FINAL REPORT

HOUSING AFFORDABILITY THROUGH DESIGN EFFICIENCY PROGRAM

The State-of-the-Art of Building Codes and Engineering Methods for Single-Family Detached Homes:

An Evaluation of Design Issues and Construction Costs

Prepared for

The National Association of Home Builders
Housing Affordability Through Design Efficiency
Subcommittee
of the Construction & Codes Committee
Washington, DC

and

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

by

NAHB Research Center, Inc.
Upper Marlboro, MD

June 2, 1997

NAHB RESEARCH CENTER

FINAL REPORT

HOUSING AFFORDABILITY THROUGH DESIGN EFFICIENCY PROGRAM

The State-of-the-Art of Building Codes and Engineering Methods
for Single-Family Detached Homes:

An Evaluation of Design Issues and Construction Costs

Prepared for

The National Association of Home Builders
Housing Affordability Through Design Efficiency Subcommittee
of the Construction & Codes Committee
Washington, DC

and

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

by

NAHB Research Center, Inc.
Upper Marlboro, MD

June 2, 1997

ACKNOWLEDGMENTS

The completion of this work was made possible by the joint sponsorship of the U.S. Department of Housing and Urban Development (HUD) and the National Association of Home Builders (NAHB). Special appreciation is extended to William Freeborne of HUD's Office of Policy Development and Research and to the builders serving on the Housing Affordability Through Design Efficiency subcommittee of NAHB's Construction and Codes Committee.

The NAHB Research Center staff contributing to the work embodied in this document include Kevin Bielat, Shawn McKee, Jay Crandell, P.E., and Don Carr.

EXECUTIVE SUMMARY

This study provides an assessment of the design, construction, and economic implications of existing model building codes and standards when applied to both simple and complex wood-frame homes over a range of design conditions and applications. Two basic approaches to the construction of a home are considered: prescriptive and engineered. By far the most common (and economical) approach has been to construct homes following relatively simple prescriptive provisions based in part on past experience and also on technical knowledge. However, in certain regions threatened by natural hazards such as hurricanes and earthquakes, the use of engineering analysis to determine home designs has been increasing. While each approach is a functional method of designing and constructing homes, these approaches are known to arrive at different solutions for the same home in the same design conditions. These solutions may also result in significant cost differences. The purpose of this report is to investigate these differences and to indicate areas where future work may serve to reconcile this less than ideal situation.

The prescriptive and engineered approaches embodied in the major model building codes and standards in the U.S. were evaluated with a particular focus on wind- and seismic-related issues. The design and cost analyses were conducted using four single-family detached homes representative of current construction practices and market preferences. A total of 42 code applications, design analyses, and construction cost evaluations were performed.

It is extremely difficult to generalize the findings of this study and the reader is cautioned regarding this concern since certain conclusions can be easily taken out of context. The intent of this study is not to compare absolute costs of codes, but rather to establish a "state-of-the-art" evaluation of building codes and engineering standards affecting the balance of safety, affordability, durability and resource utilization in current residential construction. This baseline of current practice may then provide a relative "measuring stick" and methodology by which future improvements to building codes and engineering standards can be systematically evaluated With this understanding, the following conclusions are based on the findings of this research:

The following conclusions can be drawn from this study:

1. There are notable variations among the engineering and prescriptive design approaches found in current building codes and standards.

2. The prescriptive code approaches demonstrate trends in construction requirements that are in conflict with current engineering knowledge, particularly in the high wind regions. Thus, the level of performance can be expected to be inconsistent across the varying design conditions found in the U.S.

3. The engineered approaches appear relatively conservative, erring toward unnecessary cost impacts; however, the trends in design condition verses design solution appear logical.

4. Wind exposure conditions for both the prescriptive or engineered design approaches are extremely important in determining wind loads to cost-effectively design safe homes.

5. Shear loads resulting from seismic design are low compared to wind loads on one- and two-story light-frame residential structures because of their low mass.

6. A rational method for engineering of conventional residential construction does not exist. Even with a significant increase in engineering knowledge related to homes, judgment will continue to be a necessary code-development factor.

7. The Wood Frame Construction Manual (WFCM) appears to embody the most economical, engineering-based prescriptive construction requirements for residential construction in high wind conditions.

TABLE OF CONTENTS

INTRODUCTION

This study assesses the design, construction, and economic implications of existing building codes and engineering standards that are applied through regulatory processes to residential construction. The intent is not to compare absolute costs of codes, but rather to establish a "state-of-the-art" evaluation of building codes and engineering standards affecting the balance of safety and affordability in current residential construction. This baseline of current practice also provides a "measuring stick" and methodology by which future improvements to building codes and engineering standards can be evaluated. The regulatory approaches investigated include both prescriptive and engineering requirements for residential design and construction. The scope of this study is limited to single-family detached wood-frame construction, but the contents are relevant to other forms of light-frame construction as well.

This report begins with a background section to place the report in its intended context. A section follows to describe the analytical approach. Next, results from the evaluation of various prescriptive and engineered approaches recognized in current U.S. building codes and engineering standards are presented for two "generic" types of homes in a *baseline study* and for two actual home plans in a *case study*. Local code variations are anecdotally addressed to supplement the case study analyses. In each case the homes are evaluated with respect to the code requirements, construction or design impacts, and construction costs of select elements of the four study home types. The report closes with conclusions summarizing the major findings and recommendations for future work.

BACKGROUND

New Challenges for Conventional Construction

Regulation of residential construction has depended largely on prescriptive requirements recognized in building codes as "conventional" construction. Conventional wood-frame construction may have taken form in the early 1930s when lumber products and their usage were standardized to promote consistent practices that provide for a "serviceable and safe" home [1]. Through time, materials and methods have changed as well as consumer preferences in housing styles. Coupled with a growing concern for natural hazards and the desire for a single national code, the perception of a serviceable home is in a state of change. This change in perception is driven by uncertainty with respect to conventional construction's capability to provide consistent and satisfactory performance in the context of modern housing styles, particularly in natural hazards such as hurricanes and earthquakes.

Recent regulatory and industry-sponsored activities in the U.S. have endorsed or implemented the adoption of engineering-based requirements for residential construction, particularly in areas prone to hurricanes. Likewise, similar activities have been ongoing in regions with high seismicity. While these efforts are motivated with good intention, engineering methods for residential construction have not been refined such that optimized solutions can be achieved from a strict "code-approved" engineering approach. In recent years, proposed and approved changes to building codes, engineering standards, and other regulatory instruments used at the local and national level, have developed at an accelerated rate. This level of regulatory activity has affected, and will continue to affect, a delicate balance between the competing needs of safety and affordability in residential construction.

Positions supporting safer homes are relatively easy to defend since the goal of improved safety or serviceability is a universal desire (particularly when separated from first cost and social impacts related to housing affordability). Conversely, positions supporting affordable construction requirements (i.e. those that appear less "safe") are difficult to defend without significant technical proof to support arguments based frequently on experience alone. In short, conventional construction needs to be rigorously substantiated (or questioned) and engineering methods used as measures of expected performance need to be made more accurate when applied to homes.

While this study has not attempted a rational cost-benefit analysis, it is known that increasing the cost of a home by $1,000 will prevent approximately 480,000 potential home buyers from qualifying for a mortgage for a home (based on a median priced home of $100,000). Furthermore, that $1,000 increase will stop 20,000 of these potential home buyers from purchasing any home at all [2]. While building a safe home is of utmost importance, affordable construction is also a critical goal which promotes home ownership and the avoidance of potentially less safe housing options. At the time this report was written, the authors were unaware of any cost-benefit studies that have included this component as a quantifiable economic parameter. Of course, there are many other issues and interests influencing the decisions related to housing construction regulation and these must also be fairly considered.

The Housing Affordability Through Design Efficiency Program

To support an approach of optimizing safety and affordability in modern homes, the National Association of Home Builders has initiated a program entitled *Housing Affordability Through Design Efficiency* (HATDE). The program is co-sponsored by the U.S. Department of Housing and Urban Development with significant co-funding from additional sources. The objective of this program is to promote a process of cost-effective code development that relies on efficient engineering methods for analyzing residential construction based on a sound technical understanding of conventionally constructed homes. The agenda includes research tasks to accurately define the performance of housing and to improve the engineering methods, including structural resistance and building load issues.

To achieve this goal, a comprehensive research agenda has been developed with significant input from construction industry, government, insurance, and academic interest groups, among others. The research agenda is in a continual process of review through communication with a broad-based "research coordination group" established under the specific sponsorship of the U.S. Department of Housing and Urban Development.

The issue of housing safety and affordability cuts across the core of the U.S. economy and society. Many entities and issues are involved, including real estate, insurance, mortgage finance, materials producers, trade organizations, consumers or homebuyers, utilization of natural resources, and many others. For this reason, the HATDE program seeks the support of co-funding partnerships with those that share a commitment to safe and affordable homes.

APPROACH

Overview

The approach followed by this study in defining a baseline of current practice for residential construction is comprehensive, but not exhaustive. Foremost, the two available building code compliance pathways for the construction of homes are investigated: prescriptive and engineered. These two regulatory compliance pathways are evaluated by two analytical approaches.

The first approach evaluates two generic homes using current codes and standards in the U.S. Compliant designs are formulated for three representative categories of design conditions defined by wind, earthquake, and snow loads. A total of 34 design and cost evaluations result from the application of eight engineered or prescriptive approaches found in the major model building codes, including one prescriptive method for high wind conditions [3][4][5][6][7][8][9][10].

The second approach utilizes two actual home plans that represent typical new residential construction with respect to architectural features and size. Compliant designs are determined for high wind and high seismic design conditions in the U.S. Local code modifications or interpretations are also investigated to the greatest extent possible. A total of 8 design and cost evaluations are performed.

In each approach, a compliant design is determined for select features of the study home for each combination of compliance pathway, subject code, and design condition. The compliant designs are then analyzed to determine construction costs related to the select features.

Baseline Studies

The basic construction characteristics of two generic homes were established for the purpose of this study using the *Builder Practices Database* [11]. Table 1 summarizes the major characteristics for the two homes. Figures 1 and 2 show the elevations of these two homes. The generic homes are representative of typical construction characteristics (i.e. roof slope, square footage, etc.) for new affordable-type homes with a simple rectangular building footprint. Design impacts caused by architectural variation, such as complexity of the floor plan and variations in the amount of fenestration, are not considered in the generic homes.

TABLE 1
Characteristics of the Two Generic Study Homes

Characteristics	One-Story House	Two-Story House
Type	Wood Frame	Wood Frame
Size	28x40 (1120sq. ft.)	28x40 (2240sq. ft.)
Height	One-story	Two-story
Roof	6:12 slope, Gable, Trusses 24"oc, or 16" o.c rafters and ceiling joists, 1 ft. overhang	8:12 slope, Gable, Trusses 24"oc, or 16" o.c. rafters and ceiling joists, 1 ft. overhang
Wall	8 ft height, studs at 16"oc	8 ft height, studs at 16"oc
Floor	NA	Wood Joists (second floor)
Foundation	Slab-on-grade	Slab-on-Grade

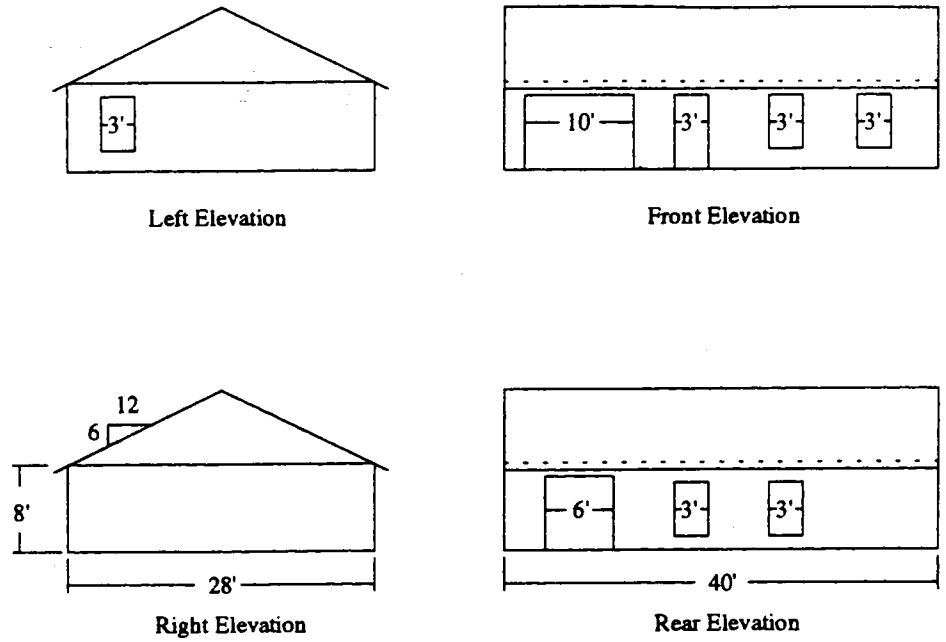


FIGURE 1. Generic one-story home elevations for baseline study.

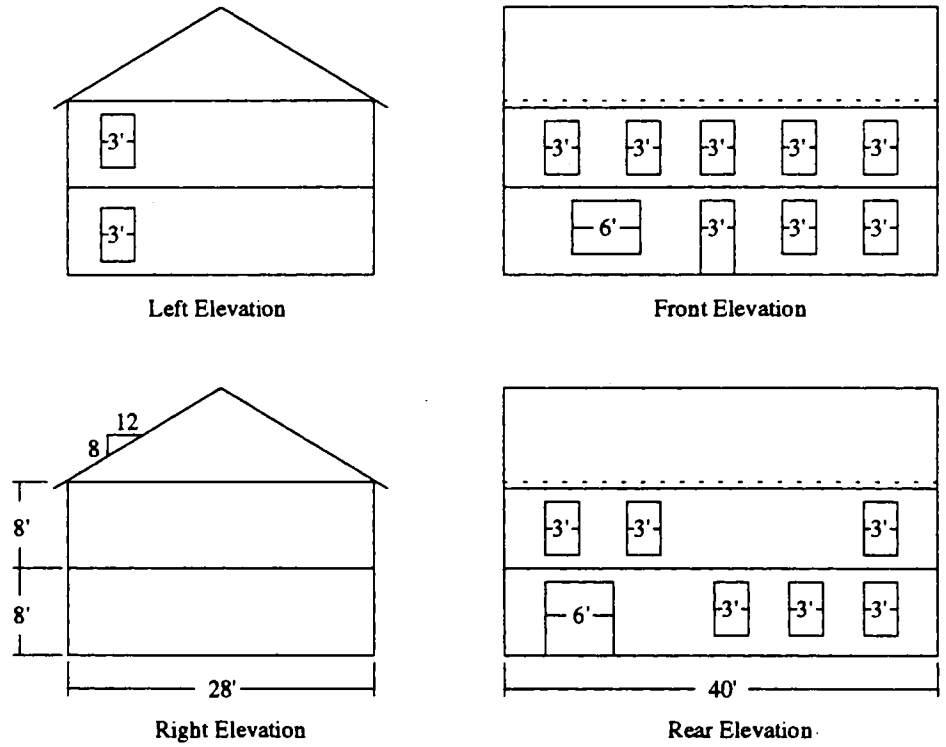


FIGURE 2. Generic two-story home elevations for baseline study.

For each of the generic homes, three representative site conditions bracketing typical combinations of wind, seismic, and snow loads were pre-determined for the study as shown in Table 2. The select features analyzed on each generic home (a one- and two-story) are as indicated in Table 3. A matrix providing an overall view of the evaluations performed is shown in Table 4. For the prescriptive and engineered analyses, a compliant design was first determined followed by a construction cost analysis for the selected features. The detailed analysis data are provided in Appendix A.

TABLE 2

Design Categories for the Generic Home Evaluations

Load Type	Design Categories by Load Conditions		
	High Wind (HW/LS)	**Moderate (MOD)**	**High Seismic (HS/LW)**
Wind[1]	127 mph-3sg 100 mph-fm (exposure C)	90mph-3sg 75mph-fm (exposure C)	85 mph-3sg 70 mph-fm (exposure C)
Seismic[2]	A_a = 0.1g Zone 1	A_a = 0.2g Zone 2	A_a = 0.4g Zone 4
Snow[3]	20 psf	30 psf	30 psf

Notes:

1. Wind speeds (mph) are reported in both 3-second gust units and in fastest-mile units to accommodate variation in wind measurements used in existing codes and standards. The conversion is purely based on measurement duration effects caused by the gustiness of wind using the 'Krayer and Marshall' curve for hurricane type winds and the 'Durst' curve for lower magnitude winds[8]. Exposure C (open terrain) site conditions are used for all evaluations. Exposure B (suburban/wooded) vs. Exposure C impacts are evaluated for select high wind conditions.

2. Seismic or earthquake loads are reported as effective peak ground accelerations which are also related to 'Zones' defined in some current building codes.

3. Snow loads are given as ground snow loads without adjustment to reflect a design roof snow load.

TABLE 3

Selected Construction Features and Design Issues for the Generic Home Evaluations

ROOF	WALL	FLOORS	FOUNDATIONS
Framing Sheathing Roof Uplift Roofing	Studs Wall Bracing Holddowns Headers Opening Protection Uplift from Roof	2nd Floor Joists 2nd Floor Sheathing	Anchors

TABLE 4

Building Codes and Standards Evaluation Matrix for Baseline Study

	Prescriptive Code Approach				Engineered Approach				
Building Type and Design Conditions	CABO-95	SBCCI-94 (Chapt 23)	BOCA-96 (Sect. 2305)	ICBO-94 (Sect. 2326 & appendix Ch. 23 for wind >80)	SBCCI-94Ch. 16 for Loads & NDS-91 for Resistance	BOCA-96 Ch. 16 for Loads & NDS-91 for Resistance	ICBO-94 Ch. 16 for Loads & Ch. 23 (Div I & III) for Resistance	ASCE 7-95 Loads with NDS-91 for Resistance	WFCM SBC (Alt. SBC Approach for High Wind) (90mph-fm)
1 Story HS/LW	X	X	see CABO	X	N/A	see ASCE 7 w/ NDS-91	X	X	N/A
1 Story, mod.	X	X	see CABO	X	X	see ASCE 7 w/ NDS-91	N/A[1]	X	N/A
1 Story, HW/LS	X	X	see CABO	X	X	see ASCE 7 w/ NDS-91	N/A[1]	X	X
2 Story, HS/LW	X	X	see CABO	X	N/A	see ASCE 7 w/ NDS-91	X	X	N/A
2 Story, mod.	X	X	see CABO	X	X	see ASCE 7 w/ NDS-91	N/A[1]	X	N/A
2 Story, HW/LS	X	X	see CABO	X	X	see ASCE 7 w/ NDS-91	N/A[1]	X	X

NOTES:

X = code/engineering and cost analysis done

N/A = cost and engineering analyses were deemed not applicable based on current regionality of building codes.

[1]This condition is similar to that of the ASCE 7-95 and NDS-91 analysis (adjacent column in table)

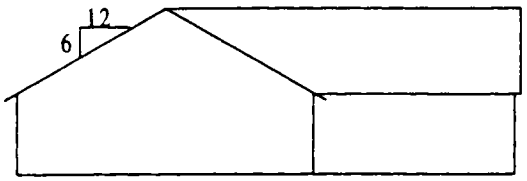
Prescriptive designs were taken directly from the applicable building code provisions using a "literal" interpretation. When engineering was required, applicable engineering provisions in the code or in a referenced standard (i.e. ASCE 7-95 and ANSI/NFoPA NDS-91) were used following a "literal" interpretation. To facilitate engineering analysis, spreadsheets were used extensively to calculate design load requirements for various components and assemblies of the homes. Construction solutions (i.e. framing members, connectors, etc.) were designed using the applicable material design standard (i.e. ANSI/NFoPA NDS-91), design data in the building code (i.e. shearwall and diaphragm capacities), manufactures data, and loads from direct code provisions or referenced standards. To analyze the resistance of wood members in accordance with NDS-91, a commercially available software package was utilized [12].

Construction costs were determined for only the select features using standardized construction costs, such as 1997 Means Residential Cost Data, to the greatest extent possible so that repeatability of the analysis is possible [13]. While code enforcement, engineering efficiency, and actual construction costs will vary significantly, the intent of this study was purely related to the function of tracking a reasonable "relative" or "baseline" effect without this added component of variation. Costs related to construction management, cycle time, engineering design and builder mark-ups were not included in the study; therefore, the cost estimates may be considered as conservative economic indicators.

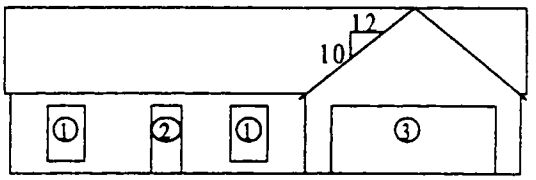
The following building components (select features) were designed by both the prescriptive and engineered approaches for each of the baseline "generic" homes at the three respective design categories (see Table 3): Roof Structure, Wall Structure, Floor Structure and Foundation Connections. The roof structure consisted of stick-framed rafters, conventional sheathing, and uplift connectors (when required). The wall structure consisted of studs, shearwall panels or let-in braces, holddowns (when required), header framing, uplift connectors (when required), and window protection (when required). The floor structure was considered to be slab-on-grade for the one-story model and conventional floor joist and sub-flooring for the second floor of the two story model. The foundation connections were considered to be conventional anchor bolts. Detailed design solutions and cost schedules are found in Appendix A.

Case Studies

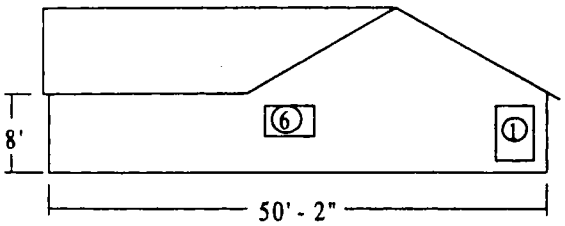
For the case study homes, two actual builder plans (blueprints) were identified to represent "typical" architectural features in modern residential construction (see Figures 3 and 4). These homes were evaluated only at the high wind and high seismic design categories in accordance with CABO-95 building code [3] and ASCE 7-95 and NDS-91 engineering standards [8][10]. The remainder of the case study analysis method closely follows the approach used for the baseline study described previously. The primary difference lies in the added complexity of the home styles and the required building code or engineering applications.



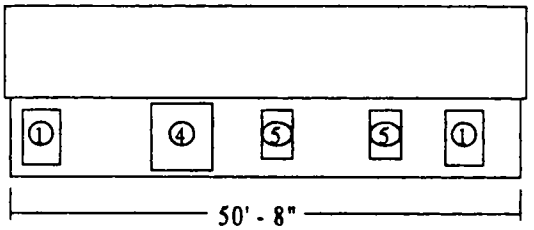
Left Elevation



Front Elevation



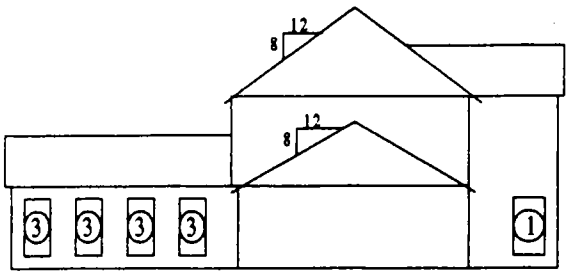
Right Elevation



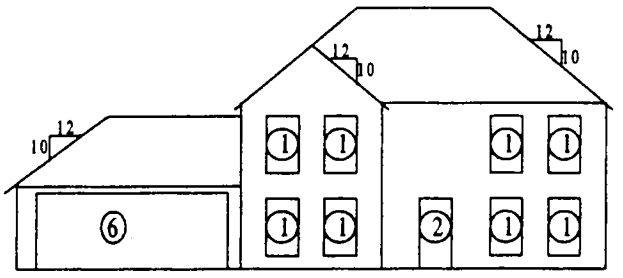
Rear Elevation

Opening Schedule
① 3' - 8" x 6' -0" Window
② 3' - 0" x 6' - 8" Door
③ 16' - 0" x 7' - 0" Garage Door
④ 6' - 0" x 6' - 8" Slider
⑤ 3' - 0" x 5' - 0" Window
⑥ 5' - 0' x 3' - 0" Window

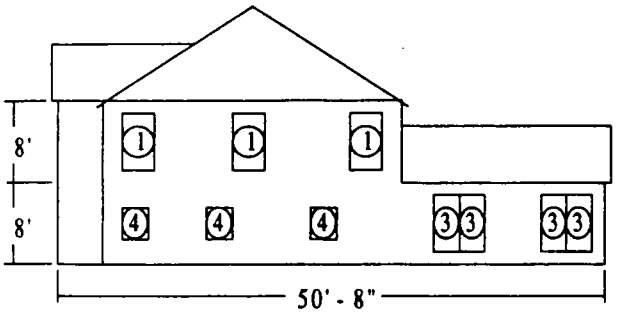
FIGURE 3. Front elevation and floor plan of one-story case study home.



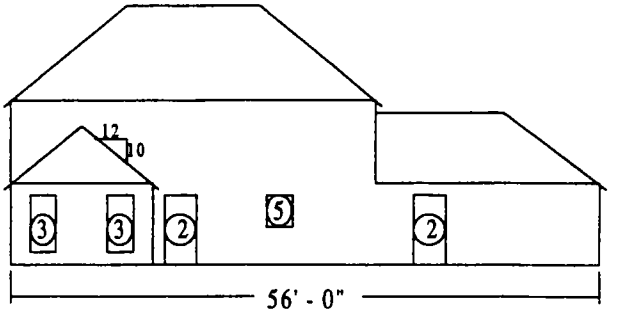
Left Elevation



Front Elevation



Right Elevation



Rear Elevation

Opening Schedule
① 3228 DH Window
② 3' - 0" x 6' - 8" Door
③ 2428 DH Window
④ 2416 DH Window
⑤ 2816 Window
⑥ 16' - 0" x 7' - 0" Garage

FIGURE 4. Front elevation and floor plan of the two-story case study home.

RESULTS

Baseline Studies

Prescriptive Codes

The investigation of prescriptive building code provisions followed a straight forward code application and construction cost comparison between the model building codes and standards. The following model building codes' prescriptive approaches were analyzed :

One- and Two-Family Dwelling Code	CABO-95	[3]
Standard Building Code	SBC-94	[4]
National Building Code	NBC-96	[5]
Uniform Building Code	UBC-94	[6]
Wood Frame Construction Manual	WFCM	[7]

Selected elements of each of the baseline homes (Figures 1 and 2) were prescriptively designed by the respective building code approach at each of the three design categories found in Table 2. A summary of the cost analyses is shown in Table 5.

TABLE 5
Prescriptive Approach Cost Summary[1], [2]

BUILDING TYPE & DESIGN CONDITIONS	NBC-96 OR CABO-95	SBC-94	UBC-94	WFCM[3] Type I[4]	WFCM[3] Type II[5]
1-Story LW/HS	$4,518	$4,554	$4,524	N/A	N/A
2-Story LW/HS	$9,163	$9,225	$9,184	N/A	N/A
1-Story MOD	$4,526	$4,531	$4,494	N/A	N/A
2-Story MOD	$9,323	$9,184	$9,123	N/A	N/A
1-Story HW/LS	$4,655	$4,500	$4,584	$5,028	$4,929
2-Story HW/LS	$11,144[6]	$9,123	$9,256	$10,855	$10,260

Notes:
1. All values are rounded to the nearest dollar and only encompasses selected design elements (see Table 3).
2. All designs were based on Exposure C [open terrain] wind conditions.
3. WFCM pertains only to High-Wind design conditions.
4. Type I design approach consists of shearwalls designed with holdowns at on both sides of wall segments with full height structural sheathing.
5. Type II design approach follows the "perforated shearwall" method with holdowns only at the corners of the building.
6. Engineering is required for walls by the CABO-95 code in this condition.

All of the prescriptive approaches produced reasonably consistent results for the 'LW/HS' and the 'MOD' design categories. However, there are noticeable discrepancies in the 'HW/LS' design category, some of which are even within the same code. For instance, the CABO-95 code yielded only a $129 increase in the one-story baseline home when changing design categories from 'MOD' to 'HW/LS' while the two-story home yielded a $1,821 increase when comparing the same design categories. The major reason for this increase is because the CABO code requires the studs and shearwall bracing of the two-story home to be designed by an engineer in the specified high wind conditions ('HW/LS'). It is appropriate that the cost impact to a larger structure would be greater; however, the relative cost impact should not be different by a ratio of 14 (two-story/one-story). This

solution is prescriptively chosen from the code. The cost difference between exposure B for load condition 'MOD' and exposure B for load condition 'HW/LS' would reduce to $0.00. The two compliant solutions would be the same because there are no uplift requirements and both solutions can be chosen from the prescriptive tables in the code using conventional connections (i.e. rafters toe-nailed to top plate). Another smaller factor contributing to cost difference was the fact that CABO-95 requires a higher uplift design for the two-story home than for the one-story home at the 'HW/LS' design category (32 psf vs 35 psf).

The SBC-94 one- and two-story designs actually decrease in construction cost when changing from 'LW/HS' to 'MOD' to 'HW/LS' design categories. The trend is very inconsistent with experience and with engineering requirements from any of the model codes and design standards, including SBC-94 engineering provisions. The major reason is that the SBC-94 prescriptive wall bracing tables are based solely on seismic requirements which cause the HW/LS design categories to produce the lowest wall design requirements when, in fact, the high wind design category produces greater lateral loads on residential structures. The SBC-94 and UBC-94 one- and two-story designs, as well as the one-story CABO-95 design for high winds, while consistent with each other, appear to be liberal in their respective design approaches with respect to increasing wind load conditions. Therefore, the construction costs at the high wind design condition appear questionably close to the moderate wind condition. The reason for these small cost increases from moderate to high wind design was primarily do to the fact that the specific "generic" home cases did not create situations triggering increases in wall and uplift design loads in the codes.

The WFCM is prescriptive design approach based on engineering requirements or high wind conditions (i.e. greater than 90 mph-fm) using SBC-94 wind loads. It is recognized in the Standard Building Code (SBC-94) and is also similar to the SSTD 10-96 Deemed-to-Comply Code [14]. The prescriptive designs by the WFCM result in the same wall studs for all three design categories. Likewise, there are modest increases in shearwall and uplift values as the prescriptive designs shift from MOD to HW/LS design categories.

Engineering Design Requirements

Engineering design provisions were analyzed to determine variation in load conditions, design implications, and construction costs. The following codes and standards were used to analyze the two baseline homes (Figures 1 and 2) at the three design categories (Table 2):

Standard Building Code	SBC-94	[4]
National Building Code	NBC-96	[5]
Uniform Building Code	UBC-94	[6]
Minimum Design Loads for Buildings and Other Structures	ASCE 7-93	[9]
National Design Specification for Wood Construction	NDS-91	[10]
Minimum Design Loads for Buildings and Other Structures	ASCE 7-95	[8]

All structural capacities of framing members were designed in accordance with NDS-91 provisions. A summary of wind load comparisons for the 'HW/LS' (high wind design category) for both one- and two-story homes can be found in Table 6 for Exposure C wind conditions. Some notable discrepancies between the model codes and standards exist. For wind loads, the differences affect the rationality and economy of engineered solutions to residential construction.

RESULTS

Baseline Studies

Prescriptive Code Requirements

The investigation of prescriptive building code provisions followed a straight forward code application and construction cost comparison between the model building codes and standards. The following model building codes' prescriptive approaches were analyzed :

One- and Two-Family Dwelling Code	CABO-95	[3]
Standard Building Code	SBC-94	[4]
National Building Code	NBC-96	[5]
Uniform Building Code	UBC-94	[6]
Wood Frame Construction Manual	WFCM	[7]

Selected elements of each of the baseline homes (Figures 1 and 2) were prescriptively designed by the respective building code approach at each of the three design categories found in Table 2. A summary of the cost analyses is shown in Table 5.

TABLE 5
Prescriptive Approach Cost Summary[1], [2]

BUILDING TYPE & DESIGN CONDITIONS	NBC-96 OR CABO-95	SBC-94	UBC-94	WFCM[3]
1-Story LW/HS	$4,518	$4,554	$4,524	N/A
2-Story LW/HS	$9,163	$9,225	$9,184	N/A
1-Story MOD	$4,494	$4,531	$4,494	N/A
2-Story MOD	$9,323	$9,184	$9,123	N/A
1-Story HW/LS	$4,597	$4,500	$4,584	$5,257
2-Story HW/LS	$11,103[4]	$9,123	$9,256	$11,276

Notes:
1. All values are rounded to the nearest dollar and only encompasses selected design elements (see Table 3).
2. All designs were based on Exposure C [open terrain] wind conditions.
3. WFCM pertains only to High-Wind design conditions.
4. Engineering required by code for walls.

All of the prescriptive approaches produced reasonably consistent results for the 'LW/HS' and the 'MOD' design categories. However, there are significant discrepancies in the 'HW/LS' design category, some of which are even within the same code. For instance, the CABO-95 code yielded only a $103 increase in the one-story baseline home when changing design categories from 'MOD' to 'HW/LS' while the two-story home yielded a $1,690 increase when comparing the same design categories. The major reason for this increase is because the CABO code requires the two-story building, both studs and shearwall bracing, to be designed by an engineer in the specified high wind conditions ('HW/LS').

The one-story, 'HW/LS' wall design is permitted to be prescriptively selected from requirements in the code resulting in a 2x4 wall with minimal shearwall bracing (i.e. let-in bracing every 25 feet). Elements requiring engineering design were analyzed using the ASCE 7-95 standard and structural data as required in the code, assuming that the site is classified as Exposure C (open terrain). If the site is classified as exposure B (suburban/wooded terrain), no engineering is required and the compliant

How about some discussion of engineering approaches lead to prescriptive solutions?

All of the prescriptive and engineered approaches produced consistent results when examining the high seismic design category. The major reason is that seismic load demands are relatively low on one- and two-story homes light-frame structures.

The prescriptive codes generally did not put much emphasis on wind design which contradicted the engineered approaches. For example, the CABO-95 prescriptive code ignores wind completely when designing rafter members. The only variation in the rafter selections comes form variations of gravity loads (i.e. snow loads, dead loads). On the contrary, the engineered approaches examine both positive and negative wind pressures and use the worst case design of the wind or gravity loads. In the higher wind conditions the negative wind pressures controlled the rafter design in the engineered approaches. This yields a notable discrepancy between the prescriptive and engineered roof designs under the high wind design category. -So which approach is correct.

Life Safety vs Property Protection Discussion

Similarly, the prescriptive approaches use an "all or nothing approach" to wall designs. If the site conditions are under a specified lateral load (i.e. 30 psf for CABO-95), the wall stud and bracing selections are chosen from a "one size fits all" table. However, if the specified lateral load threshold is broken the prescriptive codes resort to an engineered design. The largest discrepancies between the prescriptive and engineered approaches resulted when the prescriptive thresholds were not quite exceeded.

What about breeching the envelope, versus having to provide a structure that can stay in place once breeched. What are these approaches, not so self evident as prescriptive?

CONCLUSIONS

The following conclusions can be drawn from this study:

1. There are notable variations among the engineering and prescriptive design approaches found in current building codes and standards.

2. The prescriptive approaches appear to be generally unconservative, particularly in the high wind regions.

But may be more defensible

3. The engineered approaches appear overly-conservative, erring toward an uneconomical design.

4. There needs to be more consistency in the engineering approaches and a more rational and economical wind design procedure is needed for residential construction.

5. Wind exposure conditions for both the prescriptive or engineered design approaches are extremely important in determining wind loads to cost-effectively design safe homes.

6. Shear loads resulting from seismic design are low compared to wind loads on one- and two-story light-frame residential structures because of their low mass.

U. S. Department of Housing and Urban Development
Washington, D.C. 20410-0000

Office of Policy Development and Research
Division Affordable Housing Research
and Technology

FAX TRANSMITTAL

Date: 5-14-97

Receiver's Name: JAY CRANDELL

Receiver's FAX Telephone No.: _____

Receiver's Office Telephone No.: _____

Sender's Name: William Freeborne

Sender's FAX Telephone No.: (202) 708-5873

Sender's Office Telephone No.: (202) 708-4370 x140

Number of pages, including this Transmittal form: 5

Comments

on HATDEB report on
Codes / engineering methods

finding indicates that either the non-engineered (prescriptive) solutions to high wind conditions in CABO-95 are not sufficient for the one-story case or the engineered approach results in an overly-conservative design and unnecessary cost for the two-story case. It is probable that both issues are contributing to the discrepancy.

The one-story, 'HW/LS' wall design is permitted by CABO-95 to be prescriptively selected from requirements in the code resulting in a 2x4 wall with minimal shearwall bracing (i.e. let-in bracing every 25 feet). Elements requiring engineering design were analyzed using the ASCE 7-95 standard and structural data as required in the code, assuming that the site is classified as Exposure C (open terrain). If the site is classified as exposure B (suburban/wooded terrain), no engineering is required and the compliant solution is prescriptively chosen from the code. The cost difference between exposure B for load condition 'MOD' and exposure B for load condition 'HW/LS' would reduce to $0.00. The two compliant solutions would be the same because there are no uplift requirements and both solutions can be chosen from the prescriptive tables in the code using conventional connections (i.e. rafters toe-nailed to top plate). Another smaller factor contributing to cost difference was the fact that CABO-95 requires a higher uplift design for the two-story home than for the one-story home at the 'HW/LS' design category (32 psf vs. 35 psf).

The SBC-94 one- and two-story designs actually decrease in construction cost when changing from 'LW/HS' to 'MOD' to 'HW/LS' design categories. The trend is not consistent with experience and with engineering requirements from the other model codes and design standards, including the SBC-94 engineering provisions. The major reason is that the SBC-94 prescriptive wall bracing tables are based solely on seismic requirements which cause the HW/LS design categories to produce the lowest wall design requirements when, in fact, the high wind design category produces greater lateral loads on typical residential structures. It is unclear from this study why this condition exists; however, this condition may explain why efforts have been focused at developing separate high wind construction requirements for regulatory purposes [14]. The SBC-94 and UBC-94 one- and two-story designs, as well as the one-story CABO-95 design for high winds, while consistent with each other, appear to be suspect in their respective design approaches with respect to increasing wind load conditions. Therefore, the construction costs at the high wind design condition appear questionably close to the moderate wind condition. The reason for these small cost increases from moderate to high wind design was primarily do to the fact that the specific "generic" home cases did not create situations triggering significant increases in wall and uplift design loads in the codes.

The WFCM is prescriptive design approach based on engineering requirements for high wind conditions (i.e. greater than 90 mph-fm) using SBC-94 engineering provisions for wind loads. It has recently been approved for future inclusion in the Standard Building Code and is also similar to the Standard Building Code's *Deemed-to-Comply Code* (SSTD 10-96) for high wind conditions [14]. Both Type I and Type II shearwalls were examined for the WFCM's prescriptive approach. The Type I shearwalls are based on a standard engineering approach which treats a wall as independent segments of shearwall elements with hold-down brackets to stabilize each segment. The Type II shearwalls are based on the "perforated shearwall" method which treats the entire wall as a unit with hold-down brackets only required at the building corners. While Type I shearwalls require less full height structural sheathing than Type II shear walls, Type I shearwalls require additional holdowns compared to Type II shear walls. The additional cost of the holdowns counter-acts the reduction in full height structural sheathing, resulting in an increased cost for the Type I shearwall design approach for both one- and two-story designs.

The WFCM prescriptive approach with Type II shearwalls produced similar results to that of CABO-95 one- and two-story designs for the 'HW/LS' design category. The WFCM Type II one-story design differs from the CABO-95 code primarily in the area of shearwall design. The additional sheathing and holdowns required by the WFCM resulted in a $274 increase over the CABO-95 requirements–a modest increase. Conversely, CABO-95 yielded a $884 larger cost than the WFCM Type II in the two-story case. This increase is the result of engineering design being required by CABO-95 for both the studs and shearwall bracing using the ASCE 7 standard for wind loads in lieu of the SBC-94 wind provisions used to derive the WFCM prescriptive requirements. It should also be noted that the roof and header uplift values for both the WFCM and CABO-95 were within 3% of each other. It is also interesting to note that the cost increase for a the one-story CABO-95 'MOD' to the one-story WFCM 'HW/LS' design using Type II shearwalls is $403. The cost increase for the two-story home under the same comparison is $937. Thus, the ratio of the cost increase for the two-story home relative to the one-story home in changing from the moderate to high wind condition is 2.3. This trend is a vast improvement over the previous comparison within the CABO-95 provisions alone which resulted in a ratio of 14.

Engineered Designs

Engineering design provisions were analyzed to determine variation in load conditions, design implications, and construction costs. The following codes and standards were used to analyze the two baseline homes (Figures 1 and 2) at the three design categories (Table 2):

Standard Building Code	SBC-94	[4]
National Building Code	NBC-96	[5]
Uniform Building Code	UBC-94	[6]
Minimum Design Loads for Buildings and Other Structures	ASCE 7-93	[9]
National Design Specification for Wood Construction	NDS-91	[10]
Minimum Design Loads for Buildings and Other Structures	ASCE 7-95	[8]

All structural capacities of framing members were designed in accordance with NDS-91. A summary of wind load comparisons for the 'HW/LS' (high wind design category) for both one- and two-story homes can be found in Table 6 for Exposure C wind conditions. Some notable discrepancies between the wind provisions of the model codes and standards exist. These differences affect the rationality and economy of engineered solutions to residential construction.

First, endwall shear loads produced by ASCE 7-95 wind provisions are about 3 times higher than those calculated using the SBC-94 wind provisions for the one-story home with a 6:12 roof slope. The two major reasons for this large difference are the variations in handling positive and negative roof pressure coefficients that contribute to the lateral load and the magnitude of the surface pressure coefficients on the wall and roof surfaces. The SBC-94 code produces negative wind pressures for both the windward and leeward sides of the roof for roof slopes less than 30 degrees. This condition results in the windward roof forces offsetting some of the lateral loads applied to the endwall of the structure. In addition to the inconsistency created by the configuration of the wind pressures, the ASCE 7-95 wind pressures are higher in magnitude (by 35 to 155 percent) at various regions of the structure.

For the two-story home with a 8:12 roof slope, endwall shear loads by ASCE 7-95 wind provisions are about 1.4 times greater than the same loads calculated by SBC-94 wind provisions. For the 8:12

roof slope, both design provisions configure the wind pressures in a similar manner. The difference exist only because the ASCE 7-95 wind loads are inherently higher in magnitude.

For roof uplift (using MWFRS loads), ASCE 7-95 uplift forces at the roof-to-wall connection are more than 1.9 times larger than those calculated using SBC-94 wind provisions for the one-story home with a 6:12 roof slope. For the two-story home with a 8:12 roof slope, ASCE 7-95 loads are greater than SBC-94 by a factor of 1.8 for roof uplift forces. The reason for these large inconsistencies between the two codes is that ASCE 7-95 uses much larger negative (suction) pressure coefficients for a wind direction parallel to the roof ridge.

Also included is a comparison to ASCE 7-93 wind load provisions (the previous edition of the ASCE 7 standard). It should be noted that for the one-story home with a 6:12 roof slope, ASCE 7-95 endwall shear loads are 1.4 times that of the ASCE 7-93 standard at equivalent wind speed conditions. For the same home, the roof uplift is also greater by a factor of about 1.8. For the two-story home with a 8:12 roof slope, ASCE 7-95 is greater than ASCE 7-93 by factors of 1.1 and 2.1 for the endwall shear load and roof uplift force, respectively. The major reason for the difference between the 1993 and 1995 versions of ASCE 7 relate to the manner of handling roof uplift pressures. First, the 1995 version of ASCE 7 has much higher pressure coefficients for wind forces parallel to the ridge. Most significantly, the 1993 version of the code provides either negative or positive windward pressure coefficients depending on roof slope, but not both. The 1995 version of the standard has both positive and negative (minimum and maximum) windward roof pressure coefficients for all roof slopes; therefore, the worst case combined wall and roof load effect is used in the design. This difference affects both the shear and uplift loads applied to the structure. The ASCE 7-93 methodology either increased uplift values or shear values depending upon the direction of the windward roof pressures. A significant trade-off related to roof slope existed: as uplift increased shear loads decreased. The 1995 approach increases both shear and uplift values because the negative windward roof pressure coefficients increase the uplift values while the positive roof uplift values increase shear loads. Again, since the worst case of the two roof pressure coefficients (positive and negative) must be used, the negative windward roof pressure coefficients always control when examining uplift loads and the positive windward roof pressure coefficients always control when examining shear loads.

Similar results are found when comparing components and cladding wind loads. A detailed components and cladding wind load comparison is also tabulated in Table 6 for Exposure C conditions.

A summary of wind load comparisons for the HW/LS (high wind design category) for both one- and two-story homes can be found in Table 7 for Exposure B conditions. The SBC-94 code only recognizes a "standard" exposure condition for low-rise construction. Therefore, this code loses some of its design economy over the 1993 and 1995 versions of ASCE 7 at the exposure C condition, particularly when determining lateral loads for shearwall design. A more thorough analysis is needed to fully investigate this situation for varying building geometries and design conditions.

When examining MWFRS pressures under exposure B conditions, the differences between ASCE 7-95 and ASCE 7-93 increase because the 1995 version of the code uses a more conservative wind profile to determine exposure B wind speeds near to the ground. On the contrary, ASCE 7-95 may be more economical than ASCE 7-93 when comparing exposure B components and cladding loads for certain elements. ASCE 7-95/93 ratios of the components and cladding loads range from a maximum of 1.19 for exposure C to a minimum of .84 for exposure B comparisons. All ASCE 7-93 components and

cladding loads are based on Exposure C loads regardless of the actual site exposure conditions. ASCE 7-95 allows exposure B components and cladding loads to be calculated by multiplying exposure C loads by a factor of 0.85 resulting in a potentially more economical design in exposure B conditions.

It is evident from these comparisons that each code or standard for wind loads has its inherent advantages and disadvantages. It is also evident that a more consistent and appropriate source for determining wind loads on small residential structures is needed. From this study, it appears that the SBC-94 wind provisions are appropriate for engineering analysis of homes, although there is room for improvement.

The engineered solutions for selected structural elements were also analyzed to determine a construction cost impact. A summary of the construction cost data is presented in Table 8. Detailed design and cost data may be found in Appendix B.

The SBC-94 construction costs are considerably lower than the construction costs of the ASCE 7-95 designs (ranging from $232 to $2,745 less expensive). The major reason for this variation in cost between the two codes is that the ASCE 7-95 standard yields much higher shear and uplift loads which require more stringent fastening schedules, shear wall panels, greater uplift and shear connections and larger roof and wall members to handle the increased bending loads resulting from the higher wind pressures. One important note is that a portion of the increase between the two codes for the high wind category is the additional window protection required by ASCE 7-95 ($616 and $824 for the one- and two-story designs, respectively). Aside from the cost issues, it appears that the SBC-94 wind load provisions would result in a suitable design based on engineering experience and documented performance in high wind events [7][15][16][17]. While ASCE 7 wind provisions result in greater loads and "stronger" construction, the cost and design impacts appear out of line with the detailing necessary to achieve suitable performance of homes in high wind conditions. It is also believed that the SBC-94 wind provisions are conservative, particularly when site conditions match exposure B (suburban/wooded) conditions.

A summary of the seismic loads is given in Table 9. Even though, ASCE7-95 loads are 23% higher than the UBC-94 loads, the end construction cost of both the one-story and two-story homes in the high seismic design categories ('LW/HS') are identical for both standards. The reason is that the loads are relatively low producing designs which fall within the same shearwall compliant solution for the generic home situations. This finding would not necessarily hold true for many homes with greater amounts of wall openings. Thus, a modest cost increase or design impact would be expected.

TABLE 6
Wind Load Comparisons for Exposure C (Open Terrain) Conditions

	ASCE 7-95 One-Story	ASCE 7-95 Two-Story	ASCE 7-93 One-Story	ASCE 7-93 Two-Story	SBC 1994 One-Story	SBC 1994 Two-Story	**ASCE 7-95/93 One-Story**	**ASCE 7-95/93 Two-Story**	**ASCE 7-95/SBC One-Story**	**ASCE 7-95/SBC Two-Story**
MWFRS Loads										
1st Floor End Wall Shear (lbs)	6,682	16,429	4,659	14,678	2,237	11,617	**1.43**	**1.12**	**2.99**	**1.41**
2nds Floor End Wall Shear (lbs)	N/A	8,710	N/A	7,450	N/A	6,323	**N/A**	**1.17**	**N/A**	**1.38**
Roof Uplift (plf)	574	647	314	314	182	358	**1.83**	**2.06**	**3.15**	**1.81**
Components and Cladding Loads										
Wall Suction (Interior Zone)(psf)	41	46	40	40	26	31	**1.03**	**1.15**	**1.58**	**1.48**
Wall Suction (Exterior Zone)(psf)	48	54	49	49	30	34	**0.98**	**1.10**	**1.60**	**1.59**
Roof Suction (Interior Zone)(psf)	36	42	37	37	24	27	**0.97**	**1.14**	**1.50**	**1.56**
Roof Suction (Edge Zone)(psf)	69	50	66	42	28	29	**1.05**	**1.19**	**2.46**	**1.72**
Roof Suction (Corner Zone)(psf)	69	50	66	42	49	37	**1.05**	**1.19**	**1.41**	**1.35**
Roof Suction (Overhang at Corner)(psf)	112	81	N/A	N/A	44	51	**N/A**	**N/A**	**2.55**	**1.59**

TABLE 7

Wind Load Comparisons for Exposure B (Suburban/Wooded) Conditions

	ASCE 7-95 One-Story	ASCE 7-95 Two-Story	ASCE 7-93 One-Story	ASCE 7-93 Two-Story	SBC 1994 One-Story	SBC 1994 Two-Story	ASCE 7-95/93 One-Story	ASCE 7-95/93 Two-Story	ASCE 7-95/SBC One-Story	ASCE 7-95/SBC Two-Story
MWFRS Loads										
1st Floor End Wall Shear (lbs)	4,218	10,857	2,772	8,739	2,237	11,617	**1.52**	**1.24**	**1.89**	**0.93**
2nds Floor End Wall Shear (lbs)	N/A	5,756	N/A	4,433	N/A	6,323	**N/A**	**1.30**	**N/A**	**0.91**
Roof Uplift (plf)	321	391	129	129	182	358	**2.49**	**3.03**	**1.76**	**1.09**
Components and Cladding Loads										
Wall Suction (Interior Zone)(psf)	35	39	19	19	26	31	**1.84**	**2.05**	**1.35**	**1.26**
Wall Suction (Exterior Zone)(psf)	41	46	24	24	30	34	**1.71**	**1.92**	**1.37**	**1.35**
Roof Suction (Interior Zone)(psf)	31	36	18	18	24	27	**1.72**	**2.00**	**1.29**	**1.33**
Roof Suction (Edge Zone)(psf)	59	42	32	20	28	29	**1.84**	**2.10**	**2.11**	**1.45**
Roof Suction (Corner Zone)(psf)	59	42	32	20	49	37	**1.84**	**2.10**	**1.20**	**1.14**
Roof Suction (Overhang at Corner)(psf)	95	69	N/A	N/A	44	51	**N/A**	**N/A**	**2.16**	**1.35**

TABLE 8

Engineered Approach Cost Summary[1], [2], [3]

BUILDING TYPE & DESIGN CONDITIONS	SBC-94	UBC-94	ASCE 7-95
1-Story LW/HS	N/A	$5,218	$5,218
2-Story LW/HS	N/A	$10,192	$10,192
1-Story MOD	$5,081	N/A[4]	$5,312
2-Story MOD	$10,160	N/A[4]	$10,688
1-Story HW/LS	$5,454	N/A[4]	$7,849
2-Story HW/LS	$11,492	N/A[4]	$14,237

Notes: N/A = Cost and engineering analysis were not performed.

1. All values are rounded to the nearest dollar
2. All designs were based on Exposure C site conditions.
3. NDS-91 used to calculate allowable capacities of members.
4. Design and cost analysis are similar to ASCE 7-95.

TABLE 9

Seismic Zone 4 Load Comparisons

	ASCE 7-95	ASCE 7-93	UBC 1994	ASCE 7-95/93	ASCE 7-95/UBC
ONE-STORY BUILDING					
Endwall to Foundation [Gross Shear (lbs)]	2,897	1,643	2,354	1.10	1.23
TWO-STORY BUILDING					
2nd Endwall to 2nd Floor [Gross Shear (lbs)]	2,897	2,643	2,354	1.10	1.23
1st Endwall to Foundation [Gross Shear (lbs)]	828	755	673	1.10	1.23

Case Studies

Design and Cost Analysis

Similar to the baseline study, the case study results tended to produce less conservative designs for the prescriptive approaches and more conservative designs for the engineered approaches. The ASCE7-95 case study designs produced trends very similar to those found in the baseline analyses. The major difference being that the design was much more complicated and the overall costs were much higher. These findings are supported by the cost figures in Table 10 and the detailed analysis data in Appendix B.

TABLE 10
Case Study Cost Summary

BUILDING TYPE & DESIGN CONDITIONS	CABO-95	ASCE 7-95
1-Story LW/HS	$8,463	$9,755
2-Story LW/HS	$16,803	$19,598
1-Story HW/LS	$8,344	$13,197
2-Story HW/LS	$21,282	$26,297

Notes: 1. All values are rounded to the nearest dollar

2. All designs were based an Exposure C site condition

The CABO-95 prescriptive analysis did not produce a logical flow when moving from the one- to two-story designs over the two design categories. The CABO-95 one-story design decreased by $119 when changing from 'LW/HS' to 'HW/LS' design categories. The reason for this reduction is the roof design compliant solution changes from a 2x8 to a 2x10 due to the increased snow load of the 'LW/HS' design category (30 psf instead of 20 psf). The cost increase associated with the roof design is more than the cost increase required from additional uplift brackets needed in the high wind CABO-95 analysis. One import issue to note is that CABO-95 uses snow load as its controlling factor on the roof design regardless of the wind loads. This trend is opposite to that found by engineering analysis. While engineering solutions demonstrate the "proper" trend for load effects, it is also apparent that the solutions are generally conservative .

The two-story CABO-95 analysis yielded a increase of $4,479 when changing design categories from 'LW/HS' to 'HW/LS'. Again, this poses a discrepancy in comparison to the one-story analysis. The reasoning is the same as noted in the "generic" home study, namely that CABO-95 requires the two-story home to have the wall system designed by engineering analysis (using ASCE 7 loads) resulting in a more conservative design than the CABO prescriptive approach.

In performing the engineering analyses on the two-story home, some unique challenges were posed because of the amount and placement of windows and doors. Of particular concern are the location of wall openings in close proximity to building corners, and the narrow wall segments that occur between closely spaced windows and at either end of the garage door. Building code provisions governing the engineering analysis of shearwalls generally prohibit these narrow segments from being considered, even though they contribute to the strength of the wall. As a result, the design is left with only a few

options: 1) remove windows from the architectural plan, 2) reduce the size of windows, 3) increase the size of the building/room to allow for longer sheathed wall segments between windows, or 4) change the structural system of the home. These options have drastic cost and architectural implications. While options 1 and 2 will decrease the cost of the home, the architectural changes are significant. Conversely, options 3 and 4 will retain the architectural features, but at great expense. For the purpose of placing an economic estimate on this design issue, option 3 was chosen in this study. This situation affected the design of the family room and the garage on the two-story case study home (Figure 4).

Investigation of Local Code Requirements

While technical and cost information is important, the HATDE program recognizes that the issue of housing affordability is often complicated by numerous political decisions at the local level where model codes are modified, adopted, interpreted, and enforced. These decisions are often made in reaction to natural disasters and public pressure without the benefit of systematic performance data and an understanding of the actual economic and risk implications.

An attempt was made to survey local building code departments in selected jurisdictions across the U.S. representing closely the load conditions of the 'HW/LS', 'MOD', and the 'LW/HS' used in the baseline study and case study analyses. To obtain local code data regarding modifications to and inconsistencies in code applications, the survey form in Appendix C was sent to local code authorities. A total of 21 responses were received.

Some interesting anecdotal findings from our surveys and other experiences are as follows:

- Prince George's County MD
  Adopts hurricane clips after a tornado strike (design wind speed=70 mph)
  Requires 30 psf ground snow load (designs snow load=20 psf or less)

- Anchorage, AK
  Increased wind loads following localized damage from a wind storm
  Plan review of engineer's analysis adds to design cost

- Victoria, TX
  Code authority wants to see "iron", regardless of what code says

- Los Angeles, CA
  Following the Northridge Earthquake, wood design values are decreased 25%, etc.

- Dade County, FL
  Bans OSB sheathing, requires onerous impact tests, etc.

It should be noted that in many cases the local codes were essentially consistent across political boundaries (i.e. counties). However, it is easy to point out the instances where inconsistencies exist in even adjacent code jurisdictions. These complications frustrate builders who conduct business across many political boundaries and add "soft cost" to the construction of homes. One possible explanation

for the numerous variations in local code jurisdictions may be related to the problems found in most prescriptive and engineering approaches analyzed in this report Though it is relative new, the WFCM [7] represents the most successful attempt to date to resolve this concern in areas with high wind conditions; however, much additional work is needed in this area. The ongoing development of a single national building code should also help in this area.

DISCUSSION

From this analysis of both prescriptive and engineered approaches to designing wood-frame homes in the major U.S. building codes and standards, it is apparent that the model building codes and standards vary significantly in their respective approaches. While the engineered approaches were more conservative, resulting in potentially uneconomical designs, prescriptive approaches (i.e. conventional construction) resulted in questionable trends, particularly in the high wind conditions. The overall cost analysis performed for this baseline study is summarized in Table 11. These cost figures serve as a suitable indicator of the relative differences and trends in the various codes and standards.

TABLE 11
Overall Cost Comparison for the Baseline Study

	Engineered Analyses			Prescriptive Analyses				
	ASCE 7-95	SBC 1994	UBC 1994	CABO 1995	SBC 1994	UBC 1994	WFCM I	WFCM II
One-Story LW/HS	$ 5,218	N/A	$ 5,218	$ 4,518	$ 4,554	$ 4,524	N/A	N/A
Two-Story LW/HS	$10,193	N/A	$10,193	$ 9,163	$ 9,225	$ 9,184	N/A	N/A
One-Story MOD	$ 5,312	$ 5,081	N/A	$ 4,526	$ 4,531	$ 4, 494	N/A	N/A
Two-Story MOD	$10,688	$10,160	N/A	$ 9,323	$ 9,184	$ 9,123	N/A	N/A
One-Story HW/LS	$ 7,849	$ 5,454	N/A	$ 4,655	$ 4,500	$ 4,584	$ 5,028	$4,929
Two-Story HW/LS	$14,297	$11,492	N/A	$11,144	$ 9,123	$ 9,256	$10,855	$10,260

In an ideal world, the prescriptive code requirements would be derived from a repeatable and accurate engineering analysis methodology (i.e. performance-based code). Then, the only conservatism introduced into the traditional prescriptive code format would be related to the number of known design economy trade-offs required to adequately simplify the prescriptive requirements for practical use over a reasonable range of conditions. The problem is that engineering analysis of homes has been shown to grossly under-estimate the performance of typical homes in whole building tests. Therefore, using a strict engineering-based approach to derive prescriptive code requirements for homes would result in significant, but unquantifiable and unnecessary, design and cost impacts.

A similar issue affecting the appropriate use of conventional construction practices (as defined by current prescriptive code requirements in the model building codes) are related to the variety of geometries and design conditions for homes in the U.S. In many situations a conventionally-built home has obviously provided adequate performance, but in other conditions the performance may be significantly lower than acceptable. For example, a two-story home built in a high wind area with a 10:12 roof slope would have a significantly lower reliability (i.e. level of safety or performance) than a one-story home with a 6:12 roof slope built in the same environment following the same prescriptive

significantly lower than acceptable. For example, a two-story home built in a high wind area with a 10:12 roof slope would have a significantly lower reliability (i.e. level of safety or performance) than a one-story home with a 6:12 roof slope built in the same environment following the same prescriptive code. Thus, much of the concern with prescriptive codes is not that they are inherently flawed, but that they need to have adequately defined scope or applicability limits such that a relatively consistent and acceptable level of risk or performance is achieved. However, this raises several questions related to defining the scope limits (i.e. roof slope, wall height, amount of openings for windows and doors, wind conditions, seismic condition, etc.) for prescriptive requirements governing conventional construction practices for homes. What level of risk relative to past experience is acceptable for homes? What methods of engineering analysis, if any, are appropriate for defining the scope limits relative to a yet defined level of acceptable performance for conventional construction? The fundamental issue is that efficient engineering procedures for analyzing conventional construction have not been developed, and the process of code development and engineering analysis must still rely on a heavy dose of judgment and experience to arrive at rational solutions for conventionally-built homes. If history is a good teacher, relying on judgment and experience will not result in a consistent and stable code development process for residential construction in the future.

As a matter of judgment, the ideal prescriptive solution should fall somewhere between the current engineered (more conservative) and prescriptive (less conservative) design approaches investigated in this study–at least in the high wind and seismic conditions. In effect the WFCM has made a significant stride in this direction by following a rational engineering-based approach to the development of prescriptive requirements for homes in high wind conditions. A similar effort is needed for high seismic conditions. Finally, additional research is needed to develop more accurate, yet simple, engineering analysis methods for conventionally-built and engineered homes in all conditions. With this knowledge it may be possible to systematically establish applicability limits for conventional construction based on a number of key parameters such as construction materials, number of stories, roof slope, wind speed, seismic conditions, and others.

CONCLUSIONS

The following conclusions can be drawn from this study:

1. There are notable variations among the engineering and prescriptive design approaches found in current building codes and standards.

2. The prescriptive code approaches demonstrate trends in construction requirements that are in conflict with current engineering knowledge, particularly in the high wind regions. Thus, the level of performance can be expected to be inconsistent across the varying design conditions found in the U.S.

3. The engineered approaches appear relatively conservative, erring toward an uneconomical design; however, the trends in design condition verses design solution appear logical.

4. Wind exposure conditions for both the prescriptive or engineered design approaches are extremely important in determining wind loads to cost-effectively design safe homes.

5. Shear loads resulting from seismic design are low compared to wind loads on one- and two-story light-frame residential structures because of their low mass.

6. A rational method for engineering of conventional residential construction does not exist. Even with a significant increase in engineering knowledge related to homes, judgment will continue to be a necessary code-development factor.

7. The Wood Frame Construction Manual (WFCM) appears to embody the most economical, engineering-based prescriptive construction requirements for residential construction in high wind conditions.

RECOMMENDATIONS

The following recommendations are given:

1. Improvements in engineering analysis methods for homes are needed such that a rational analysis of conventional residential construction is possible. There also needs to be a suitable definition for acceptable performance (i.e. reliability) for residential construction. Also, a consistent and practical wind design procedure is needed for residential construction.

2. Prescriptive code requirements should be made more consistent with variations in risk; however, this will be difficult and potentially costly with existing engineering technology for home design.

3. Economic implications of major changes to building codes and standards should be evaluated for affordability (first-cost) impacts following the procedures used in this study.

4. First-cost impacts and risk studies should be supplemented with rational cost-benefit studies which include factors such as home ownership or housing affordability implications. Resource utilization impacts should also be included in such a study. However, there are seemingly few instances where sufficient data of reasonable quality exists to serve as fundamental inputs into such an analysis.

REFERENCES

1. HEW (1956). *Light Frame House Construction*, Vocational Division Bulletin No. 145. U.S. Department of Health, Education, and Welfare (HEW), Washington, D.C., 1931 (reprint 1956).

2. NAHB (1994). *Housing Economics*, The Outlook, National Association of Home Builders, Washington, D.C.

3. CABO (1995). *The One and Two Family Dwelling Code*, The Council of American Building Officials, Falls Church, VA, 1995.

4. SBC (1994). *Standard Building Code*. Southern Building Code Congress International, Inc., Birmingham, AL, 1995.

5. NBC (1994). *National Building Code.* Building Officials and Code Administrators International, Inc., Country Club Hills, IL, 1995.

6. UBC (1994). *Uniform Building Code.* International Conference of Building Officials, Whittier, CA, 1995.

7. WFCM-SBC (1995). *Wood Frame Construction Manual for One- and Two-Family Dwellings.* American Forest & Paper Association, American Wood Council, Washington, D.C., 1995.

8. ASCE (1995). *Minimum Design Loads for Buildings and Other Structures* (ASCE 7-95). American Society of Civil Engineers, New York, NY, 1995.

9. ASCE (1993). *Minimum Design Loads for Buildings and Other Structures* (ASCE 7-93). American Society of Civil Engineers, New York, NY, 1993.

10. ANSI/NFoPA NDS (1991). *National Design Specification® for Wood Construction.* American Forest & Paper Association, Washington, D.C., 1993.

11. NAHB Research Center, Inc. (1995). *Builder Practices Database.* NAHB Research Center, Inc., Upper Marlboro, MD, 1995.

12. Wood Works-Software for Wood Design, User Guide, (1994) (Commercially available). American Forest and Paper Association, Washington, D.C.

13. Means Residential Cost Data, 1997.

14. STD-10-96 (1996). *Standard for Hurricane Construction* (Deemed to Comply Code). Southern Building Code Congress International, Inc., Birmingham, AL, October 1996.

15. NAHB Research Center, Inc. (1996). *Assessment of Damage to Homes Caused by Hurricane Opal,* Final Report. NAHB Research Center, Inc., Upper Marlboro, MD, 1996.

16. NAHB Research Center, Inc. (1993). *Assessment of Damage to Single-Family Homes Caused by Hurricanes Andrew and Iniki.* Prepared for the U.S. Department of Housing and Urban Development, Office of Policy Development and Research, Washington, D.C., 1993.

17. NAHB Research Center, Inc. (1997). *Statistical Assessment of Construction Characteristics and Performance of Homes in Hurricanes Andrew and Opal.* NAHB Research Center, Inc., Upper Marlboro, MD, 1997.

APPENDIX A

Baseline Study Data

The following stepwise analysis procedure was utilized in performing the design and cost analyses:

Prescriptive Code Approach

Step 1: Select a compliant design solution from prescriptive requirements (i.e. tables) in the subject building code.

Step 2: Analyze the cost of the compliant solution using unit cost data.

Step 3: Sum the cost for all of the compliant solutions for select features on the study home.

Engineering Design Approach

Step 1: Analyze structural loads using the engineering load provisions in the subject building code.

Step 2: Determine the member or connection solution having sufficient capacity to resist the loads calculated in step 1 using the approved material design specification and structural data in the subject code.

Step 3: Analyze the cost of the compliant solution using unit cost data.

Step 4: Sum the cost for all of the compliant solutions for select features on the study home.

The following tables summarize the results of implementing these two analysis approaches. The tables in Appendix B for the case study homes were generated in an identical fashion.

Categogy	Item	Description	Units	Matl	Labor	Ohead	Profit	Total	References
Roof Structure									
	Rafters	16" o.c. 2x8, 6:12 pitch	Plan S.F.	0.980	0.660			$1.640	Means Residential
		16" o.c. 2x10, 6:12 pitch	"	1.214	0.760			$1.974	Cost Data, 1997,
		16" o.c. 2x12, 6:12 pitch	"	1.367	0.860			$2.227	Page 139 & 520
		16" o.c. 3x10, 6:12 pitch	"	1.942	0.960			$2.902	
		16" o.c. 3x12, 6:12 pitch	"	2.279	1.060			$3.339	
		16" o.c. 2x8, 8:12 pitch	"	1.040	0.780			$1.820	
		16" o.c. 2x10, 8:12 pitch	"	1.288	0.880			$2.168	
		16" o.c. 2x12, 8:12 pitch	"	1.450	0.980			$2.430	
		16" o.c. 3x10, 8:12 pitch	"	2.061	1.080			$3.141	
		16" o.c. 3x12, 8:12 pitch	"	2.495	1.180			$3.675	
		16" o.c. 2x6, 10:12 pitch	"	0.807	0.800			$1.607	
		16" o.c. 2x8, 10:12 pitch	"	1.100	0.900			$2.000	
		16" o.c. 2x10, 10:12 pitch	"	1.362	1.000			$2.362	
		16" o.c. 2x12, 10:12 pitch	"	1.533	1.100			$2.633	
		16" o.c. 3x10, 10:12 pitch	"	2.180	1.200			$3.380	
		16" o.c. 3x12, 10:12 pitch	"	2.639	1.300			$3.939	
	Sheathing	7/16" OSB, 6:12 pitch, 6-12	Plan S.F.	0.490	0.380			$0.870	Means Residential
		7/16" OSB, 6:12 pitch, 6-8	"	0.493	0.395			$0.888	Cost Data, 1997,
		7/16" OSB, 6:12 pitch, 6-6	"	0.496	0.410			$0.906	Page 139 & 519
		7/16" OSB, 6:12 pitch, 4-4	"	0.499	0.425			$0.924	
		7/16" OSB, 8:12 pitch, 6-12	"	0.520	0.400			$0.920	
		7/16" OSB, 8:12 pitch, 6-8	"	0.524	0.415			$0.939	
		7/16" OSB, 8:12 pitch, 6-6	"	0.528	0.430			$0.958	
		7/16" OSB, 8:12 pitch, 6-4	"	0.532	0.445			$0.977	
		7/16" OSB, 10:12 pitch, 6-12	"	0.550	0.420			$0.970	
		7/16" OSB, 10:12 pitch, 6-8	"	0.555	0.435			$0.990	
		7/16" OSB, 10:12 pitch, 6-6	"	0.587	0.450			$1.037	
		7/16" OSB, 10:12 pitch, 6-4	"	0.620	0.465			$1.085	
Wall Structure									
	Wall Framing	2x4 (Stud Grade) studs, 16"o.c.	Wall S.F.	0.390	0.400			$0.790	Means Residential
		2x6 (Stud Grade)studs, 16"o.c.	"	0.550	0.440			$0.990	Cost Data, 1997,
		2x4 (No. 2) studs, 16"o.c.	"	0.440	0.400			$0.840	Page 137
	Bracing	let-in, studs 16"o.c. w/pbd	Wall S.F.	0.270	0.310			$0.580	Means Residential
		15/32" ply, 6-12 8d	"	0.590	0.300			$0.890	Cost Data, 1997,
		15/32" ply, 4-12 8d	"	0.595	0.320			$0.915	Page 137
		15/32" ply, 3-12 8d	"	0.600	0.340			$0.940	
		15/32" ply, 2-12 8d	"	0.610	0.360			$0.970	
		15/32" ply, 2-12 10d***	"	0.650	0.420			$1.070	-Adjusedt for 10d nail-
		5/16" OSB, 6-12 6d	"	0.340	0.270			$0.610	
		7/16" OSB, 6-12 8d	"	0.390	0.300			$0.690	
		7/16" OSB, 4-12 8d	"	0.395	0.320			$0.715	
		7/16" OSB, 3-12 8d	"	0.400	0.340			$0.740	
		7/16" OSB, 2-12 8d	"	0.410	0.380			$0.790	
	Headers	2-2x4, 2'-4" long	Each	1.804	5.367			$7.171	Means Residential
		2-2x6, 2'-4" long	"	2.567	5.677			$8.244	Cost Data, 1997,
		2-2x4, 3' long	"	2.320	6.900			$9.220	Page 137
		2-2x5, 3' long	"	2.920	7.100			$10.020	
		2-2x6, 3' long	"	3.300	7.300			$10.600	
		2-2x8, 3' long	"	4.680	7.750			$12.430	
		2-2x4, 3'-2" long	"	2.449	7.283			$9.732	
		2-2x6, 3'-2" long	"	3.483	7.706			$11.189	
		2-2x4, 3'-8" long	"	2.836	8.433			$11.269	
		2-2x8, 3'-8" long	"	5.720	9.472			$15.192	
		2-2x8, 4'-4" long	"	6.760	11.194			$17.954	
		2-2x4, 4'-8" long	"	3.609	10.733			$14.342	
		2-2x6, 4'-8" long	"	5.133	11.356			$16.489	
		2-2x6, 5' long	"	5.500	12.167			$17.667	
		2-2x10, 5' long	"	11.417	13.708			$25.125	
		2-2x6, 6' long	"	6.600	14.650			$21.250	
		2-2x8, 6' long	"	9.350	15.500			$24.850	
		2-2x10, 6' long	"	13.700	16.450			$30.150	
		2-2x12, 6'long	"	22.867	21.834			$44.701	
		2-3x10, 6' long	"	22.330	16.930			$39.260	
		2-2x10, 10' long	"	23.000	27.500			$50.500	
		2-3x12, 10' long	"	44.140	32.000			$76.140	
		1-3x10, 10' long Glulam	"	60.250	24.800			$85.050	
		2-2x6, 16' long	"	17.600	29.750			$47.350	
		2-2x12, 16' long	"	45.734	43.667			$89.401	
		Addl Jack or King 2x4	"	2.400	0.860			$3.260	
		Addl Jack or King 2x6	"	3.470	0.940			$4.410	
	Window and Door Protection	2416 DH protection	Each					$20.341	3/4" plywood, hardware,
		2420 DH protection	"					$27.122	and labor
		2428 DH protection	"					$36.163	
		3228 DH protection	"					$49.078	
		3046 protection	"					$39.230	
		3050 protection	"					$40.205	
		3056 protection	"					$41.180	
		3 ft door protection	"					$42.590	
		3860 protection	"					$52.054	
		5030 protection	"					$40.205	
		6056 protection	"					$89.490	
		6 ft slider protection	"					$92.150	
		10' Garage Door protection	"					$96.590	
		16' Garage Door protection	"					$154.540	
Floor Structure									
	Joists	2x10, 16" o.c.	Plan S.F.	1.140	0.480			$1.620	Means Residential
		2x12, 16" o.c.	"	1.520	0.510			$2.030	Cost Data, 1997,
									Page 131
	Sheathing	5/8 ply	Plan S.F.	0.56	0.33			0.89	Means Residential
									Cost Data, 1997,
									Page 131
	Anchors	1/2" dia., 6" long	Each	0.970	1.350			$2.320	Means Residential
		5/8" dia., 6" long	"	1.580	1.430			$3.010	Cost Data, 1997,
									Page 346

Connectors									
	Roof Uplift	16 penny toe nail (95#)	Each	0.014	0.040			$0.054	Simpson Strong-Tie
		Simpson H4 (360#) [Rafter to plate]	"	0.240	0.290			$0.530	P-97-1 Price Book
		Simpson H2.5 (415#) [Rafter to plate]	"	0.280	0.376			$0.656	
		Simpson H3 (455#) [Rafter to plate]	"	0.300	0.290			$0.590	
		Simpson H1 (585#) [Rafter to plate]	"	0.690	0.376			$1.066	
		Simpson H10 (905#) [Rafter to plate]	"	1.320	0.832			$2.152	
		Simpson H15 (1300#) [Rafter to plate to stud]	"	4.410	1.040			$5.450	
	Wall Uplift	Simpson A35F (440#) [Plate to stud]	Each	0.360	0.444			$0.804	
		Simpson LTP4 (685#) [Plate to stud]	"	0.410	0.444			$0.854	
		Simpson MTS12 (1000#) [Rafter to plate to stud	"	0.870	1.276			$2.146	
	Header Uplift	8d x 3-1/2" long nail (78#)	Each	0.007	0.030			$0.037	
		16d x 3-1/2" long nail (95# or 142#)	"	0.014	0.040			$0.054	
		Simpson A35F (440#)	"	0.360	0.444			$0.804	
		Simpson LTP4 (685#)	"	0.410	0.444			$0.854	
		Simpson MTS12 (1000#)	"	0.870	1.276			$2.146	
	Shearwall	ETA12 (615#) (1st Floor/Concrete)	Each	0.350	0.719			$1.069	
		ETA40 (980#) (1st Foor/Concrete)	"	4.380	0.776			$5.156	
		PAHD42(2945#) (1st Floor/Concrete)	"	9.710	0.868			$10.578	
		HPAHD42(4170#) (1st Floor/Concrete)	"	11.040	1.101			$12.141	
		MSTA9 (445#) (2nd Floor)	"	0.450	0.290			$0.740	
		MSTA24 (1025#) (2nd Floor)	"	1.200	0.936			$2.136	
		HD2A (2775#) (1st or 2nd Floor)	"	6.620	6.234			$12.854	
		HD8A (7460#) (1st or 2nd Floor)	"	19.900	8.354			$28.254	
		HTT22 (5250#) (1st or 2nd Floor)	"	17.540	3.838			$21.378	
		HD10A (9540#) (1st or 2nd Floor)	"	17.540	3.838			$21.378	

CABO-95 Prescriptive Code Evaluation, 1 Story, 28' x 40', 6:12 roof pitch 70 mph (fastest mile), Zone 4, 30psf						1 Story HS/LW
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	Rafters	2x8, 16" o.c.	1120	$1.640	$1,836.80	
Sheathing/ Diaphragm	Sheathing	7/16" OSB	1120	$0.870	$974.40	
	Nail Spacing	6:12 8d			N/A	
Roof Uplift	Roof to Wall	N/A			N/A	
	Wall to Floor	N/A			N/A	
WALL STRUCTURE						
Studs	Studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls & Holddowns	Wall bracing	Let-in brace/pressbd	1088	$0.580	$631.04	
	Holddown		2	$12.141	$24.28	HPAHD42 needed @ garage, Note 2
Headers and Opening Framing	3' Header	2-2x4	6	$9.220	$55.32	
	3' Connection	N/A			N/A	
	6' Header	2-2x6	1	$21.250	$21.25	
	Additional King Studs	N/A			N/A	
	6' Connection	N/A			N/A	
	10' Header	2-2x10	1	$50.500	$50.50	
	Additional Jack Studs	N/A			N/A	
	Additional King Studs	N/A			N/A	
	10' Connection	N/A			N/A	
Windows & Doors	No protection required	No Protection Required			N/A	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/ Diaphragm	Floor Sheathing	N/A			N/A	
	Floor Nail Spacing "	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	1/2" dia., 6' o.c.	12	$2.320	$27.84	
	Side Wall Plate	1/2" dia., 6' o.c.	16	$2.320	$37.12	

House Total = $4,518.07

Notes:
1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. Holdown addition per section 602.9 "EXCEPTION"

CABO-95 Prescriptive Code Evaluation, 1 Story, 28' x 40', 6:12 roof pitch 75 mph (fastest mile), Zone 2, 20psf						1 Story MOD
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	Rafters	2x8, 16" o.c.	1120	$1.640	$1,836.80	
Sheathing/	Sheathing	7/16" OSB	1120	$0.870	$974.40	
Diaphragm	Nail Spacing	6:12 8d			N/A	
Roof Uplift	Roof to Wall	160 lbs			N/A	Conventional nailing OK
	Wall to Floor	160 lbs			N/A	Conventional nailing OK
WALL STRUCTURE						
Studs	Studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls	Wall bracing	Let-in brace/pressbd	1088	$0.580	$631.04	
& Holddowns	Holddown		2	$12.141	$24.28	HPAHD42 needed @ garage, Note 2
Headers	3' Header	2-2x4	6	$9.220	$55.32	
and	3' Connection	180 lbs			N/A	Conventional Nailing OK
Opening	6' Header	2-2x6	1	$21.250	$21.25	
Framing	Additional King Studs	N/A			N/A	
	6' Connection	360 lbs	2	$1.873	$3.75	Simpson A35F & ETA12
	10' Header	2-2x10	1	$50.500	$50.50	
	Additional Jack Studs	N/A			N/A	
	Additional King Studs	N/A			N/A	
	10' Connection	600 lbs	2	$1.923	$3.85	Simpson LTP4 & ETA12
Windows & Doors	No protection required	No Protection Required			N/A	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/	Floor Sheathing	N/A			N/A	
Diaphragm	Floor Nail Spacing *	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation	End Wall Plate	1/2" dia., 6' o.c.	12	$2.320	$27.84	
Anchors	Side Wall Plate	1/2" dia., 6' o.c.	16	$2.320	$37.12	

House Total = $4,525.66

Notes:
1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. Holdown addition per section 602.9 "EXCEPTION"

CABO-95 Prescriptive Code Evaluation, 1 Story, 28' x 40', 6:12 roof pitch 100 mph (fastest mile), Zone 1, 20psf						1 Story HW/LS
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	Rafters	2x8, 16" o.c.	1120	$1.640	$1,836.80	
Sheathing/	Sheathing	7/16" OSB	1120	$0.870	$974.40	
Diaphragm	Nail Spacing	6:12 8d	N/A		N/A	
Roof Uplift	Roof to Wall	400 lb	62	$0.590	$36.58	Simpson H3, Note 3
	Wall to Floor	400 lb	62	$0.590	$36.58	Simpson H3, Note 3
WALL STRUCTURE						
Studs	Studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls	Wall bracing	Let-in brace/pressbd	1088	$0.580	$631.04	
& Holddowns	Holddown		2	$12.141	$24.28	HPAHD42 needed @ garage, Note 2
Headers	3' Header	2-2x4	6	$9.220	$55.32	
and	3' Connection	450 lb	12	$1.923	$23.08	Simpson LTP4 & ETA12, Note 3
Opening	6' Header	2-2x6	1	$21.250	$21.25	
Framing	Additional King Studs	N/A	N/A		N/A	
	6' Connection	900 lb	2	$6.864	$13.73	2 Simpson LTP4 & ETA40, Note 3
	10' Header	2-2x10	1	$50.500	$50.50	
	Additional Jack Studs	N/A	N/A		N/A	
	Additional King Studs	N/A	N/A		N/A	
	10' Connection	1500 lb	2	$13.578	$27.16	Simpson MTS12, LTP4 & PAHD42, Note 3
Windows & Doors	No protection required	No protection required			N/A	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/	Floor Sheathing	N/A			N/A	
Diaphragm	Floor Nail Spacing	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation	End Wall Plate	1/2" dia., 6' o.c.	12	$2.320	$27.84	
Anchors	Side Wall Plate	1/2" dia., 6' o.c.	16	$2.320	$37.12	

House Total = $4,655.19

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. Holdown addition per section 602.9 "EXCEPTION"
3. For Exposure B deduct:
   - $36.58 for Roof to Wall uplift
   - $36.58 for Wall to Floor uplift
   - $23.08 for 3' header connections
   - $13.73 for 6' header connection
   - $27.16 for 10' header connection

   $137.13 for reduction to Exposure B

House Total(Exp B) = $4,518.06

CABO-95 Prescriptive Code Evaluation, 2 Story, 28' x 40', 8:12 roof pitch 70 mph (fastest mile), Zone 4, 30psf snow						2 Story HS/LW
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost References**
ROOF STRUCTURE						
Framing	Rafters	2x8 rafters, 16" o.c.	1120	$1.820	$2,038.40	
Sheathing/ Diaphragm	Sheathing	7/16" OSB	1120	$0.920	$1,030.40	
	Nail Spacing	6:12 8d			N/A	
Roof Uplift	Roof to Wall	N/A			N/A	
	2nd Floor	N/A			N/A	
	1st Floor	N/A			N/A	
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
	2nd Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls & Holddowns	2nd Floor Wall Bracing	Let-in brace/press	1088	$0.580	$631.04	
	1st Floor Wall Bracing	Let-in brace/press	1088	$0.608	$661.50	Note 2
	2nd Floor Holddown	N/A			N/A	
	1st Floor Holddown	N/A			N/A	
Headers and Opening Framing	3' 1st Header	2-2x6	7	$10.600	$74.20	
	3' 1st Connection	N/A			N/A	
	3' 2nd Header	2-2x4	9	$9.220	$82.98	
	3' 2nd Connection	N/A			N/A	
	6' 1st Header	2-2x8	2	$24.850	$49.70	
	Additional King Studs	N/A			N/A	
	6' 1st Connection	N/A			N/A	
Windows & Doors	No protection required	No protection required			NA	
FLOOR STRUCTURE						
Joists	2nd Floor	2x10, 16" O.C.	1120	$1.620	$1,814.40	
Sheathing/ Diaphragm	2nd Floor Sheathing	5/8" ply	1120	$0.890	$996.80	
	2nd Floor Nail Spacing	6:12 8d			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	1/2" dia., 6' o.c.	12	$2.320	$27.84	
	Side Wall Plate	1/2" dia., 6' o.c.	16	$2.320	$37.12	

House Total = $9,163.42

Notes:

1. Unless noted all members are No, 2 S.P.F. or Hem Fir
2. Let-in brace with press board for 75% of wall area and 7/16" OSB 6-12 8d for 25% of wall area
   The following price adjustments were made:

   0.25 x $0.69 = 0.1725
   0.75 x $0.58 = 0.4350
   $0.608 weighted unit cost

CABO-95 Prescriptive Code Evaluation, 2 Story, 28' x 40', 8:12 roof pitch 75 mph (fastest mile), Zone 2, 20 psf snow						2 Story MOD
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost References**
ROOF STRUCTURE						
Framing	Rafters	2x8 rafters, 16" o.c.	1120	$1.820	$2,038.40	
Sheathing/ Diaphragm	Sheathing	7/16" OSB	1120	$0.920	$1,030.40	
	Nail Spacing	6:12 8d				
Roof Uplift	Roof to Wall	214 lb	62	$0.530	$32.86	Simpson H4
	2nd Floor	214 lb	62	$0.530	$32.86	Simpson H4
	1st Floor	214 lb	62	$0.530	$32.86	Simpson H4
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
	2nd Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls & Holddowns	2nd Floor Wall Bracing	Let-in brace/press	1088	$0.580	$631.04	
	1st Floor Wall Bracing	Let-in brace/press	1088	$0.580	$631.04	
	2nd Floor Holddown	N/A			N/A	
	1st Floor Holddown	N/A			N/A	
Headers and Opening Framing	3' 1st Header	2-2x6	7	$10.600	$74.20	
	3' 1st Connection	241 lb	14	$1.873	$26.22	Simpson A35F & ETA12
	3' 2nd Header	2-2x4	9	$9.220	$82.98	
	3' 2nd Connection	241 lb	18	$1.608	$57.89	Simpson A35F at top and bottom
	6' 1st Header	2-2x8	2	$24.850	$49.70	
	Additional King Studs	N/A			N/A	
	6' 1st Connection	482 lb	4	$1.923	$7.69	Simpson LTP4 & ETA12
Windows & Door	No protection required	No protection required			N/A	
FLOOR STRUCTURE						
Joists	2nd Floor	2x10, 16" O.C.	1120	$1.620	$1,814.40	
Sheathing/ Diaphragm	2nd Floor Sheathing	5/8" ply	1120	$0.890	$996.80	
	2nd Floor Nail Spacing	6:12 8d				
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	1/2" dia., 6' o.c.	12	$2.320	$27.84	
	Side Wall Plate	1/2" dia., 6' o.c.	16	$2.320	$37.12	

House Total = $9,323.34

Notes: 1. Unless noted all members are No. 2 S.P.F. or Hem Fir

CABO-95 Evaluation, 2 Story, 28' x 40', 8:12 roof pitch 100mph (fastest mile), Zone 1, 30psf snow						2 Story HW/LS
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost References**
ROOF STRUCTURE						
Framing	Rafters	2x8 rafters, 16" o.c.	1120	$1.820	$2,038.40	
Sheathing/ Diaphragm	Sheathing	7/16" OSB	1120	$0.920	$1,030.40	
	Nail Spacing	6:12 8d			N/A	
Roof Uplift	Roof to Wall	460 lb	62	$0.590	$36.58	Simpson H3
	2nd Floor	460 lb	62	$0.590	$36.58	Simpson H3
	1st Floor	460 lb	62	$0.590	$36.58	Simpson H3
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c.	2x6 Stud Grade	1088	$0.990	$1,077.12	Design Required
	2nd Floor studs, 16 o.c.	2x6 Stud Grade	1088	$0.990	$1,077.12	Design Required
Shearwalls & Holddowns	2nd Floor Wall Bracing	7/16 w/ 4:12 8d	1088	$0.715	$777.92	Design Required
	1st Floor Wall Bracing	7/16 w 2:12 8d	1088	$0.790	$859.52	Design Required
	2nd Floor Holddown	1807 lb	26	$25.708	$668.41	Simpson HD2A
	1st Floor Holddown	3319 lb	26	$12.141	$315.67	Simpson HPAHD22
Headers and Opening Framing	3' 1st Header	2-2x6	7	$10.600	$74.20	
	3' 1st Connection	518 lb	14	$1.923	$26.92	Simpson LTP4 & ETA12
	3' 2nd Header	2-2x4	9	$9.220	$82.98	
	3' 2nd Connection	518 lb	18	$1.708	$30.74	Simpson LTP4 at top and bottom
	6' 1st Header	2-2x8	2	$24.850	$49.70	
	Additional King Studs	N/A			N/A	
	6' 1st Connection	1035 lb	4	$12.286	$49.14	2 Simpson LTP4 & PAHD42
Windows & Doors	No protection required	No protection required			N/A	
FLOOR STRUCTURE						
Joists	2nd Floor	2x10, 16" O.C.	1120	$1.620	$1,814.40	
Sheathing/ Diaphragm	2nd Floor Sheathing	5/8" ply	1120	$0.890	$996.80	
	2nd Floor Nail Spacing	6:12 8d			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	1/2" dia., 6' o.c.	12	$2.320	$27.84	
	Side Wall Plate	1/2" dia., 6' o.c.	16	$2.320	$37.12	

House Total = $11,144.14

Notes:

1. Unless noted all members are No, 2 S.P.F. or Hem Fir
2. Wall designed according to SBC-94
3. Design costs are not included
4. For Exposure B deduct:

-$36.58 for Roof to Wall uplift
-$36.58 for 2nd Floor uplift
-$36.58 for 1st Floor uplift
-$(1077.12 - 859.52) for 2nd floor studs
-$(1077.12 - 859.52) for 1st floor studs
-$(777.92 - 631.04) for 2nd floor wall bracing
-$(859.52 - 631.04) for 2nd floor wall bracing
-$668.41 for 2nd floor holddown
-$315.67 for 1st floor holddown
-$26.92 for 1st floor 3' header
-$30.74 for 2nd floor 3' header
-$49.14 for 1st floor 6' header

$2011.18 for reduction to Exposure B

House Total(Exp B) = $9,132.96

WFCM-95 Prescriptive Code Evaluation (Type 1), 1 Story, 28' x 40', 6:12 roof pitch **1 Story**
100 mph (fastest mile), Zone 1, 20psf snow HW/LS

Category	Item	Compliant Solution	Qty	Unit Cost	Total Cost	Design and Cost Notes
ROOF STRUCTURE						
Framing	Rafters	2x8, 16" o.c.	1120	$1.640	$1,836.80	
Sheathing/ Diaphragm	Sheathing	7/16" OSB	1120	$0.906	$1,014.72	
	Nail Spacing	6:6 8d				
Roof Uplift	Roof to Wall	407 lb	62	$0.557	$34.54	Simpson H3 and Simpson H4, Note 2
	Wall to Floor	319 lb	62	$0.239	$14.84	Simpson H4 and Conventional Nailing , Note 2, Note 3
WALL STRUCTURE						
Studs	Studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls & Holddowns	Wall bracing	7/16 w/ 6:12 8d	1088	$0.608	$661.50	Note 4
	Holddown	3375 lb	20	$12.141	$242.82	Simpson HPAHD42
Headers and Opening Framing	3' Header	2-2x4	6	$9.220	$55.32	
	3' Connection	458 lb	12	$1.923	$23.08	Simpson LTP4 & ETA12
	6' Header	2-2x8	1	$24.850	$24.85	
	Additional Jack Studs	1-2x4	2	$3.260	$6.52	
	6' Connection	915 lb	2	$6.864	$13.73	2 Simpson LTP4 & ETA40
	10' Header	1-3x10 Glulam	1	$85.050	$85.05	
	Additional Jack Studs	1-2x4	2	$3.260	$6.52	
	Additional King Studs	N/A			N/A	
	10' Connection	1526 lb	2	$13.578	$27.16	Simpson MTS12, LTP4 & PAHD42
Windows & Door	No protection required	No Protection Required			N/A	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/ Diaphragm	Floor Sheathing	N/A			N/A	
	Floor Nail Spacing	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plates	1/2" dia., 3' o.c.	22	$2.320	$51.04	
	Side Wall Plates	1/2" dia., 3' o.c.	30	$2.320	$69.60	

House Total = $5,027.60

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. Tabulated uplift requirements shall be permitted to be multiplied by 0.7 for framing not located within 8 feet of building corners.
   [(8*12/16)+1]* 4=28 connectors located 8 feet from corners and 62-28=34 connectors not located 8 feet from corners.
3. Uplift requirements may be reduced by 66plf for each full wall above
4. Filler board for 75% of wall area and 7/16" OSB 6-12 8d for 25% of wall area
   The following price adjustments were made:

0.25 x $0.69 = 0.1725
0.75 x $0.58 = 0.4350
$0.608 weighted unit cost

WFCM-95 Prescriptive Code Evaluation (Type 2), 1 Story, 28' x 40', 6:12 roof pitch 1 Story 100 mph (fastest mile), Zone 1, 20psf snow HW/LS						
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	Rafters	2x8, 16" o.c.	1120	$1.640	$1,836.80	
Sheathing/	Sheathing	7/16" OSB	1120	$0.906	$1,014.72	
Diaphragm	Nail Spacing	6:6 8d			N/A	
Roof Uplift	Roof to Wall	407 lb	62	$0.557	$34.54	Simpson H3 and Simpson H4, Note 2
	Wall to Floor	319 lb	62	$0.239	$14.84	Simpson H4 and Conventional Nailing , Note 2, Note 3
WALL STRUCTURE						
Studs	Studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls	Wall bracing	7/16 w/ 6:12 8d	1088	$0.690	$750.72	
& Holddowns	Holddown	3375 lb	4	$13.869	$55.48	Simpson HPAHD42 & 2-16d common nails @ 6" o.c.
Headers	3' Header	2-2x4	6	$9.220	$55.32	
and	3' Connection	458 lb	12	$1.923	$23.08	Simpson LTP4 & ETA12
Opening	6' Header	2-2x8	1	$24.850	$24.85	
Framing	Additional Jack Studs	1-2x4	2	$3.260	$6.52	
	6' Connection	915 lb	2	$6.864	$13.73	2 Simpson LTP4 & ETA40
	10' Header	1-3x10 Glulam	1	$85.050	$85.05	
	Additional Jack Studs	1-2x4	2	$3.260	$6.52	
	Additional King Studs	N/A			N/A	
	10' Connection	1526 lb	2	$13.578	$27.16	Simpson MTS12, LTP4 & PAHD42
Windows & Door	No protection required	No Protection Required			N/A	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/	Floor Sheathing	N/A			N/A	
Diaphragm	Floor Nail Spacing	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation	End Wall Plates	1/2" dia., 3' o.c.	22	$2.320	$51.04	
Anchors	Side Wall Plates	1/2" dia., 3' o.c.	30	$2.320	$69.60	

House Total = $4,929.48

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. Tabulated uplift requirements shall be permitted to be multiplied by 0.7 for framing not located within 8 feet of building corners. [(8*12/16)+1]* 4=28 connectors located 8 feet from corners and 62-28=34 connectors not located 8 feet from corners.
3. Uplift requirements may be reduced by 66plf for each full wall above

WFCM-95 Prescriptive Code Evaluation (Type 1), 2 Story, 28' x 40', 8:12 roof pitch 100mph (fastest mile), Zone 1, 20psf snow						2 Story HW/LS
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost References**
ROOF STRUCTURE						
Framing	Rafters	2x8 rafters, 16" o.c.	1120	$1.820	$2,038.40	
Sheathing/ Diaphragm	Sheathing	7/16" OSB	1120	$0.958	$1,072.96	
	Nail Spacing	6:6 8d			N/A	
Roof Uplift	Roof to Wall	448 lb	62	$0.557	$34.54	Simpson H3 and Simpson H4 , Note 2
	2nd Floor	360 lb	62	$0.530	$32.86	Simpson H4 and Simpson H4, Note 2, Note 3
	1st Floor	272 lb	62	$0.239	$14.84	Simpson H4 and Conventional Nailing, Note 2, Note 3
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c.	2x6 Stud Grade	1088	$0.990	$1,077.12	
	2nd Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls & Holddowns	2nd Floor Wall Bracing	7/16 w/ 6:12 8d	1088	$0.608	$661.50	Note 4
	1st Floor Wall Bracing	7/16 w 6:12 8d	1088	$0.608	$661.50	Note 3
	2nd Floor Holddown	3375 lb	22	$23.106	$508.33	Simpson HTT22 & 2-16d common nails @ 6"o.c.
	1st Floor Holddown	6750 lb	22	$29.982	$659.60	Simpson HD8A & 2-16d common nails @ 6" o.c.
Headers and Opening Framing	3' 1st Header	2-2x6	7	$10.600	$74.20	
	Additional Jack Studs	1-2x6	2	$4.410	$8.82	
	3' 1st Connection	503 lb	14	$1.923	$26.92	Simpson LTP4 & ETA12
	3' 2nd Header	2-2x6	9	$9.220	$82.98	
	Additional Jack Studs	1-2x4	2	$3.260	$6.52	
	3' 2nd Connection	503 lb	18	$1.708	$30.74	Simpson LTP4 at top and bottom
	6' 1st Header	2-2x12	2	$44.701	$89.40	
	Additional Jack Studs	2-2x6	4	$4.410	$17.64	
	6' 1st Connection	1007 lb	4	$6.864	$27.46	2 Simpson LTP4 & ETA40
Windows & Doors	No protection required	No protection required			NA	
FLOOR STRUCTURE						
Joists	2nd Floor	2x10, 16" O.C.	1120	$1.620	$1,814.40	
Sheathing/ Diaphragm	2nd Floor Sheathing	5/8" ply	1120	$0.890	$996.80	
	2nd Floor Nail Spacing	6:12 8d			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	1/2" dia., 2' o.c.	30	$2.320	$69.60	
	Side Wall Plate	1/2" dia., 2' o.c.	42	$2.320	$97.44	

House Total = $10,964.11

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. Tabulated uplift requirements shall be permitted to be multiplied by 0.7 for framing not located within 8 feet of building corners. [(8"12/16)+1]" 4=28 connectors located 8 feet from corners and 62-28=34 connectors not located 8 feet from corners.
3. Uplift requirements may be reduced by 66plf for each full wall above
4. Let-in brace with press board for 75% of wall area and 7/16" OSB 6-12 8d for 25% of wall area

The following price adjustments were made:

0.25 x $0.69 = 0.1725

0.75 x $0.58 = 0.4350

$0.608 weighted unit cost

WFCM-95 Prescriptive Code Evaluation (Type 2), 2 Story, 28' x 40', 8:12 roof pitch 100mph (fastest mile), Zone 1, 20psf snow						2 Story HW/LS
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost References**
ROOF STRUCTURE						
Framing	Rafters	2x8 rafters, 16" o.c.	1120	$1.820	$2,038.40	
Sheathing/ Diaphragm	Sheathing	7/16" OSB	1120	$0.958	$1,072.96	
	Nail Spacing	6:6 8d			N/A	
Roof Uplift	Roof to Wall	448 lb	62	$0.557	$34.54	Simpson H3 and Simpson H4 , Note 2
	2nd Floor	360 lb	62	$0.530	$32.86	Simpson H4 and Simpson H4, Note 2, Note 3
	1st Floor	272 lb	62	$0.239	$14.84	Simpson H4 and Conventional Nailing, Note 2, Note 3
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c.	2x6 Stud Grade	1088	$0.990	$1,077.12	
	2nd Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls & Holddowns	2nd Floor Wall Bracing	7/16 w/ 6:12 8d	1088	$0.690	$750.72	
	1st Floor Wall Bracing	7/16 w 3:12 8d	1088	$0.740	$805.12	
	2nd Floor Holddown	3375 lb	4	$23.106	$92.42	Simpson HTT22 & 2-16d common nails @ 6"o.c.
	1st Floor Holddown	9225 lb	4	$34.682	$138.73	Simpson HD10A & 2-16d common nails @ 6" o.c.
Headers and Opening Framing	3' 1st Header	2-2x6	7	$10.600	$74.20	
	Additional Jack Studs	1-2x6	2	$4.410	$8.82	
	3' 1st Connection	503 lb	14	$1.923	$26.92	Simpson LTP4 & ETA12
	3' 2nd Header	2-2x6	9	$9.220	$82.98	
	Additional Jack Studs	1-2x4	2	$3.260	$6.52	
	3' 2nd Connection	503 lb	18	$1.708	$30.74	Simpson LTP4 at top and bottom
	6' 1st Header	2-2x12	2	$44.701	$89.40	
	Additional Jack Studs	2-2x6	4	$4.410	$17.64	
	6' 1st Connection	1007 lb	4	$6.864	$27.46	2 Simpson LTP4 & ETA40
Windows & Doors	No protection required	No protection required			NA	
FLOOR STRUCTURE						
Joists	2nd Floor	2x10, 16" O.C.	1120	$1.620	$1,814.40	
Sheathing/ Diaphragm	2nd Floor Sheathing	5/8" ply	1120	$0.890	$996.80	
	2nd Floor Nail Spacing	6:12 8d				
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	1/2" dia., 2' o.c.	30	$2.320	$69.60	
	Side Wall Plate	1/2" dia., 2' o.c.	42	$2.320	$97.44	

House Total = $10,260.16

Notes:

1. Unless noted all members are No, 2 S.P.F. or Hem Fir
2. Tabulated uplift requirements shall be permitted to be multiplied by 0.7 for framing not located within 8 feet of building corners. [(8*12/16)+1]* 4=28 connectors located 8 feet from corners and 62-28=34 connectors not located 8 feet from corners.
3. Uplift requirements may be reduced by 66plf for each full wall above

SBCCI-94 Prescriptive Code Evaluation, 1 Story, 28' x 40', 6:12 roof pitch 70 mph (fastest mile), Zone 4, 30psf snow						1 Story HS/LW
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	Rafters	2x8, 16" o.c.	1120	$1.640	$1,836.80	Note 2
Sheathing/	Sheathing	7/16" OSB	1120	$0.870	$974.40	Note 2
Diaphragm	Nail Spacing	6:12 8d				
Roof Uplift	Roof to Wall	N/A			N/A	
	Wall to Floor	N/A			N/A	
WALL STRUCTURE						
Studs	Studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls	Wall bracing	Let-in brace/pressbd	1088	$0.608	$661.50	Note 3
& Holddowns	Holddown	N/A			N/A	
Headers	3' Header	2-2x4	6	$9.220	$55.32	
and	3' Connection	N/A			N/A	
Opening	6' Header	2-2x6	1	$21.250	$21.25	
Framing	Additional King Studs	N/A			N/A	
	6' Connection	N/A			N/A	
	10' Header	2-2x10	1	$50.500	$50.50	
	Additional Jack Studs	1-2x4	2	$3.260	$6.52	
	Additional King Studs	N/A			N/A	
	10' Connection	N/A			N/A	
Windows & Door	No protection required	No Protection Required			N/A	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/	Floor Sheathing	N/A			N/A	
Diaphragm	Floor Nail Spacing	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation	End Wall Plates	1/2" dia., 4' o.c.	16	$2.320	$37.12	
Anchors	Side Wall Plates	1/2" dia., 4' o.c.	22	$2.320	$51.04	

House Total = $4,553.97

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. CABO-95 used in lieu of NFoPA Span Tables for Joists and Rafters
3. Let-in brace with press board for 75% of wall area and 7/16" OSB 6-12 8d for 25% of wall area
   The following price adjustments were made:

   0.25 x $0.69 = 0.1725
   0.75 x $0.58 = 0.4350
   $0.608 weighted unit cost

SBCCI-94 Prescriptive Code Evaluation, 1 Story, 28' x 40', 6:12 roof pitch 75 mph (fastest mile), Zone 2, 20psf snow						1 Story MOD
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	Rafters	2x8, 16" o.c.	1120	$1.640	$1,836.80	Note 2
Sheathing/	Sheathing	7/16" OSB	1120	$0.870	$974.40	Note 2
Diaphragm	Nail Spacing	6:12 8d				
Roof Uplift	Roof to Wall	N/A			N/A	
	Wall to Floor	N/A			N/A	
WALL STRUCTURE						
Studs	Studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls	Wall bracing	Let-in brace/pressbd	1088	$0.608	$661.50	Note 3
& Holddowns	Holddown	N/A			N/A	
Headers	3' Header	2-2x4	6	$9.220	$55.32	
and	3' Connection	N/A			N/A	
Opening	6' Header	2-2x6	1	$21.250	$21.25	
Framing	Additional King Studs	N/A			N/A	
	6' Connection	N/A			N/A	
	10' Header	2-2x10	1	$50.500	$50.50	
	Additional Jack Studs	1-2x4	2	$3.260	$6.52	
	Additional King Studs	N/A			N/A	
	10' Connection	N/A			N/A	
Windows & Door	No protection required	No Protection Required			N/A	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/	Floor Sheathing	N/A			N/A	
Diaphragm	Floor Nail Spacing	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation	End Wall Plates	1/2" dia., 6' o.c.	12	$2.320	$27.84	
Anchors	Side Wall Plates	1/2" dia., 6' o.c.	16	$2.320	$37.12	

House Total = $4,530.77

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. CABO-95 used in lieu of NFoPA Span Tables for Joists and Rafters
3. Let-in brace with press board for 75% of wall area and 7/16" OSB 6-12 8d for 25% of wall area

The following price adjustments were made:

0.25 x $0.69 = 0.1725

0.75 x $0.58 = 0.4350

$0.608 weighted unit cost

SBCCI-94 Prescriptive Code Evaluation, 1 Story, 28' x 40', 6:12 roof pitch 100 mph (fastest mile), Zone 1, 20psf snow						1 Story HW/LS
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	Rafters	2x8, 16" o.c.	1120	$1.640	$1,836.80	Note 2
Sheathing/	Sheathing	7/16" OSB	1120	$0.870	$974.40	Note 2
Diaphragm	Nail Spacing	6:12 8d				
Roof Uplift	Roof to Wall	N/A			N/A	
	Wall to Floor	N/A			N/A	
WALL STRUCTURE						
Studs	Studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls	Wall bracing	Let-in brace/pressbd	1088	$0.580	$631.04	
& Holddowns	Holddown	N/A			N/A	
Headers	3' Header	2-2x4	6	$9.220	$55.32	
and	3' Connection	N/A			N/A	
Opening	6' Header	2-2x6	1	$21.250	$21.25	
Framing	Additional King Studs	N/A			N/A	
	6' Connection	N/A			N/A	
	10' Header	2-2x10	1	$50.500	$50.50	
	Additional Jack Studs	1-2x4	2	$3.260	$6.52	
	Additional King Studs	N/A			N/A	
	10' Connection	N/A			N/A	
Windows & Door	No protection required	No Protection Required			N/A	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/	Floor Sheathing	N/A			N/A	
Diaphragm	Floor Nail Spacing	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation	End Wall Plates	1/2" dia., 6' o.c.	12	$2.320	$27.84	
Anchors	Side Wall Plates	1/2" dia., 6' o.c.	16	$2.320	$37.12	

House Total = $4,500.31

Notes:
1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. CABO-95 used in lieu of NFoPA Span Tables for Joists and Rafters

SBCCI-94 Prescriptive Code Evaluation, 2 Story, 28' x 40', 8:12 roof pitch 70 mph (fastest mile), Zone 4, 30psf snow						2 Story HS/LW
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost References**
ROOF STRUCTURE						
Framing	Rafters	2x8 rafters, 16" o.c.	1120	$1.820	$2,038.40	Note 2
Sheathing/ Diaphragm	Sheathing	7/16" OSB	1120	$0.920	$1,030.40	Note 2
	Nail Spacing	6:12 8d			N/A	
Roof Uplift	Roof to Wall	N/A			N/A	
	2nd Floor	N/A			N/A	
	1st Floor	N/A			N/A	
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
	2nd Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls & Holddowns	2nd Floor Wall Bracing	Let-in brace/press	1088	$0.608	$661.50	Note 3
	1st Floor Wall Bracing	Let-in brace/press	1088	$0.624	$678.91	Note 4
	2nd Floor Holddown	N/A			N/A	
	1st Floor Holddown	N/A			N/A	
Headers and Opening Framing	3' 1st Header	2-2x4	7	$9.220	$64.54	
	3' 1st Connection	N/A			N/A	
	3' 2nd Header	2-2x4	9	$9.220	$82.98	
	3' 2nd Connection	N/A			N/A	
	6' 1st Header	2-2x8	2	$24.850	$49.70	
	Additional King Studs	N/A			N/A	
	6' 1st Connection	N/A			N/A	
Windows & Doors	No protection required	No protection required			N/A	
FLOOR STRUCTURE						
Joists	2nd Floor	2x10, 16" O.C.	1120	$1.620	$1,814.40	Note 2
Sheathing/ Diaphragm	2nd Floor Sheathing	5/8" ply	1120	$0.890	$996.80	Note 2
	2nd Floor Nail Spacing	6:12 8d			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	1/2" dia., 4' o.c.	16	$2.320	$37.12	
	Side Wall Plate	1/2" dia., 4' o.c.	22	$2.320	$51.04	

House Total = $9,224.84

Notes:

1. Unless noted all members are No, 2 S.P.F. or Hem Fir
2. CABO-95 used in lieu of NFoPA Span Tables for Joists and Rafters
3. Let-in brace with press board for 75% of wall area and 7/16" OSB 6-12 8d for 25% of wall area
   The following price adjustments were made:

   0.25 x $0.69 = 0.1725
   0.75 x $0.58 = 0.4350
   $0.608 weighted unit cost

4. Let-in brace with press board for 60% of wall area and 7/16" OSB 6-12 8d for 40% of wall area
   The following price adjustments were made:

   0.40 x $0.69 = 0.276
   0.60 x $0.58 = 0.348
   $0.624 weighted unit cost

SBCCI-94 Prescriptive Code Evaluation, 2 Story, 28' x 40', 8:12 roof pitch 75 mph (fastest mile), Zone 2, 20psf snow						2 Story MOD
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost References**
ROOF STRUCTURE						
Framing	Rafters	2x8 rafters, 16" o.c.	1120	$1.820	$2,038.40	Note 2
Sheathing/ Diaphragm	Sheathing	7/16" OSB	1120	$0.920	$1,030.40	Note 2
	Nail Spacing	6:12 8d			N/A	
Roof Uplift	Roof to Wall	N/A			N/A	
	2nd Floor	N/A			N/A	
	1st Floor	N/A			N/A	
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
	2nd Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls & Holddowns	2nd Floor Wall Bracing	Let-in brace/press	1088	$0.608	$661.50	Note 3
	1st Floor Wall Bracing	Let-in brace/press	1088	$0.608	$661.50	Note 3
	2nd Floor Holddown	N/A			N/A	
	1st Floor Holddown	N/A			N/A	
Headers and Opening Framing	3' 1st Header	2-2x4	7	$9.220	$64.54	
	3' 1st Connection	N/A			N/A	
	3' 2nd Header	2-2x4	9	$9.220	$82.98	
	3' 2nd Connection	N/A			N/A	
	6' 1st Header	2-2x8	2	$24.850	$49.70	
	Additional King Studs	N/A			N/A	
	6' 1st Connection	N/A			N/A	
Windows & Doors	No protection required	No protection required			N/A	
FLOOR STRUCTURE						
Joists	2nd Floor	2x10, 16" O.C.	1120	$1.620	$1,814.40	
Sheathing/ Diaphragm	2nd Floor Sheathing	5/8" ply	1120	$0.890	$996.80	
	2nd Floor Nail Spacing	6:12 8d			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	1/2" dia., 6' o.c.	12	$2.320	$27.84	
	Side Wall Plate	1/2" dia., 6' o.c.	16	$2.320	$37.12	

House Total = $9,184.23

Notes:

1. Unless noted all members are No, 2 S.P.F. or Hem Fir
2. CABO-95 used in lieu of NFoPA Span Tables for Joists and Rafters
3. Let-in brace with press board for 75% of wall area and 7/16" OSB 6-12 8d for 25% of wall area
   The following price adjustments were made:

   0.25 x $0.69 = 0.1725
   0.75 x $0.58 = 0.4350
   $0.608 weighted unit cost

SBCCI-94 Prescriptive Code Evaluation, 2 Story, 28' x 40', 8:12 roof pitch 100 mph (fastest mile), Zone 1, 20psf snow						2 Story HW/LS
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost References**
ROOF STRUCTURE						
Framing	Rafters	2x8 rafters, 16" o.c.	1120	$1.820	$2,038.40	Note 2
Sheathing/	Sheathing	7/16" OSB	1120	$0.920	$1,030.40	Note 2
Diaphragm	Nail Spacing	6:12 8d			N/A	
Roof Uplift	Roof to Wall	N/A			N/A	
	2nd Floor	N/A			N/A	
	1st Floor	N/A			N/A	
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
	2nd Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls	2nd Floor Wall Bracing	Let-in brace/press	1088	$0.580	$631.04	
& Holddowns	1st Floor Wall Bracing	Let-in brace/press	1088	$0.580	$631.04	
	2nd Floor Holddown	N/A			N/A	
	1st Floor Holddown	N/A			N/A	
Headers	3' 1st Header	2-2x4	7	$9.220	$64.54	
and	3' 1st Connection	N/A			N/A	
Opening	3' 2nd Header	2-2x4	9	$9.220	$82.98	
Framing	3' 2nd Connection	N/A			N/A	
	6' 1st Header	2-2x8	2	$24.850	$49.70	
	Additional King Studs	N/A			N/A	
	6' 1st Connection	N/A			N/A	
Windows & Doors	No protection required	No protection required			N/A	
FLOOR STRUCTURE						
Joists	2nd Floor	2x10, 16" O.C.	1120	$1.620	$1,814.40	Note 2
Sheathing/	2nd Floor Sheathing	5/8" ply	1120	$0.890	$996.80	Note 2
Diaphragm	2nd Floor Nail Spacing	6:12 8d			N/A	
FOUNDATION STRUCTURE						
Foundation	End Wall Plate	1/2" dia., 6' o.c.	12	$2.320	$27.84	
Anchors	Side Wall Plate	1/2" dia., 6' o.c.	16	$2.320	$37.12	

House Total = $9,123.30

Notes:

1. Unless noted all members are No, 2 S.P.F. or Hem Fir
2. CABO-95 used in lieu of NFoPA Span Tables for Joists and Rafters

ICBO-94 Prescriptive Code Evaluation, 1 Story, 28' x 40', 6:12 roof pitch 70 mph (fastest mile), Zone 4, 30psf snow						1 Story HS/LW
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	Rafters	2x8, 16" o.c.	1120	$1.640	$1,836.80	
Sheathing/	Sheathing	7/16" OSB	1120	$0.870	$974.40	
Diaphragm	Nail Spacing	6:12 8d			N/A	
Roof Uplift	Roof to Wall	N/A			N/A	
	Wall to Floor	N/A			N/A	
WALL STRUCTURE						
Studs	Studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls	Wall bracing	Let-in brace/press	1088	$0.608	$661.50	Note 2
& Holddowns	Holddown	N/A			N/A	
Headers	3' Header	2-2x4	6	$9.220	$55.32	
and	3' Connection	N/A			N/A	
Opening	6' Header	2-2x6	1	$21.250	$21.25	
Framing	Additional King Studs	N/A			N/A	
	6' Connection	N/A			N/A	
	10' Header	2-2x10	1	$50.500	$50.50	
	Additional Jack Studs	N/A			N/A	
	Additional King Studs	N/A			N/A	
	10' Connection	N/A			N/A	
Windows & Door	No protection required	No Protection Required			N/A	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/	Floor Sheathing	N/A			N/A	
Diaphragm	Floor Nail Spacing	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation	End Wall Plates	1/2" dia., 6' o.c.	12	$2.320	$27.84	
Anchors	Side Wall Plates	1/2" dia., 6' o.c.	16	$2.320	$37.12	

House Total = $4,524.25

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. Let-in brace with press board for 75% of wall area and 7/16" OSB 6-12 8d for 25% of wall area

The following price adjustments were made:

0.25 x $0.69 = 0.1725

0.75 x $0.58 = 0.4350

$0.608 weighted unit cost

ICBO-94 Prescriptive Code Evaluation, 1 Story, 28' x 40', 6:12 roof pitch 75 mph (fastest mile), Zone 2, 20psf snow						1 Story MOD
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	Rafters	2x8, 16" o.c.	1120	$1.640	$1,836.80	
Sheathing/	Sheathing	7/16" OSB	1120	$0.870	$974.40	
Diaphragm	Nail Spacing	6:12 8d			N/A	
Roof Uplift	Roof to Wall	N/A			N/A	
	Wall to Floor	N/A			N/A	
WALL STRUCTURE						
Studs	Studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls	Wall bracing	Let-in brace/pressbd	1088	$0.580	$631.04	
& Holddowns	Holddown	N/A			N/A	
Headers	3' Header	2-2x4	6	$9.220	$55.32	
and	3' Connection	N/A			N/A	
Opening	6' Header	2-2x6	1	$21.250	$21.25	
Framing	Additional King Studs	N/A			N/A	
	6' Connection	N/A			N/A	
	10' Header	2-2x10	1	$50.500	$50.50	
	Additional Jack Studs	N/A			N/A	
	Additional King Studs	N/A			N/A	
	10' Connection	N/A			N/A	
Windows & Door	No protection required	No Protection Required			N/A	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/	Floor Sheathing	N/A			N/A	
Diaphragm	Floor Nail Spacing	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation	End Wall Plates	1/2" dia., 6' o.c.	12	$2.320	$27.84	
Anchors	Side Wall Plates	1/2" dia., 6' o.c.	16	$2.320	$37.12	

House Total = $4,493.79

Notes: 1. Unless noted all members are No. 2 S.P.F. or Hem Fir

ICBO-94 Prescriptive Code Evaluation, 1 Story, 28' x 40', 6:12 roof pitch 100 mph (fastest mile), Zone 1, 20psf snow						1 Story HW/LS
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	Rafters	2x8, 16" o.c.	1120	$1.640	$1,836.80	
Sheathing/	Sheathing	7/16" OSB	1120	$0.870	$974.40	
Diaphragm	Nail Spacing	6:12 8d			N/A	
Roof Uplift	Roof to Wall	Note 2	22	$1.066	$23.45	UBC Appendix Chapter 23, Simpson H1
	Wall to Floor	Note 3	22	$0.530	$11.66	UBC Appendix Chapter 23, Simpson H4
WALL STRUCTURE						
Studs	Studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls	Wall bracing	Let-in brace/pressbd	1088	$0.580	$631.04	
& Holddowns	Holddown	N/A			N/A	
Headers	3' Header	2-2x4	6	$9.220	$55.32	
and	3' Connection	Note 3	12	$1.873	$22.48	Simpson A35F and ETA12
Opening	6' Header	2-2x6	1	$21.300	$21.30	
Framing	Additional King Studs	N/A			N/A	
	6' Connection	Note 3	2	$1.873	$3.75	Simpson A35F and ETA12
	10' Header	2-2x10	1	$50.500	$50.50	
	Additional Jack Studs	N/A			N/A	
	Additional King Studs	N/A			N/A	
	10' Connection	Note 3 & Note 4	2	$2.677	$5.35	Simpson A35F and ETA12
Windows & Door	No protection required	No Protection Required			N/A	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/	Floor Sheathing	N/A			N/A	
Diaphragm	Floor Nail Spacing	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation	End Wall Plates	1/2" dia., 4' o.c.	16	$2.320	$37.12	
Anchors	Side Wall Plates	1/2" dia., 4' o.c.	22	$2.320	$51.04	

House Total = $4,583.73

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. Tie straps with 10-10d nails are required @ 48" o.c.
3. Tie straps with 8-10d nails are required @ 48" o.c.
4. Where openings exceed 6 feet in width the required number of straps is to be doubled.

ICBO-94 Prescriptive Code Evaluation, 2 Story, 28' x 40', 8:12 roof pitch 70 mph (fastest mile), Zone 4, 30psf snow						2 Story HS/LW
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost References**
ROOF STRUCTURE						
Framing	Rafters	2x8 rafters, 16" o.c.	1120	$1.820	$2,038.40	
Sheathing/ Diaphragm	Sheathing	7/16" OSB	1120	$0.920	$1,030.40	
	Nail Spacing	6:12 8d			N/A	
Roof Uplift	Roof to Wall	N/A			N/A	
	2nd Floor	N/A			N/A	
	1st Floor	N/A			N/A	
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
	2nd Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls & Holddowns	2nd Floor Wall Bracing	Let-in brace/press	1088	$0.608	$661.50	Note 2
	1st Floor Wall Bracing	Let-in brace/press	1088	$0.608	$661.50	Note 2
	2nd Floor Holddown	N/A			N/A	
	1st Floor Holddown	N/A			N/A	
Headers and Opening Framing	3' 1st Header	2-2x4	7	$9.220	$64.54	
	3' 1st Connection	N/A			N/A	
	3' 2nd Header	2-2x4	9	$9.220	$82.98	
	3' 2nd Connection	N/A			N/A	
	6' 1st Header	2-2x8	2	$24.850	$49.70	
	Additional King Studs	N/A			N/A	
	6' 1st Connection	N/A			N/A	
Windows & Doors	No protection required	No protection required			NA	
FLOOR STRUCTURE						
Joists	2nd Floor	2x10, 16" O.C.	1120	$1.620	$1,814.40	
Sheathing/ Diaphragm	2nd Floor Sheathing	5/8" ply	1120	$0.890	$996.80	
	2nd Floor Nail Spacing	6:12 8d			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	1/2" dia., 6' o.c.	12	$2.320	$27.84	
	Side Wall Plate	1/2" dia., 6' o.c.	16	$2.320	$37.12	

House Total = $9,184.23

Notes:

1. Unless noted all members are No, 2 S.P.F. or Hem Fir
2. Let-in brace with press board for 75% of wall area and 7/16" OSB 6-12 8d for 25% of wall area
   The following price adjustments were made:

   0.25 x $0.69 = 0.1725
   0.75 x $0.58 = 0.4350
   $0.608 weighted unit cost

ICBO-94 Prescriptive Code Evaluation, 2 Story, 28' x 40', 8:12 roof pitch 75 mph (fastest mile), Zone 2, 20psf snow					2 Story MOD	
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost References**
ROOF STRUCTURE						
Framing	Rafters	2x8 rafters, 16" o.c.	1120	$1.820	$2,038.40	
Sheathing/ Diaphragm	Sheathing	7/16" OSB	1120	$0.920	$1,030.40	
	Nail Spacing	6:12 8d			N/A	
Roof Uplift	Roof to Wall	N/A			N/A	
	2nd Floor	N/A			N/A	
	1st Floor	N/A			N/A	
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
	2nd Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls & Holddowns	2nd Floor Wall Bracing	Let-in brace/pressbd	1088	$0.580	$631.04	Note 2
	1st Floor Wall Bracing	Let-in brace/pressbd	1088	$0.580	$631.04	Note 2
	2nd Floor Holddown	N/A			N/A	
	1st Floor Holddown	N/A			N/A	
Headers and Opening Framing	3' 1st Header	2-2x4	7	$9.220	$64.54	
	3' 1st Connection	N/A			N/A	
	3' 2nd Header	2-2x4	9	$9.220	$82.98	
	3' 2nd Connection	N/A			N/A	
	6' 1st Header	2-2x8	2	$24.850	$49.70	
	Additional King Studs	N/A			N/A	
	6' 1st Connection	N/A			N/A	
Windows & Doors	No protection required	No protection required			NA	
FLOOR STRUCTURE						
Joists	2nd Floor	2x10, 16" O.C.	1120	$1.620	$1,814.40	
Sheathing/ Diaphragm	2nd Floor Sheathing	5/8" ply	1120	$0.890	$996.80	
	2nd Floor Nail Spacing	6:12 8d			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	1/2" dia., 6' o.c.	12	$2.320	$27.84	
	Side Wall Plate	1/2" dia., 6' o.c.	16	$2.320	$37.12	
				House Total =	**$9,123.30**	

Notes: 1. Unless noted all members are No, 2 S.P.F. or Hem Fir

ICBO-94 Prescriptive Code Evaluation, 2 Story, 28' x 40', 8:12 roof pitch 100 mph (fastest mile), Zone 1, 20psf snow						2 Story HW/LS
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost References**
ROOF STRUCTURE						
Framing	Rafters	2x8 rafters, 16" o.c.	1120	$1.820	$2,038.40	
Sheathing/ Diaphragm	Sheathing	7/16" OSB	1120	$0.920	$1,030.40	
	Nail Spacing	6:12 8d			N/A	
Roof Uplift	Roof to Wall	Note 2	22	$1.066	$23.45	UBC Appendix Chapter 23, Simpson H1
	2nd Floor	Note 3	22	$0.530	$11.66	UBC Appendix Chapter 23, Simpson H4
	1st Floor	Note 4	22	$0.530	$11.66	UBC Appendix Chapter 23, Simpson H4
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
	2nd Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls & Holddowns	2nd Floor Wall Bracing	Let-in brace/pressbd	1088	$0.580	$631.04	
	1st Floor Wall Bracing	Let-in brace/pressbd	1088	$0.580	$631.04	
	2nd Floor Holddown	N/A			N/A	
	1st Floor Holddown	N/A			N/A	
Headers and Opening Framing	3' 1st Header	2-2x4	7	$9.220	$64.54	
	3' 1st Connection	Note 4	14	$1.873	$26.22	Simpson A35F and ETA12
	3' 2nd Header	2-2x4	9	$9.220	$82.98	
	3' 2nd Connection	Note 3	18	$1.608	$28.94	Simpson A35F at top and bottom
	6' 1st Header	2-2x8	2	$24.850	$49.70	
	Additional King Studs	N/A			N/A	
	6' 1st Connection	Note 4	4	$1.873	$7.49	Simpson A35F and ETA12
Windows & Doors	No protection required	No protection required			N/A	
FLOOR STRUCTURE						
Joists	2nd Floor	2x10, 16" O.C.	1120	$1.620	$1,814.40	
Sheathing/ Diaphragm	2nd Floor Sheathing	5/8" ply	1120	$0.890	$996.80	
	2nd Floor Nail Spacing	6:12 8d			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	1/2" dia., 4' o.c.	16	$2.320	$37.12	
	Side Wall Plate	1/2" dia., 4' o.c.	22	$2.320	$51.04	

House Total = $9,255.93

Notes:

1. Unless noted all members are No, 2 S.P.F. or Hem Fir
2. Tie straps with 10-10d nails are required @ 48" o.c.
3. Tie straps with 8-10d nails are required @ 48" o.c.
4. Tie straps with 6-10d nails are required @ 48" o.c.

ASCE7-95 Engineered Design, 1 Story, 28' x 40', 6:12 roof pitch 85 mph (3sec gust), Zone 4, 30psf snow						1 STORY LW/HS
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	Rafters	2x10, 16" O.C.	1120	$1.974	$2,210.88	
Sheathing/ Diaphragm	Sheathing	7/16" OSB	1120	$0.870	$974.40	
	Nail Spacing	6:12 8d			N/A	
Roof Uplift	Roof to Wall	253 lb	62	$1.060	$65.72	Simpson H4 @ rafter & plate
	1st Floor	147 lb	62		N/A	Conventional OK
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c.	2x4 SPF SG	1088	$0.790	$859.52	
Shearwalls & Holddowns	1st Floor Panels	5/16" OSB 6:12	1088	$0.610	$663.68	
	1st Floor Holddown	827.7 lb	24	$5.156	$123.74	Simpson ETA40
Headers and Opening Framing	3' 1st Header	2-2x5	6	$10.020	$60.12	
	3' 1st Connection	285 lb	12	$1.873	$22.48	A35F & ETA12
	6' 1st Header	2-2x10	1	$30.150	$30.15	
	6' 1st Connection	570 lb	2	$1.923	$3.85	LTP4 & ETA12
	Additional King Studs	1-2x4 SPF SG	2	$3.260	$6.52	
	10' 1st Header	1-3x10 Glulam	1	$85.050	$85.05	
	10' 1st Connection	950 lb	2	$7.302	$14.60	MTS12 & ETA40
	Additional Jack Studs	1-2x4 SPF SG	2	$3.260	$6.52	
	Additional King Studs	1-2x4 SPF SG	2	$3.260	$6.52	
Windows & Doors	3056 Window	N/A			N/A	
	6056 Window	N/A			N/A	
	3 foot door	N/A			N/A	
	6 foot slider	N/A			N/A	
	10 garage door	N/A			N/A	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/ Diaphragm	1st Floor Sheathing	N/A			N/A	
	1st Floor Nail Spacing	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	5/8" bolt, 6' O.C.	12	$3.010	$36.12	
	Side Wall Plate	5/8" bolt, 6' O.C.	16	$3.010	$48.16	

House Total = $5,218.03

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. All shear walls are fully sheathed with structural I sheathing
3. Roof uplift values are calculated from wind acting parallel to ridge using MWFRS exterior zone pressure coefficients
4. Shear wall holddowns are required at ends of walls and at all openings.
5. Shear wall holddowns must be tied to foundation and connected to a double stud
6. Jack and King stud required at each side of opening
7. Shearwall design is based on sesmic loads eventhough wind loads control

ASCE7-95 Engineered Design, 1 Story, 28' x 40', 6:12 roof pitch 90 mph (3sec gust), Zone 2, 20psf snow						1 STORY MOD
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	Rafters	2x10, 16" O.C.	1120	$1.974	$2,210.88	
Sheathing/ Diaphragm	Sheathing	7/16" OSB	1120	$0.888	$994.56	
	Nail Spacing	6:11 8d			N/A	uplift controls interior spacing
Roof Uplift	Roof to Wall	304 lb	62	$1.060	$65.72	Simpson H4 @ rafter & plate
	1st Floor	197 lb	62		N/A	Conventional OK
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c.	2x4 No. 2 SPF	1088	$0.840	$913.92	
Shearwalls & Holddowns	1st Floor Panels	5/16" OSB 6:12	1088	$0.610	$663.68	
	1st Floor Holddown	958 lb	24	$5.156	$123.74	Simpson ETA40
Headers and Opening Framing	3' 1st Header	2-2x5	6	$10.020	$60.12	
	3' 1st Connection	342 lb	12	$1.873	$22.48	A35F@ Header & ETA12 @ slab
	6' 1st Header	2-2x10	1	$30.150	$30.15	
	6' 1st Connection	684 lb	2	$6.010	$12.02	LTP4 @ Header & ETA40 @ slab
	Additional King Studs	1-2x4 No. 2 SPF	2	$3.260	$6.52	
	10' 1st Header	1-3x10 Glulam	1	$85.050	$85.05	
	10' 1st Connection	1140 lb	2	$12.724	$25.45	MTS12 @ Header & PAHD42 @ slab
	Additional Jack Studs	1-2x4 No. 2 SPF	2	$3.260	$6.52	
	Additional King Studs	1-2x4 No. 2 SPF	2	$3.260	$6.52	
Windows & Doors	3056 Window	N/A			N/A	
	6056 Window	N/A			N/A	
	3 foot door	N/A			N/A	
	6 foot slider	N/A			N/A	
	10 garage door	N/A			N/A	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/ Diaphragm	1st Floor Sheathing	N/A			N/A	
	1st Floor Nail Spacing	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	5/8" bolt, 6' O.C.	12	$3.010	$36.12	
	Side Wall Plate	5/8" bolt, 6' O.C.	16	$3.010	$48.16	

House Total = $5,311.61

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. All shear walls are fully sheathed with structural I sheathing
3. Roof uplift values are calculated from wind acting parallel to ridge using MWFRS exterior zone pressure coefficients
4. Shear wall holddowns are required at ends of walls and at all openings.
5. Shear wall holddowns must be tied to foundation and connected to a double stud
6. Jack and King stud required at each side of opening

ASCE7-95 Engineered Design, 1 Story, 28' x 40', 6:12 roof pitch 127 mph (3sec gust), Zone 1, 20psf snow						1 STORY HW/LS
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	Rafters	3x10, 16" O.C.	1120	$2.902	$3,250.24	
Sheathing/	Sheathing	7/16" OSB	1120	$0.924	$1,034.88	
Diaphragm	Nail Spacing	6:5 8d			N/A	Uplift controls interior spacing
Roof Uplift	Roof to Wall	765 lb	62	$5.450	$337.90	Simpson H15 connects rafter & plate to stud
	1st Floor	659 lb	62	$1.069	$66.28	ETA12
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c.	2x6 Stud Grade	1088	$0.990	$1,077.12	
& Holddowns	1st Floor Panels	7/16" w/ 4:12 8d	1088	$0.715	$777.92	
	1st Floor Holddown	1909 lb	24	$10.578	$253.87	Simpson PAHD42
Headers	3' 1st Header	2-2x5	6	$10.020	$60.12	
and	3' 1st Connection**	861 lb	12	$7.302	$87.62	Simpson MTS12 @ Header & ETA40 @ slab
Opening	6' 1st Header	2-2x10	1	$30.150	$30.15	
Framing	6' 1st Connection**	1722 lb	2	$14.870	$29.74	2-MTS12 @ Header & PAHD42 @ slab
	Additional King Studs	1-2x6 Stud Grade	2	$4.410	$8.82	
	10' 1st Header	2-3x12	1	$76.140	$76.14	
	10' 1st Connection**	2870 lb	2	$17.016	$34.03	3-MTS12 @ Header & PAHD42 @ slab
	Additional Jack Studs	1-2x6 Stud Grade	2	$4.410	$8.82	
	Addtional King Studs	1-2x6 Stud Grade	2	$4.410	$8.82	
Windows & Doors	3056 Window	impact protection	5	$41.180	$205.90	
	6056 Window	impact protection	2	$89.490	$178.98	
	3 foot door	impact protection	1	$42.590	$42.59	
	6 foot slider	impact protection	1	$92.150	$92.15	
	10 garage door	impact protection	1	$96.590	$96.59	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/	1st Floor Sheathing	N/A			N/A	
Diaphragm	1st Floor Nail Spacing	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation	End Wall Plate	5/8" bolt, 5' O.C.	14	$3.010	$42.14	
Anchors	Side Wall Plate	5/8" bolt, 6' O.C.	16	$3.010	$48.16	

House Total = $7,848.99

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. All shear walls are fully sheathed with structural I sheathing
3. Roof uplift values are calculated from wind acting parallel to ridge using MWFRS exterior zone pressure coefficients
4. Shear wall holddowns are required at ends of walls and at all openings.
5. Shear wall holddowns must be tied to foundation and connected to a double stud
6. Jack and King stud required at each side of opening

ASCE7-95 Engineered Design, 2 Story, 28' x 40', 8:12 roof pitch 85 mph (3 sec gust), Zone 4, 30psf snow						2 STORY LW/HS
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost References**
ROOF STRUCTURE						
Framing	Rafters	2x10, 16" O.C.	1120	$2.168	$2,428.16	
Sheathing/ Diaphragm	Sheathing	7/16" OSB	1120	$0.920	$1,030.40	
	Nail Spacing	6:12 8d			N/A	
Roof Uplift	Roof to Wall	297 lb	62	$1.060	$65.72	H4 @ rater and plate
	2nd Floor	191 lb			N/A	Convential OK
	1st Floor	N/A			N/A	
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
	2nd Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls & Holddowns	2nd Floor Panels	5/16" w/ 6:12 6d	1088	$0.610	$663.68	
	1st Floor Panels	7/16" w/ 6:12 8d	1088	$0.690	$750.72	
	2nd Floor Holddown	827.71 lb	26	$2.136	$55.54	MSTA24
	1st Floor Holddown	1630.2 lb	26	$10.587	$275.26	PAHD24
Headers and Opening Framing	3' 1st Header	2-2x8	7	$12.430	$87.01	
	3' 1st Connection	N/A			N/A	
	3' 2nd Header	2-2x6	9	$10.600	$95.40	
	3' 2nd Connection	335 lb	18	$1.923	$34.61	LPT4 @ Header ETA12 @ Base
	6' 1st Header	2-3x10	2	$39.260	$78.52	
	6' 1st Connection	N/A			N/A	
	Additional King Studs	1-2x4 Stud Grade	4	$3.260	$13.04	
Windows & Doors	3046 Window	N/A			N/A	
	3056 Window	N/A			N/A	
	3 foot door	N/A			N/A	
	6056 Window	N/A			N/A	
	6 foot slider	N/A			N/A	
FLOOR STRUCTURE						
Floor Joist	2nd Floor	2x10, 16" O.C.	1120	$1.620	$1,814.40	
Diaphragm	2nd Floor Sheathing	23/32"	1120	$0.890	$996.80	
	2nd Floor Nail Spacing	6:12 8d			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	5/8" bolt, 6' O.C.	12	$3.010	$36.12	
	Side Wall Plate	5/8" bolt, 6' O.C.	16	$3.010	$48.16	

House Total = $10,192.582

Notes:

1. Unless noted all members are No, 2 S.P.F. or Hem Fir
2. All shear walls are fully sheathed with structural I sheathing
3. Uplift values are calculated from wind acting parallel to ridge using worst case exterior zone pressure coefficients
4. Shear wall holddowns are required at ends of walls and at all openings.
5. Shear wall holddowns must be tied to foundation and connected to a double stud
6. Jack and King stud required at each side of opening
7. Shearwall design is based on sesmic loads eventhough wind loads control

ASCE7-95 Engineered Design, 2 Story, 28' x 40', 8:12 roof pitch 90 mph (3 sec gust), Zone 2, 20psf snow						2 STORY MOD
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost References**
ROOF STRUCTURE						
Framing	Rafters	2x10, 16" O.C.	1120	$2.168	$2,428.16	
Sheathing/ Diaphragm	Sheathing	7/16" OSB	1120	$0.920	$1,030.40	
	Nail Spacing	6:12 8d			N/A	
Roof Uplift	Roof to Wall	327 lb	62	$1.060	$65.72	H4 @ rafter & plate
	2nd Floor	247 lb	62	$0.740	$45.88	MSTA9
	1st Floor	N/A			N/A	
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
	2nd Floor studs, 16 o.c	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls & Holddowns	2nd Floor Panels	7/16" w/ 6:12 8d	1088	$0.690	$750.72	
	1st Floor Panels	7/16" w/ 3:12 8d	1088	$0.740	$805.12	
	2nd Floor Holddown	1249 lb	26	$12.584	$327.18	HD2A
	1st Floor Holddown	2347 lb	26	$10.587	$275.26	PAHD24
Headers and Opening Framing	3' 1st Header	2-2x8	7	$12.430	$87.01	
	3' 1st Connection	N/A			N/A	
	3' 2nd Header	2-2x6	9	$10.600	$95.40	
	3' 2nd Connection	368 lb	18	$1.920	$34.56	A35F @ Header & MSTA9 @ Floor
	6' 1st Header	2-3x10	2	$39.260	$78.52	
	6' 1st Connection	N/A			N/A	
	Additional King Studs	1-2x4 No. 2 SPF	4	$3.260	$13.04	
Windows & Doors	3046 Window	N/A			N/A	
	3056 Window	N/A			N/A	
	3 foot door	N/A			N/A	
	6056 Window	N/A			N/A	
	6 foot slider	N/A			N/A	
FLOOR STRUCTURE						
Floor Joist	2nd Floor	2x10, 16" O.C.	1120	$1.620	$1,814.40	
Diaphragm	2nd Floor Sheathing	23/32"	1120	$0.890	$996.80	
	2nd Floor Nail Spacing	6:12 8d			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	5/8" bolt, 4' O.C.	24	$3.010	$72.24	
	Side Wall Plate	5/8" bolt, 6' O.C.	16	$3.010	$48.16	

House Total = $10,687.616

Notes:

1. Unless noted all members are No, 2 S.P.F. or Hem Fir
2. All shear walls are fully sheathed with structural I sheathing
3. Uplift values are calculated from wind acting parallel to ridge using worst case exterior zone pressure coefficients
4. Shear wall holddowns are required at ends of walls and at all openings.
5. Shear wall holddowns must be tied to foundation and connected to a double stud
6. Jack and King stud required at each side of opening

ASCE7-95 Engineered Design, 2 Story, 28' x 40', 8:12 roof pitch 127 mph (3 sec gust), Zone 1, 20psf snow						2 STORY HW/LS
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost References**
ROOF STRUCTURE						
Framing	Rafters	3x10, 16" O.C.	1120	$3.141	$3,517.92	
Sheathing/ Diaphragm	Sheathing	7/16"	1120	$0.958	$1,072.96	
	Nail Spacing	6:7 8d				uplift controls interior spacing
Roof Uplift	Roof to Wall	863 lb	62	$5.450	$337.90	H15 Connects rafter & plate to stud
	2nd Floor	756 lb	62	$2.136	$132.43	MSTA24
	1st Floor	463 lb	62	$1.069	$66.28	ETA12
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c	2x6 Stud Grade	1088	$0.990	$1,077.12	
	2nd Floor studs, 16 o.c	2x6 Stud Grade	1088	$0.990	$1,077.12	
Shearwalls & Holddowns	2nd Floor Panels	15/32" w/ 4:12 8d	1088	$0.915	$995.52	
	1st Floor Panels	15/32" w/ 2:12 10d	1088	$1.070	$1,164.16	
	2nd Floor Holddown	2500 lb	26	$12.854	$334.20	HD2A
	1st Floor Holddown	4694 lb	26	$12.141	$315.67	HPAHD22
Headers and Opening Framing	3' 1st Header	2-2x8	7	$12.430	$87.01	
	3' 1st Connection	641 lb	14	$1.923	$26.92	LPT4 @ header & ETA12 @ slab
	3' 2nd Header	2-2x6	9	$10.600	$95.40	
	3' 2nd Connection	971 lb	18	$4.282	$77.08	MTS12 @ Header & MSTA24 @ Floor
	6' 1st Header	2-3x10	2	$39.260	$78.52	
	Additional King Studs	1-2x6 Stud Grade	4	$4.410	$17.64	
	6' 1st Connection	1281 lb	4	$12.286	$49.14	2-LPT4 @ Header & PAHD42 @ Slab
Windows & Doors	3046 Window	impact protection	9	$39.230	$353.07	
	3056 Window	impact protection	6	$41.180	$247.08	
	3 foot door	impact protection	1	$42.590	$42.59	
	6056 Window	impact protection	1	$89.490	$89.49	
	6 foot slider	impact protection	1	$92.150	$92.15	
FLOOR STRUCTURE						
Joists	2nd Floor	2x10, 16" O.C.	1120	$1.620	$1,814.40	
Sheathing/ Diaphragm	2nd Floor Sheathing	23/32"	1120	$0.890	$996.80	
	2nd Floor Nail Spacing	6:12 8d			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	5/8" bolt, 2' O.C.	30	$3.010	$90.30	
	Side Wall Plate	5/8" bolt, 6' O.C.	16	$3.010	$48.16	

House Total = $14,297.03

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. All shear walls are fully sheathed with structural I sheathing
3. Roof uplift values are calculated from wind acting parallel to ridge using MWFRS exterior zone pressure coefficients
4. Shear wall holddowns are required at ends of walls and at all openings.
5. Shear wall holddowns must be tied to foundation and connected to a double stud
6. Jack and King stud required at each side of opening

SBC 1994 Engineered Design, 1 Story, 28' x 40', 6:12 roof pitch 75 mph (fastest mile), Zone 2, 20 psf snow					1 STORY MOD	
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost References**
ROOF STRUCTURE						
Framing	Rafters	2x10, 16" O.C.	1120	$1.974	$2,210.88	
Sheathing/ Diaphragm	Sheathing	7/16" OSB	1120	$0.870	$974.40	
	Nail Spacing	6:12 8d			N/A	
Roof Uplift	Roof to Wall	42 lb			N/A	Convetional nailing OK
	1st Floor	0 lb			N/A	
WALL STRUCTURE						
Studs & Holddowns	1st Floor studs, 16 o.c.	2x4 Stud Grade	1088	$0.790	$859.52	
	1st Floor Panels	5/16" w/ 6:12 6d	1088	$0.610	$663.68	
	1st Floor Holddown	377 lb	24	$1.069	$25.66	ETA 12
Headers and Opening Framing	3' 1st Header	2-2x5	6	$10.020	$60.12	
	3' 1st Connection	63 lb			N/A	conventional O.K. ,0 lb @ slab
	6' 1st Header	2-2x10	3	$30.150	$90.45	
	6' 1st Connection	126 lb			N/A	conventional O.K. ,0 lb @ slab
	Additional King Studs	1-2x4 Stud Grade	6	$3.260	$19.56	
	10' 1st Header	2-3x12	1	$76.140	$76.14	
	10' 1st Connection	210 lb	2	$1.608	$3.22	A35F
	Additional Jack Studs	1-2x4 Stud Grade	2	$3.260	$6.52	
	Addtional King Studs	1-2x4 Stud Grade	2	$3.260	$6.52	
Windows & Doors	3056 Window	N/A			N/A	
	6056 Window	N/A			N/A	
	3 foot door	N/A			N/A	
	6 foot slider	N/A			N/A	
	10 garage door	N/A			N/A	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/ Diaphragm	1st Floor Sheathing	N/A			N/A	
	1st Floor Nail Spacing	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	5/8" bolt, 6' O.C.	12	$3.010	$36.12	
	Side Wall Plate	5/8" bolt, 6' O.C.	16	$3.010	$48.16	

House Total = $5,080.94

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. All shear walls are fully sheathed with structural I sheathing
3. Roof uplift values are calculated from wind acting parallel to ridge using MWFRS exterior zone pressure coefficients
4. Shear wall holddowns are required at ends of walls and at all openings.
5. Shear wall holddowns must be tied to foundation and connected to a double stud
6. Jack and King stud required at each side of opening

SBC 1994 Engineered Design, 1 Story, 28' x 40', 6:12 roof pitch 100 mph (fastest mile), Zone 1, 20 psf snow						1 STORY HW/LS
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost References**
ROOF STRUCTURE						
Framing	Rafters	2x10, 16" O.C.	1120	$1.974	$2,210.88	
Sheathing/ Diaphragm	Sheathing	7/16" OSB	1120	$0.870	$974.40	
	Nail Spacing	6:12 8d			N/A	
Roof Uplift	Roof to Wall	182 lb			N/A	Convetional nailing OK
	1st Floor	102 lb			N/A	Convetional nailing OK
WALL STRUCTURE						
Studs & Holddowns	1st Floor studs, 16 o.c.	2x6 Stud Grade	1088	$0.990	$1,077.12	
	1st Floor Panels	5/16" w/ 6:12 6d	1088	$0.610	$663.68	
	1st Floor Holddown	639 lb	24	$5.160	$123.84	ETA40
Headers and Opening Framing	3' 1st Header	2-2x5	6	$10.020	$60.12	
	3' 1st Connection	273 lb	12	$1.873	$22.48	A35F @ Header,ETA12 @ slab
	6' 1st Header	2-2x10	3	$30.150	$90.45	
	6' 1st Connection	546 lb	6	$1.923	$11.54	LPT4 @ header, ETA12 @ slab
	Additional King Studs	1-2x6 Stud Grade	6	$4.410	$26.46	
	10' 1st Header	2-3x12	1	$76.140	$76.14	
	10' 1st Connection	910 lb	2	$7.302	$14.60	MTS12 @header, ETA40 @ slab
	Additional Jack Studs	1-2x6 Stud Grade	2	$4.410	$8.82	
	Addtional King Studs	1-2x6 Stud Grade	2	$4.410	$8.82	
Windows & Doors	3056 Window	N/A			N/A	
	6056 Window	N/A			N/A	
	3 foot door	N/A			N/A	
	6 foot slider	N/A			N/A	
	10 garage door	N/A			N/A	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/ Diaphragm	1st Floor Sheathing	N/A			N/A	
	1st Floor Nail Spacing	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	5/8" bolt, 6' O.C.	12	$3.010	$36.12	
	Side Wall Plate	5/8" bolt, 6' O.C.	16	$3.010	$48.16	

House Total = $5,453.63

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. All shear walls are fully sheathed with structural I sheathing
3. Roof uplift values are calculated from wind acting parallel to ridge using MWFRS exterior zone pressure coefficients
4. Shear wall holddowns are required at ends of walls and at all openings.
5. Shear wall holddowns must be tied to foundation and connected to a double stud
6. Jack and King stud required at each side of opening

SBC-1994 Engineered Design, 2 Story, 28' x 40', 8:12 roof pitch 75 mph (fastest mile), Zone 2, 20 psf snow						2 STORY MOD
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	Rafters	2x10, 16" O.C.	1120	$2.168	$2,428.16	
Sheathing/ Diaphragm	Sheathing	7/16"	1120	$0.920	$1,030.40	
	Nail Spacing	6:12 8d				
Roof Uplift	Roof to Wall	197 lb			N/A	convention nailing O.K.
	2nd Floor	91 lb			N/A	convention nailing O.K.
	1st Floor	0 lb			N/A	convention nailing O.K.
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c.	2x4 SPF No.2	1088	$0.840	$913.92	
	2nd Floor studs, 16 o.c	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls & Holddowns	2nd Floor Panels	5/16 w/ 6:12 6d	1088	$0.610	$663.68	
	1st Floor Panels	7/16 w/ 6:12 8d	1088	$0.690	$750.72	
	2nd Floor Holddown	1016 lb	26	$2.136	$55.54	MSTA24
	1st Floor Holddown	1867 lb	26	$10.580	$275.08	PAHD42
Headers and Opening Framing	3' 1st Header	2-2x6	7	$12.430	$87.01	
	3' 1st Connection	0 lb			N/A	
	3' 2nd Header	2-2x6	9	$10.600	$95.40	
	3' 2nd Connection	222 lb	18	$0.804	$14.47	A35F
	6' 1st Header	2-3x10	2	$39.260	$78.52	
	Additional King Studs	1-2x4 SPF No.2	2	$3.260	$6.52	each side of header
	6' 1st Connection	0 lb			N/A	
Windows & Doors	3046 Window	N/A			N/A	
	3056 Window	N/A			N/A	
	3 foot door	N/A			N/A	
	6056 Window	N/A			N/A	
	6 foot slider	N/A			N/A	
FLOOR STRUCTURE						
Joists	2nd Floor	2x10, 16" O.C.	1120	$1.620	$1,814.40	
Sheathing/ Diaphragm	2nd Floor Sheathing	23/32"	1120	$0.890	$996.80	
	2nd Floor Nail Spacing	6:12 8d				
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	5/8" bolt, 5' O.C.	14	$3.010	$42.14	
	Side Wall Plate	5/8" bolt, 6' O.C.	16	$3.010	$48.16	

House Total = $10,160.44

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. All shear walls are fully sheathed with structural I sheathing
3. Roof uplift values are calculated from wind acting parallel to ridge using MWFRS exterior zone pressure coefficients
4. Shear wall holddowns are required at ends of walls and at all openings.
5. Shear wall holddowns must be tied to foundation and connected to a double stud
6. Jack and King stud required at each side of opening

SBC-1994 Engineered Design, 2 Story, 28' x 40', 8:12 roof pitch 100 mph (fastest mile), Zone 1, 20 psf snow						2 STORY HW/LS
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	Rafters	2x12, 16" O.C.	1120	$2.227	$2,494.24	
Sheathing/ Diaphragm	Sheathing	7/16"	1120	$0.920	$1,030.40	
	Nail Spacing	6:12 8d				
Roof Uplift	Roof to Wall	477 lb	62	$1.596	$98.95	rafter strap (H1)& plate strap (H4)
	2nd Floor	371 lb	62	$1.060	$65.72	2 H4 straps (plate and floor)
	1st Floor	77 lb			N/A	conventional nails can handle
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c.	2x6 Stud Grade	1088	$0.990	$1,077.12	
	2nd Floor studs, 16 o.c	2x6 Stud Grade	1088	$0.990	$1,077.12	
Shearwalls & Holddowns	2nd Floor Panels	7/16 w/ 4:12 8d	1088	$0.715	$777.92	
	1st Floor Panels	7/16 w/ 2:12 8d	1088	$0.790	$859.52	
	2nd Floor Holddown	1807 lb	26	$12.840	$333.84	HD2A
	1st Floor Holddown	3319 lb	26	$12.141	$315.67	HPAHD42
Headers and Opening Framing	3' 1st Header	2-2x8	7	$12.430	$87.01	
	3' 1st Connection	207 lb	14	$1.544	$21.62	A35F @ Header & MSTA9 @ Floor
	3' 2nd Header	2-2x6	9	$10.600	$95.40	
	3' 2nd Connection	537 lb	18	$2.990	$53.82	LPT4 @ Header & MSTA24 @ Floor
	6' 1st Header	2-3x10	2	$39.260	$78.52	
	Additional King Studs	1-2x6 Stud Grade	2	$4.410	$8.82	each side of header
	6' 1st Connection	1074 lb	4	$23.596	$94.38	MTS12 @ header & MSTA24 @ Floor
Windows & Doors	3046 Window	N/A			N/A	
	3056 Window	N/A			N/A	
	3 foot door	N/A			N/A	
	6056 Window	N/A			N/A	
	6 foot slider	N/A			N/A	
FLOOR STRUCTURE						
Joists	2nd Floor	2x10, 16" O.C.	1120	$1.620	$1,814.40	
Sheathing/ Diaphragm	2nd Floor Sheathing	23/32"	1120	$0.890	$996.80	
	2nd Floor Nail Spacing	6:12 8d			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	5/8" bolt, 3' O.C.	21	$3.010	$63.21	
	Side Wall Plate	5/8" bolt, 6' O.C.	16	$3.010	$48.16	

House Total = $11,492.64

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. All shear walls are fully sheathed with structural I sheathing
3. Roof uplift values are calculated from wind acting parallel to ridge using MWFRS exterior zone pressure coefficients
4. Shear wall holddowns are required at ends of walls and at all openings.
5. Shear wall holddowns must be tied to foundation and connected to a double stud
6. Jack and King stud required at each side of opening

UBC 1994 Engineered Design, 1 Story, 28' x 40', 6:12 roof pitch 85 mph (3 sec gust), Zone 4, 30 psf snow						1 STORY LW/HS
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	Rafters	2x10, 16" O.C.	1120	$1.974	$2,210.88	
Sheathing/ Diaphragm	Sheathing	7/16" OSB	1120	$0.870	$974.40	
	Nail Spacing	6:12 8d				
Roof Uplift	Roof to Wall	253 lb	62	$1.060	$65.72	Simpson H4 @ rafter & plate
	1st Floor	147 lb			N/A	Conventional OK
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c.	2x4 SPF SG	1088	$0.790	$859.52	
Shearwalls & Holddowns	1st Floor Panels	5/16" OSB 6:12	1088	$0.610	$663.68	
	1st Floor Holddown	672.57 lb	24	$5.156	$123.74	Simpson ETA40
Headers and Opening Framing	3' 1st Header	2-2x5	6	$10.020	$60.12	
	3' 1st Connection	285 lb	12	$1.873	$22.48	A35F & ETA12
	6' 1st Header	2-2x10	1	$30.150	$30.15	
	6' 1st Connection	570 lb	2	$1.923	$3.85	LTP4 & ETA12
	Additional King Studs	1-2x4 SPF SG	2	$3.260	$6.52	
	10' 1st Header	1-3x10 Glulam	1	$85.050	$85.05	
	10' 1st Connection	950 lb	2	$7.302	$14.60	MTS12 & ETA40
	Additional Jack Studs	1-2x4 SPF SG	2	$3.260	$6.52	
	Additional King Studs	1-2x4 SPF SG	2	$3.260	$6.52	
Windows & Doors	3056 Window	N/A			N/A	
	6056 Window	N/A			N/A	
	3 foot door	N/A			N/A	
	6 foot slider	N/A			N/A	
	10 garage door	N/A			N/A	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/ Diaphragm	1st Floor Sheathing	N/A			N/A	
	1st Floor Nail Spacing	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	5/8" bolt, 6' O.C.	12	$3.010	$36.12	
	Side Wall Plate	5/8" bolt, 6' O.C.	16	$3.010	$48.16	

House Total = $5,218.03

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. All shear walls are fully sheathed with structural I sheathing
3. Roof uplift values are calculated from wind acting parallel to ridge using MWFRS exterior zone pressure coefficients
4. Shear wall holddowns are required at ends of walls and at all openings.
5. Shear wall holddowns must be tied to foundation and connected to a double stud
6. Jack and King stud required at each side of opening
7. Shearwall design is based on sesmic loads eventhough wind loads control

UBC 1994 Engineered Design, 2 Story, 28' x 40', 8:12 roof pitch 85 mph (3 sec gust), Zone 4, 30 psf snow						2 STORY LW/HS
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost References**
ROOF STRUCTURE						
Framing	Rafters	2x10, 16" O.C.	1120	$2.168	$2,428.16	
Sheathing/ Diaphragm	Sheathing	7/16" OSB	1120	$0.920	$1,030.40	
	Nail Spacing	6:12 8d				
Roof Uplift	Roof to Wall	297 lb	62	$1.060	$65.72	H4 @ rater and plate
	2nd Floor	191 lb			N/A	Convential nailing OK
	1st Floor	N/A			N/A	
WALL STRUCTURE						
Studs	1st Floor studs, 16 o.c	2x4 Stud Grade	1088	$0.790	$859.52	
	2nd Floor studs, 16 o.c	2x4 Stud Grade	1088	$0.790	$859.52	
Shearwalls & Holddowns	2nd Floor Panels	5/16" w/ 6:12 6d	1088	$0.610	$663.68	
	1st Floor Panels	7/16" w/ 6:12 8d	1088	$0.690	$750.72	
	2nd Floor Holddown	672.6 lb	26	$2.136	$55.54	MSTA24
	1st Floor Holddown	1324.86 lb	26	$10.587	$275.26	PAHD42
Headers and Opening Framing	3' 1st Header	2-2x6	7	$12.430	$87.01	
	3' 1st Connection	N/A			N/A	
	3' 2nd Header	2-2x6	9	$10.600	$95.40	
	3' 2nd Connection	335 lb	18	$1.923	$34.61	LPT4 @ Header ETA12 @ Base
	6' 1st Header	2-3x10	2	$39.260	$78.52	
	6' 1st Connection	N/A			N/A	
	Additional King Studs	1-2x4 Stud Grade	4	$3.260	$13.04	
Windows & Doors	3046 Window	N/A			N/A	
	3056 Window	N/A			N/A	
	3 foot door	N/A			N/A	
	6056 Window	N/A			N/A	
	6 foot slider	N/A			N/A	
FLOOR STRUCTURE						
Floor Joist	2nd Floor	2x10, 16" O.C.	1120	$1.620	$1,814.40	
Diaphragm	2nd Floor Sheathing	23/32"	1120	$0.890	$996.80	
	2nd Floor Nail Spacing	6:12 8d			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	End Wall Plate	5/8" bolt, 6' O.C.	12	$3.010	$36.12	
	Side Wall Plate	5/8" bolt, 6' O.C.	16	$3.010	$48.16	

House Total = $10,192.582

Notes:

1. Unless noted all members are No, 2 S.P.F. or Hem Fir
2. All shear walls are fully sheathed with structural I sheathing
3. Uplift values are calculated from wind acting parallel to ridge using worst case exterior zone pressure coefficients
4. Shear wall holddowns are required at ends of walls and at all openings.
5. Shear wall holddowns must be tied to foundation and connected to a double stud
6. Jack and King stud required at each side of opening
7. Shearwall design is based on sesmic loads eventhough wind loads control

APPENDIX B

Case Study Data

CABO-95 Case Study Evaluation, 1 Story 70 mph (fastest mile), Zone 4, 30psf snow						1 Story HS/LW
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	Rafters, 6:12 pitch	2x10, 16" o.c.	1612	$1.974	$3,182.09	15 ft span
	Rafters, 10:12 pitch	2x6, 16" o.c.	414	$1.575	$652.05	10 ft span
Sheathing/ Diaphragm	Sheathing, 6:12 pitch	7/16" OSB	1612	$0.870	$1,402.44	
	Nail Spacing, 6:12 pitch	6:12 8d			N/A	
	Sheathing, 10:12 pitch	7/16" OSB	414	$0.970	$401.58	
	Nail Spacing, 10:12 pitch	6:12 OSB			N/A	
Roof Uplift	Roof to Wall, 6:12 pitch	N/A			N/A	
	Wall to Floor, 6:12 pitch	N/A			N/A	
	Roof to Wall, 10:12 pitch	N/A			N/A	
	Wall to Floor, 10:12 pitch	N/A			N/A	
WALL STRUCTURE						
Studs	Studs, 16 o.c.	2x4 Stud Grade	1777	$0.790	$1,403.83	
Shearwalls	Wall bracing	Let-in brace/pressbd	1777	$0.580	$1,030.66	
	Holddown		2	$12.141	$24.28	HPAHD42 needed @ garage, Note 2
& Holddowns	Holddown	Garage Opening Extra's			$66.67	Note 3
Headers and Opening Framing	3' Header	2-2x4	4	$9.220	$36.88	
	3' Connection	N/A			N/A	
	3' - 8" Header	2-2x4	5	$11.269	$56.35	
	3' - 8" Connection	N/A			N/A	
	5' Header	2-2x6	2	$17.667	$35.33	
	Additional King Studs	N/A			N/A	
	5' Connection	N/A			N/A	
	6' Header	2-2x6	1	$21.250	$21.25	
	Additional King Studs	N/A			N/A	
	6' Connection	N/A			N/A	
	16' Header	2-2x12	1	$89.401	$89.40	
	Additional Jack Studs	N/A			N/A	
	Additional King Studs	N/A			N/A	
	16' Connection	N/A			N/A	
Windows & Doors	No protection required				N/A	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/ Diaphragm	Floor Sheathing	N/A			N/A	
	Floor Nail Spacing	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	30' End Wall Plate	1/2" anchor bolts,6' o.c.	6	$2.320	$13.92	
	20' End Wall Plate	1/2" anchor bolts,6' o.c.	5	$2.320	$11.60	
	51' Side Wall Plate	1/2" anchor bolts,6' o.c.	10	$2.320	$23.20	
	20' Side Wall Plate	1/2" anchor bolts,6' o.c.	5	$2.320	$11.60	

House Total = $8,463.13

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. Holddown addition per section 602.9 " Exception"
3. An additional 4 in. is required at the garage to meet the requirements of 602.9 "Exception"
   (8ft)(4in/12in)*($25.00/sf)= $66.667

CABO-95 Case Study Evaluation, 1 Story 100 mph (fastest mile), Zone 1, 20psf						1 Story HW/LS
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	Rafters, 6:12 pitch	2x8, 16" o.c.	1612	$1.640	$2,643.68	15 ft span
	Rafters, 10:12 pitch	2x6, 16" o.c.	414	$1.575	$652.05	10 ft span
Sheathing/ Diaphragm	Sheathing, 6:12 pitch	7/16" OSB	1612	$0.870	$1,402.44	
	Nail Spacing, 6:12 pitch	6:12 8d			N/A	
	Sheathing, 10:12 pitch	7/16" OSB	414	$0.970	$401.58	
	Nail Spacing, 10:12 pitch	6:12 OSB			N/A	
Roof Uplift	Roof to Wall, 6:12 pitch	427 lb	78	$0.590	$46.02	Simpson H3
	Wall to Floor, 6:12 pitch	427 lb	78	$0.590	$46.02	Simpson H3
	Roof to Wall, 10:12 pitch	267 lb	32	$0.530	$16.96	Simpson H4
	Wall to Floor, 10:12 pitch	267 lb	32	$0.530	$16.96	Simpson H4
WALL STRUCTURE						
Studs	Studs, 16 o.c.	2x4 Stud Grade	1777	$0.790	$1,403.83	
Shearwalls	Wall bracing	Let-in brace/pressbd	1777	$0.580	$1,030.66	
	Holddown		2	$12.141	$24.28	HPAHD42 needed @ garage, Note 2
& Holddowns	Garage Opening Extra's				$66.67	Note 3
Headers and Opening Framing	3' Header	2-2x4	4	$9.220	$36.88	
	3' Connection	961 lb	8	$6.864	$54.91	2 Simpson LTP4 & ETA40
	3' - 8" Header	2-2x4	5	$11.269	$56.35	
	3' - 8" Connection	1174 lb	10	$12.286	$122.86	2 Simpson LTP4 & PAHD42
	5' Header	2-2x6	2	$17.667	$35.33	
	Additional King Studs	N/A			N/A	
	5' Connection	1601 lb	4	$13.140	$52.56	3 Simpson LTP4 & PAHD42
	6' Header	2-2x6	1	$21.250	$21.25	
	Additional King Studs	N/A			N/A	
	6' Connection	1922 lb	2	$13.140	$26.28	3 Simpson LTP4 & PAHD42
	16' Header	2-2x12	1	$89.401	$89.40	
	Additional Jack Studs	N/A				
	Additional King Studs	N/A				
	16' Connection	3204 lb	2	$18.579	$37.16	4 Simpson MTS12 & HPAHD42
Windows & Doors	No protection required				N/A	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/ Diaphragm	Floor Sheathing	N/A			N/A	
	Floor Nail Spacing	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	30' End Wall Plate	1/2" anchor bolts,6' o.c.	6	$2.320	$13.92	
	20' End Wall Plate	1/2" anchor bolts,6' o.c.	5	$2.320	$11.60	
	51' Side Wall Plate	1/2" anchor bolts,6' o.c.	10	$2.320	$23.20	
	20' Side Wall Plate	1/2" anchor bolts,6' o.c.	5	$2.320	$11.60	

House Total = $8,344.45

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. Holddown addition per section 602.9 " Exception"
3. An additional 4 in. is required at the garage to meet the requirements of 602.9 "Exception"
   (8ft)(4in/12in)*($25.00/sf)= $66.667

ASCE7-95 Case Study Evaluation, 1 Story 85 mph (3 sec. gust), Zone 4, 30 psf snow load						1 Story HS/LW
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	Rafters, 6:12 pitch	2x10, 16" O.C.	1612	$1.974	$3,182.09	15'span
	Rafters, 10:12 pitch	2x8, 16" O.C.	414	$2.000	$828.00	10' span
Sheathing/ Diaphragm	Sheathing, 6:12 pitch	7/16" OSB	1612	$0.870	$1,402.44	
	Nail Spacing, 6:12 pitch	6:12 8d			N/A	
	Sheathing, 10:12 pitch	7/16" OSB	414	$0.970	$401.58	
	Nail Spacing, 10:12 pitch	6:12 8d			N/A	
Roof Uplift	Roof to Wall, 6:12 pitch	271 lb	78	$0.530	$41.34	Simpson H4
	Wall to Floor, 6:12 pitch	164 lb			N/A	Conventional nailing OK
	Roof to Wall, 10:12 pitch	189 lb			N/A	Conventional nailing OK
	Wall to Floor, 10:12 pitch	83 lb			N/A	Conventional nailing OK
WALL STRUCTURE						
Studs	Studs, 16 o.c.	2x4 Stud Grade	1777	$0.790	$1,403.83	
Shearwalls	Wall bracing	7/16" 6:12 8d	1777	$0.690	$1,226.13	
	Holddown	1030 lb	24	$10.578	$253.87	Simpson PAHD42
& Holddowns	Garage Opening Extra's				$500.04	
Headers	3' Header	2-2x6	4	$10.600	$42.40	
and	3' Connection	305 lb	8	$1.873	$14.98	Simpson A35F & ETA12
Opening	3' - 8" Header	2-2x8	5	$15.192	$75.96	
Framing	3' - 8" Connection	373 lb		$1.873	N/A	Simpson A35F & ETA12
	5' Header	2-2x10	2	$25.125	$50.25	
	Additional King Studs	N/A			N/A	
	5' Connection	508 lb	4	$1.923	$7.69	Simpson LTP4 & ETA12
	6' Header	2-2x12	1	$89.401	$89.40	
	Additional King Studs	2x4 Stud Grade	2	$6.520	$13.04	
	6' Connection	609 lb	2	$1.923	$3.85	Simpson LTP4 & ETA12
	16' Header	2-2x6	1	$89.401	$89.40	
	Additional Jack Studs	2x4 Stud Grade	4	$3.260	$13.04	
	Additional King Studs	2x4 Stud Grade	4	$3.260	$13.04	
	16' Connection	1136 lb	2	$12.286	$24.57	2 Simpson LTP4 & PAHD42
Windows & Doors	No protection required	N/A			N/A	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/ Diaphragm	Floor Sheathing	N/A			N/A	
	Floor Nail Spacing	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	30' End Wall Plate	5/8" anchor bolts, 6' o.c.	6	$3.010	$18.06	
	20' End Wall Plate	5/8" anchor bolts, 6' o.c.	5	$3.010	$15.05	
	51' Side Wall Plate	5/8" anchor bolts, 6' o.c.	10	$3.010	$30.10	
	20' Side Wall Plate	5/8" anchor bolts, 6' o.c.	5	$3.010	$15.05	

House Total = $9,755.21

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. An additional 18.4 sf of wall area was added at the garage opening along with 56 sf. of 7/16" OSB applied as interior sheathing at 4:12 spacing with 8d nails to provide sufficient shear resistence.
3. One header is for fireplace opening

ASCE7-95 Case Study Evaluation, 1 Story 127 mph (3 sec. gust), Zone 1, 20 psf snow load						1 Story HW/LS
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	Rafters, 6:12 pitch	3x10, 16" O.C.	1612	$2.902	$4,678.02	15'span
	Rafters, 10:12 pitch	2x10, 16" O.C.	414	$2.362	$977.87	10' span
Sheathing/ Diaphragm	Sheathing, 6:12 pitch	7/16" OSB	1612	$0.924	$1,489.49	
	Nail Spacing, 6:12 pitch	4:4 8d			N/A	
	Sheathing, 10:12 pitch	7/16" OSB	414	$0.990	$409.86	
	Nail Spacing, 10:12 pitch	6:8 8d			N/A	
Roof Uplift	Roof to Wall, 6:12 pitch	815 lb	78	$2.152	$167.86	Simpson H10
	Wall to Floor, 6:12 pitch	708 lb	78	$2.152	$167.86	Simpson H10
	Roof to Wall, 10:12 pitch	568 lb	32	$1.066	$34.11	Simpson H1
	Wall to Floor, 10:12 pitch	461 lb	32	$1.066	$34.11	Simpson H1
WALL STRUCTURE						
Studs	Studs, 16 o.c.	2x6 Stud Grade	1777	$0.990	$1,759.23	
Shearwalls & Holddowns	Wall bracing	7/16" 3:12 8d	1777	$0.740	$1,314.98	
	Holddown	2353 lb	24	$10.578	$253.87	Simpson PAHD42
	Garage Opening Extra's				$504.24	Note 2
Headers and Opening Framing	3' Header	2-2x6	4	$10.600	$42.40	
	3' Connection	917 lb	8	$6.864	$54.91	2 Simpson LPT4 & ETA40
	3' - 8" Header	2-2x8	5	$15.192	$75.96	
	3' - 8" Connection	1121 lb	10	$12.286	$122.86	2 Simpson LPT4 & PAHD42
	5' Header	2-2x10	2	$25.125	$50.25	Note 3
	Additional King Studs	N/A			N/A	
	5' Connection	1528 lb	4	$13.578	$54.31	Simpson LPT4, MTS12 & PAHD42
	6' Header	2-2x12	1	$44.701	$44.70	
	Additional King Studs	2x6 Stud Grade	2	$4.410	$8.82	
	6' Connection	1833 lb	2	$14.870	$29.74	2 Simpson MTS 12 & PAHD42
	16' Header	2-2x6	1	$47.350	$47.35	
	Additional Jack Studs	2x6 Stud Grade	4	$4.410	$17.64	
	Additional King Studs	2x6 Stud Grade	4	$4.410	$17.64	
	16' Connection	3408 lb	2	$19.383	$38.77	3 Simpson MTS 12, A35F & HPAHD42
Windows & Doors	3050 Protection		2	$40.205	$80.41	
	3 ft Door Protection		2	$42.590	$85.18	
	3860 Protection		5	$52.054	$260.27	
	5030 Protection		1	$40.205	$40.21	
	6 ft Slider Protection		1	$92.150	$92.15	
	Garage Protection		1	$154.540	$154.54	
FLOOR STRUCTURE						
Joists	1st Floor	N/A			N/A	
Sheathing/ Diaphragm	Floor Sheathing	N/A			N/A	
	Floor Nail Spacing	N/A			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	30' End Wall Plate	5/8" anchor bolts,4' o.c.	9	$3.010	$27.09	
	20' End Wall Plate	5/8" anchor bolts,6' o.c.	5	$3.010	$15.05	
	51' Side Wall Plate	5/8" anchor bolts,6' o.c.	10	$3.010	$30.10	
	20' Side Wall Plate	5/8" anchor bolts,6' o.c.	5	$3.010	$15.05	

House Total = $13,196.89

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. An additional 18.4 sf of wall area was added at the garage opening along with 56 sf. of 7/16" OSB applied as interior sheathing at 2:12 spacing with 8d nails to provide sufficient shear resistence.
3. One header is for fireplace opening

CABO-95 Case Study Evaluation, 2 Story 70 mph fastest mile, Zone 4, 30psf					2 Story HS/LW	
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	8:12 pitch, Hipped, Main	2x8, 16" o.c.	964	$3.458	$3,333.51	14 ft span @ 8:12 and 11 ft span @ 10:12, Note 2
	8:12 pitch, Hipped, Garage	2x8, 16" o.c.	484	$2.679	$1,296.64	11 ft span @ 8:12 and 9 ft span @ 10:12, Note 2
	10:12 pitch, Gable, Family	2x6, 16" o.c.	276	$1.575	$434.70	7 ft span
	10:12 pitch, Gable, Entrance	2x6, 16" o.c.	54	$1.575	$85.05	7 ft span
Sheathing/ Diaphragm	Sheathing, 8:12 pitch, Main	7/16" OSB	964	$1.288	$1,241.63	Note 3
	Nail Spacing, 8:12 pitch, Main	6:12 8d			N/A	
	Sheathing, 8:12 pitch, Garage	7/16" OSB	484	$1.288	$623.39	Note 3
	Nail Spacing, 8:12 pitch, Garage	6:12 8d			N/A	
	Sheathing, 10:12 pitch, Family	7/16" OSB	276	$0.970	$267.72	
	Nail Spacing, 10:12 pitch, Family	6:12 8d			N/A	
	Sheathing, 10:12 pitch, Entrance	7/16" OSB	54	$0.970	$52.38	
	Nail Spacing, 10:12 pitch, Entrance	6:12 8d			N/A	
Roof Uplift	Roof to Wall, 8:12 pitch, Main	N/A			N/A	
	2nd Floor, 8:12 pitch, Main	N/A			N/A	
	1st Floor, 8:12 pitch, Main	N/A			N/A	
	Roof to Wall, 8:12 pitch, Garage	N/A			N/A	
	1st Floor, 8:12 pitch, Garage	N/A			N/A	
	Roof to Wall, 10:12 pitch, Family	N/A			N/A	
	1st Floor, 10:12 pitch, Family	N/A			N/A	
	Roof to Wall, 10:12 pitch, Entrance	N/A			N/A	
	2nd Floor, 10:12 pitch, Entrance	N/A			N/A	
	1st Floor, 10:12 pitch, Entrance	N/A			N/A	
WALL STRUCTURE						
Studs	1st Floor Studs, 16" o.c.	2x4 Stud Grade	1743	$0.790	$1,376.97	
	2nd Floor Studs, 16" o.c.	2x4 Stud Grade	1045	$0.790	$825.55	
Shearwalls & Holddowns	1st Floor Shearwall 1 Bracing	Let-in brace/pressbd	195	$0.608	$100.92	Note 4
	1st Floor Shearwall 1 Holddown	N/A			N/A	
	1st Floor Shearwall 2 Bracing	Let-in brace/pressbd	141	$0.608	$85.73	Note 4
	1st Floor Shearwall 2 Holddown	N/A			N/A	
	1st Floor Shearwall 3 Bracing	Let-in brace/pressbd	157	$0.580	$91.06	
	1st Floor Shearwall 3 Holddown	1,800 lb	2	$12.141	$24.28	Note 5, Simpson HPAHD42
	Additional FTA to fit shear panels	4 ft^2	4	$65.000	$260.00	Note 5
	1st Floor Shearwall 4 Bracing	Let-in brace/pressbd	112	$0.580	$64.96	
	1st Floor Shearwall 4 Holddown	1,800 lb	2	$12.141	$24.28	Note 5, Simpson HPAHD42
	Additional FTA to fit shear panels	21 ft^2	21.3333	$65.000	$1,386.67	Note 5
	1st Floor Shearwall 5 Bracing	Let-in brace/pressbd	373	$0.608	$226.78	Note 4
	1st Floor Shearwall 5 Holddown	1,800 lb	2	$12.141	$24.28	Note 5, Simpson HPAHD42
	Additional FTA to fit shear panels	12 ft^2	12	$65.000	$780.00	Note 5
	1st Floor Shearwall 6 Bracing		336	$0.608	$204.29	Note 4
	1st Floor Shearwall 6 Holddown	N/A			N/A	
	1st Floor Shearwall 7 Bracing	Let-in brace/pressbd	176	$0.580	$102.08	
	1st Floor Shearwall 7 Holddown	N/A			N/A	
	1st Floor Shearwall 8 Bracing	Let-in brace/pressbd	176	$0.608	$107.01	Note 4
	1st Floor Shearwall 8 Holddown	1,800 lb	2	$12.141	$24.28	Note 5, Simpson HPAHD42
	Additional FTA to fit shear panels	3 ft^2	2.66667	$25.000	$66.67	Note 5
	1st Floor Shearwall 9 Bracing	Let-in brace/pressbd	107	$0.580	$62.06	
	1st Floor Shearwall 9 Holddown	N/A			N/A	
	2nd Floor Wall bracing	Let-in brace/pressbd	1045	$0.580	$606.10	
	2nd Floor Holddown	N/A			N/A	
Headers and Opening Framing	2'-4" 1st Header	2-2x4	6	$7.171	$43.03	No floor above
	2'-4" 1st Connection	N/A			N/A	
	2'-4" 1st Header	2-2x6	3	$8.244	$24.73	One floor above
	2'-4" 1st Connection	N/A			N/A	
	3' 1st Header	2-2x4	1	$9.220	$9.22	No floor above
	3' 1st Connection	N/A			N/A	
	3' 1st Header	2-2x6	2	$10.600	$21.20	One floor above
	3' 1st Connection	N/A			N/A	
	3'-2" 1st Header	2-2x6	5	$11.199	$55.95	One floor above
	3'-2" 1st Connection	N/A			N/A	
	3'-2" 2nd Header	2-2x4	7	$9.732	$68.12	
	3'-2" 2nd Connection	N/A			N/A	
	4'-6" 1st Header	2-2x6	2	$16.489	$32.98	No floor above
	Additional King Studs	N/A			N/A	
	4'-6" 1st Connection	N/A			N/A	
	4'-6" 2nd Header	2-2x6	1	$16.489	$16.49	
	Additional King Studs	N/A			N/A	
	4'-6" 2nd Connection	N/A			N/A	
	16' 1st Header	2-2x12	1	$89.401	$89.40	
	Additional Jack Studs	N/A			N/A	
	Additional King Studs	N/A			N/A	
	16' 1st Connection	N/A			N/A	
Windows & Doors	No protection required				N/A	
FLOOR STRUCTURE						
Joists	2nd Floor	2x10, 16" o.c.	1017	$1.620	$1,647.54	
Sheathing/ Diaphragm	2nd Floor Sheathing	5/8" ply	1017	$0.890	$905.13	
	2nd Floor Nail Spacing	8:12 8d			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	Main End Wall	1/2" bolt every 6'	14	$2.320	$32.48	
	Main Side Wall	1/2" bolt every 6'	15	$2.320	$34.80	
	Garage End Wall	1/2" bolt every 6'	5	$2.320	$11.60	
	Garage Side Wall	1/2" bolt every 6'	5	$2.320	$11.60	
	Family End Wall	1/2" bolt every 6'	4	$2.320	$9.28	
	Family Side Wall	1/2" bolt every 6'	5	$2.320	$11.60	

House Total = $16,803.54

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. A cost factor of 1.9 was multiplied to gable roof framing to determine the cost of hipped roof framing (Means Residential Cost Data)
3. A cost factor of 1.4 was multiplied to gable roof sheathing to determine the cost of hipped roof sheathing (Means Residential Cost Data)
4. Let-in brace with press board for 75% of wall area and 7/16" OSB 8-12 8d for 25% of wall area
   The following price adjustments were made:

   0.25 x $0.69 = 0.1725
   0.75 x $0.58 = 0.4350
   $0.608 weighted average

5. Holdown addition per section 802.9 "EXCEPTION"

CABO-95 Case Study Evaluation, 2 Story 100 mph fastest mile, Zone 1, 20psf snow load						2 Story HW/LS
Category	Item	Compliant Solution	Qty	Unit Cost	Total Cost	Design and Cost Notes
ROOF STRUCTURE						
Framing	6:12 pitch, Hipped, Main	2x6, 16" o.c.	964	$3.458	$3,333.51	14 ft span @ 6:12 and 11 ft span @ 10:12, Note 2
	6:12 pitch, Hipped, Garage	2x6, 16" o.c.	484	$2.679	$1,296.64	11 ft span @ 6:12 and 9 ft span @ 10:12, Note 2
	10:12 pitch, Gable, Family	2x6, 16" o.c.	276	$1.575	$434.70	7 ft span
	10:12 pitch, Gable, Entrance	2x6, 16" o.c.	54	$1.575	$85.05	7 ft span
Sheathing/ Diaphragm	Sheathing, 6:12 pitch, Main	7/16" OSB	964	$1.288	$1,241.63	Note 3
	Nail Spacing, 6:12 pitch, Main	6:12 8d			N/A	
	Sheathing, 6:12 pitch, Garage	7/16" OSB	484	$1.288	$623.39	Note 3
	Nail Spacing, 6:12 pitch, Garage	6:12 8d			N/A	
	Sheathing, 10:12 pitch, Family	7/16" OSB	276	$0.970	$267.72	
	Nail Spacing, 10:12 pitch, Family	6:12 8d			N/A	
	Sheathing, 10:12 pitch, Entrance	7/16" OSB	54	$0.970	$52.38	
	Nail Spacing, 10:12 pitch, Entrance	6:12 8d			N/A	
Roof Uplift	Roof to Wall, 6:12 pitch, Main	460 lb	102	$1.066	$108.73	Simpson H1
	Wall to Floor, 6:12 pitch, Main	460 lb	102	$1.066	$108.73	Simpson H1
	Roof to Wall, 6:12 pitch, Garage	320 lb	54	$0.530	$28.62	Simpson H4
	Wall to Floor, 6:12 pitch, Garage	320 lb	54	$0.530	$28.62	Simpson H4
	Roof to Wall, 10:12 pitch, Family	213 lb	32	$0.530	$16.96	Simpson H4
	Wall to Floor, 10:12 pitch, Family	213 lb	32	$0.530	$16.96	Simpson H4
	Roof to Wall, 10:12 pitch, Entrance	245 lb	8	$0.530	$4.24	Simpson H4
	Wall to Floor, 10:12 pitch, Entrance	245 lb	8	$0.530	$4.24	Simpson H4
WALL STRUCTURE						
Studs	1st Floor Studs, 16" o.c.	2x6, 16" o.c.	1743	$0.990	$1,725.57	Design Required
	2nd Floor Studs, 16" o.c.	2x6, 16" o.c.	1045	$0.990	$1,034.55	Design Required
Shearwalls & Holdowns	1st Floor Shearwall 1 Bracing	Double 7/16" 3:12 8d	165	$1.480	$244.20	Design Required
	1st Floor Shearwall 1 Holddown	3,282 lb	8	$12.141	$97.13	Simpson HPAHD42
	1st Floor Shearwall 2 Bracing	Double 15/32" 3:12 10d	141	$1.680	$265.08	Design Required
	1st Floor Shearwall 2 Holddown	6,532 lb	6	$28.254	$169.52	Simpson HD8A
	1st Floor Shearwall 3 Bracing	7/16" 3:12 8d	157	$0.740	$116.18	Design Required
	1st Floor Shearwall 3 Holddown	2,234 lb	10	$10.578	$105.78	Simpson PAHD42
	1st Floor Shearwall 4 Bracing	Double 7/16" 3:12 8d	112	$1.480	$165.76	Design Required
	1st Floor Shearwall 4 Holddown	2,234 lb	4	$10.578	$42.31	Simpson PAHD42
	Additional FT^ to fit shear panels	51 ft^2	51.2	$65.000	$3,328.00	
	1st Floor Shearwall 5 Bracing	5/16" 6:12 8d	373	$0.610	$227.53	Design Required
	1st Floor Shearwall 5 Holddown	751 lb	10	$5.156	$51.56	Simpson ETA40
	1st Floor Shearwall 6 Bracing	7/16" 4:12 8d	336	$0.715	$240.24	Design Required
	1st Floor Shearwall 6 Holddown	2,065 lb	6	$10.578	$63.47	Simpson PAHD42
	1st Floor Shearwall 7 Bracing	7/16" 6:12 8d	176	$0.690	$121.44	Design Required
	1st Floor Shearwall 7 Holddown	1,455 lb	2	$10.578	$21.16	Simpson PAHD42
	1st Floor Shearwall 8 Bracing	15/32" 3:12 10d	176	$0.940	$165.44	Design Required
	1st Floor Shearwall 8 Holddown	1,189 lb	4	$10.578	$42.31	Simpson PAHD42
	Additional FT^ to fit shear panels	12 ft^2	12.3	$25.000	$307.50	
	1st Floor Shearwall 9 Bracing	Double 7/16" 3:12 8d	107	$1.480	$158.36	Design Required
	1st Floor Shearwall 9 Holddown	3,282 lb	6	$12.141	$72.85	Simpson HPAHD42
	2nd Floor Wall bracing	7/16" OSB 3:12 8d	1045	$0.740	$773.30	Design Required
	2nd Floor Holddown	2,115 lb	20	$25.708	$514.16	Simpson HD2A
Headers and Opening Framing	2'-4" 1st Header	2-2x4	6	$7.171	$43.03	No floor above
	2'-4" 1st Connection	373 lb	12	$1.873	$22.48	Simpson A35F & ETA12
	2'-4" 1st Header	2-2x6	3	$8.244	$24.73	One floor above
	2'-4" 1st Connection	805 lb	6	$6.764	$40.58	2 Simpson A35F & ETA40
	3' 1st Header	2-2x4	1	$9.220	$9.22	No floor above
	3' 1st Connection	720 lb	2	$6.764	$13.53	2 Simpson A35F & ETA40
	3' 1st Header	2-2x6	2	$10.600	$21.20	One floor above
	3' 1st Connection	1035 lb	4	$12.286	$49.14	2 Simpson LTP4 & PAHD42
	3'-2" 1st Header	2-2x6	5	$11.189	$55.95	One floor above
	3'-2" 1st Connection	1093 lb	10	$12.286	$122.86	2 Simpson LTP4 & PAHD42
	3'-2" 2nd Header	2-2x4	7	$9.732	$68.12	
	3'-2" 2nd Connection	1150 lb	14	$14.562	$203.87	2 Simpson LTP4 & HD2A
	4'-8" 1st Header	2-2x6	2	$16.489	$32.98	No floor above
	Additional King Studs	N/A			N/A	
	4'-8" 1st Connection	746 lb	4	$6.764	$27.06	2 Simpson A35F & ETA40
	4'-8" 2nd Header	2-2x6	1	$16.489	$16.49	
	Additional King Studs	N/A			N/A	
	4'-8" 2nd Connection	1610 lb	2	$15.416	$30.83	3 Simpson LTP4 & HD2A
	16' 1st Header	2-2x12	1	$89.401	$89.40	
	Additional Jack Studs	N/A			N/A	
	Additional King Studs	N/A			N/A	
	16' 1st Connection	3840 lb	2	$20.725	$41.45	4 Simpson MTS12 & HPAHD42
Windows & Doors	No protection required				N/A	
FLOOR STRUCTURE						
Joists	2nd Floor	2x10, 16" o.c.	1017	$1.620	$1,647.54	
Sheathing/ Diaphragm	2nd Floor Sheathing	5/8" ply	1017	$0.890	$905.13	
	2nd Floor Nail Spacing	6:12 8d			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	Main End Wall	1/2" bolt every 6'	14	$2.320	$32.48	
	Main Side Wall	1/2" bolt every 6'	15	$2.320	$34.80	
	Garage End Wall	1/2" bolt every 6'	5	$2.320	$11.60	
	Garage Side Wall	1/2" bolt every 6'	5	$2.320	$11.60	
	Family End Wall	1/2" bolt every 6'	4	$2.320	$9.28	
	Family Side Wall	1/2" bolt every 6'	5	$2.320	$11.60	

House Total = $21,282.47

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. A cost factor of 1.9 was multiplied to gable roof framing to determine the cost of hipped roof framing (Means Residential Cost Data)
3. A cost factor of 1.4 was multiplied to gable roof sheathing to determine the cost of hipped roof sheathing (Means Residential Cost Data)
4. Wall designed according to ASCE7-95
5. Design costs not included

ASCE7-95 Evaluation, 2 Story "Case Study" 85 mph (3 sec. gust), Zone 4, 30psf						2 Story LW/HS
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	8:12 pitch, Hipped, Main	2x10, 16" o.c.	964	$4.119	$3,970.91	14 ft span @ 8:12 and 11 ft span @ 10:12, Note 2
	8:12 pitch, Hipped, Garage	2x8, 16" o.c.	484	$3.458	$1,673.67	11 ft span @ 8:12 and 9 ft span @ 10:12, Note 2
	10:12 pitch, Gable, Family	2x6, 16" o.c.	276	$1.575	$434.70	7 ft span
	10:12 pitch, Gable, Entrance	2x6, 16" o.c.	54	$1.575	$85.05	7 ft span
Sheathing/ Diaphragm	Sheathing, 8:12 pitch, Main	7/16" OSB	964	$1.288	$1,241.63	Note 3
	Nail Spacing, 8:12 pitch, Main	6:12 8d			N/A	
	Sheathing, 8:12 pitch, Garage	7/16" OSB	484	$1.288	$623.39	Note 3
	Nail Spacing, 8:12 pitch, Garage	6:12 8d			N/A	
	Sheathing, 10:12 pitch, Family	7/16" OSB	276	$0.970	$267.72	
	Nail Spacing, 10:12 pitch, Family	6:12 8d			N/A	
	Sheathing, 10:12 pitch, Entrance	7/16" OSB	54	$0.970	$52.38	
	Nail Spacing, 10:12 pitch, Entrance	6:12 8d			N/A	
Roof Uplift	Roof to Wall, 8:12 pitch, Main	297 lb	102	$0.530	$54.06	Simpson H4
	2nd Floor, 8:12 pitch, Main	191 lb			N/A	Conventional nailing OK
	1st Floor, 8:12 pitch, Main	N/A			N/A	
	Roof to Wall, 8:12 pitch, Garage	205 lb	54	$0.530	$28.62	Simpson H4
	1st Floor, 8:12 pitch, Garage	99 lb			N/A	Conventional nailing OK
	Roof to Wall, 10:12 pitch, Family	141 lb			N/A	Conventional nailing OK
	1st Floor, 10:12 pitch, Family	35 lb			N/A	Conventional nailing OK
	Roof to Wall, 10:12 pitch, Entrance	141 lb			N/A	Conventional nailing OK
	2nd Floor, 10:12 pitch, Entrance	35 lb			N/A	Conventional nailing OK
	1st Floor, 10:12 pitch, Entrance	N/A			N/A	
WALL STRUCTURE						
Studs	1st Floor Studs, 16" o.c.	2x4, 16" o.c.	1743	$0.790	$1,376.97	
	2nd Floor Studs, 16" o.c.	2x4, 16" o.c.	1045	$0.790	$825.55	
Shearwalls & Holddowns	1st Floor Shearwall 1 Bracing	7/16" 2:12 8d	165	$0.790	$130.35	
	1st Floor Shearwall 1 Holddown	1,965 lb	8	$10.578	$16.58	Simpson PAHD42
	1st Floor Shearwall 2 Bracing	7/16" 2:12 8d	141	$0.790	$111.39	
	1st Floor Shearwall 2 Holddown	2,265 lb	8	$10.578	$16.58	Simpson PAHD42
	1st Floor Shearwall 3 Bracing	5/16" 6:12 8d	157	$0.610	$95.77	
	1st Floor Shearwall 3 Holddown	766 lb	10	$5.156	$51.56	Simpson ETA40
	1st Floor Shearwall 4 Bracing	7/16" 3:12 8d	112	$0.740	$82.88	
	1st Floor Shearwall 4 Holddown	860 lb	4	$5.156	$20.62	Simpson ETA40
	Additional FT^ to fit shear panels	51 ft^2	51.2	$65.000	$3,328.00	
	1st Floor Shearwall 5 Bracing	5/16" 6:12 8d	373	$0.610	$227.53	
	1st Floor Shearwall 5 Holddown	615 lb	10	$1.069	$10.69	Simpson ETA12
	1st Floor Shearwall 6 Bracing	7/16" 6:12 8d	336	$0.690	$231.84	
	1st Floor Shearwall 6 Holddown	1,197 lb	8	$10.578	$63.47	Simpson PAHD42
	1st Floor Shearwall 7 Bracing	5/16" 6:12 8d	176	$0.610	$107.36	
	1st Floor Shearwall 7 Holddown	498 lb	2	$1.069	$2.14	Simpson ETA12
	1st Floor Shearwall 8 Bracing	7/16" 4:12 10d	176	$0.715	$125.84	
	1st Floor Shearwall 8 Holddown	498 lb	4	$1.069	$4.28	Simpson ETA12
	Additional FT^ to fit shear panels	12 ft^2	12.3	$25.000	$307.50	
	1st Floor Shearwall 9 Bracing	7/16" 2:12 8d	107	$0.790	$84.53	
	1st Floor Shearwall 9 Holddown	1,965 lb	8	$10.578	$16.58	Simpson PAHD42
	2nd Floor Wall bracing	5/16" 6:12 8d	1045	$0.610	$637.45	
	2nd Floor Holddown	711 lb	20	$2.136	$42.72	Simpson MSTA24
Headers and Opening Framing	2'-4" 1st Header	2-2x6	6	$8.244	$49.46	No floor above
	2'-4" 1st Connection	259 lb	12	$1.873	$22.48	Simpson A35F & ETA12
	2'-4" 1st Header	2-2x6	3	$8.244	$24.73	One floor above
	2'-4" 1st Connection	3 lb			N/A	Conventional nailing OK
	3' 1st Header	2-2x6	1	$10.600	$10.60	No floor above
	3' 1st Connection	334 lb	2	$1.873	$3.75	Simpson A35F & ETA12
	3' 1st Header	2-2x8	2	$12.430	$24.86	One floor above
	3' 1st Connection	5 lb			N/A	Conventional nailing OK
	3'-2" 1st Header	2-2x8	5	$13.121	$65.61	One floor above
	3'-2" 1st Connection	5 lb			N/A	Conventional nailing OK
	3'-2" 2nd Header	2-2x6	7	$11.189	$78.32	
	3'-2" 2nd Connection	353 lb	14	$1.544	$21.62	Simpson A35F & MSTA9
	4'-8" 1st Header	2-2x12	2	$26.075	$52.15	
	4'-8" 1st Connection	7 lb			N/A	Conventional nailing OK
	4'-8" 2nd Header	2-2x10	1	$23.450	$23.45	
	4'-8" 2nd Connection	520 lb	2	$2.990	$5.98	Simpson LTP4 & MSTA24
	16' 1st Header	3x10 Glu Lam	1	$136.080	$136.08	
	Additional Jack Studs	2x6 Stud Grade			N/A	
	Additional King Studs	2x6 Stud Grade			N/A	
	16' 1st Connection	1,784 lb	2	$14.670	$29.74	2 Simpson MTS12 & PAHD42
Windows & Doors	No Protection Required				N/A	
FLOOR STRUCTURE						
Joists	2nd Floor	2x10, 16" o.c.	1017	$1.620	$1,647.54	
Sheathing/ Diaphragm	2nd Floor Sheathing	5/8" ply	1017	$0.890	$905.13	
	2nd Floor Nail Spacing	6:12 8d			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	Main End Wall	5/8" bolt every 6'	14	$3.010	$42.14	
	Main Side Wall	5/8" bolt every 6'	15	$3.010	$45.15	
	Garage End Wall	5/8" bolt every 6'	5	$3.010	$15.05	
	Garage Side Wall	5/8" bolt every 6'	5	$3.010	$15.05	
	Family End Wall	5/8" bolt every 6'	4	$3.010	$12.04	
	Family Side Wall	5/8" bolt every 6'	5	$3.010	$15.05	

House Total = $10,598.28

Notes:

1. Unless noted all members are No. 2 S.P.F. or Hem Fir
2. A cost factor of 1.9 was multiplied to gable roof framing to determine the cost of hipped roof framing (Means Residential Cost Data)
3. A cost factor of 1.4 was multiplied to gable roof sheathing to determine the cost of hipped roof sheathing (Means Residential Cost Data)

ASCE7-95 Evaluation, 2 Story "Case Study" 127 mph (3 sec. gust), Zone 1, 20psf						2 Story HW/LS
Category	**Item**	**Compliant Solution**	**Qty**	**Unit Cost**	**Total Cost**	**Design and Cost Notes**
ROOF STRUCTURE						
Framing	8:12 pitch, Hipped, Main	3x10, 16" o.c.	984	$5.968	$5,753.06	14 ft span @ 8:12 and 11 ft span @ 10:12, Note 2
	8:12 pitch, Hipped, Garage	2x10, 16" o.c.	484	$4.119	$1,993.69	11 ft span @ 8:12 and 9 ft span @ 10:12, Note 2
	10:12 pitch, Gable, Family	2x6, 16" o.c.	276	$1.575	$434.70	7 ft span
	10:12 pitch, Gable, Entrance	2x6, 16" o.c.	54	$2.000	$108.00	7 ft span
Sheathing/ Diaphragm	Sheathing, 8:12 pitch, Main	7/16" OSB	984	$1.315	$1,267.27	Note 3
	Nail Spacing, 8:12 pitch, Main	6:8 8d			N/A	
	Sheathing, 8:12 pitch, Garage	7/16" OSB	484	$1.315	$636.27	Note 3
	Nail Spacing, 8:12 pitch, Garage	6:8 8d			N/A	
	Sheathing, 10:12 pitch, Family	7/16" OSB	276	$0.990	$273.24	
	Nail Spacing, 10:12 pitch, Family	6:8 8d			N/A	
	Sheathing, 10:12 pitch, Entrance	7/16" OSB	54	$0.990	$53.46	
	Nail Spacing, 10:12 pitch, Entrance	6:8 8d			N/A	
Roof Uplift	Roof to Wall, 8:12 pitch, Main	883 lb	102	$2.152	$219.50	Simpson H10
	2nd Floor, 8:12 pitch, Main	756 lb	102	$2.152	$219.50	Simpson H10
	1st Floor, 8:12 pitch, Main	483 lb	102	$1.068	$108.73	Simpson H1
	Roof to Wall, 8:12 pitch, Garage	617 lb	54	$2.152	$116.21	Simpson H10
	1st Floor, 8:12 pitch, Garage	511 lb	54	$1.068	$57.56	Simpson H1
	Roof to Wall, 10:12 pitch, Family	420 lb	32	$0.590	$18.88	Simpson H3
	1st Floor, 10:12 pitch, Family	313 lb	32	$0.530	$16.96	Simpson H4
	Roof to Wall, 10:12 pitch, Entrance	473 lb	8	$0.590	$4.72	Simpson H3
	2nd Floor, 10:12 pitch, Entrance	367 lb	8	$0.590	$4.72	Simpson H3
	1st Floor, 10:12 pitch, Entrance	167 lb			N/A	Conventional nailing OK
WALL STRUCTURE						
Studs	1st Floor Studs, 16" o.c.	2x6, 16" o.c.	1743	$0.990	$1,725.57	
	2nd Floor Studs, 16" o.c.	2x6, 16" o.c.	1045	$0.990	$1,034.55	
Shearwalls & Holdowns	1st Floor Shearwall 1 Bracing	Double 7/16" 3:12 8d	185	$1.480	$244.20	
	1st Floor Shearwall 1 Holddown	3,282 lb	8	$12.141	$97.13	Simpson HPAHD42
	1st Floor Shearwall 2 Bracing	Double 15/32" 3:12 10d	141	$1.880	$265.08	
	1st Floor Shearwall 2 Holddown	6,532 lb	6	$28.254	$169.52	Simpson HD8A
	1st Floor Shearwall 3 Bracing	7/16" 3:12 8d	157	$0.740	$116.18	
	1st Floor Shearwall 3 Holddown	2,234 lb	10	$10.578	$105.78	Simpson PAHD42
	1st Floor Shearwall 4 Bracing	Double 7/16" 3:12 8d	112	$1.480	$165.76	
	1st Floor Shearwall 4 Holddown	2,234 lb	4	$10.578	$42.31	Simpson PAHD42
	Additional FT^ to fit shear panels	51 ft^2	51.2	$85.000	$3,328.00	
	1st Floor Shearwall 5 Bracing	5/16" 6:12 8d	373	$0.610	$227.53	
	1st Floor Shearwall 5 Holddown	751 lb	10	$5.156	$51.56	Simpson ETA40
	1st Floor Shearwall 6 Bracing	7/16" 4:12 8d	336	$0.715	$240.24	
	1st Floor Shearwall 6 Holddown	2,065 lb	6	$10.578	$63.47	Simpson PAHD42
	1st Floor Shearwall 7 Bracing	7/16" 6:12 8d	176	$0.690	$121.44	
	1st Floor Shearwall 7 Holddown	1,455 lb	2	$10.578	$21.16	Simpson PAHD42
	1st Floor Shearwall 8 Bracing	15/32" 3:12 10d	176	$0.940	$165.44	
	1st Floor Shearwall 8 Holddown	1,189 lb	4	$10.578	$42.31	Simpson PAHD42
	Additional FT^ to fit shear panels	12 ft^2	12.3	$25.000	$307.50	
	1st Floor Shearwall 9 Bracing	Double 7/16" 3:12 8d	107	$1.480	$158.36	
	1st Floor Shearwall 9 Holddown	3,282 lb	8	$12.141	$72.85	Simpson HPAHD42
	2nd Floor Wall bracing	7/16" OSB 3:12 8d	1045	$0.740	$773.30	
	2nd Floor Holddown	2,115 lb	20	$25.708	$514.16	Simpson HD2A
Headers and Opening Framing	2'-4" 1st Header	2-2x6	8	$8.244	$49.46	No floor above
	2'-4" 1st Connection	751 lb	12	$6.764	$81.17	2 Simpson A35F & ETA40
	2'-4" 1st Header	2-2x6	3	$8.244	$24.73	One floor above
	2'-4" 1st Connection	495 lb	8	$1.923	$11.54	Simpson LTP4 & ETA12
	3' 1st Header	2-2x6	1	$10.600	$10.60	No floor above
	3' 1st Connection	971 lb	2	$6.764	$13.53	2 Simpson A35F & ETA40
	3' 1st Header	2-2x8	2	$12.430	$24.86	One floor above
	3' 1st Connection	641 lb	4	$6.010	$24.04	Simpson LTP4 & ETA40
	3'-2" 1st Header	2-2x8	5	$13.121	$65.61	One floor above
	3'-2" 1st Connection	675 lb	10	$6.010	$60.10	Simpson LTP4 & ETA40
	3'-2" 2nd Header	2-2x6	7	$11.189	$78.32	
	3'-2" 2nd Connection	1,024 lb	14	$3.844	$53.82	2 Simpson LTP4 & MSTA24
	4'-8" 1st Header	2-2x12	2	$26.075	$52.15	
	4'-8" 1st Connection	996 lb	4	$12.286	$49.14	2 Simpson LTP4 & PAHD42
	4'-8" 2nd Header	2-2x8	1	$19.336	$19.34	
	4'-8" 2nd Connection	1,510 lb	2	$5.980	$11.96	2 Simpson LTP4 & 2 Simpson MSTA24
	16' 1st Header	3x10 GluLam	1	$136.080	$136.08	
	Additional Jack Studs	2x6 Stud Grade	2	$4.410	$8.82	
	Additional King Studs	2x6 Stud Grade	2	$4.410	$8.82	
	16' 1st Connection	5,178 lb	2	$24.794	$49.59	4 Simpson LTP4 & HTT22
Windows & Doors	2416 DH Protection		3	$20.341	$61.02	
	2428 DH Protection		6	$36.163	$216.98	
	3 ft Door Protection		3	$42.590	$127.77	
	3228 DH Protection		12	$49.078	$588.94	
	2-2420 DH Protection		1	$54.244	$54.24	
	2-2428 DH Protection		2	$72.326	$144.65	
	16 ft Garagr Door Protection		1	$154.540	$154.54	
FLOOR STRUCTURE						
Joists	2nd Floor	2x10, 16" o.c.	1017	$1.620	$1,647.54	
Sheathing/ Diaphragm	2nd Floor Sheathing	5/8" ply	1017	$0.890	$905.13	
	2nd Floor Nail Spacing	6:12 8d			N/A	
FOUNDATION STRUCTURE						
Foundation Anchors	Main End Wall	5/8" bolt every 2'	37	$3.010	$111.37	
	Main Side Wall	5/8" bolt every 5'	18	$3.010	$54.18	

APPENDIX C

Local Code Survey Form

BUILDER SURVEY OF LOCAL BUILDING CODE REQUIREMENTS

Name: _____

Title: _____

Department: _____

Address: _____

_____

_____

Phone/Fax: _____

Residential Code Used for Single-Family

BOCA (year) _____
ICBO (year) _____
SBCCI (year) _____
CABO (year) _____

Describe briefly the major local modifications to model code with respect to single-family homes:

_____

_____

_____

Design Conditions:

Ground Snow Load: _____ psf

Wind Speed: _____ mph-fastest-mile

Wind Exposure (B or C): _____

Frost Depth: _____ in. (to bottom of footing)

Percentage of single-family homes failing inspections due to structural problems/non-compliance (circle one):

<5 10 20 30 40 >50

Top five reasons for failed inspections (structural issues only, rank highest to lowest):

1. _____
2. _____
3. _____
4. _____
5. _____

Under what conditions does your jurisdiction require engineering for a single-family home and for what aspects of the structure?

_____

_____

_____

Does your department perform plan reviews for single-family homes? Yes No

Does your department review engineering calculations for single-family homes when required? Yes No NA

What fees are charged for single-family homes?

Permit $_____ Plan Review $_____

Inspection(s) $_____

Other (?) $_____

Other (?) $_____

What types of mandatory inspections does your department perform for single-family homes?

_____

_____

_____

Please Return Completed Form To:

Jay Crandell
NAHB Research Center, Inc.
400 Prince George's Boulevard
Upper Marlboro, MD 20774-8731
800-638-8556/301-218-8827 (fax)

NAHB RESEARCH CENTER

400 Prince George's Boulevard • Upper Marlboro, MD 20774-8731 • (301) 249-4000 • FAX (301) 249-0305