwellings* [1]
- *International Residential Code, IRC 2000* [3]
- *1995 CABO One- and Two-Family Dwelling Code* [2]
- *AF&PA Wood Frame Construction Manual* [28]
- *Builder’s Guide to Residential Steel Floors* [29]
- *Residential Steel Beam and Column Load/Span Tables* [30]

It is essential that you review the limitations of each published document and evaluate its applicability for each project.

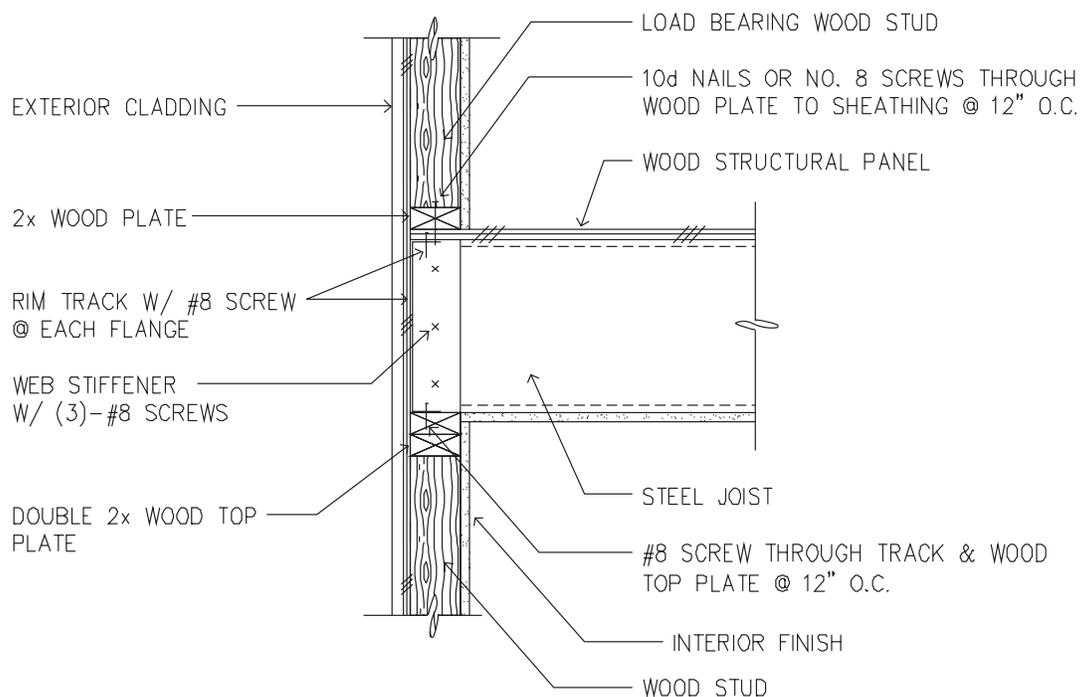
Users can also refer to manufacturer’s installation instructions and catalogs for framing steel and wood floors. Floor loading requirements can be found in the local building code. A 30 psf (1.44 kN/m²) live load is usually specified for sleeping areas and a 40 psf (1.92 kN/m²) live load for all other areas.



5 Hybrid Connection Details

Title: Steel Joist to Wood Wall Connection

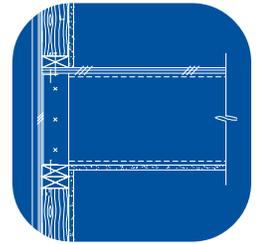
Detail No. F1



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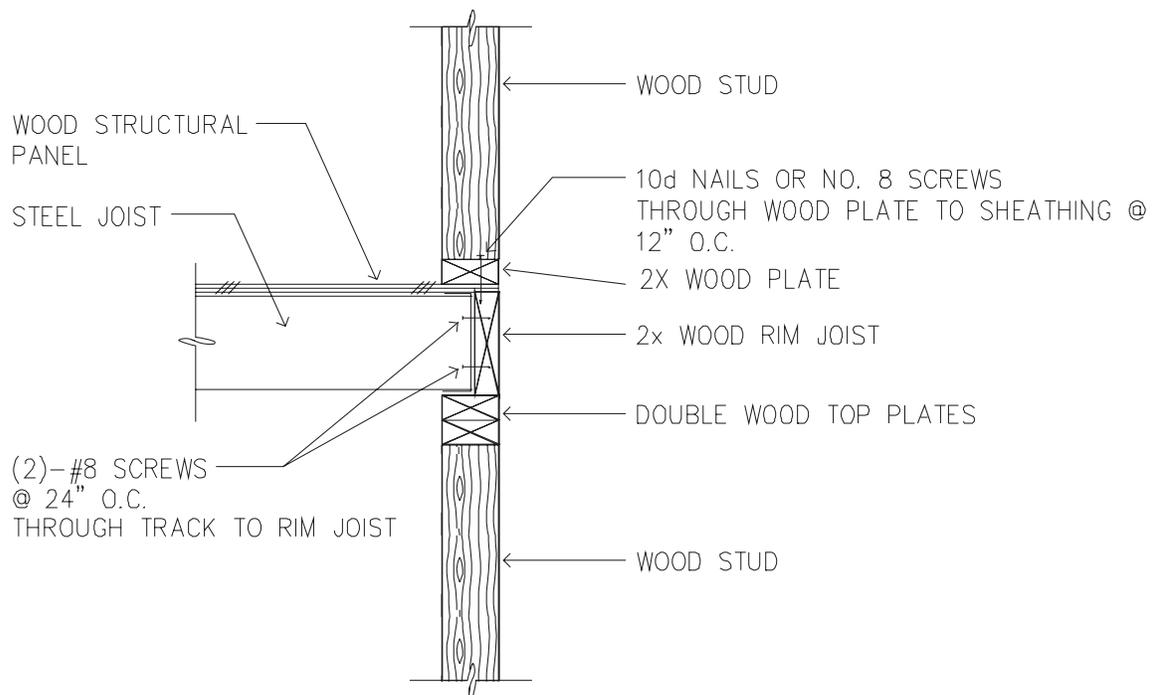
- Steel joists need not be aligned with studs below when double wood top plates are used.
- Web stiffeners are required at all support and bearing locations for steel joists unless designed otherwise.
- Steel joist span tables can be found in the *International Residential Code* or the *Prescriptive Method*.
- Refer to Detail W5 for floor to wall straps in high-wind and seismic regions.
- 10d nail can be used in lieu of #8 screws to fasten the top or bottom wood plates to steel joists.



5 Hybrid Connection Details

Title: Steel Joist to Wood Wall Connection (Alternative Detail)

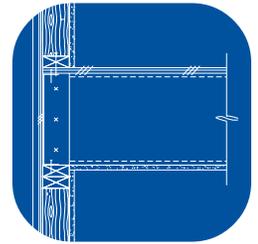
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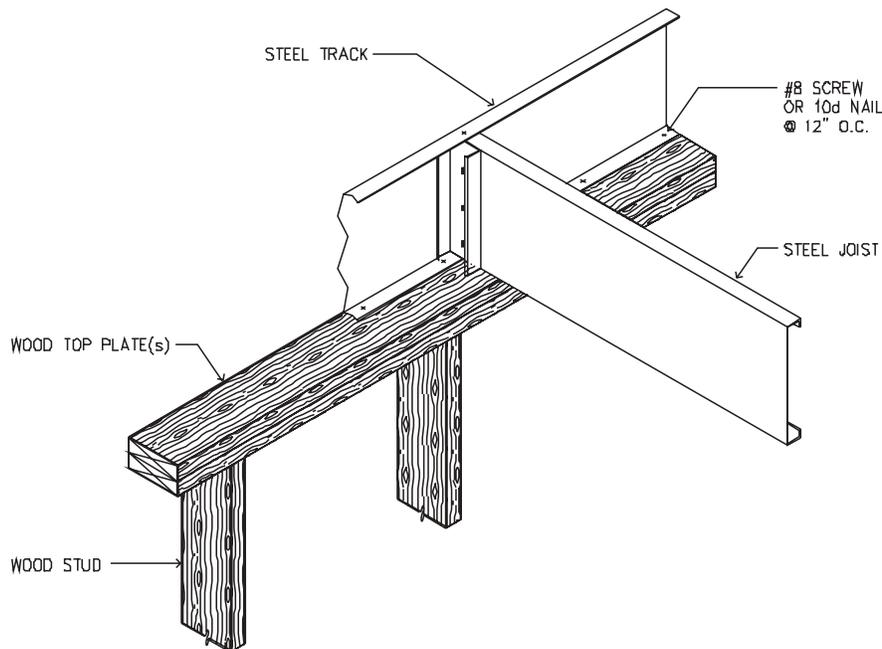
- Steel joists need not be aligned with studs below when double wood plates are used.
- Web stiffeners are required at all support and bearing locations for steel joists unless designed otherwise.
- Steel joist span tables can be found in the *International Residential Code* or the *Prescriptive Method*.
- Refer to Detail W6 for floor to wall straps in high wind and seismic regions.



5 Hybrid Connection Details

Title: Steel Floor to 2x Wood Top Plate Connection Detail

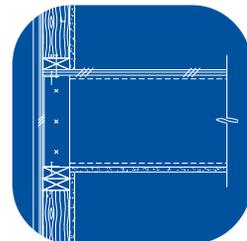
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Commentary:

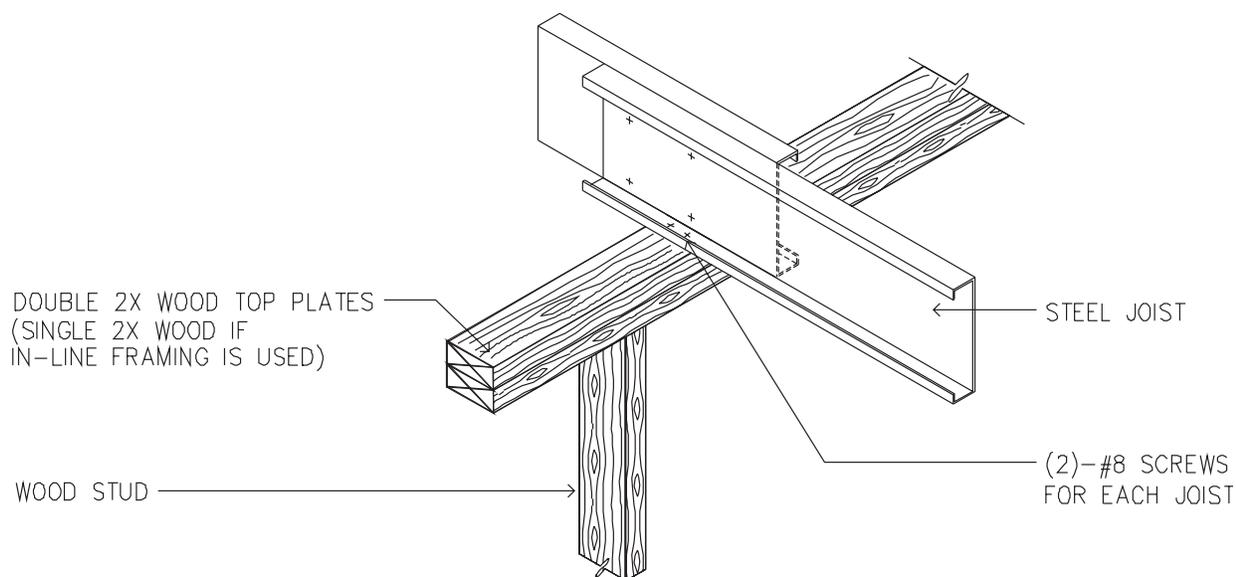
- Steel joists need not be aligned with studs below when double wood plates are used.
- Web stiffeners are required at all support and bearing locations for steel joists unless designed otherwise.
- Steel joist span tables can be found in the *International Residential Code* or the *Prescriptive Method*.
- Refer to Detail W5 for floor to wall straps in high-wind and seismic regions.
- 10d nail can be used in lieu of #8 screws to fasten the track to wood plate.



5 Hybrid Connection Details

Title: Lapped Steel Joists over Wood Wall

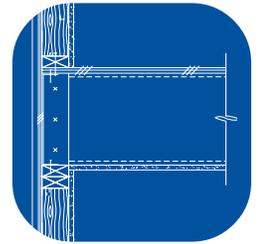
Detail No. F5



Data:

Commentary:

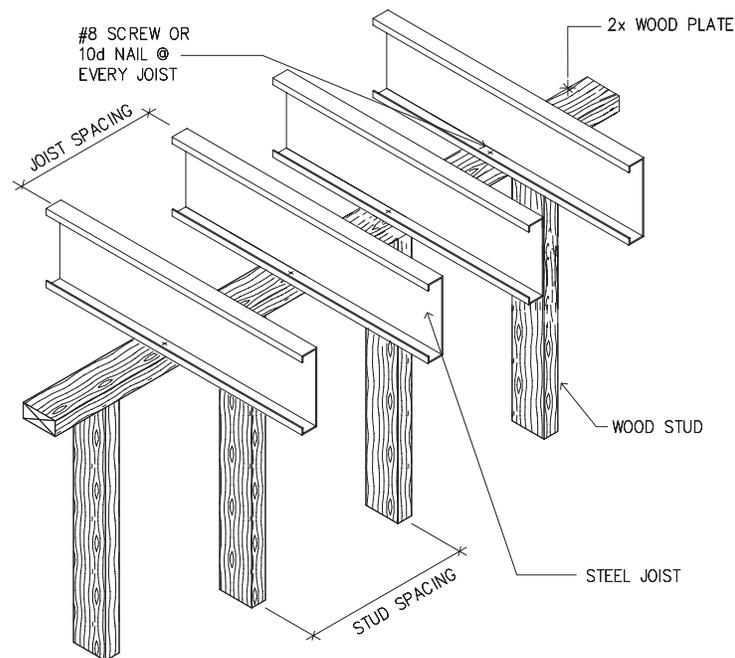
- Steel joists need not be aligned with studs below when double wood plates are used.
- Web stiffeners are not required over the bearing wall (unless a bearing wall is constructed above), provided that the joists overlap a minimum of 6 inches.
- Steel joist span tables can be found in the *International Residential Code* or the *Prescriptive Method*.
- Blocking between the steel joists is not required.
- 10d nail can be used in lieu of #8 screws to fasten the joists to top wood plate.



5 Hybrid Connection Details

Title: Nonstructural Wood Wall Perpendicular to Steel Joist

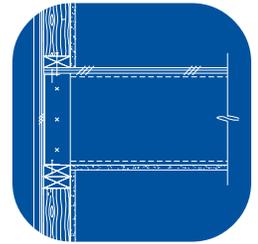
Detail No. F6



Data:

Commentary:

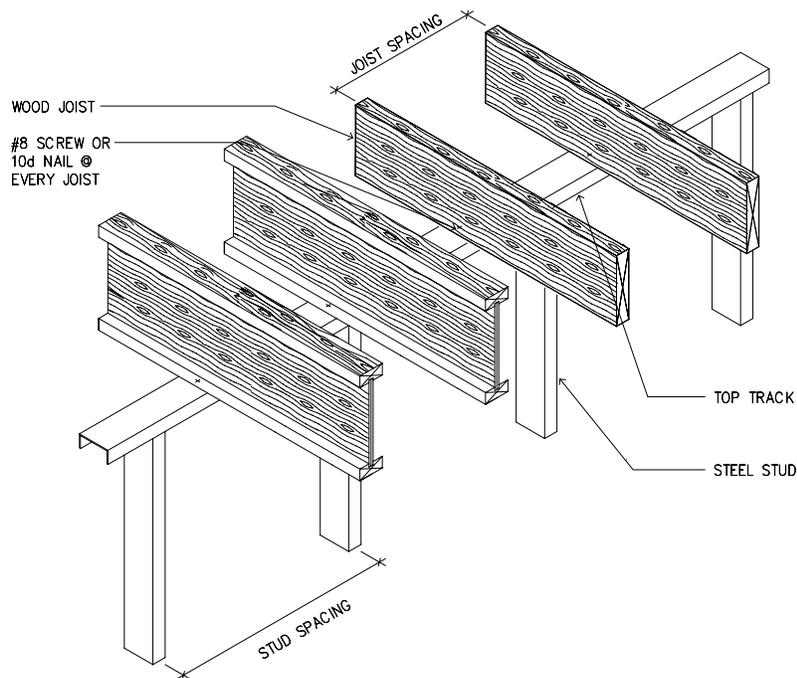
- Bearing stiffeners are not required for steel joists at top wood plate.
- Wood studs need not be aligned with steel joists above.



5 Hybrid Connection Details

Title: Nonstructural Steel Wall Perpendicular to Wood Joist

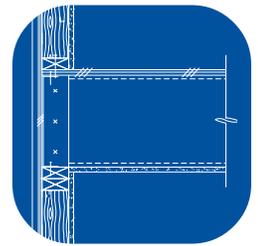
Detail No. F7



Data:

Commentary:

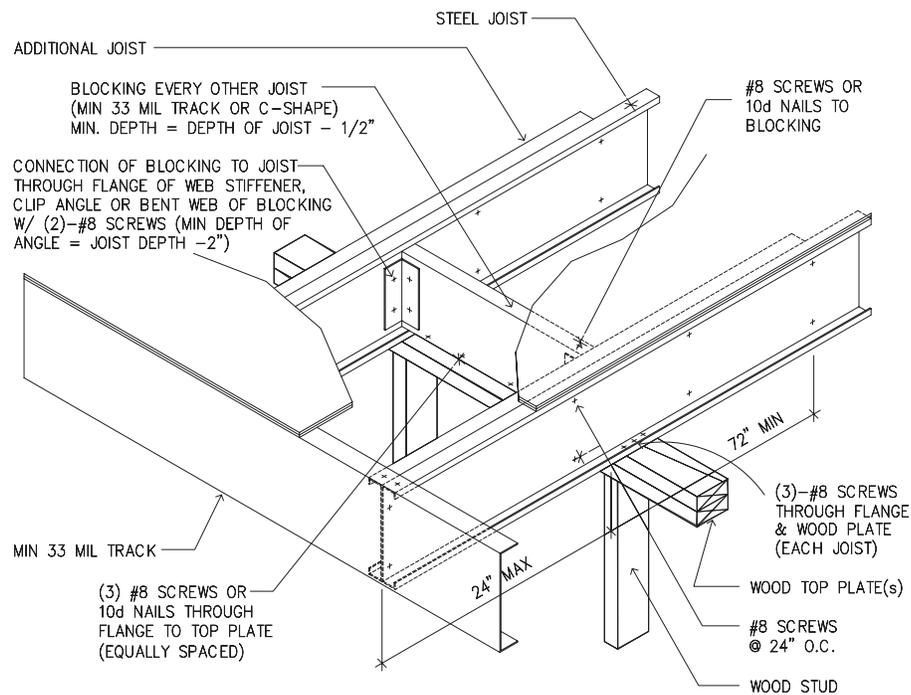
- Care is required so that no vertical (bending) load is applied on the steel top track.
- Steel studs need not be aligned with joists above.
- Nails or screws can be oriented upwards or downwards (i.e., driven in either orientation). Toe nails are also permitted.



5 Hybrid Connection Details

Title: Wood Wall Supporting Cantilevered Steel Floor
(Cantilever Supporting One Floor and Roof)

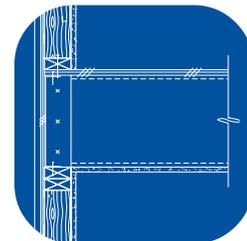
Detail No. F8



Data:

Commentary:

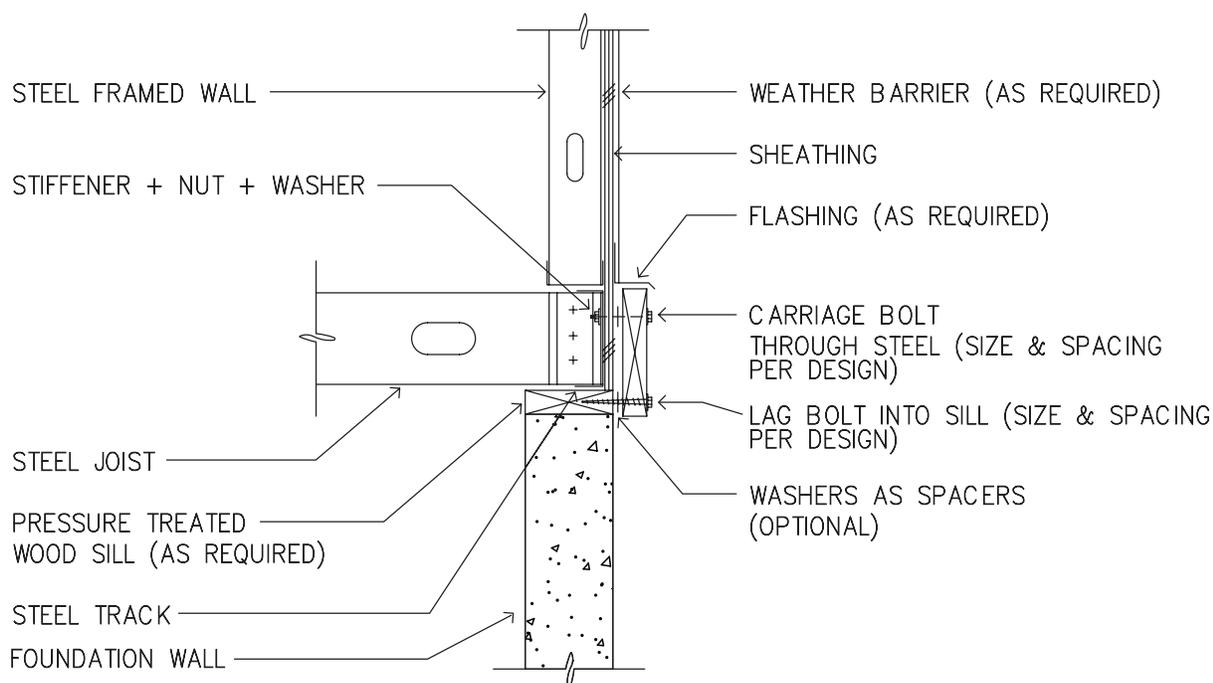
- This detail is applicable to the first story of a two-story building.
- Steel joists need not be aligned with studs below when double wood plates are used.
- Web stiffeners are required at all support and bearing locations for steel joists unless designed otherwise.
- Steel joist span tables can be found in the *International Residential Code* or the *Prescriptive Method*.
- Blocking of steel joists is required between every other joist.



5 Hybrid Connection Details

Title: Deck Ledger Board Connection (Steel Floor and Wall)

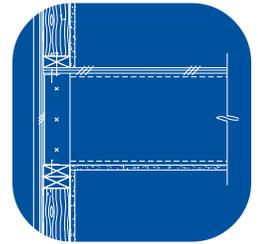
Detail No. F9



Data:

Commentary:

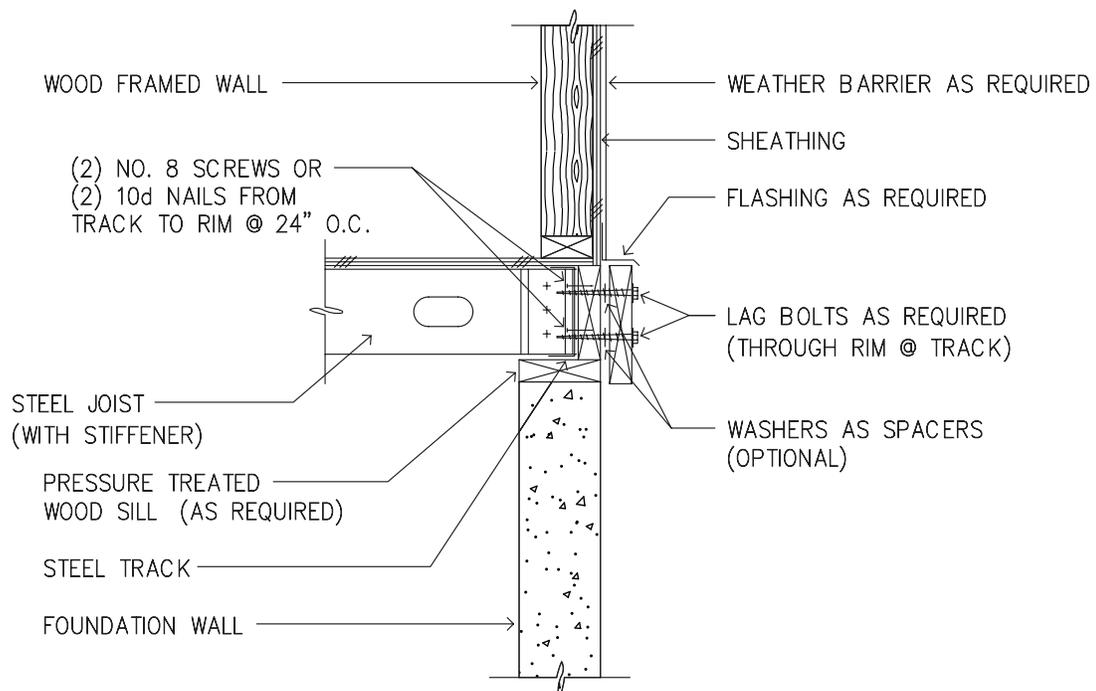
- Web stiffeners are required at all support and bearing locations for steel joists unless designed otherwise.
- Steel joist span tables can be found in the *International Residential Code* or the *Prescriptive Method*.



5 Hybrid Connection Details

Title: Deck Ledger Board Connection (Steel Floor and Wood Wall)

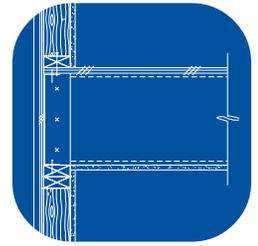
Detail No. F10



Data:

Commentary:

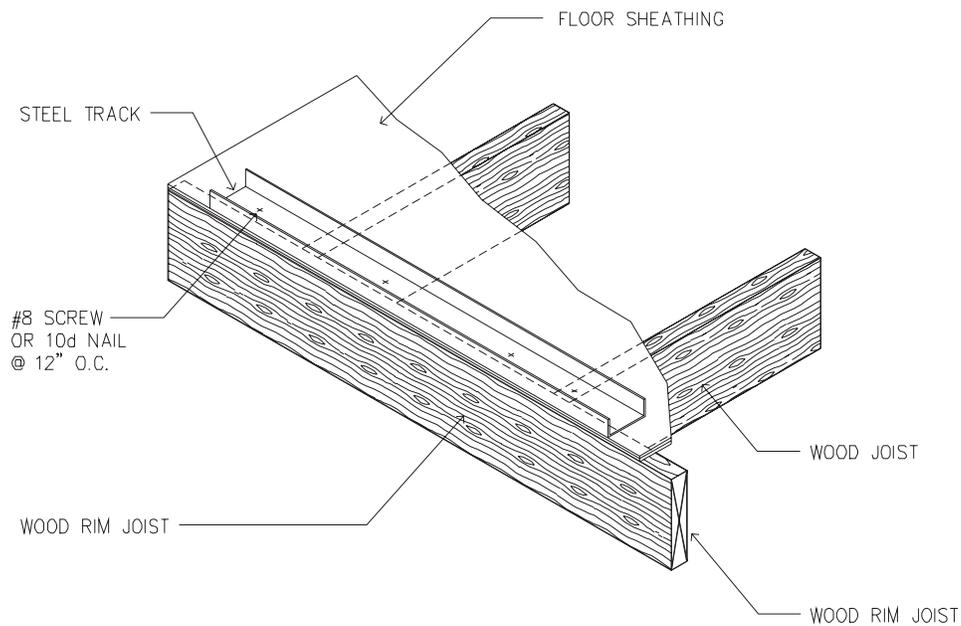
- Web stiffeners are required at all support and bearing locations for steel joists unless designed otherwise.
- Steel joist span tables can be found in the *International Residential Code* or the *Prescriptive Method*.



5 Hybrid Connection Details

Title: Steel Track to Sheathed Wood Floor Detail

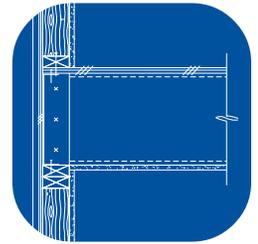
Detail No. F11



Data:

Commentary:

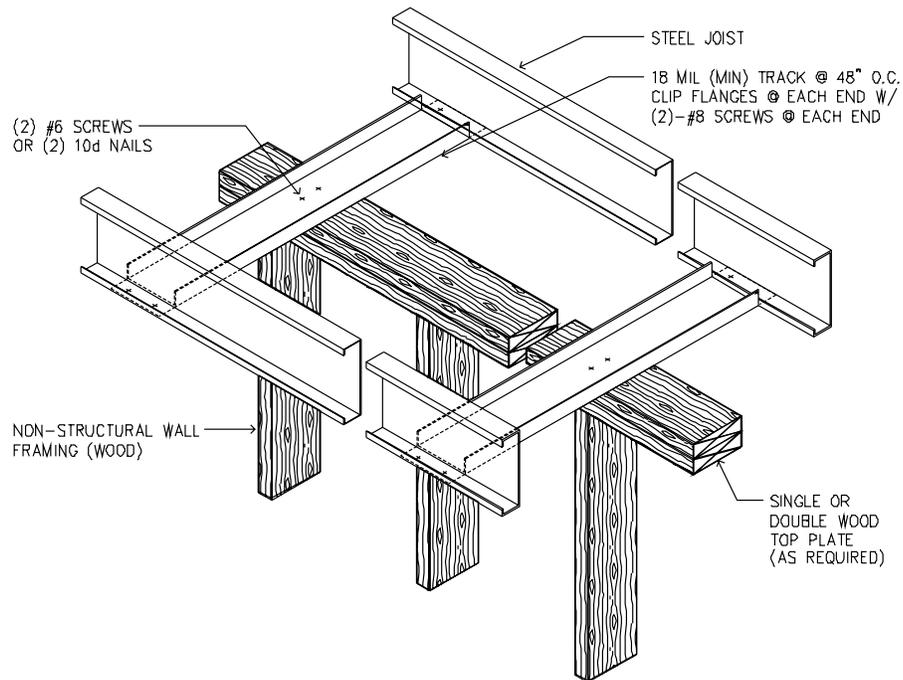
- Additional fasteners may be required for high-wind and seismic regions.
- Screws used to fasten the track to the rim joist should have a flat bottom on the head (not the countersunk variety).



5 Hybrid Connection Details

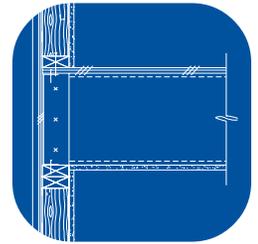
Title: Wood Interior Nonstructural Wall to Steel Joist or Truss

Detail No. F12



Data:

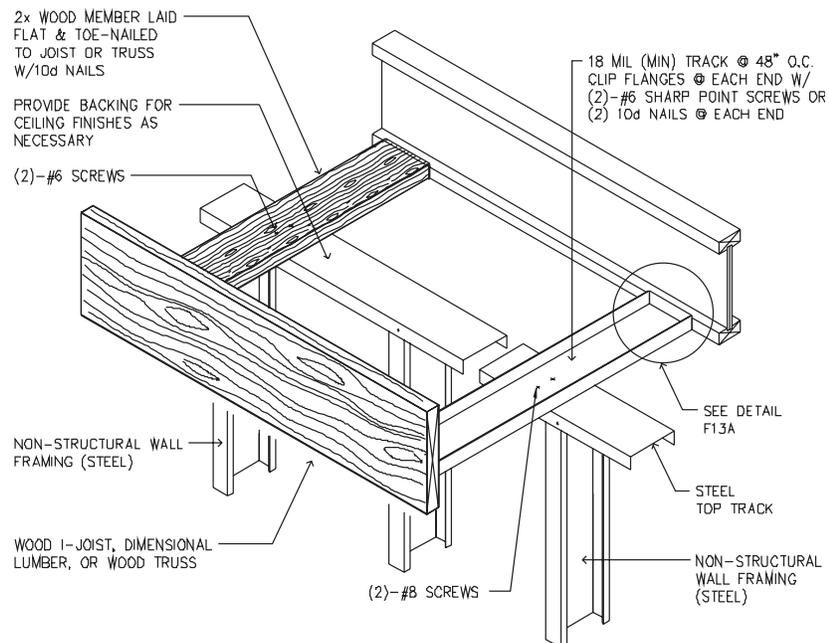
Commentary:



5 Hybrid Connection Details

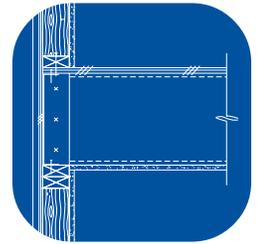
Title: Steel Interior Nonstructural Wall Parallel to Wood Joist or Truss

Detail No. F13



Data:

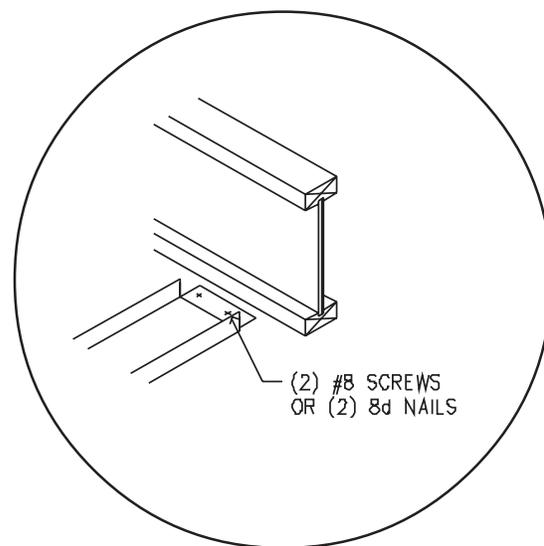
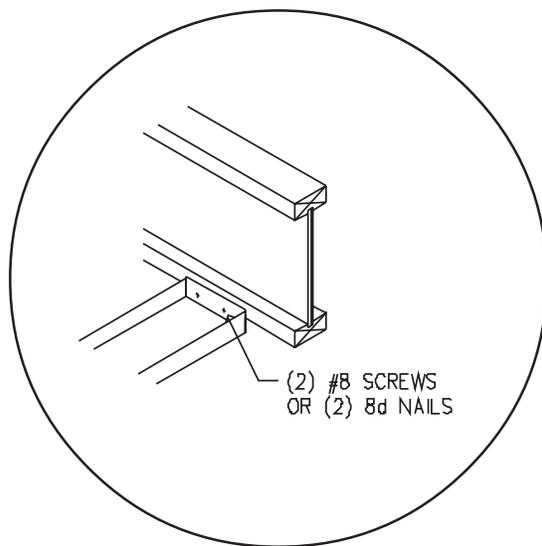
Commentary:



5 Hybrid Connection Details

Title: Track to Joist or Truss Connection for Interior Nonstructural Walls

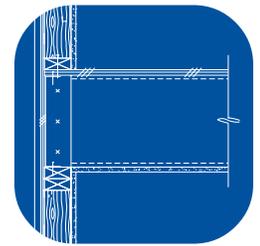
Detail No. F13a



Data:

Commentary:

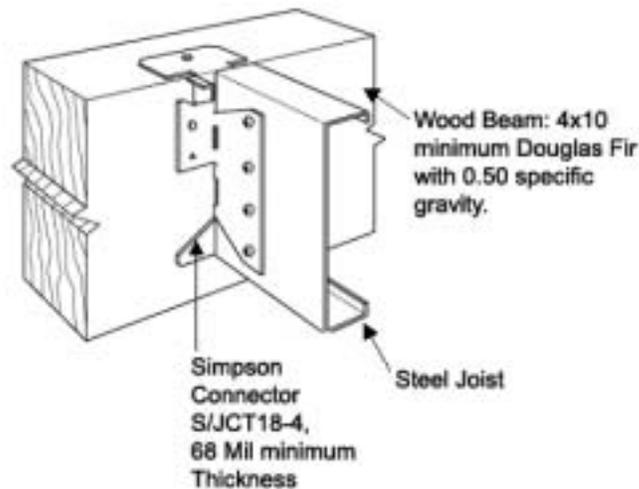
- The 2x wood member can be toe nailed or end nailed to the joists or trusses.



5 Hybrid Connection Details

Title: Specialty Connector for Steel Joist to Wood Beam Detail

Detail No. F14



Data:

Manufacturer's Model No.	Fasteners		Steel Joist	Maximum Allowable Load (lbs.)
	Wood Beam			
	Top	Face		
Straight Hanger				
S/JCT18-4 (Min.)	1 10d Nail	2 10d Nails	4 #10 Screws	880
S/JCT18-4 (Max.)	1 10d Nail	4 10d Nails	4 #10 Screws	1,280
Skew Hanger				
S/JCT18-4	1 10d Nail	2 10d Nails	4 #10 Screws	840

Commentary:

- Steel joist span tables can be found in the *International Residential Code* or the *Prescriptive Method*.
- Steel joist shall be laterally braced per designer specification.
- No load duration increase allowed.
- Use round holes for minimum load, use round and triangular holes for maximum load.
- Field skewable up to 45° left or right.



5 Hybrid Connection Details

5.3 Wall Details

Similar to floor framing, steel and wood wall construction typically follow the conventional construction method. The reference documents that are commonly used for wall construction (size, thickness, details, fastening, and so forth) are:

- *Standard for Cold-Formed Steel Framing—Prescriptive Method for One- and Two-Family Dwellings* [1]
- *International Residential Code, IRC 2000* [3]
- *1995 CABO One- and Two-Family Dwelling Code* [2]
- *1998 International One and Two Family Dwelling Code* [6]
- *Wood Frame Construction Manual* [28]
- *Shearwall Design Guide* [31]
- *Standard for Cold Formed Steel Framing—Header Design* [32]
- *L-Header Field Guide* [33]
- *Builder’s Steel Stud Guide* [34]
- *Low-Rise Residential Construction Details* [35]
- *Fastener Loads for Plywood—Screws* [26]

Users can also refer to manufacturer’s installation instructions and catalogs for framing steel walls. Wall design requires the knowledge of certain load and design parameters such as:

- Snow load
- Wind load
- Live and dead loads
- Seismic loads
- Deflection criteria

These design parameters are typically contained in the local building code. Users should check with their building department for such loads. In the absence of local code requirements, ASCE 7 [4] loads should be used.

Span tables provided in this section are based on the applicability limits of Table 2.1.

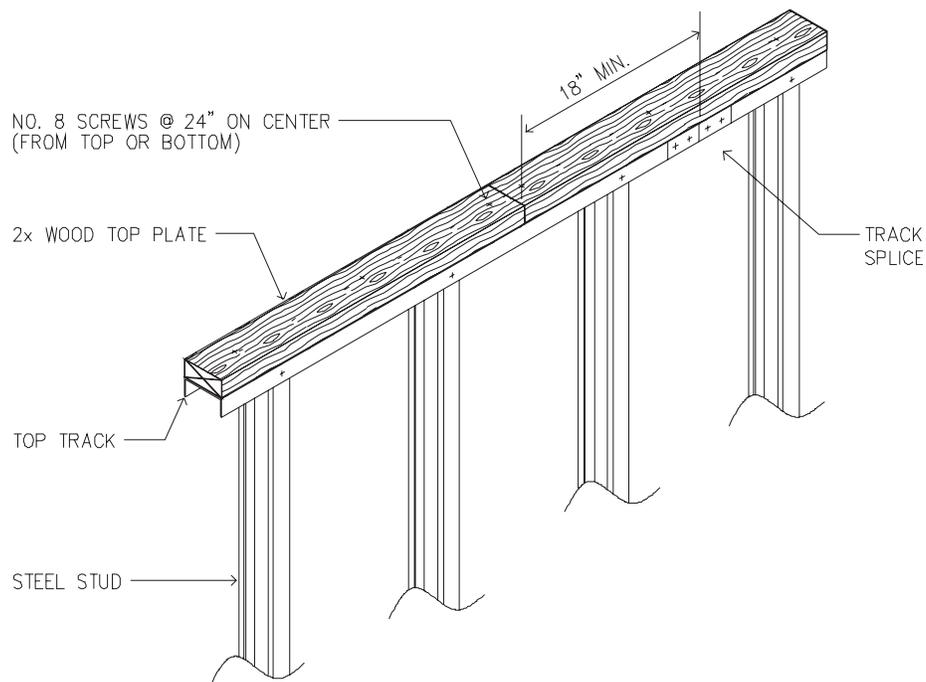
It is essential that you review the limitations of each published document and evaluate its applicability for each project.



5 Hybrid Connection Details

Title: Wood Top Plate to Steel Wall Detail

Detail No. W1



Data:

See next page.

Commentary:

- Refer to Detail W2 for multiple wood top plate splice detail.
- Refer to Detail W4 for steel splice detail.



5 Hybrid Connection Details

Title: Wood Top Plate to Steel Wall Detail–*continued*

Detail No. W1

Data:

The ultimate capacity of a top load bearing track (350T125-33) with 2x4 wood top plate had been determined by testing to be 6,084 lb. [36]. For ASD, the allowable design capacity shall be determined by multiplying the ultimate capacity by a factor of safety of 1.90. For LRFD, the design capacity shall be determined by multiplying the ultimate capacity by a factor 0.74.

Minimum Thickness (Mil) of Load-Bearing Top Track¹

Building Width (feet)	Track Under Roof and Ceiling Only or Track Under One Floor, Roof and Ceiling			
	Ground Snow Load ² (psf)			
	20	30	50	70
Up to 40 Feet	350T125-33			

For SI: 1 mil = 1/1000 inch = 0.0254 mm, 1 psf = 4.88 kg/m².

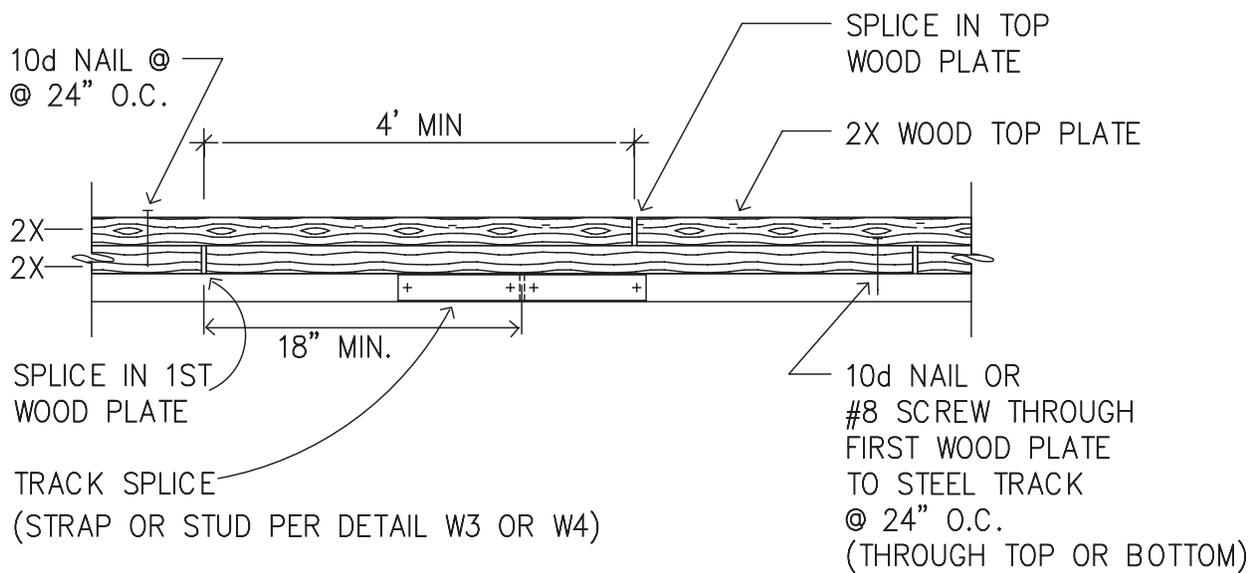
¹Values are applicable for framing member spacing not greater than 24 inches (610 mm) on center and all Prescriptive Method applicability limits. Values also apply to top tracks over center load bearing walls. Maximum roof overhang is 2 feet (610 mm).



5 Hybrid Connection Details

Title: Typical Wall Top Track Splice: Double Wood Top Plates and Steel Track Splice Detail

Detail No. W2



Data:

Commentary:

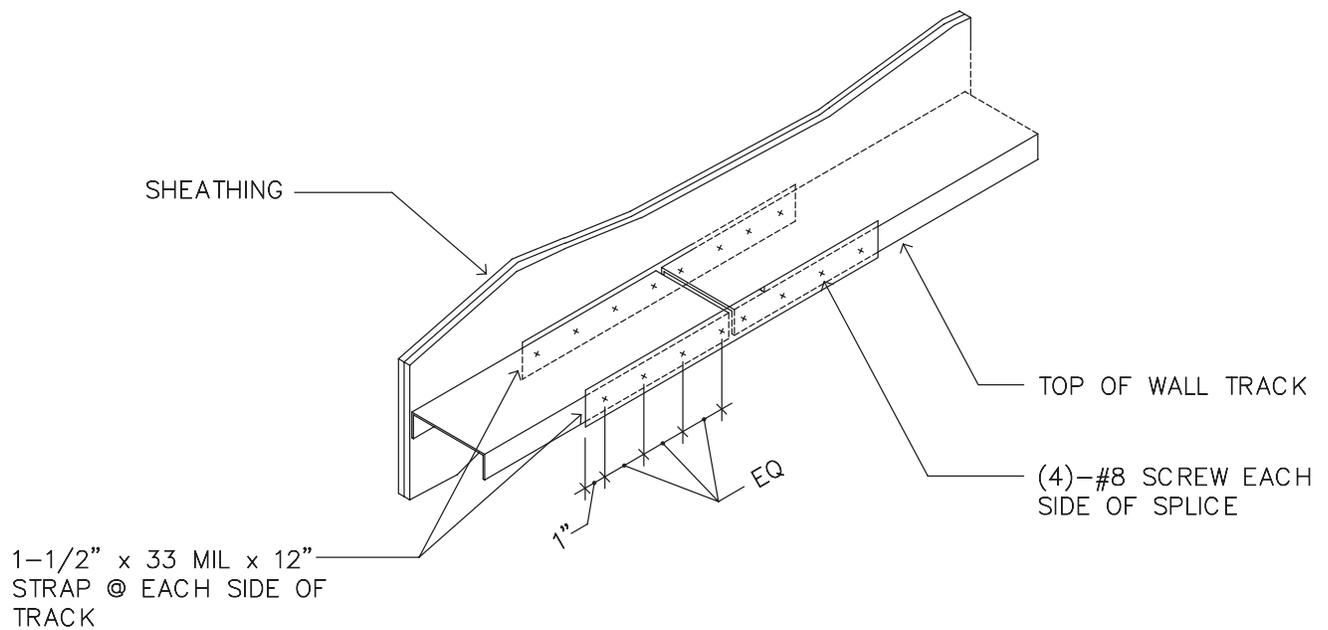
- Refer to Detail W3 and W4 for splice dimensions.



5 Hybrid Connection Details

Title: Steel Track Splice

Detail No. W3



Data:

Commentary:

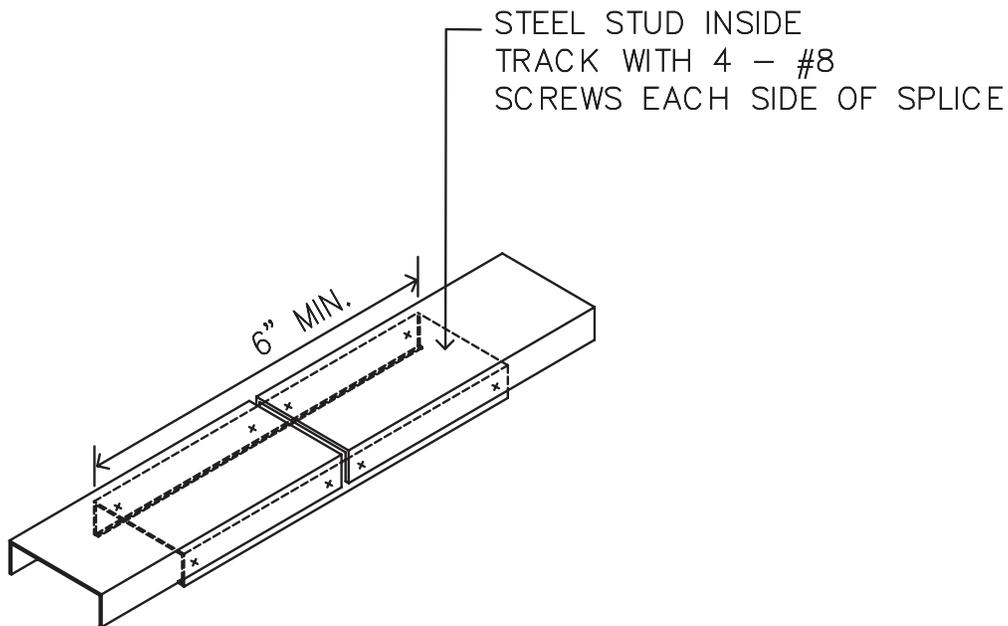
- Refer to Detail W2 and W4 for splice dimensions.



5 Hybrid Connection Details

Title: Typical Wall Top Track Splice

Detail No. W4



Data:

Commentary:

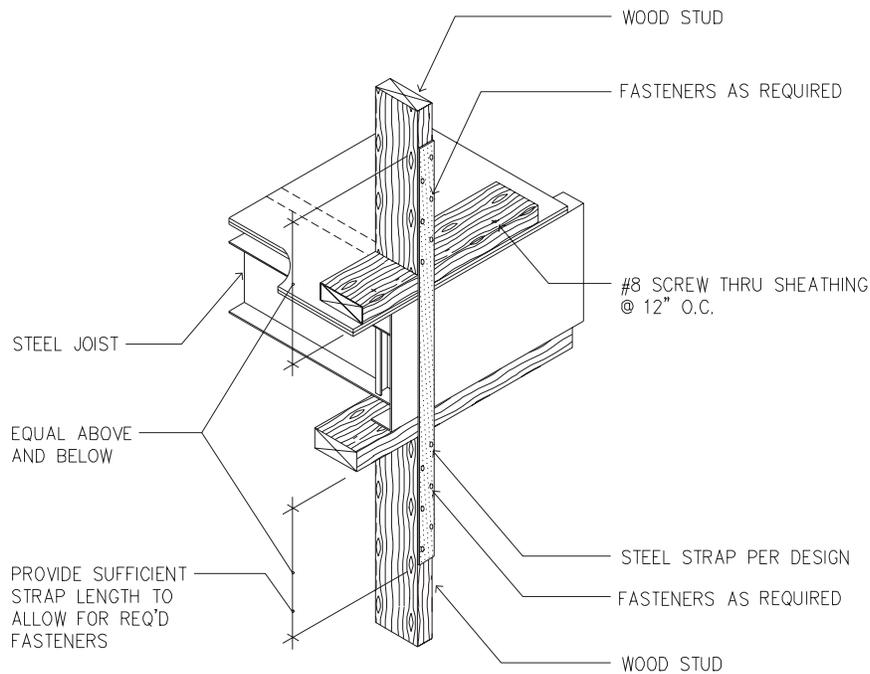
- Screws can be applied through flanges or through webs.
- Steel stud shall be the same thickness as steel track.
- Refer to Detail W2 and W3 for splice dimensions.



5 Hybrid Connection Details

Title: Floor to Wall Strap Holdown (Steel Floor)

Detail No. W5

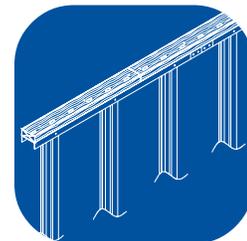


Data:

Strap Thickness		F _y (ksi)	Strap Capacity (lbs.)			
Mil	Gauge		1-Inch Strap	1½-Inch Strap	2-Inch Strap	3-Inch Strap
33	20	50	1,030	1,550	2,070	3,110
43	18	50	1,340	2,020	2,690	4,040
54	16	50	1,690	2,540	3,390	5,080
68	14	50	2,130	3,200	4,260	6,400
97	12	50	3,040	4,560	6,080	9,130
118	10	50	3,710	5,570	7,430	11,150

For SI: 1 inch = 25.4 mm, 1 lb. = 4.448 N.
 Values are based on 50 ksi minimum yield strength and 65 ksi minimum tensile strength.

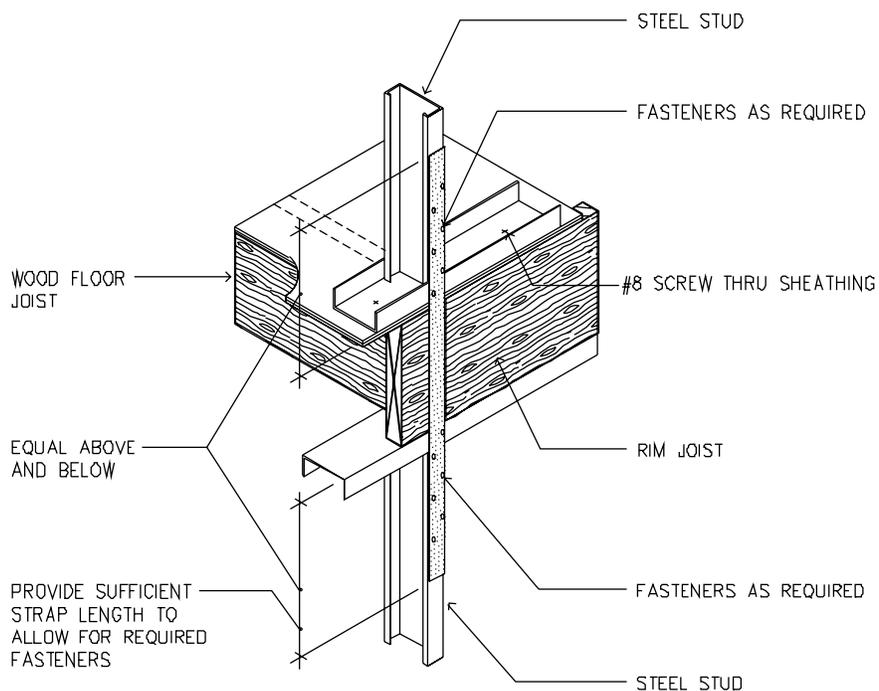
Commentary:



5 Hybrid Connection Details

Title: Wood Floor to Steel Wall Strap Holddown

Detail No. W6



Data:

Strap Thickness		F _y (ksi)	Strap Capacity (lbs.)			
Mil	Gauge		1-Inch Strap	1½-Inch Strap	2-Inch Strap	3-Inch Strap
33	20	50	1,030	1,550	2,070	3,110
43	18	50	1,340	2,020	2,690	4,040
54	16	50	1,690	2,540	3,390	5,080
68	14	50	2,130	3,200	4,260	6,400
97	12	50	3,040	4,560	6,080	9,130
118	10	50	3,710	5,570	7,430	11,150

For SI: 1 inch = 25.4 mm, 1 lb. = 4.448 N.
 Values are based on 50 ksi minimum yield strength and 65 ksi minimum tensile strength.

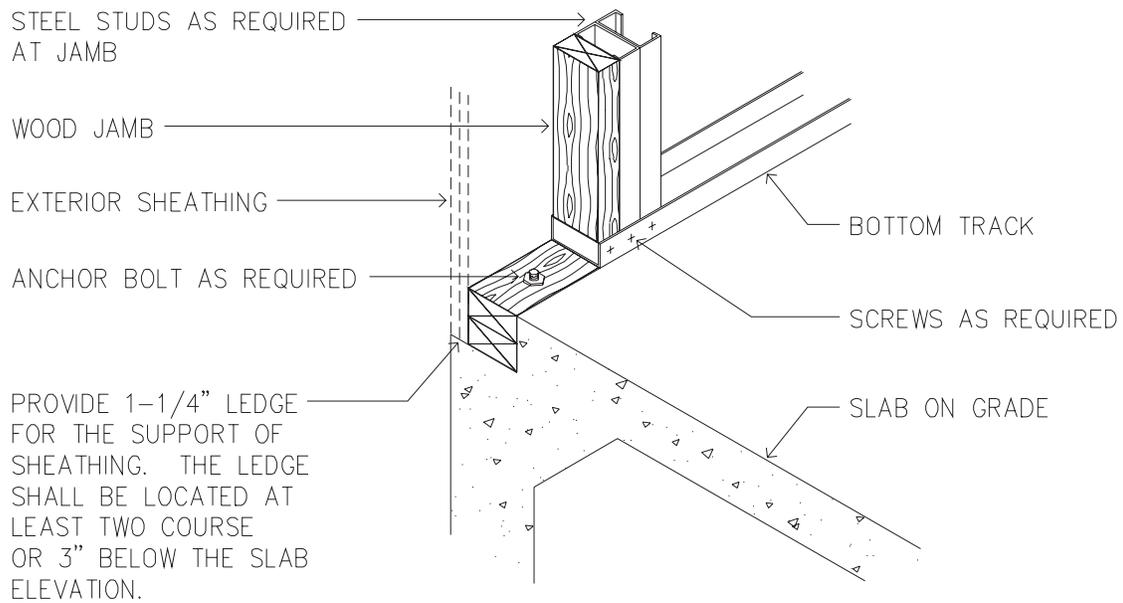
Commentary:



5 Hybrid Connection Details

Title: Door Jamb Base at Slab on Grade

Detail No. W7



Data:

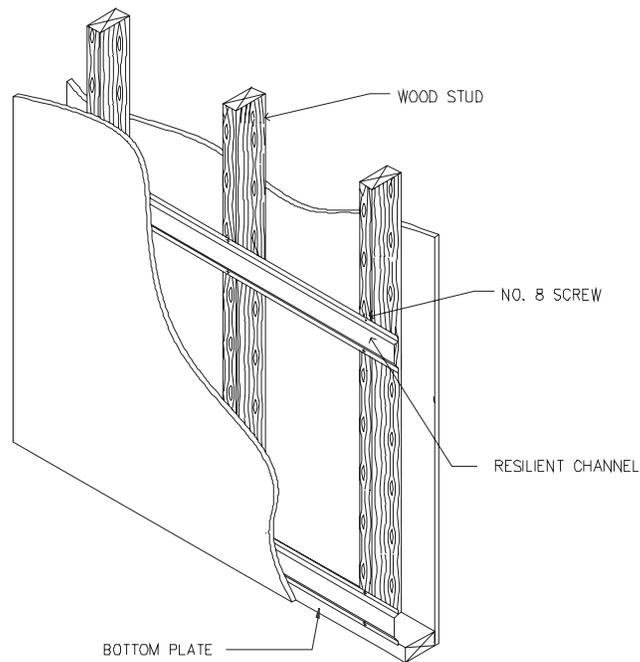
Commentary:



5 Hybrid Connection Details

Title: Resilient Channel to Wall Stud Detail

Detail No. W8



Data:

Commentary:

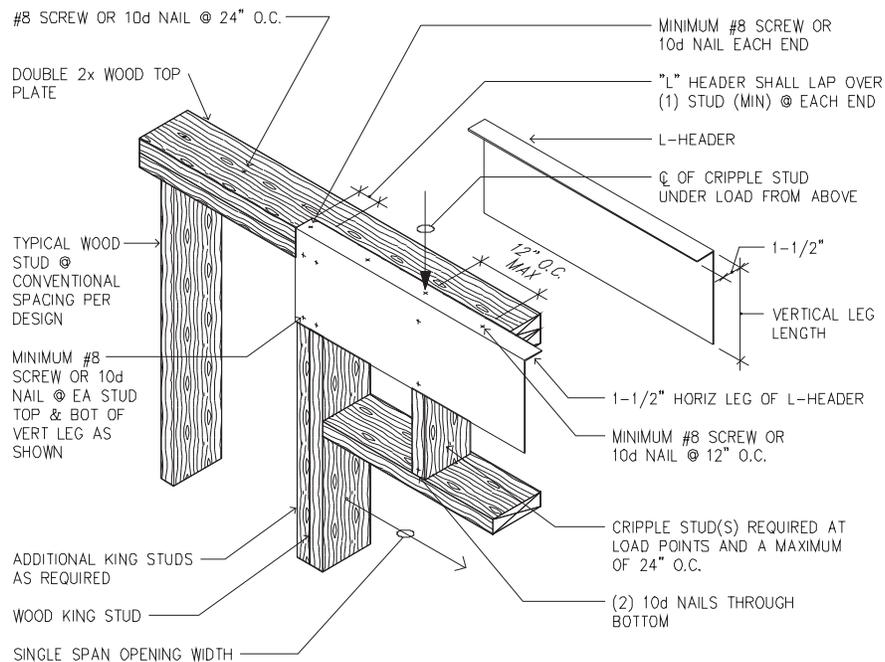
- This detail is commonly used in light commercial construction when a specified sound rating is required.
- Refer to Gypsum Association's *Fire Resistance Design Manual* [37].



5 Hybrid Connection Details

Title: Double L-Shaped Steel Header to Wood Wall Detail

Detail No. W9



Data:

Ultimate Capacity for Double L-Header with Wood Wall¹ [38]

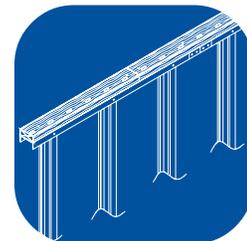
600L150-33	600L150-43
5548 lb.	7349 lb.

For SI: 1 inch = 25.4 mm, 1 lb. = 4.448 N.
¹For ASD allowable capacity, use a factor of safety of 1.95.
 For LRFD design capacity use a phi factor of 0.75

Data continued on next page.

Commentary:

- Prescriptive tables shown for headers up to 4 feet wide. No available design procedure or tables available for openings greater than 4 feet wide.



5 Hybrid Connection Details

Title: Double L-Shaped Steel Header to Wood Wall Detail-
continued

Detail No. W9

Data:

Minimum Thickness (Mil) of 600L150 Double L-Shaped Headers for Openings Not Greater than 4 Feet (Headers Supporting Roof and Ceiling Only)

Building Width ¹ (feet)	Ground Snow Load (psf)			
	20	30	50	70
24	33	33	33	43
28	33	33	33	43
32	33	33	43	43
36	33	33	43	43
40	33	43	43	43

For SI: 1 mil = 1/1000 inch = 25.4 mm, 1 foot = 305 mm, 1 psf = 0.0479 kN/m².
¹Building width is in the direction of horizontal framing members supported by the wall studs.

Minimum Thickness (Mil) of 600L150 Double L-Shaped Headers for Openings Not Greater than 4 Feet (Headers Supporting One Floor, Roof, and Ceiling)

Building Width ¹ (feet)	Ground Snow Load (psf)			
	20	30	50	70
24	43	43	43	43
28	43	43	43	43
32	43	43	43	43
36	43	43	43	43
40	43	43	43	43

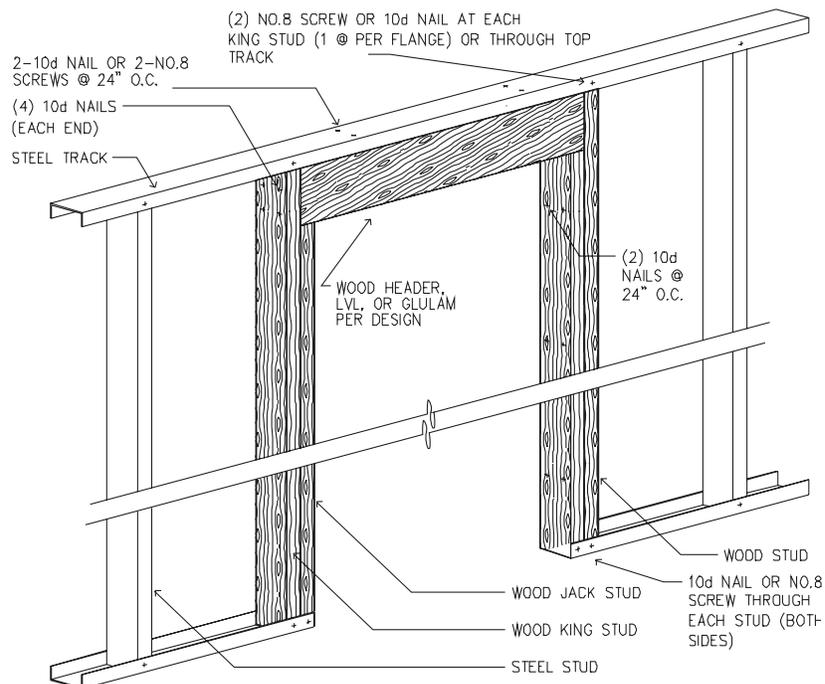
For SI: 1 mil = 1/1000 inch = 25.4 mm, 1 foot = 305 mm, 1 psf = 0.0479 kN/m².
¹Building width is in the direction of horizontal framing members supported by the wall studs.



5 Hybrid Connection Details

Title: Wood Header Assembly to Steel Wall Detail

Detail No. W10



Data:

Commentary:

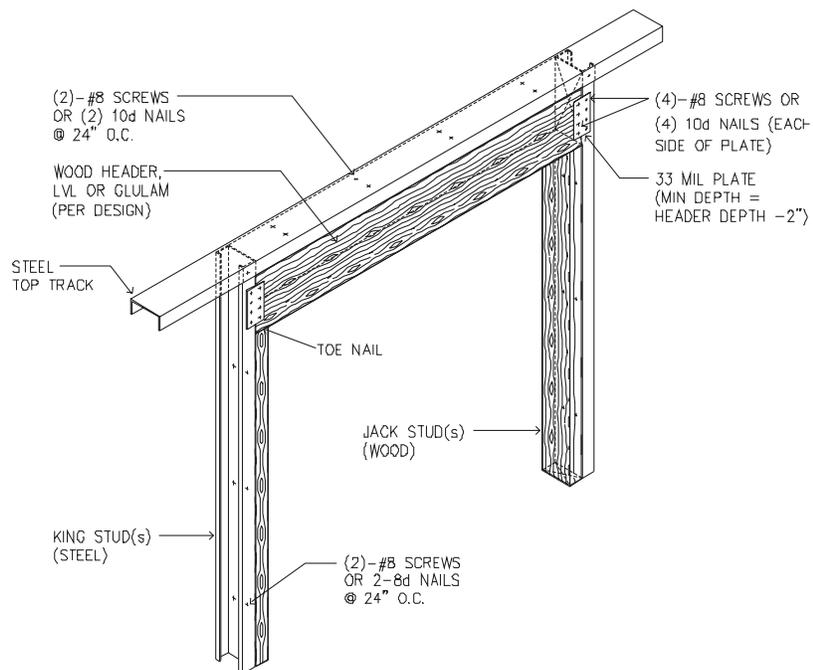
- Wood header size can be obtained from the *International Residential Code* or other approved documents.
- The number of jack and king studs varies depending on the header and opening size.



5 Hybrid Connection Details

Title: Wood Header to Steel Wall Detail

Detail No. W11



Data:

Commentary:

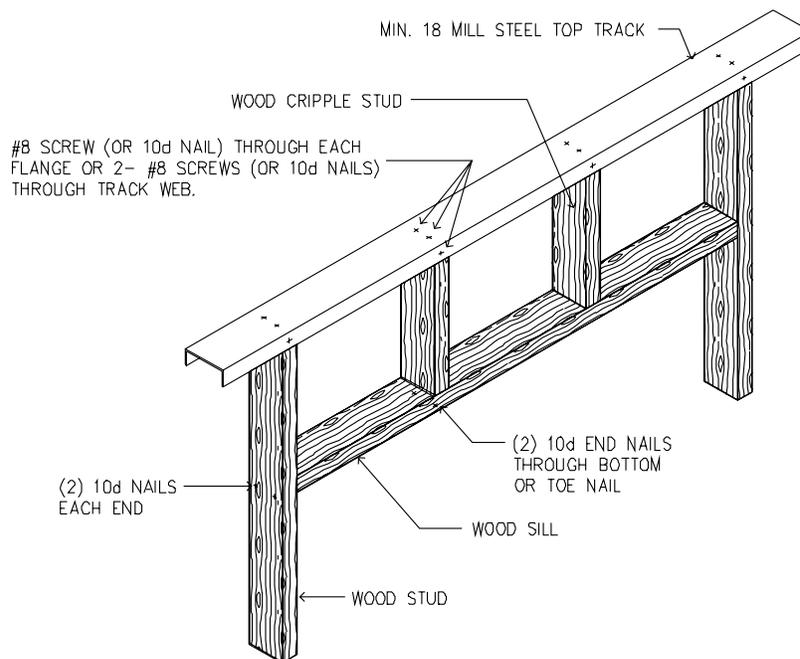
- Wood header size can be obtained from the *International Residential Code* or other approved documents.
- The number of jack and king studs varies depending on the header and opening size.



5 Hybrid Connection Details

Title: Nonstructural Header Detail with Steel Top Rack

Detail No. W12



Data:

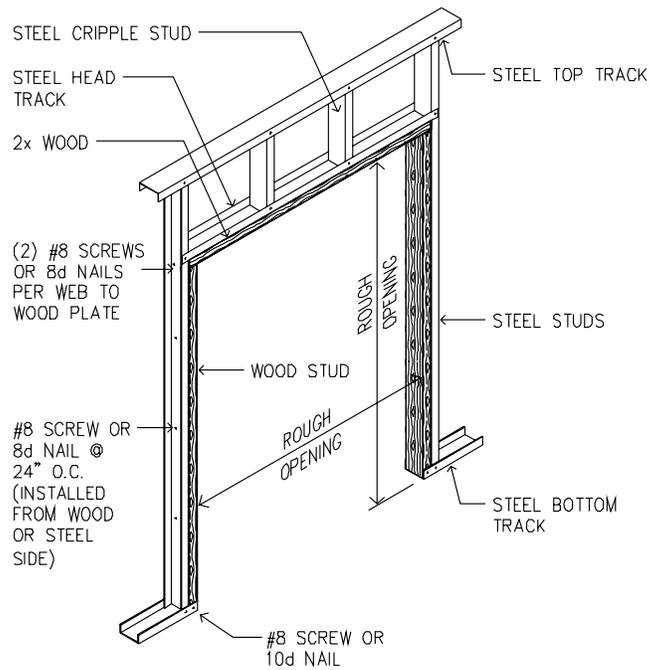
Commentary:



5 Hybrid Connection Details

Title: Nonstructural Steel Opening Detail Bucked with Wood

Detail No. W13



Data:

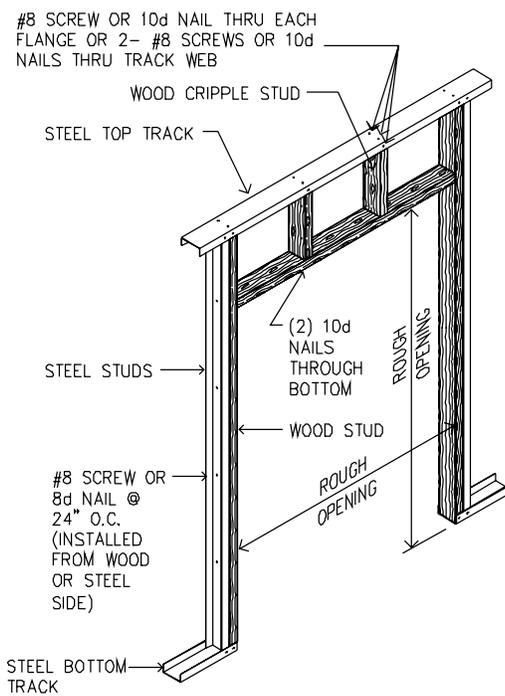
Commentary:



5 Hybrid Connection Details

Title: Nonstructural Steel Opening Detail Bucked with Wood (Alternative Detail)

Detail No. W14



Data:

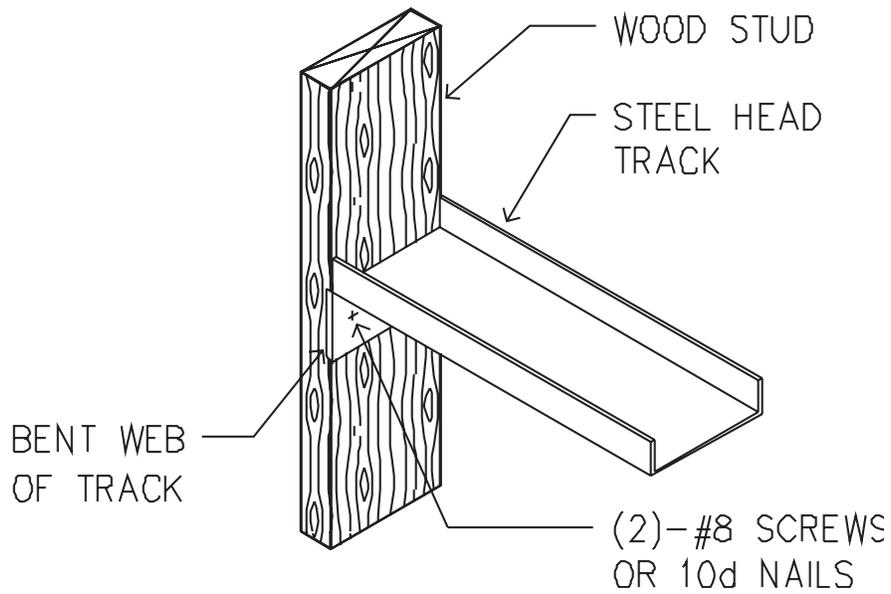
Commentary:



5 Hybrid Connection Details

Title: Head Track to Wood Stud Connection

Detail No. W15



Data:

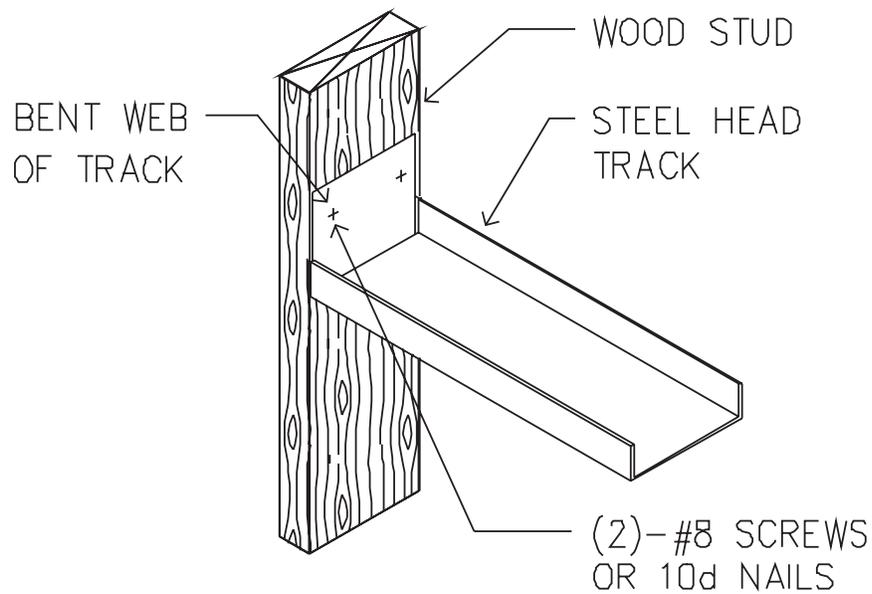
Commentary:



5 Hybrid Connection Details

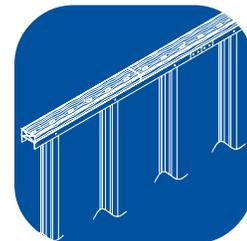
Title: Head Track Connection to Wood Stud (Alternative Detail)

Detail No. W16



Data:

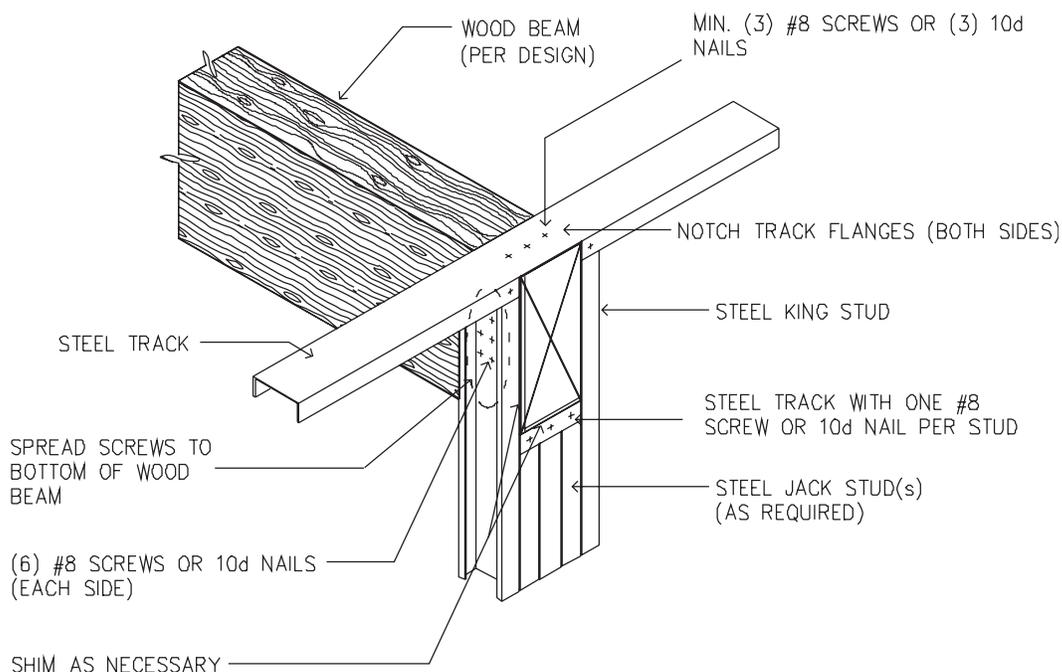
Commentary:



5 Hybrid Connection Details

Title: Wood Beam in Steel Wall Detail

Detail No. W17



Data:

Jack Stud Designation	Jack Stud Allowable Capacity ¹ (lbs.)		
	8-Foot	9-Foot	10-Foot
350S162-33	2,276	2,031	1,788
350S162-43	3,096	2,766	2,444
350S162-54	4,000	3,551	3,116
350S162-68	4,972	4,440	3,927
550S162-33	2,720	2,532	2,346
550S162-43	3,740	3,499	3,249
550S162-54	4,960	4,650	4,323
550S162-68	6,607	6,175	5,719

For SI: 1 ft. = 0.3 m, 1 lb. = 4.448 N.
¹Axial capacity is based on stud height of 1 foot less than the height of the stud shown with mid-height bracing.

Commentary:

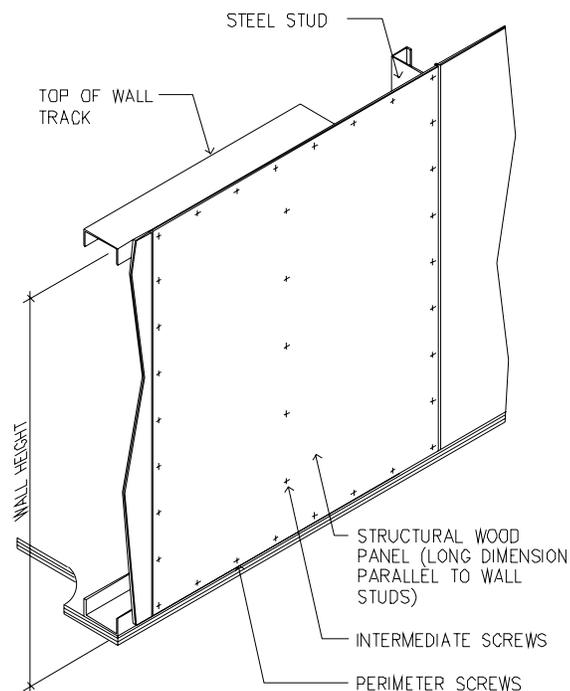
- Wood beam (or header) size can be obtained from the *International Residential Code* or manufacturer's catalog.



5 Hybrid Connection Details

Title: Wood Structural Panel Attachment to Structural Wall (Sheathing Parallel to Stud)

Detail No. W18

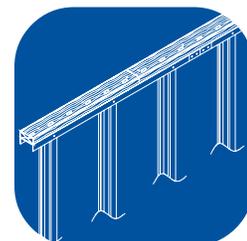


Data:

See next page.

Commentary:

- The *Prescriptive Method* shear wall table requires sheathing to be fastened to steel studs at 6 inches on-center at perimeter and 12 inches on-center at intermediate supports.



5 Hybrid Connection Details

Title: Wood Structural Panel Attachment to Structural Wall (Sheathing Parallel to Stud)-*continued*

Detail No. W18

Data:

Nominal Shear Value (lbs/ft) for Shear Walls Framed with Cold-Formed Steel with Maximum On-Center Framing Spacing of 24 Inches^{1,2,4}

For Wind Forces								
Assembly Description	Spacing of Fasteners at Panel Edges ³							
	2		3		4		6	
	1997 UBC	2000 IBC	1997 UBC	2000 IBC	1997 UBC	2000 IBC	1997 UBC	2000 IBC
¹⁵ / ₃₂ -inch Structural 1 Sheathing (4-ply) One Side	—	—	—	—	—	—	1,065 ⁴	1,065 ⁴
⁷ / ₁₆ -inch Rated Sheathing (OSB) One Side	1,910	1,910	1,735	1,735	1,410	1,410	910 ⁴	910 ⁴

For Seismic Forces								
Assembly Description	Spacing of Fasteners at Panel Edges ³							
	2		3		4		6	
	1997 UBC	2000 IBC	1997 UBC	2000 IBC	1997 UBC	2000 IBC	1997 UBC	2000 IBC
¹⁵ / ₃₂ -inch Structural 1 Sheathing (4-ply) One Side	1,625	1,625	1,465	1,465	990	990	780	780
⁷ / ₁₆ -inch Rated Sheathing (OSB) One Side	1,625	1,625	1,275	1,275	915	915	700	700

¹Nominal shear values shall be multiplied by the appropriate resistance factor to determine design strength or divided by the appropriate safety factor to determine allowable shear values.

²Unless otherwise shown, studs shall be a minimum 350S162-33 (maximum spacing is 24 inches on-center). Tracks shall be a minimum 350T125-33. Both studs and tracks shall conform to ASTM A 446 Grade A (or ASTM A 653, SQ, Grade 33). Framing screws shall be # 8 by ⁵/₈-inch (16 mm) wafer head self-drilling. Plywood and OSB screws shall be a minimum # 8 by 1-inch (25 mm) flat head with a minimum head diameter of 0.292 inch (7.4 mm).

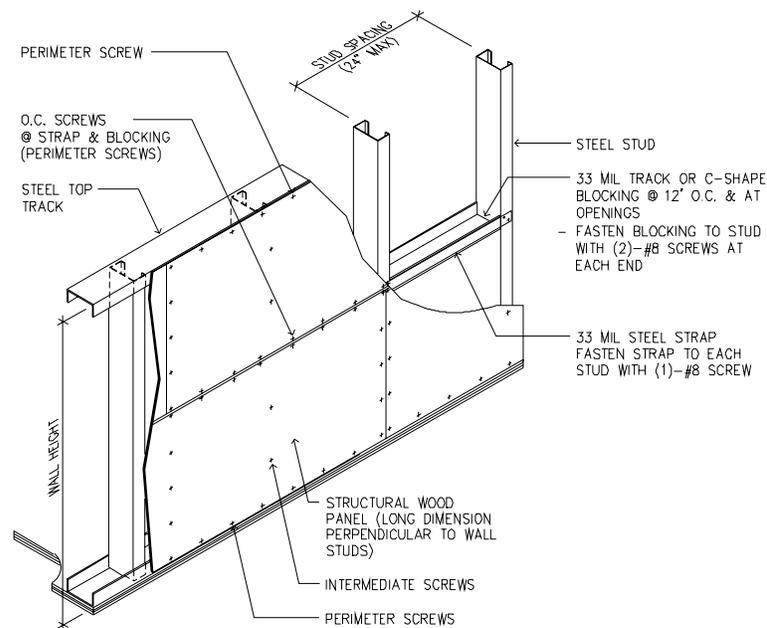
³Screws in the field of the panel shall be installed 12 inches on-center (305 mm) unless otherwise shown.

⁴Nominal shear values shown may be increased by 30% where fully blocked gypsum board is applied to the opposite side of the assembly (7-inch-maximum on-center screw spacing).

5 Hybrid Connection Details

Title: Wood Structural Panel Attachment to Structural Wall (Sheathing Perpendicular to Studs)

Detail No. W19

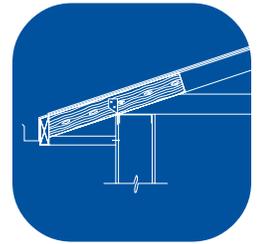


Data:

Same as Data for W18.

Commentary:

- The *Prescriptive Method* shear wall table requires sheathing to be fastened to steel studs at 6 inches on-center at the perimeter and 12 inches on-center at intermediate supports.



5 Hybrid Connection Details

5.4 Roof Framing Details

Roof framing can be divided into two categories:

- Rafters and ceiling joists
- Roof trusses

The building code typically specifies rafters and ceiling joists, span tables, provisions, and connection details. Roof trusses are usually pre-engineered components.

The reference documents commonly used for roof construction (size, thickness, details, fastening, and so forth) are:

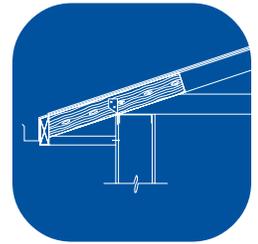
- *Standard for Cold Formed Steel Framing—Prescriptive Method for One- and Two-Family Dwellings* [1]
- *International Residential Code, IRC 2000* [3]
- *1995 CABO One- and Two-Family Dwelling Code* [2]
- *Wood Frame Construction Manual* [28]
- *Low-Rise Residential Construction Details* [35]
- *Standard for Cold-Formed Steel Framing—Truss Design* [39]
- TPI’s *National Design Standard for Metal Plate Connected Wood Truss Construction* (ANSI/TPI 1) [40].
- *Field Installation for Cold-Formed Steel Roof Trusses* [41].
- DSB-89: *Recommended Design Specification for Temporary Bracing of Metal Plate Connected Wood Trusses* [42].
- HIB-91 “Booklet”: *Commentary & Recommendations for Handling, Installing & Bracing Metal Plate Connected Wood Trusses* [43].
- *Design Guide for Construction Bracing of Cold-Formed Steel Trusses* [44].
- *Specifying Pre-Engineered Cold-Formed Steel Roof and Floor Trusses* [45].

For framing steel floors, users can also refer to manufacturer’s installation instructions and catalogs. Roof design requires the knowledge of certain load and design parameters such as:

- Snow load
- Wind load
- Live and dead loads
- Seismic loads
- Deflection criteria
- Roof pitch

These design parameters are typically contained in the local building code. Users should check with their building department for such loads. In the absence of local code requirements, ASCE 7 [4] loads should be used.

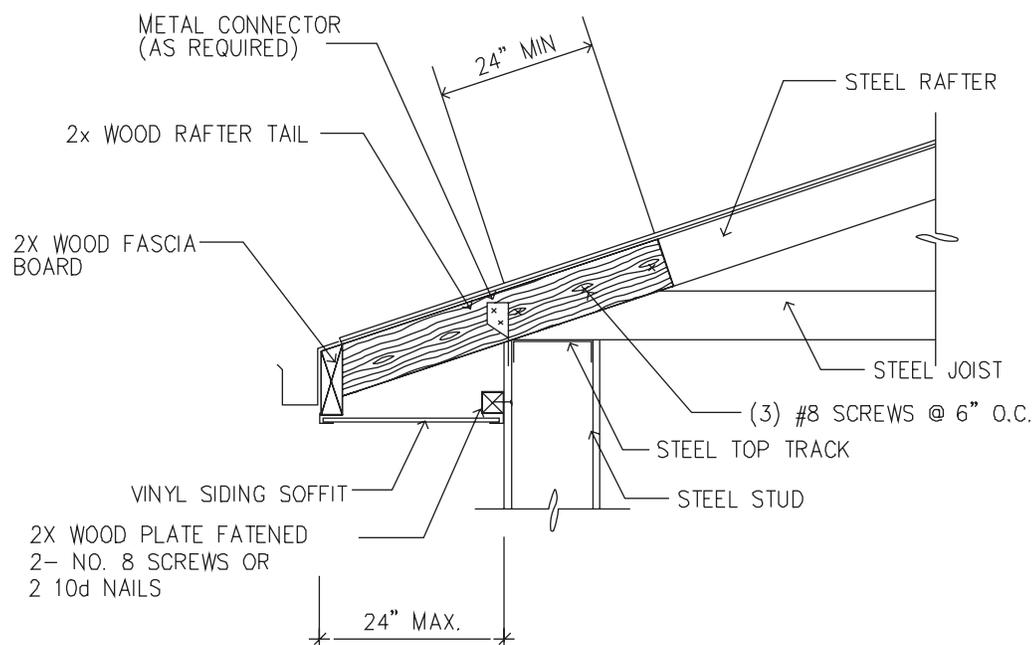
It is essential that you review the limitations of each published document and evaluate its applicability for each project.



5 Hybrid Connection Details

Title: Roof Soffit Connection Detail

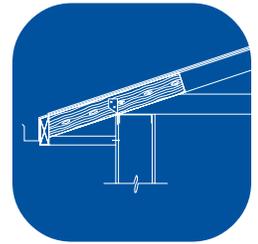
Detail No. R1



Data:

Commentary:

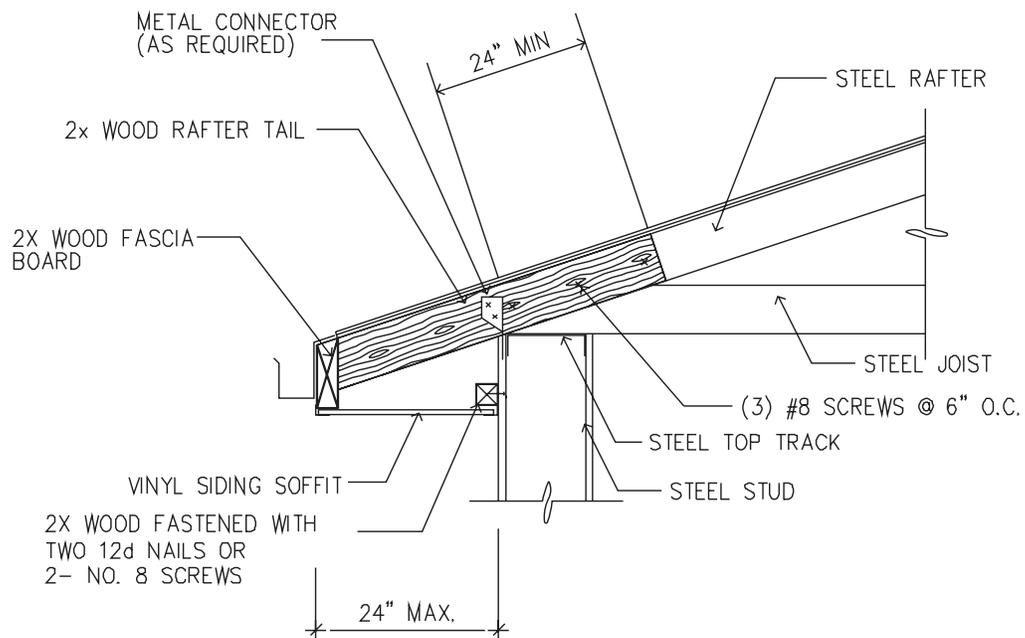
- Steel rafters and ceiling joists span tables can be found in the *International Residential Code* or the *Prescriptive Method*.
- Refer to Detail R2 for alternative vinyl siding soffit blocking detail.



5 Hybrid Connection Details

Title: Roof Soffit Alternative Connection Detail

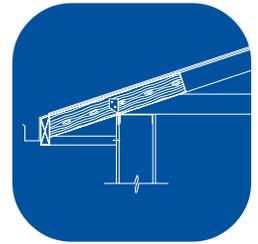
Detail No. R2



Data:

Commentary:

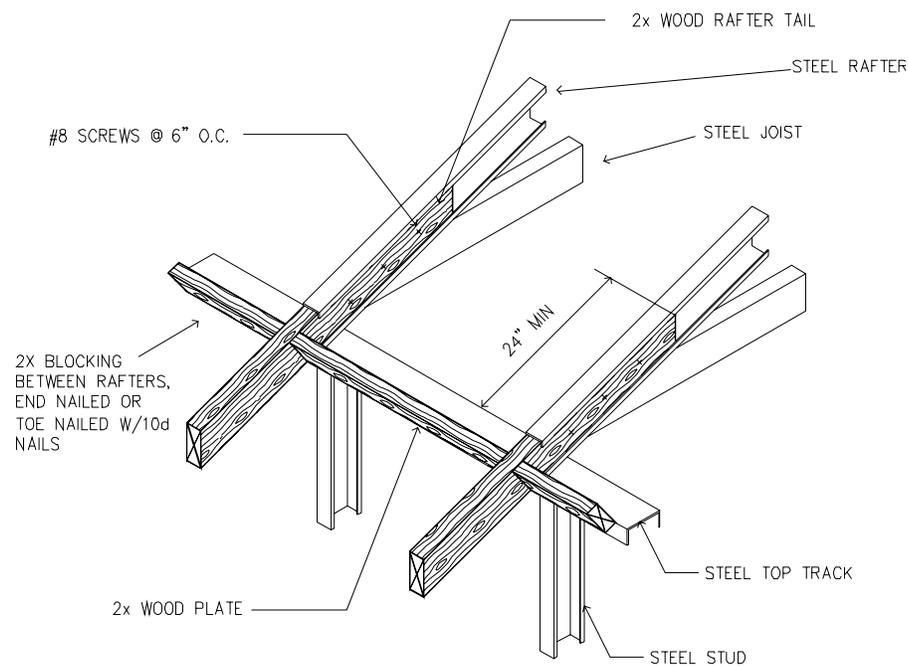
- Work this detail with Detail R1.



5 Hybrid Connection Details

Title: Exposed Wood Rafter Tails to Steel Truss or Rafter

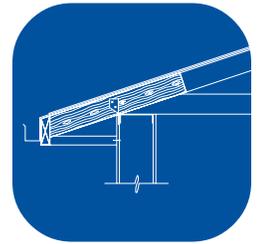
Detail No. R3



Data:

Commentary:

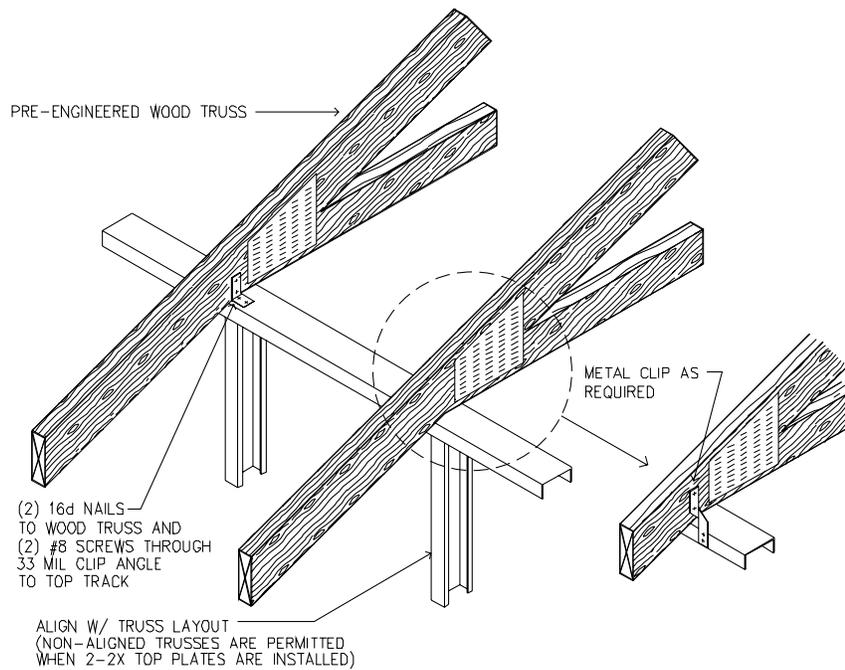
- Steel rafter and ceiling joist span tables can be found in the *International Residential Code* or the *Prescriptive Method*.
- Maximum rafter or truss overhang (cantilever) is 24 inches (610 mm).



5 Hybrid Connection Details

Title: Steel Truss to Wood Wall Detail

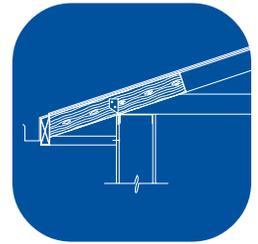
Detail No. R4



Data:

Commentary:

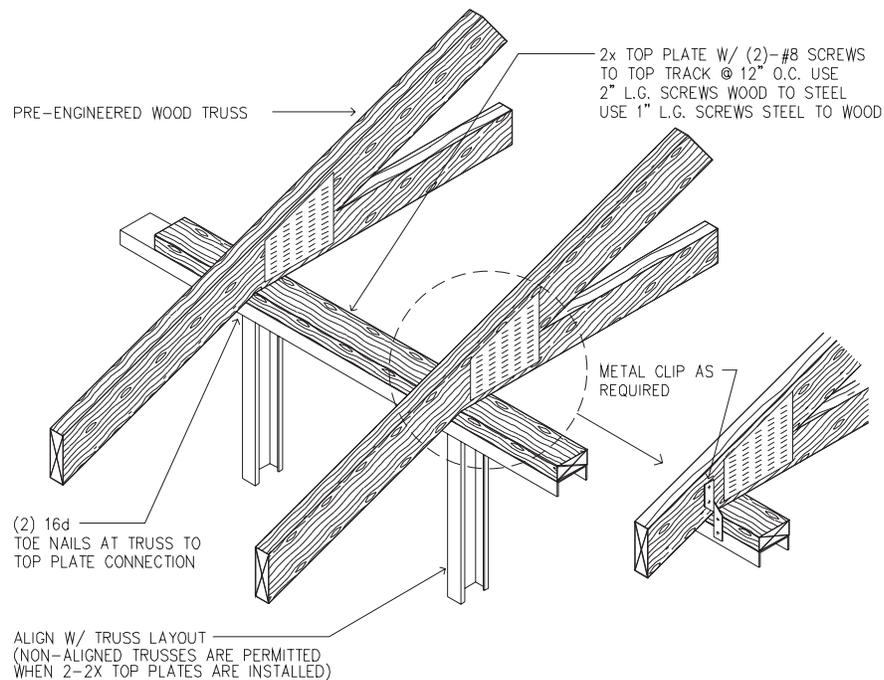
- Truss manufacturer's installation instructions should be followed.
- Additional straps or hurricane clips may be required for high-wind and seismic regions.



5 Hybrid Connection Details

Title: Wood Truss to Steel Wall with Wood Top Plate
Detail

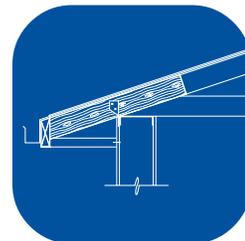
Detail No. R5



Data:

Commentary:

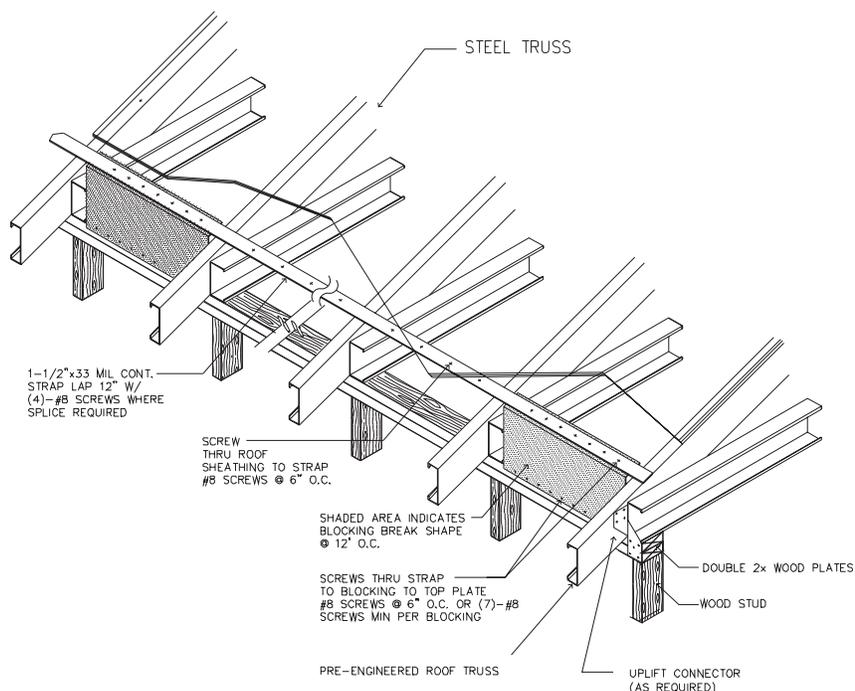
- Truss manufacturer's installation instructions should be followed.
- Additional straps or hurricane clips may be required for high-wind and seismic regions.



5 Hybrid Connection Details

Title: Steel Truss to Wood Wall Detail (High-Wind and Seismic Regions)

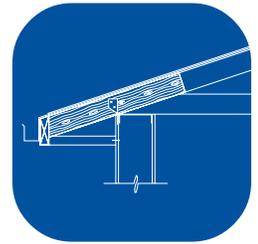
Detail No. R6



Data:

Commentary:

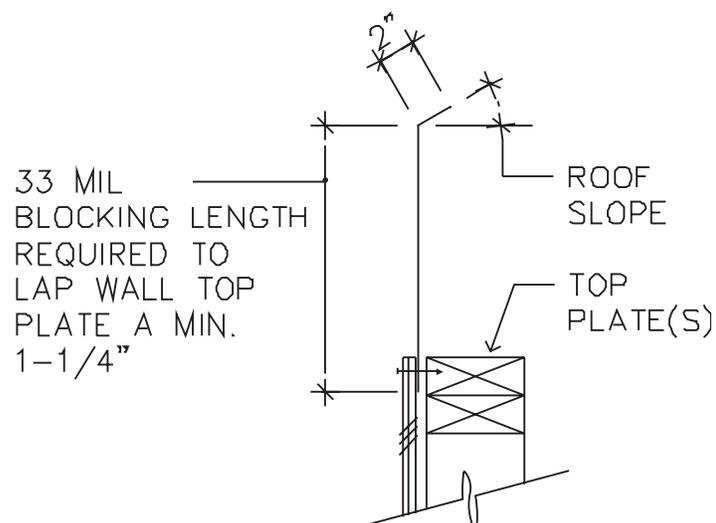
- This detail is applicable to high-wind and seismic regions.
- Refer to Detail R7 for the blocking detail.
- Truss manufacturer's installation instructions should be followed.
- Approved design is required for straps, uplift clips, or hurricane clips.
- Alignment of trusses to wall studs below is not required when two wood top plates are used.



5 Hybrid Connection Details

Title: Blocking Detail (High-Wind and Seismic Regions)

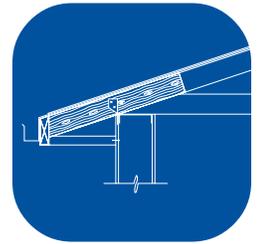
Detail No. R7



Data:

Commentary:

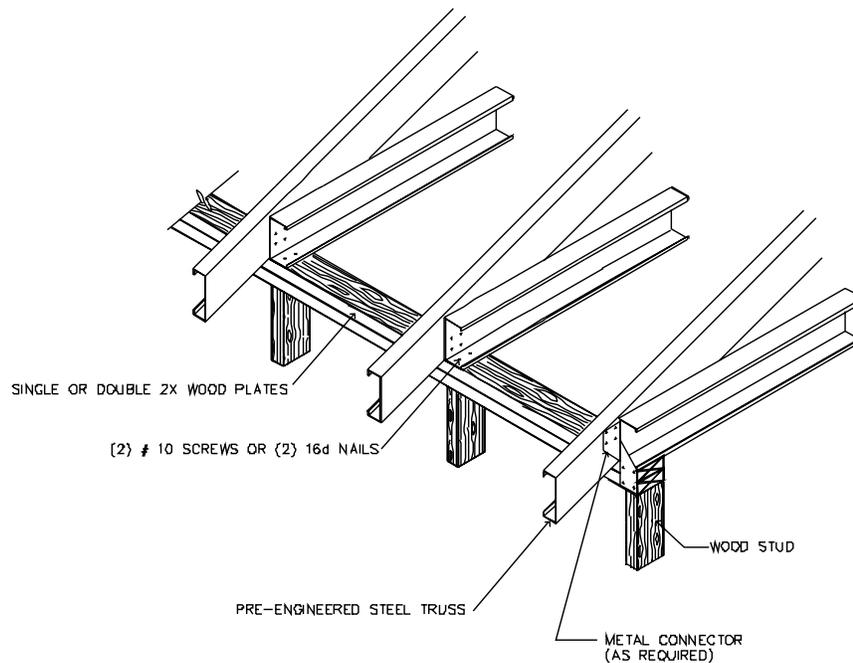
- Work this detail with Detail R6.



5 Hybrid Connection Details

Title: Steel Truss to Wood Wall Detail (Low-Wind and Seismic Regions)

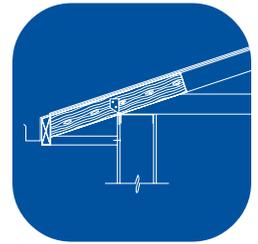
Detail No. R8



Data:

Commentary:

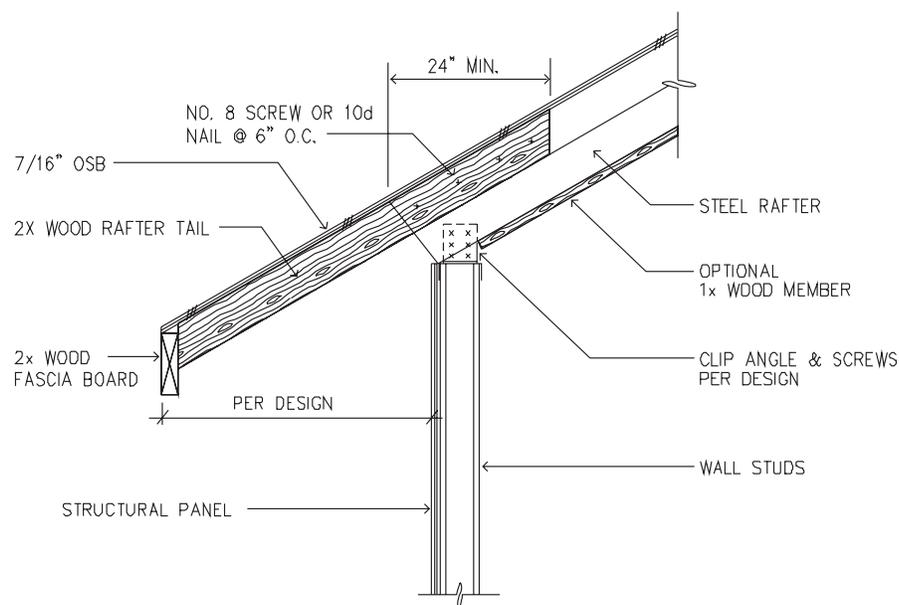
- Refer to Detail R6 for high wind and seismic regions.
- Truss manufacturer's installation instructions should be followed.
- Alignment of trusses to wall studs below is not required when two wood top plates are used.



5 Hybrid Connection Details

Title: Roof Eave and Cathedral Ceiling
(Alternative Detail)

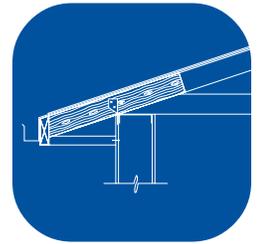
Detail No. R9



Data:

Commentary:

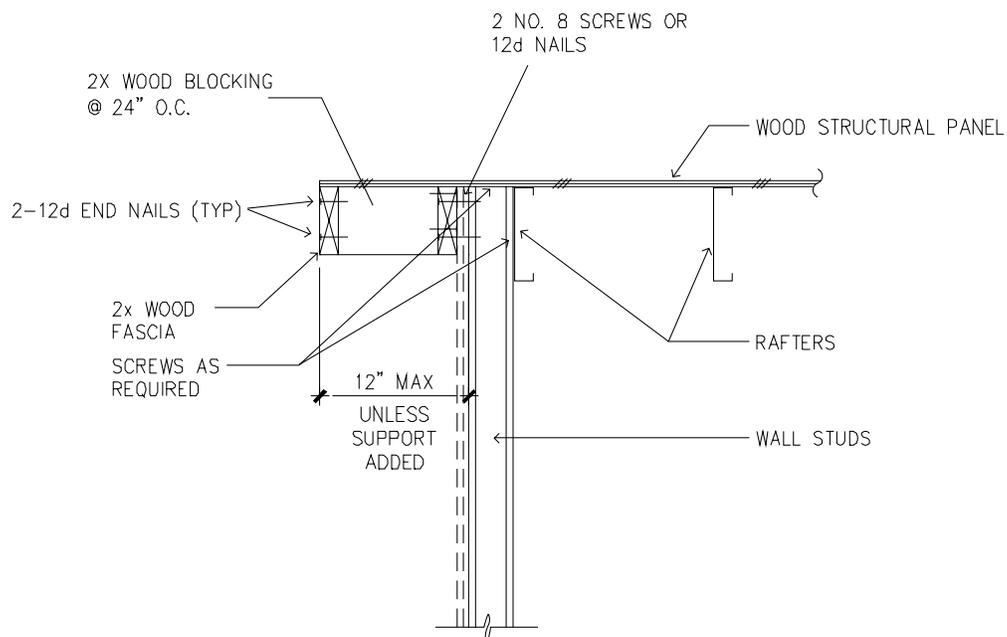
- Steel rafter and ceiling joist span tables can be found in the *International Residential Code* or the *Prescriptive Method*.
- Details for cathedral ceilings are not provided in the *International Residential Code* or the *Prescriptive Method*.



5 Hybrid Connection Details

Title: Gable Roof End with Wood Ladder Framing

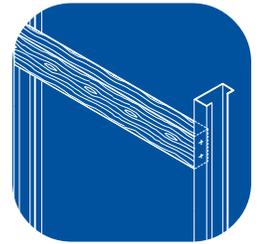
Detail No. R10



Data:

Commentary:

- Steel rafter span tables can be found in the *International Residential Code* or the *Prescriptive Method*.



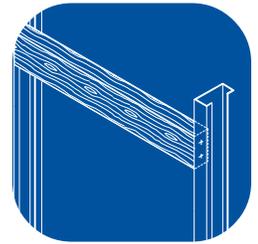
5 Hybrid Connection Details

5.5 Miscellaneous Details

This section contains miscellaneous details that are usually needed to facilitate the trades' attachments to steel-framed components with wood plates (such as attaching kitchen cabinets to steel walls). The details shown in this section are common details and for illustrative use only. The user can construct other workable details that can accommodate trade installation.

There are limited reference documents that are commonly used for miscellaneous construction details.

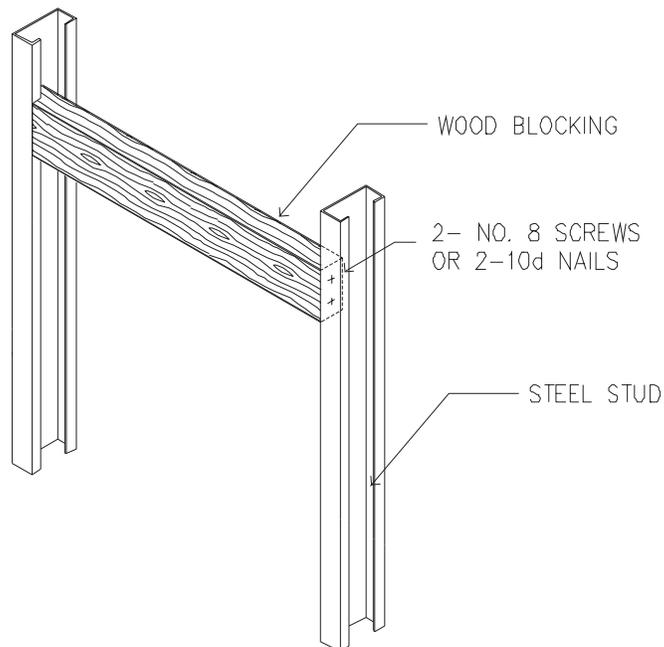
- *Builder's Steel Stud Guide* [34]
- *Residential Steel Framing Handbook* [46]



5 Hybrid Connection Details

Title: Wood Backing between Steel Studs for Cabinet Installation

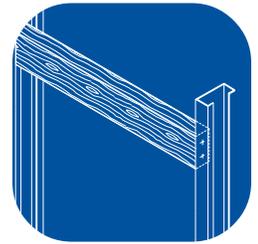
Detail No. M1



Data:

Commentary:

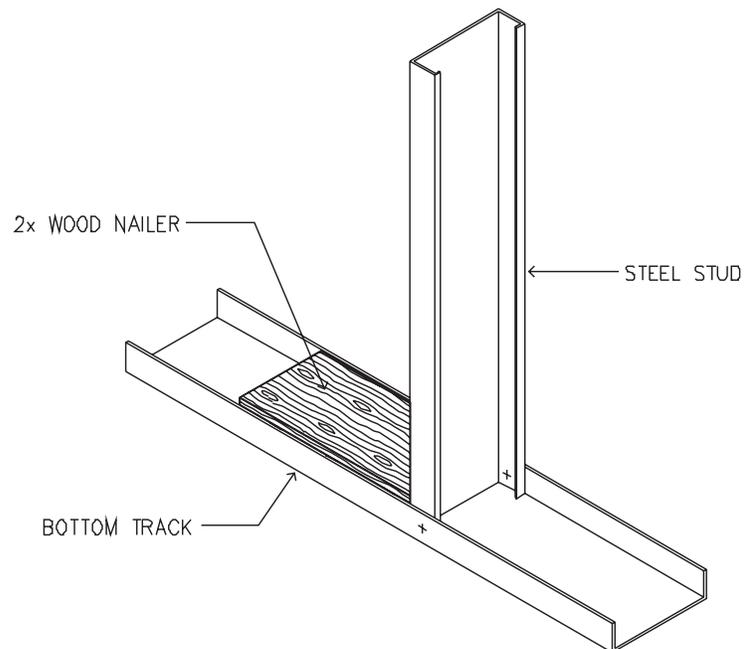
- Wood blocking needs to be notched on one end at the lip of the stud.
- When installing electrical panels, a 2x6 wood stud can be installed between the steel studs above the panel to provide a nailer for securing wiring entering the panel.
- This detail is appropriate for moderately heavy kitchen and bathroom cabinets and fixtures, except lavatories and wall-mounted toilets.



5 Hybrid Connection Details

Title: Wood Nailer in a Steel Wall

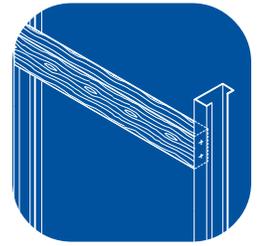
Detail No. M2



Data:

Commentary:

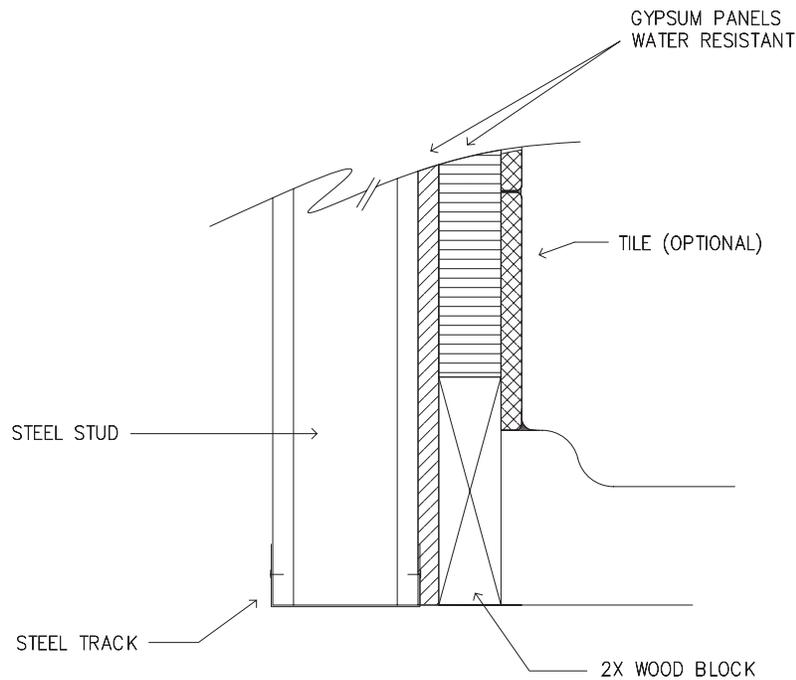
- Make sure that wood nailer fits tight inside track.
- Use finishing nails for trim.



5 Hybrid Connection Details

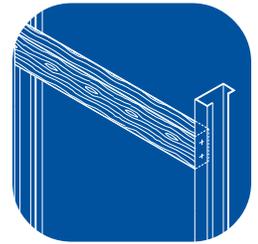
Title: Tub to Steel Framed Wall Detail

Detail No. M3



Data:

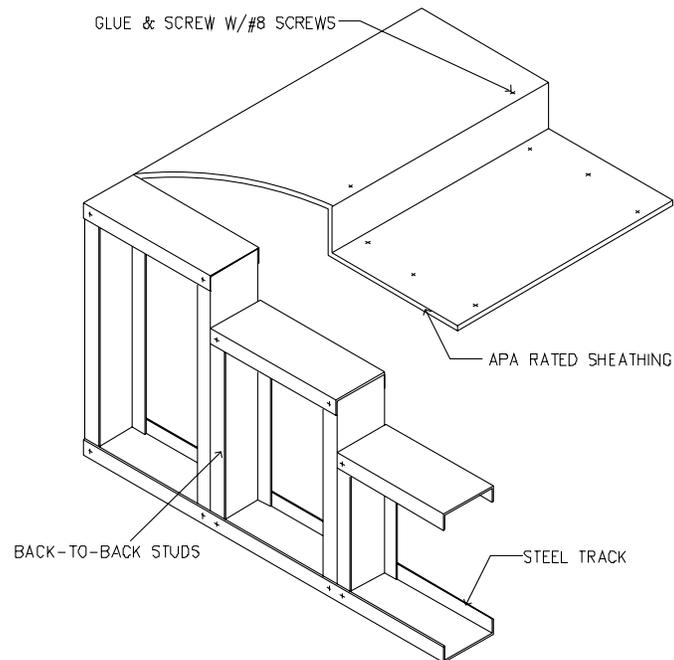
Commentary:



5 Hybrid Connection Details

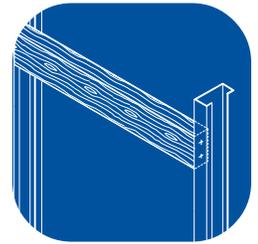
Title: Wood Treads to Steel Stairs

Detail No. M4



Data:

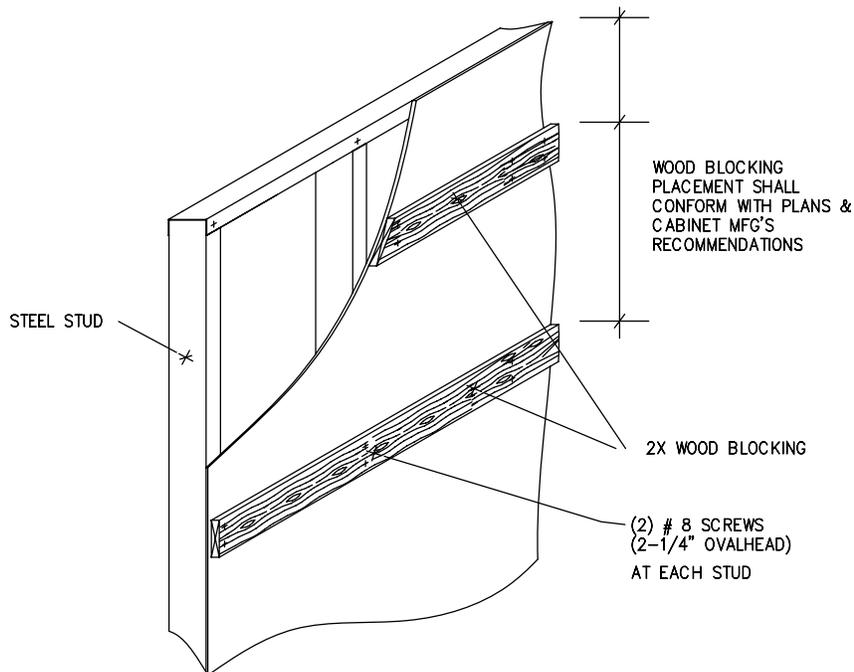
Commentary:



5 Hybrid Connection Details

Title: Wood Cabinet Hanger Strips

Detail No. M5



Data:

Detail is suitable for loads for cabinets weighing up to 65 pounds for studs spaced at 16-inch on center and up to 40 pounds for studs spaced at 24-inch on center.

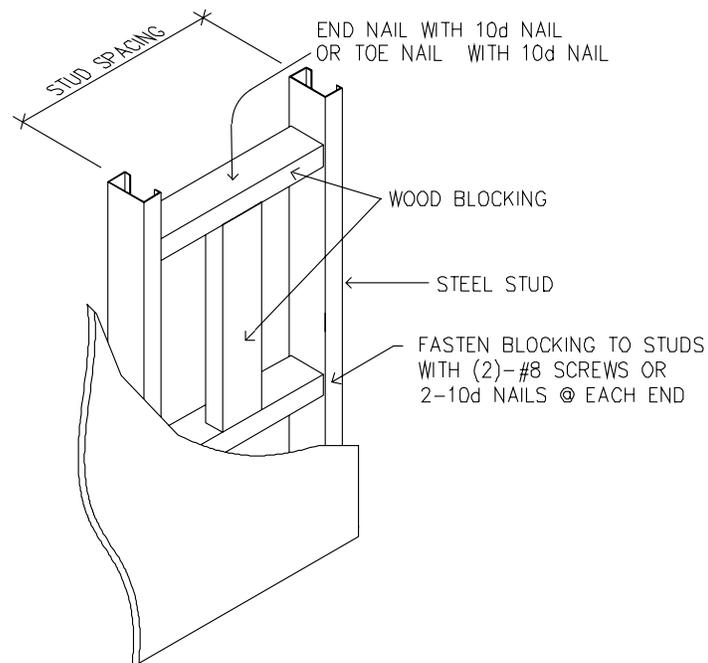
Commentary:



5 Hybrid Connection Details

Title: Wood Backing Detail

Detail No. M6



Data:

Detail is suitable for loads for cabinets weighing up to 65 pounds for studs spaced at 16-inch on center and up to 40 pounds for studs spaced at 24-inch on center.

Commentary:

- This detail is typically used for shelving.



6 References

- 1 American Iron and Steel Institute (AISI). 2001. *Standard for Cold-Formed Steel Framing—Prescriptive Method for One- and Two-Family Dwellings (AISI/COFS/PM 2001)*. Washington, DC.
- 2 Council of American Building Officials (CABO). 1995. *CABO One- and Two-Family Dwelling Code*. Falls Church, VA.
- 3 International Code Council, Inc. (ICC). *International Residential Code (IRC)*. 2000 Edition. Falls Church, VA.
- 4 American Society of Civil Engineers (ASCE). 1998. *Minimum Design Loads for Buildings and Other Structures (ASCE 7-98)*. Reston, VA.
- 5 Steel Framing Alliance (SFA). *2001 Steel Framing Alliance Annual Report*. Washington, DC.
- 6 International Code Council, Inc. (ICC). 1998. *International One and Two Family Dwelling Code*. Falls Church, VA.
- 7 American Iron and Steel Institute (AISI). 2001. *Standard for Cold-Formed Steel Framing—General Provisions (AISI/COFS/GP 2001)*. Washington, DC.
- 8 American Society for Testing and Materials (ASTM). 2000. *Standard Specification for Steel Sheet, Carbon, Metallic- and Nonmetallic-Coated for Cold-Formed Framing Members (ASTM A1003)*. West Conshohocken, PA.
- 9 American Iron and Steel Institute (AISI). 1996. *Durability of Cold-Formed Steel Framing Members (RG-9605)*. Washington, DC.
- 10 American Galvanizers Association (AGA). 1995. *Galvanizing for Corrosion Protection—A Specifier’s Guide*. Aurora, CO.
- 11 Federal Emergency Management Agency (FEMA). 1996. Corrosion Protection for Metal Connectors in Coastal Areas for Structures Located in Special Flood Hazard Areas in Accordance with the National Flood Insurance Program. *Technical Bulletin 8-96*. Washington, DC.
- 12 U.S. Department of Agriculture (USDA) Forest Service, Forest Products Laboratory. 1999. Wood Handbook—Wood as an Engineering Material, *Gen. Tech. Rep. FPL-GTR-113*. Madison, WI.
- 13 American Forest and Paper Association (AFPA), American Wood Council. 1997. *National Design Specification for Wood Construction (NDS)*. Washington, DC.
- 14 U.S. Department of Housing and Urban Development (HUD). *Residential Structural Design Guide*. 2000 Edition. Washington, DC.
- 15 Wood Truss Council of America (WTCA). 1997. *Metal Plate Connected Wood Truss Handbook*. Third Edition. Madison, WI.
- 16 U.S. Department of Commerce (DOC). *American Softwood Lumber Standard (PS 20-70)*. Washington, DC.
- 17 American Plywood Association (APA). *Construction and Industrial Plywood (Voluntary Product Standard PS 1-95)*. Tacoma, WA.
- 18 American Plywood Association (APA). *Performance Standard for Wood-Based Structural-Use Panels (Voluntary Product Standard PS 2-92)*. Tacoma, WA.
- 19 American Iron and Steel Institute (AISI). *Specification for the Design of Cold-Formed Steel Structural Members*. 1996 Edition with 1999 Amendments. Washington, DC.
- 20 Light Gauge Steel Engineers Association (LGSEA). 1998. Pneumatically Driven Pins for Wood Based Panel Attachment. *Tech Note 561b*. Washington, DC.
- 21 Light Gauge Steel Engineers Association (LGSEA). 1999. Welding Cold-Formed Steel. *Tech Note 560-b1*. Washington, DC.
- 22 Light Gauge Steel Engineers Association (LGSEA). 1999. Clinched (Integral) Fastening of Cold-Formed Steel. *Tech Note 560c*. Washington, DC.
- 23 American Society for Testing and Materials (ASTM). 2001. *Standard Terminology of Nails for Use with Wood and Wood-Base Materials (ASTM F547-01)*. West Conshohocken, PA.
- 24 American Society for Testing and Materials (ASTM). 2002. ASTM F1667-02a *Standard Specification for Driven Fasteners: Nails, Spikes, and Staples*, West Conshohocken, PA.
- 25 National Evaluation Service, Inc. (NES). 1997. *Power-Driven Staples and Nails for Use in All Types of Building Construction (NER-272)*. Falls Church, VA.
- 26 American Plywood Association (APA), 1995. Fastener Loads for Plywood—Screws, *Technical Note No. E830C*. Tacoma, WA.



6 References

- 27 U.S. Department of Agriculture (USDA) Forest Service. *Agricultural Handbook No. 72*. 1974. Madison, WI.
- 28 American Forest and Paper Association (AF&PA). 2001. *The Wood Frame Construction Manual (WFCM) for One- and Two-Family Dwellings*. 2001 Edition. Washington, DC.
- 29 U.S. Department of Housing and Urban Development (HUD). 1999. *Builder's Guide to Residential Steel Floors*. Washington, DC.
- 30 American Iron and Steel Institute (AISI). 1993. Residential Steel Beam and Column Load/Span Tables. *Publication No. RG-936*. Washington, DC.
- 31 American Iron and Steel Institute (AISI). 1998. Shearwall Design Guide. *Publication No. RG-9804*. Washington, DC.
- 32 American Iron and Steel Institute (AISI). 2001. *Standard for Cold-Formed Steel Framing—Header Design (AISI/COFS/Header 2001)*. Washington, DC.
- 33 Steel Framing Alliance (SFA). 2000. *L-Shaped Header—Field Guide*. Washington, DC.
- 34 American Iron and Steel Institute (AISI). 1994. Builder's Steel Stud Guide. *Publication No. RG-9607*. Washington, DC.
- 35 American Iron and Steel Institute (AISI). 2000. Low-Rise Residential Construction Details. *Publication No. RG-934*. Washington, DC.
- 36 Elhadj, Nader. 2003. *Cold-formed Steel Top Load Bearing Tracks*. Test Report prepared by the NAHB Research Center for the Steel Framing Alliance (SFA). Washington, DC.
- 37 Gypsum Association (GA). 2000. *Fire-Resistance Design Manual*. 16th Edition. Washington DC.
- 38 Elhadj, Nader. 2002. *Testing of Steel L-Headers on Wood Walls*. Test Report prepared by the NAHB Research Center for the U.S. Department of Housing and Urban Development (HUD) and the Steel Framing Alliance (SFA). Washington, DC.
- 39 American Iron and Steel Institute (AISI). 2001. *Standard for Cold-Formed Steel Framing—Truss Design (AISI/COFS/Truss 2001)*. Washington, DC.
- 40 Truss Plate Institute, Inc. (TPI). 2002. *National Design Standard for Metal Plate Connected Wood Truss Construction (ANSI/TPI 1-2002)*. Madison, WI.
- 41 Light Gauge Steel Engineers Association (LGSEA). *Field Installation for Cold-Formed Steel Roof Trusses*. Washington, DC.
- 42 Truss Plate Institute, Inc. (TPI). 1989. *Recommended Design Specification for Temporary Bracing of Metal Plate Connected Wood Trusses (DSB-89)*. Madison, WI.
- 43 Truss Plate Institute's (TPI). 1991. *Commentary & Recommendations for Handling, Installing & Bracing Metal Plate Connected Wood Trusses (HIB-91)*. Madison, WI.
- 44 Light Gauge Steel Engineers Association (LGSEA). Design Guide for Construction Bracing of Cold-Formed Steel Trusses. *Tech Note 551d*. Washington, DC.
- 45 Light Gauge Steel Engineers Association (LGSEA). 1998. Specifying Pre-Engineered Cold-Formed Steel Roof and Floor Trusses. *Tech Note 551f*. Washington, DC.
- 46 Scharf, Robert. 1996. *Residential Steel Framing Handbook*. New York, NY.



Appendix A-Metric Conversion Factors

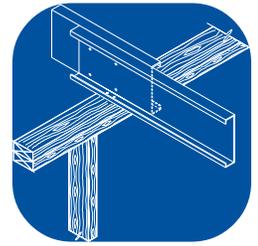
The following list provides the conversion relationship between U.S. customary units and the International System (SI) units. A complete guide to the SI system and its use can be found in ASTM E 380, Metric Practice.

To Convert from	To	Multiply by
Length		
Inch (in.)	Micrometer (mm)	25,400
Inch (in.)	Millimeter (mm)	25.4
Inch (in.)	Centimeter (cm)	2.54
Inch (in.)	Meter (m)	0.0254
Foot (ft.)	Meter (m)	0.3048
Yard (yd.)	Meter (m)	0.9144
Mile (mi.)	Kilometer (km)	1.6093
Area		
Square foot (sq. ft.)	Square meter (sq. m)	0.0929
Square inch (sq. in.)	Square centimeter (sq. cm)	6.452
Square inch (sq. in.)	Square meter (sq. m)	0.000645
Square yard (sq. yd.)	Square meter (sq. m)	0.8391
Square mile (sq. mi.)	Square kilometer (sq. km)	2.5898
Volume		
Cubic inch (cu. in.)	Cubic centimeter (cu. cm)	16.3871
Cubic inch (cu. in.)	Cubic meter (cu. m)	0.00001639
Cubic foot (cu. ft)	Cubic meter (cu. m)	0.0283
Cubic yard (cu. yd)	Cubic meter (cu. m)	0.7645
Gallon (gal.) Can. liquid	Liter	4.546
Gallon (gal.) Can. liquid	Cubic meter (cu. m)	0.004546
Gallon (gal.) U.S. liquid*	Liter	3.7854
Gallon (gal.) U.S. liquid	Cubic meter (cu. m)	0.0037854
Fluid ounce (fl. oz.)	Milliliters (ml)	29.5735
Fluid ounce (fl. oz.)	Cubic meter (cu. m)	0.00002957
Force		
Kip (1,000 lb.)	Kilogram (kg)	453.6
Kip (1,000 lb.)	Newton (N)	4,448.222
Pound (lb.)	Kilogram (kg)	0.4536
Pound (lb.)	Newton (N)	4.4482
Stress or Pressure		
Kip/square inch (ksi)	Mega Pascal (Mpa)	6.8948
Kip/square inch (ksi)	Kilogram/square centimeter (kg/sq. cm)	70.31
Pound/square inch (psi)	Kilogram/square centimeter (kg/sq. cm)	0.0703
Pound/square inch (psi)	Pascal (Pa)**	6,894.757
Pound/square inch (psi)	Mega Pascal (Mpa)	0.00689



Appendix A-Metric Conversion Factors

To Convert from	To	Multiply by
Stress or Pressure		
Pound/square foot (psf)	Kilogram/square meter (kg/sq. m)	4.8824
Pound/square foot (psf)	Pascal (Pa)	47.88
Mass (Weight)		
Pound (lb.)	Kilogram (kg)	0.4536
Ton, 2,000 lbs.	Kilogram (kg)	907.1848
Grain	Kilogram (kg)	0.0000648
Mass (Weight) per Length		
Kip per linear foot (klf)	Kilogram per meter (kg/m)	0.001488
Pound per linear foot (plf)	Kilogram per meter (kg/m)	1.488
Moment		
1 foot-pound (ft.-lb.)	Newton-meter (N-m)	1.356
Mass per Volume (Density)		
Pound per cubic foot (pcf)	Kilogram per cubic meter (kg/cu m)	16.0185
Pound per cubic yard (lb./cu. yd.)	Kilogram per cubic meter (kg/cu m)	0.5933
Velocity		
Mile per hour (mph)	Kilometer per hour (km/hr.)	1.6093
Mile per hour (mph)	Kilometer per second (km/sec.)	0.4470
Temperature		
Degree Fahrenheit (°F)	Degree Celsius (°C)	$t_c = (t_f - 32)/1.8$
Degree Fahrenheit (°F)	Degree Kelvin (°K)	$t_k = (t_f + 59.7)/1.8$
Degree Kelvin (°K)	Degree Celsius (°C)	$t_c = (t_k - 273.15)$
Degree Celsius (°C)	Degree Fahrenheit (°F)	$t_f = 1.8t_c + 32$
* One U.S. gallon equals 0.8327 Canadian gallon.		
** A Pascal equals 1,000 Newton per square meter.		
<i>The prefixes and symbols below are commonly used to form names and symbols of the decimal multiples and submultiples of the SI units.</i>		
Multiplication Factor	Prefix	Symbol
1,000,000,000 = 10 ⁹	Giga	G
1,000,000 = 10 ⁶	Mega	M
1,000 = 10 ³	Kilo	k
0.01 = 10 ⁻²	Centi	c
0.001 = 10 ⁻³	Milli	m
0.000001 = 10 ⁻⁶	Micro	μ
0.000000001 = 10 ⁻⁹	Nano	n



Glossary

Accepted Engineering Practice. An engineering approach that conforms to accepted principles, tests, technical standards, and sound judgment.

Approved. Approval by a building official, code official, design professional, or authority with jurisdiction.

Base Metal Thickness. The thickness of bare steel exclusive of all coatings.

Basic Wind Speed. The 3-second gust wind speed in accordance with the local building code or, in the absence of a building code, in accordance with ASCE 7. Wind speeds in this document are given in units of miles per hour (mph) by “3-second gust” measurements (refer to Table 2.2 to convert to fastest-mile wind speed).

Bearing Stiffener. Refer to *Web Stiffener*.

Blocking. C-shaped, track, break shape, or flat strap material attached to structural members, flat strap, or sheathing panels to transfer shear forces.

Bracing. Structural elements that are installed to provide restraint or support (or both) to other framing members so that the complete assembly forms a stable structure.

Bridging. Cross-bracing or blocking placed between joists to provide lateral support.

Buckling. A kink, wrinkle, bulge, or other loss in the original shape of a member due to compression, bending, bearing, or shear loads.

Ceiling Joist. A horizontal structural framing member that supports ceiling components and that may be subject to attic loads.

Clip Angle. An L-shaped short piece of steel (normally with a 90-degree bend) typically used for connections.

Cripple Stud. A stud that is placed between a header and a window or door head track, a header and wall top track, or a window sill and a bottom track to provide a backing to attach finishing and sheathing material.

C-Shape. A cold-formed steel shape used for structural and nonstructural framing members consisting of a web, two flanges, and two lips (edge stiffeners). The name comes from the member’s C-shaped cross-sectional configuration. It is also called a “C-section.” Web depth measurements are taken to the outside of the flanges. Flange width measurements also use outside dimensions.

Design Professional. An individual who is registered or licensed to practice his or her respective design profession

as defined by the statutory requirements of the state in which the project is to be constructed.

Design Thickness. The steel thickness used in design which is equal to the minimum base metal thickness divided by 0.95.

Diaphragm. A floor, ceiling, or roof assembly designed to resist in-plane forces (e.g., wind or seismic loads).

Dwelling. Any building that contains one or two dwelling units for living purposes.

Eave Overhang. The horizontal projection of the roof measured from the outside face of the exterior wall framing to the outside edge of the roof.

Flange. That portion of the C-shape framing member or track that is perpendicular to the web.

Flat Strap. Sheet steel cut to a specified width without any bends and typically used for bracing and transferring loads by tension.

Floor Joist. A horizontal structural framing member that supports floor loads and superimposed vertical loads.

Foundation. The structural elements through which the load of a structure is transmitted to earth.

Gauge. A unit of measurement traditionally used to describe the nominal thickness of steel. The lower the gauge the greater the thickness.

Grade. The finished ground level adjoining the building at exterior walls.

Ground Snow Load. Measured load on the ground due to snow accumulation developed from a statistical analysis of weather records expected to be exceeded once every 50 years at a given site.

Header. A horizontal structural framing member used over floor, roof, or wall openings to transfer loads around the opening to supporting structural framing members.

High Seismic Area. An area where the Seismic Design Category is D_1 or higher.

High-Wind Area. An area where basic wind speeds are equal to 110 mph (177 km/hr) up to and including 130 mph (209 km/hr).

In-Line Framing. Framing method where all vertical and horizontal load-carrying members are aligned when required to transfer loads properly.



Jack Stud. A stud that does not span the full height of the wall and provides bearing for headers.

King Stud. A stud adjacent to a jack stud that spans the full height of the wall and supports vertical and lateral loads.

Lateral Load. A horizontal force created by wind or earthquake that acts on a structure or its components.

Lip. That part of a C-shape framing member that extends from the flange as a stiffening element at 90 degrees to the flange (Edge Stiffener).

Loads, Live and Dead. Dead loads are the weight of the walls, partitions, framing, floors, ceilings, roofs, and all other permanent construction entering into and becoming a part of a building. Live loads are transient and sustained loads usually created by people and furnishing, respectively.

Material Thickness (Steel). The base metal thickness excluding any protective coatings. Thickness is expressed in mils (1/1000 of an inch).

Metallic-Coated Steel. Steel that has a metallic coating for protection against corrosion. The level of protection is measured by the weight of the metallic coating applied to the surface area of the steel. Typical zinc-based coatings are galvanizing, galvalume, or galfan.

Mil. A unit of measurement used in measuring the thickness of thin steel elements. One mil equals 1/1000 of an inch (e.g., 33 mil = 0.033 inch).

Multiple Span. The span made by a continuous member with intermediate supports.

Nonstructural Stud. A member in a steel framed wall system that is limited to a lateral (transverse) load of not more than 5 lb./ft.² (240 Pa); a superimposed vertical load, exclusive of sheathing materials, of not more than 100 lb./ft. (1460 N/m); or a superimposed vertical load of not more than 200 lbs (890 N).

Punchout. A hole or opening in the web of a steel-framing member. A punchout may be made during the manufacturing process or in the field.

Rake Overhang. The horizontal projection of the roof measured from the outside face of a gable endwall to the outside edge of the roof.

Ridge. The horizontal line formed by the joining of the top edges of two sloping roof surfaces.

Rim Joist. A horizontal structural member that is connected to the end of a floor joist.

Roof Rafter. A horizontal or sloped structural framing member that supports roof loads.

Roof Snow Load. Uniform live load on the roof due to snow accumulation; equivalent to 70% of the ground snow load for one- and two-family dwellings.

Seismic Design Category (SDC). A classification assigned to a building based on the building's importance and the severity of the design earthquake ground motion at the building site as given in the local building code or, in the absence of a building code, as given in ASCE 7.

Shear Wall. A wall assembly designed to resist lateral forces from wind or seismic loads acting parallel to the plane of the wall.

Single Span. The span made by one continuous structural member without any intermediate supports.

Span. The clear horizontal distance between bearing supports.

Story. That portion of the building included between the upper surface of any floor and the upper surface of the floor next above, except that the top-most story shall be that habitable portion of a building included between the upper surface of the top-most floor and the ceiling or roof above.

Story above Grade. Any story with its finished floor surface entirely above grade except that a basement shall be considered as a story above grade when the finished surface of the floor above the basement is (a) more than 6 feet (1.8 m) above the grade plane, (b) more than 6 feet (1.8 m) above the finished ground level for more than 50 percent of the total building perimeter, or (c) more than 12 feet (3.7 m) above the finished ground level at any point.

Strap. Flat or coiled sheet steel material typically used for bracing and blocking that transfers loads by tension and/or shear.

Structural Member. A floor joist, rim joist, structural stud, wall track in a structural wall, wall plate in structural wall, ceiling joist, roof rafter, header, or other member that is designed or intended to carry loads.

Structural Stud. A stud in an exterior wall or an interior stud that supports superimposed vertical loads and may transfer lateral loads. Includes full-height wall studs, king studs, jack studs, and cripple studs.

Structural Sheathing. The covering (e.g., plywood or oriented strand board) used directly over structural members (e.g., joists) to distribute loads, brace walls, and generally strengthen the assembly.



Stud. A vertical framing member in a wall system or assembly.

Townhouse. Attached single-family dwelling units constructed in a row with each unit separated by fire walls at property lines.

Track. A framing member consisting of only a web and two flanges. Track web depth measurements are taken to the inside of the flanges.

Truss. A coplanar system of structural members joined together at their ends usually to construct a series of triangles that form a stable beam-like framework.

Wall Height. The clear vertical distance between the finished floor and the finished ceiling. Where a finished floor does not exist (i.e., crawlspace), the wall height is the clear vertical distance between the interior finish grade and the finished ceiling.

Web. The part of a C-shape or track that connects the two flanges.

Web Crippling. The localized permanent (inelastic) deformation of the web member subjected to concentrated load or reaction at bearing supports.

Web Opening. See “Punchout.”

Web Perforation. See “Punchout.”

Web Stiffener. Additional material that is attached to the web to strengthen the member against web crippling. Also called bearing or transverse stiffener.

Wind Exposure. Wind exposure in accordance with the local building code or, in the absence of a building code, in accordance with ASCE 7. For the purpose of this document, Exposures A/B represents urban, suburban, or wooded terrain. Exposure C represents open terrain with scattered obstructions.

U.S. Department of Housing and Urban Development

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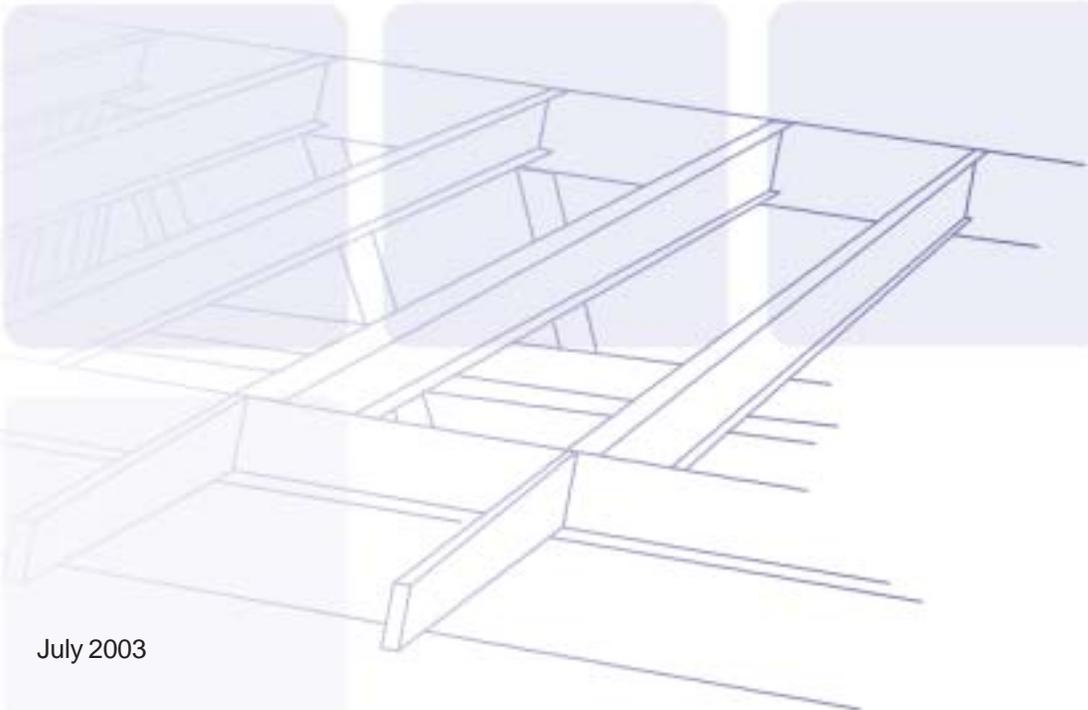
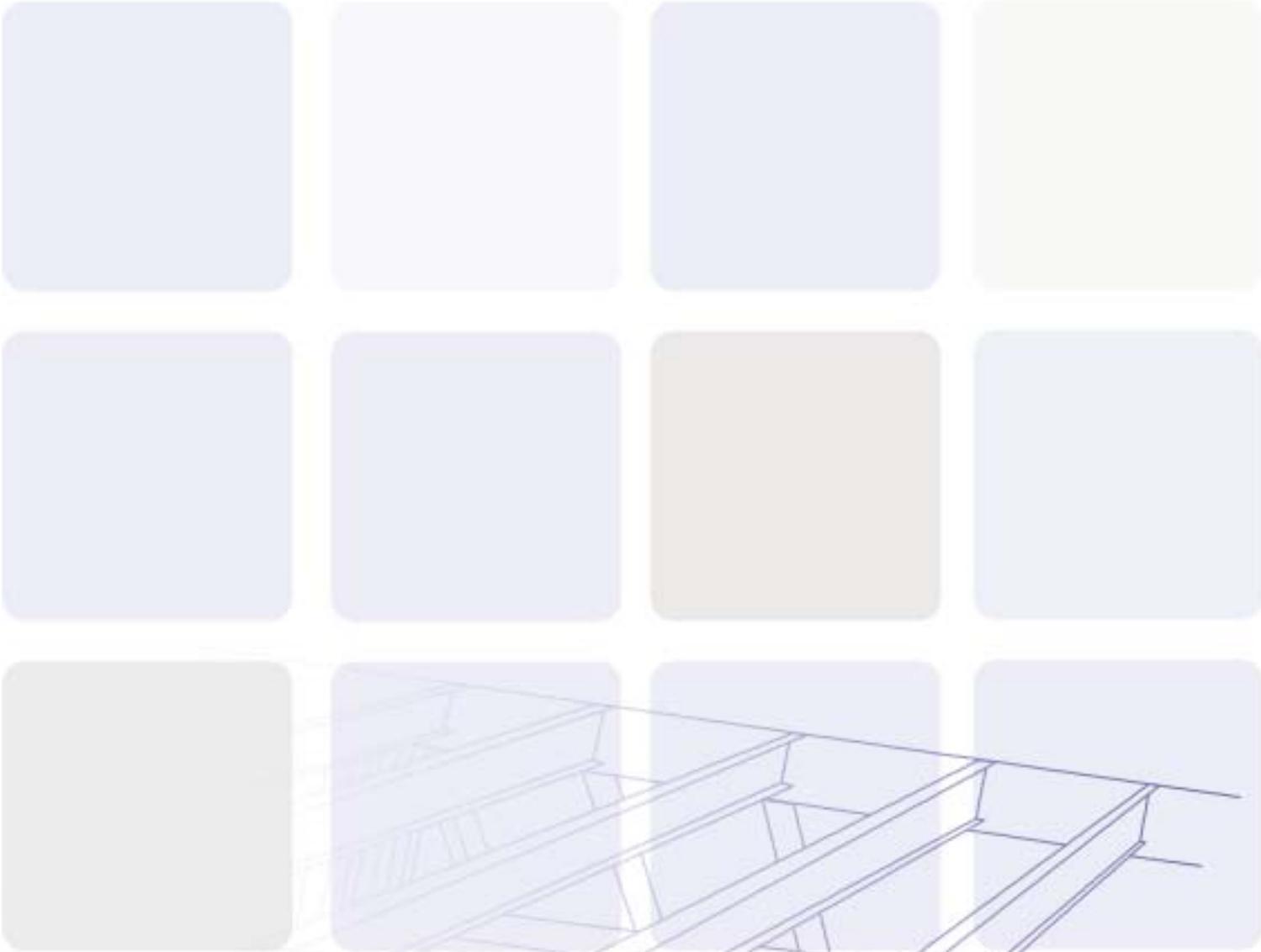
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