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Light-Gauge Steel Verses Conventional Wood Framing In Residential Construction

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This article examines light-gauge steel in residential construction with emphasis upon the economic differences and implications of its use as compared to conventional wood frame construction. Use of lumber for residential construction in the United States is influenced by several external factors. Increases in lumber prices directly affect residential market decisions. Environmental pressures to change the methods and public policy concerning timber harvesting have precipitated higher lumber prices and reduced the availability of the product. These market changes are causing developers, builders and architects to seriously consider alternate methods of construction. Two alternative forms of residential framing to conventional lumber construction are structures utilizing principally engineered lumber and light-gauge steel. Unfortunately, these systems also have their shortcomings. Residential construction can be done by simply substituting steel studs, which are manufactured in the same nominal widths and thickness, for wood studs in normal platform type construction. Although light-gauge steel has long been used in the commercial construction industry, principally for non-structural partition walls due to its fire-resistance; it has only recently become a serious alternative to lumber in residential construction. Steel framing is more commonly used in geographic locations that more frequently experience weather-related damage or natural disasters such as hurricanes and earthquakes. The many advantages of steel as compared to wood would indicate that steel has a very optimistic future in the near future, even if it should fall short of the predictions of market share that the steel industry anticipates.

Key Words: Residential Construction, Construction Framing, Building Materials, Steel Framing, Light-Gauge Steel

Introduction

The conventional use of lumber for residential construction in the United States is currently being influenced by two external factors that are causing developers, builders and architects to seriously consider alternative methods of construction. Several sharp increases in lumber prices in recent years and the continual fluctuation of such prices have been the most serious cause of this concern. The other factor, which some would argue has itself been reflected in increased lumber prices, has been environmental pressures to change the methods and public policy concerning timber harvesting.

The two most viable alternate forms of residential framing to conventional lumber are engineered lumber and light-gauge steel. These systems also have their shortcomings. For example, engineered lumber costs more than traditional milled lumber and has raised environmental concerns due to numerous chemicals used in its production. Also, steel has as its most significant shortfall the simple fact that it is a very good thermal conductor which means that it is a very poor insulator for the structures that are made from it.

The purpose of this article is to examine light gauge steel in residential construction with emphasis upon the economic differences and implications of its use as compared to conventional wood frame construction.

Traditional Use of Wood in Residential Construction

Wood has long been the material of choice in United States residential construction. Recently, wood has been questioned as the preferred framing material because of its gradually increasing and volatile prices in addition to concerns about decreasing quality and future availability (Yost, 1995).

The average single family detached home consumes some 11,000 board feet of lumber. The framing in such a house consists of joists, roof trusses plus exterior and interior walls which accounts for approximately 85% of the lumber used in construction of such a structure. The use of wood framing for residential construction constitutes some 60% of the U.S. softwood lumber consumption (Yost, 1995).

But according to Timm Locke of the Portland, Oregon-based Western Wood Products Association, stricter federal control over forestlands has caused a shift in available resources from old-growth timber to younger, smaller diameter trees. "Because we're using second-growth trees," explains Locke, "there's a decreased percentage of large members available. There's also a higher incidence of knots in the milled lumber." Higher demand and lower supply of suitable lumber have driven prices up (Barreneche, 1994).

Trends in Light Gauge Steel in Residential Construction

Although light-gauge steel has long been used in the commercial construction industry, principally for non-structural partition walls due to its fire-resistance; it has only recently become a serious alternative to lumber in residential construction. "Between 1979 and 1992 the number of steel framed homes increased more than 300 percent" (American Iron and Steel Institute (AISI), 1994). Yost (1995) cites a National Association of Home Builders (NAHB) survey that reveals that some 13,000 homes were built with light-gauge steel in 1993 which represents approximately 1% of the new homes built. This compares to only 500 steel framed homes a year earlier. The author assumes that the AISI figures demonstrate long-term growth in the inventory of steel frame homes while the NAHB statistics point out an explosive growth in new steel homes during a single year.

How significant is the trend toward steel frame residential construction. In an NAHB publication entitled Nations Building News it has been reported that a survey at the Pacific Coast Builders Conference in June 1995 showed three out of every four west coast builders, who have built with steel, are continuing to build with steel as a substitute for wood framing. A poll conducted at the NAHB convention in January 1995 indicated that 22% of builders nationwide were planning to use light-gauge steel, while on a more regional basis, it was reported that 35% of west coast builders were planning to use steel.

More optimistically, Yost (1995) states that an estimate by the steel industry predicts 75,000 to 85,000 new steel framed homes will be built in 1995 and they also project 250,000 to 350,000 such homes to be built in the year 1997. This assumption, if realized, would represent 25% of new home starts at that time.

Currently, steel framing is more commonly used in geographic locations that more frequently experience weather-related damage or natural disasters such as hurricanes and earthquakes. Steel is used in such locations because it has higher tensile and greater bending strength than lumber thus it can better resist the destructive forces exerted upon residential structures during such occurrences. For these reasons steel framing has been employed more often in Florida, Texas (particularly Dallas), southern California, Hawaii, and the Pacific Northwest (Yost, 1995).

Light-Gauge Steel

Light-gauge steel is made by a cold-forming process where sheets of steel are passed through a series of roll forming dies to create there desired shade. The desired strength is achieved by a combination of the thickness or gauge of the steel utilized as well as the shape of the member. The various bends in the member's cross-section add to the stiffness and ultimate strength of the piece. Because of the strength advantage produced by this bending process, steel framing material has a strength-to-weight ratio that is very favorable when compared to most other materials, particularly wood (Waite, 1994).

The gauge or thickness of sheet steel ranges from 10 to 25. By convention the higher the gauge number the thinner the steel. The more lightweight non load-bearing interior walls of residential structures are usually made of 25-gauge steel, while the exterior load-bearing steel studs are usually built from stronger 18 or 20 gauge steel.

To protect steel from rusting, steel is zinc galvanized. This protection is necessary both during storage, construction and while in use to avoid damage and loss of strength due to rusting.

Weirton Steel Corporation (1995) advertises several advantages of light-gauge steel construction which are quoted below:

1. Steel components weigh 60% less than wood. A 2000 square foot home requires only 6 tons of steel compared to 20 tons of lumber.
2. No other construction material can match steel's superior strength and durability.
3. Steel construction components can be pre-measured and precut to exact specifications. On-site adjustments are generally not required.
4. Steel is simply impervious to termites and other damage-causing bugs and pests.
5. Steel stays straight and true, while wood may warp or crack.
6. Because steel is noncombustible and termite-proof, it qualifies for what insurance companies call -superior construction' and premiums are typically lower.

7. Steel components generate minimal waste and all light-gauge steel construction materials are 100% recyclable.

Other advantages or variations of the above are:

Steel has a consistent quality because it is a manufactured product and during construction there is not the 10-20% material waste that is typically experienced with wood framing operations (Yost, 1995). As previously discussed steel framing also has its own disadvantages that were best identified by Yost (1995) as follows:

1. Steel is an excellent thermal conductor requiring additional exterior insulation or thermal breaks to overcome this disadvantage. Thermal conductivity is probably the most serious of steel's disadvantages.

2. Because light-gauge steel frame construction is relatively new and innovative within the residential construction industry, it is not only unfamiliar to craftsmen but it is also unfamiliar to engineers and code officials.

   "Additional costly engineering analysis may be required. Residential building codes incorporating steel framing are currently under consideration but have not been implemented". The learning curve of builders and craftsmen may be slow until these individuals become familiar with the new skills required to construct with steel.

3. In addition to the labor training required to convert to the use of steel, builders and laborers must obtain some new tools not presently used by carpenters. The combination of additional training and tools translate to increased costs of construction for a short period of time.

Performance Problems of Steel Stud Wall Assemblies

It is well known that steel will conduct energy much better than wood and has very little thermal insulation value. This means that better exterior insulation is necessary to economically maintain the desired temperature of a home's interior during both cooling and heating seasons.

In Canada, the National Research Council's Institute for Research in Construction (IRC) has been researching the thermal characteristics of steel studs for years (Brown and Swartz, 1994). "The IRC research demonstrated that for the steel-stud wall assemblies ... , the R-value of the total assembly is approximately half that of the insulation. In other words, the presence of steel studs substantially reduces the overall performance of the whole assembly" (Brown and Stephenson+s study (as cited in Brown and Swartz, 1994)). Brown and Swartz also reference a report by Sasaki that said: " ... modifying the steel-stud web by introducing openings achieved improvements of up to 50% in thermal performance compared to conventional steel studs. By reducing the cross-sectional area of the steel web, the thermal performance of the wall assembly improved".

Brown and Swartz pose the question: "will insulation added to the outside face of the studs improve the thermal performance of the wall assembly?" They reply that it will improve thermal performance but they go on to state the IRC has found that although exterior insulation will contribute its R-value to the wall assembly, it will not remove the effect of the steel stud and there is the obvious economic cost of installing this exterior insulation.

The phenomenon known as "dust-marking" - a discoloration of the finished wall above the top of studs - is another thermal effect. Again insulation added to the exterior wall surface can help to reduce this problem (Brown and Swartz, 1994).

The results of IRC acoustical tests showed that non load-bearing steel stud walls performed approximately the same as wood studded walls. Surprisingly load-bearing steel stud walls performed better acoustically than wood stud walls (Brown and Swartz, 1994).

Brown and Swartz (1994) stated: "There is no particular evidence to suggest that steel-stud walls are more prone to moisture damage than wood-frame houses." They go on to point out "moisture in the wall assembly can cause their corrosion (just as it causes rotting of studs in wood-frame construction). The control of moisture can be undermined in many ways — poor design, poor construction practices, or a combination of both."

Types of Construction

Residential construction can be done by simply substituting steel studs that are manufactured in the same nominal widths and thickness for wood studs in normal platform type construction.

Efficient structures can also be designed that utilize the superior strength of steel by increasing the stud spacing to four feet or more (Waite, 1994).

Nearly all building systems to include light-gauge steel employ standard size structural members that have evolved over time based upon conventional lumber dimensions. The rational has been to be able to use existing components such as prefabricated door and window units thus avoiding the necessity of having door and window units custom fabricated. Consequently light-gauge steel members are the same size as wood frame structural members, such as nominal 2+ thicknesses with nominal 4+, 6+, 8+ and etc. widths and lengths in typical 2 foot lengths. Similarly, the sheathing and interior wallboard systems are based upon the use of standard 4+ x 8+ panels.

The three basic light-gauge steel assembly methods are stick-built construction, panelized systems, and pre-engineered systems. The American Iron and Steel Institute (1994) best describes these three methods as follows:

Stick-Built Construction

Stick-built construction is virtually the same in wood and steel. This framing method has actually gone through a transformation incorporating many of the techniques used in panelized construction. The steel materials are delivered to the job-site in stock lengths or in some cases cut to length. The layout and assembly of steel framing is the same as for lumber, except components are screwed together rather than nailed. Steel joists can be ordered in long lengths to span the full width of the home. This expedites the framing process and eliminates lap joints. Sheathing and finish materials are fastened with screws or pneumatic pins.

Panelized Systems

Panelization consists of a system for pre-fabricating walls, floors and/or roof components into sections. This method of construction is most efficient where there is a repetition of panel types and dimensions. Panels can be made in the shop or in the field. A jig is developed for each type of panel. Steel studs and joists are ordered cut-to-length for most panel work, placed into the jig and fastened either by screws or welding. The exterior sheathing, or in some cases, the complete exterior finish, is applied to the panel prior to erection.

Shop panelization can offer several significant advantages to the builder. The panel shop provides a controlled environment where work can proceed regardless of weather conditions. Application of sheathing and finish systems is easier and faster with the panels in a horizontal position. Although the panels must be transported from the panel shop to the job, most often the cost advantages of panelization offset the added transportation costs.

A major benefit of panelization is the speed of erection. A job can usually be framed in about one quarter of the time required to stick-build. When you consider that the exterior finish system may also be part of the panel, the overall time saving may be even greater.

Pre-Engineered Systems

Because of steel's high strength and design flexibility, innovative systems are possible which are not possible using other materials. Engineered systems typically space the primary load carrying members more than 24 inches on center, sometimes up to 8 feet. These systems use either secondary horizontal members to distribute wind loads to the columns or lighter weight steel in-fill studs between columns. Furring channels used to support sheathing materials also provide a break in the heat flow path to the exterior, which increases thermal efficiency.

Many of the pre-engineered systems provide framing members that are pre-cut to length with pre-drilled holes for bolts or screws. Most of the fabrication labor is done by supplier, allowing a home in as little as one day.

Development of Prescriptive Standards

Currently, there are no accepted standards for residential light-gauge steel design that may be adopted by building code officials. This situation places light-gauge steel construction at a slight disadvantage to wood frame residential construction that has had accepted prescriptive standards for some time. The disadvantage of not having prescriptive standards for residential steel frame construction is that for a builder to have a home approved by the building code officials, a qualified engineer this adds to the cost of completed structure must approve the design.

The cost of having engineering analysis performed for a light-gauge steel home can increase the cost of construction from $.75 to $1.50 per square foot according to Bill Farkas, research engineer at the National Association of Home Builders Research Center. Farkas explains the above situation arises because steel is relatively new in residential construction and no standardized tables exist for the building codes. He goes further to state "Once a specific home design 'is approved and stamped,' however, it can be reused without further analysis" (Ryan, 1995).

Why is the development of an industry standard for light-gauge steel so difficult? First, the North American manufacturers who produce raw steel utilize several established quality codes. Thus the steel that finds its way into light-gauge metal studs is not standardized. Next, the cold-formed steel companies produce numerous products, all of which must meet the standards and guidelines of the ASTM (American Society of Testing and Materials) but again nothing is standardized as to the size and shape of the product produced. The result is that the shapes and sizes of light-gauge steel vary significantly from one producer to another making the development of a prescriptive design standard extremely difficult. Consequently, "an engineered design is usually required to build a home with steel as load bearing members" (Waite, 1995).

How may this obstacle be overcome? Through the coordinated efforts of the U.S. Department of Housing and Urban Development (HUD), National Association of Home Builders (NAHB), and the American Iron and Steel Institute (AISI) "a steering committee of industry experts, including code officials, engineers, researches, manufacturers and builders was assembled to assist in planning and directing" the development of a code change to the Council of American Building Officials (CABO) One and Two-Family Dwelling Code, according to Jay Crandell, project manager for the NAHB Research Center (Building Code to Include ... , 1995).

Crandell goes on to emphasis that "Prescriptive construction guidelines is also a key element of the new residential building code since it provides a 'cookbook' approach to light-gauge steel framing." "Giving builders clear information on what designs, types of materials and construction techniques comply with the codes will drastically ease the process of building a steel-frame house," said Crandell. (Building Code to Include ..., 1995).

The NAHB has the lead and responsibility of coordinating the efforts of the other participants in development of this prescriptive standard.

Within the AISI, a taskgroup within the Codes and Standards Subcommittee has been formed that is developing industry standards and labeling requirements. These standards will be incorporated into the "NAHB's prescriptive standard work that will be finalized this fall" (Meyers, 1995).

Meyers (1995) states that the AISI will complete their light-gauge steel standards development by the fall of 1995 that "will preserve the integrity of our product, insure a cost-effective position, respect the business interests of all cold form applications, and increase the user friendliness of the product".

It is noted by Meyers (1995) that the steel fastener industry has made a significant impact upon the development of a prescriptive standard through their effort in new product development. He cites Erico Tool and Fasteners for their development of a new fastener to attach foam insulation to steel framing and ITW Paslode's new fastener attachment for wood sheathing.

Cost Comparison Between Wood and Light Gauge Steel

When comparing the cost of residential construction with wood versus light-gauge steel, the factors that must be considered are: price of materials, labor costs and design flexibility. The price of dimensional lumber has gradually increased over the last few years with large price fluctuations while steel by comparison has gradually declined in price due to increased capacity of steel smelting and hot-rolled sheet production plus steel industry increases in galvanizing capacity. Additionally, the price fluctuation of steel has been less dramatic than that of wood (Yost, 1995). The combined impact of these factors, states Yost (1995), is that "steel-framing costs are at least comparable to and possibly lower than for lumber framing" (as cited from Bauer, 1992).

A California builder has obtained a 12% cost savings of steel versus wood construction by using an engineered design for steel framing rather than a simple one-for-one structural member substitution. This translates to a $1200 to $1500 cost reduction per home (Yost, 1995 who referenced McLeister, 1993).

Yost (1995) goes on to reference an article from Building Systems Builder that cost savings for steel framing material can range from 30 to 59% for wall studs and up to 25% for steel floor joists.

Steel framing cost savings can be as high as 30% when compared to the price of wood, claims Irv Hughes of Columbus, Ohio. Hughes is a local builder and Vice-President of the Building Industry Association of Licking County (Peck, 1994).

Wolcott (1995) states "In 1993 and 1994, lumber prices varied from $310 to $500 per thousand board feet. Both timber and industry officials agree that steel becomes a competitive substitute when wood prices range between $350 and $400 per thousand board feet."

The NAHB Research Center with funding from HUD conducted three case studies comparing three residential construction systems to conventional building wood frame construction. Steel frame construction was observed and the Group-Timing Technique was used to gather data for

23 homes built as part of phase II of the Sunset Ridge Limited development in Imperial, California. During the framing of the 25 homes in phase I the framers became experienced in the use of the use of light-gauge steel framing methods. The steel framed homes studied all had slab-on-grade foundations and ranged in size from 1,175 to 1,940 square feet. Similar observations were made of comparable conventional wood frame construction (Waite, 1994).

The results as reported by Waite (1994) were:

> "The material costs for the light-gauge steel walls were 2 percent less than for the conventional wood walls, while the total costs for the light-gauge steel walls were 7 percent more than the walls in the conventional wood-framed house."

Conclusion

Based upon the information available at his time it is probably debatable that light-gauge steel framing is cheaper than conventional wood frame construction. Many of the statements in the literature concerning the economics of light-gauge steel frame construction as compared to lumber appear to be measuring the two differently. When one says, "steel framing is cheaper than wood framing", is one saying that engineered light-gauge steel framing (24 inches on center (o.c.) or greater) is cheaper than non-engineered conventional wood framing (16 inches o.c.)? Unfortunately, many of the light-gauge steel articles available today are published in trade journals with more of a marketing perspective than literary journals that explain the scientific methods utilized to develop their stated results or position. The body of literature on this subject, beyond comparing steel framing to wood framing, does not begin to address the economic impact of additional building systems within the initial purchase price of a residence. It appears that some residential sub-contractors that perform activities after the framing is complete are charging more for their work in steel framed residences than in wood framed residences. Whether or not these additional costs are justified is possibly debatable, but if additional charges are being made, the resulting increase on the sales price of the home has an impact on the economic acceptance of light-gauge steel framing by future homebuyers.

The many advantages of steel as compared to wood would seem to indicate that steel has a very optimistic outlook in the near future, even if it should fall short of the predictions of market share that the steel industry anticipates.

During the writing of this literature review on light-gauge steel framing, several unanswered questions came to mind:

1. What are the square foot framing costs of identical homes of engineered light-gauge steel and conventional wood frame construction?
2. What is the average square foot cost to complete construction to the same standard for the two framing systems described in the above question? A subset of questions within the previous question is what are average cost factors, charged by the many sub-contractors who follow the steel framers, above and beyond what they normally charge for comparable work within conventional wood framed homes?

3. How time and cost effective are the new pneumatic nail guns that are being developed to replace manually fed screw guns? How effective are the nails/fasteners from these pneumatic nail guns when placed in withdrawal versus shear?
4. How cost effective would it be to panelize large light-gauge steel exterior wall sections and roof trusses on an assembly line, transport them to the building site and erect them with reasonably light weight material handling equipment utilizing small crews of workman?

References

American Iron and Steel Institute. (1994). *Build it with steel - An introduction to residential steel framing* (3rd ed.) [Brochure]. Washington, D.C.: Author.

Barreneche, R. A. (1994, October) Framing alternatives - Traditional lumber-based construction is now being challenged by lightweight steel and engineered wood. *Architecture, 83,10*. pp. 103-107 and p 131.

Brown, W. C. and Swartz, J. (1994, April). Steel studs in residential construction. *Architect, 39, 12*. p 29 and p 37.

Building codes to include steel framing for the first time. (1995, Fall). *Metal Home Digest,* 3, 4, p 46.

Meyers, M. N. (1995, Fall). AISI residential advisory group update: Metalcon '95 spotlights residential. *Metal Home Digest,* 3, 4, pp. 48-49.

Peck, D. (1994, March). Update on steel framing. *Sun Coast,* pp. 22-25.

Ryan, M. (1995, February 15). Area "homes" in on steel construction. *Business Journal of the Five-County Region*, 11, 11 p. 36.

"Survey finds steel framing endearing out west". (1995, 17 July). *Nation's Building News*, 11, 8.

Waite, T. J. (1994, July). *Alternative framing materials in residential construction: three case studies* Upper Marlboro, MD: National Association of Home Builders Research Center.

Weirton Steel Corporation (1995, Fall). Weirton presents: 11 great reasons for using steel construction materials on your next project. *Metal Home Digest*, 3, 4, pp. 41-42.

Wolcott, J. (1995, May 5). Steel framing in timber country. *Puget Sound Business Journal*, p 21

Yost, C. (1995, June). Building houses with steel. *Chemtech,* 25, 6, pp. 51-54.