



**PDHonline Course S101 (2 PDH)**

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# **An Overview of Cold-Formed Steel Structures**

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# An Overview of Cold-Formed Steel Structures

*Helen Chen, Ph.D., PE*

## Course Outline

Cold-formed steel has been widely used in building construction, from residential houses to industrial buildings. This two-hour course discusses the manufacturing process of cold-formed steel, the fundamental theories of cold-formed steel design, advantages of cold-formed steel over other construction materials, cold-formed steel applications in today's construction market, and the connection methods. This course includes a multiple-choice quiz at the end, which is designed to enhance the understanding of course materials.

## Learning Objective

At the conclusion of this course, the student will:

- Understand the manufacturing process of cold-formed steel;
- Understand the effect of cold-work;
- Understand the structural behavior of cold-formed steel;
- Be familiar with the current design method for cold-formed steel;
- Be familiar with the cold-formed steel products;
- Be familiar with the types of connections used for cold-formed steel; and
- Be familiar with the industry standard nomenclature and color-coding scheme for steel studs and tracks.

## Course Content

Cold-formed steel offers versatility in building because of its lightweight and ease of handling and use. Did you know that cold-formed steel represents over 40 percent of the steel construction market, and this share is increasing?

### What is Cold-Formed Steel?

In building construction, there are primarily two types of structural steel: hot-rolled steel shapes and cold-formed steel shapes. The hot-rolled steel shapes are formed at elevated temperatures while the cold-formed steel shapes are formed at room temperature. Cold-formed steel structural members are shapes commonly manufactured from steel plate, sheet or strip material. The manufacturing process involves forming the material by either press-braking or cold roll-forming to achieve the desired shape. Examples of the cold-formed steel are corrugated steel roof and floor decks, steel wall panels, storage racks and steel wall studs.

Press-braking is often used for production of small quantity of simple shapes. Cold roll-forming is the most widely used method for production of roof, floor and wall panels. It is

also used for the production of structural components such as Ceesees, Zees, and hat sections. Sections can usually be made from sheet up to 60 inches (1.5m) wide and from coils more than 3,000 feet (1,000m) long.

During cold roll-forming, sheet stock is fed longitudinally through a series of rolls, each of which works the sheet progressively until it reaches the desired shape (Figures 1 and 2). A simple section may require as few as six pairs of roll, but a complex shape can require as many as 24 to 30. The thickness of material that can be formed generally ranges between 0.004 (0.10mm) up to 0.312 inches (7.9mm), although heavy duty cold forming mills can handle steel up to 3/4 of an inch (19mm) thick.

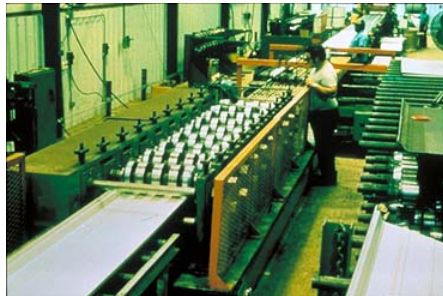


Figure 1

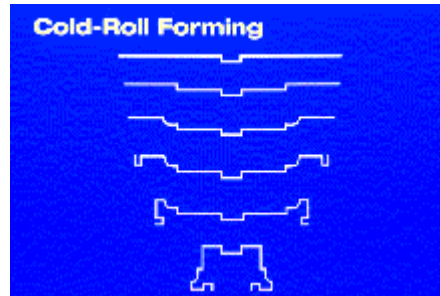


Figure 2

### Effect of Cold Work

When steel is formed by press-braking or cold rolled-forming, there is a change in the mechanical properties of the material by virtue of the cold working of the metal.

When a steel section is cold-formed from flat sheet or strip, the yield strength, and to a lesser extent the ultimate strength, is increased as a result of this cold working, particularly in the bends of the section.

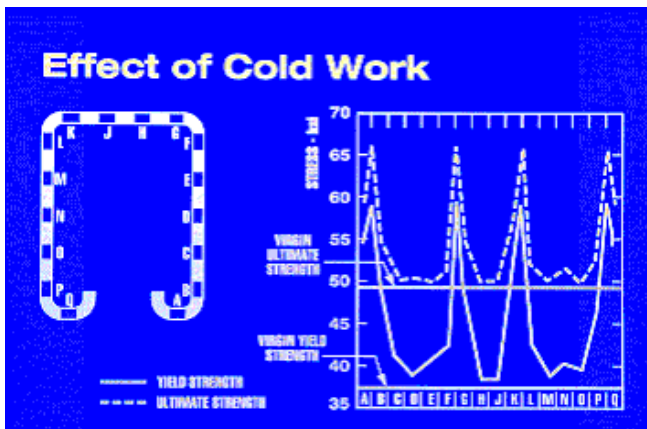


Figure 3

The right part of Figure 3 shows the developed centerline of the section and the variation of yield and ultimate strength along the centerline. One can see that these strengths are unaffected in the three flat portions where little cold work has taken place and the strength is much higher in the corners, which have been strongly cold-worked in the forming process.

Since cold work produced during forming increases the strength of the steel, it permits the designer to treat the formed steel as a stronger material than the original unformed steel. Often, it is possible to take a weighted average of the post-forming strength of the cross section and use this higher figure as the overall strength of the steel.

A shape that is cold worked to a higher degree will have a higher yield strength, which may make it more appropriate for certain applications. Sometimes cold work is added by overbending and straightening. The end result is that a more complex shape may have higher strength than a less complex shape. Other factors that can affect cold working include roll pressure, corner radius and the properties of the steel.

Depending on the type of cold-forming and the thickness of the steel, the amount of strength increase could reach 20% to 50%. However, the ductility of the steel is reduced as result of cold-forming process.

### Properties of Cold-Formed Steel

Generally, the grades of carbon steel and high strength low alloy steel used for cold-formed steel products are characterized by two main properties: the yield point and the tensile strength. Other important properties are ductility, hardness and weldability.

The yield point of the steels commonly used for cold-forming ranges from 33 to 55 ksi (230 to 380 MPa), and may be higher. Tensile strength and ductility are important because of the way they relate to formability, and because of the local deformation demands of bolted and other types of connection. In members that include bolted connection or that, because of special design, may be subject to high stress concentrations, the tensile strength often must be taken into account. The ratio of tensile strength to yield strength for cold-formed steels commonly ranges from 1.2 to 1.8. However, steels with a lower ratio can be used for specific applications.

### Cold-Formed Steel Types

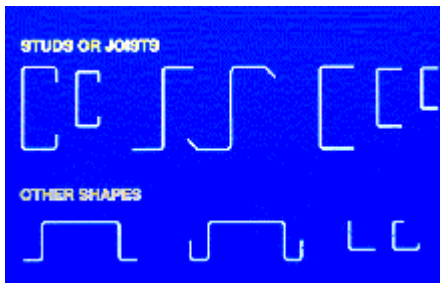


Figure 4

There are two major types of cold-formed steel products: structural shapes and panels. Of the former, there are a variety of shapes produced. They include open sections, closed sections, and built-up sections, such as Cee sections (also called lipped channels), zee sections, double channel I beams with stiffened flanges, hat sections with and without intermediate stiffeners, box sections, U sections and others. These are used in buildings for such structural functions as eave struts, purlins, and girts as well as joists and studs and other components.

Generally, the depth of cold-formed individual framing members range from 2 to 12 inches (50 to 300mm) and the thickness of material ranges from 0.035 to about ¼ inches (0.90 to 6.4mm)

### Cold-Formed Steel vs. Hot-Rolled Steel

The differences between cold-formed and hot-rolled steel are not just in the thickness and the shapes. Since cold-formed steel members are formed at room temperature, the material becomes harder and stronger. Its lightweight makes it easier and more economical to mass-produce, transport and install.

One of the main differences between designing with cold-formed steel shapes and with hot-rolled structural shapes is that with the hot-rolled, one is primarily concerned about two types of instability: column buckling and lateral buckling of unbraced beams. The dimensions of hot-rolled shapes are such that local buckling of individual constituent elements generally will not occur before yielding.

This is not the case with cold-formed members. Here local buckling must also be considered because, in most cases, the material used is thin relative to its width. This means that the individual flat, or plate, elements of the section often have width to thickness ratios that will permit buckling at stresses well below the yield point.

### Local Buckling

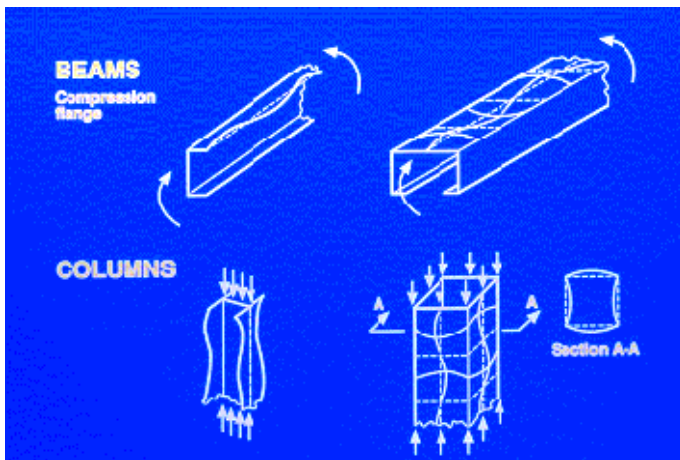


Figure 5

Local buckling, for such plate elements, is not the same as overall beam or column buckling. Although the element begins to deflect out of its original straight or plane shape, it does not fail when the initial buckling stress is reached. On the contrary it can resist increasing compression stresses often well in excess of those at which local buckling first appears.

In this case, the member develops out-of-plane deformations which are shown (highly exaggerated) for these beams and columns, but they will continue to carry increasing load. This is known as their post-buckling strength.

There are two types of thin, compressed sheet elements. One type is stiffened by other components along both longitudinal edges. Such elements are called stiffened compression elements, and you see them in the compression flange of the C-section beam, or in all four faces of the box column. The other type is called unstiffened compression elements that are stiffened only along one of the two longitudinal edges. The other edges remain free. These elements appear in the compression flange of the channel section beam, and in all flanges of the I-section column. The behavior of these two types of elements is similar, though not identical.

## Effective Width and Effective Properties

The concept of effective width is the key to the design of cold-formed steel. Considering the element as the compression flange of some member (see Figure 6), the total compressive force is the area under this stress distribution curve, times the thickness of the element. What is needed in design, really, is only this total compressive force. It is convenient to replace the actual variable stress distribution with a fictitious uniform stress distribution, of the same intensity of the edge stress,  $f$ , as in the real element as indicated by the dotted lines.

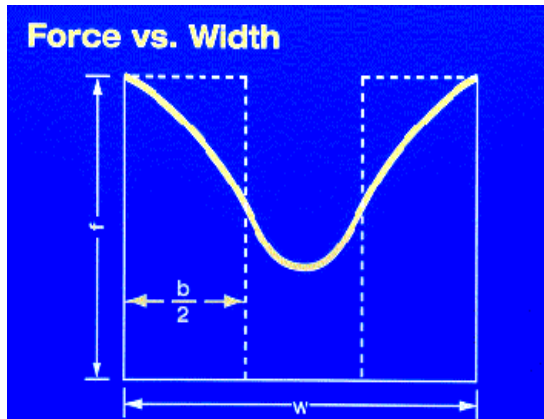


Figure 6

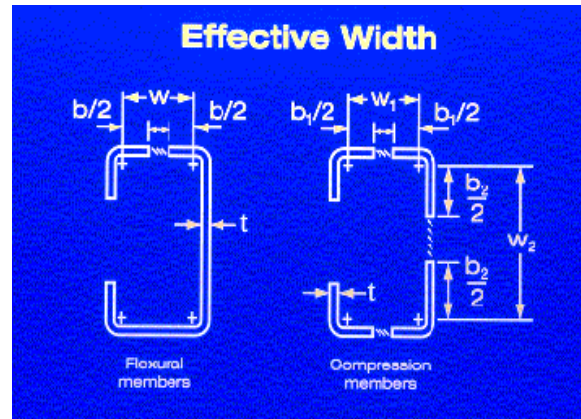


Figure 7

In order to get the same total compression force in the fictitious (dotted) as in the real (solid) distribution, the areas under the two must be equal. This means adjusting the width of each of the two fictitious rectangles,  $b/2$ , until the combined area of the two rectangles is equal to that under the solid curve. This width is known as the effective width,  $b$ .

Once this effective width,  $b$ , is known, structural members, such as beams or columns, can be designed simply by replacing the real width,  $w$ , of each compression element by its effective width,  $b$ . This is shown for several frequently used shapes in Figure 7. To the left is a flexural member, to the right a compression member. The two effective portions of the compression elements are shown solid, and the portions considered removed are dotted. For each element, the total effective width is, of course,  $b$  (or  $b_1$ ).

Then, effective section properties, such as area, section modulus, and moment of inertia, can be calculated by using for each compression element its effective width,  $b$ , instead of its real width,  $w$ .

## Effective Width Equation

The basic equation for the effective width,  $b$ , are the result of very extensive research, and are shown below:

$$b = w \quad \text{when} \quad \lambda \leq 0.673$$

$$b = \rho w \quad \text{when} \quad \lambda > 0.673$$

Figure 8

The effective width is calculated by multiplying the actual width, **w**, by a reduction factor  $\rho$ , when the slenderness parameter  $\lambda$  is greater than 0.673. As  $\lambda$  increases the effective width decreases.

$$\lambda = \frac{1.052}{\sqrt{k}} \left( \frac{w}{t} \right) \sqrt{\frac{f}{E}}$$

$$\rho = (1 - 0.22 / \lambda) / \lambda$$

Figure 9

It is seen that the slenderness parameter,  $\lambda$ , depends on the ratio of actual width to thickness (**w/t**), the plate buckling coefficient, **k**, and the maximum edge stress, **f**.  $\lambda$  increases with the increasing edge stress, **f**, and also with increasing flat width-to-thickness ratio, **w/t**.

**Stiffened vs. Unstiffened Sections**



Figure 10

A thin, flat sheet of steel cannot support much weight, but if it is formed into a corrugated sheet, the folds act as stiffeners, and can increase the strength of the same sheet many times over.

The load-carrying capacity of the compression components in beams or columns can be increased significantly by the use of the edge stiffeners or intermediate stiffeners. The lip on the flanges of C-shaped steel studs is an example of edge stiffener.

When a compression component has stiffeners on along two parallel edges, it is considered as a fully stiffened or partially stiffened section depending on the stiffness of the stiffeners. When a compression component has the stiffener along one edge only, it is considered as an unstiffened section. The flanges of C-shaped steel studs are examples of fully or partially stiffened sections while the flanges of U-shaped steel track are examples of unstiffened sections.

### Applications of Cold-Formed Steel

Cold-formed shapes can be used for entire buildings and for complete roof, floor and wall systems. They can also be used as individual framing members such as studs, joists and truss members.

From structural standpoint, the cold-formed steel can serve as both primary structures and secondary structures. An example of the cold-formed steel used as primary structures is the steel stud load-bearing wall. Steel studs providing the lateral support to exterior wall finish are usually secondary structures since they rely on the primary structure for support.

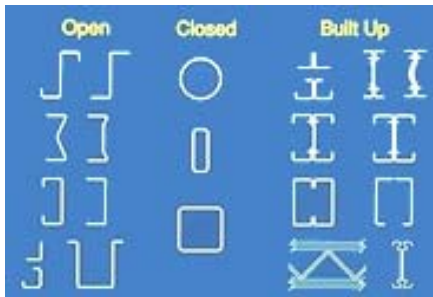


Figure 11

There are two major types of cold-formed steel products: structural shapes and panels. Of the former, there are a variety of cold-formed structural shapes available on the market. They include open sections, closed sections and built-up sections. Cee-, zee-, double channel I-sections, and hat sections are open sections while box sections and pipes are closed sections. These structural shapes can be used in buildings as eave struts, purlins, girts, studs, headers, floor joist, braces and other building components.

### Regular Decks



Figure 12

Floor decks, roof decks and wall systems are the prime applications for cold-formed steel in panel form. These are made in both simple, or single-component types, as well as more complex units made up of several elements. Permanent metal deck forms are usually galvanized, and are fabricated from lightweight steel in thickness that vary from 0.020 to 0.075 inches (0.50 to 1.9mm) and depths of 2, 3, and 4-1/2 inches (51, 76 and 115mm), depending on slab thickness and design span.

Permanent metal deck forms are designed to support the wet weight of concrete, a construction load, reinforcing steel and the weight of the form itself.



Figure 13

Composite metal deck forms also provide the tension reinforcement for the slab. The embossments provide interlock between the deck and the concrete. The ribs are generally trapezoidal in shape for roof and floor deck applications, although they may vary by manufacturer. The panels may be punched with a pattern of holes to absorb sound.



### Multi-Function Deck

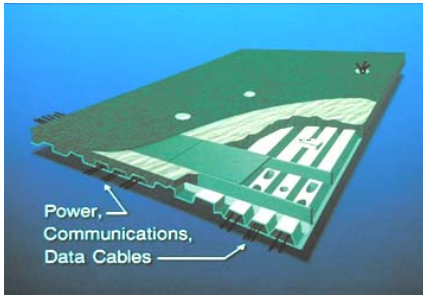


Figure 14

Some deck systems use cellular cold-formed steel shapes to permit lightweight floors that reduce deadweight. These floor systems can provide electrical power, communications and data cable distribution as well as heating and air conditioning ducts.

This eliminates separate space requirements in floors, walls and ceilings for ductwork or conduit systems. The modular construction possible with cold-formed steel sections

permits access to many points in the deck, making it easy to rearrange wiring or ventilation outlets.

### Standing Seam Metal Roof



Figure 15

The cold-formed steel standing seam roof was introduced in 1969 as a new concept in roofing. Today, there is over a billion square feet of standing seam roofing installed.

The system consists of factory or job-site roll-formed panels with elevated, field-secured seams and concealed clips that fasten the panels to the structure and permit the panels to accommodate thermal expansion and contraction.

There are two basic types of standing seam roof systems:



Figure 16

The first type is structural standing seam roof panels that provide a water-tight barrier and are generally installed on low-slope applications, with a minimum slope of about  $\frac{1}{4}$  in 12. These panels provide their own support, usually spanning about five feet (1.5m) between purlins. The system can also be installed over existing flat roofs by using a sloped sub-assembly system made of light steel structurals. The "attic" created by the sub-assembly affords a convenient area of adding insulation.

Leaving the old roof in place means avoiding the release of potentially hazardous materials into the environment and eliminating the cost of disposing of the existing roof. Most importantly, a new metal roof can be installed with little or no interruption to the building's occupants. The preferred material for the roof panel is galvanized or aluminum-zinc coated sheet steel.



Figure 17

The second type is architectural standing seam roof panels. They are generally used on roofs with slopes of 3 to 12 or greater, and provide water protection as well as aesthetic value. These panels usually require some form of decking for support. The preferred materials for architectural standing seam roof panels are prepainted galvanized and prepainted aluminum-zinc coated sheet steel. The architectural possibilities provided by the variety of colors and patterns are limitless.

### Insulated Panel

Cold-formed steel panels are also used for enclosing the building to keep out the weather and keep in the heat. There are now available cold-formed steel panels with insulation already incorporated in the construction of the panel. Some of these configurations make use of foamed in place rigid urethanes sandwiched in between the steel. Others use different types of insulation, the more conventional being fiberglass installed in the panels.

### Wall Panels



Figure 18

There are wide varieties of panel systems. The simple, single element is available primarily as a ribbed sheet; formed, coated and otherwise modified to fulfill special functions that may be required.

Panels for walls may be as straightforward as a painted ribbed panel or as interesting as a porcelain or metal and glass curtain wall system.

In many metal buildings, the wall panel is similar to the ribbed roof panel, with either wide or narrow ribs, and is painted or aluminum coated for long service life. The same tongue and groove lap or standing seam joints is employed here.

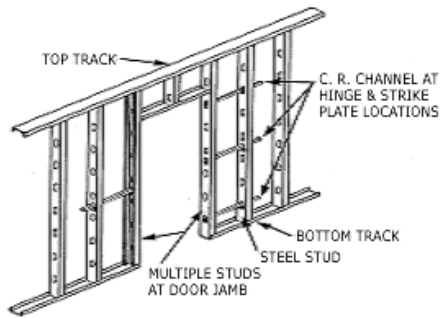


Figure 19

More sophisticated systems are made from cold-formed steel for curtain wall systems of buildings. These may include varying amounts of glass, either tinted or clear, complex or simple trim work and clean expanses of sheet steel.

There are many advantages in using these cold-formed steel curtain walls. They include high strength and lightweight, and modular installation for lower construction costs. They permit a beautiful surface, available in a variety of coatings, textures and colors to meet any architectural concept. Like other panels, these may have insulation pre-installed. The curtain wall module may span several window bays or several floors, to minimize installation time.

### Exterior Walls



Metal stud framing is widely used as the structural support for the exterior brick veneer and exterior insulation finishing system (EIFS). A stud wall framing is a wall system with studs connected to the top and bottom tracks and braced with cold-rolled channel bridging or diagonal bracing. The stud wall system can be used to carry the floor load (load bearing wall), to resist the lateral load such as wind or seismic load (curtain wall), or to provide lateral stability for the building (shear wall).

Figure 20

Stud wall framing has been widely used in both non-load-bearing and load-bearing construction.

### Building Interior Partitions and Enclosures

Cold-formed steel framing is also used for interior walls and partitions that provide flexibility in layout of interior spaces as well as the freedom to relocate and redesign. In addition, cold-formed steel framing is used to support the shaft walls, ceilings, and duct enclosures.

### Residential Uses



Figure 21

Another area in construction where cold-formed steel is finding wider application is in residential steel framing systems. Here, steel is used instead of lumber for joists, studs and other structural components of residential construction. The steel components are usually of Cee, I or hat shape and galvanized or painted. They can be cut to the required length by the manufacturers, thereby minimizing construction labor.

### Culverts



Figure 22 (Source: NCSPA)

Cold-formed, corrugated steel pipes are used for everything from storm sewers to utility tunnels, and from simple tunnels under roadways to huge bridge structures. The corrugated steel pipe can be installed in a cut, then covered with fills and topped out with a roadway to form an inexpensive and durable bridge.

### Floor and Roof Trusses



Figure 23 (Source: Dietrich Industries)

Cold-formed steel trusses have gained a significant market share in recent years. They can be made from regular C-section studs or from other proprietary shapes. Cold-formed steel trusses provide the same span capabilities and design flexibilities as wood trusses, yet they are lighter and more dimensionally stable than wood trusses. Most cold-formed steel roof trusses are pre-engineered and prefabricated using computer software, which makes it possible to accommodate various roof configurations. This design flexibility makes cold-formed steel trusses ideal for almost any building type – residential, commercial, institutional, educational and industrial structures.

### Racks



Figure 24

Material handling and storage specialists rely on cold-formed steel racks and rack systems to efficiently store and retrieve everything from groceries to heavy steel bars. New rack systems are so huge that they fill entire buildings and have stacker cranes that rise as high as 100 feet (30m).

## Pre-Engineered Buildings



Figure 25

There is a whole industry built around cold-formed steel building components. Manufacturers of pre-engineered metal building provide custom designed structures for anything from a small tool shed to a range of sophisticated structures such as schools, churches and other complex manufacturing facilities.

## Other Applications

Cold-formed steel is also used for a variety of building products such as doors and windows. In highway construction, cold-formed steel is also used for guardrails, median and glare barriers, permanent bridge deck forms, signs and other components.

## Advantages of Cold-Formed Steel

Cold-formed steel products are shaped at ambient temperature from steel sheet, strip plate or flat bars by roll-forming machines, press brakes or bending brake operations. They can be produced in large quantity and at high speed with consistent quality. A typical automated rolling machine can run at a speed range of 75-150 feet per minute, and the products can be as small as a three-quarter inch wide cold-rolled channel section to as big as a thirty-six inch wide roof deck section. In addition, cold-formed steel possesses many other superior advantages over other construction materials:

1. *Lightweight* - Cold-formed steel weighs significantly less than wood and masonry materials. A typical stud wall weights only 10% to 15% of the masonry wall, which means easy handling during the construction and transportation.
2. *High strength and stiffness* – As a result of the cold-forming process, cold-formed steel possesses one of the highest strength-to-weight ratios of any building materials. This high strength and stiffness advantage means better design flexibility, wider spans and better material usage.
3. *Fast and easy erection and installation* – Building components made of cold-formed steel can be fabricated with high accuracy in a plant and then assembled on job sites, which greatly increases erection efficiency and ensures construction quality.
4. *Dimensionally stable* - Cold-formed steel does not expand or contract with moisture content. In addition, it does not split or warp as time goes by and, therefore, is dimensionally stable. Cracked sheetrock walls, nailhead popping and other common problems with wood framed structures can be virtually eliminated in buildings with cold-formed steel stud walls.
5. *No formwork needed* – The use of cold-formed steel decks eliminates the formwork for pouring concrete floor. In addition, composite action between the steel deck and concrete increases floor strength and stiffness.

6. *Durable* - Cold-formed steel is durable because it is termite-proof and rot-proof. In addition, galvanized cold-formed steel products can provide long-term resistance to corrosion.
7. *Economy in transportation and handling* - The cold-formed members or panels are easy to handle and to transport due to their lightweight. In addition, they can be staggered and bundled, thus with small space occupancy.
8. *Non-combustible* - Steel does not burn and will not contribute fuel to the spread of a fire, which will result in better fire resistance and lower insurance premiums.
9. *Recyclable* - Steel is an environment friendly "green" material. It can be recycled and reused. Steel-framed housing dramatically reduces the amount of trees consumed for residential construction, thus conserving one of nature's most precious resources.

### Connections

The main forms of connections of cold-formed steel in construction are mechanical fasteners, welding and seams of various designs.

### Seam Types

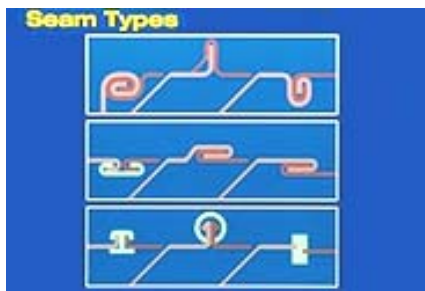


Figure 24

Seams are used on roof decks, corrugated steel pipes and in other products. Possible seam designs include the single lock seam, grooved single lock seam and batten seam. Others include the double lock standing seam, standing seam and double lock seam.

### Bolts



Figure 23

With mechanical fasteners, and particularly bolted connections, the ratio of bolt diameter to plate thickness is usually much larger in cold-formed steel construction than in heavy construction. This means that larger numbers of smaller diameter mechanical fasteners should be used in joining cold-formed sheet steel sections, although the general rules governing their placement are not unlike those of hot rolled structural steel. These general rules, however, are strongly subject to modification for behavior in particular cases.

Sometimes it is necessary to conduct tests to determine the best type and placement of fasteners, although for commercially available products, this information is supplied by the manufacturer. Bolts are usually hex-head and are used with washers.

### Screws



Figure 24

Self-tapping and self-drilling screws are important fasteners for cold-formed steel. They come in a variety of lengths, diameters, strengths and coatings, and their use should be in accordance with the manufacturer's suggestions. Minimum penetration of screws shall include the thickness of joined material plus three (3) exposed threads.

Self-drilling screws drill and tap their own hole and are used with mechanical drivers. Because these types of screws require no pre-drilled hole, they are useful where lineup of the parts being joined is accomplished through other means before joining.

These kinds of fasteners are used with steel framing systems for joining framing members to one another and for fastening sheathing material to the framing structure. For the latter job, there are many specialized types of screws, nails and staples. They are designed to anchor into both the framework and sheathing. Special coatings such as cadmium, zinc and other metals provide longer fastener life.

### Powder Actuated Fasteners



Figure 25

Powder actuated fasteners, also called power nails, are used to connect cold-formed steel framing to concrete or structural steel. Use of powder actuated fasteners enables speedy installation. The typical diameter of powder actuated fasteners is 0.145"φ for structural applications. A minimum ¾" penetration, 3" edge distance, and 4" spacing in concrete is required. In structural steel, minimum edge distance shall be ½" and minimum spacing 1½". The point of the fastener should be driven completely through the backside of the hot rolled steel member or embedded minimum ½" into hot rolled steel.

## Expansion Anchors and Anchor Screws



Figure 26

Expansion anchors and anchor screws are used to fasten cold-formed steel framing to concrete or masonry. Their load capacities are usually higher than that of powder actuated fasteners. A minimum 3" edge distance and 4" spacing in concrete and masonry are required for all expansion anchors to achieve design load capacity.

Since it is necessary to drill a hole for each anchor, it takes longer to install an expansion anchor or anchor screw than a powder actuated fastener.

## Welding



Figure 27

Welding is widely used for joining cold-formed sheet steel parts. The two types of welds used are fusion and resistance. Fusion welding includes a group of weld types such as fillet welds, butt welds, plug welds and puddle welds, in which sheets are welded together by bringing them to the molten state at the surface to be joined by means of deposition of weld metal. Fusion welds are often used for erection, joining one cold-formed steel member to another or to hot-rolled framing members.

Resistance welding includes spot and projection welding. In this type of welding, coalescence is produced by the heat obtained from resistance to an electric current passed through the work parts, which are held together under pressure by electrodes. Resistance welding is mostly used for in-shop fabrication of cold-formed steel components.

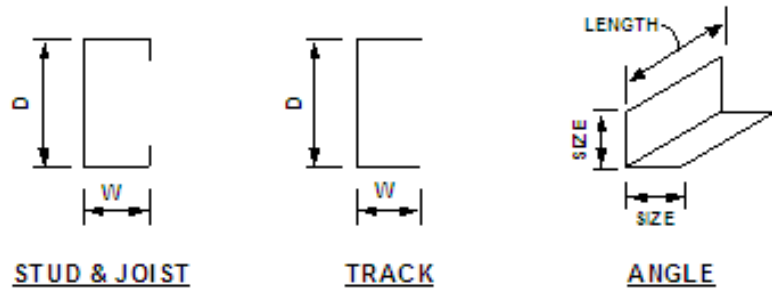
If cold-formed steel members are welded, minimum steel thickness shall be 18 gauge (43 mils). Special low amperage welding equipment and small diameter rods shall be used to prevent blowholes in the cold-formed steel. Typical welds for 12 gauge (97mils) and lighter materials is 1/8" flare-groove or fillet welds. Welded areas shall be touched up with a zinc-rich paint.



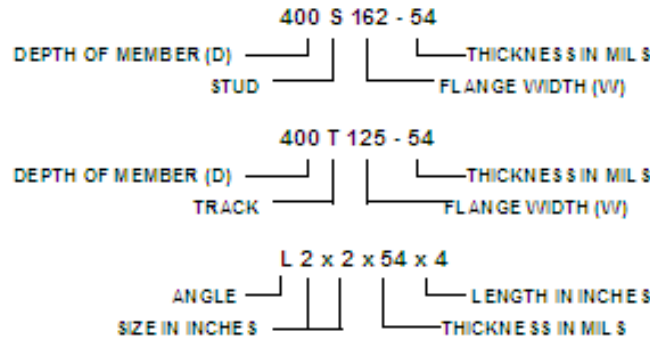
### Industry Standard Nomenclature for Steel Studs and Tracks

For many years, steel stud manufacturers had used different in-house nomenclatures for their own products, which made it inconvenient for designers to specify the cold-formed steel stud products. In 1996, an industry standard nomenclature was introduced by two steel stud manufacturers associations. The standard nomenclature identifies cold-formed steel products by member size (both depth and flange width), style, and material thickness as follows:

### Standard Nomenclature



MEMBERS ARE DESIGNATED ON DESIGN DRAWINGS AS FOLLOWS:



THICKNESS CONVERSION	EQUIVALENT MEMBER DEPTH OR FLANGE WIDTH	
33 MILS = 20 GA.	125 = 1.25" = 1 1/4"	362 = 3.62" = 3 5/8"
43 MILS = 18 GA.	137 = 1.37" = 1 3/8"	400 = 4.00" = 4"
54 MILS = 16 GA.	162 = 1.62" = 1 5/8"	600 = 6.00" = 6"
68 MILS = 14 GA.	200 = 2.00" = 2"	800 = 8.00" = 8"
97 MILS = 12 GA.	250 = 2.50" = 2 1/2"	1000 = 10.00" = 10"

Although the steel stud thickness can be as thin as 18 mils (25 gauge) for interior construction applications, the minimum material thickness shall be 33 mils (20 gauge) for any structural applications. In addition, a galvanized finish with a minimum G60 coating is recommended for most structural applications not exposed to weather. A heavy protective coating G90 should be considered for structural applications exposed to weather.

To help designers and contractors identify the material thickness of cold-formed steel products in the field, stud manufacturers usually paint one end of studs and tracks according to the color-coding table on the next page.

**Table 1. Steel Gauge Identification by Color**

Minimum Delivered Thickness (mils)	Reference Gauge Number	Color Code
18 or 27	25 or 22	None
33	20	White
43	18	Yellow
54	16	Green
68	14	Orange
97	12	Red

**Special Considerations for Load-Bearing Studs**

As more and more cold-formed steel studs are used in the load-bearing applications, a cold-formed steel designer needs to pay special attention to the unique characteristics of steel stud construction and to require better quality control during the construction. One of the most common problems with load-bearing stud construction is the gap at the top and bottom of steel studs. For lightly loaded studs, the connection between the stud and the track can be designed to carry the axial load without the direct bearing. For heavily loaded studs, load-bearing stud wall panels shall be fabricated in a plant where the gap between the stud and the track can be eliminated using a special pressing equipment.

When there is a significant axial load in the steel studs, horizontal cold-rolled steel channel bracing may not be sufficient to provide adequate bracing force to the heavy gauge steel studs. In this case, horizontal and diagonal steel strap bracing on each face of load-bearing stud walls should be considered. Another option is to introduce stand-alone box-sections so that each composite stud can function properly without relying on the horizontal bracing.

Unless adequate load distribution members are provided at each floor level, it is imperative for steel studs align vertically for direct load transfer from the top floor to the bottom floor. To allow certain construction tolerance, a designer may consider using heavy gauge tracks with 2- to 3-inch deep legs at the top and bottom of heavy load-bearing stud walls.

**Design Methods**

Much of the research and engineering knowledge about cold-formed steel design is available to you in the form of the American Iron and Steel Institute **Cold-Formed Steel Design Manual**. This publication, in allowable stress design and load and resistance factor design, include the **Specification for the Design of Cold-Formed Steel Structural Members and its Commentary**. The commentary helps the designer understand how the criteria were developed and gives references to the original sources. The Beam Design, Column Design and Connection Design parts provide various design examples, tables and charts for design use. The Design Manual also includes Supplementary Information and Test Procedures.

To order design related publications, please visit [AISI Publications](#) on the [AISI website](#).

## Course Summary

Cold-formed steel has been used more and more in the manufactured products and construction industry. Noticeable progress has been made in the areas of cold-formed roof trusses and load-bearing stud walls in the mid-rise buildings. It is important for engineers and architects to understand the standard nomenclature and unique characteristics of the cold-formed steel so that they can specify the cold-formed steel for the proper applications.

## Related Links

For additional technical information related to this subject, please visit the following websites or web pages:

[American Iron and Steel Institute](#)  
[AISI Construction - Cold-Formed Steel Design](#)  
[Center for Cold-Formed Steel Structures](#)  
[Light Gauge Steel Engineers Association](#)  
[Steel Stud Manufacturers Association](#)

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The material presented in this course is partly based on the AISI Slide Show "[A Look at Cold-Formed Steel Structures](#)".

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**Once you finish studying the course material, you need to take a quiz to obtain the LU/PDH credits.**

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