Steel-Frame Construction

Steel has been used for more than 150 years in shaping the built environment. Although the idea of steel conjures up images of a heavy or cumbersome material, the steel used in residential construction is quite the opposite. Cold-formed steel (CFS) is lightweight, easy to handle, cost effective, and a high quality alternative to traditional residential framing materials. CFS offers the builder a strong, dimensionally stable, easy-to-work framing system whose use can be traced back to 1850.

In the late 1920s and early 1930s cold-formed steel entered the building construction arena with products manufactured by a handful of fabricators. Although these products were successful in performance, they faced difficulties with acceptance for two reasons: (1) there was no standard design methodology available, and (2) cold-formed steel was not included in the building codes at that time. Many of the CFS applications were unable to be used due to the lack of design methodology and product recognition.

Growth in Popularity

Between 1979 and 1992 the number of steel-framed homes saw a substantial increase. Cold-formed steel framing was used in 5% of housing starts in the U.S. in 1993. This percentage increased to 8% in 2000 and had reached 12% in 2005. The emphasis has been on single-family homes in the Sunbelt and on multi-family homes in the north. The popularity of steel framing in the Sunbelt is expected to continue to increase rapidly because of the concern over termites, decay, and high winds. Urban areas and fire hazard districts are also expected to show a growing interest in steel framing.

According to the Washington DC-based Steel Framing Alliance there is no national system (http://www.steelframingalliance.com) in place to track the use of steel framing in homes accurately. However, the Alliance estimates that steel was being used in 3 to 6 percent of the housing starts in the US in 1999.

In Florida, however, every building built must have an Energy Code Compliance Form prepared and submitted when applying for a permit. Included in this form is a description of the exterior wall configuration including the type of building system. Presented below is a summary of the mix of building systems used in Florida in 2000 and 2001. Based on a random sample of over 1,600 single-family detached homes, less than 1% of the homes built in the Central climatic zone employed steel framing. (See table below)

Climatic zone	Face brick		Concrete		Lt Wt Conc		Poly bead aggregate	Wood frame	Steel frame	Log	Other
	Wood frame	Conc block	Int insul	Ext insul	Int insul	Ext insul					
South (350 units)	0.5%	0.5%	62.0%	1.7%	3.4%	1.1%	-	39.7%	-	0.2%	-
Central (932 units)	-	-	42.8%	1.7%	1.6%	0.1%	0.5%	53.2%	0.2%	-	-
North (330 units)	14.8%	0.6%	9.1%	0.3%	0.6%	-	0.9%	79.4%	-	-	-

Environmentally Friendly

The Steel Framing Alliance claims that cold-formed steel framing is an environmentally friendly building system because:

- Steel is recyclable, using old cars, buildings, bridges, steel cans, etc.
- Steel is the world's most versatile material to recycle.
- Yearly, steelmakers recycle about ***500*** million tons of steel world-wide.
- It takes at least ***60%*** less energy to produce steel from scrap than it does from iron ore.
- It takes about ***6*** old cars to produce enough steel to frame a basic residential dwelling.

Easy on Land Fills

In addition to being environmentally friendly, steel framing results in a reduction in construction waste that would normally end up in a land fill:

- The average landfill consists of approximately ***60% c***onstruction debris - mostly concrete, wood, and plastic.
- Every ton of steel recycled conserves ***2,500*** pounds of iron ore, ***1,400*** pounds of coal, and ***120*** pounds of limestone.
- Less than ***6%*** of landfill is steel - such as staples, nails in wood, and steel rebar inside chunks of concrete.
- Debris from a typical wood-framed home accounts for ***50 ft^3*** of landfill waste, compared to only ***2 ft^3*** from a steel-framed house

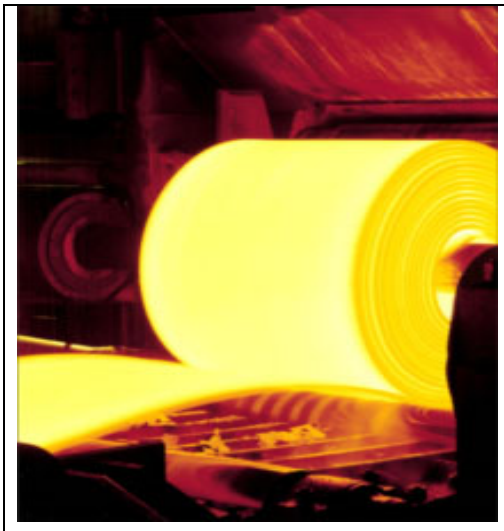
Advantages of Steel Framing

- Consistent Material Quality

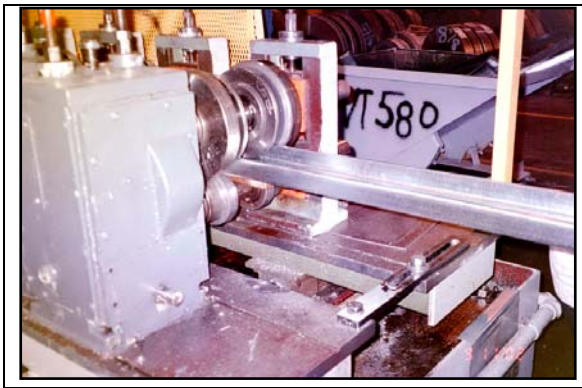
- Non-Combustible Material
- Dimensionally Stable in any Climate
- Insect Resistance and steel will not Rot
- Engineering not required for common home designs (see Prescriptive method: IRC 2003)

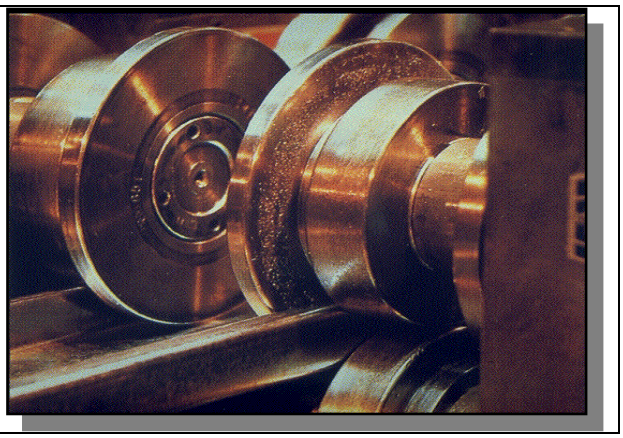
Manufacturing Process

Cold-formed steel products begin as a very large coil of steel. These coils may weight up to 13 tons.

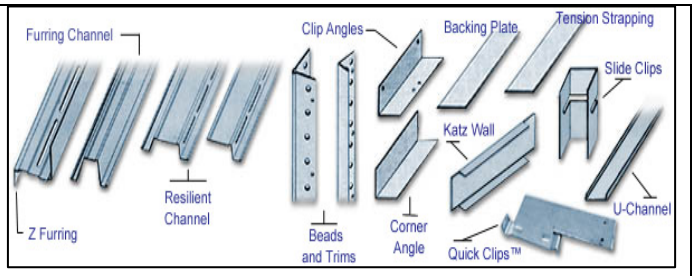


After the hot coil has been rolled to the desired thickness and after it has cooled, the ribbon of steel passes through a series of rollers to form the desired products:



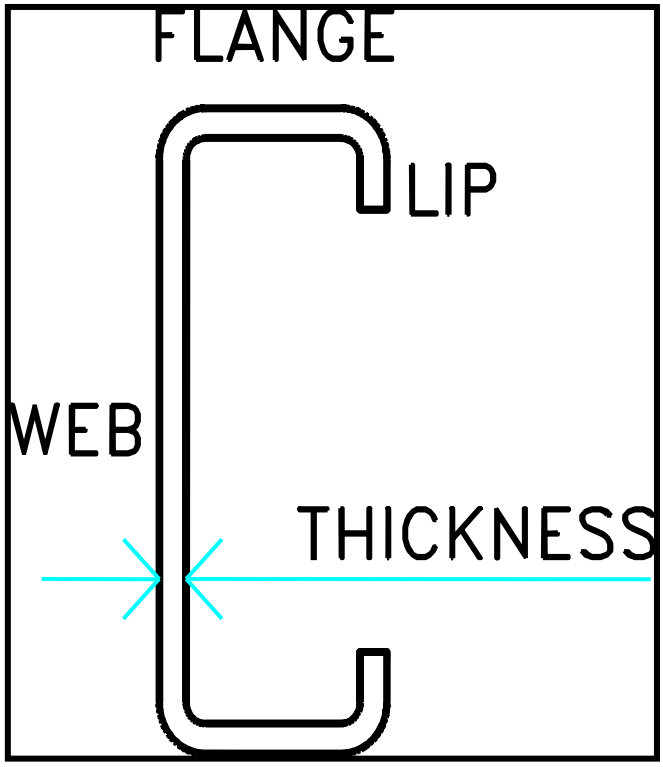


Rolling the coiled ribbon of steel produces a variety of cold-formed steel components used in construction.



Studs & joists, tracks, U-channels, Furring channels

However, the basic cold-formed C-shape is by far the most common component:



Steel Studs and Joists

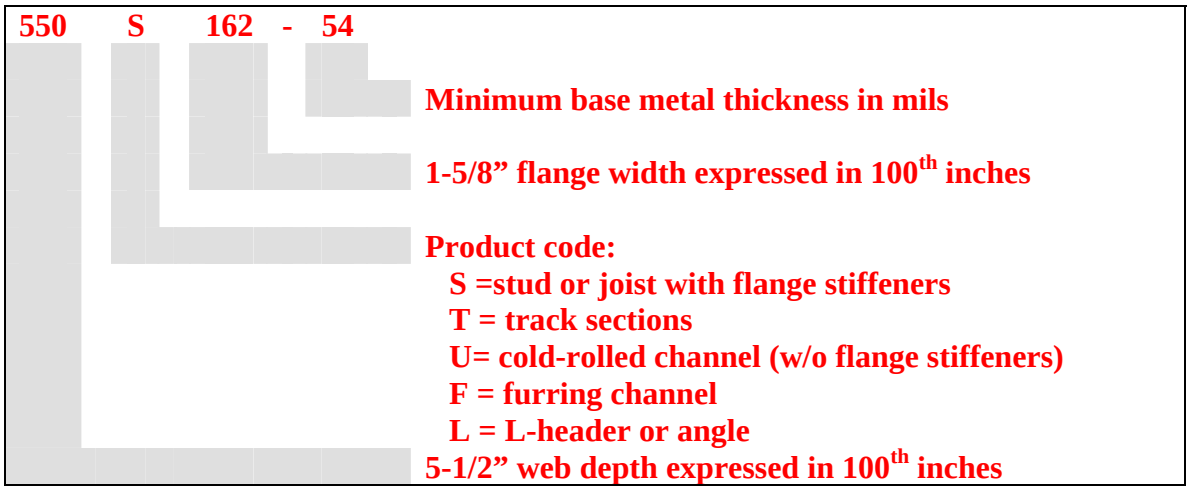
Structural cold-formed steel studs are produced with a 1-5/8” flange and ½” return lips using a 33-97 mil thickness steel covered with a G60 galvanized coating.

Non-structural cold-formed steel studs are not intended to carry loads. They typically are produced with 1.25” flanges and ¼” return lips using steel with a 33 mil thickness-or-less and a G40 galvanized coating.

Floor joists are produced the same as the structural studs but their webs range from 6”, 8”, 10”, or 12”.

Specification

A universal designator system, similar to a grade stamp used for lumber products, is typically used to identify each steel component produced. The designator for at 5-1/2”, 16-gauge, C-shape stud with 1-5/8” flanges and 54-mil galvanized coating would appear as: **550S162-54**. The elements of the designator are described in the diagram below.



The product specification is imprinted on members produced at intervals of 48" much like the grade stamp applied to lumber products. The label typically includes:

- Manufacturer's identification or logo
- Minimum uncoated steel thickness
- Minimum yield strength
- Coating designation if other than minimum

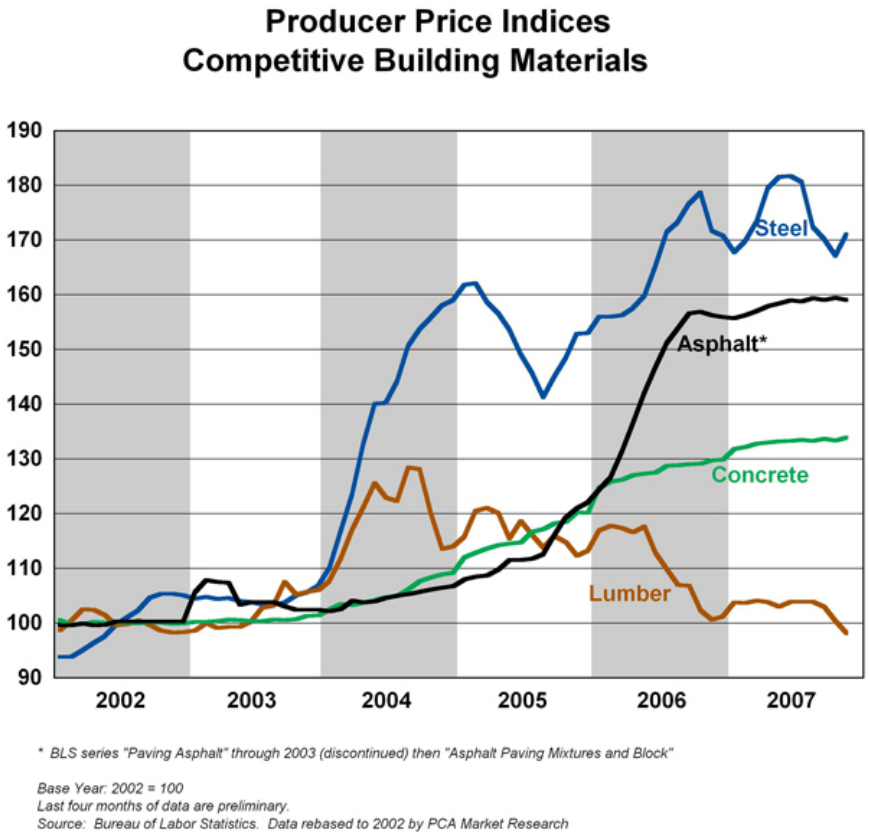
Steel and Fire

Steel is non-combustible, will not support flame, and does not generate smoke. However, steel looses strength at high temperatures and should be protected from excessive temperatures in accordance with code requirements (e.g., gypsum wallboard or other approved material).

Price Stability

Price and stability of supply have driven many builders to adopt residential steel framing. While the price of steel has remained relatively stable since the 1980s and continuing through 2003, steel mill product prices jumped about 50% in 2004. In 2005, steel prices declined about 12% and then climbed nearly 30%. (See figure below)

Such volatility in pricing makes it very difficult for estimators to predict prices more than a couple weeks ahead, let alone months ahead. As a result, the market penetration of cold-formed steel has slowed significantly. In addition to steel fluctuating, concrete prices have risen 15%; asphalt has increased 14%; and lumber has increased 7% during the same period. (Source: Department of Labor, Bureau of Labor Statistics, www.bls.gov).



According to the NAHB Research Center's *Toolbase Services* (See: www.toolbase.org), at current steel prices, **the steel framing materials required to frame a typical house (average 2,150 sq. ft.) will be less expensive than the wood framing materials required to frame the same house when the "Random Lengths Composite Index" is ~$350 or higher for lumber.** However, if the builder, framing contractor or other subcontractor is new to steel, then labor costs could account for a $1.00 – $2.50 per square foot premium for steel framing. Historically speaking, steel material prices have remained flat, while wood material prices have fluctuated greatly. The steel industry continues to improve the processes by which steel homes are built, bringing hard construction costs down to a minimum, so that builders will be able to enjoy a competitive and stable framing package price.

Benefits of Steel

There are benefits for both the builder and the homeowner associated with steel.

From the builder's perspective it is important that steel will not rot, twist, warp, swell, or split and it is non-combustible. Steel framing is a proven technology that is considered to be user friendly and offers an easy transition from other materials. Competitive pricing and consistent quality are clearly important benefits to builders. The strength of steel usually translates into fewer members and many of those members are as much as 60% lighter than the corresponding wood members. Nationally, cold-formed steel members

have come to be produced in a variety of standard pre-cut shapes and sizes. Standardized patterns for pre-punched holes for running electrical wiring and plumbing lines help to minimize preparation work for tradesmen. This standardization serves to minimize construction waste. The finished steel framing accommodates all types of commonly used finish materials.

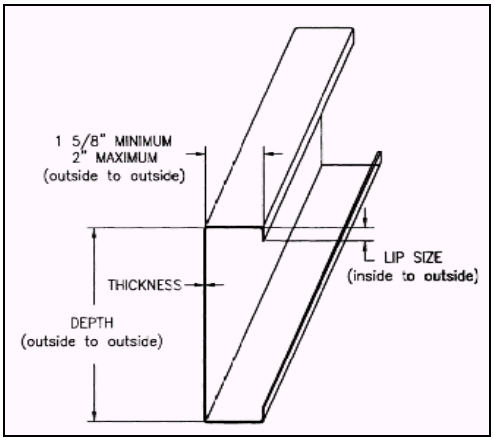
Homeowners reap many of the same benefits. In addition, homes can be designed to meet the highest seismic and wind load specifications in any part of the country. Because steel framed homes can be so resistant to natural forces, some homeowners save as much as 30% on their homeowner's insurance. Steel framing does not need to be treated to resist termites and is free of resin adhesives and other chemicals used to treat wood. Because of its strength, steel can span greater distances offering the homeowner larger open spaces and greater design flexibility. Remodeling is also easily accomplished by removing, altering, and relocating non-load-bearing walls.

Environmentally Sensitive

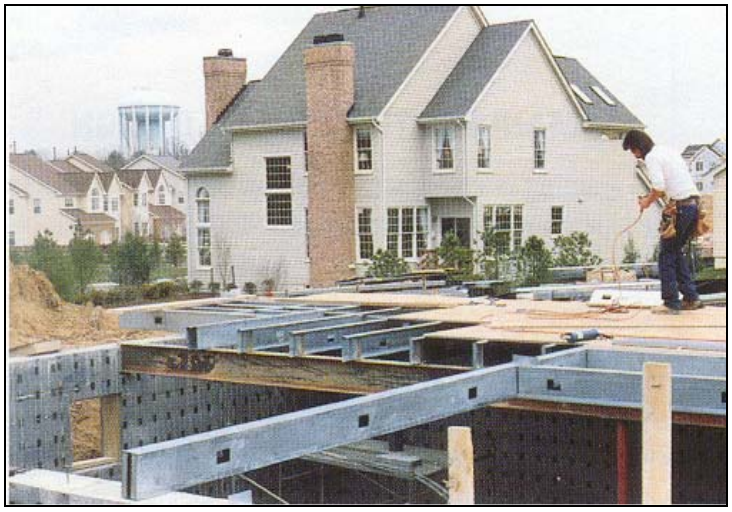
All steel products are recyclable! The overall recycling rate for steel products in the US is 60%. **In steel building products, the minimum recycled content is 25%.** This recycling is accomplished with no degradation in product quality or loss of properties. A contributing factor in the steel industry's ability to achieve significant recycling is that magnetic separation is the easiest and most economical method of removing steel from the solid waste stream. The amount of energy needed to produce a ton of steel has been reduced by 34% since 1972.

Steel Framing Components

The steel component known as the structural "C" is the predominant shape for framing floors, walls, and roofs. The primary difference from one use to another is the thickness of the steel and the depth of the member.



Floors – Builders commonly opt for steel floor joists ranging in depth from 6- to 12-inches and steel thickness from 0.034- to 0.101-inches. Instead of using overlapped joists at a center support, a single length of steel joist is commonly used to span continuously.



Walls – There are two basic types of studs:

- Structural "C" studs for interior and exterior load-bearing walls that range in depth from 2½" to 8" to accommodate the necessary insulation thickness and ranging in thickness from 0.034- to 0.071-inches depending on the anticipated load.
- Drywall studs for non-load-bearing partitions that range in depth from 1⅝- to 6-inches and metal thichness ranging from 0.01- to 0.034-inches.

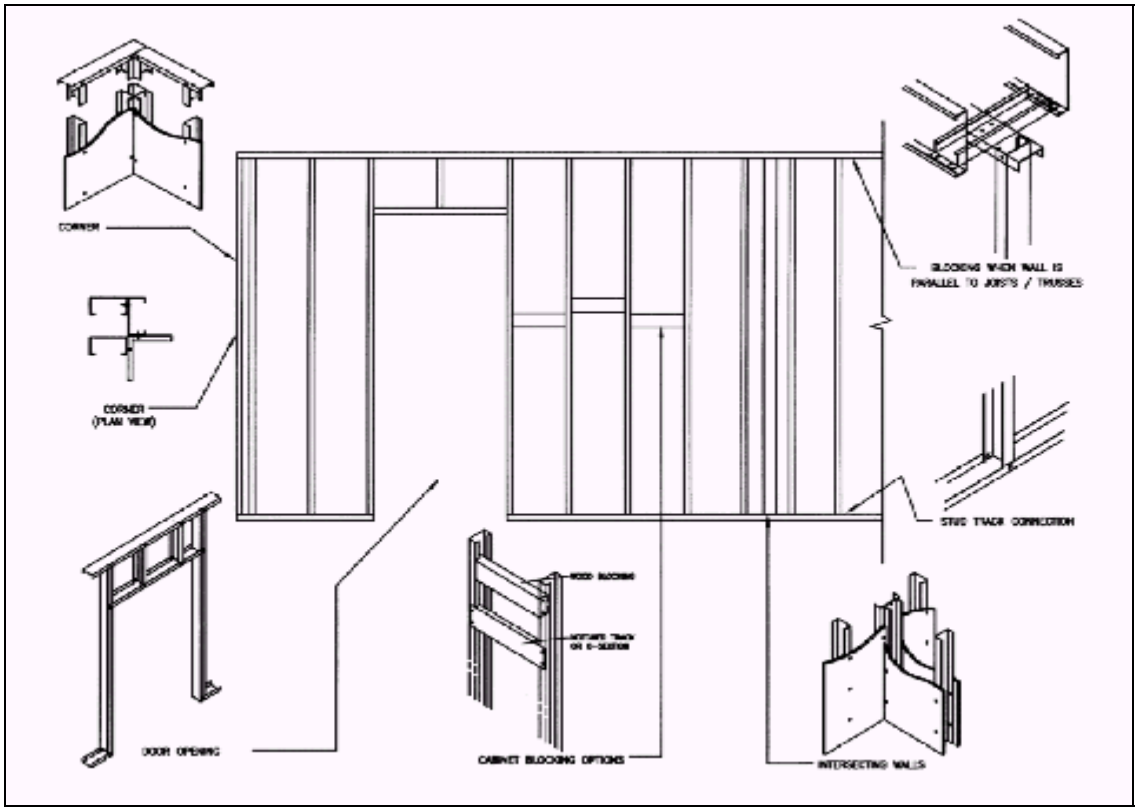
The thermal efficiency of the steel-framed exterior walls may be increased by installing insulation board on the exterior of the wall.

Roofs – The broad range of available sizes and thicknesses allow steel framing to be used in virtually any roof system. Steel trusses can be built on-site or off-site in truss fabrication plants.

Framing Methods

There are three basic residential steel framing methods: stick-built, panelized, and pre-engineered.

- **Stick-built** - Replace wood members with steel members (one-for-one replacement). As shown below, the steel-framed non-load-bearing wall appears very similar to that of a comparable wood-framed wall.

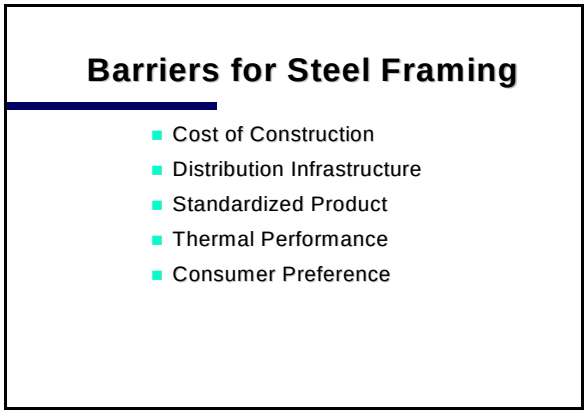


- **Panelized** - Factory-assembled panels delivered to site and connected together. The panelized approach represents an efficient approach for repetitive building designs and, as a result, is a popular approach in hotel/motel construction and other multi-unit applications.
- **Engineered** - Location and placement of framing members is engineered to take advantage of steel's properties. Spacing of framing members may increase to as much as 8-feet with horizontal stabilizers.

Barriers to Steel Framing

Five key barriers to the expansion of residential steel framing have been identified.

- **Cost of Construction -** To have wide spread markets, the steel industry has to make cold-formed steel framing economically competitive. It is not now competitive because it costs more in **labor** to frame a house out of steel. All of the workers have tools and accessories that were optimized for wood construction, not steel. The steel industry is committed to taking away this barrier by doing their own product development, causing product development to happen, or funding product development as necessary to bring these things for steel framing at the same price.
- **Distribution Infrastructure -** Buying 800 wooden studs from a lumberyard is routine. Steel framing has achieved that status in most markets. One of the reasons is that the industry did not have the material distribution system in place to provide the necessary supply quantities.



- **Standardized Product** - Another barrier was that there were no standardized products. There were 73 steel manufactures in the nation, and all of them previously made basically identical shapes, called them all different names, published different section properties, and published different load tables. The industry has now standardized these products.
- **Consumer Preference** - The last barrier is consumer preference. What the industry did was turn the standard profiles into standard section properties with

standard load tables and then into prescriptive methods. Houses in about 80% of the country are designed by purely prescriptive methods, no engineering is required. The other 20% are a combination of prescriptive and engineering. Steel framed structures originally had to be completely engineered and that costs three to six weeks and $0.70 to $2.00 a square foot. The prescriptive tables have solved the problem and may be found in the International Residential Code (IRC). Nearly everyday somewhere in North America a seminar is being conducted in front of a group of plan checkers and building inspectors to try and get them to understand how to use the prescriptive method and then to adopt it so that steel structures can be designed prescriptively like wood structures. That eliminates the engineering barrier.

Even though the steel products were standardized, the whole world doesn't know what they are. Nearly everyone knows what a 2x4 is; not everyone knows what a C-section steel stud is designated with the designation: "550S162-54". As a result software has been developed and is available for building designers. If you can do a takeoff with wood, then this software will turn it into a steel takeoff and produce the order sheets and the sheets for the job site.

The lumber industry can run studs out that are cut to length at a couple hundred feet a minute with a plus-or-minus quarter inch tolerance. Today, steel studs can be rolled at up to 500 feet a minute with up to one one-thousandth of an inch tolerance. This capability translates into part of the vision the steel industry has of the future. This vision includes contractor suppliers, lumberyards, or other distribution channels throughout the nation with bins full of 8-foot, 9-foot, and 10-foot plate-height studs cut exactly to length.

- **Thermal Performance -** Steel studs are excellent conductors of heat. They conduct heat better than wood. Because of this characteristic, the steel industry has had to take remedial action such as adding foam board on the outside of the exterior wall framing. As long as builders have to take this step, it may solve the thermal problem, but it costs something. It costs $0.65 a square foot or more to make steel houses as energy efficient as wood framed houses. This added insulation is a major cost barrier that will have to be resolved for steel to become a serious competitor for wood.

Framer training is a major issue that the steel industry is attacking on two fronts. It is very simple to frame a house out of steel. The problem is you have to use different tools; you have to cut it a little differently; you have to know what you are looking at; and you have to screw it together. Using screws is a giant pain for carpenters compared to nailing it together. All of the differences conspire to cause a framer not to have a big incentive to try steel framing. Even if they like the idea, they don't have the time or can't afford to take the time. Therefore the steel industry developed a national training curriculum. It's a huge impressive document that has been widely acclaimed everywhere that it was introduced. The training materials are getting into junior colleges and vo-tech schools by the thousands. The goal is to grow a generation of framers that will be ready to use this

product as the other elements come together. The industry is working with the NAHB and NAHB Research Center to come up with a way to train existing framers that makes it worthwhile for them.

Designing Homes with Cold-Formed Steel

An excellent article on the considerations for designing with cold-formed steel is available at the "Toolbase Services" web site:

http://www.toolbase.org/Construction-Methods/Steel-Framing/designing-homes-cold-formed-steel

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