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The Utilization of Light Gauge Steel in Residential Construction on the State of Utah

Matthew Zaugg Perkins
Brigham Young University - Provo

THE UTILIZATION OF LIGHT GAUGE STEEL IN RESIDENTIAL CONSTRUCTION IN THE STATE OF UTAH

by

Matthew Z. Perkins

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of a thesis submitted by

Matthew Z. Perkins

This thesis has been read by each member of the following graduate committee and by majority vote has been found to be satisfactory.

Date	Jay P. Christofferson, Chair
Date	Kevin R. Miller
Date	D. Mark Hutchings

BRIGHAM YOUNG UNIVERSITY

As chair of the candidate's graduate committee, I have read the thesis of Matthew Z. Perkins in its final form and have found that (1) its format, citations, and bibliographical style are consistent and acceptable and fulfill university and department style requirements; (2) its illustrative materials including figures, tables, and charts are in place; and (3) the final manuscript is satisfactory to the graduate committee and is ready for submission to the university library.

Date

Jay P. Christofferson
Chair, Graduate Committee

Accepted for the School

Barry M. Lunt
Graduate Coordinator

Accepted for the College

Alan R. Parkinson
Dean, Ira A. Fulton College of Engineering and Technology

ABSTRACT

THE UTILIZATION OF LIGHT GAUGE STEEL IN RESIDENTIAL CONSTRUCTION IN THE STATE OF UTAH

Matthew Z. Perkins

School of Technology

Master of Science

This thesis researched why light gauge steel framing members are not used more in single-family residential construction.

A survey was designed to extract information from licensed contractors in Utah on uses of light gauge steel framing members in residential homes. The purpose of the research was to discover what Utah builder's perception was concerning light gauge steel framing. Also, the researcher tried to learn a little about the contractors to see if there was a correlation between contractors that used light gauge steel and those that did not. Names of licensed general building contractors and residential contractors and their contact information were acquired from the State of Utah's Department of Professional Licensing. A random sample of the licensed contractors was selected. They were contacted by mail and telephone and invited to participate in a survey.

The researcher discovered that light gauge steel was used in a very limited amount. The respondents seemed build using traditional methods, namely lumber. They were unfimiliar with light gauge steel and its properties, as well as the benefits and disadvantages of light gauge steel.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 Introduction

Over time, better materials and methods of construction have been developed for the home building industry, resulting in new and improved building systems (Smith, 2007). Construction materials and building methods have improved to help advance the construction of homes, making homes more energy efficient, durable, "smarter", safer, affordable, and environmentally friendly. An important part of a home design model used to achieve optimum building conditions includes the framing components of the building envelope, the interior partition design, the floor system, and the roof system.

When a home is designed and built, consideration should be given concerning the different types framing members; their design, layout, and assembly methods. One part of intelligent home design includes using materials that are readily available to all builders. Dimensional wood members are the most frequently used building materials for residential framing in the United States; light gauge steel is the second most common (Bateman, 1997).

"For the last fifty years, steel framing's traditional domain has been commercial buildings. The residential housing market has been slow to assimilate steel structural techniques into custom-built homes (Imhoff, 1997)." Light gauge steel members have been gaining in popularity in the residential market over the past several years. Between 1979 and 1992 the number of steel-framed homes in the United States increased more

than 300 percent (AISI, 1994). Steel framing has been gaining preference in many countries throughout the world (MacQuiod, 1996). However, in the United States, designers and contractors seem to be slow to adapt to this material. At the beginning of 2003 less than 5% of all U.S. homes were framed in steel (Hewlett, 2003).

A review of related literature of this thesis explains that some builders in different parts of the United States have discovered the benefits of using light gauge steel framing materials for certain parts of the framing system. After overcoming a learning curve, the builders who have switched to light gauge steel saw fewer callbacks associated with wood framing and increased profits from faster building times and more efficient use of materials (Hewlett, 2003, Richmond, 2002, Loughead, 2008). The following is a simplified list found in chapter two of this paper of advantages for using light gauge steel framing materials:

1. Steel Components weigh 60% less than wood, allowing less fatigue in construction; foundations and seismic loads can be reduced (CSSBI, 1994).
2. Steel framing has superior strength-to-weight ratio and durability over wood; thus, fewer studs need to be used in the construction of a home (Bateman, 1997).
3. Steel framing components can be precut to exact specifications, saving on labor and waste (Weirton Steel Corporation, 1995). Light gauge steel stud have pre-punched holes in them that allow for electrical and mechanical materials to be installed quicker.
4. Steel is impervious to termites and other damage-causing bugs and pests.
5. Light gauge steel remains straight and true, while wood may warp or crack (Weirton Steel Corporation, 1995).

6. Steel is considered noncombustible, although it has a high melting point (Amundarain, 2006).
7. The noncombustible and termite-proof characteristics of steel can qualify for what insurance companies call superior construction, which typically means lower premiums (Weirton Steel Corporation, 1995).
8. Light gauge steel framing generates minimal waste, of which 100% is recyclable (Henkenius, 1997).
9. When combined with the use of framing screws, light gauge steel framing performs favorably compared to other building materials during hurricanes and earthquakes (Bateman, 1997).
10. Historically, at least through 2002, steel has provided a more reliable supply of framing materials for the building industry not affected by shortages and sharp price increases (Richmond, 2002).
11. Steel framing walls can easily accommodate future remodeling (Yost, 1995).
12. Steel studs may perform better acoustically than wood (Brown, 1994).

As with most building materials, steel is not without its weaknesses. The following list identifies some of the shortcomings of light gauge steel:

1. The greatest disadvantage to light gauge steel framing is thermal bridging (Bateman, 1997).
2. There is a controversy over the fire behavior properties of steel studs. Steel is adversely affected by high temperatures (Sakumoto, 2003).

3. Light gauge steel framing is unfamiliar to most residential contractors and subcontractors, residential architects and engineers, and some building officials (Yost, 1995).
4. Galvanic action, or electrolysis, can occur between two dissimilar metals, such as steel and copper.
5. Steel's environmental impact as compared to wood is difficult to calculate, but is a concern.

Despite light gauge steel's weaknesses, there might be some advantages to using this building material in residential construction. Reviewing the benefits of light gauge steel suggest that using light gauge steel in residential construction could improve the quality of homes.

1.1 Problem Statement

By observation, there seems to be a lack of utilization of light gauge steel framing in residential construction in Utah. The problem is that builders may not be taking advantage of materials that may improve the quality of their construction.

1.2 Purpose of Study

The purpose of this study was to discover the utilization of light gauge steel in residential construction and why light gauge steel is not being used more in residential construction.

1.3 Research Questions

1. Are single-family residential home builders using light gauge steel framing members in the State of Utah?
    a. Where in residences is light gauge steel being used?
    b. What design layouts are being used with light gauge steel?
2. Why do Utah contractors choose to use materials other than light gauge steel?
3. What is the perception of residential contractors concerning light gauge steel framing in residential construction in the State of Utah?

1.4 Population

The population that was considered for this study consisted of licensed builders in Utah that built residential homes. The license holders included R100, residential contractor, and B100, general contractor. The B100 contractors were included in this study because under their license, they can build single-family residences.

1.5 Methodology

To research this problem, this study considered responses from a random survey of licensed residential contractors in the State of Utah. A full explanation of the research methodology is found in Chapter 3.

1.6 Delimitations of the Study

This study focused on residential single-family homes, and did not consider multifamily homes.

This study only considered residential homes in the Utah market being built by builders licensed in the State of Utah. Architects, designers, or homeowners were not considered. The study did not consider building contractors in other states.

1.7 Definitions

C-Shape - A cold-formed steel shape used for structural and non-structural framing members consisting of a web, two (2) flanges and two (2) lips (edge stiffeners). See Figure 1.

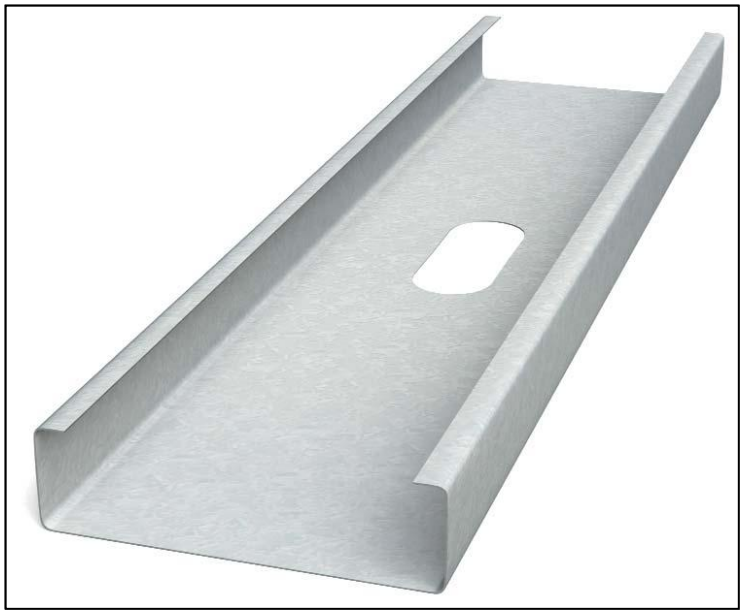

Figure 1: Picture of a C-Stud.

Clinching - a mechanical fastening method to join sheet metal without additional components using special tools to form a mechanical interlock between the sheet metals. The tools consist typically of a punch and a die. There are two primary types of dies: solid "fixed cavity" dies, and dies with moving components. The punch forces the two layers of sheet metal into the die cavity forming a permanent connection. The pressure exerted by the punch forces the metal to flow laterally. Clinching is used primarily in the automotive, appliance and electronic industries, where it replaces spot welding very often. See Figure 2.

Figure 2: Picture of a clinching tool.

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

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

Galvanic Corrosion - is an electrochemical process in which two dissimilar metals that are in contact with each other corrode.

In-Line Framing - A framing method where all vertical and horizontal load-carrying members are aligned.

Light-Gauge Steel Framing - Thin sheets of galvanized (to prevent oxidation and corrosion) steel formed into steel studs used as a building material for rough-framing in commercial or residential construction, as well as many other applications. The dimension of the room is established with horizontal track that is anchored to the floor and ceiling to outline each room. The vertical studs are arranged in the tracks, and fastened at the top and bottom. This creates a framework to support drywall or other finish materials. The primary shapes used in residential construction are the C-shape stud and the U-shaped track, and a variety of other shapes. Framing members are generally produced in a thickness of 12 to 25 gauges. The wall finish is anchored to the two flange sides of the stud, which varies from 1-1/4" to 3" thick, and the width of web ranges from 1-5/8" to 14". Rectangular sections are removed from the web to provide access for electrical wiring.

Sound Transmission Class (STC) A rating system used to measure the insulation (or isolation) of airborne sound provided by a barrier. STC is determined from a sound-transmission-loss curve obtained from a standardized test of a large-scale specimen. The higher the STC rating, the more soundproof the construction. For every increase of 5 points, the sound transmission decreases be 50 percent.

Strength-to-Weight Ratio - The relationship between a material's strength and its weight. Also known as specific strength, it is the material's strength, which is the force per unit area at failure, divided by its density. Materials that are light but are also very strong have a high strength-to-weight ratio.

Thermal Bridging - A thermal bridge is created when materials that are poor insulators come in contact, allowing heat to flow through the path created. Insulation around a bridge is of little help in preventing heat loss or gain due to thermal bridging; the bridging has to be eliminated, rebuilt with a reduced cross-section or with materials that have better insulating properties, or with an additional insulating component (a thermal break). Three types of thermal bridging found in construction are as follows:

- Repeating thermal bridges - where bridges occur following a regular pattern, such as made by wall ties penetrating a cavity wall.
- Non-repeating thermal bridges - such as the bridging of a cavity wall by a single lintel.
- Geometrical thermal bridges - at the junction of two planes, such as at the corner of a wall.

Thermal Conductivity - The ability of a material to conduct heat. The formula is Fourier's Law, which is defined as the quantity of heat transmitted during time through a thickness of material in a direction normal to a surface area due to a temperature difference under a steady state of conditions and when the heat transfer is dependent only on the temperature gradient.

Track - A framing member consisting of only a web and two (2) flanges. Track 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. Trusses are generally found in floor and roofing components.

2 Literature Review

The following sections are a review of the author's readings concerning light gauge steel framing, its properties, and known issues. First, the history of light gauge steel was examined. Next, the advantages and disadvantages of light gauge steel were considered. Finally, emerging technologies of light gauge steel were previewed.

2.1 Topic 1 – History of Light Gauge Steel Framing Construction

Bruce Bateman of Texas A&M University wrote an article in 1997 that examined the use of light gauge steel. He considered the traditional use of wood in residential construction and the trends concerning the use of light gauge steel in homes. In his writings of the use of wood in residential construction, he stated the following:

> 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 (Lund, 1994).

> But according to Tim 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).

Bateman then looked at the trend of light gauge steel in residential construction as follows:

> 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).

Though there are advantages and disadvantages to using light gauge steel, there is a definite place for steel framing in residential construction. However, only about 10 percent of builders have used light-gauge steel in residential construction (Heavens, 2001).

2.2 Topic 2 – Advantages of Light Gauge Steel Framing Construction

New technologies, methods of doing things, and ideas are often hard for people to accept at first. Sometimes new products enter a market as 'new' or 'innovative', the way of the future. Those products tout many advantages only to have their Achilles' heel exposed a few years later. Of many examples to choose from, polybutylene, the predecessor to PEX water supply lines, come to mind quickly. The plumbing lines were less labor intensive to install. However, a problem was soon exposed with its brass fittings, which in turn created a negative perception concerning that method of plumbing for quite some time (Beardwood, 2003).

Light gauge steel framing is much in the same boat. "Switching from wood to steel framing is a major change for many builders and homeowners. For that changeover

to happen, there have to be solid benefits that make steel a feasible building alternative. Advocates of steel say those benefits do exist and include strength, durability, eco-friendly, non-combustible, design flexibility, and fast build times (Koones, 2006)."

Some builders have attempted to use light gauge steel to solve warranty issues. For instance, Centex Homes' division in Columbus, Ohio, began using steel in its flooring systems to build a higher quality home. Of the roughly 300 homes built yearly out of wood by the division, 85 percent generated callbacks associated with floor squeaks and twists, humps, or dips in the floor. "'Frankly, there's nothing we hate more than having to put customers up in a hotel room for three days while our crew rips their floor up to fix wood joists that have either twisted, bowed, or weren't installed properly to begin with,' says Bob Gardner, purchasing and estimating manager for the division (Richmond, 2002)."

Several Houston area builders and industry leaders say homeowners appreciate the advantages steel has to offer over wood framing, including its traditional high strength-to-weight ratio. Some builders have realized the benefits of light gauge steel framing as well. One worker can carry a steel truss by himself; the same truss made of wood would require two individuals. Jerry Huckeba, a builder, stated that a 2,000 square-foot house can go up in a few days instead of weeks. Builders also like light gauge steel's resistance to insect damage, warp and rot, mold, and the safety aspect of using fire resistant material (Hewlett, 2003).

Jeff Loughhead, a builder, made the switch to light gauge steel framing materials seven years ago. He was tired of useless lumber that kept coming on his lumber deliveries. He discovered that is was easier to do takeoffs for bids using light gauge

steel as the building material. There was less wasted material on the job site. Though there was a learning curve involved with light gauge steel framing, he discovered that wise use of the material led to better profit than wood framing members (Loughead, 2008).

Steel framing members have many advantages over wood framing members and engineered lumber. It is strong and light weight as compared to wood materials. Steel framing is easy to work with. The following is a list of advantages light gauge steel has over wood and engineered framing:

1. Steel components weigh 60% less than wood. A 2,000-square-foot home requires only 6 tons of steel compared to 20 tons of lumber (Weirton Steel Corporation, 1995). With a lighter building material in place, foundations and seismic loads can be reduced (CSSBI, 1994).
2. Steel framing material has a strength-to-weight ratio that is very favorable when compared to most other materials, particularly wood (Waite, 1994). Because of steel's superior strength and durability, fewer studs need to be used in the construction of a home. Some may knock steel because it seems flimsy, but it has to be understood that steel stud strength comes with its assembly as part of a system, not as a stand-alone stud. The diaphragm action created when drywall or other material is fastened to steel studs with tracks makes it strong (Presutti, 2008).

> 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 (Bateman, 1997).

Nicholas Lane, a framing contractor company based in Anaheim, Calif., which works with contractors Brookfield and Lennar, has been working with steel since 1993. According to the company's director of development, the contractor would build all of their homes out of steel if they could, but 40 percent of their clients still ask for wood. One of the reasons the director likes light gauge steel is that it has a stronger strength-to-weight ratio and can reach longer spans, which allow framers to eliminate beams in the basement and take advantage of design possibilities that would be cost-prohibitive with wood. The director states that many of Brookfield's homes look custom built, which is an added touch that comes at no extra cost to the builder, or to the purchaser (Richmond, 2002).

3. Steel construction components can be pre-measured and precut to exact specifications. On-site adjustments are generally not required if the light gauge steel is preordered to specific lengths (Weirton Steel Corporation, 1995). This not only saves labor, but also saves waste.
4. Steel is impervious to termites and other damage-causing bugs and pests.
5. Steel stays straight and true, while wood may warp or crack. Light gauge steel is not susceptible to rot, does not shrink, warp, crack or swell, and resists corrosion (Weirton Steel Corporation, 1995). There is no need to sort through a stack of studs to find suitable pieces, saving time and producing less waste. Steel framing members are constant in its quality.

In a year-and-a-half, by using light gauge framing materials Lennar Homes reduced their framing cycle time by 40 percent in its Southern California division. "We're always looking at alternative products and methods for operational efficiencies," says Dave Ball, the region's director of product development. "The steady decline in wood quality, coupled with its rising costs, prompted us to look forward in the marketplace five years and make the investment in steel now.

"Lennar is expanding its steel operations -- including doing its own panelization -- from one to six California divisions, and it plans 10 hybrid communities for this calendar year." Ball states that Steel is lighter than wood, which is easier on their crews, and lends itself better to panelization as a process. He said that there are less stucco cracks, cleaner jobsites, and liability costs are down by 20 percent for them and the homeowners (Richmond, 2002).

6. Galvanized steel is noncombustible. However, while the structural characteristics of light gauge steel framing has been extensively studied, fire behavior is hardly understood (Amundarain, 2006). Galvanized steel is rust resistant.

7. Because steel is noncombustible and termite-proof, it qualifies for what insurance companies call superior construction and premiums are typically lower (Weirton Steel Corporation, 1995). Building with fire resistive materials, like cold-formed steel, can net builders a 25% or more savings on builder's risk premiums through commercial insurers like Zurich. Allstate offers 10% premium discounts for policies covering homes of fire-resistant construction (Toolbase.org).

8. Light gauge steel framing generates minimal waste. All light gauge steel construction materials are 100% recyclable. All cold-formed steel framing contains a minimum of 25% recycled steel (Toolbase.org), and some green materials as much as 72%. C. Yost states that builders have incurred additional material costs attributable to increased waste as lumber quality has declined. According to an NAHB spokesman, 59% of builders surveyed expressed concern about lumber quality, particularly regarding its stability and the prevalence of knots and splits. These concerns were relatively consistent by region and size of builder (Yost, 1995).

9. When combined with the use of framing screws that resist uplifting loads more effectively than nails, steel framing produces a structure that performs favorably compared to other building materials during hurricanes and earthquakes (Bateman, 1997).

10. Historically, at least through 2002, Steel provides a more reliable supply of framing materials for the building industry and isn't affected by the shortages and sharp price increases in the lumber industry.

"Steel escapes the vicious cycle of fluctuating costs -- 2 percent to 3 percent compared to 3 percent to 15 percent for wood -- and gives control back to the builder," said Chuck Robertson, president and COO of Whitepoint Homes and Steel Homes in Summerville, S.C. They planned to build just fewer than 100 homes in 2002 (Richmond, 2002).

11. Steel-framing can easily accommodate future remodeling since non-load bearing walls can usually be removed without difficulty, altered, and relocated (Yost, 1995).

12. Steel studs may perform better acoustically then wood. 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, 1994). Table 1 shows how the different Sound Transmission Class (STC) values change under different scenarios. The table considers a wall system that consists of 1/2" fire rated gypsum wallboard on both sides of a 3-5/8" light gauge steel stud wall with the studs spaced 24" on center. That wall assembly achieves a STC rating of 39. The table then adds or replaces different parts of the wall system and shows how much to add or subtract from the STC rating. A higher STC means a material or system that is more sound resistant. Every five points is a 50 percent reduction in sound transfer (Cavanaugh, 1999).

Table 1: Table for estimating the STC rating of typical gypsum wallboard (GWB) partitions.

A 1/2" Fire Rated GWB on both sides of stud with 3-5/8" Light Gauge Metal Stud, 24" o.c. achieves a STC rating of 39.		
From (or Add)	To	Change in STC rating
½" GWB	5/8 GWB	0
Studs 24" o.c	Studs 16" o.c.	-1
Add glass fiber batt		+5
Metal studs	Wood studs	-5
Metal studs	Wood studs w/resilient channels	+1
24 to 28 ga. Studs	Add resilient channels	0
16 to 20 ga. studs	Add resilient channels	+2
Add one layer of GWB		+2
Add two layers of GWB		+4
Stagger Studs		+5
3-5/8" Studs	6" Studs	+3
Note: Increasing GWB from ½" to 5/8" thickness produces little or no improvement in STC rating, but does improve low frequency sound transmission loss, particularly below the STC contour range (Cavanaugh, 1999).		

2.3 Topic 3 – Disadvantages of Light Gauge Steel Framing Construction

Light gauge steel framing has a few disadvantages as well. Most are minor; however, there are two major issues, listed below. In examining these two issues, it should be noted that there is support for and against both of the issues.

1. The greatest disadvantage to most light gauge steel framing is known as thermal bridging. A thermal bridge is created when materials that are poor insulators

come in contact, allowing heat to flow through the path created. In cold climates, thermal bridging could result in increased heating costs and in hot climates heat gain could result in moisture damage. Because of thermal bridging, most light gauge metal studs that are of the most common design in the U.S. are a poor choice for exterior walls, unless extra steps and materials, which may cause light gauge steel to lose its pricing advantage over lumber, are used to interrupt the transfer of heat.

Amundarian, Torero, Usmani, and Al-Remal dispute some of the thermal claims. They claim that light gauge steel framing has been extensively used in cold climate countries, specifically due to its good thermal and structural behavior (Amundrian 2006). However, there has been ample research conducted to prove otherwise. The common light gauge steel stud acts as a thermal bridge allowing heat to transfer between the exterior and interior of the structure. One of the more common concerns amongst homebuyers, architects and builders, when it comes to light steel framing, is its energy efficiency. Builders framing their projects with lightweight steel desire to achieve comparable levels of insulation as those achieved with other constructive forms, such as wood frames, while using the same insulating materials.

Thermal bridging has been identified as the main issue to be resolved for improved thermal efficiency in light gauge steel framing systems (Kosny 2004). A concern arises in that by focusing only thermal bridging issues may result in reduced effectiveness in other properties of light gauge steel that are not generally thought of as priorities. “The two main issues that require added consideration are fire and structural performance. Modifications on the light gauge steel framing design have the potential to affect its behavior under fire conditions (Amundarain, 2006).”

According to the 1995 Model Energy Code, which is referenced by the three model codes, the effective R value of R-11 cavity insulation is halved, to 5.5, in a wall framed with 16 gauge 2-by-4 steel studs spaced 16 inches on center. 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, 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, 1994)."

However, thermal bridging is only one part of a home energy model. Air infiltration is a major source of heat loss in a home. Steel framed systems has the advantage over wood framed systems "due to steel's uniformity and stability in dimension, there is little chance for gaps to form as a result of shrinking or warping. This will reduce the likelihood of air infiltration (Amundarain, 2006)."

An important principle to remember is that framing is just one part of the overall building envelope. Framing members account for between eighteen percent and twenty-five percent of a house's structural materials. Roof and floor framing each add between a fifth and a quarter (Imhoff, 1997). Heat is not only transferred through wall studs, it is also radiated through doors, windows, chimneys, vents, holes and cracks. Analyst Dr. Harold Glasser, at the Foundation for Deep Ecology, wonders whether focusing on the thermal bridging is perhaps too narrow and theoretical. "All sources of heat transfer in a house have to be considered to assess the true impacts of thermal bridging. You have

to analyze the studs in the context of the overall building envelope. Studies must move to actual working houses (Imhoff, 1997)."

There are many methods to reduce thermal bridging (Kosny 2004). They include insulating sheathing, steel stud web modification, steel stud flange modification, spacers to reduce contact area between the steel studs and exterior sheathing, reflective surfaces to improve thermal resistance of air space, local foam insulation for studs and a combination of foam/steel studs (Amundarain, 2006).

Bruce Bateman notes 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 (Bateman, 1997)."

Transcon Steel, a light gauge steel stud manufacture chose the Delta Stud metal framing system for its structural integrity, thermal performance (see Figure 3), strength-to-weight ratio, and cost. The Delta Stud provided an additional benefit by being tested by Underwriter Laboratory (UL) as the only stud to surpass the one-hour fire rating with single layer 5/8" gypsum wallboard. One of the most impressive advantages of the Delta Stud is unparalleled thermal efficiency. As shown by the color temperature chart in Figure 3, when subjected to the same exterior wall heat source, Delta Stud transfers much less heat to the interior wall side compared to the conventional "C" stud. The reason is simple: Delta Stud's large web openings reduce the path for heat transfer across the stud.

Heat flow is confined to the slender ribs that cross the web. In a typical 8-foot section, Delta Stud shows 75% less thermal transference than "C" studs. Encased in structural foam, the thermal and structural performance of through-wall metal stud framing is unmatched. Delta Stud also delivers a higher Sound Transmission Coefficient rating due to the acoustic superiority of the profile (transconsteel.com).

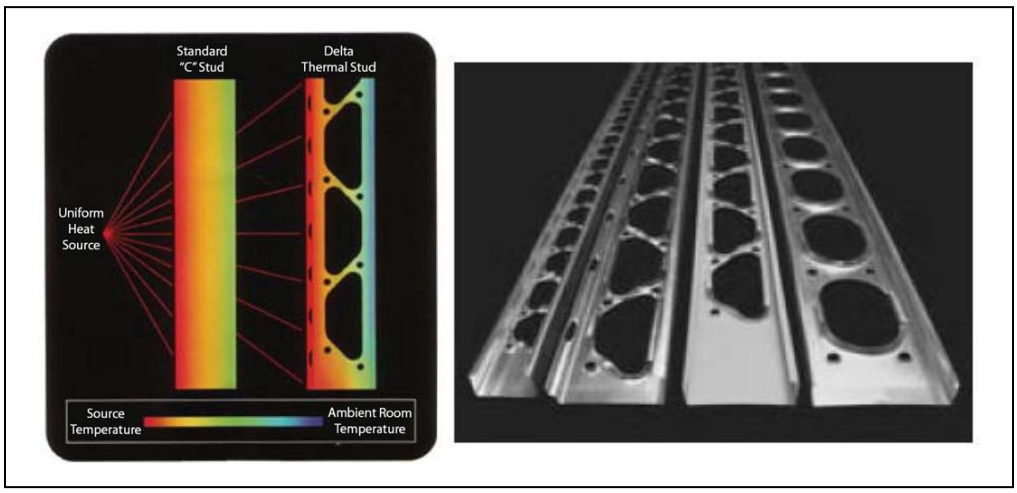

Figure 3: The Delta Stud. (http://www.transconsteel.com/products/ultraframe/stud.asp)

To help lessen the effects of thermal bridging, the steel industry recommends sheathing the outside of metal studs with rigid-board insulation such as extruded polystyrene, expanded polystyrene, or polyisocyanurate foam. "This forms an effective thermal break and increases R values significantly," according to AISI's Thermal Design Guide for Exterior Walls, published in January 1995 (Solomon, 1997).

Wood framing is not without its faults in thermal inefficiencies. "Inferior-grade wood can warp, twist, and shrink—initially and over time. Significant thermal inefficiency can be detected in wood framed houses as early as five years after sitting," says Dr. Stan Rhodes of Scientific Certification Systems, "due to gaps in building corners or in the interface where walls and roof lines connect. Other industry experts point out that builders are becoming increasingly frustrated with rejecting as much as twenty percent of each truckload of wood studs due to unacceptable imperfections (Imhoff, 1997)."

2. Although light gauge steel framing is noncombustible, the steel studs are directly affected by high temperatures. This issue is addressed by Gregory Havel in an article found in Fire Engineering journal:

> As in any noncombustible or fire-resistive building, early stages of fire are most likely to involve room contents and interior finishes. Furniture, furnishings, paper, upholstery, and combustible finishes burn as readily in a noncombustible structure as in a combustible structure.
>
> Although the structure is noncombustible, it will still be affected by heat. Since there is not much mass to the steel studs and joists in this type of construction, they are as likely as steel trusses and bar joists to be weakened quickly by heat and as prone to early collapse. Although the self drilling screws used to assemble steel studs and trusses are less likely to release in a fire than the gang-nailers used in wood trusses, they may be no more stable if the screws or the steel is rusted or if the screws were over tightened and the threads stripped.
>
> Even if fire-stopping is installed inside the walls between floors and where pipes and cables penetrate fire-rated assemblies, an entire wall or floor assembly can be considered to be a single void space, since the sheet metal of the steel studs and joists has holes punched through it at the factory for ease in installing cables, pipes, and conduits. Since void spaces inside walls are often connected to the void spaces inside floor assemblies, and since fire-stopping is not always perfect, expect that smoke will travel through

> the void spaces to other parts of the building as readily as it would in truss construction. Where smoke can go, fire can follow.
>
> Even if this type of noncombustible structure has an automatic fire sprinkler system, the void spaces will be unprotected. The fire can spread into the voids if the sprinklers are ineffective in controlling the fire in its room of origin or if the fire breaks through the drywall board enclosing the voids.
>
> Gypsum board provides some protection to the steel studs as long as the fire is confined to the room of origin even if it is not fire resistant. However, the heat of the fire will cause steel studs to fail more quickly than wood studs, especially if the fire has extended inside a wall or ceiling void. This is especially important if the partition or ceiling assembly is fire rated. (Havel, 2008)

Fire issues for light gauge steel are of concern over that of wood framing systems. This again is related to the thermal expansion and integrity of the steel framing members. The fire resistance of a structure is enhanced through the wall assemblies as a whole, as in the case of two by four construction with gypsum board and insulation, but fire resistance with the use of light gauge steel framing is inferior to that of wooden members due to the following:

1. Gypsum Board installed on ceilings will detach quicker due to the thermal expansion of the light gauge steel framing;

2. After the gypsum board has fallen off, the rise in the light gauge steel temperature is fast, and the fire rating of the light gauge steel is not prolonged, unlike the wooden members having combustible allowances (Sakumoto, 2003).

From the loaded heat test results it can be surmised that the prevention of gypsum board from falling off is important for improving the fire resistance of partition walls, exterior walls, and floors, and that the increase in the number and

thickness of gypsum board to be applied and the use of gypsum board with organic fibers are effective. Also, by including glass fibers, mineral fibers, and plywood in the wall system, although they are combustible, are effective in improving the wall's fire resistance (Sakumoto, 2003).

3. Another disadvantage of light gauge steel framing is that it is unfamiliar to residential contractors and subcontractor, residential architects and engineers, and some building officials. Framing crews would need to retool for working with light gauge steel, which requires a small initial investment.

   Yost states that most residential framing is done by small firms. Smaller firms tend to resist new technologies, including new building materials. Some firms consider light gauge framing as an untested technology and are apprehensive to use it. Home builders also worry about their ability to absorb the learning curve costs associated with using a new product like light gauge steel. "Other potential pitfalls for steel use include higher charges by subcontractors to work with steel and some buyer hesitation in accepting the use of a new building material in their home (Yost, 1995)."

4. Galvanic action is another concern that builders must address when using light gauge steel framing. Galvanic action is the effect of electrolysis between two dissimilar metals, such as steel and copper. Dissimilar metals need to be isolated from each other.

5. "Environmentally friendly" is a buzz term that we hear often. The argument between the wood verses light gauge steel can be bitter.

> Of all the points of contention, the environmental-impact question is perhaps the most volatile issue and the toughest to call.

> Historically, both industries have been heavy polluters and both wreak havoc on local ecosystems through either resource harvesting or manufacturing.
>
> To their credit, both industries are working to maximize resources and minimize environmental damage. The timber industry had developed a variety of engineered-wood products that make better use of immature, reforested trees and alternate species. Though it is more costly, manufactured wood is more uniform and moisture-resistant dimensionally than traditional lumber.
>
> The steel industry, for its part, has greatly reduced smokestack emissions. A typical steel mill today emits 95% less sulfur and 28% less carbon dioxide than it did a decade ago. Steel also boast a 65% recycling rate, but this figure is a bit distorted, as it includes scrap produced in manufacturing. A rate of 50% is probably more realistic. Moreover, most recycled scrap goes into heavy steel products, with cold-formed steel claiming only 24%. Still, even this amount is encouraging (Henkenius, 1997).

Despite the disadvantages of light gauge steel, there is place for this material in residential construction. Light gauge steel is a great choice for most interior partitions and chases, and other areas of the home where thermal bridging is not an issue. Partitions and chases can take advantage of the positive aspects of light gauge steel.

2.4 Topic 4 – Emerging Technologies of Light Gauge Steel Framing Construction

As new technologies are discovered concerning the methods and materials of light gauge steel, it is likely that the use of light gauge steel framing will increase. An example of a simple technology that probably made light gauge steel framing a practical reality is the self-drilling self tapping screw with a corrosion resistant coating (Lindegard, 1990).

Another example of an emerging technology is the use of clinching as a joining method for frame constructions of light-frame housing. Clinching has been used for many years in the car and “white goods” industry. “There has been much research into

the method, the tools, suitable materials and applications. Few articles have been published concerning clinching of high-strength structural steels, which are currently the most relevant materials for house construction (Varis, 2003)."

Flex-C Trac (see Figure 4) with Hammer-Lock feature is offered by Flex-Ability Concepts. The company produces track for light gauge steel framing that curves, allowing the builder to quickly erect curved walls and arched doorways. The Flex-C Trac with hammer lock offers a feature where "once the track is formed simply hammer down the tabs to secure the shape. It's fast and strong (Flex-Ability Concepts, 2007)."

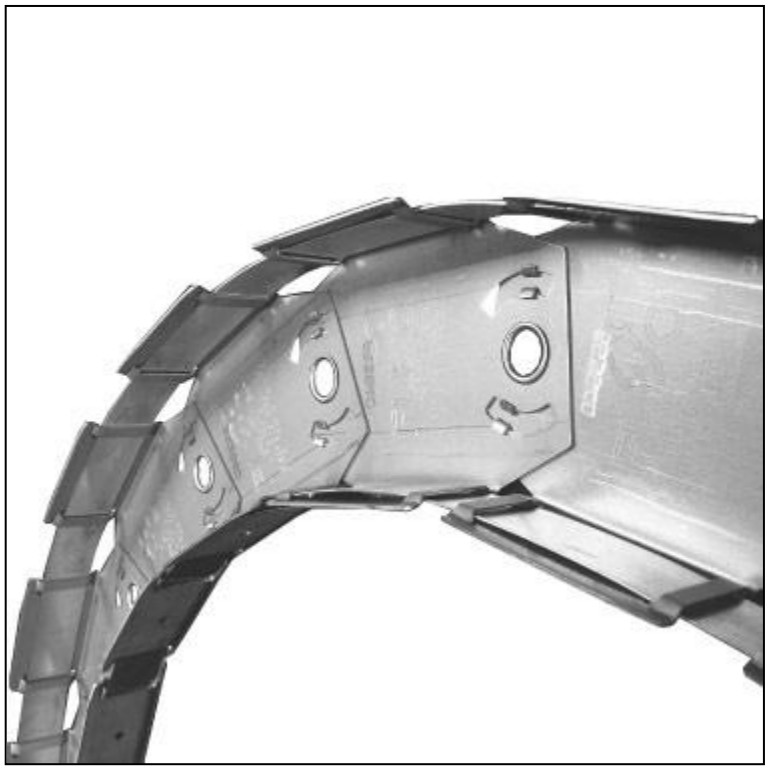

Figure 4: Flex-C Trac. (http://www.proplaster.com.au/ products/flex-c-trac-system-with-hammer-lock-feature)

A new type of steel stud incorporates dimples on the surface (see Figure 5). The result of this type of innovation is quicker installation and noise absorption. "...the product's cold-rolled, 'dimple' process yields a higher strength-stud using lighter-gauge steel.... Meanwhile, old-style, 'flat' studs are being phased out." The article goes on to say that "the dimpled surface offers a thicker material that grabs hold of screws and then locks them into place. Stud flanges have a textured V-grove that gives builders a sight line to help them fit joints with more precision than before. Independent lab tests have found that the studs are more resistant to bending, fire and noise transmission than traditional-style metal studs (ENR, 2006)."

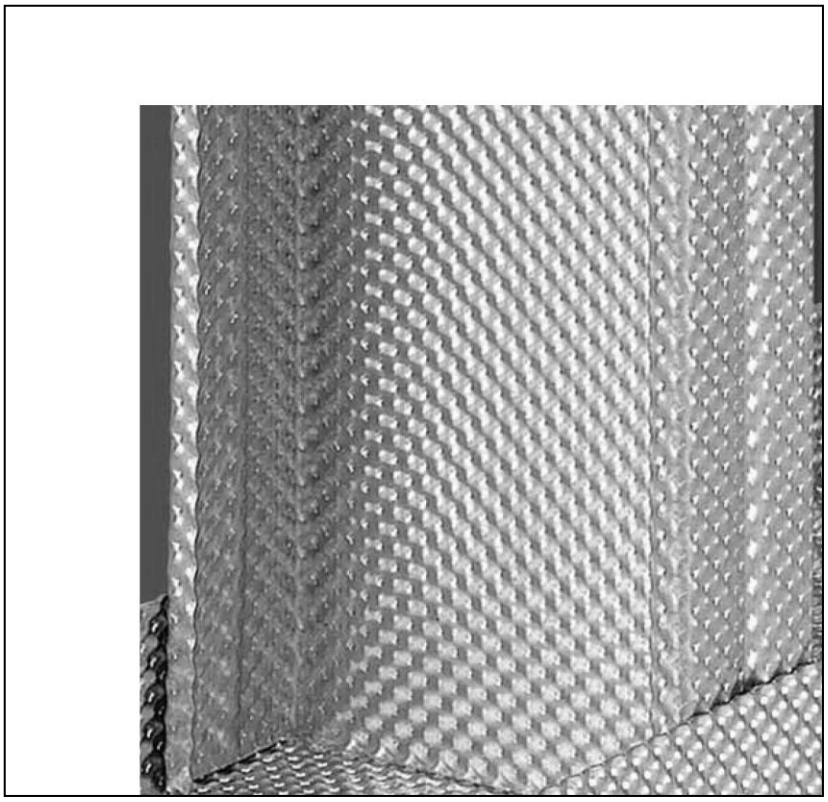

Figure 5: Dimpled stud and track

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 get better thermal performance; however, Brown and Swartz go on to clarify that “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 (Bateman, 1997).”

A light gauge steel framer, Erik Elwell has framing with light gauge steel down to a science. One of the things he incorporates in his work is foam strips called Shadwell 143 Integrity Gasket shown in Figure 6 that attach directly to the studs and tracks – between the screws. This enhances the sound attenuation of the walls and creates a flat surface for hanging drywall (Elwell, 2005).

Figure 6: Integrity™ Gasket forms a thermal break at external wall framed with metal studs to prevent "shadowing" on gypsum board and reduce sound transmission. (http://www integritygasket.com/oldgallery1.asp)

Don Allen, executive director of the Light Gauge Steel Engineers Association stated that "There are new standards for steel framing, and more are coming out soon, for truss headers, steel shear walls, and lateral load resistance." Engineer Timothy J. Waite stated "entirely new steel-frame approaches are emerging, including R-value-boosting 'slit-web studs,' corrosion-resistant galvanized members, and single L shaped headers (Allen, 2004)."

"Several manufactured systems are on the market, and for larger homes, components are custom made. In addition, one method allows builders to actually fabricate the framing members on-site, using 'stud-formers' and a steel roll (Hewlett, 2003)."

2.5 Conclusion

The following anecdote as presented by Iris Richmond sums up the situation best: Jeffrey Prostor, president of Brookfield Homes, likes turning the tables. He asks people to imagine a history in which builders have been using steel, instead of wood, for the past 100 years. Imagine what would transpire if such a builder was approached by someone, product in hand, proposing wood: "Here's wood. Now, I have to warn you that it's heavier to carry and not as straight, it warps, cracks, and squeaks, it can catch fire: it doesn't span as well: and its price per foot will fluctuate. Did I mention that it's organic and therefore susceptible to mold? Oh, and there's a bug you should know about, its called a termite... (Richmond, 2002)."

Environmental Building News (EBN, see review p. 57) dedicated their July/August 1994 issue to the steel-versus-wood framing question. The author, Nadav Malin, researched the following important categories for comparing the two materials:

- Embodied energy
- Manufacturing emissions
- Renewability of resources
- End-of-use recyclability
- Thermal efficiency
- Pricing
- Earthquake performance
- Fire performance
- Air quality

"Malin concluded that certified, sustainably harvested wood was preferable for external wall framing, but that light-gauge steel offered potential advantages in specific applications and hot climactic zones (Imhoff, 1997)."

Should builders use wood or light gauge steel in residential construction? The solution is found in the following statement:

> The answer, fortunately, is not formulaic. It depends. It no longer makes sense to choose a material based on its chemistry alone. Sustainable building is achieved with integrated building systems – heating and cooling respond to light and occupancy, for example. The burden is on architects and builders to weigh not only one material against another, but to consider all the materials as part of a whole, and it's the whole that must remain sustainable throughout the entire life cycle of the building (Hart, 1999).

Light gauge steel has positive properties that should be considered by builders for use in the construction of single family homes. For residential construction, using light gauge steel for interior partitions and wood for the exterior framing would be advisable at this time (Chini, 1995).

"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 (Bateman, 1997)." Those builders who incorporate light gauge steel framing into their construction of residencies may find that they have a better product for the consumer, and a better bottom line.

3 Methodology and Procedures

This chapter will discuss the methodology used to accomplish the research. The statistical methods used to determine the sample size are described. The methods employed to create the survey are discussed.

3.1 Methodology

To research why light gauge steel is not used more in residential construction in Utah, qualitative information was gathered. Both Utah licensed general building contractors (B100 classification) and licensed residential and small commercial building contractors (R100 classification) were considered part of the population because both classifications are involved with home building. To discover the perception and use of light gauge steel framing in residential construction in Utah, a questionnaire was devised which will be discussed in section 3.3 of this chapter. Once the survey was administered, statistical methods were used to analyze the data and can be found in chapter 4.

This research was conducted following Brigham Young University's Institutional Review Board for Human Subjects protocols. An application to conduct the research using human subjects was submitted to the Institution. A letter was received from the Institution granting administrative approval for the research to take place.

To obtain contact information for B100 and R100 contractors, the researcher went to Utah's Department of Professional Licensing (DOPL). To access the contractors' information, the administrative approval letter from Brigham Young University was submitted to the DOPL and a fee of about $415 was paid. The list was then emailed from DOPL to the researcher in a Microsoft Excel format. The breakdown by county of contractors and the type of license they hold is seen in Table 2.

3.2 Statistical Methods

The total population of B100 and R100 contractors in Utah was 10,248. The goal was to have a confidence level of 95 percent with a margin of error of 6 percent. From the researchers' observation, light gauge steel framing was not being used throughout Utah; therefore, an estimate of 15 percent was used to estimate the proportion of the population that might use light gauge steel. The researcher used the statistical sample size equation, or m= z^2*v / e^2, where m = sample size, z = z-score for the confidence level (1.96 at 95% confident), v = variance (In proportions this is equal to p * (1 – p) where p is the estimate proportion of the population to believe a certain way (in this case 15 percent), and e = margin of error. So m = ((1.96^2)(0.15*(1-0.15)))/0.06^2=136.

The researcher then used a second equation, n = m / (1 + m/N), known as the finite population correction (fpc), which adjust the sample size if the known population is finite. By plugging the numbers, n = 136/(1+136/10,248) = a sample size of 134.27. The researcher estimated that there would be a 25 percent response rate based on advice from a statistical consultant. To reach a response rate of 134.27, the sample size was divided

by 25 percent, or .25, for the total mailings needed of 537. A total of 539 was sent for good measure.

Table 2: Number of B100 and R100 Contractors Licensed in the State of Utah

	B100 General Contractor	R100 Residential and Small Commercial	
Beaver	18	7	25
Box Elder	115	60	175
Cache	264	160	424
Carbon	56	21	77
Daggett	2	1	3
Davis	579	288	867
Duchesne	69	29	98
Emery	27	7	34
Garfield	17	8	25
Grand	46	22	68
Iron	161	93	254
Juab	39	18	57
Kane	33	24	57
Millard	15	15	30
Morgan	32	35	67
Piute	5	3	8
Rich	10	10	20
Salt Lake	2240	1079	3319
San Juan	30	3	33
Sanpete	65	43	108
Sevier	35	35	70
Summit	254	146	400
Tooele	86	66	152
Uintah	46	51	97
Utah	1298	489	1787
Wasatch	138	105	243
Washington	640	321	961
Wayne	15	6	21
Weber	520	248	768
Totals	6855	3393	**10248**

Once a sample group was calculated, the names of the contractors were listed on a Microsoft Excel worksheet. A number was placed by each name. A simple randomizing formula was used in the Excel worksheet to randomly select the 539 contractors.

3.3 Survey

The survey was created dynamically, in other words, depending on how a question was answered, additional questions might appear. For example, one of the questions asked those surveyed if they build homes. If they answered no, the survey would skip questions concerning home building; otherwise questions concerning home building would be presented. The questions were multiple choice or short answer. To construct the survey, the researcher divided the survey into two sections. First, the researcher asked questions concerning light gauge steel. The following is a summery of those questions and the reason why the researcher ask it:

1. *What type of license do you hold*? Even though the researcher had the names of the contractors and the license they held, the survey was conducted in confidence. This question was asked to determine if one type of license was more favorable toward steel over the other license.
2. *Do you build single-family residential homes*? Not all contractors build homes.
3. *Where do you get the house plans that you build*? This question only appeared if question 2 was answered "yes". This question was asked to see if architects and engineers have a big influence on what materials are used in

building a home. If the home builder designed their own plans, the goal was to see if there was a correlation between that and the use of light gauge steel.

4. *Considering the single-family homes that you build, which of the following do you use light gauge steel framing members?* This question only appeared if question 2 was answered "yes". This question attempts to discover if the contractor built homes using light gauge steel. Choices to this question included exterior walls, interior walls, floor systems, roof truss systems, and light gauge steel is not used. If light gauge steel was used, an addition question appeared that asked what spacing they placed their framing members. This was asked to see if they are utilizing the steels strength.

5. *Why do you choose to use materials other than light gauge steel for exterior walls? Why do you choose to use materials other than light gauge steel for interior walls? What are the benefits, if any, of using light gauge steel framing materials in single-family residential construction? What are the drawbacks, if any, of using light gauge steel in framing assemblies for single-family homes in residential construction? What do you do overcome drawbacks, if any, of using light gauge steel in for single-family homes in residential construction?* These questions are asked to discover the perception and thoughts of the builder concerning light gauge steel. They attempt to pull information from the builder concerning their knowledge and thoughts on light gauge steel.

The second section of the survey tried to discover information about the contractors' experience, education, and their company's size. It was considered that perhaps there

might be a correlation between the use and non-use of light gauge steel and experience, education, and their company size.

1. *How many years have you been in the construction industry? How many years have you been a contractor?* These questions are asked to find out about the contractors' experience.
2. *What formal education do you have? Please indicate your subject of study.* This question is asked to discover how much education the builder has.
3. *What work do you self perform? How many single-family homes do you build per year? What is the average size (in square feet) of single-family homes you build? Of the single-family homes that you construct, what percent are custom homes? How many employees work for your company? What is your business's gross revenue?* All of these questions were asked to ascertain the size of the company, and also to see if they fit into a particular niche.

The survey questions were reviewed and approved by the committee over this thesis. The survey was imputed and issued through a software program called "LimeSurvey".

A postcard was created that included a brief description on what was being researched and a web page that they could log onto to fill out the questionnaire. The web pages address was http://www.cm-ihd.org/ and required a token (password) to take the survey. The password condition was done to control who was participating. On the postcard a specific token was assigned to each builder. A disclaimer was added to ensure the contractors being sampled that their information would be confident, protected, and

not be sold. The post card was sent to the randomly selected 539 contractors in Utah. A couple of weeks later, a follow-up letter was sent to remind the contractors about the survey, and re-invited them to respond.

In an attempt to increase the response rate, a random drawing occurred in the presence of officials to select one of the participants to receive a $300 gift certificate to Cabela's, Sportsman's Warehouse, Home Depot, or Lowes. The drawing was held and the researcher fulfilled his obligation.

4 Findings

A response rate of 49 respondents or 36.6 percent of the sample was achieved. To increase the response rate, an individual with experience in administering surveys was hired to contact the sample and implement the survey. An additional 29 contractors participated, for a total of 78 respondents, or 58.2 percent of the sample size. A copy of the survey was exported out of LimeSurvey into this paper, and is included in appendix A.

Since the number of respondents fell short of the sample size needed, the error of margin was recalculated. By solving for e in the statistical formula found in chapter 3, the error of margin for this research was 7.9 percent. It should be noted that the researcher estimated the p value to be 15 percent. The literature review stated that the only ten percent of the builders in the United States used light gauge steel (Heavens, 2001). Using 10 percent as the p value would have meant that with a 95 percent confidence value and an error of margin of 6 percent, the sample size should have been 96. This would have led to an adjustment due to the number of respondents of the survey to an error of margin of 6.7 percent.

The responses to the survey can be found in appendix B. The researcher believes that the responses to the survey were insightful in answering the research questions found in this thesis.

4.1 Is Light Gauge Steel Used?

According to the survey, 94 percent of contractors surveyed had not used light gauge steel to build single-family residential homes. The 6% of contractors that had used light gauge steel had used it in limited construction, but used lumber as their main building material.

Of the builders using light gauge steel, the responses suggest that contractors that used light gauge steel did not build more than 6 homes per year. No homes under 2,500 square foot were built of light gauge steel. Contractors that used light gauge steel did not have more than 15 employees. Therefore, construction firms which are most likely to use light gauge steel are small to mid-size firms building homes larger than 2,500 square feet.

4.2 Why Are Other Materials Used?

In answering the question, "Why do you choose to use materials other than light gauge steel for exterior walls", the subjects generally answered three different ways; 1) 50 percent said they build out of tradition, 2) 33 percent of the respondents said they are unfamiliar with light gauge steel, and/or 3) 20 percent said they do not believe there is a cost benefit in using light gauge steel. Also of note is that 8 percent stated that they just build what the architect delivers to them and 5 percent mentioned issues with thermal bridging. Thermal bridging is one of the main issues with using light gauge steel for the exterior framing members.

Tradition and unfamiliarity seem to go hand in hand. One of the respondents said that he personally feels that wood is an easier thing to work with, which is one reason he hadn't bothered with steel. Others stated that they already have the tools for working

with lumber and are familiar with how to effectively build with wood. They have always used lumber to frame homes; it is what they are comfortable using, and it is where their skill set lies.

4.3 The Perception

The general perception about light gauge steel is that it was meant for commercial construction projects, and lumber should be used for residential construction projects. Some of the contractors recognize that there are advantages to light gauge steel. However, the respondents were concerned about price, tools, unfamiliarity of light gauge steel construction by themselves and their subcontractors, and the time it takes to assemble light gauge steel assemblies.

4.3.1 Advantages of Light Gauge Steel

In answer to the question, "What are the benefits, if any, of using light gauge steel framing materials in single family residential construction?", 36 percent of the respondents recognized that steel is straight and true, unlike today's lumber which tends to warp and twist. Interesting 30.6 percent did not know or could not name any benefits of using light gauge steel. Approximately 9.3 percent said that there is no benefit to light gauge steel. Table 3 is a breakdown of what the contractors thought the benefits of light gauge steel are.

Table 3: Benefits of light gauge steel as stated by the contractors by answering the survey question "What are the benefits, if any, of using light gauge steel framing materials in single family residential construction?"

Benefits of Light Gauge Steel as Stated by the Respondents	Percent of the Respondents Answering in Favor of the Listed Benefit
Straight and true	36%
Builder did not know of any	30.6%
No benefits at all	9.3%
Cost	9.3%
Non-combustible	8.0%
Ease of use	6.7%
Minimal waste	6.7%
Positive for the environment	5.3%
Strength	4.0%
Pre-punched holes	4.0%
Resistant to termites and pests	4.0%
Light weight	2.6%

4.3.2 Disadvantages of Light Gauge Steel

To discover the builders' perception of the disadvantages of light gauge steel, the question was asked, "What are the drawbacks, if any, of using light gauge steel in framing assemblies for single family homes in residential construction?" One of the biggest concerns with 26.2 percent of the contractors was that they and their subcontractors were unfamiliar with light gauge steel. The contractors said that finding a light gauge steel framer is difficult. Also, 32.3 percent of the respondents did not know enough about light gauge steel and answer by stating "I don't know." The builders often

felt that they could not be efficient in building with light gauge steel. Table 4 is a breakdown of what the contractors thought the disadvantages of light gauge steel are.

Table 4: Disadvantages of light gauge steel as stated by the contractors by answering the survey question "What are the drawbacks, if any, of using light gauge steel in framing assemblies for single family homes in residential construction?"

Disadvantages of Light Gauge Steel as Stated by the Respondents	Percent of the Respondents Answering in Favor of the Listed Disadvantages
Contractor, subcontractors, and/or architects were unfamiliar with light gauge steel	32.3%
Builder did not know of any	26.2%
Cost	15.2%
Did not have proper tools	10.8%
No disadvantage at all	7.7%
Sound transfer	6.2%
Not as strong as wood	6.2%
Thermal bridging	4.6%
Bad for environment	3.1%

4.4 Why Light Gauge Steel is not used more

The answer to this thesis problem statement, "Why is light gauge steel not used more in residential construction in Utah", can be summed up with three words: Tradition, Ignorance, and Cost.

1. Tradition – as stated in chapter two, one of the reasons for contractors to build using the methods and materials they choose to use is out of tradition. It is the way they were taught; it is what they are familiar and comfortable with. The

research discovered that some of the contractors were unwilling to even consider other materials in their construction practices

2. Ignorance – by reviewing the answers given by contractors on the survey, an amazing 58.5 percent of the contractors were not knowledgeable concerning the properties of light gauge steel. The most common response was either the contractor and/or their subcontractors and architects were unfamiliar with light gauge steel framing, or blatantly "I don't know". Approximately 98 percent of the respondents could only name a few benefits or drawbacks, if any. They did not know how it could benefit their projects, or how it could benefit the owners.
3. Cost – 15.2 percent of the contractors listed cost as an important reason to use wood over steel. In the literature review for this thesis, no data was discovered that would support or discount the respondents claim. Interestingly, there were 9.3 percent of the contractors who thought that cost was a benefit.

To overcome the drawbacks of using light gauge steel, three of the contractors suggested that training and research might help them. One said that there should be some educational classes given to the contractors about light gauge steel's uses and advantages.

One contractor believed that volume was the answer. He said that when doing a whole subdivision of houses that are identical with only a few changes, the contractor would overcome problems on the first few. Then the contractor might come out ahead of the conversion curve of moving from lumber to metal. He concluded by saying that all trades hate tooling up for only a few jobs.

Another respondent said the only way he would know how to overcome the drawbacks would be to start using light gauge steel and then work through the problems.

Someone else stated that contractors should just start using light gauge steel in residential applications, or in the words of another contactor just “suck it up and change.”

5 Conclusion and Recommendations

This chapter reflects the author's findings for the research, conclusions derived from the literature review and personal field observations, and recommendations.

5.1 Review of the Findings

The findings point to two important concepts. First, contractors should be willing to research and become better educated concerning the materials they are using to construct homes. Second, understanding the properties of the building materials they are using might encourage contractors to produce a better product that is more energy efficient, durable, affordable, environmentally friendly, and safe. Tradition sometimes needs to be broken in favor of constructing a better home, something that both the builder and the home owner will benefit from.

5.2 Conclusion

In view of the research, 58.5 percent of contactors in Utah are ignorant to any benefits of light gauge steel. Too often in the construction industry construction practices seem to be implemented because of tradition. Contractors tend to do things the way they were taught as laborers and as skilled workers. Their Tradition is not necessarily good or

bad; however, being entrenched with tradition can lead to slow progression to an improved product.

The researcher noticed that there were no ‘apple to apple’ comparison studies between light gauge steel and lumber framing materials and systems so that the benefits of one material over the other material can be more easily compared. Cost was a concern to contractors in the survey. There were contractors that thought that cost was a benefit to light gauge steel, while other contractors though that cost was a disadvantage.

The researcher has pointed out that thermal bridging is a major problem for using light gauge steel as part of the exterior framing system; although there are many technologies working to resolve this problem, such as the Delta Stud. The author concludes that because of thermal bridging, an integrated building system is the right solution. Framing methods that uses both lumber and light gauge steel will help produce better quality homes.

From observation, and now through the instrument of the survey that is part of this thesis; it is evident that light gauge steel is not common in residential construction. Evidence from the literature review and survey suggest that light gauge steel is lighter, straighter, stronger, and faster to install.

5.3 Recommendations

The researcher concluded that the lack of knowledge concerning light gauge steel is a major problem. Education seems to be one of the major keys to helping contractors to be better informed. Perhaps building associations, suppliers of light gauge steel, and other related institutions should offer more classes throughout the state of Utah on

building materials, such as light gauge steel. If institutions are currently conducting classes, then perhaps better advertising should take place to alert the contractors.

Another way to inform builders of products is thought marketing. Manufacturers of light gauge steel should create more ad campaigns to educate builders on light gauge steel. The researcher also believes that the ad campaigns should extend to residential architects and drafters. The more that builders and designers see and hear about the advantages of and how to use light gauge steel framing, the more likely they are to change the way they build.

Since there are many positive properties of light gauge steel, it should be used for interior partitions, soffits, chases, and possibly floors; basically, any place where thermal bridging will not be an issue. Lumber should be used for exterior walls, ceilings, and some blocking until better technology is exposed. Gauge is important. A 25-gauge stud is considerably weaker than a 20-gauge stud. Therefore, the researcher would use 20-gauge studs for the interior walls, and 25-gauge studs for the soffits and chases.

5.4 Future Research

The author recommends the following questions for further research on the subject of light gauge steel:

1. What are the cost differences between a home built out of light gauge steel and one built from wood, considering not only the cost of time and materials of the framing system, but also the cost of time and materials of the other trades involved in the construction of the home?

2. How can residential contractors overcome tradition, in general, in favor of producing a better product?
3. How are the building's other systems, such as drywall, affected by the use of wood (which can shrink and/or twist) or metal (which expands and contracts with temperature changes) together.
4. What technologies are currently being developed to deal with the issues of thermal bridging?
5. How much time does it take to frame a home with lumber versus framing an exact duplicate with light gauge steel?
6. How much time does it take to frame the interior partitions of a home with lumber versus with light gauge steel?
7. One of the aspects of light gauge steel that needs serious research is its fire behavior in conjunction with its associated building systems. There is definitely a conflict in the data on the properties of light gauge steel in fire situations. What are the true properties of light gauge steel concerning fire behavior?
8. What are architect's and designer's perception concerning light gauge steel in residential construction?
9. What are home owner's perception concerning light gauge steel in residential construction?

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APPENDICES

Appendix A. Building Contractor Questionnaire

The following are the questions asked to the contractors for the survey.

“This survey is for a master's thesis research project in Construction Management at Brigham Young University. The data collected from the survey focuses on the use of Metal Studs by Utah B100 and R100 contractors. The survey should take no longer than 10 minutes.

“Participation is voluntary. Your personal information will be kept confidential. If you have any questions concerning this survey or research, please contact Matt Perkins.

Framing

This section will review your framing methods and materials for Residential construction of single-family homes.

* 31: What type of license do you hold?

Please choose *all* that apply:

B100

R100

Other

_____

* 80: Do you build single-family residential homes?

Please choose *only one* of the following:

Yes

No

[Only answer this question if you answered 'Yes' to question '80 ']

* 36: Where do you get the house plans that you build?

Please choose *all* that apply:

Architect

Draftsman

Pre-designed, i.e.: a magazine or catalog

Customer Designed

Designed in-house

Other

[Only answer this question if you answered 'Yes' to question '80 ']

* 59:

Considering the single-family homes that you build, which of the following do you use light gauge steel framing members?

Please choose *all* that apply:

Exterior walls

Interior walls

Floor systems

Roof truss system

Light gauge framing systems are NOT used

[Only answer this question if you answered 'Exterior walls' to question '59 ' and if you answered 'Yes' to question '80 ']

* 55: What stud spacing do you use for your exterior framing assembles in single-family residential construction?

Please choose *all* that apply:

16" on center

19.2" on center

24" on center

[Only answer this question if you answered 'Interior walls' to question '59 ' and if you answered 'Yes' to question '80 ']

* 56: What stud spacing do you use for your interior framing assemblies in single-family residential construction?

Please choose *all* that apply:

16" on center

19.2" on center

24" on center

[Only answer this question if you answered 'Floor systems' to question '59 ' and if you answered 'Yes' to question '80 ']

* 57: What joist spacing do you use for your floor framing assemblies in single-family residential construction.

Please choose *all* that apply:

12" on center

16" on center

19.2" on center

24" on center

[Only answer this question if you answered 'Roof truss system' to question '59 ' and if you answered 'Yes' to question '80 ']

* 58: What truss spacing do you use for your roof truss framing assemblies in single-family residential construction?

Please choose *all* that apply:

16" on center

19.2" on center

24" on center

32" on center

[Only answer this question if you answered 'Yes' to question '80 ']

* 60: Why do you choose to use materials other than light gauge steel for exterior walls?

Please write your answer here:

[Only answer this question if you answered 'Yes' to question '80 ']

* 61: Why do you choose to use materials other than light gauge steel for interior walls?

Please write your answer here:

_____

* 62:

What are the benefits, if any, of using light gauge steel framing materials in single-family residential construction?

Please write your answer here:

_____

* 65: What are the drawbacks, if any, of using light gauge steel in framing assemblies for single-family homes in residential construction?

Please write your answer here:

_____

* 66.: What do you do overcome drawbacks, if any, of using light gauge steel in for single-family homes in residential construction?

Please write your answer here:

_____

Contractor Information

This section will collect a little information about you.

* 2: How many years have you been in the construction industry?

Please choose *only one* of the following:

0-5 years

6-10 years

11-15 years

16-20 years

21+ years

---

* 1: How many years have you been a contractor?

Please choose *only one* of the following:

0-3 years

4-6 years

7-10 years

11-15 years

16+ years

10: What formal education do you have? Please indicate your subject of study.

Please choose *only one* of the following:

High School Diploma

Technical or Vocational School

2 Year Degree

4 Year Degree

Graduate Degree

Make a comment on your choice here:

---

* 29: What work do you self perform?

Please choose *all* that apply:

Excavation/Earthwork

Footings/Foundations

Flatwork

Framing

Electrical

Plumbing

HVAC

Drywall

Painting

Finish Trim

Roofing

Siding

Tile work

Flooring

Masonry

Communications/Home Entertainment Systems

Landscaping

Other

_____

* 33: How many single-family homes do you build per year?

Please choose *only one* of the following:

1-3 homes

4-6 homes

7-10 homes

11-20 homes

21+ homes

34: What is the average size (in square feet) of single-family homes you build?

Please choose *only one* of the following:

less than 1500

1500 to 2000

2000 to 2500

2500 to 4000

greater than 4000

37: Of the single-family homes that you construct, what percent are custom homes?

Please write your answer here:

---

* 5: Which of the following best describes you?

Please choose *all* that apply:

Construction company owner

Work for a construction company that you don't have ownership in

Not actively using your contractors license

---

* 11: How many employees work for your company?

Please choose *only one* of the following:

0-3 employees

4-6 employees

7-15 employees

16-30 employees

30+ employees

---

* 28: What is your business's gross revenue?

Please choose *only one* of the following:

less then $500,000

$500,001 to $1,000,000

$1,000,001 to $2,500,000

$2,500,001-$5,000,000

$5,000,000+

---

* 69: If you are willing to be contacted for further information, please enter your email address below.

Please write your answer here:

Submit Your Survey.

Thank you for completing this survey..

Appendix B Results

Results
Total records in survey: 78 Percentage of total sample: 14.47%

Field Summary for 31:		
What type of license do you hold?		
Answer	**Count**	**Percentage**
B100 (160)	56	71.79%
R100 (161)	20	25.64%
Other (162)	9	11.54%
Field Summary for 80:		
Do you build single-family residential homes?		
Answer	**Count**	**Percentage**
No answer	0	0
Yes (Y)	58	74.36%
No (N)	20	25.64%

Field Summary for 36:		
Where do you get the house plans that you build?		
Answer	**Count**	**Percentage**
Architect (180)	23	29.49%
Draftsman (181)	19	24.36%
Pre-designed, i.e.: a magazine or catalog (182)	14	17.95%
Customer Designed (183)	19	24.36%
Designed in-house (184)	16	20.51%
Other (185)	20	25.64%

Field Summary for 59:		
Considering the single-family homes that you build, which of the following do you use light gauge steel framing members?		
Answer	**Count**	**Percentage**
Exterior walls (290)	0	0
Interior walls (291)	5	6.41%
Floor systems (292)	0	0
Roof truss system (293)	2	2.56%
Light gauge framing systems are NOT used (294)	73	93.59%

Field Summary for 55:		
What stud spacing do you use for your exterior framing assembles in single-family residential construction?		
Answer	**Count**	**Percentage**
16" on center (250)	0	0
19.2" on center (251)	0	0
24" on center (252)	0	0

Field Summary for 56:		
What stud spacing do you use for your interior framing assemblies in single-family residential construction?		
Answer	**Count**	**Percentage**
16" on center (260)	6	7.69%
19.2" on center (261)	0	0
24" on center (262)	0	0

Field Summary for 57:		
What joist spacing do you use for your floor framing assemblies in single-family residential construction.		
Answer	**Count**	**Percentage**
12" on center (270)	0	0
16" on center (271)	0	0
19.2" on center (272)	0	0
24" on center (273)	0	0

Field Summary for 58:		
What truss spacing do you use for your roof truss framing assemblies in single-family residential construction?		
Answer	**Count**	**Percentage**
16" on center (280)	2	2.56%
19.2" on center (281)	0	0
24" on center (282)	1	1.28%
32" on center (283)	0	0

	Field Summary for 60:		
	Why do you choose to use materials other than light gauge steel for exterior walls?		
	Answer	**Count**	**Percentage**
	Answer	40	51.28%
	No answer	38	48.72%
	Answers		
1	Too difficult to make shear wall from steel.		
2	availability and structural strength		
3	Habit...I have always used lumber.		
4	Familiarity.		
5	Because we always have.		
6	Cheaper.		
7	Haven't had a request to use them on residential no one in the area that can frame the hole home with steel studs and be efficient.		
8	Allows for expansion and contraction Lower costs to customer.		
9	Framers are more familiar with wood framing. Easier to use local framers that are familiar with wood framing.		
10	r value and labor experience.		
11	The price.		
12	Familiarization.		
13	Easier to work with wood and you can be more creative with it, not just square. Also steel has a very low R-value unless insulated.		
14	Cost prohibits use of steel. Also, there are no qualified distributors or installers of the steel stud systems.		
15	Industry standard practice is wood.		
16	Steel studs are not currently used with homes in my building market.		

17	My tooling is for wood.
18	Labor for steel systems in residential building is limited.
19	Never have used and cost.
20	Tradition.
21	We go from what the Architect has specified.
22	Conventional construction methods I guess. No new tools to invest in.
23	Construction time longer with steel subs in my area are not familiar with steel framing methods I feel that with steel framing the flexibility (i.e., radius, arches, etc) are not conducive.
24	I priced out steel versus wood awhile ago and wood was cheaper. Also, I have all the tools and more experience for wood framing than for steel.
25	Tradition.
26	For loads, it's my experience these studs are not structural according to the ICBO.
27	I have always used lumber to frame with.
28	Price prefers wood.
29	The home owners prefer lumber.
30	Changes, modifications, drilling and attaching are not as easily done.
31	Like wood, not ever used metal other than steel buildings.
32	Never used enough to find the advantage to the metal studs, wood is easier for me to work with. Strength.
33	It’s what the plans call out for when we do use it the metal studs they are straighter.
34	Availability, used wood my whole career.
35	Framing goes faster.
36	I use wood studs because they are cheaper, easier, more convenient and that is what the plans I use call for.
37	I personally feel wood would be an easier thing to work with which is one of the reasons I haven't bothered with others.

38	It is what I was taught to use.
39	I myself like lumber because I'm equipped to fashion. I already have the tools for lumber.
40	It's something I'm more familiar with rather then steel, which I'm not.

Field Summary for 61:

Why do you choose to use materials other than light gauge steel for interior walls?

Answer	Count	Percentage
Answer	31	39.74%
No answer	47	60.26%

Answers

1	Inconvenient.
2	Availability and structural strength.
3	Habit...I have always used lumber.
4	Familiarity.
5	Habit & familiarity.
6	Cheaper.
7	Same as above the path of least resistants but in commercial we will use light gauge steel.
8	Lower cost.
9	I have used some light gauge steel on interior walls in some small commercial projects, but again finding sub-contractors that do the light gauge steel framing and a draftsman familiar with it is not easy.
10	Accessibility, labor experience; note: we have rapped truck lines and framed basements.
11	The price.

12	Familiarization.
13	Standard practice is wood.
14	Steel studs are not currently used with homes in my building market.
15	Tooling.
16	Labor for steel systems in residential building is limited.
17	Cost.
18	Tradition, I have heard it said that sound quality from room to room is different with steel construction.
19	Cost of materials, time to put it together, and again arches, radiuses, custom work much easier to accomplish with traditional wood methods that steel.
20	Home owners preference.
21	Ease and time, wood is much faster.
22	I never used steel studs.
23	The home owners prefer lumber.
24	Because I use wood.
25	Mostly because the crew install the wood and another crew would haven't to come in and do the metal studs.
26	Framing goes faster.
27	I use wood studs because they are cheaper, easier, more convenient and that is what the plans I use call for.
28	It is what I'm use to and I just don't see the point in changing everything I do.
29	It's what I was taught to use. Its what I'm comfortable with and know the most about.
30	Same reason. We are used to doing wood and have the tools for it. They are used to it.
31	I really don't know that much about light gauge steel.

	Field Summary for 62:		
	What are the benefits, if any, of using light gauge steel framing materials in single-family residential construction?		
	Answer	**Count**	**Percentage**
	Answer	76	97.44%
	No answer	2	2.56%
	Answers		
1	Easy to work with, but often not sturdy.		
2	Non termite material.		
3	Cost.		
4	Ease of use.		
5	Not sure...I have heard that during the framing process the walls are weaker, but once sheeted and sheetrock that they are actually stronger. However, I do not know if this is true or not.		
6	Uniformity.		
7	Straighter walls.		
8	I see no benefits.		
9	We build concrete dams and bridges. We are not a home builder.		
10	True straight material.		
11	I HAVE BEEN AROUND BOTH STEEL AND LUMBER STRUCTURES DURING CONSTRUCTION AND I FEEL THAT THERE AREN'T ANY REAL BENEFITS OF USING STEEL FOR THE CONTRACTOR. COST IS A PUSH AND INCONVENIENCES EXPERIENCED IN THE INSTALLATION OF THE PRODUCT AND ONTO THE PRODUCT BY OTHER SUBS IS A PROBLEM.		
12	Don't know.		
13	I am not aware of what the advantages would be.		
14	I like to frame with them over un even concrete.		

15	Much stronger and you get a straight wall all the way around so you don't have to worry about bowed or twisted studs. Also the holes are already there for the electricians, etc...
16	No warpage.
17	I don't know, maybe if it was all precut the connections would be fast, but with the price of metal going up I think that all cancels out.
18	Studs made of steel would be straighter than wood studs, lighter in weight and would result in less waste due to no warpage.
19	Walls stay a lot straighter.
20	Straight studs.
21	Precision and eco friendly!
22	Unsure.
23	Straightness.
24	Very straight walls and pre-punched holes for electrical & plumbing. Also there is less waste with steel.
25	No twisting of studs, and the fire rating.
26	Don't know.
27	Perhaps there may be cost savings?
28	Save on wood product resources.
29	Your walls are going to be perfectly straight.
30	I don't know.
31	Material is true and straight and more environmentally friendly. A hard sale for the higher price not only to the builder but to the home owner.
32	Fire protection.
33	Insect resistance and good straight studs and walls (no bowed material).
34	Material costs, plumb / true walls, pre-punched holes.
35	Strait and easy to work with.

36	They are always true, don't bow or splinter.
37	I don't know.
38	None.
39	None.
40	Straighter, flatter walls, less change with temperatures during and after const. spans can easily be longer.
41	Fire protection.
42	Unknown.
43	Fire resistant, straight.
44	Usually there isn't any benefits just that the metal studs are straighter.
45	There always strait.
46	Have never used this before.
47	Straight construction possibly less waste.
48	Cost effective, light and simple and fast to install.
49	Stronger, no termites or termite damage.
50	Walls will be straighter and truer.
51	Don't use.
52	None.
53	Not much waste, price is consistent, steel is straight, can do more.
54	Save our planet, more practical.
55	Don't know.
56	Haven't used before.
57	Haven't looked into it.
58	Fire proof.
59	Never used steel studs.
60	Know nothing about steel.
61	Haven't worked with it.

62	Straightness
63	No experience.
64	I have never used steel before, but from what I can tell nothing.
65	Honestly don't know.
66	Fire safe. But everything on the outside still burns.
67	I really wouldn't know because I haven't personally used it, but it looks different.
68	I have used it before and find no benefits.
69	Most cost savings. Larger screws for sheet rock.
70	I think they are more easy to use. I don't have much exp. but from what I know, yes.
71	Never used before, but they look very unique.
72	Nothing in my opinion.
73	Haven't used it.
74	I personally think it's better to use because of cost and things you can do with it.
75	I have never used it.
76	I don't use it.

Field Summary for 65:

What are the drawbacks, if any, of using light gauge steel in framing assemblies for single-family homes in residential construction?

Answer	Count	Percentage
Answer	65	83.33%
No answer	13	16.67%

Answers

1	None.
2	Not as easy to retrofit changes.
3	Ability to use studs as backing for railings bath bars ex.
4	Cost.

5	Not many framers would know how to work with them.
6	Cost, lack of familiarity, need to revamp methods and tools.
7	Different set of tools.
8	None.
9	The know how to use the product efficient.
10	STEEL IS HARDER TO CUT AND SECURE, ESPECIALLY WHERE MOST SUBS ARE SET UP TO DEAL WITH WOOD. THE SCREWS USED TO SECURE METAL ALSO PROTRUDE BEYOND THE STUDS AND CREATE THICKER WALLS WHERE THEY ARE SET, ESSENTIALLY CREATING A BUMP IN THE SHEETROCK WALLS THAT CAN SOMETIMES BE A FACTOR.
11	More expensive.
12	Hard to find a draftsman familiar or framers that specialize in the light gauge steel.
13	r value and labor experience.
14	The price as well as possible heat or sound transfer.
15	More labor involved.
16	Price, new tools, harder to work with both for you and subs, and it's either to hot or to cool to the touch.
17	There is a limited work force that has the adequate knowledge to install steel. The building codes and inspectors are not up to speed on the new tech. of steel. Equipment used to install steel is not as readily available as that used on steel. In short, the steel stud industry has a ways to go before it will replace wood in the residential on site framing industry.
18	Cost used to be an issue, I'm not sure that is the case now. Most residential contractors are not set up to do metal framed houses. Residential Plumbers and Electricians have to also be set up to work with metal studs.
19	Subs aren't set up to use them. Don't have the right tools and don't know how to be efficient.

20	Light gauge says it all. Not as sound as lumber.
21	Unsure.
22	fastening sheeting etc.
23	Labor is not plentiful.
24	Many not familiar with steel system. Learning how everything else attaches to the system. Are they conductive to electricity?
25	Don't know.
26	Unknown.
27	Very cold material with no "R" Value.
28	I think the biggest drawback is that most home owners are not used to seeing this type of wall construction in single home dwellings. Tough sale.
29	I don't know.
30	Time, methods, mind set, limited on "custom" applications as mentioned above.
31	Requires tools not carried by most framers.
32	Harder to work with (for me), seemed to have more flex and less noise dampening in a finished wall (in my opinion from the one time I worked with them years ago), and I think they are more expensive.
33	Does not use conventional tools and fasteners making it difficult to hang doors, windows, sheeting, etc.
34	None.
35	Time, all trades must use screws.
36	I don't know.
37	Labor tools sub don't like them.
38	Unknown.
39	All wood attachments are more difficult: wood stairs, trusses, cabinets, wood floors, finish work, etc.
40	Cost.

41	Unknown.
42	None that I know of.
43	You can not tie them to the exterior wall very easily and it is harder for the crew to do the openings because they have to have wood in the openings.
44	Strength if needed.
45	Have never used this before.
46	Slower progress, possibly price depending on each market.
47	Transfers sound through the wall. Can't nail door jambs, casing, and base to it.
48	Less convenient than wood, not as much knowledge regarding steel.
49	Any interior load bearing partitions would need to be engineered to heavier gauge studs to carry.
50	Don't use.
51	Cost, doesn't bend well, heat and sound transference, more aggressive.
52	Cost.
53	Inexperience.
54	The cost.
55	From what I have heard, it's more difficult to use than wood.
56	Honestly don't know.
57	I can't think of any. Steel is straighter. I think it's probably better.
58	Again, I really wouldn't know much about it, so it's a hard thing to answer.
59	It's harder to work with and in my opinion, pointless to try.
60	Structural.
61	Not as good for the environment. More costly.
62	Don't know.
63	It's not eco friendly.
64	I don't think there is any.
65	Don't know.

	Field Summary for 66:		
	What do you do overcome drawbacks, if any, of using light gauge steel in for single-family homes in residential construction?		
	Answer	**Count**	**Percentage**
	Answer	61	78.21%
	No answer	17	21.79%
	Answers		
1	Extra support.		
2	Nothing.		
3	Install wood backing for support.		
4	Calc costs upfront and price finished construction accordingly.		
5	Only way I know of would be to start using them and then work through the problems as they arise.		
6	Don't use them.		
7	Suck it up and change.		
8	I don't.		
9	Just start using it in residential application.		
10	I JUST DEAL WITH THE CHALLENGES AS THEY COME. I HAVEN'T HAD TO MODIFY ANY WALLS YET BUT IT WOULD BE SOMEWHAT DIFFICULT IN A REMODEL SITUATION.		
11	None.		
12	I don't use them.		
13	The price.		
14	Training.		
15	I don't use it.		
16	Most of my work has been commercial where we used metal stud framing as a standard practice. In Las Vegas there was a complete residential subdivision that		

	metal studs were used on all walls, bearing and non-bearing. I still feel cost is an issue and that's the main drawback.
17	I don't do anything because I don't use them.
18	Unsure.
19	Modify my tooling.
20	Nothing for now.
21	Build with wood.
22	None.
23	Unknown.
24	Extra bracing and insulation.
25	It is always an easy fight when the Architect is supportive of the idea.
26	I don't use them
27	I don't use steel frame and don't intend to unless specifically designated by the home owner, architect.
28	If it were more common, more contractors would carry the tools.
29	I don't use it.
30	I don't use them.
31	I don't.
32	None.
33	I don't know.
34	I don't use them.
35	I don't use light gauge steel.
36	Volume--when doing a whole subdivision of houses that are identical few changes, overcome problems on the first few) then you might come out ahead of the conversion curve over to metal. (All trades hate tooling up for only a few jobs.)
37	Shop around.
38	Unknown.

39	There should be some educational classes given to the contractors about their uses and advantages.
40	We usually do not use light gauge steel in residential construction we use it in are commercial job.
41	Replace with wood.
42	Have not used this product before.
43	Not Used.
44	Wrap door opening with 2x4 .use finish screws for trim.
45	Research to find the benefits of using light gauge steel.
46	Won't work or be beneficial in all applications.
47	Bnll.
48	Don't use.
50	You can use different sound boards. Use foam. Double steel studs for flex.
51	Use wood.
52	Something different.
53	I don't use it.
54	Honestly don't know.
55	I have nothing to overcome because I don't use it.
56	Don't use it.
57	Technology. Use it more.
58	I don't use it much.
59	I would say using lumber instead.
60	I don't use it.
61	Don't get it.

Field Summary for 2:		
How many years have you been in the construction industry?		
Answer	**Count**	**Percentage**
No answer	0	0
0-5 years (r)	3	3.85%
6-10 years (r1)	9	11.54%
11-15 years (r2)	16	20.51%
16-20 years (r3)	10	12.82%
21+ years (r4)	40	51.28%

Field Summary for 1:		
How many years have you been a contractor?		
Answer	**Count**	**Percentage**
No answer	0	0
0-3 years (q)	9	11.54%
4-6 years (q1)	9	11.54%
7-10 years (q2)	11	14.10%
11-15 years (q3)	17	21.79%
16+ years (q4)	32	41.03%

Field Summary for 10:		
What formal education do you have? Please indicate your subject of study.		
Answer	**Count**	**Percentage**
No answer	2	2.56%
High School Diploma (301)	31	39.74%
Technical or Vocational School (302)	13	16.67%
2 Year Degree (303)	12	15.38%
4 Year Degree (304)	11	14.10%
Graduate Degree (305)	9	11.54%

Field Summary for 29:		
What work do you self perform?		
Answer	**Count**	**Percentage**
Excavation/Earthwork (130)	33	42.31%
Footings/Foundations (143)	42	53.85%
Flatwork (140)	35	44.87%
Framing (132)	56	71.79%
Electrical (133)	11	14.10%
Plumbing (141)	6	7.69%
HVAC (134)	2	2.56%
Drywall (146)	31	39.74%
Painting (150)	24	30.77%
Finish Trim (144)	46	58.97%
Roofing (135)	30	38.46%
Siding (136)	27	34.62%
Tile work (142)	24	30.77%

Flooring (137)	17	21.79%
Masonry (138)	10	12.82%
Communications/Home Entertainment Systems (139)	5	6.41%
Landscaping (145)	17	21.79%
Other (131)	19	24.36%

Field Summary for 33:		
How many single-family homes do you build per year?		
Answer	**Count**	**Percentage**
No answer	0	0
1-3 homes (p1)	45	57.69%
4-6 homes (p2)	14	17.95%
7-10 homes (p3)	7	8.97%
11-20 homes (p4)	5	6.41%
21+ homes (p5)	7	8.97%

Field Summary for 34:		
What is the average size (in square feet) of single-family homes you build?		
Answer	**Count**	**Percentage**
No answer	11	14.10%
less than 1500 (n1)	9	11.54%
1500 to 2000 (n2)	20	25.64%
2000 to 2500 (n3)	23	29.49%
2500 to 4000 (n4)	8	10.26%
greater than 4000 (n5)	7	8.97%

Field Summary for 37:	
Of the single-family homes that you construct, what percent are custom homes?	
Calculation	Null values are ignored in calculations Q1 and Q3 calculated using Minitab method
Count	
Sum	
Standard Deviation	
Average	
Minimum	
1st Quartile (Q1)	
2nd Quartile (Median)	
3rd Quartile (Q3)	
Maximum	

Field Summary for 5:		
Which of the following best describes you?		
Answer	**Count**	**Percentage**
Construction company owner (s)	68	87.18%
Work for a construction company that you don't have ownership in (s1)	8	10.26%
Not actively using your contractors license (s2)	5	6.41%

Field Summary for 11:		
How many employees work for your company?		
Answer	**Count**	**Percentage**
No answer	0	0
0-3 employees (t1)	53	67.95%
4-6 employees (t2)	11	14.10%
7-15 employees (t3)	6	7.69%
16-30 employees (t4)	2	2.56%
30+ employees (t5)	6	7.69%

Field Summary for 28:		
What is your business's gross revenue?		
Answer	**Count**	**Percentage**
No answer	0	0
less then $500,000 (u1)	42	53.85%
$500,001 to $1,000,000 (u2)	20	25.64%
$1,000,001 to $2,500,000 (u3)	4	5.13%
$2,500,001-$5,000,000 (u4)	6	7.69%
$5,000,000+ (u5)	6	7.69%