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Steel vs. Wood
Cost Comparison
Beaufort Demonstration Homes

January 2002

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Steel vs. Wood
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Prepared for

The U.S. Department of Housing and Urban Development
Office of Policy Development and Research
Washington, DC

North American Steel Framing Alliance (NASFA)
Washington, DC

and

National Association of Home Builders
Washington, DC

by

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Disclaimer

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ABOUT THE NAHB RESEARCH CENTER, INC.

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EXECUTIVE SUMMARY

Steel framing has been used for many years for interior non-load bearing and curtain walls in commercial construction. However, cold-formed steel members have only recently attracted attention for use in load bearing wall, floor, and roof framing applications in residential construction.

Despite the availability of cold-formed steel framing, there are still basic barriers that impede its adoption in the residential market. Probably the primary barrier is that the building industry is generally reluctant to adopt alternative building methods and materials unless they exhibit clear cost or quality advantages. A second barrier is how the thermal conductivity of steel affects energy use in homes. Given improvements in the technology over the past few years, it is not clear how steel compares with wood framing in terms of overall cost to the builder.

The scope of this project was limited to constructing two identical side-by-side homes at three different locations in the U.S. Each location had unique labor rates, material costs, size, shape and style of construction. The sites include Indiana, South Carolina, and North Dakota. Each site has a house framed with conventional dimensional lumber and a second one framed with cold-formed steel. Blower door tests are to be conducted for all demonstration homes to determine the levels of air infiltration for each house. Co-heat tests are also to be conducted at two sites (Valparaiso, Indiana and Fargo, North Dakota) to determine the energy consumption of each tested house.

A modified version of the Group–Timing Technique (GTT) was used to gather information for these houses. The GTT is a work measurement procedure for multiple activities that allows one observer using a stopwatch to make a detailed time study of an entire work crew at the same time. Continuous observations were made on a 15- minute interval and were recorded as tallies on a form that listed the elements of the job. Nonproductive time was also identified and removed from the totals to establish a normal time for each component of work. Time values were used to calculate the productivity of each of the houses for comparison.

This report is limited to the findings of the demonstration homes in Beaufort, South Carolina. Installed costs of the steel framing material were determined and compared with that of conventional wood framing. Results indicate that the cost of the demonstration steel-framed home is 14.2% more than an identical wood home, however, the framers' labor hours for the steel-framed home were only 4.3% higher than those of an identical wood home. The results also indicated that certain aspects of cold-formed steel (such as interior non-load bearing walls) are within the range that might be expected to be cost–effective with wood. An infiltration test was conducted for each home. Results indicated that both steel and wood-framed homes have approximately the same leakage (infiltration) rate.

When using the information in this report, extreme care should be taken in drawing comparisons with costs in a particular area, as local labor rates, availability of materials, and regional skill levels all influence a particular material's final cost. The unit costs developed in this report were based on the data obtained from a small sample. This information does not include nonproductive time, builder overhead or profit. Results do not reflect a definitive study but rather indicate whether builders should consider cold-formed steel framing when searching for solutions to lumber problems and concerns. The reader should also be careful when using the cost data shown in Appendix B for a specific activity, as the data provided may not be representative of the true cost for that specific activity in another project, location, or circumstances.

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1. INTRODUCTION

This report is the second of three reports of a multi–year study of cost and energy comparisons of steel and wood houses conducted for the U.S. Department of Housing and Urban Development (HUD), the North American Steel Framing Alliance (NASFA), and the National Association of Home Builders (NAHB). This study is conducted by the NAHB Research Center, Inc.

Steel framing has been used for many years for interior non-load bearing and curtain walls in commercial construction. However, cold-formed steel members are only recently attracting attention for use in load bearing wall, floor, and roof framing applications in residential construction.

Despite the availability of cold-formed steel framing, there are still basic barriers that impede its adoption in the residential market. Probably the largest barrier is that the building industry is generally reluctant to adopt alternative building methods and materials unless they exhibit clear cost or quality advantages. A second large barrier is the question of how the higher thermal conductivity of steel affects energy use in homes. Given improvements in the technology over the past few years, it is not clear how steel compares with wood framing in terms of overall cost for builders.

Little objective reporting exists comparing the total costs associated with framing with cold-formed steel versus conventional wood-frame homes. In addition, the labor component and impact of steel framing on other trades and systems in the home are particularly difficult to assess. This project helps address these concerns by:

- determining the in-place labor and material cost for components of nearly identical homes built with steel and wood framing;
- determining the impact of cold-formed steel framing on other trades; and,
- determining the short-term energy consumption for nearly identical wood and steel homes.

The scope of this project was limited to three sites. The three sites are located as follows:

- Valparaiso, Indiana;
- Beaufort, South Carolina; and,
- Fargo, North Dakota.

This report is limited to the findings of the demonstration homes in Beaufort, South Carolina.

2. OBJECTIVE

The purpose of this report was to compare the labor and material cost and energy performance (i.e., energy consumption) of steel-framed homes to those of nearly identical wood-framed homes. More specifically, the intent was to determine if the costs of steel-framed homes were "in the same ballpark" as wood-framed homes, realizing that local labor rates, material availability, and other factors will ultimately determine the cost in a specific area. None-the-less, results can be considered by builders when assessing the potential use of steel in their homes.

In order to assess the costs, an observer was sent to the job site where the materials were being used to frame the houses. The houses selected for observation are referred to in this report as the demonstration houses. To effectively make a comparison, both steel and wood houses were erected side-by-side in Beaufort, South Carolina. Framers, plumbers, and electricians were questioned in the field to provide input on the workability of each of the two materials and their practical applications. The in-place labor and material requirements and costs were monitored for both homes. Infiltration tests were also conducted to compare and contrast the tightness (leakage) of each house.

Each set of houses, to the extent possible, had nearly identical floor plan, dimensions, orientation, exposure, HVAC equipment. The demonstration homes were erected side-by-side.

3. COLLECTION OF LABOR HOURS

A modified version of the Group- Timing Technique (GTT) was used to gather information on each demonstration home. The GTT is a work measurement procedure for multiple activities that allows one observer using a stopwatch to make a detailed elemental time study on an entire work crew at the same time. Each activity performed at the job site was broken into components (e.g., floor framing, wall framing, and roofs), subcomponents (e.g., studs, headers, etc.), and tasks (e.g., measure, cut, brace, etc.) (see list of time and motion study categories for data collection in Appendix B). Continuous observations were made at fifteen-minute intervals and recorded as tallies on a form that listed the elements of the job. Nonproductive time (e.g., breaks, lunch, etc.) was identified and removed from the totals to establish a normal time for each component of work. The resulting numbers provided standard time values that were used to calculate the productivity of each of the two framing systems that were used for comparison. This technique was designed to simulate, as close as possible, a production setting and permits a comparison of the labor required to conduct a given task.

To the extent possible, all phases of construction that are directly or indirectly impacted by the framing materials were monitored and time and motion data were collected[1]. The data collection concentrated on the following components and subcomponents: Framing, Insulation, Sheathing, HVAC, Electrical, Plumbing, Drywall & Paint, Carpentry, Windows, Doors, Siding, Porch and Floor Covering.

[1] The cost of engineering, building permits, blueprints, rough and final stake, water lines, sewer lines, excavation, backfill, foundations, sand and stone, damp proofing, footing drains, structural steel (I-beam and lolly columns), interior concrete, interior and exterior lights, appliances, mirrors, monthly utility bills, general site cleanup, driveways, sidewalks, exterior concrete, landscaping, and interest on loan were not documented in this report.

4. SITE LOCATION

Beaufort, South Carolina: Habersham Development

Habersham is a new waterfront community located on the banks of the Broad River in northern Beaufort County, South Carolina, and sited on a 283 acres former antebellum plantation. The demonstration houses are built on lots 113 and 115 across the street from the Mum Grace Park in Phase I of the Habersham development. The front doors of both homes face northwest. The average annual maximum temperature in Beaufort is 101°F (38°C); the average annual minimum temperature is 13°F (-11°C)[2].

The address for each of the houses is as follows:

Steel House:	113 Grace Park Rd. Habersham, SC 29901	Wood House:	115 Grace Park Rd. Habersham, SC 29901
Builder:	Seaway Development Habersham Land Company	Steel Supplier:	Steel Framing Inc. Charleston SC.

The approximately 1,428-square-foot (133 m^2) homes were built with three bedrooms and two and a half baths over a crawl space (see Appendix A for plans). Both exterior and interior walls were built with conventional stick framing techniques.

Builder: Seaway Development: A builder that builds single-family homes, town-homes, and condominiums in South Carolina. Seaway Development offers the option of either steel or wood frame houses.

5. CHARACTERISTICS OF DEMONSTRATION HOMES

All framing elements in the wood and steel demonstration homes were fabricated of conventional lumber or cold-formed steel members using local common practices. All framing materials were shipped to each site where all floors, walls, headers, and roofs were constructed. A 2x6 treated wood sill plate was secured to the top of foundation walls for the wood house. One-half inch (12.7 mm) anchor bolts secured the sill plates to the top of foundation walls. The bottom track was secured directly to the top of the foundation of the steel house. The roofs were framed using ceiling joists and rafters, and sheathed with ½ inch (12.7 mm) nominal OSB, and covered with asphalt fiberglass roofing shingles over 15-pound felt underlayment. The walls, ceilings and crawl space floors were insulated with R-19, R-40 and R13 fiberglass batt insulation, respectively. Wood siding was applied over oriented-strand-board (OSB) sheathing for the exterior finish of both houses.

Steel Demonstration Home:

Wall studs were spaced at 24 inches (610 mm) on center with load bearing studs located directly in-line with roof rafters and floor joists in-line framing). All structural steel studs were 350S162-33 mil (0.84 mm) (2x4x33 mil) except studs under the main header and the stairs were 550S162-33. Non-structural steel studs were 350S162-27 (2x4x27 mil). All steel-framed members were designed

[2] ASHRAE 1997.

using the *Prescriptive Method for Residential Cold-Formed Steel-Framing*[3]. All steel studs were delivered pre-punched with holes spaced at 24 inches (610 mm) on center. All steel members were precut by the steel supplier to the lengths required by the builder[4]. Exterior walls were sheathed with 7/16 inch (11 mm) APA rated oriented-strand-board (fully sheathed walls). The front porch of the steel house was designed with a gable roof to provide a slightly different appearance of that of the wood house (flat roof).

Wood Demonstration Home:

Wall studs were spaced at 16 inches (406 mm) on-center with load bearing studs located directly in-line with roof rafters and floor joists. The 16-inches (406 mm) on center represent local practice in the Beaufort area for wood framing. All structural wood studs were 2x6 Spruce Pine Fir cut to length. Non-structural wood studs were 2x4 Spruce Pine Fir cut to length. Exterior walls were sheathed with 7/16 inch (11 mm) APA rated oriented-strand-board (fully sheathed walls). The front porch has a flat roof to provide a different architectural look than the steel house's porch.

The homes were marketed for between $180,000 and $200,000 depending on the options selected. Table 5.1 summarizes the characteristics and geometry of each of the demonstration homes built at the Beaufort site.

Table 5.1 – Characteristics of Each Beaufort Demonstration Home[1]

Characteristic	Steel House	Wood House
House Orientation	Front Door Faces Northwest	Front Door Faces Northwest
House Type	Colonial	Colonial
Number of Stories	2	2
Foundation Type	Crawl Space	Crawl Space
Roof Type	Steel Ceiling Joists and Rafters	Wood Ceiling Joists and Rafters
Roof Covering	Asphalt Fiberglass Shingles	Asphalt Fiberglass Shingles
Roof Pitch	9:12	9:12
House Width	22 ft.	22 ft.
House Length	34 ft.	34 ft.
1st Floor Wall Height	9 ft.	9 ft.
2nd Floor Wall Height	9 ft.	9 ft.
No. of Bedrooms	3	3
Front Porch Size	8 ft. x 21 ft.	8 ft. x 21 ft.
A/C Unit	Trane 16 RLA Compressor, 3-Ton	Trane 16 RLA Compressor, 3-Ton
Thermostat	Bryant Zone Perfect Plus	Bryant Zone Perfect Plus
Furnace	Trane 80% A.F.U.E. Gas Forced Air	Trane 80% A.F.U.E. Gas Forced Air

For SI: 1 ft. = 305 mm
[1] Refer to Appendix A for house dimensions.

[3] *Prescriptive Method for Residential Cold-Formed Steel Framing*, Second Edition. U.S. Department of Housing and Urban Development (HUD), Washington, DC. September 1997.
[4] It is not common practice for steel suppliers to deliver pre-cut (to length) steel members. Typically, steel studs come in lengths with 2-foot increments. The builder paid a cost premium to have the steel members cut to length. The builder's cost is used in the cost comparison.

6. TOOLS AND EQUIPMENTS

Common tools were used in the construction of both demonstration homes.

Screws for the steel-framed home were driven using variable speed screw guns, provided by Dewalt (Black and Decker), with a clutch to prevent operator-induced fastening problems such as overdriving. Pneumatic pin drivers were used to fasten wood sheathing to steel wall studs. A chop saw with an abrasive aluminum oxide blade was used to cut steel members including studs, joists, and tracks (when needed). A standard circular saw with an abrasive blade and hand-held power shears were also used to cut steel members. Other tools for the steel house were used such as drywall screw guns, vise clamps, metal hole puncher, tape measure, felt pencil, etc.

Common tools for the wood house were used such as: hammers, nail guns, air compressor, circular saw, drywall screw gun, tape measure, etc. Table 6.1 provides a list of tools and other equipment used in the construction of the two demonstration homes.

Table 6.1 – Tools and Equipment Used for the Beaufort Demonstration Homes

Component	Steel House		Wood House	
	Tools	Other Equipment	Tools	Other Equipment
Floor, Wall and Roof Framing	2 Screw Guns 2 Skill Saws	Air Compressor	2 Nail Guns 2 Skill Saws	Air Compressor
Roof Sheathing	2 Screw Guns Circular Saw	Air Compressor Table Saw Forklift	2 Nail Guns Circular Saw	Air Compressor Table Saw Forklift
Roof Covering	Circular Saw Power Nailer	Table Saw Air Comp. Miter Box	2 Nail Guns Carpenter Knife	Air Compressor
Stair Framing	Screw Gun Circular Saw	Air Compressor	Nail Gun Circular Saw	Air Compressor
Front Porch Framing	Nail Gun Screw Gun Circular Saw Jigsaw	Air Compressor	Nail Gun Circular Saw	Air Compressor
Windows and Doors	Hammer Nail Kicker Nails/Staples	None	Hammer Nail Kicker Nails/Staples	None
Stucco	Trowel Floater Scraper	Scaffolding	Trowel Floater Scraper	Scaffolding
Kitchen Cabinets/Counter top	Drill Jigsaw Clamps	None	Drill Jigsaw Clamps	None
Trim Carpentry Baseboard Trim	Power Mitre Box Sander Jigsaw Nail Gun Kicker	Air Compressor Table Saw	Power Mitre Box Sander Jigsaw Nail Gun Kicker	Air Compressor Table Saw

Table 6.1 – Tools and Equipment Used for the Beaufort Demonstration Homes (cont.)

Component	Steel House		Wood House	
	Tools	Other Equipment	Tools	Other Equipment
HVAC	Tin Snips Circular Saw Clips Staples/Gun	None	Tin Snips Circular Saw Clips Staples/Gun	None
Electrical	Circular Saw Drill Puncher	None	Circular Saw Drill Puncher	None
Plumbing	Circular Saw Puncher Drills Pipe Wrench Teflon Tape Pipe Dope	None	Circular Saw Puncher Drills Pipe Wrench Teflon Tape Pipe Dope	Bulldozer
Batt Insulation	Scalper Blower Hoses	Air Compressor	Scalper Blower Hoses	Air Compressor
Siding	4 Nail Guns Table Saw Power Mitre Box	Air Compressor	4 Nail Guns Table Saw Power Mitre Box	Air Compressor
Drywall Installation	Screw Gun Drywall saw Tape Joint Compound Sandpaper	None	Screw Gun Hammers Drywall saw Tape Joint Compound Sandpaper	None
Painting	Sprayer Brushes	Air Compressor	Sprayer Brushes	Air Compressor
Floor Covering	Kicker, N G Circular Saw Table Saw	Air Compressor	Kicker, N G Circular Saw Table Saw	Air Compressor
Fire Place Installation	Circular Saw Hammer Screw Gun	None	Circular Saw Hammer Nail Gun	None

7. HOUSE CONSTRUCTION

Table 7.1 provides a summary of framing details for each component of the two demonstration homes. Detailed floor plans are shown in Appendix A to this report.

Table 7.1 – Beaufort Demonstration Homes Framing Details

Component	Steel House	Wood House
Crawl Space	Concrete Masonry Units	Concrete Masonry Units
Floors	Cold-Formed Steel	Framing Lumber
Sill Plate/Bottom Track	350S162-33	2x12 Spruce Pine Fir
First Floor Joist Size & Spacing	TradeReady® 1200S200-68 @ 16" and 24" o.c.	2x12 Spruce Pine Fir @ 16" o.c.
Second Floor Joist Size & Spacing	TradeReady® 1200S200-68 @ 24"o.c.	2x12 Spruce Pine Fir @ 16" o.c.
Joist Fasteners	No. 10 x ¾" Hex Head Screws	16d Nails
Rim Joist	TradeReady® 1200T162-68	2x12 Spruce Pine Fir
Floor Sheathing	23/32" x 4'x8' T&G Plywood	23/32" x 4'x8' T&G Plywood
Sheathing Fasteners	No. 10 x 1-1/4" Hex Head Screws	8d Nails
Floor Headers	TradeReady® 1200S162-68	2x12 Spruce Pine Fir
First Floor Joist Insulation	R13 Fiberglass Batts	R13 Fiberglass Batts
Structural Walls	Cold-Formed Steel	Framing Lumber
Stud Size and Spacing	350S162-33 @ 24" o.c. 550S162-33 @ 24" o.c.	2x4, 2x6 & 2x8 Spruce Pine Fir @ 16" o.c.
Stud Fasteners	No. 8 x 1/2" Pan Head Screws	16d Nails
Top Plate/Track	350T162-33 550T162-33	2x4 Spruce Pine Fir 2x6 Spruce Pine Fir
Wall Sheathing	7/16"x4'x8' OSB (Huber)	7/16" x4'x8' OSB (Huber)
Sheathing Fasteners	ET&F Pins	8d Nails
Drywall Size	1/2"x4'x8'/12'	1/2"x4'x8'/12'
Drywall Fasteners	No. 6x1-1/4" Drywall Screws	No. 6x1-1/4" Drywall Screws
Siding Material	Wood Siding	Wood Siding
Wall Cavity Insulation Type	R19, Fiberglass Batts	R19, Fiberglass Batts
Non-Structural Walls	Cold-Formed Steel	Framing Lumber
Stud Size and Spacing	350S162-27 @ 24" o.c.	2x4 Spruce Pine Fir @ 16" o.c.
Stud Fasteners	No. 8 x 1/2" Pan Head Screws	16d Nails
Drywall Size and Fasteners	1/2"x4'x8'/12'/12' w/Drywall screws	1/2"x4'x8'/12' /12' w/Drywall screws
Ceiling Joists and Roof Rafters	Cold-Formed Steel	Framing Lumber
Joist Size and Spacing	550S162-43 @ 24"o.c.	2x8 Spruce Pine @ 16" o.c.
Joist Fasteners	No. 10 x 1-1/4" Hex Head Screws	16d Nails
Joist Top Sheathing	½" x 4'x8' T&G Plywood	½"x 4'x8' T&G Plywood
Drywall Size and Fastening	½"x4'x8'/12' w/Drywall screws	½"x4'x8'/12' w/Drywall screws
Rafter Size and Spacing	550S162-33 @ 24" o.c	2x8 Spruce Pine Fir @ 16" o.c.
Rafter Fasteners	No. 10 x 1-1/4" Hex Head Screws	16d Nails
Ridge Beam	Nested 800S162-43; 800T162-43	2x10 Spruce Pine Fir
Roof Sheathing	7/16"x4'x8' OSB	7/16" x4'x8' OSB
Roof Insulation Type and Thickness	R40 Cellulose, Blown in	R40 Cellulose, Blown in
Rafter Insulation	R30 Fiberglass Batts	R30 Fiberglass Batts

Table 7.1 – Beaufort Demonstration Homes Framing Details (cont.)

Component	Steel House	Wood House
Front Porch		
Bottom Floor Joists	2x8 Spruce Pine Fir @ 16" o.c.	2x8 Spruce Pine Fir @ 16" o.c.
Top Floor Joists	2x8 Spruce Pine Fir @ 16" o.c.	2x8 Spruce Pine Fir @ 16" o.c.
Ceiling Joists	800S162-43 @24" o.c.	None
Rafters	800S162-43 @ 24" o.c.	2x6 Spruce Pine Fir @ 16" o.c.
Roof Sheathing	7/16"x4'x8' OSB	7/16" x4'x8' OSB
Roof Covering	Fiberglass Roofing Shingles	Fiberglass Roofing Shingles
Miscellaneous		
Wall Headers	550S162-33, 1200S200-68, 1200S200-54, 1000S162-33	2x14 4-ply Main Header (First Floor)
Collar Ties	550S162-43	2x6 Spruce Pine Fir
Facia	33 mil Brake Shape	2x4 Spruce Pine Fir
House Wrap	9'x150' TYVEK Roll	9'x150' TYVEK Roll
Flashing Tape	6"x100' Roll, Self-Stick W/P Tape	6"x100' Roll, Self-Stick W/P Tape
Roof Covering	Fiberglass Roofing Shingles	Fiberglass Roofing Shingles

For SI: 1 ft. = 305 mm, 1 inch = 25.4 mm.

8. AIR LEAKAGE TESTS

Air Leakage Test (Blower Door Test)

Natural air infiltration into and out of a house is a critical component in a home's energy performance and durability. Air infiltration comprises a large portion of the overall heating and cooling load in a home.

Blower door testing is used to quantify how much fresh air enters a building with all exterior openings closed. The results of a blower door test indicate how leaky a house is, where the major sources of air leakage are located, and how the house compares to other homes of similar size and type.

Test Method

A blower door test is performed in accordance with ASTM E779[5]. The results of the blower door tests are shown in Section 13 of this report.

Results of blower door testing are presented in several ways, including Air Changes per Hour (ACH) value. An Air Change occurs when a building has its entire volume of air replaced with new air. The length of time required for this to take place is the infiltration rate of a building.

An ACH50 value is often used to relate a home's blower door results because the value is directly obtainable from the test and does not require any assumptions about the building's performance under natural (i.e. not under artificially elevated pressures) conditions. Results may also be presented in terms of airflow at a pressure differential of 50 Pascals, or CFM50.

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[5] ASTM E779-99 *Standard Test Method for Determining Air Leakage Rate by Fan Pressurization*. American Society for Testing and Materials, West Conshohocken PA.

Interpretation of blower door results usually involves a reference to some allowable leakage level. Many energy programs specify a maximum allowable ACH50 value. Others approximate a natural infiltration rate by dividing the ACH50 value by a factor that typically ranges from 17 – 20. These natural infiltration estimations are often criticized for being inaccurate. Other performance criteria may relate leakage to the square footage of the house, like CFM50 per square foot of living area.

9. FACTORS IMPACTING CONSTRUCTION AND COLLECTED DATA

It is important to address the factors that could have significant impact on the data collected. These factors include trained supervision, availability of skilled labor and stud size and spacing.

Trained Supervision

Construction on the steel house began with an experienced lead framer (steel supplier). This lead framer and his crew left shortly after the floor was framed. This caused some delays and nonproductive times in framing the rest of the house because the remaining crew was left without direct supervision for some time. This issue was not a factor at all in the construction of the wood house. Availability of trained supervision is an issue that must be considered when using an alternative material such as steel, as such, no adjustment factors will be used on the steel house.

Availability of Trained Labor

Experienced wood framers framed most of the steel home. The steel supplier (lead framer) brought his crew to train the wood framers. The training went on throughout the floor construction, but stopped after the steel framer and his crew pulled out. The wood framing crew on the other hand was relatively stable throughout the construction period. No adjustment factors for the steel house will be used here also, as lack of trained labor is another issue that must be considered when using an alternative material such as steel.

It is to be noted that the framing crew for both homes made several costly mistakes, especially in framing floor headers and the front porch. Furthermore, the framers installed an unnecessary (and time consuming) header in a non-load bearing wall in the first floor of the steel house. The header is needed for the wood house but not for the steel house. No adjustments will be made for this framing errors do happen.

Stud Size and Spacing

The wood house uses 2x4 exterior wood studs spaced at 16” (406 mm) on center while the steel house uses 350S162-33 (2x4x33) exterior steel studs spaced at 24” (610 mm) on center. Local practice in Beaufort is to place 2x4 wood studs at 16” (410 mm) on center. This is done because of the difficulty in drywall installation for 24” (610 mm) on center wood stud spacing and the need for stronger studs due to the location of the house in a high wind region (90 mph exposure C). The steel studs were selected from the *Prescriptive Method*, which specifies 350S162-33 (2x4x33) studs spaced at 24 in. on center for the specified design wind speed. Although the practice is to place wood studs at 16” (406 mm) on center, value engineering analysis could show that a 24” (610 mm) on center stud (wood) spacing can be structurally satisfactory. If engineering can show that wood studs can be placed at 24” on center, the difference could have a significant impact on the material cost of the steel house. The impact of the stud spacing will be addressed in the conclusion of this report. However, for this report, no adjustment factors will be used for these differences.

10. PRODUCTIVITY COMPARISONS

The two-story wood and steel demonstration homes were approximately 1,428 square-foot (133 m^2) each. Floor plans for the demonstration homes are shown in Appendix A. The Beaufort site presented several regional conditions that make steel framing a particularly attractive alternative:

- a fast growing area that is receptive to new and advanced technologies;
- a mild-semitropical climate with an average yearly temperature of 65°F (18 °C)
- abundant suppliers of steel framing materials in the region;
- steel framing is accepted by the local building officials;
- engineering is required for both steel- and wood-framed homes (high wind area). Although the Prescriptive Method was used in the design of the steel house, engineered drawings were still required similar to those of the wood house.
- local code does not require steel homes to have exterior foam sheathing. This provides a good candidate for long-term energy monitoring of both similar houses in a relatively warm climate.

Framing for both houses began in mid August 2000. The framing crews for both houses include: (see Table 10.1)

- a steel lead framer with experience of more than 10 years using cold-formed steel framing for residential construction. This framer acted as the initial trainer for the builder's crew. The framer also supplied the steel (for the demonstration home) that he purchased from another supplier,
- a steel framing crew who exclusively frame with steel, but previously framed with wood,
- trained (on steel) wood framers by the steel lead framer,
- two wood framers with combined experience of more than 24 years using conventional wood framing construction. The framers worked for the builder; and,
- a wood framing foreman who exclusively frames with wood.

A NAHB Research Center engineer monitored the construction process for both wood and steel homes from start to finish. The site engineer was present during every aspect of the construction process. A modified version of the group timing technique was used to document the time to build each of the two demonstration homes. The activity of each crewmember was recorded at 15-minute intervals. Data were collected and coded for each component of the house (walls, floors, roofs, etc.) and sub-component of the framing (studs, sheathing, etc.). Nonproductive time such as breaks or idle time was separated from productive time. Increases in time for personnel, fatigue, and delays were not added to productive time.

Table 10.1 – Crew Composition for Beaufort Demonstration Homes

Component	Steel House			Wood House		
	Carpenter/ Foreman	Helper	Laborer	Carpenter/ Foreman	Helper	Laborer
First Floor Framing	1	4	1	1	4	1
Second Floor Framing	1	5	1	1	5	1
First Floor Structural Walls	1	5	1	1	5	1
Second Floor Structural Walls	1	6	1	1	6	1
First Floor Non-Structural Walls	1	6	1	1	6	1
Second Floor Non-Structural Walls	1	7	1	1	5	1
Ceiling Joists Framing	1	5	1	1	5	1
Roof Rafters Framing	1	4	3	1	4	3
Roof Sheathing	1	2	-	1	2	-
Roof Covering	2	1	-	2	1	-
Stair Framing	1	2	-	1	2	-
Front Porch Framing	1	2	-	1	2	-
Windows and Doors	1	2	-	1	2	-
Stucco	1	1	-	1	1	-
Kitchen Cabinets/Countertop	1	1	-	1	1	-
Trim Carpentry	1	1	-	1	1	-
Baseboard Trim	1	1	-	1	1	-
HVAC	1	1	-	1	1	-
Electrical	1	1	-	1	1	-
Plumbing	1	4	-	1	4	-
Insulation	1	1	-	2	1	-
Siding	2	5	-	2	5	-
Drywall Installation	2	2	-	2	2	-
Painting	1	2	-	1	2	-
Floor Covering	1	1	-	1	1	-
Fire Place Installation	1	1	-	1	1	-

Summary of Data Collected

Appendix B contains a detailed breakdown by component and sub-component of the labor man-minutes from the time and motion study conducted at each site. Appendix C contains normalized labor man-minutes for each component of the house. The normalization was done based on the size (such as square footage of floor, walls, roofs, etc) for each of the framing components and based on the living area square footage for the subtrades. The normalization procedure assumed that all activities not involving the framing material should be the same (e.g., cutting OSB for the floor framing or installing furnace in the basement). This way, the activity that has a direct impact on the framing material or that is directly impacted by the framing material is identified. Appendix D contains detailed material take off and costs for each of the two houses.

Table 10.2 provides a list contractors and sub-contractors for each of the demonstration homes. Table 10.3 summarizes the dimensions of the different components for each of the demonstration homes as obtained (measured) from each site. Table 10.4 provides a detailed summary of the total man-hours for each component of each of the demonstration homes, based on the normalized man-minutes from Appendix C.

Table 10.5 provides a summary of fasteners cost (nails, screws, … etc) as paid by builder. Table 10.6 provides a summary of material and labor cost for each of the demonstration homes. The costs in Tables 10.5 and 10.6 were taken directly from the builder's invoices and budget reports. Table 10.7 normalizes the material costs shown in Table 10.5. Material costs that are not impacted by the framing material were set to be equal (such as fireplace, siding, plumbing, etc.)

Table 10.2 – Contractors for Beaufort Demonstration Homes

Component	Steel House	Wood House
Floors, Walls, and Roof Framing	Seaway Development	Seaway Development
Roofing	Admiral Roofing	Admiral Roofing
HVAC	Bootle Air	Bootle Air
Electrical	Foster Electrical, & Beever Services	Foster Electrical
Plumbing	Vic's Plumbing	Vic's Plumbing
Insulation	Advanced Insulation Company	Advanced Insulation Company
Siding	Maro Lack Siding Company	Maro Lack Siding Company
Drywall Installation	Unit Drywall	Unit Drywall
Trim Carpentry	The Carpentry	The Carpentry
Drywall Finishing	Unit Drywall	Unit Drywall
Painting	Singleton Paint Company	Singleton Paint Company
Windows and Doors	Seaway Development	Seaway Development
Kitchen Cabinets	Looper	Looper
Floor Covering	The Carpentry	The Carpentry
Front Porch Framing	Seaway Development	Seaway Development
Stucco	Quality Stucco	Quality Stucco
Stairs	Seaway Development	Seaway Development
Fire Place Installation	Seaway Development	Seaway Development

Table 10.3 - Dimensions of Beaufort Demonstration Homes

Component	Steel House	Wood House
Floor Area		
First floor	748 ft^2	748 ft^2
Second floor	680 ft^2	680 ft^2
Total Floor Area	1,428 ft^2	1,428 ft^2
Load-Bearing Walls (linear footage)		
First story load bearing walls	123 ft	167 ft
Second story load bearing walls	160 ft	166 ft.
Total load bearing walls	283 ft	333 ft
Load-Bearing Walls (square footage)		
First story load bearing walls	1107 ft^2	1503 ft^2
Second story load bearing walls	1440 ft^2	1494 ft^2
Total load bearing walls	2,547 ft^2	2,997 ft^2
Non-Load-Bearing Walls (linear footage)		
First story non-load bearing walls	108 ft	64 ft
Second story non-load bearing walls	85 ft	77 ft
Total non-load bearing walls	193 ft	141 ft
Non-Load-Bearing Walls (square footage)		
First story non-load bearing walls	972 ft^2	576 ft^2
Second story non-load bearing walls	765 ft^2	693 ft^2
Total load bearing walls	1,737 ft^2	1,269 ft^2
Roof Area		
Ceiling	748 ft^2	748 ft^2
Roof (surface area)	1060 ft^2	1060 ft^2
Porch Area		
Top and bottom porch	352 ft^2	352 ft^2
Porch roof (surface area)	176 ft^2	240 ft^2

For SI: 1 ft^2 = 0.093 m^2, 1 ft = 305 mm.

Table 10.4 – Normalized Labor Hours for Beaufort Demonstration Homes

Framing Component	**Total Labor Man-Hours (Hours)**	
	Steel House	**Wood House**
Floors[1]	80.50	74.00
First Floor Framing[1]	*31.00*	*26.75*
Second Floor Framing[1]	*49.50*	*47.25*
Structural Walls[1]	137.75	127.75
First Story Structural Walls	*83.75*	*78.25*
Second Story Structural Walls	*54.00*	*49.50*
Non-Structural Walls	41.00	43.00
First Story Non-Structural Walls	*14.75*	*16.25*
Second Story Non-Structural Walls	*26.25*	*26.75*
Roof[1]	96.25	95.00
Ceiling Joists	*28.50*	*26.25*
Rafters w/Decking	*67.75*	*68.75*
Front Porch Framing[2]	155.00	153.25
Stairs	24.75	24.50
Total Framing	**535.25**	**517.50**
Total Framing without Porch	***380.25***	***364.25***
HVAC	55.00	56.25
Electrical	58.50	53.50
Plumbing	56.75	55.50
Insulation	51.75	41.00
Siding	122.75	121.75
Drywall Installation, Finishing & Painting	173.75	177.00
Windows and Doors	39.25	39.25
Kitchen Cabinets	8.25	8.00
Baseboard Trim	112.00	111.50
Floor Covering	31.75	31.75
Roof Shingles	21.50	21.50
Fire Place Installation	9.50	9.50
Vinyl Facia	3.25	3.25
Apply Stucco	38.75	38.75
Install Felt Paper	5.00	5.00
Chimney Installation	41.50	41.50
Total Hours	**1364.50**	**1332.50**

[1] Hours include sheathing.
[2] The front porch for the steel house has a gable roof while the porch roof for the wood house is flat.

Table 10.5 – Fasteners Cost Paid by Builder

Fastener	Steel House	Wood House
AB-66 6x6 Adjustable Post Base	$35.07	-
LUS210-3 2x10 TRPL JST Hanger	$21.56	
LUS28-3 2x8x10 Joist Hanger	$18.60	
NUTS-Bolts Screws -Washers	$11.98	
NUTS-Bolts Screws -Washers	$11.98	
1 1/4" Self Drilling Screws	$11.20	
1" Self Drilling Screws	$10.10	
1/2" Self Drilling Screws	$11.20	
16D CC Sinker Nail 50 LB	$17.57	
8D GALV Common 5LB	$5.32	
BOX 2 1/2" Self Tapping Screw	$18.98	
BX 1 1/4" TEK Screw	$179.90	
BX 1 3/4" Paslode Coil Nail	$578.00	
N8DB 1LB 1-1/2" Hanger Nail	$14.95	
Self Tap DW Screw 5LB	$14.99	
No. 6x1-1/4" Drywall Screws	(1)	(1)
LuS28 2x8 & 2x10 Joist Hangers		$21.24
2x2 Square Washers, 1/8"		$13.00
Hanger Nails		$20.00
SIM TIE DOWN H-5 (TECOJR)		$36.00
Adhesive Const 29 oz PL 400		$41.88
16d Galvanized Common 50 lb.		$64.64
Nails 50# cc Sinkers 8d		$30.02
Nails 50# cc Sinkers 16d		$14.74
8d Galvanized Common 5 lb.		$5.32
Total	$961.40	$247.02

[1] Cost of drywall screws is included in the drywall material cost.

Table 10.6 – Total Material and Labor Cost Paid by Builder

Component/Trade	Total Material Cost from Builder's Invoices		Total Labor Cost from Builder's Invoices	
	Steel House	Wood House	Steel House	Wood House
Framing Materials	$ 9,618.26	$ 7,125.51	$ 15,892.69	$ 11,220.27
Fasteners	$ 961.40	$ 247.02	?	?
Exterior Trim	$ 7,992.33	$ 10,693.91	$ 10,151.08	$ 8,487.00
Interior Trim	$ 5,781.36	$ 3,313.91	$ 5,065.92	$ 4,410.31
Interior Doors	$ 815.30	$ 815.30	(1)	(1)
Exterior Doors/Windows	$ 10,209.41	$ 10,209.41	(1)	(1)
Plumbing	$ 7,500.00	$ 8,085.00	(1)	(1)
HVAC	$ 6,546.67	$ 6,547.62	(1)	(1)
Electrical	$ 4,992.36	$ 3,152.82	(1) (2)	(1)
Drywall	$ 5,238.84	$ 4,827.14	(1)	(1)
Roofing	$ 2,207.20	$ 1,921.25	(1)	(1)
Insulation	$ 2,542.00	$ 2,542.00	(1)	(1)
Siding	$ 2,097.36	$ 2,097.36	(1)	(1)
Stucco	$ 1,649.46	$ 1,489.30	(1)	(1)
Fireplace	$ 1,093.17	$ 1,080.73	(1)	(1)
Kitchen Cabinets & Counter Top	$ 5,640.92	$ 6,098.87	(1)	(1)
Painting	$ 10,521.01	$ 11,309.13	(1)	(1)
Floor Covering	$ 8,790.89	$ 7,515.83	$ 1,119.25	$ 1,119.25
Supervision	$ 3,249.58	$ 2,517.27	?	?
Total	**$97,447.52**	**91,589.38**	**$32,228.94**	**$25,236.83**

[1] Labor cost included in the material cost.

[2] The electrician cost appears higher because two different electricians were sued for the steel. No credit was given to the builder for the work that the first electrician had done.

Table 10.7 – Normalized Material and Actual Labor Cost Paid by Builder

Component/Trade	Total Material Cost from Builder's Invoices		Total Labor Cost from Builder's Invoices	
	Steel House	Wood House	Steel House	Wood House
Framing Materials	$ 9,618.26	$ 7,125.51	$ 15,892.69	$ 11,220.27
Fasteners	$ 961.40	$ 247.02	?	?
Exterior Trim	$ 10,693.91	$ 10,693.91	$ 10,151.08	$ 8,487.00
Interior Trim	$ 3,313.91	$ 3,313.91	$ 5,065.92	$ 4,410.31
Interior Doors	$ 815.30	$ 815.30	(1)	(1)
Exterior Doors/Windows	$ 10,209.41	$ 10,209.41	(1)	(1)
Plumbing	$ 7,500.00	$ 8,085.00	(1)	(1)
HVAC	$ 6,546.67	$ 6,547.62	(1)	(1)
Electrical	$ 4,992.36	$ 3,152.82	(1)	(1)
Drywall	$ 5,238.84	$ 4,827.14	(1)	(1)
Roofing	$ 1,921.25	$ 1,921.25	(1)	(1)
Insulation	$ 2,542.00	$ 2,542.00	(1)	(1)
Siding	$ 2,097.36	$ 2,097.36	(1)	(1)
Stucco	$ 1,489.30	$ 1,489.30	(1)	(1)
Fireplace	$ 1,080.73	$ 1,080.73	(1)	(1)
Kitchen Cabinets & Counter Top	$ 6,098.87	$ 6,098.87	(1)	(1)
Painting	$ 11,309.13	$ 11,309.13	(1)	(1)
Floor Covering	$ 7,515.83	$ 7,515.83	$ 1,119.25	$ 1,119.25
Supervision	$ 2,517.27	$ 2,517.27	-	-
Total	**$96,461.80**	**$91,537.06**	**$32,228.94**	**$25,236.83**

[1] Labor cost included in the material cost.

11. ANALYSIS OF DATA

Available house plans and framing plans are shown in Appendix A. Material invoices and builder's budget reports were used to allocate material and labor cost for each framing component.

Tables 11.1 and 11.2 summarize the total labor hours and material cost for each framing component of the steel and wood demonstration homes in Beaufort, respectively. Normalized labor hours (from Table 10.4) are used in these tables. Costs associated with framing only are included in these tables (e.g. roof shingles are independent of framing materials and thus are not included).

Tables 11.3 and 11.4 summarize normalized labor and material costs (from Tables 10.4 and 10.7) for the different trades (and subtrades) for each of the two demonstration homes. The material costs used in these tables were taken directly from builder's invoices. Hours per square foot for each of the trades are also tabulated in Tables 11.3 and 11.4

Tables 11.5 through 11.9 itemize the cost of each of the main framing components in the house (floors, walls, roof and stairs) using labor cost as paid by the builder and normalized labor hours as shown in Table 10.4. The tabulated costs include sheathing installation. Labor costs were taken from builder's invoices and allocated to each framing element based on the number of hours spent. The allocation is calculated based on the number of hours spent for each activity multiplied by the total labor cost paid by builder divided by the total labor hours spent as follows:

$$Labor\ Cost = \frac{\$15{,}893 x\ Hours/Activity}{380.25} \qquad \text{for the steel house}$$

$$Labor\ Cost = \frac{\$11{,}220\ x\ Hours\,/\,Activity}{364.25} \qquad \text{for the wood house}$$

Where the 380.25 and the 364.25 are the total labor hours for the steel and wood homes respectively. These hours include framing and sheathing (floors, walls, roof) and excludes the porch framing. The porch framing hours were excluded because of the dissimilarities between the steel and wood porches and the fact that the steel porch was framed for the most part with wood. These hours are obtained from Table 10.4.

Table 11.10 estimates the cost per square foot of floor area, roof area and wall area for the different trades. Normalized builder's costs were used.

Table 11.11 provides the total framing cost of each of the two houses. The framing cost includes material cost from Tables 11.1 and 11.2 (including fasteners) and labor cost for floors, walls, and roof from table 10.7 (without roof covering).

Table 11.12 shows the total cost of the framing and trades for each of the two demonstration homes. The cost includes materials and labor for framing, HVAC, electrical, plumbing, insulation, siding, drywall, painting, windows and doors, cabinets, trim carpentry, floor covering, and roof covering (from Tables 11.1, 11.2 and 11.10).

Fasteners cost were obtained from the builder's material invoices, which were provided and categorized by framing component.

Tool costs were not included in any of the tables. Tool costs vary based on the type of tools used. Furthermore, all framers (for wood and steel homes) had their tools with them. The builder supplied all necessary tools and did not have a separate line item for tools on his budget reports.

The steel demonstration home in Beaufort had several factors that could have impacted the total costs documented in this report. Some of these factors could have falsely showed the cost of steel-framed homes to be "in the same ballpark" as wood framed homes. These factors include:

1. Engineering costs were not included for both homes. The steel house was built in accordance with the Prescriptive Method (steel framing provisions are currently in the IRC[6] and the Prescriptive Method have been accepted by some jurisdictions). An approved wood house plan was used to build the wood demonstration home.
2. The builder supplied the framers with all necessary tools for both homes (tool costs were not included for both steel and wood homes).
3. The steel studs were framed at 24" (610 mm) on center while the wood studs were framed at 16" (406 mm) on center (refer to Section 14 of this report for impact of 24" (610 mm) versus 16" (406 mm) spacing). The wider stud spacing is one of the benefits that steel framing offers.

[6] International Residential Code for One- and Two-Family Dwellings, 2000 Edition. International Code Council. Falls Church, Virginia.

Table 11.1 – Normalized Framing Labor Hours and Material Cost of Beaufort Steel House

Framing Component	Labor Hours (Hrs.)	Material Cost ($)	Fastener Cost ($)	Total Material Cost ($)
First Floor[1]	31.00	$1,455.50	$160.65	$1,616.15
Second Floor[1]	49.50	$1,367.90	$160.00	$1,527.90
1st Story Structural Walls[1]	83.75	$1,746.50	$221.50	$1,968.00
2nd Story Structural Walls[1]	54.00	$1,590.00	$221.60	$1,811.60
1st Story Non-Structural Walls	14.75	$250.45	$46.75	$297.20
2nd Story Non-Structural Walls	26.25	$325.60	$45.50	$371.10
Ceiling Joists	28.50	$878.90	$24.10	$903.00
Rafters/Roof[1]	67.75	$1,623.41	$68.80	$1,692.21
Stairs	24.75	$380.00	12.50	$392.50
Totals	**380.25**	**$9,618.26**	**$961.40**	**$10,579.66**

[1] Material cost includes wood sheathing for floors, walls and roofs, excluding porch framing.

Table 11.2 – Normalized Framing Labor Hours and Material Cost of Beaufort Wood House

Framing Component	Labor Hours (Hrs.)	Material Cost ($)	Fastener Cost ($)	Total Material Cost ($)
First Floor[1]	26.75	$1,031.96	$40.00	$1,071.96
Second Floor[1]	47.25	$1,088.30	$36.00	$1,124.30
1st Story Structural Walls[1]	78.25	$1,556.78	$55.00	$1,611.78
2nd Story Structural Walls[1]	49.50	$1,077.49	$45.00	$1,122.49
1st Story Non-Structural Walls	16.25	$159.58	$9.00	$168.58
2nd Story Non-Structural Walls	26.75	$258.22	$9.00	$267.22
Ceiling Joists	26.25	$525.68	$14	$539.68
Rafters/Roof[1]	68.75	$1,047.50	$31.02	$1,078.52
Stairs	24.50	$380.00	8.00	$388.00
Totals	**364.25**	**$7,125.51**	**$247.02**	**$7,372.53**

[1] Material cost includes wood sheathing for floors, walls and roofs, excluding porch framing. Random Length Lumber index was $321 per 1000 board feet.

Table 11.3 – Trades Normalized Labor and Material Cost for Beaufort Steel House

Trade	Builder's Material Cost ($)	Labor Hours	Builder's Labor Cost ($)	Hours/ ft^2 of House[1]
HVAC	$6,547	55.00	(2)	0.039
Electrical	$4,992	58.50	(2)	0.041
Plumbing	$7,500	56.75	(2)	0.040
Insulation	$2,542	51.75	(2)	0.036
Siding (include stucco)	$3,587	161.50	(2)	0.113
Drywall Installation/Finish	$4,547	78.00	(2)	0.055
Exterior/Interior Paint	$11,309	85.75	(2)	0.060
Windows and Ext. Doors	$10,209	39.25	(2)	0.027
Kitchen Cabinets & Counter top	$5,641	8.25	(2)	0.006
Trim (interior and exterior)	$14,008	112.00	$15,217	0.078
Floor Covering	$7,516	31.75	$1,119	0.022
Roof Covering	$1,921	21.50	(2)	0.015
Total	**$80,319**	**760**	**$18,977**	**0.530**

For SI: 1 ft^2 = 0.093 m^2
[1] Hours per square foot of the living area (1,428 ft^2).
[2] Included in material cost.

Table 11.4 – Trades Normalized Labor and Material Cost for Beaufort Wood House[1]

Trade	Builder's Material Cost ($)	Labor Hours	Builder's Labor Cost ($)	Hours/ ft^2 of House[1]
HVAC	$6,548	56.25	(2)	0.039
Electrical	$3,153	53.50	(2)	0.037
Plumbing	$4,827	55.50	(2)	0.039
Insulation	$2,542	41.00	(2)	0.029
Siding (include stucco)	$3,587	160.50	(2)	0.112
Drywall Installation/Finish	$4,827	80.75	(2)	0.057
Exterior/Interior Paint	$11,309	96.25	(2)	0.067
Windows and Ext. Doors	$10,209	39.25	(2)	0.027
Kitchen Cabinets & counter top	$5,641	8.00	(2)	0.006
Trim (interior and exterior)	$14,008	111.50	$12,898	0.078
Floor Covering	$7,516	31.75	$1,119	0.022
Roof Covering	$1,921	21.50	(2)	0.015
Total	**$76,088**	**755.75**	**$14,017**	**0.528**

For SI: 1 ft^2 = 0.093 m^2
[1] Hours per square foot of the living area (1,428 ft^2).
[2] Includes material cost.

Table 11.5 – Total Floor Framing Cost

House	Floor Area (ft^2)	Material and Fastener Cost ($)	Total Hours (hours)	Labor Cost ($)	Material Cost per FT^2 of Floor Area ($\$/ft^2$)	Labor Cost per FT^2 of Floor Area ($\$/ft^2$)	Hours per FT^2 of Floor Area (hours/ft^2)	Total Cost per FT^2 of Floor Area ($\$/ft^2$)
Steel House	1,428	$3,144	80.50	$3,365	$2.20	$2.36	0.0564	$4.56
Wood House	1,428	$2,196	74.00	$2,279	$1.54	$1.60	0.0518	$3.14

Table 11.6 – Total Structural Walls Framing Cost

House	Wall Length (ft)	Material and Fastener Cost ($)	Total Hours (hours)	Labor Cost ($)	Material Cost per Foot of Wall Length ($/ft)	Labor Cost per Foot of Wall Length ($/ft)	Cost per Foot of Wall Length (hours/ft)	Total Cost per Foot of Wall Length ($/ft)
Steel House	283	$3,780	137.74	$5,757	$13.36	$20.34	0.49	$33.70
Wood House	333	$2,734	127.75	$3,935	$8.21	$11.82	0.38	$20.03

Table 11.7 – Total Non-Structural Walls Framing Cost

House	Wall Length (ft)	Material and Fastener Cost ($)	Total Hours (hours)	Labor Cost ($)	Material Cost/Foot of Wall Length ($/ft)	Labor Cost per Foot of Wall Length ($/ft)	Cost per Foot of Wall Length (hours/ft)	Total Cost per Foot of Wall Length ($/ft)
Steel House	193	$668	41.00	$1,714	$3.46	$8.88	0.21	$12.36
Wood House	141	$436	43.00	$1,325	$3.09	$9.40	0.30	$12.49

Table 11.8 – Total Roof Framing Cost

House	Floor Area (ft^2)	Material and Fastener Cost ($)	Total Hours (hours)	Labor Cost ($)	Material Cost/FT^2 of Roof Area ($\$/ft^2$)	Labor Cost per FT^2 of Roof Area ($\$/ft^2$)	Cost per FT^2 of Roof Area (hours/ft^2)	Total Cost per FT^2 of Roof Area ($\$/ft^2$)
Steel House	1,428	$2,595	96.25	$4,023	$1.82	$2.82	0.0674	$4.64
Wood House	1,428	$1,618	95.00	$2,926	$1.13	$2.05	0.0665	$3.18

Table 11.9 – Total Stairs Framing Cost

House	Floor Area (ft^2)	Material and Fastener Cost ($)	Total Hours (hours)	Labor Cost ($)	Material Cost/FT^2 of Floor Area ($\$/ft^2$)	Labor Cost per FT^2 of Roof Area ($\$/ft^2$)	Cost per FT^2 of Floor Area (hours/ft^2)	Total Cost per FT^2 of Floor Area ($\$/ft^2$)
Steel House	1,428	$392	24.75	$1,034	$0.27	$0.72	0.017	$0.99
Wood House	1,428	$388	24.50	$755	$0.27	$0.53	0.017	$0.80

Table 11.10 – Trades Costs[1]

Trade	STEEL HOUSE				WOOD HOUSE			
	Labor Cost ($)	Material Cost ($)	Total Cost ($)	Cost/FT^2 of House ($/ft^2)	Labor Cost ($)	Material Cost ($)	Total Cost ($)	Cost/FT^2 of House ($/ft^2)
HVAC	(2)	$6,547	$6,547	$4.58	(2)	$6,548	$6,548	$4.59
Electrical	(2)	$4,992	$4,992	$3.50	(2)	$3,153	$3,153	$2.21
Plumbing	(2)	$7,500	$7,500	$5.25	(2)	$4,827	$4,827	$3.38
Insulation	(2)	$2,542	$2,542	$1.78	(2)	$2,542	$2,542	$1.78
Siding and stucco	(2)	$3,587	$3,587	$2.51	(2)	$3,587	$3,587	$2.51
Drywall Installation/Finish	(2)	$4,547	$4,547	$3.18	(2)	$4,827	$4,827	$3.38
Exterior/Interior Paint	(2)	$11,309	$11,309	$7.92	(2)	$11,309	$11,309	$7.92
Windows and Ext. Doors	(2)	$10,209	$10,209	$7.15	(2)	$10,209	$10,209	$7.15
Kitchen Cabinets & Counter top	(2)	$5,641	$5,641	$3.95	(2)	$5,641	$5,641	$3.95
Trim (interior & exterior)	$15,217	$14,008	$29,225	$20.47	$12,898	$14,008	$26,906	$18.84
Floor Covering	$1,119	$7,516	$8,635	$6.05	$1,119	$7,516	$8635	$6.05
Roof Covering	(2)	$1,921	$1,921	$1.35	(2)	$1,921	$1,921	$1.35
Total	**$16,336**	**$80,319**	**$96,655**	**$67.69**	**$14,017**	**$76,088**	**$90,105**	**$63.10**

For SI: 1 ft^2 = 0.093 m^2

[1] Costs are shown per square foot of living area (1,428 ft^2)

[2] Included in material cost. The builder did not provide separate cost data for labor and material.

Table 11.11 – Total Framing Cost [1]

House	Total Living Area (ft^2)	Material Cost ($)	Builder's Labor Cost ($)	Builder's Total Cost ($)	Total Cost/FT^2 of Living Area ($/ft^2)	Total Hours/FT^2 of Living Area (Hr/ft^2)
Steel House	1,428	$10,580	$15,893	$26,473	$18.54	0.266
Wood House	1,428	$7,372	$11,220	$18,592	$13.02	0.255

For SI: 1 ft^2 = 0.093 m^2

[1] Includes framing materials, sheathing and fasteners (excludes porch).

Table 11.12 – Total Framing and Trades Cost [1]

House	Total Living Area (ft^2)	Material Cost ($)	Builder's Labor Cost ($)	Builder's Total Cost ($)	Total Cost/FT^2 of Living Area ($/ft^2)	Total Hours/FT^2 of Living Area (Hr/ft^2)
Steel House	1,428	$63,014	$32,229	$95,243	$66.70	0.696
Wood House	1,428	$58,141	$25,237	$83,378	$58.39	0.674

For SI: 1 ft^2 = 0.093 m^2

[1] Includes framing materials, fasteners, HVAC, Electrical, Plumbing, Insulation, Siding, Drywall, Kitchen Cabinetry, Roofing and interior trim (excludes porch).

12. AIR LEAKAGE TEST COMPARISON

The blower door test was performed on the wood and steel houses in Beaufort, South Carolina on April 4, 2001. The results are summarized in Table 12.1 below:

Table 12.1 – Summary of Blower Door Tests

Measurement	Steel House	Wood House
Blower Door – ACH50	7.47	7.21
Estimated Natural ACH	0.35	0.34
Estimated Leakage Area-ELA (in^2)	107.19	101.66

For SI: 1 CFM = 0.0283 m^3/minute, 1 in^2 = 645 mm^2.

The blower door results are virtually identical for the two houses, as the difference between the two is only 3.6%. Neither of the two houses are considered very tight by today's construction standard (when compared to a general database of building tightness measurements.) The similarity of the results may indicate that the leakage is originating from common details like the rim joists, windows, plumbing/electrical penetrations, recessed lights, and attic hatches.

13. CONCLUSION

This report provides a description of each demonstration home, a description of the framing components, list of materials, productivity and unit cost comparisons and short-term energy comparisons. Engineering costs were not included in this report as these costs typically vary depending on who provides the service. Co-heat test results are also not included in this report as the tests are not conducted yet.

Cost Comparison

The cost data indicate that the costs of certain framing components of steel-framed-homes (such as interior non-load bearing walls) are comparable with those framed with wood. However, using the builder's costs, a steel-framed home cost is shown to be 14.2% higher than the cost of a nearly identical wood-framed home (refer to Table 11.12). The steel-framing package cost (framing labor and material) is 42.4% higher than that of a wood-framing package (refer to Table 11.11). The total framing time (labor hours) for the steel house was 4.3% higher than that for a nearly identical wood house; the framing material cost for the steel house was 43.5% higher (refer to Table 11.11). The lumber for the wood house was purchased in August 2000 when the Random Length lumber index was at $321 per 1000 board feet[7] and the CME futures price index was at $300.1[8]

It should be noted that the differences in the framing method (such as 16" (406 mm) on center for wood vs. 24" (610 mm)) on center for steel) could have a significant impact on the total cost and could potentially put the steel-framed home at a higher cost disadvantage. In fact the structural walls could cost an additional 1.6% (of the framing package) if the steel labor and material costs were adjusted for the stud spacing[9]. However, the wall framing spacing in the two homes is representative of the standard construction practice for each material and the inherent perception of the structural superiority of steel framing.

[7] Random Lengths. January 7, 2000.
[8] Chicago Mercantile Exchange. January 7, 2000.
[9] Approximately an additional $430 ($180 in material and $250 in labor).

The cost impact on trades and sub trades, due to steel framing, does not appear to be significant. In fact, for certain trades, the difference in cost between wood and steel-framed homes was negligible, while for others the cost differential was favorable to steel. The trades cost (labor and material) for the steel house were 7.3% higher than those for the identical wood house ($96,655 for the steel house and $90,105 for the wood house from Table 11.2).

The higher cost of the steel house is attributed to three reasons:

1. Inexperienced framing crew was used in framing the steel house. As the crew becomes familiar with steel framing the steel's framing cost is expected to go down.
2. The steel supplier charged a higher amount for the steel package. The cost of a similar steel package from alternative suppliers would have been approximately 25% less than what the builder had paid. If the builder shopped around and obtained a more reasonable cost for the steel package, the cost of the steel-framed house would have been lower.
3. The first electrical contractor for the steel house was replaced with another one after he pulled the wires throughout the house. The new contractor charged the builder as if nothing was previously done. The builder ended up paying almost double the cost of an electrician. If the problem with the electrical contractor did not exist, the cost of the trades would have been similar for both houses (steel and wood)

When using the information in this report, extreme care should be taken in drawing comparisons with costs in a particular area, as local labor rates, availability of materials, and regional skill levels all influence a particular material's final cost. The unit costs developed in this report were based on the data obtained from a small sample. This information does not include nonproductive time, builder overhead or profit. Results do not reflect a definitive study but rather indicate whether builders should consider cold-formed steel framing when searching for solutions to lumber problems and concerns. The reader should also be careful when using the cost data shown in Appendix B for a specific activity, as the data provided may not be representative of the true cost for that specific activity in another project, location, or circumstances.

Blower Door Test

Blower door (infiltration) tests concluded that both steel-framed and wood-framed homes have approximately the same leakage rate.

This report is the second of three reports that will be summarized and compiled into one comprehensive report at the end of the program. The final report will average the labor and material costs from the three sites to provide a more accurate cost comparison for steel and wood-framed homes.