SSIC PANEL
DEMONSTRATION HOUSE
PHASE I — FIRST DESIGN
PHASE II — SECOND DESIGN

ENERGY EFFICIENT INDUSTRIALIZED HOUSING RESEARCH PROGRAM

CENTER FOR HOUSING INNOVATION
UNIVERSITY OF OREGON

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SSIC PANEL DEMONSTRATION HOUSE PROJECT
INDUSTRY PARTNERS

AFM Corporation
American Standard
Ashland Chemical
BASF Corp.
Bonneville Power Administration
Brownlee Lighting
Cadet Manufacturing Co.
Challenger Electrical Equipment Corp.
DEC International
Dura Undercushions, Ltd.
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Wasco Products, Inc.
Western Red Cedar Lumber Association
Weyerhaeuser Co.
Willamette Industries
Wirecon

CONTENTS

FIGURES

TABLES

1.0 EXECUTIVE SUMMARY

The Demonstration House project seeks to show that a house built of Stressed Skin Insulating Core (SSIC) panel construction can provide equal energy performance, yet cost $2000 less than an "architecturally equivalent" conventionally framed Reference House which meets stringent Long Term Super Good Cents energy standards (a glossary of terms and phrases is given in Section 8.0; details of the Bonneville Power Administration Super Good Cents Program are given in Appendix 9.1). This report summarizes the first two phases of design work toward the construction of an SSIC panel Demonstration House, as part of the Energy Efficient Industrialized Housing research project funded by the U.S. Department of Energy. Phase I includes the research work through May, 1992 to design and evaluate a prototype house to meet project goals; Phase II continues that work (another cycle of design and evaluation) through April, 1993. The final stage of design and evaluation prior to construction — Phase III — is described in a subsequent report.

Phase I

Phase I of the work described here involves the design of a two story, 1271 square foot SSIC panelized house with three bedrooms and 1-3/4 baths. The program requirements for this house are those of the project developer, the St. Vincent dePaul Society of Lane County. The general form of the house is derived from considerations of compactness for good energy performance, efficient panel utilization, and ease of construction for economy.

This phase of the research also involves cost, structural and energy analyses of both the SSIC Demonstration House and a comparable conventionally framed Reference House. Because the Long Term Super Good Cents energy conservation program offers a $2000 incentive to builders, the SSIC Demonstration House is intended to cost at least this much less than the Reference House. Initial cost analyses of both these versions of the house shows that the SSIC Demonstration House shell — if built in Eugene, Oregon in 1990 — would cost $17,752.18, $2,651.97 more than the conventionally framed Reference House at $15,100.21. Square foot costs for the two house shells (less foundations, interior walls, plumbing, wiring and mechanical systems) would be $14.00 for the SSIC

and $11.91 for the conventionally framed houses, respectively. Thus the difference in square foot costs is $2.09.

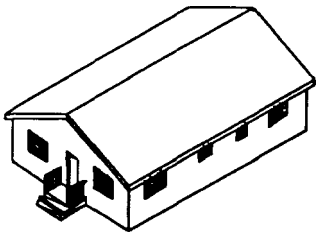
Comparative energy analysis shows that the SSIC panel house barely fails to match the annual energy budget performance of the Reference House, which was designed to Long Term Super Good Cents prescriptive standards, by 3.2%. However, structural analysis indicates that the SSIC panel Demonstration House as designed is unnecessarily strong, suggesting potential cost savings.

Phase II

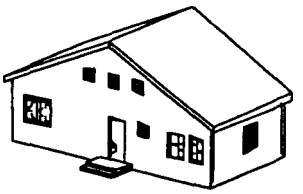
Phase II of the research involves reiterated design efforts and further cost, structural and energy analyses in order to refine and exploit the capabilities of the SSIC panel system as revealed in Phase I. The work began with a series of background studies, summarized in Table 1 - 1, which examined the comparative cost effectiveness of various house configurations.

These study results helped refine the design into a 1-1/2 story, 1260 square foot house with three bedrooms and two baths — the most cost-competitive Demonstration House design among the five alternatives examined. Descriptions and projected envelope component and "whole house" costs for these designs are given in Appendices 10.1 through 10.5 for both the SSIC panel (Demonstration) and conventionally built (Reference) versions.

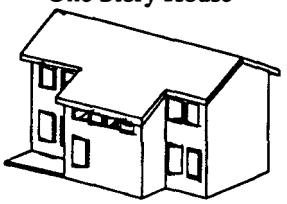
To simplify the cost comparison process in Phase II, comparisons were made between SSIC panel Demonstration and Reference versions of each house designed only to meet current Oregon Energy Code standards. The BPA has established, however, that the cost of upgrading a typical Reference House to meet Long Term Super Good Cents standards averages $2,000. The cost of the lot is not included in this analysis.



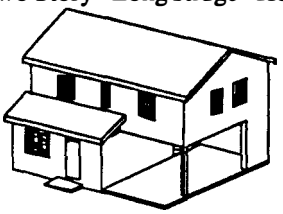
One Story House



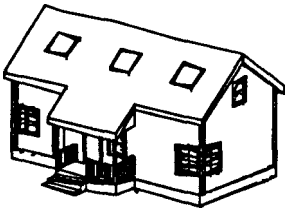
1-1/2 Story "Short Ridge" House



Two Story "Long Ridge" House



Two Story "Crosswise" House



1 1/2 Story "Long Ridge" House

DESIGN		HOUSE ENVELOPE COST BY COMPONENT							
		Roof	Walls	Floors	Int. Floor	Int. Walls	Misc.	Total	Difference
Two Story	**D**	5,237	9,968	4,487	2,597	1,906	12,603	36,801	**5,791**
	R	4,272	6,579	3,018	2,629	1,906	12,603	31,009	
Short Ridge	**D**	5,926	6,783	4,465	2,285	1,640	9,713	30,812	**4,395**
	R	4,272	4,954	3,252	2,586	1,640	9,713	26,417	
Long Ridge	**D**	5,540	6,226	4,011	2,848	1,925	11,339	31,889	**3,682**
	R	4,694	4,235	3,219	2,881	1,839	11,339	28,209	
One Story	**D**	8,332	7,574	8,010	0.00	2,871	12,603	39,392	**8,615**
	R	5,616	4,470	5,216	0.00	2,871	12,603	30,777	
Cross-wise	**D**	4,401	9,624	3,166	2,922	1,906	12,603	34,624	**4,860**
	R	3,449	5,785	2,347	3,718	1,906	12,556	29,763	

TABLE 1- 1
Summary of Background Studies:
Demonstration/Reference House Envelope Cost Comparisons for Five Designs

Further studies examined the relative cost impact of dormers and skylights on the 1-1/2 story "long ridge" design, in order to improve its relative cost position. These studies are summarized in Tables 1-2 and 1-3:

HOUSE ENVELOPE COST BY COMPONENT

	Roof	Walls	Floors	Int. Floor	Int. Walls	Misc.	Total	Difference
D	7302	6227	4011	2848	1926	11339	33653	
R	6642	4235	3219	2881	1839	11339	29955	**3698**

TABLE 1-2
1-1/2 Story Long Ridge House with 2 Dormers + 1 Skylight
Demonstration/Reference House Envelope Cost Comparisons

HOUSE ENVELOPE COST BY COMPONENT

	Roof	Walls	Floors	Int. Floor	Int. Walls	Misc.	Total	Difference
D	6386	6227	4011	2848	1926	11339	32737	
R	5678	4235	3219	2881	1839	11339	29191	**3546**

TABLE 1-3
1-1/2 Story Long Ridge House with 3 Skylights
Preliminary Design Envelope Cost Comparison

Note that these Demonstration House designs, and their associated building costs, reflect the use of SSIC panels throughout the building envelope — for roof, exterior walls and ground floor. The floor application is in fact somewhat rare in present SSIC panel building practice. In this application the structural and thermal characteristics of the panels do not provide an efficient match; the panel thicknesses necessary for customary floor spans result in excessive floor insulation levels.

In Phase II the research also involved a number of cost and structural analyses pertinent to the design. These were focused on a number of subassemblies and components: the panels themselves, examined to optimize cost and thermal performance in the building envelope, and the interaction of panel thickness and window quality, for cost optimization of the entire building thermal envelope. The comparative cost analysis of these five design approaches to the house shows

that the 1-1/2 story "long ridge" design is the most cost competitive user of SSIC panels. This Demonstration House, built in Eugene, Oregon in 1992 would cost $31,889 — $3,682 more than the conventionally framed Reference House at $28,209. Square foot costs for the two house shells (less foundations, interior walls, plumbing, wiring and mechanical systems) would be $25.30 for the SSIC and $22.30 for the conventionally framed houses, respectively. Thus the difference in square foot costs is $3.00.

Analysis of annual energy budgets shows that the SSIC panel Demonstration House barely fails to match the annual energy budget performance of the Reference House, which is designed to Long Term Super Good Cents prescriptive standards, by 3.2%. However, structural analysis indicates that the SSIC panel house as designed provides a margin of excess strength, suggesting cost savings possible through less conservative design. Further cost, structural and energy analyses follow to inform subsequent design efforts, which will attempt to refine and exploit the capabilities of the SSIC panel system.

2.0 INTRODUCTION

This report summarizes the first two phases phase of design work (originally part of Subtask 5.2, "Demonstration Projects," and reorganized in March 1993 as Task 5.1.A, Demonstration Projects - Stressed Skin Insulating Core (SSIC) Panel House) toward the construction of a Stressed Skin Insulating Core (SSIC) panel Demonstration House. Phase I describes the research work through May, 1992; Phase II continues through April, 1993.

The Demonstration House project seeks to show that a house of SSIC construction can provide equal energy performance, yet cost $2000 less than an "architecturally equivalent" conventionally framed Reference House which meets stringent Long Term Super Good Cents energy standards (a glossary of terms and phrases is given in Section 8.0; details of the Bonneville Power Administration Super Good Cents Program are given in Appendix 9.1).

Phase I

Phase I of the work reported here involves the design of a two story, 1271 square foot SSIC panelized house with three bedrooms and 1-3/4 baths. The program requirements for this house are supplied by the project developer, the St. Vincent dePaul Society of Lane County. The general form of the house is derived from considerations of compactness for good energy performance, efficient panel utilization, and ease of construction for economy. The design process and its consequences are described in Section 3.0.

This phase of the research also involves energy, cost and structural analyses of both the SSIC Demonstration version and a comparable conventionally framed Reference House. These analyses and their results are described in Sections 4.0, 5.0, and 6.0, respectively.

Figure 2-1 diagrams the overall strategy of the study. A design for the Demonstration House was developed following program requirements of the developer/research partner, the St. Vincent dePaul Society of Lane County, and general principles such as compactness and simplicity of form which would contribute to energy efficiency and economy — plus whatever concessions the

design team felt would make best use of SSIC panel construction. An architecturally similar Reference House was also described, whose construction and insulation details are drawn from the prescriptive standards of the Long Term Super Good Cents (LTSGC) program.

The WATTSUN computer program was used to establish compliance of both versions of the house with the LTSGC requirements, and CALPAS was employed to examine heat flows in the houses, for instance to determine most effective insulation (panel thickness) placement in the Demonstration House. Finally DOE II was used to compare the annual heating/cooling energy budgets for both houses.

Simultaneously, construction costs for both houses were estimated and compared, to measure progress toward the goal that the Demonstration House should cost $2000 less than its conventionally framed Reference House counterpart.

Last, the structural capabilities of the Demonstration House were examined both to insure design integrity and to discover potential cost savings in excess structural capacity.

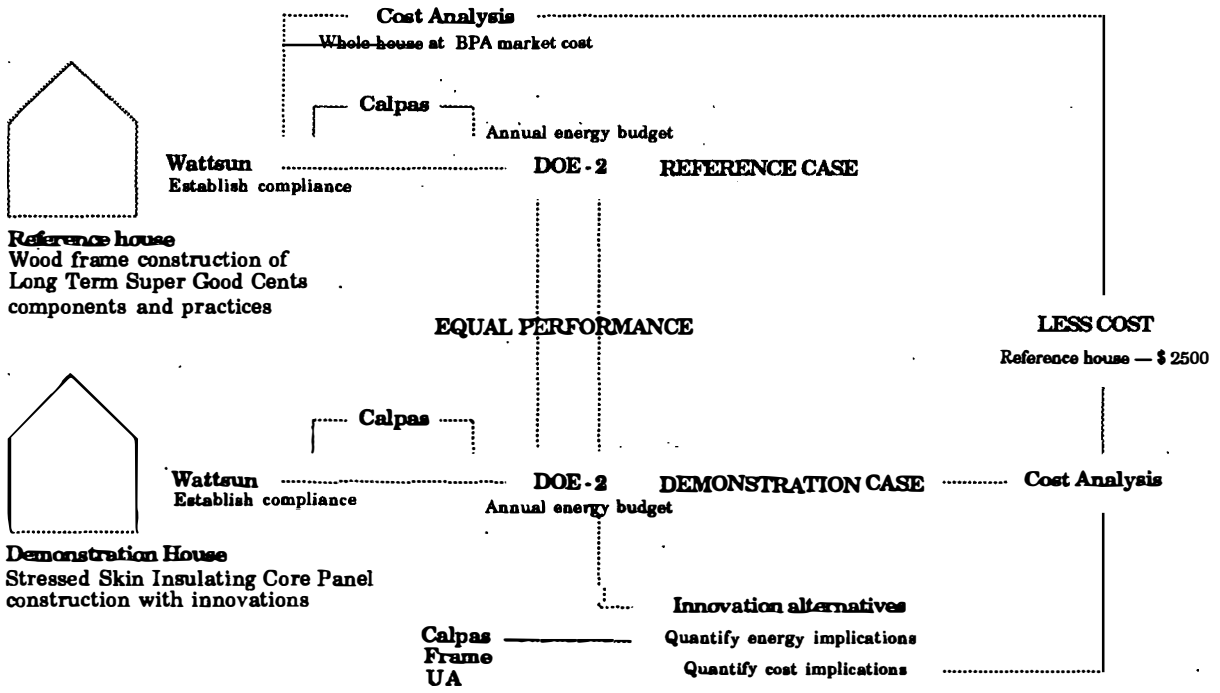
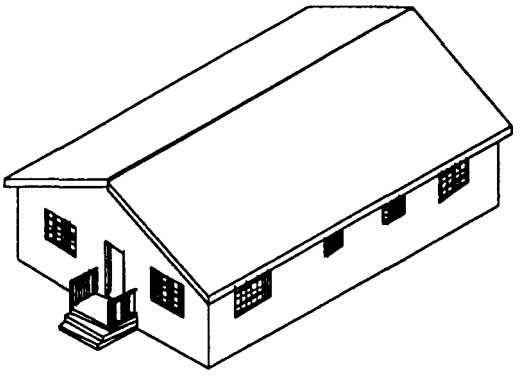


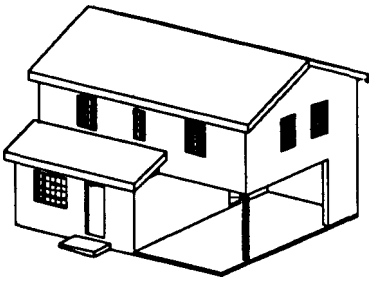
Figure 2-1
Task 5.2 Demonstration Project Overview — Phase I

Phase II

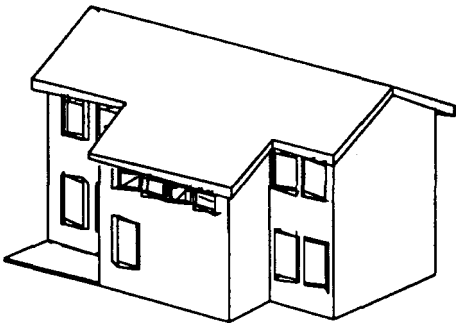
Phase II of the research involved further pursuit of the energy and cost goals established in Phase I. This work involved cost, structural and energy analyses and redesign efforts, in order to refine and exploit the capabilities of the SSIC panel system as revealed in Phase I. A series of background design studies developed and examined the comparative cost competitiveness (SSIC panel vs. conventional construction) of the five different basic house configurations shown in Figure 2-2.



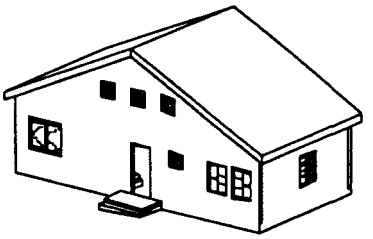
One Story House



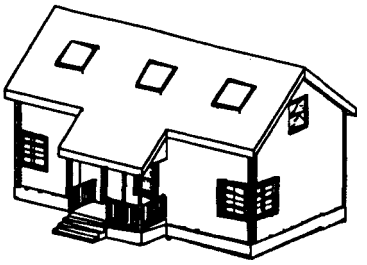
Two Story "Crosswise" House



Two Story "Long Ridge" House



1-1/2 Story "Short Ridge" House



1-1/2 Story "Long Ridge" House

Figure 2-2
Candidate Demonstration House Designs

This design process is described in Section 3.0. Energy analyses are given in Section 4.0. Cost comparisons (Demonstration vs. Reference) for the design alternates are described in Section 5.0. Structural considerations are treated in Section 6.0.

3.0 DESIGN

Phase I Design Criteria

The houses described here have been developed to compare an SSIC panelized Demonstration House to a conventional "stick framed" Reference House with a common annual energy use target. For the purposes of this comparison, the basic design drawings are applicable to either construction method. Construction components and details for the Reference House were derived from the 1991 Long Term Super Good Cents Residential Construction Reference Manual (Appendix 9.1). Components and details for the Demonstration House were generally adapted from published AFM R-Control construction practices and performance data (the AFM Corporation is an industry partner in, and supplier of the SSIC panels for, the Demonstration House project; a complete partner list is given in the front matter of this report).

The Demonstration House examined in Phase I is a two story, 1271 square foot residence with three bedrooms and 1-3/4 baths. The basic program requirements were established by St. Vincent dePaul, the project developer. The design team added the following design objectives: consolidated plumbing core removed from exterior walls, ground level bedroom with rental or office space potential, layout which facilitates cross ventilation and daylighting possibilities, reduced surface-to-volume ratio via two story approach, and a modularization of activity areas to facilitate remodeling or addition.

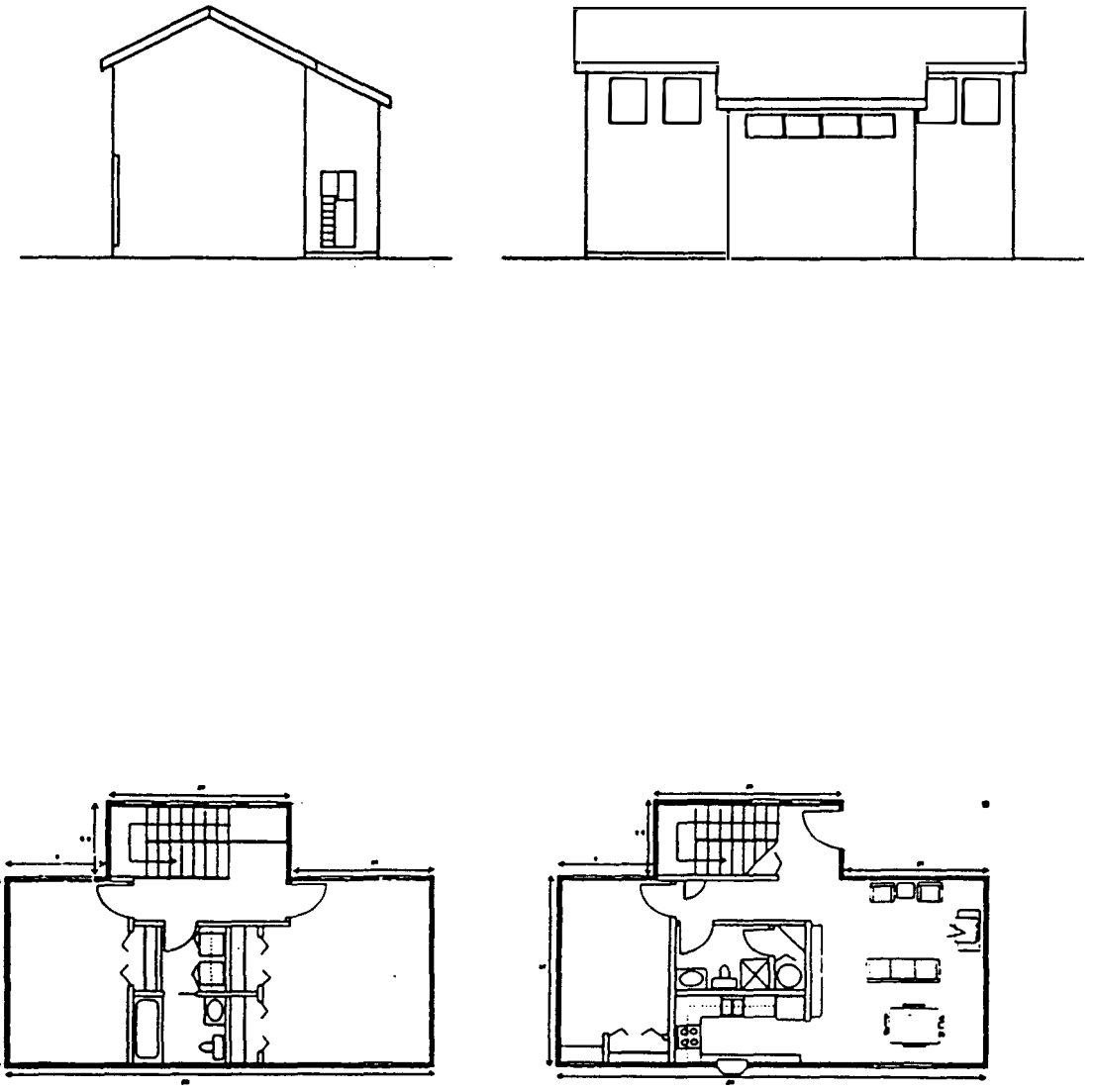


Figure 3-1
Demonstration House

There has been an effort to optimize the design for panelized construction. The dimensions were chosen to minimize the material waste and erection time of a panelized system. In addition, the house was designed to achieve the best match between prescriptive energy requirements of Long Term Super Good Cents Standards and the manufacturer's published structural data (given in Appendix 9.2).

Design Details

The width of the house is based on a 7-3/8" (nominal 8") core thickness, R-30 floor panel spanning 16'-0". The intermediate floor connects, using a ledger system, with floor-to-roof (balloon framed) wall panels. The walls consist of a 5-1/2" core thickness, R-22 panels 4' to 8' wide and 16'-0" tall. The wall panels rest on the foundation along with the floor panel. The 9-3/8" core thickness, R-38 roof panel spans vary from 10' to 18'. This roof construction would provide cathedral ceilings for the upper story bedrooms with a storage loft above the bath.

Vinyl windows with a 0.35 U-value are used to meet Long Term Super Good Cents criteria. The windows have been placed to provide effective cross ventilation and daylighting. Total window area equals 15% of the floor area, and has not been optimized for thermal performance.

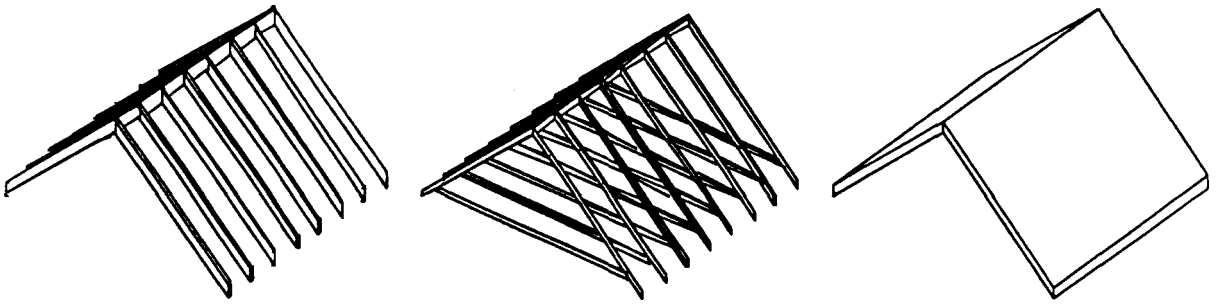
Phase I Unresolved Issues

At the end of Phase I design, several areas of component design appear to warrant further study. The roofing materials initially selected are asphalt shingles; however, an integrated metal roof system might reduce costs. Factory application of gypsum board and T1-11-type structural siding as panel faces might generate savings. Changes in window installation details might eliminate some thermal breaks and reduce labor costs. Foundation system variants to study include pressure treated lumber, continuous concrete and pier systems.

Phase II Design Criteria

Following Phase I of the Demonstration House Task 5.2, a choice was made to consider in the design the Reference House the "most likely to be built" approach, rather than one that was simply "architecturally equivalent." The purpose of this shift was to recognize the cost restraints that affect the average builder. For

example, if a construction company were to build a house with a straight gable roof, the builder would almost certainly use manufactured roof trusses rather than 2x14 conventional lumber for savings in materials and labor, as Figure 3-2 indicates:



RAFTERS $5.60/SF

TRUSSES $5.18/SF

PANELS $7.40/SF

Figure 3-2
Comparative Roof Structure Costs

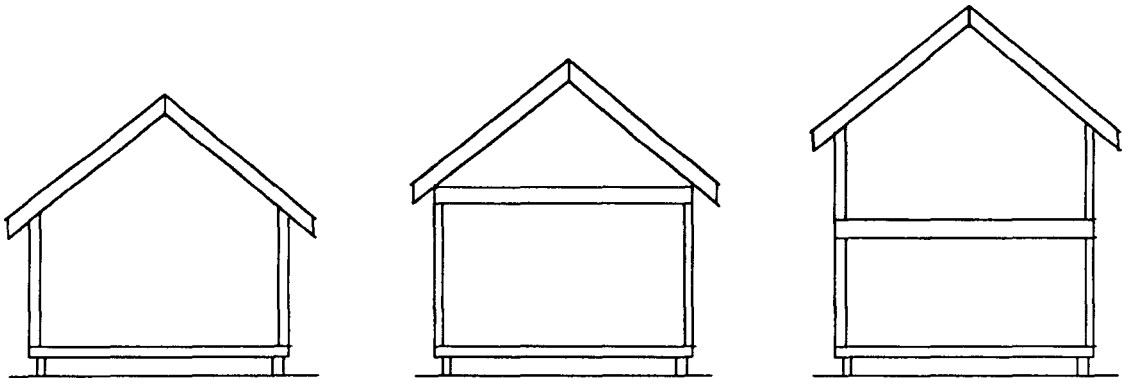
In Phase I, the Demonstration House had difficulty matching the cost performance of the Reference House because the panels were being adapted to conventional building methods. In Phase II, therefore, a decision was made to exploit through design what panels do effectively, but what might be costly to duplicate conventionally. Specifically, the SSIC panel roof, walls and floor were investigated to develop an understanding of their inherent structural and thermal advantages over conventional residential construction.

The results from these investigations led to the selection of a house "type" that would be used to compare the Demonstration and References Houses. In this portion of the study, various house designs were compared using innovations identified with the panels (long spans, vaulted space, reduced labor, etc.). The 1, 1-1/2 and 2 story designs were evaluated based on cost, program adherence and architectural esthetics. From these evaluations, a house design was selected for construction.

Roof

The investigation of SSIC panels for roof applications revealed several advantages. First, the panels offer "free" vaulted space. Roof panels typically clear span from the top plate to the ridge without intermediate support. Because the lower side of the panel has oriented strand board (OSB) applied in the factory, the ceiling is ready for a finish surface. Second, the spanning capability under typical roof loading conditions (35 PSF LL & DL) is good. A typical 10" roof panel can achieve up to a 24' span under these loading conditions (APC International, *Designer's Handbook*, p. 14). The additional thickness required to achieve longer spans is optimally placed in the roof because of the energy performance requirements. Third, panels do not require venting because the exterior skins are laminated directly to the insulation core. Fourth, with exterior skins already in place, the entire roof sheathing step can be eliminated.

Many of the advantages associated with panel roofs such as eliminating the roof sheathing step apply equally to all of the various house designs. The advantage for a particular house type comes from how the panel attributes relate to the inherent spatial qualities associated with that design type. Since the vaulted space provided by roof panels is one of its most desirable features, the design investigation focused on which housing type utilized vaulted space in the most rational fashion. Figure 3-3 shows three house configurations with differing degrees of suitability for SSIC panel construction.



1 Story **1-1/2 Story** **2 Story**

Figure 3-3
Alternate Vaulted Ceiling House Configurations

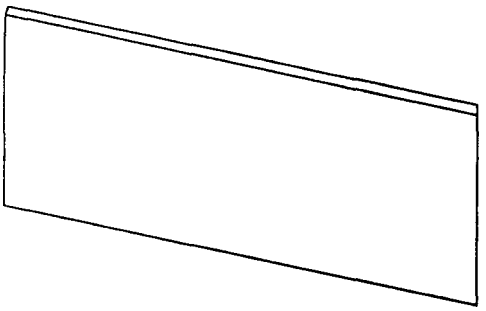
Since all three of the house types shown above have vaulted ceilings, the design question becomes: which type best utilizes the panels' advantages?

Of the houses above, the 1-1/2 story house was the most cost competitive design when compared to a conventionally built version of the same design. Both the single story and the two story house could use scissors trusses to build the vault. With the 1-1/2 story house headroom becomes a problem with scissor trusses; thus the most reasonable method of construction would employ rafters. The addition of a roof dormer would further necessitate the need to use rafters in conventional construction. The increased difficulty associated with building the 1-1/2 story roof with rafters suggested that it provided a competitive opportunity for the panel system.

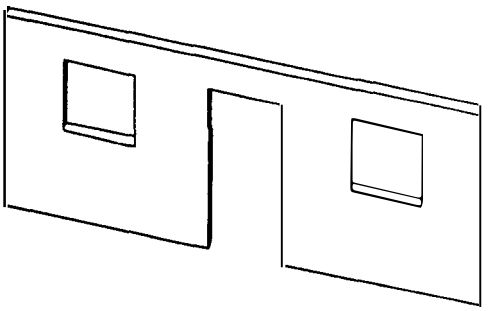
Walls

The walls were the next area investigated in terms of panel advantages. With two layers of OSB laminated to the rigid insulation core, the panels form a tall "box" beam. If the walls perform like beams, the foundation can be point loaded rather than requiring a continuous footing. To achieve the same effect with conventional framing would require extensive shear paneling and would be expensive. Thus another advantage of the panel system might be the elimination of the traditional concrete foundation. A pier foundation using drilled holes as formwork could be fast and inexpensive. Concentrating the building loads in concrete piers would have the advantage of requiring less excavation and grading, in addition to eliminating formwork cost.

Panel size is another major consideration when selecting the most appropriate house type to compete with conventional building. The choice is essentially this: small panels which permit manual assembly, versus large panels which require hoisting machinery but permit very speedy shell construction. Each panel type has advantages and disadvantages which can affect the form of the house. A major advantage of long roof panels is in their spanning ability. Using a long wall panel enables a builder to erect an entire house wall in one step. A disadvantage to long panels, however, is waste. Because a long panel is monolithic, any opening in that wall or roof area must be cut out of the panel.



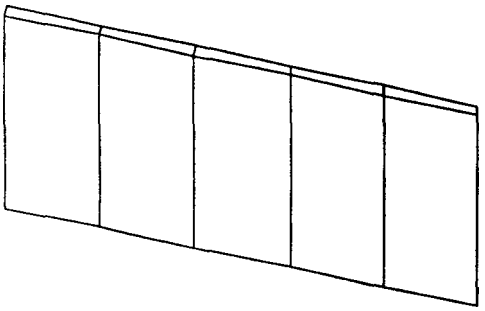
Large Panel-Standard



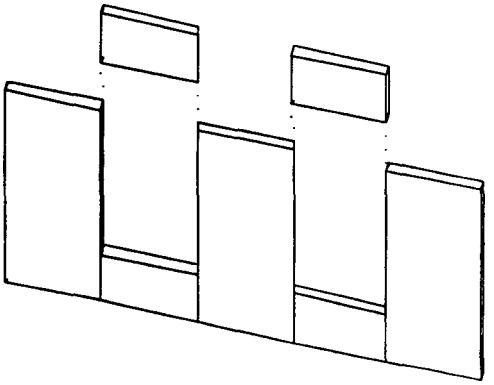
Large Panel-Modified

Panel offcuts are difficult to reuse and often end up as waste. Given the importance of cost in this project, waste figured significantly in the decision between large and small panels. Smaller panels offer an obvious modularity when confronting the issue of waste. A series of small panels can be organized and modified around wall openings to keep waste at a minimum.

The standard width for a small panel is 4'-0". Using this dimension as a guide, wall openings can be designed to fit within a standard grid module. 4'x8' panels could be used to form 4'x4' opening. In this way one 4'x8' panel could be used for two 4'x4' windows without any waste.



Small Panels-Standard



Small Panels-Modified

Both small and large panels use splines for connection. Connecting the panels is one of the most labor intensive phases of construction. A disadvantage associated with small panels is higher labor totals due to the increased number of splines needed to connect them. Also, small wall panels offer less spanning capability as

beams. While this characteristic implies flexibility in some areas, such walls tend to rely on traditional load bearing foundations.

Siding might provide another opportunity for the Demonstration House to achieve an advantage over the Reference House. If the exterior panel OSB layer could be replaced with structural siding material, then the process and cost of siding the house in the field could be eliminated.

Floor

A design objective for the Demonstration House was to provide an entire building envelope of stressed skin panels, meaning that the floor would have to consist of panels. Stressed skin panels are not typically used as floor surfaces, however. The depth that a panel needs to achieve a significant spanning capacity places more insulation in the floor than is required for the most efficient building envelope. Given the thermal requirements for the house and the expense associated with thicker panels, the Demonstration House floor needed to be as thin as possible. Typical floor loads (55 PSF) applied to a thin panel would imply short spans, thus rather closely spaced intermediate supports.

As a floor system, the panels basically behave like a one-way slab. For structural efficiency, this type of structural system implies a regular building footprint. The combination of the limited panel spanning ability and one-way structural behavior led to the decision to pursue a rectangular building footprint.

Structural Cost Summary

Five house designs were developed in one story, 1-1/2 story and two story types. These were compared for suitability for panel construction methods, and for cost competitiveness with conventionally built versions. Of the five house designs evaluated, the 1-1/2 story "long ridge" design was the most cost competitive, and was also judged to utilize panel advantages better than the other designs.

A relatively small wall area helps keep this 1-1/2 story Demonstration House design competitive with the Reference House, and reduces the overall cost of the project (by creating rooms directly under the roof panels, the long ridge exterior wall area is minimized).

The two story house can utilize the vaulted space in a similar way as the long ridge house, but it pays a cost penalty in increased wall area. To fit all the program requirements into the one story version, the building foundation area is so large that the vaulted spaces become unpractical. Also, the width of the one story design requires several intermediate floor supports due to the short spanning ability of the thin panels selected for optimal thermal cost efficiency.

In contrast to the one story design, the 1-1/2 story long ridge house requires only one intermediate floor support. Its 20-foot width requires that the Reference House version also have a similar intermediate support, so that it has no resulting cost advantage.

4.0 ENERGY ANALYSIS

Phase I Process

The Reference House and Demonstration House designs were both modeled on the WATTSUN 5.2 energy code compliance program. This analysis is the initial phase in the process described in Figure 2-1. The Reference House is used as a base case which meets Long Term Super Good Cents standards. This base case is used to establish a reference energy budget on the WATTSUN program which is compared to like designs of the Demonstration House. In this way, the Demonstration House can be tested to be in compliance with the Long Term Super Good Cents goal of the project. The envelope requirements of the Long Term Super Good Cents program are summarized below:

Vaulted ceiling	R-38
Advanced framed walls	R-26
Under floor insulation	R-30
Slab on grade (edge)	R-15
Windows (U-value)	0.35

Table 4-1
Long Term Super Good Cents Insulation Standards
Source: Bonneville Power Administration (Appendix 9.1)

Energy analyses of the Reference House were conducted using the WATTSUN default component U-values established by Ecotope of Seattle (Appendix 9.5). The values for floor, wall, and ceiling of the proposed design components were input into the WATTSUN program based on the Stress Skin Panel Default U-Value Update from the Washington State Energy Office (Appendix 9.5).

Phase I Conclusions

The energy comparison and compliance test reveal a gap between Reference House and Demonstration House performance. Based on the energy budget analysis alone, the Demonstration House fails to comply with LTSGC standards by 3.2%. Given the slight difference, due primarily to a U-value deviation in wall components, it appears that this value would be eliminated by more detailed energy analysis.

Phase II Process

The results of Phase I called for further design work and more detailed energy analysis. As indicated in Figure 2-1, more detailed energy studies were conducted on CALPAS and DOE 2.1C programs; these include alternate thickness and density strategies for SSIC panels, in order to optimize insulation levels and panel costs, and optimization studies of component and whole house insulation volume.

Likewise pertinent are the impacts of infiltration and heat recovery ventilation. The performance of an air-to-air heat exchanger with water heating loop could not be determined by the preliminary energy analysis, but it could have a significant impact on whole house energy use. The exploration of these kinds of questions, however, calls for more precise tools than were available.

For Phase II, the insulation values established by the Bonneville Power Administration were used to establish the total heat loss for the Reference House.

Methodology

A spread sheet was developed using Macintosh Excel to test the overall energy performance of the Demonstration House. This spread sheet was to serve two functions. The main task was to establish the extent of the heat loss through the building envelope. Energy performance of the various building components (floors, walls and roofs) was established using the formula:

$$Q = UAdT$$

An example of an energy analysis for one building component is given below:

Area =	1029.25 sf
T (in) =	68°f
T (out) =	22°f

Component	Material	R value	R/in	Thickness (in)
Int surface	gypsum t=0.5"	0.450		
R2(OSB)		0.810	1.850	0.438
R3	EPS insulation	36.113	3.850	9.380
R4(OSB)	OSB	0.809	1.850	0.438
R5	building paper	0.060		
ext. surface	siding	0.810		
Sum R =		39.053		
air film (in)		0.685	1.460	
air film (out)		0.250	4.000	
Total R =		39.988		
Wall U = 1/R		Wall U value =0.025		
Heat loss		**Q = UAdT = 1184.004**		

TABLE 4-2
Wall Heat Loss Calculations
Note: a complete summary of the Demonstration House energy analysis is given in Appendix 10-6.

A second function of the spread sheet was to determine the optimal placement of insulation in the panel envelope. In preliminary studies of the panels, the R-value per dollar was established for various panel thicknesses. The dollar R-value was used to relate the cost of the panels to the appropriate energy requirements of a building component. For example, the floor panel thickness was determined by relating the energy requirements of the floor and the R-value per dollar. The floor thickness was selected by the most efficient use of R-value.

While the R-value per dollar is greater for the thicker panels, the 11-3/8" panel is not an efficient selection for floor systems because it provides excessive insulation levels and unnecessary expense. R-value per dollar is graphically listed below:

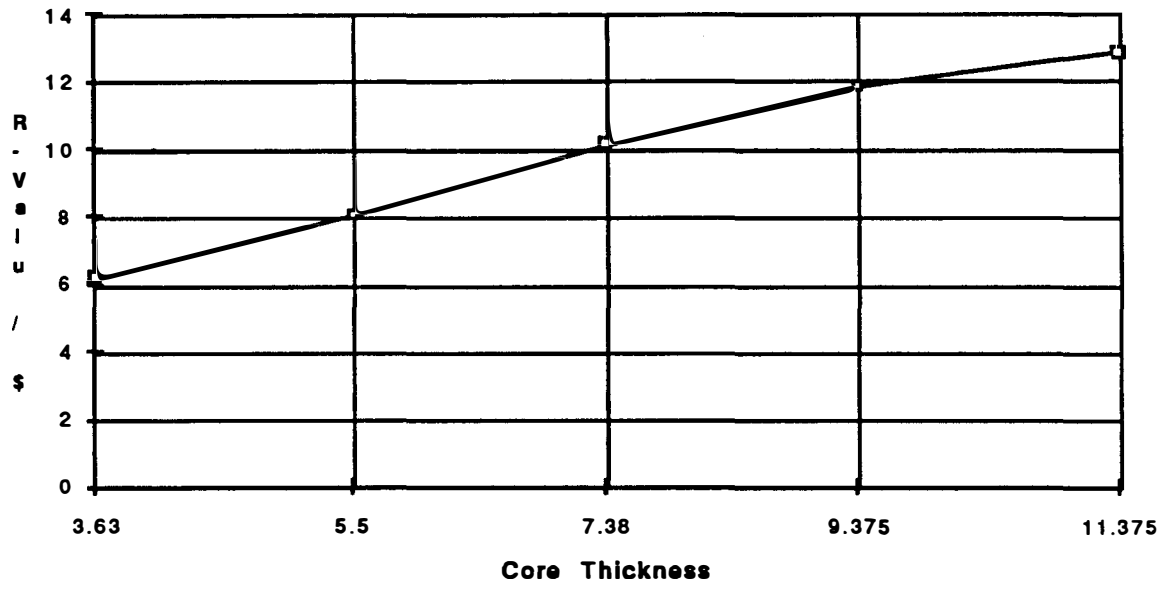


Figure 4-1
R-Value / Dollar vs Core Thickness

The thickness of the various panels was selected by choosing an overall heat loss of the building (determined by Long Term Super Good Cents standards), and combining a variety of panel thicknesses to meet that standard. In the case of the floor, the ceiling thickness was kept constant while changing the floor and walls. This process was repeated for both the walls and the ceiling.

The final configuration of the floor, walls and roof was determined by comparing the energy performance goal for the house and the most efficient use of the panels. A wall/floor analysis is listed in Table 4-3 below. Portions of the table that are italicized satisfy the energy requirements of the building.

Assume Roof = 9.375"
Assume Glazing U=0.35
Q target ≤7400 Btu/hr

Wall	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	Floor
3.00	8451	7804	7369	7056	6821	6637	6489	6368	6267	6181	
3.50	8356	7709	7274	6961	6726	6542	6394	6273	6172	6086	
4.00	8277	7630	7195	6882	6646	6463	6315	6194	6093	6007	
4.50	8211	7563	7128	6815	6580	6396	6248	6127	6026	5940	
5.00	8153	7506	7071	6758	6523	6339	6191	6070	5969	5883	
5.50	8104	7456	7021	6709	6473	6289	6141	6020	5919	5833	
6.00	8061	7413	6978	6665	6430	6246	6098	5977	5876	5790	
6.50	8022	7375	6940	6627	6392	6208	6060	5939	5838	5752	
7.00	7989	7341	6906	6593	6358	6174	6026	5905	5804	5718	
7.50	7958	7311	6876	6563	6327	6144	5996	5875	5774	5688	
8.00	7931	7283	6848	6536	6300	6116	5969	5848	5746	5661	
8.50	7906	7259	6824	6511	6276	6092	5944	5823	5722	5636	
9.00	7884	7236	6801	6489	6253	6069	5922	5800	5699	5613	
9.50	7864	7216	6781	6468	6233	6049	5901	5780	5679	5593	
10.00	7845	7197	6762	6449	6214	6030	5882	5761	5660	5574	

TABLE 4-3
Floor Panel Thickness vs Wall Panel Thickness Meeting Overall Heat Flow Criteria

Based on the comparison of cost and energy performance, the final configuration for the various building components selected by this process is listed as follows:

Component	Thickness	R-value
Walls	8-7/16"	30
Floors	6-3/8"	22
Roof	10-1/4"	38

TABLE 4-4
Final Demonstration House Envelope Panel Configuration

5.0 COST ANALYSIS

Phase I Process

Cost comparisons between the Reference House and Demonstration House are important components of our study. A spreadsheet tool was developed which could calculate all costs associated with house construction. The tool allows the estimator to enter either unit costs with associated quantity of material, or a total cost per component. This process was used for both material and labor costs. In addition, total costs were also computed.

For accuracy, actual contemporary construction costs in Eugene, Oregon, were incorporated; material prices were quoted from local building products suppliers (unless otherwise noted). Labor costs were derived from Means Construction Cost Data 1990 and adjusted for inflation and by the City Cost Index for Eugene.

The City Cost Index is a weighting factor which shows the comparable market costs for materials and installation labor in selected cities, compared to a national average. For Eugene, Oregon, the City Cost Indices are as follows:

Division	Materials	Installation Labor	Total
~~Site Work~~	96.7%	105.8%	100.7%
Formwork	120.7%	94.4%	100.3%
Reinforcing	101.3%	104.9%	102.8%
Cast in Place Concrete	100.7%	124.1%	114.8%
Concrete	104.7%	110.7%	108.5%
Metals	103.4%	111.8%	106.3%
Wood & Plastics	92.2%	92.2%	92.2%
Moisture Protection	86.6%	86.4%	86.5%
Doors, Windows, Glass	101.9%	95.4%	98.6%
Drywall	112.0%	87.9%	100.8%
Flooring	123.2%	95.3%	115.7%
Painting	119.8%	82.4%	90.0%
Finishes	115.2%	86.8%	100.0%
Mechanical	98.7%	94.1%	96.4%
Electrical	102.7%	86.8%	91.7%

Table 5-1
City Cost Index for Eugene, Oregon
Source: Means Construction Cost Data 1990

Because Means Construction Cost Data 1990 was the most recent edition available at the time of the study, it was necessary to inflate the labor and some material costs to 1991 figures. Building material and labor inflation were calculated by comparing the square foot costs of producing five different structures (single family data were not available) from 1988-1991, as tracked in Means Construction Cost Data and Means Assemblies Cost Data. The percentages resulting from the calculations for building material and labor inflation were then averaged to produce a composite average inflation rate.

1989	1990	1991
3.086%	3.192%	3.69%

Table 5-2
Inflation Averages for Construction Material and Labor
Source: Means Construction Cost Data and Means Assemblies Cost Data.

In order to calculate costs taken from Means Construction Cost Data 1990 to input to the spreadsheet tool, the following formula was used:

(material cost) x (inflation rate) x (city cost index) = 1991 cost in Eugene, OR

The spreadsheet tool we used shows costs of individual components of the Reference House and Demonstration House: envelope (roof, floor, and walls), interior partitions, intermediate floor, miscellaneous materials, services, site work, and soft costs. The estimator can enter either unit costs with associated quantity of material or a total cost per component. In addition, the spreadsheet calculates the Total Shell Costs and $/sf, Total Hard Costs and $/sf, Total Soft Costs, and Total House Costs and $/sf.

Using Cost Sheet 1-8 from Appendix 9.6 as an example, Columns A through H show the format and range of inputs to compute house costs. Column I, Adjusted Total Costs, compares Eugene costs to a Means calculated national average. This information will allow us to assess the effect of strategies developed for the Demonstration House in Eugene in other regions or nationwide.

	A	B	C	D	E	F	G	H	I
1	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB $	LAB TOT $	TOTAL $	ADJ TOTAL $
2	ROOF: R-Control 9 3/8"								
3	6@8x10 panel	480	sf	3.35	1608.00	0.59	283.20	1891.20	1915.16
4	2@8x18 panel	288	sf	3.35	964.80	0.59	169.92	1134.72	1149.10
5	2@4x10 panel	80	sf	3.20	256.00	0.59	47.20	303.20	307.19
6	**Panel Sub-Total**	**848**	**sf**		**2828.00**		**500.32**	**3329.12**	**3371.45**

	J	K	L	M	N
1	MAT INDEX	ADJ MAT $	LAB INDEX	ADJ LAB $	NOTES
2					
3	1.000	1608.00	0.922	307.16	Means 4x8 Roof Panel Installation Labor, R-Control Materials
4	1.000	864.80	0.922	184.30	"
5	1.000	256.00	0.922	51.19	"

Figure 5-1
Sample Cost Spreadsheet

Columns J and L list the City Cost Index used for each line, while columns K and M show costs adjusted back to the national average. Column N lists the source of information used and assumptions made by the estimator.

Phase I Conclusions

Initial cost comparison shows that the SSIC Demonstration House shell built in Eugene, Oregon in 1990 would cost $17,752.18 — $2,651.97 more than the conventionally framed Reference House at $15,100.21. Square foot costs for the two house shells (less foundations, interior walls, plumbing, wiring and mechanical systems; assumed to be equal for both houses) would be $14.00 for the Demonstration and $11.91 for the Reference Houses, respectively. Thus the difference in square foot costs is $2.09 greater for the Demonstration House.

It is evident from this initial cost estimate that further reductions are necessary in envelope costs of the Demonstration House — perhaps achieved, for example, by applying exterior siding and interior gypsum wallboard in the factory to offset field labor costs. Another approach is reducing the cost of materials and/or processes in the factory, to lower the panel cost and thus make it more competitive with stick-built construction. Further explorations of the relationship between cost and R-value of the insulation, panel thickness, energy performance, and structural capability are also indicated, and are described in Section 4.0. These and similar questions shaped Phase II of the research.

Phase II Process

The next phase of research focused on optimization of panel capabilities, costs and manufacturing processes in order to make the Demonstration House more cost-competitive with its Reference House counterpart. In addition, exploration of design innovations to exploit the strengths of Stressed Skin Insulating Core panels over conventional construction was continued.

As in Phase I, Means was the data source for estimating material cost and labor. In Phase II, however, Means Residential Cost Data 1992 was used rather than Means Building Construction Cost Data 1992. It was decided that because this project represented a single family prototype and not a series of buildings, a residential estimation would be more appropriate. However, because of the small number of private residences using stressed skin panels, Means Residential Estimator did not have data on installation or cost of stressed skin panels. Therefore, a combined system was developed using data from Means Residential and Construction estimators.

In both the Residential and Construction Cost Data sources, Means assigns a basic unit of production associated with a specific task. With respect to stressed skin panels, the unit is square feet. Means also develops a basic unit of productivity called a "man hour unit," which represents the number of man hours required to produce one unit of work. To estimate the time associated with a given task, the man hour unit is multiplied by the required output. For example:

Quantity	x	Man Hour Unit	=	Duration
1725 SF	x	0.023	=	39.675

The man hour unit is independent of the crew size and represents only what one worker can produce in one hour. Using the data from the example above, a crew of two men would take 2.48 days to set 1725 square feet of wall panel:

2 Workers @ 8 Hours/Day = 16 Manhours/Day
39.625 Manhours/16 Manhours/Days = 2.48 Days

The material and labor rates in Phase II were taken from two sources. The cost of the panels was provided by Premier Building Systems and represents actual dollar amounts. The labor estimate was a combination of Means Residential Cost Data and Means Construction Cost Data, 1992 Editions. To derive the labor cost per square foot for a given task, the manhour unit is multiplied by the worker's hourly rate:

Rate	x	Manhour Unit	=	Labor/SF
$14.85	x	0.023	=	$0.34/SF

The difference between the hourly rate for a commercial carpenter ($21.65/hour) and a residential carpenter ($14.85/hour) required that the labor unit be adjusted for the difference.

As in Phase I, spread sheets were created to estimate the material and labor costs of each building component: floors, walls, roof, etc. The various trades and materials were indexed from the national average to reflect regional differences and are contained in Appendix 10.7. In addition, overhead and profit are included with the base total amount.

Cost and Design

More than any other factor, the relative costs of the Demonstration House and Reference House was the main influence on how design decisions were made. If a particular design feature could be developed that would create a cost advantage for the Demonstration House, then that feature was incorporated into the design. As previously discussed in the design section, the main areas of investigation were the walls, floor and roof. The first step in comparing the two construction methods was to develop an understanding of how the various components measured up to each other in terms of cost. Panel versions and stick versions of the walls, floor and roof were analyzed side by side to see how one square foot of assembly compared with the other. The goal was to get a basic cost per square foot for each of the two systems as a starting point for comparison.

The cost estimate for the 1-1/2 story "Long Ridge" house was broken down by building components. A building component is considered to be a major system

within the house — walls, floors, the roof and foundation, for example. The component estimates were further divided into estimates of materials and labor. A complete list of building components for the Demonstration and Reference Houses is given below:

Component	Material	Labor	Total
Reference House Totals			
Roof	3962.24 60%	2777.85 40%	6740.09
Floor	2456.10 72%	952.12 28%	3408.22
Wall	1883.46 49%	1901.92 51%	3985.38
Demonstration House Totals			
Roof	4772.34 68%	2336.51 32%	7108.85
Floor	3618.08 87%	579.18 13%	4197.26
Wall	3982.56 69%	1896.76 31%	5879.32

TABLE 5-3
Comparative Building Costs by Component
See Appendix 10.7 for full cost breakdowns

For the Demonstration House, the average cost breakdown between materials and labor is 73% and 27%, respectively. For the Reference House the average materials and labor figures are 60% and 40%, respectively. These figures indicate that 42% as much of construction cost for the walls, floor and roof is allocated to labor in the Reference versus the Demonstration House.

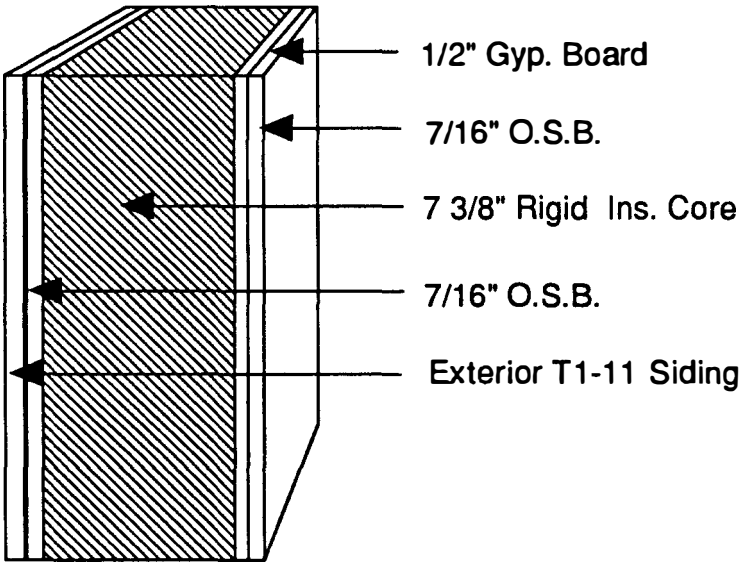
With labor representing the main difference in the envelope cost, the strategy for improving the cost performance of the Demonstration House was to concentrate on reducing field installation time. Combining as many component subtasks as possible (siding applied to the foam in the factory, for example), the amount of

time required to erect the house would be kept at a minimum. Reducing site construction will also lower costs associated with construction loans and administration.

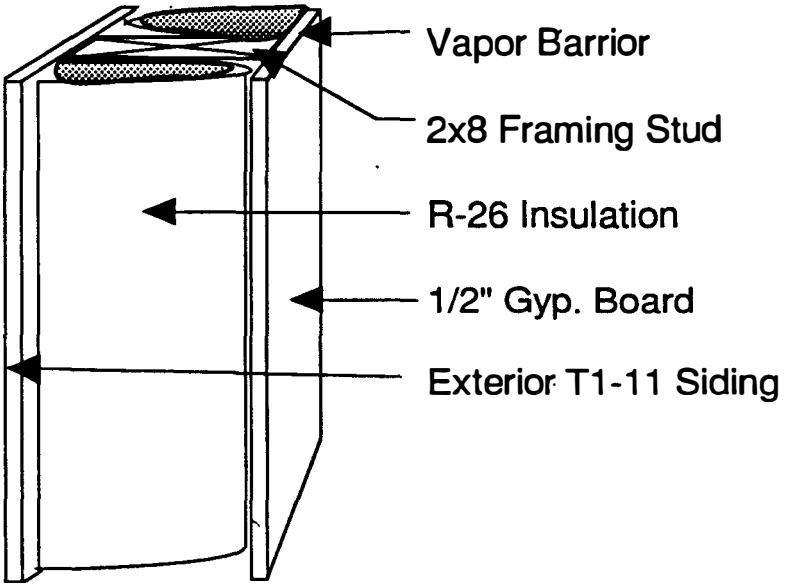
Walls

The cost analysis for the wall panels concentrated on waste and the cost per square foot of a wall assembly. The discussion of waste deals with whether to use large vs. small panels. The large panels have the advantage of reduced labor due to the reduced assembly time, though wall openings must be cut directly from the panel stock. The Demonstration House using large panels would realize $564.00 of waste ($2.95/sf panel cost x 191 sf wall opening). This amount of waste represents 28% of the $2,000 cost savings goal.

Because the cost of wall panels is on the order of $3.00/sf, minimizing panel waste became an important design consideration. At door and window openings, for example, the use of large (full wall) panels requires that openings be cut out, and usually discarded. Using smaller panels to piece around these openings avoids this waste but tends to require more labor, plus a potential energy penalty through increased panel joint length. Calculation of the relative costs of large vs. small panels showed net savings for the small-panel approach. Because of the projected cost savings associated with smaller panels, they were selected for the Demonstration House.



1 Sq. Ft. of SSIC Panel Wall - $3.89 per s.f.



1 Sq. Ft. of Conventionally Framed Wall - $1.89 per s.f.

Figure 5-2
Comparative Wall Costs

Panel assembly is another area where savings can occur. The standard panel assembly consists of two layers of oriented strand board (OSB) laminated to a rigid EPS insulation core. Panels used as walls must have an additional layer of finished siding applied in the field. If this installation could be eliminated through manufacturing, assembly of the house would be simplified. By combining structural siding to the exterior of the panel foam, the installation of the siding of the house could be eliminated in the field. The net cost savings is computed to be $0.33/sf or $370 total. This represents a 7% savings.

Roof

The roof of the Demonstration House was designed to provide maximum cost advantage for SSIC panel construction. An important consideration was to find a roof configuration for which the Reference House could not employ manufactured trusses — usually a very cost-effective structural system. Even using conventional rafters, the Reference House roof is still $980 less expensive than the Demonstration House.

To reduce this margin, a variety of options was explored. The first was the basic idea of altering the panels to combine a variety of field construction steps. Factory applied sheet rock and finished roofing were the two main areas of concentration. While these refinements appear promising, there is still a significant amount of research needed. Structural testing is necessary to confirm the reliability of both roofing and sheet rock as a siding material. In addition, thermal expansion of these materials must be compatible with the rigid insulation core.

Another area of exploration was to combine a dormer with the roof to improve the cost competitiveness of the Demonstration House roof. A variety of dormer configurations was explored. A complete list of dormer configurations is contained in Appendix 10.7. The result of these studies concluded that the cost of panel-fabricated gable dormers was too high.

In contrast, a panel-built shed dormer could compete with a conventionally built version because there was a minimal amount of panel alteration required to build the dormer. The panel layout for the roof is only modified by changing the roof pitch over the dormer. No special cuts are required for fabrication. The only

additional material required is for the wall area around the roof. For the conventionally built Reference version, the additional material to build the dormer is minimal, but labor costs are significant. A comparison of the two shed dormer costs is given below:

Item	Demonstration	Reference
New 12' x 12' dormer roof	659.00	562.91
Front wall (less windows, trim, paint)	157.44	159.53
End walls	265.00	215.16
Total	1081.44	937.60
12' x 18' roof section replaced by dormer	895.28	692.33

Dormer cost difference = 1081.44 - 937.60 = 143.84 (Reference advantage)
Roof section cost difference = 895.28 - 692.33 = 202.95 (Reference advantage)

Use of a dormer reduces the Reference House cost advantage by
202.95 - 143.84 = 59.11

Because it improves the cost competitiveness of the Demonstration House relative to the Reference House, plus offering architectural advantages to the basic house design (stair headroom, south-facing windows, and improved daylighting), a shed dormer was incorporated into the design.

Foundation Cost

In addition to the roof, walls and floor, the foundation is the last major area where a design innovation had a significant cost impact. For the Demonstration House, the goal was to create a foundation that performed with the floor panels as an integrated system — a system uniquely suited to panel floors so that any cost saving wouldn't be passed on to a conventional counterpart. In other words, conventional floor framing couldn't be used with the Demonstration House foundation.

In preliminary cost estimates for foundations using a strip footing and stem wall, 33% of the total foundation cost was associated with formwork. A foundation that

did not require conventional formwork could achieve significant cost savings.

The initial idea for an alternative floor system was to hang the floor off the walls. With the walls acting as beams, the distributed building loads could be carried to bearing points at the ground. Point loading could employ a pier foundation that would not require an exterior stem wall. Replacing a traditional stem wall foundation with a pier foundation would create cost savings by eliminating much of the material cost, form work and site labor.

Due to structural limitations of the panels, the foundation system was modified so that the walls were bearing on top of the floor panels. Even with the modifications, however, the pier support system was maintained. The net result was a foundation cost savings of $1,448.

Conclusion – Reaching the $2000 Goal

Matching the cost of the Reference House is a difficult task for the Demonstration House. While the site labor required to erect a panel home is half that of a conventionally built home, the higher material costs of SSIC panel construction is limiting. On average, the material component assembly cost for panels is $1.50/sf more than its conventionally built counterpart. For panel homes to be as competitive as possible, it is clear that basic material costs must be reduced.

There are two ways to achieve this reduction: the first is to combine as many construction steps as possible. Assembly in the factory would have the affect of reducing waste in the field. Wall, floor and roof components could be designed and assembled with material savings in mind. The "hidden" labor built into the material cost paid by builders must be addressed. New and more efficient manufacturing processes need to be implemented to help reduce the material cost. Eventually the price for panels paid by builders will be less as the demand increases. To stimulate demand for the panels, builders need to be educated about how to build with this relatively new product.

The second way to reduce panel cost is to optimize how panels are assembled. Panels specifically designed to span longer distances as floor slabs, or walls that act as load bearing beams need to be developed. The material cost savings will be

achieved by how one manufactured component integrates with the building as a whole.

An example of this idea is the Demonstration House floor and foundation. The cost of the Demonstration House floor per se was $771 more than that of the Reference House version. This difference was overcome by designing a foundation specifically for a panel floor. The idea employed was to think about the net savings that could be achieved by thinking of building components as a system. The combination of a panel floor with a specially designed foundation yields a $659 cost savings over a conventionally built floor and foundation system. This idea needs to be translated to all other components of the house. Ultimately, for SSIC panel housing to be completely cost competitive, it must be designed around a logical way to build with panels.

6.0 STRUCTURAL ANALYSIS

Phase I Process

The structural components of the Demonstration House were developed using accepted AFM engineering data and specifications. All construction details were derived from the AFM R-Control General Recommendations dated 1991. Both Reference House and Demonstration House comply with 1990 State of Oregon (CABO) One and Two Family Dwelling Code.

Phase I Conclusions

For the Demonstration House, the panel thickness selected for each component was that which most closely corresponded to the Bonneville Power Administration's prescriptive Long Term Super Good Cents energy standards, and met the manufacturer's and CABO structural criteria. However, a preliminary analysis provided by Professor Tom Miller, Department of Civil Engineering at Oregon State University (Appendix 9-7) suggests panel structural capacities in excess of the building's needs. This finding suggests that further refinement might reduce structural performance and cost of the panels.

Component selection for the Demonstration House was based on manufacturer' s data. The AFM R-Control system is based on insulated core thicknesses which correspond to dimensional lumber sizes. By allowing other core thicknesses, however, it is believed that optimization of the structural qualities of panels and panel construction can occur. For example, the use of engineered members to replace dimensional lumber in the component constructions extends the structural capabilities of the system. A system based on optimization of cost, structure and energy performance should be investigated.

Phase II

The decision to design a house that best utilizes the construction advantages associated with SSIC panels requires a complete understanding of how the panels behave structurally. In the case of the Demonstration House, the design was intended to create advantages for panel users. These advantages were to be the result of selecting a house type which best exploits the structural characteristics of the panels. During this phase of the investigation the 1, 1-1/2

and 2 story designs were evaluated to test their compatibility with panel construction. Compatibility in our investigation is gauged by the cost benefits derived from the efficient structural use of the panels. The focus of our investigation is aimed at a maximizing structural efficiency, resulting in cost savings over conventional construction.

Panel Joinery

The panel splice test results we followed (Appendix 10-9) are based on nail spacing of 6" oc, plus structural adhesive. The racking shear calculated is based on this same information using 1x4 splines. The Demonstration House design involves a few localized conditions, however, where more shear strength must be developed than approved by ICBO (such as at openings in shear walls). It seems that a closer spacing of the nails would develop more shear strength, unless the shear is in fact developed by the adhesive, and the nails serve chiefly to hold the parts in place while the adhesive sets.

In the Demonstration House, many of the window openings occupy the full 4' panel width, with a 13" high header panel above the window, and an apron panel below the window. In some cases this assembly occurs in a bearing wall; in others the wall is nonbearing. It would be useful to know what vertical load could be supported by the panel above the opening without using an insulated header supported by vertical framing members. The published tests we employed show the load capacity of such an opening only if it is cut into a larger panel where there are no splices above the window opening at each jamb.

There are also published details that show splines between panels using double 2 x framing members at the joint (such as AF-108, Appendix 10.9), but none that show a single 2 x framing member, as is common in plywood shear walls and diaphragms. This, however, is assumed to be an acceptable joint because the nailing width is marginal.

Structural Properties

For the majority of panel uses in any building, the available information on span and loading conditions for floors, walls and roofs is sufficient. Usually the conventional panel connections are adequate. However, there are situations for

which we need more information to design adequately. Some of these problems are identified as follows:

Floor

Floor panels continuous over an intermediate support, without panel edge framing members, cause a concern not addressed in tests. A two span continuous member has a substantially higher shear than would be encountered in two simple spans.

In addition, the bearing between the panel and beam puts a high localized compressive stress on the foam. Compressive load values are published which result in a 10% panel core deformation. However, this is excessive because on a 5-1/2" core the deflection would exceed 1/2" if the stress is distributed through the panel at some angle (such as 45°) and substantially reducing the compressive stress as the panel thickness increases. We are using 2%, but this may be conservative. We need testing to determine what the maximum compressive stress can be. These questions apply to maximum wall loads on panels without side framing members.

ICBO approval is given to floor and roof panels when they are installed with splines fastened according to published details. However, in two instances we found ICBO reports which seem to contradict this requirement, because they state that normally the floor and roof panels will have splines at the top face only (see Report No. PFC-4645, Assembly Description at bottom of page 5 for Thermosave panels — Appendix 10.9).

Two Story Walls

This system has some problems that need to be resolved. Here the structural concept is based on the wall cantilevering above the second floor to take the thrust of the roof panels. This concept requires the wall panels to be connected to each floor and each wall panel to be continuous for its full height. A large part of the Demonstration House wall, however, does not meet this requirement. The stairway opening on the second floor eliminates anchorage at that point. The openings in the wall for windows and doors disrupt the vertical wall panel continuity at those places.

To overcome these problems the thrust loads need to be distributed horizontally at the top to the wall across the discontinuous wall panels to panels that are continuous from top to bottom. Those continuous wall panels must have adequate strength and stiffness.

A wall panel without side framing members that is continuous from top to bottom is not quite adequate, even assuming the floors and walls have no openings. Framing members at the sides of the panels to reinforce these panels could overcome this problem. A member (plate or structural soffit) across the top of the wall openings could transfer the thrust to the adjacent continuous wall panels. A porch roof or similar stiff element would be required to transfer the thrust loads across the large opening in the second floor. Then a way could be devised to get this larger load transferred to the second floor diaphragm.

Roof

A single **folded plate** structural approach seems to utilize the sandwich panels' ability to resist shear in the plane of the panel. This approach carries spreading thrusts to the ends of the building and is not dependent on the walls' resistance to bending. The long walls would carry only vertical loads, no bending. The thrust could be carried by a rod concealed in the end wall. Half of the total roof load would be carried to the corners through shear in the roof diaphragm.

The vertical wall panels would probably not need side framing members, except possibly at openings. The panels could be either 4 or 8 feet wide. The porch roof or other thrust members described in the two story wall system would not be required.

Openings in the roof could not be close to the edges or ends. Framing members around the perimeter of the sloping diaphragm would be required. Some framing members might be needed along the edges of the panels near the gable end of the roof, if adequate shear could not be developed by the splines alone. More information is required if this system is seriously considered.

This roof would be difficult to build in place because of the scaffolding required. It

might instead be built it on the ground and lifted into place.

Collar tied panels might be prefabricated and then lifted into place, or assembled in place. This approach might use horizontal ties 4' on center at door head height. The ties would eliminate thrust at the wall panels. The long side walls would be designed similar to the folded plate approach, except that there would be no concentrated loads at the corners.

This system seems most amenable to openings in the roof, permitting all types in the 4' panels as long as there is a solid panel adjacent on each side. It would require side framing members on the panel edges. This system would probably be more difficult to build in place than to prefabricate.

The **ridge beam** system is relatively conventional. Openings in the roof would be similar to those of the collar tied system, requiring framing members only at the sides of the panels with openings.

The problem with this system is the ridge beam itself. It would require a large beam, particularly if it spans the full 36' building length (roughly a 1-1/8" x 19-1/2" or 6-3/4" x 18" beam). With a center support a sawn beam (4 x 12) or microlam beam (1-3/4" x 11-7/8") could be used. The support might be either a bearing wall or a "truss" built into a partition wall to transfer the loads to the perimeter. The truss seems preferable to avoid carrying wall loads on the interior of the building. The wall loads would transfer forces to the floor, requiring a larger floor beam, or to a wall below, which could cause excessive forces on the lower floor panels.

This system would be relatively easy to construct, but has little else to offer.

Conclusion

By concentrating on the structural behavior of the various building components (floors, walls and roof) the results could then be applied to the house types. In a general sense, the results of our investigation translate to each type. In creating house designs, however, the structural performance of the panels is clearly impacted by the configuration of that design. As previously stated, cost was the most important factor in deciding which design to develop as the Demonstration

House. In the cases where the structural performance of the panels was a problem, the panel behavior impacted the selection of the house design.

Floor/Foundation System

The spanning ability of the floor panels is limited by their thickness. To achieve significant spans, excessive insulation is allocated to the floor. As a result, a foundation system was designed to provide intermediate supports, permitting use of thinner and more economical panels. A complete list of the foundation studies is collected in Appendix 10-7.

The common link between the different foundation studies was the dependence on two-way slab structural behavior of the floor panels. The floor loads are borne in both long and short panel directions. The foundation was designed to provide just enough intermediate support to achieve the required span and distribute most of the load to the house perimeter. It should also be noted that because of the slenderness of the intermediate supports, this system could not use conventional floor joists.

Walls

Because of the relative weakness of the spline connections, walls composed of a series of narrow panels do not effectively function as beams. The Demonstration House panels were therefore treated like a conventional wall system. The vertical loads are transferred to the perimeter load bearing foundation.

With respect to the various house designs examined, the conventional wall system is applicable to them all. However, the wall system cantilevered past the intermediate floor (2 story and 1-1/2 story designs) has some serious problems. To resist the horizontal thrust of the roof panels, significant modifications to the wall panels would be required, probably including the factory installation of some internal support. In addition, vertical dimensional lumber would be required to assist the panels because of the potential problem of delamination. The panels without the lumber do not have the required stiffness to resist the thrust of the roof. Because of the cost of the necessary modifications and the potential thermal weaknesses with its design, the cantilevered wall system was not pursued.

Roof

A ridge beam is the standard solution for supporting a panel roof. In the Demonstration House, however, a ridge beam poses several problems. First, the basic structural system of the Demonstration House is a perimeter load-bearing system. The panels do not easily accommodate point loads. A center-supported ridge beam would impose a substantial interior point load. In addition, there would be significant point loads at the end walls.

In order to span the 36' length of the house the depth of the ridge beam would be considerable, as noted earlier — potentially a large thermal break. Because of these negative factors, a ridge beam was not seen as a structural solution.

7.0 REFERENCES

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8.0 GLOSSARY

The terms listed below are particularly defined relative to the Stress Skin Insulated Core Demonstration House research project:

Equal energy performance is based on an annual energy budget derived by simulating the performance of a conventionally framed Reference House designed using prescriptive Long Term Super Good Cents components and practices.

Less cost is measured against the market "whole house" (inclusive of construction processes) cost of the Reference House, minus the $2000 Long Term Super Good Cents builder incentive.

Architecturally equivalent refers to designs that are comparable within the discipline of different construction systems — that is, they are equal in terms of size, layout and configuration, with some dissimilar components and systems as appropriate to their respective construction systems.

9.0 APPENDIX — PHASE I DATA

9.1 Bonneville Power Administration Super Good Cents Specifications

LONG-TERM SUPER GOOD CENTS PROGRAM MEASURES

Envelope

Zone I All measures payment - $2000

R-49 advanced attic
R-38 vaulted ceiling (same as present level)
R-26 advanced walls
R-30 under floor insulation (same as present level)
R-15 slab-on-grade at edge
R-21 basement wall with R-5 at edge of slab
.35 - Windows

Zone II All measures payment - $2000

R-49 advanced attic
R-38 vaulted ceiling (same as present level)
R-26 advanced walls
R-30 under floor insulation (same as present level)
R-15 slab-on-grade at edge
R-21 basement wall with R-10 at edge of slab
.35 - Windows

Zone III All measures payment - $2000

R-49 advanced attic (same as present level)
R-38 vaulted ceiling (same as present level)
R-26 advanced walls (same as present level)
R-38 under floor insulation
R-15 slab-on-grade at edge
R-21 basement wall with R-10 at edge of slab
.35 - Windows

Water Efficiency

	ANNUAL KWH	PAYMENT
All Shower Heads 2.5 gpm (per single family)	327	$40
All Shower Heads 2.5 gpm (per multi-family unit)	327	$20
Water Heaters EF .95 (59 gallons or less)	273	$60
Water Heaters EF .93 (60 gallons or more not to exceed 120 gallons)	273	$60

ADDITIONAL NEW RESIDENTIAL MEASURES

Energy Efficient Heat Pumps

HSPF's	7.2		7.4		8.5	
	KWH	PAYMENT	KWH	PAYMENT	KWH	PAYMENT
Zone I	1270	480	1300	500	2120	800
Zone II	2100	800	2200	830	3460	1300
Zone III	2430	920	2500	950	4000	1500

	KWH	PAYMENT
Exhaust Air Heat Pump	2430	1200
Air to Air Heat Exchangers/Infiltration Package	?	750
* Refrigerators (only offered in 1992 - Top 15% of Market)	224	60
* Interior Lighting (per residence)	-	50
* Exterior Lighting (per fixture)	-	10

*These measures must receive The Department Of Energy's Environmental Clearence before they could be implemented in the Long-term Program.

THREE TIER PROGRAM APPROACH

1 Homes that meet the new reference path savings are
- eligible for a $2000 payment,
- have an efficient water heater and shower head,
- meet the new ventilation requirements, and
- can be certified SGC:
- only Tier eligible for heat pump payment

2 Homes that exceed 75% to 99.9% of the current MCS savings as compared to the new reference path are
- eligible for a $1000 payment
- have an efficient water heater and shower head,
- meet the new ventilation requirements,
- however are not eligible to be certified SGC.

3 Homes that exceed 50% to 74.9% of the current MCS savings as compared to the new reference path are
- eligible for a $500 payment
- have an efficient water heater and shower head,
- meet the new ventilation requirements,
- however are not eligible to be certified SGC.

- Multiple Family numbers will not be available until August 23, 1991. The Council's numbers will be used for determining savings and payments. It presently appears the payment will be no less than $250 per unit. Measures will be R-49 Advanced Attic, R-21/26 Standard Walls, .35 windows, & R-15 at the slab edge. A similar tiered approach could be developed for the Multiple Family market.

- The 50% and 75% options would be phased out over time, the time lines to be determined during 1992 and 1993.
- Full slab insulation will be down graded to R-15 at the edge with the possibility of being of changed in 1993.

RICHARD H. WATSON
Director

MAY 15 1989

STATE OF WASHINGTON

WASHINGTON STATE ENERGY OFFICE

809 Legion Way S.E., FA-11 • Olympia, Washington 98504-1211

May 12, 1989

R. CONTROL HOUSE
WATTSON RUN.

Martin Thompson
OSU Extension Energy
950 W. 13th Avenue
Eugene, OR 97402-3999

Dear Mr. Thompson:

I have calculated several component U-values for use as defaults with R-Control brand and other similar stress skin panels. While these are not "official" BPA approved defaults, they should be adequate for use until such time as the Super Good Cents Technical Specifications are amended to contain stress skin panel default U-values.

The same prototype house was used to create these values as was used to come up with the other defaults in the Technical Specifications, Appendix B. I made certain assumptions about construction details which you may want to double check before giving these numbers out. The following table lists U-Values and assumptions:

(COLD THRU)

Stress Skin Panel Default U-Values

Panel Thickness	Wall U-value	Ceiling U-Value	Floor U-value
3 1/2"	0.063	0.046	0.061
5 1/2	0.043	0.035	0.042
7 1/4	0.034	0.030	0.032
9 1/4	0.028	0.025	0.026
11 1/4	0.023	0.022	0.022

Walls
Single top and bottom plate; two stud corners; 2x window and door rough out, thickness of cavity, with no other headers. 7.6 percent framing.

Ceilings
Unvented vault; 0 percent framing.

Floors
Post and beam on 4' centers; 5 1/2" beams.

You might also be interested in the LOTUS123 spreadsheet which was created by Ecotope, Inc. for the purpose of calculating Super Good Cents component U-Values. It comes in handy for this type of work. Contact Roy Rinehart at BPA Headquarters in Portland for more information on getting a copy.

(206) 586-5000 or SCAN 321-5000 Teletax (206) 753-2397

9.2 AFM Details and Specifications

LOAD DESIGN CHART NO. 1

AFM R-CONTROL® STRUCTURAL PANELS																
ROOF & WALL PANEL SPAN		DEFL.	EPS CORE THICKNESS													
			3 1/2" CORE					5 1/2" CORE					7 1/4" CORE			
			WAFERBOARD THICKNESS					WAFERBOARD THICKNESS					WAFERBOARD THICKNESS			
			3/8"	7/16"	1/2"	5/8"	3/4"	3/8"	7/16"	1/2"	5/8"	3/4"	3/8"	7/16"	1/2"	5/8"	3/4"
TRANSVERSE LOAD PSF	8'-0"	L/180	[2] 46	[2] 46	[2] 46	[2] 46	[2] 46	[2] 61	[2] 61	[2] 61	[2] 61	[2] 61	[2] 76	[2] 76	[2] 76	[2] 76	[2] 76
		L/240	39	39	41	43	44	[2] 61	[2] 61	[2] 61	[2] 61	[2] 61	[2] 76	[2] 76	[2] 76	[2] 76	[2] 76
		L/360	25	25	26	27	27	40	40	41	42	43	55	55	59	60	60
		[1] [2]	L/213 45	L/213 46	L/219 46	L/229 46	L/235 46	L/253 61	L/253 61	L/259 61	L/267 61	L/271 61	L/280 76	L/280 76	L/291 76	L/291 76	L/299 76
	10'-0"	L/180	38	38	39	40	42	[2] 57	[2] 57	[2] 57	[2] 57	[2] 57	[2] 68	[2] 68	[2] 68	[2] 68	[2] 68
		L/240	29	29	30	31	32	44	44	44	46	46	[2] 68	[2] 68	[2] 68	[2] 68	[2] 68
		L/360	19	19	20	21	21	30	30	30	30	31	56	56	56	56	57
		[1] [2]	L/150 46	L/150 46	L/154 46	L/158 46	L/162 46	L/182 57	L/182 57	L/186 57	L/189 57	L/194 57	L/300 68	L/300 68	L/300 68	L/300 68	L/308 68

[1] DEFLECTION AT FAILURE LOAD DIVIDED BY A FACTOR OF SAFETY OF THREE [3].
[2] FAILURE LOAD DIVIDED BY A FACTOR OF SAFETY OF THREE [3].

LOAD DESIGN CHART NO. 2

AFM R-CONTROL® STRUCTURAL PANELS																
	WALL PANEL HEIGHT OR SPAN	EPS CORE THICKNESS														
		3 1/2" CORE					5 1/2" CORE					7 1/4" CORE				
		WAFERBOARD THICKNESS					WAFERBOARD THICKNESS					WAFERBOARD THICKNESS				
		3/8"	7/16"	1/2"	5/8"	3/4"	3/8"	7/16"	1/2"	5/8"	3/4"	3/8"	7/16"	1/2"	5/8"	3/4"
AXIAL [2] LOAD [plf]	8'0"	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
	10'-0"	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
[1] [2] COMBINED AXIAL AND BENDING LOAD [psf]	8'-0"	45	45	46	46	46	59	59	60	61	61	72	72	74	76	76
	10'-0"	33	33	34	35	36	38	38	39	41	42	43	43	44	46	47
@ 1/8" def. RACKING SHEAR	[3]	185 plf					185 plf					185 plf				
ULTIMATE [2]		323 plf					323 plf					323 plf				
48" [4] OPENING	L/480	504 plf					504 plf					504 plf				

[1] MAXIMUM ALLOWABLE AXIAL LOAD IS LIMITED TO THE LOADS TABULATED FOR AXIAL CONDITION ALONE.
[2] FAILURE LOAD DIVIDED BY A FACTOR OF SAFETY OF (3).
[3] PANELS ASSEMBLED PER AF-102. NO REINFORCING BOUNDRY 2X MEMBERS UTILIZED.

AFM R-CONTROL® STRUCTURAL PANELS									
EPS CORE THICKNESS									
9 1/4" CORE WAFERBOARD THICKNESS					11 1/4" CORE WAFERBOARD THICKNESS				
3/8"	7/16"	1/2"	5/8"	3/4"	3/8"	7/16"	1/2"	5/8"	3/4"
[2] 109	[2] 109	[2] 109	[2] 109	[2] 109	[2] 96	[2] 96	[2] 96	[2] 96	[2] 96
[2] 109	[2] 109	[2] 109	[2] 109	[2] 109	[2] 96	[2] 96	[2] 96	[2] 96	[2] 96
90	90	90	90	90	[2] 96	[2] 96	[2] 96	[2] 96	[2] 96
L/320 109	L/320 109	L/320 109	L/320 109	L/320 109	L/500 96	L/500 96	L/500 96	L/500 96	L/500 96
[2] 70	[2] 70	[2] 70	[2] 70	[2] 70	[2] 70	[2] 70	[2] 70	[2] 70	[2] 70
[2] 70	[2] 70	[2] 70	[2] 70	[2] 70	[2] 70	[2] 70	[2] 70	[2] 70	[2] 70
[2] 70	[2] 70	[2] 70	[2] 70	[2] 70	[2] 70	[2] 70	[2] 70	[2] 70	[2] 70
L/444 70	L/444 70	L/444 70	L/444 70	L/444 70	L/436 70	L/436 70	L/436 70	L/436 70	L/436 70

* LOAD VALUES BASED ON 9 1/4" CORE PANEL TEST RESULTS.

LOAD DESIGN CHART #3

EPS Core Thickness	Defl.	PANEL LENGTH								Floor Panels Max. Spans
		10'	12'	14'	16'	18'	20'	22'	24'	
5 1/2"	L/360	100**	68	43	28	20	14	-----	-----	12 ft
	L/240	100**	100**	64	43	30	23	-----	-----	
	L/180	100**	100**	86	57	40	30	-----	-----	
7 1/4"	L/360	100**	100**	67	46	31	24	-----	-----	14 ft.
	L/240	100**	100**	100**	68	47	34	-----	-----	
	L/180	100**	100**	100**	82*	63	45	-----	-----	
9 1/4"	L/360	100**	100**	100**	70	47	34	33	27	16 ft.
	L/240	100**	100**	100**	98	71	52	50	42	
	L/180	100**	100**	100**	100**	86***	69	67	53	
11 1/4"	L/360	100**	100**	100**	100**	87	64	48	38	18 ft.
	L/240	100**	100**	100**	100**	100**	96	72	55	
	L/180	100**	100**	100**	100**	100**	100**	88***	73	

*ULTIMATE FAILURE LOAD DIVIDED BY A SAFETY FACTOR OF 3.
** LOADS EXCEEDING 100 PSF NOT RECOMMENDED WITHOUT SPECIAL REVIEW.
***LOAD DETERMINED BY BENDING STRENGTH, NOT DEFLECTION.

ROOF, WALL AND FLOOR PANEL SPANS USING PANELS MANUFACTURED TO AFM STANDARDS AND INSTALLED IN ACCORDANCE WITH DETAIL AF-108 USING MIN. 7/16 IN. APA RATED 24/16 SHEATHING TOP AND BOTTOM. FRAME WITH DOUBLE 2X'S 4'-0" O.C. AND SINGLE 2X'S AS PANEL END BLOCKING USING MIN. #2 SPF (EXCEPT WHERE NOTED), OR PRE-ENGINEERED EQUIVALENT. PANELS BELOW SHADED LINE USE #2 F-L 2X'S MIN., OR PRE-ENGINEERED EQUIVALENT. SEE DRAWINGS AF-108 IN THE R-CONTROL DETAIL BOOKLET FOR PROPER LAYOUT OF FLUSH FRAMED ROOF AND FLOOR DECKS. SPANS OF 10' AND LESS CAN BE OBTAINED USING LOAD DESIGN CHART #1 AND DETAIL AF-102.

TOP SKIN THICKNESS FOR FLOOR PANELS SHOULD BE 3/4" MIN. OPTIONAL: MIN. 7/16" TOP SKIN, OVERLAYED WITH A MIN. 7/16" FINISH FLOORING PERPENDICULAR TO THE PANELS. THIS WILL PROVIDE ADEQUATE RESISTANCE TO IMPACT AND POINT LOADING.

AFM R-CONTROL® PANEL WEIGHT (p.s.f.)*						
		EPS CORE THICKNESS				
WAFERBOARD THICKNESS		3½"	5½"	7¼"	9¼"	11¼"
	3/8"	2.93	3.10	3.28	3.43	3.61
	7/16"	3.37	3.55	3.72	3.87	4.05
	½"	3.81	3.99	4.16	4.32	4.49
	5/8"	4.67	4.85	5.02	5.18	5.35
	¾"	5.56	5.73	5.91	6.06	6.23

*NOTE: Material weight plus 5%

AFM® Corporation

Box 246, Excelsior, MN 55331
Phone 612/474-0809, 1-800-255-0176

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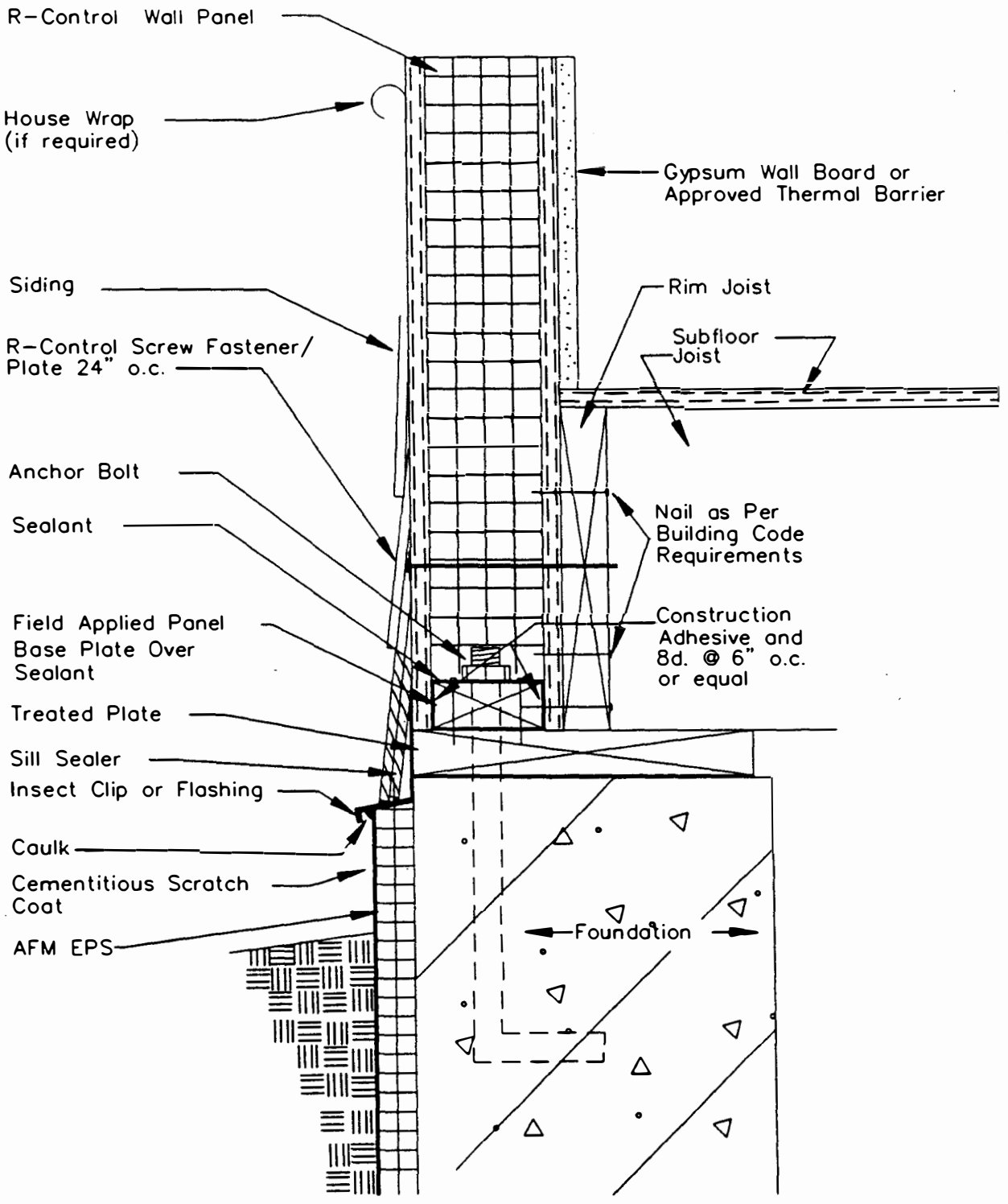
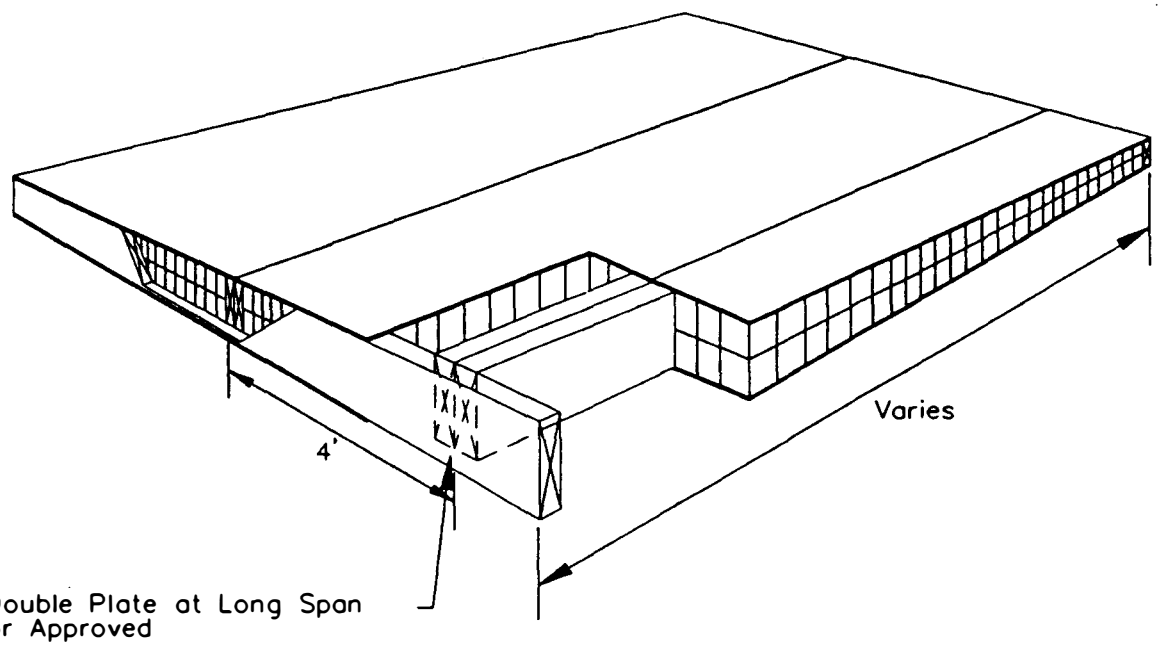
A690



Section View

AFM R–Control® Panel

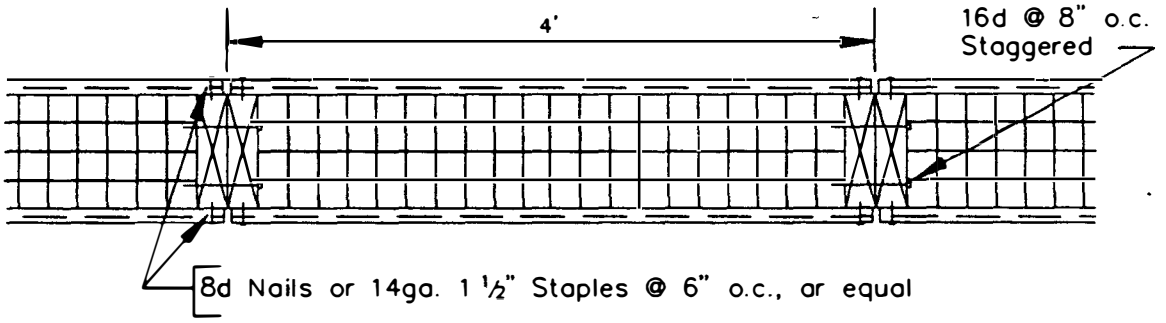
TITLE	NO.
Foundation Framing	AF–105a



Double Plate at Long Span or Approved Engineered Member

Top Sheathing – Consult Load Design Chart #3, Skin Thickness Requirements.

2x6, 2x8, 2x10, or 2x12 Side Members, or Approved Engineered Structural Members for Floor and Roof Panels

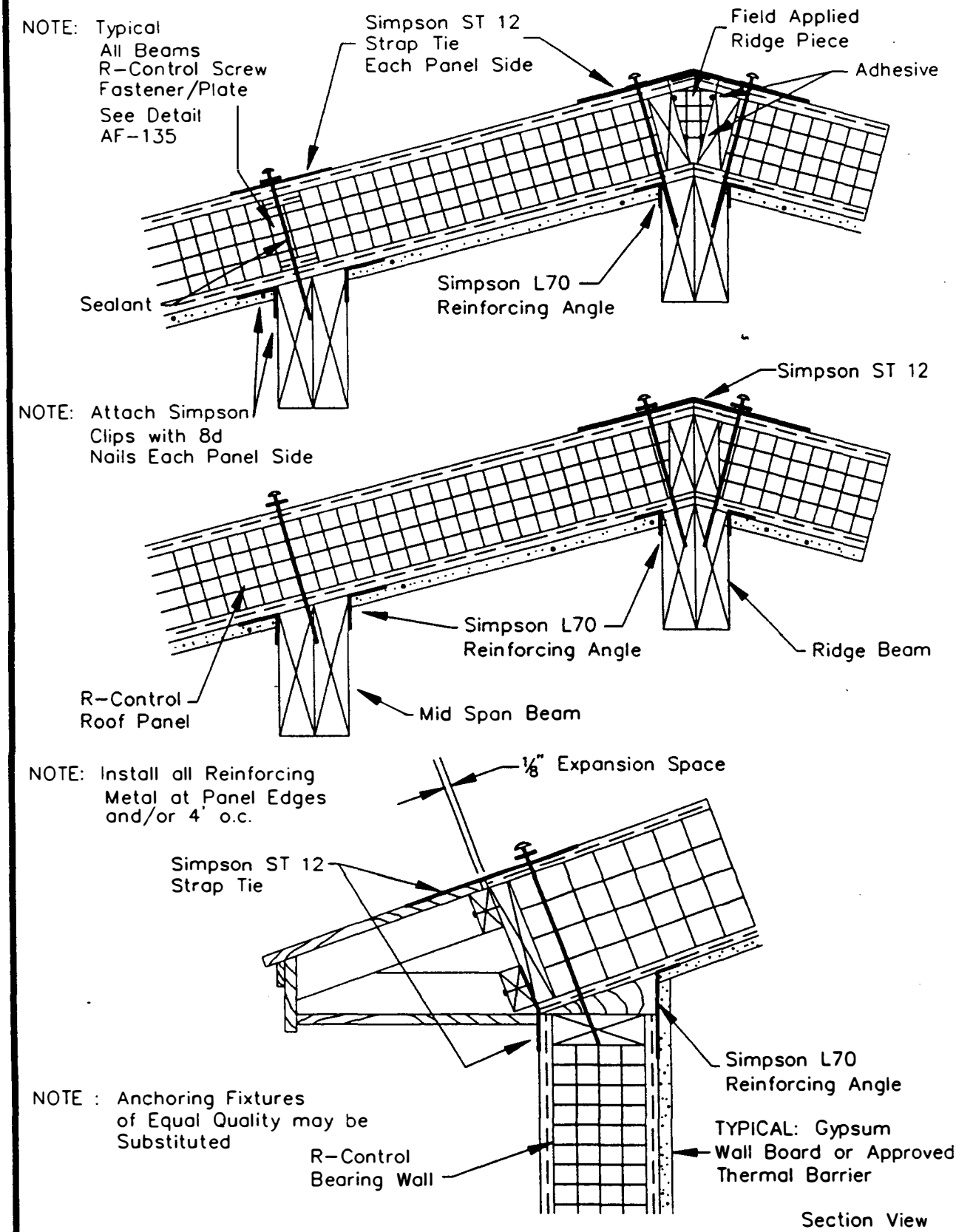


NOTE: See AFM Load Design Chart #3 for Design Utilization.

Section View

AFM R-Control® Panel

TITLE	NO.
Long Span Flush Framed Floor and Roof Deck	AF-108

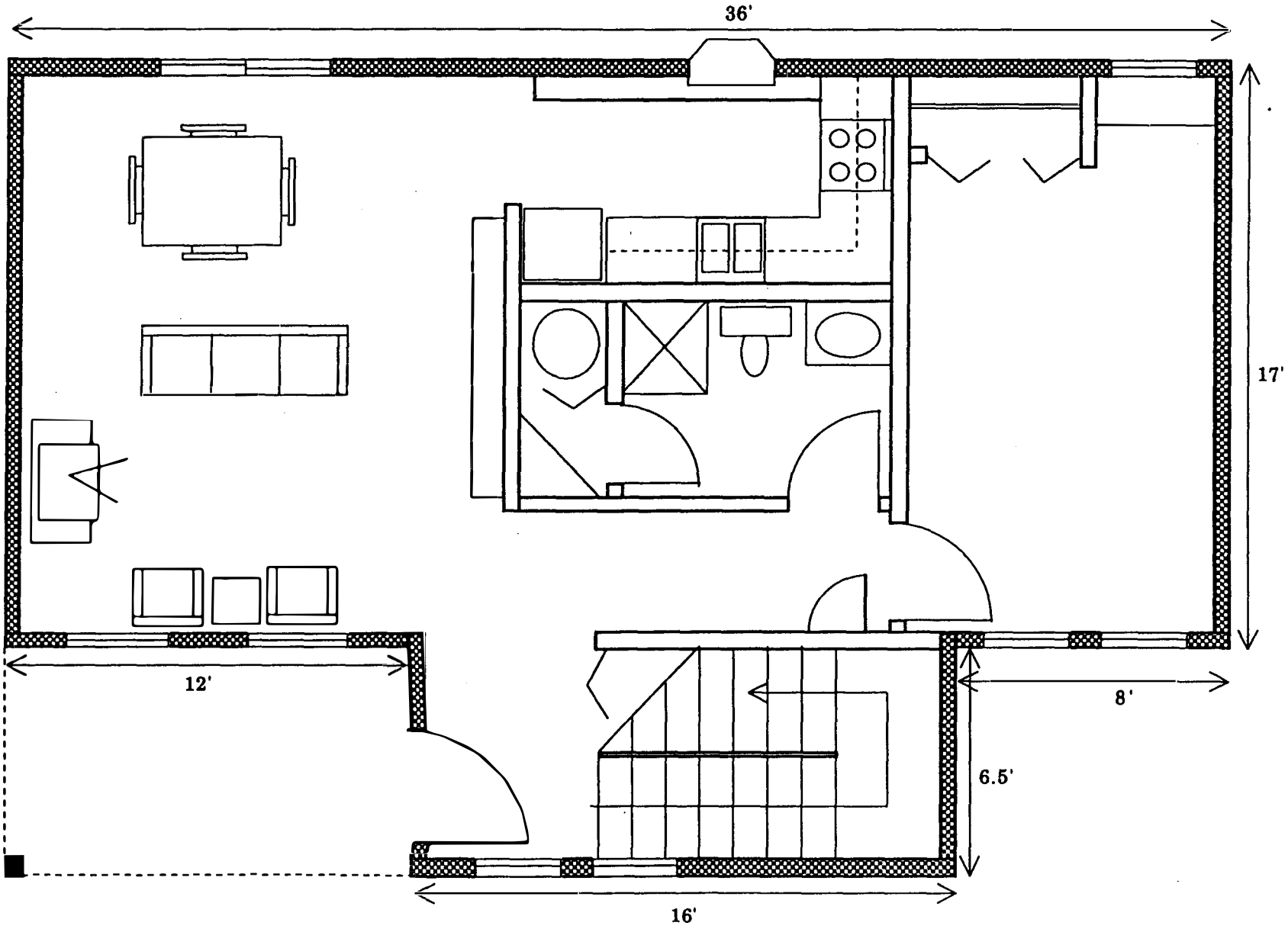


AFM R-Control® Panel

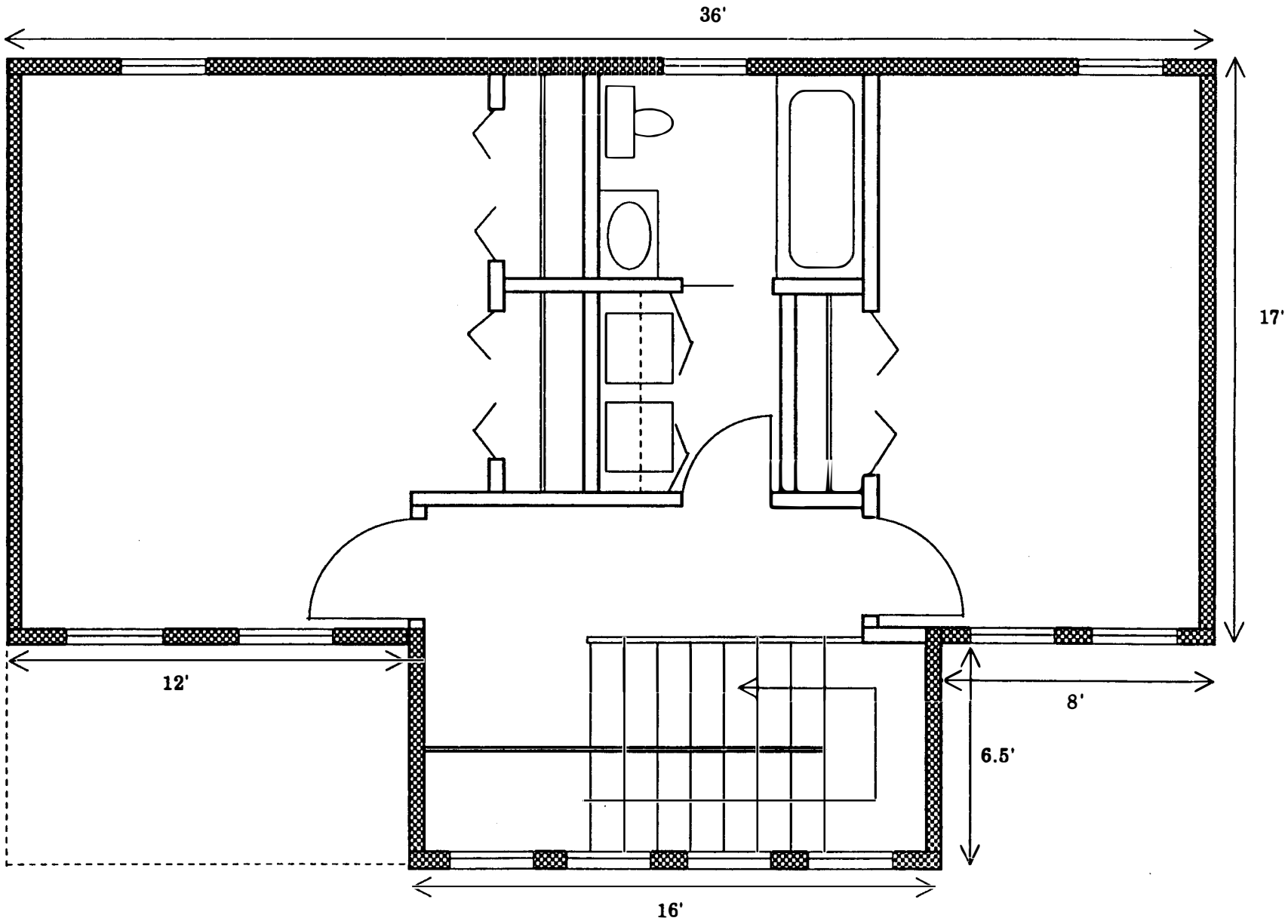
TITLE	NO.
Roof Panels Reinforcing Angles and Straps	AF-120

9.3 Design Drawings

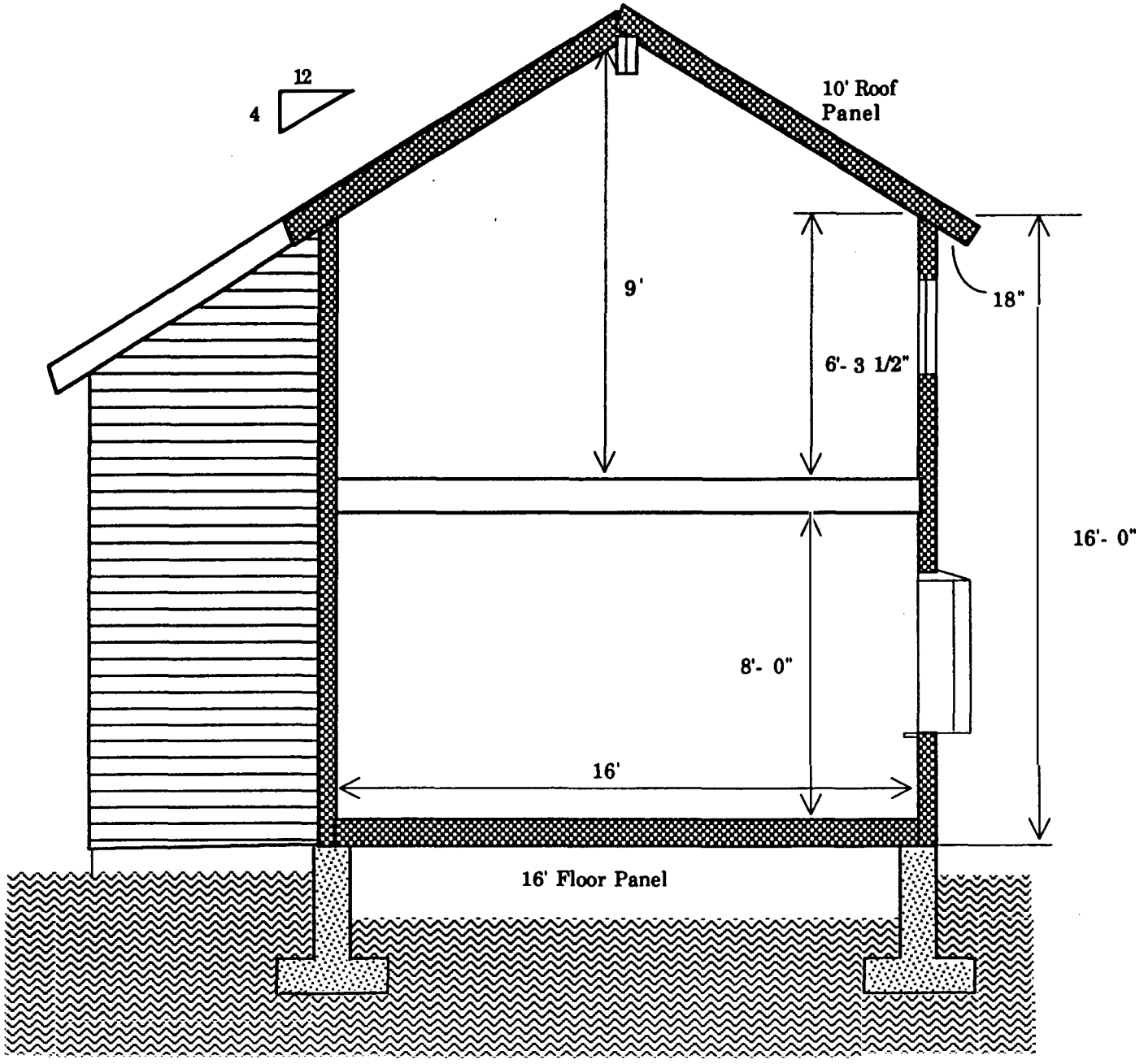
SVDP Demo Floor Plan 1/8/92

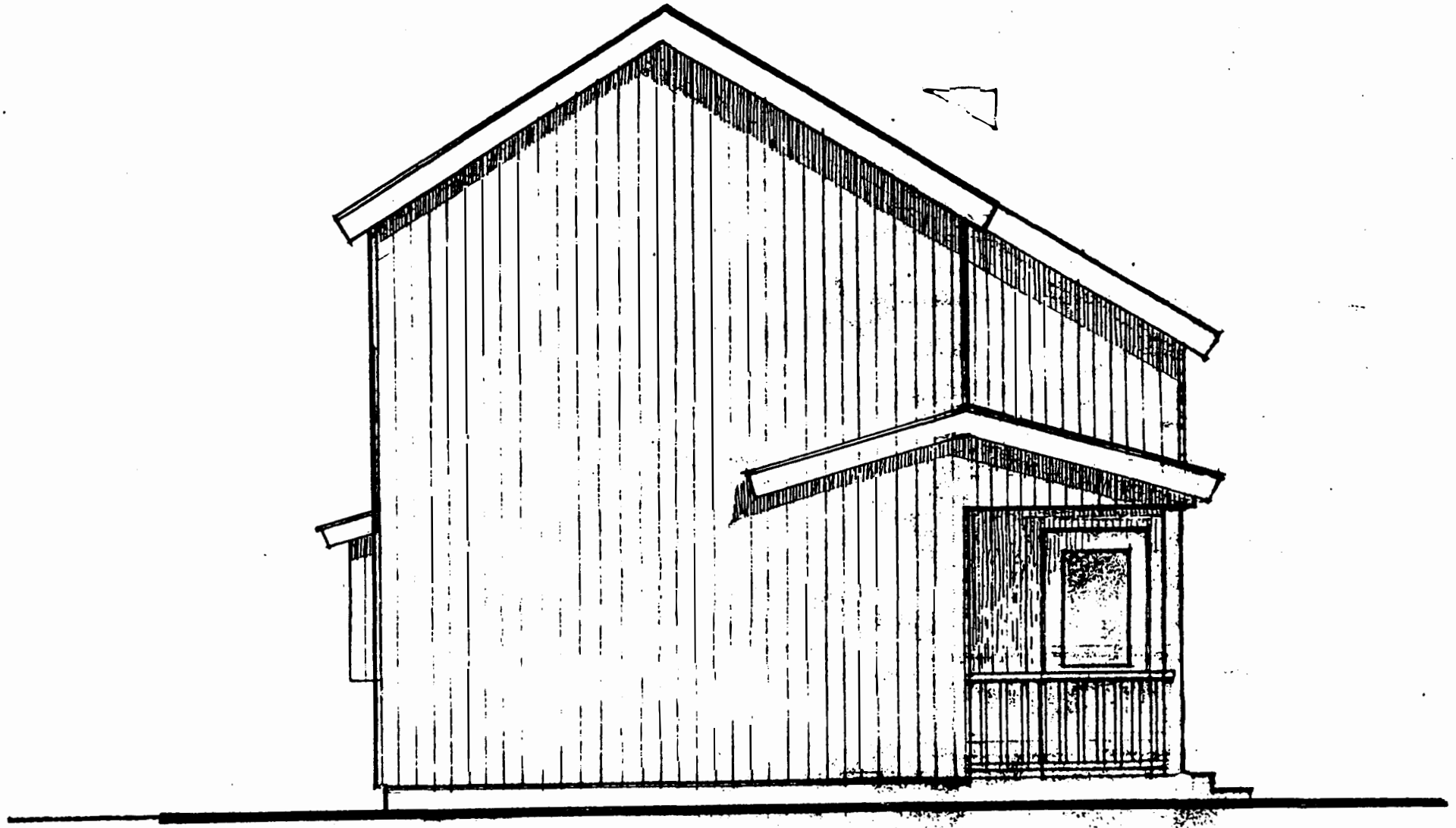


SVDP Demo 2nd Floor Plan 1/8/92



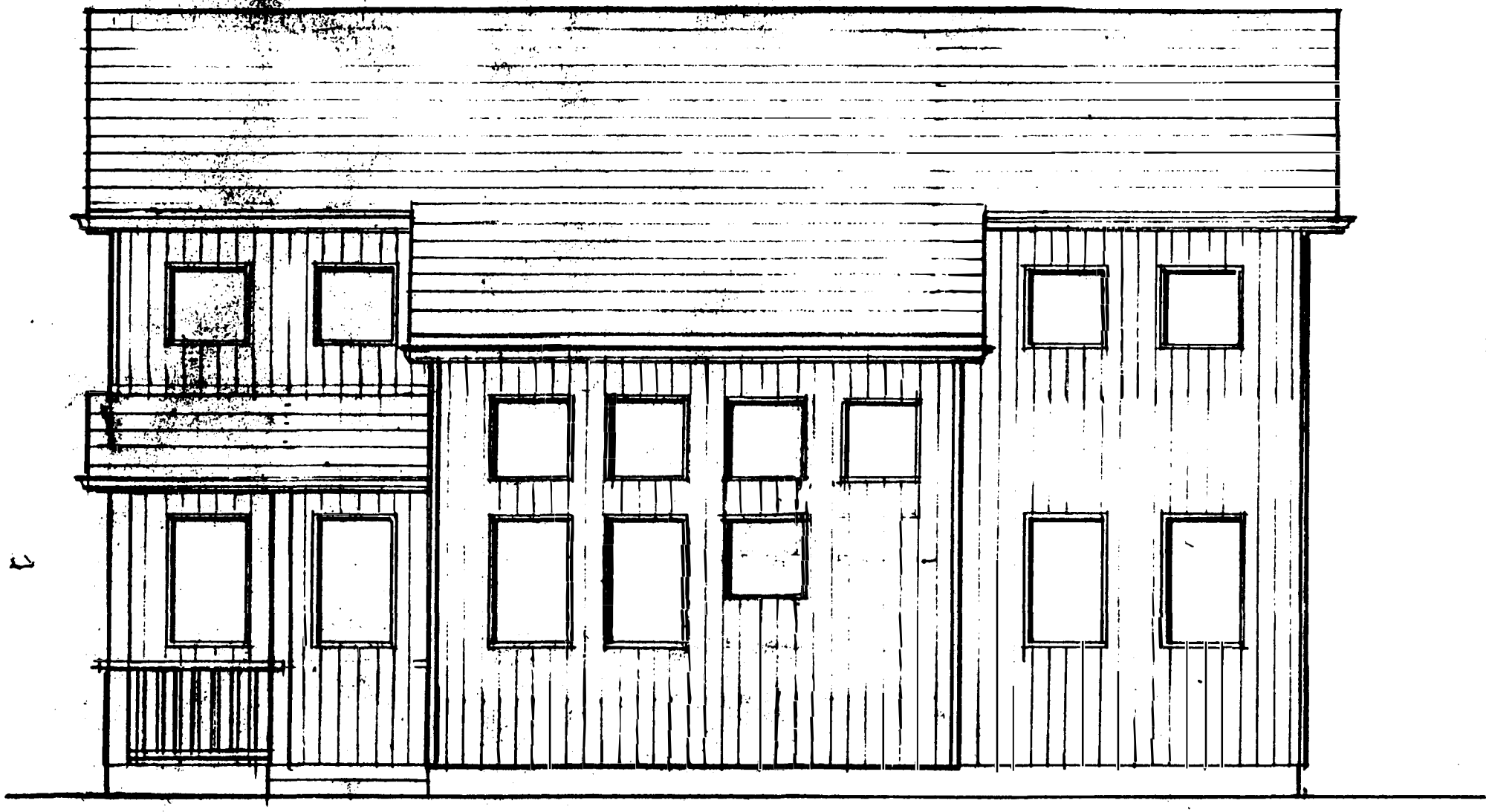
SVDP Demo House 1/8/92





BASE CASE ELEVATION

• NO EAST OR WEST-FACING WINDOWS



BASE CASE :

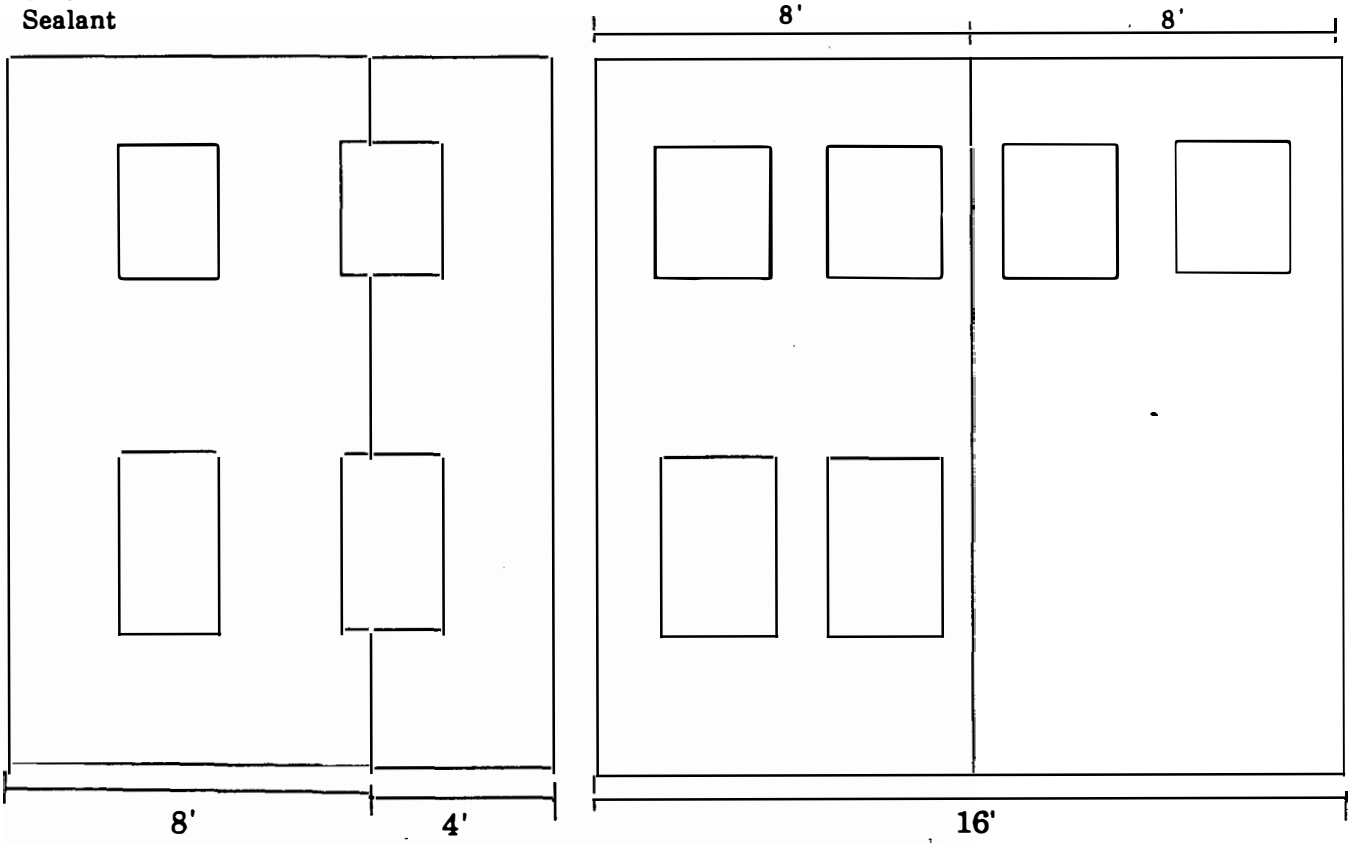
- SURFACE MOUNT WINDOWS
- T-111 SIDING
- ASPHALT SHINGLE ROOF

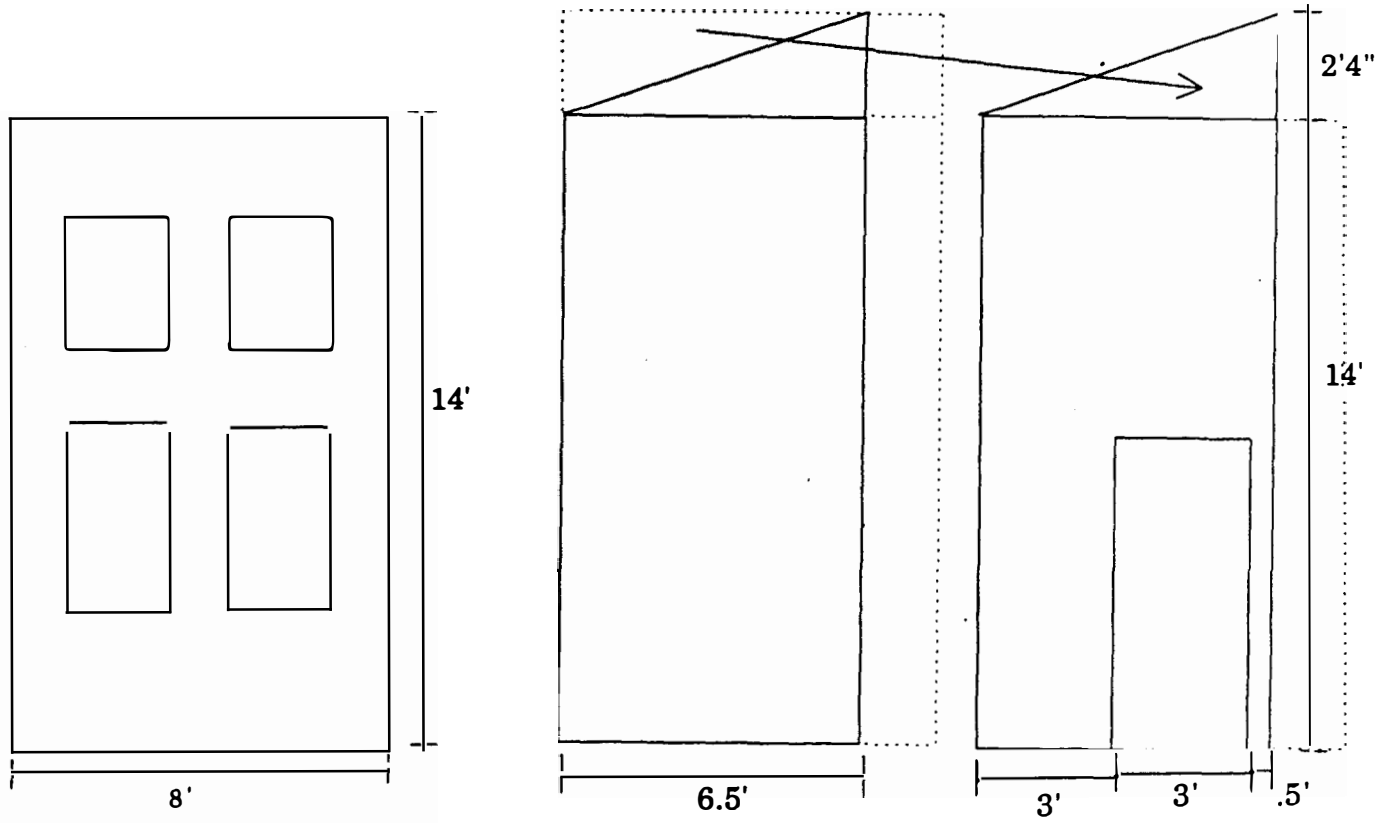
9.4 Construction Drawings

R-22 R-Control Opt 1 Wall

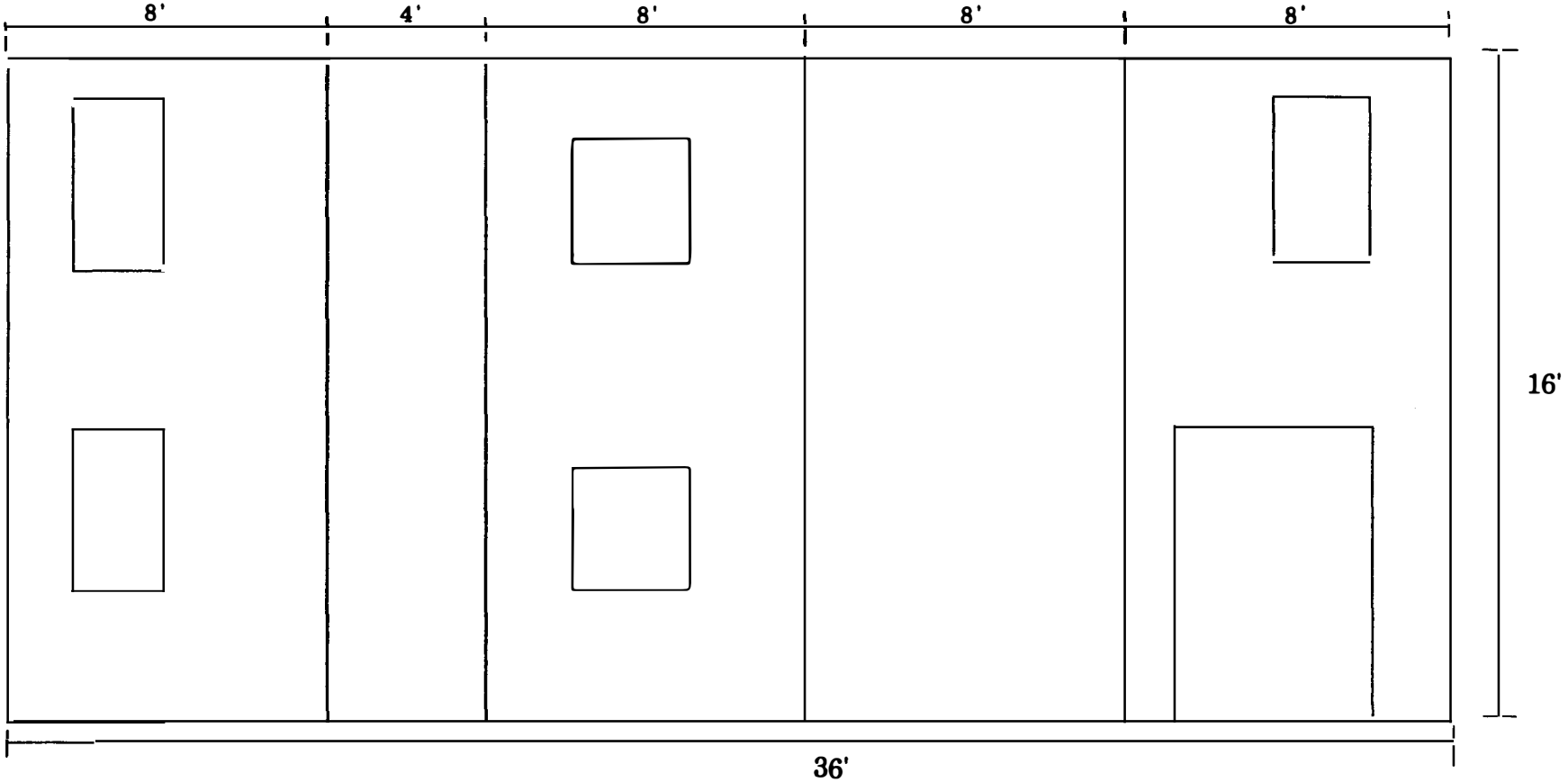
Splines
Screws
Sealant

Plates





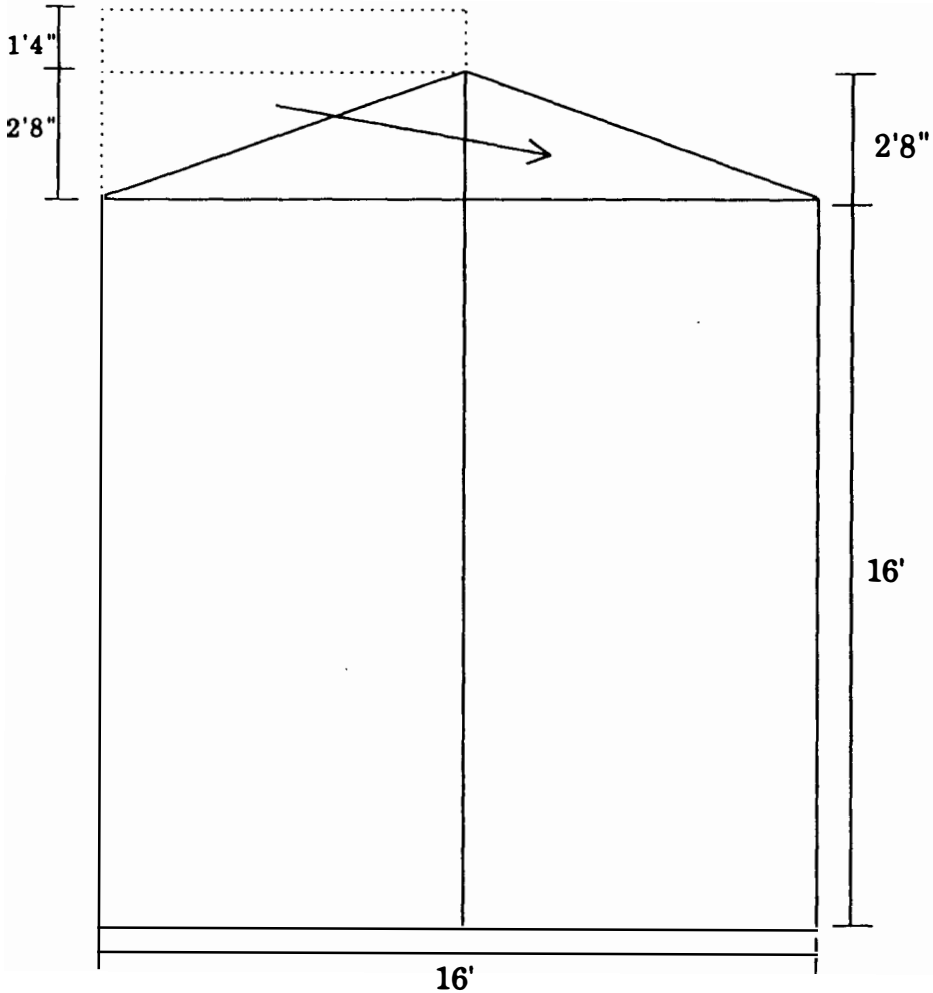
R-22 R-Control Opt 1 Wall
Splines
Screws
Sealant
Plates



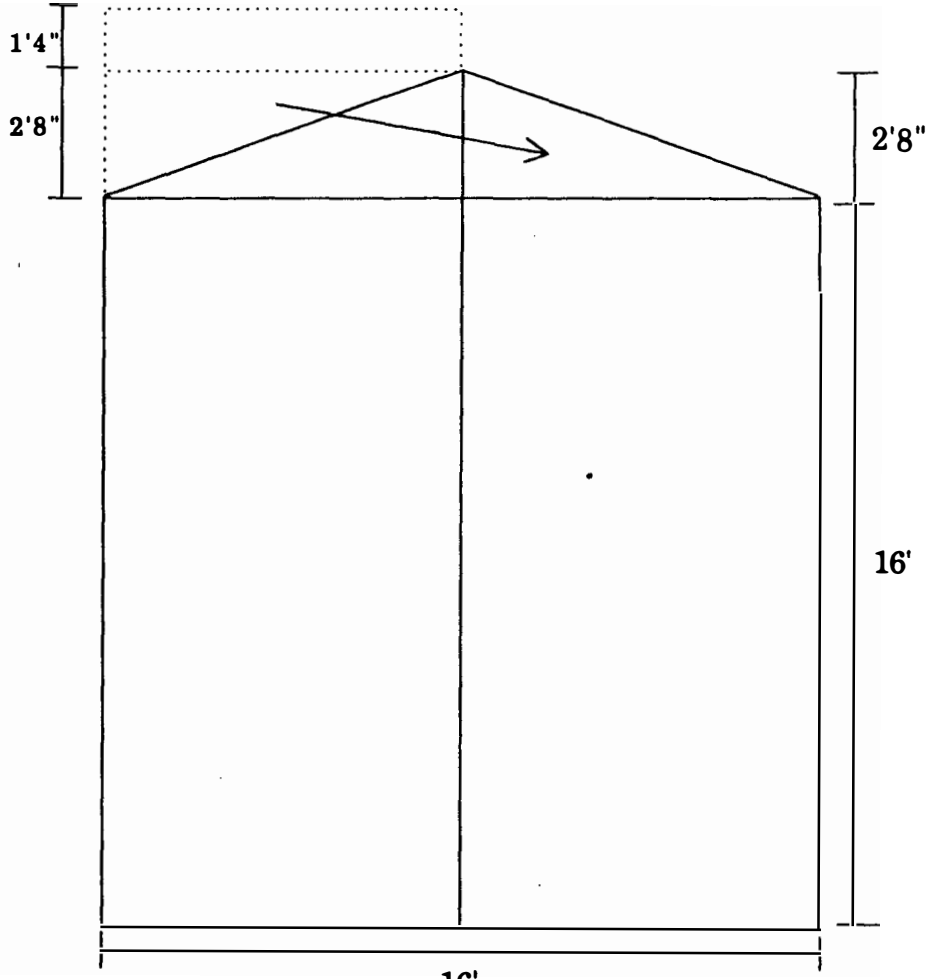
South Wall

R-Control Opt 1 South Wall

R-22 R-Control Opt 1 Wall
Splines
Screws
Sealant
Plates



East Exterior Wall

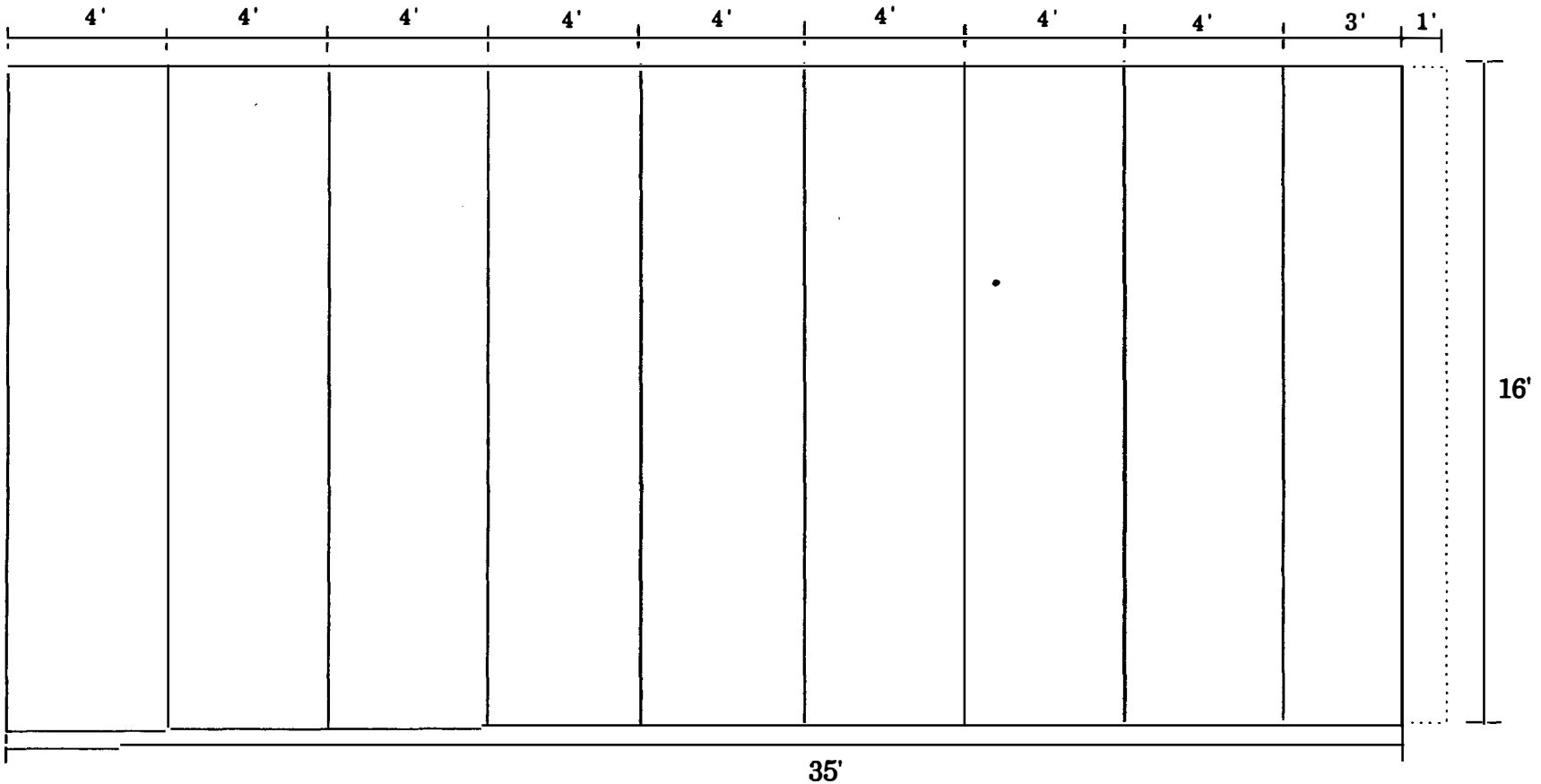


West Exterior Wall

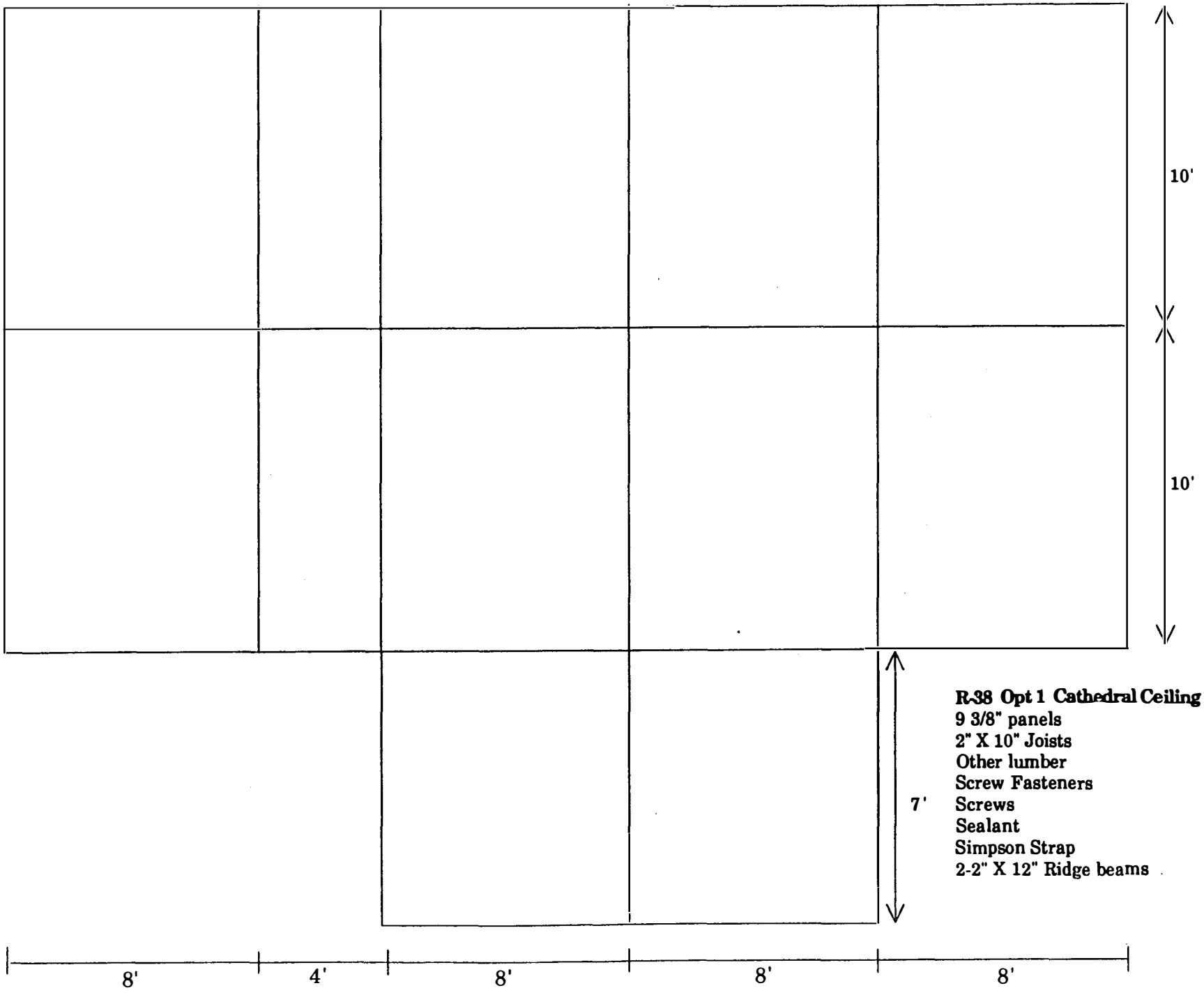
R-Control Opt 1 End Walls

R-30 R-Control Opt 1 First Floor

7 3/8" Panels
Engineered Members
Screws
Sealant
Treated Plate



First Floor Framing Plan



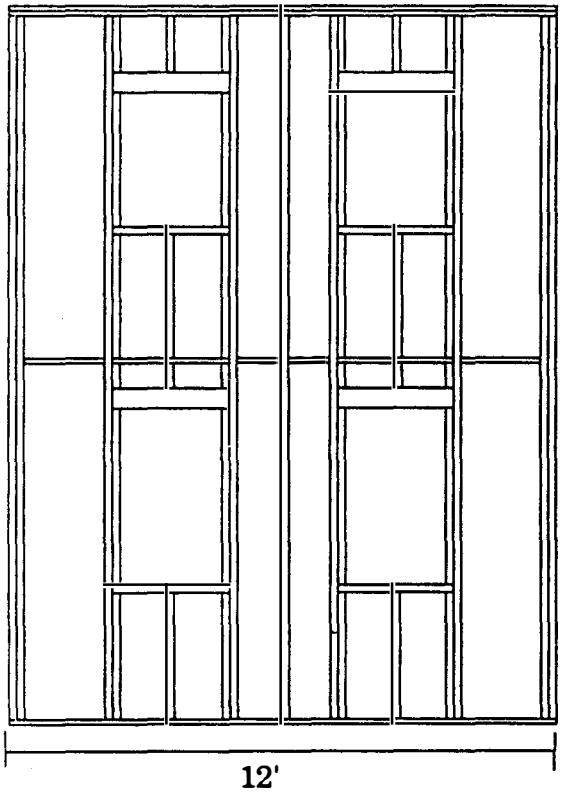
R-38 Opt 1 Cathedral Ceiling
9 3/8" panels
2" X 10" Joists
Other lumber
Screw Fasteners
Screws
Sealant
Simpson Strap
2-2" X 12" Ridge beams

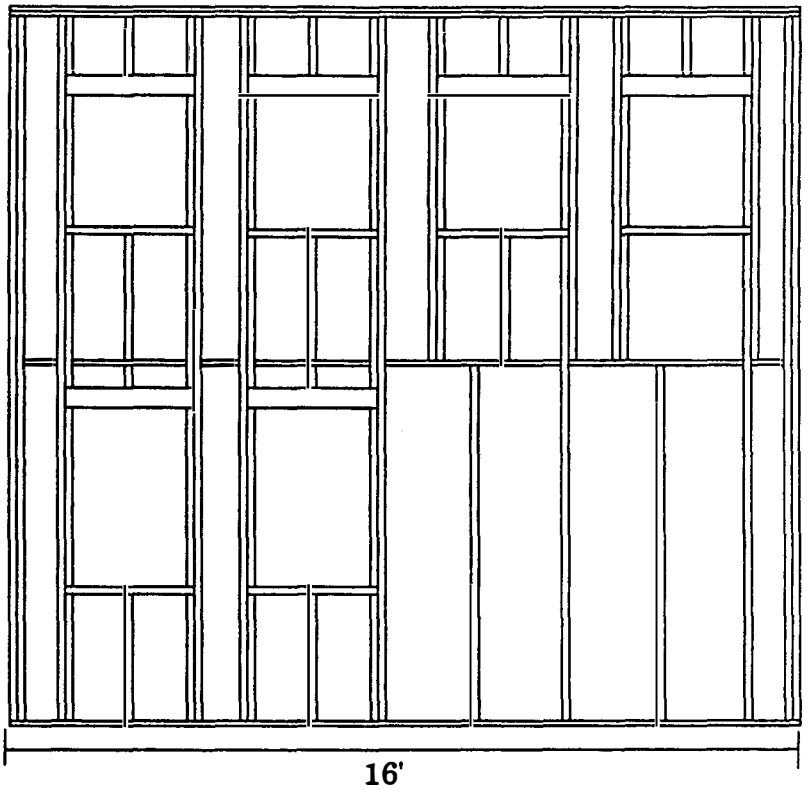
R-26 Wall (Advanced Framing)

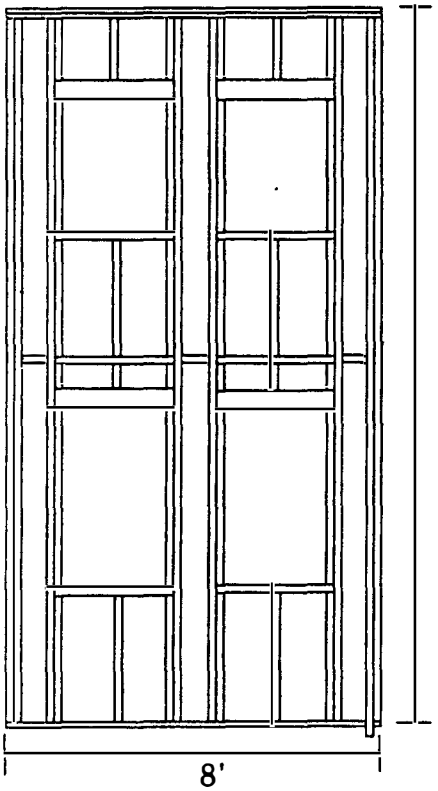
2" X 6" Studs
2" X 6" Cripples
2" X 6" Plates

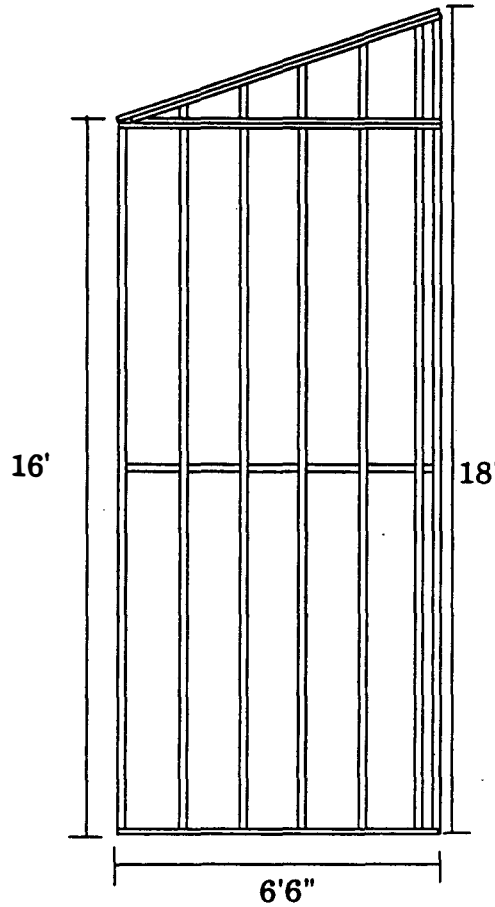
4" X 8" Headers
R-21 Batt Insulation
2" Rigid Insulation

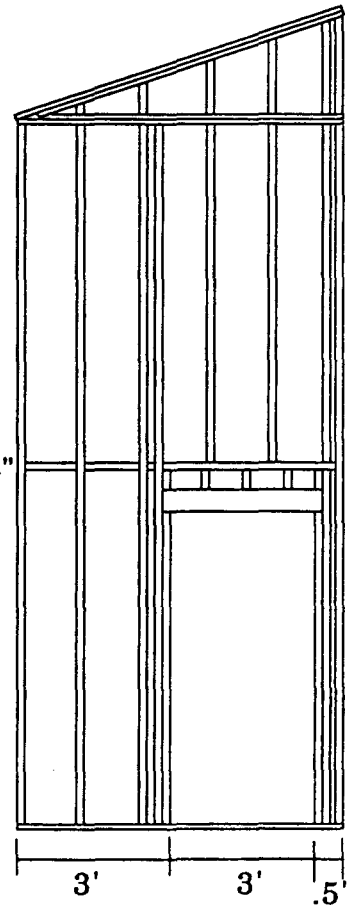
1" Rigid Insulation
5/8" Sheathing





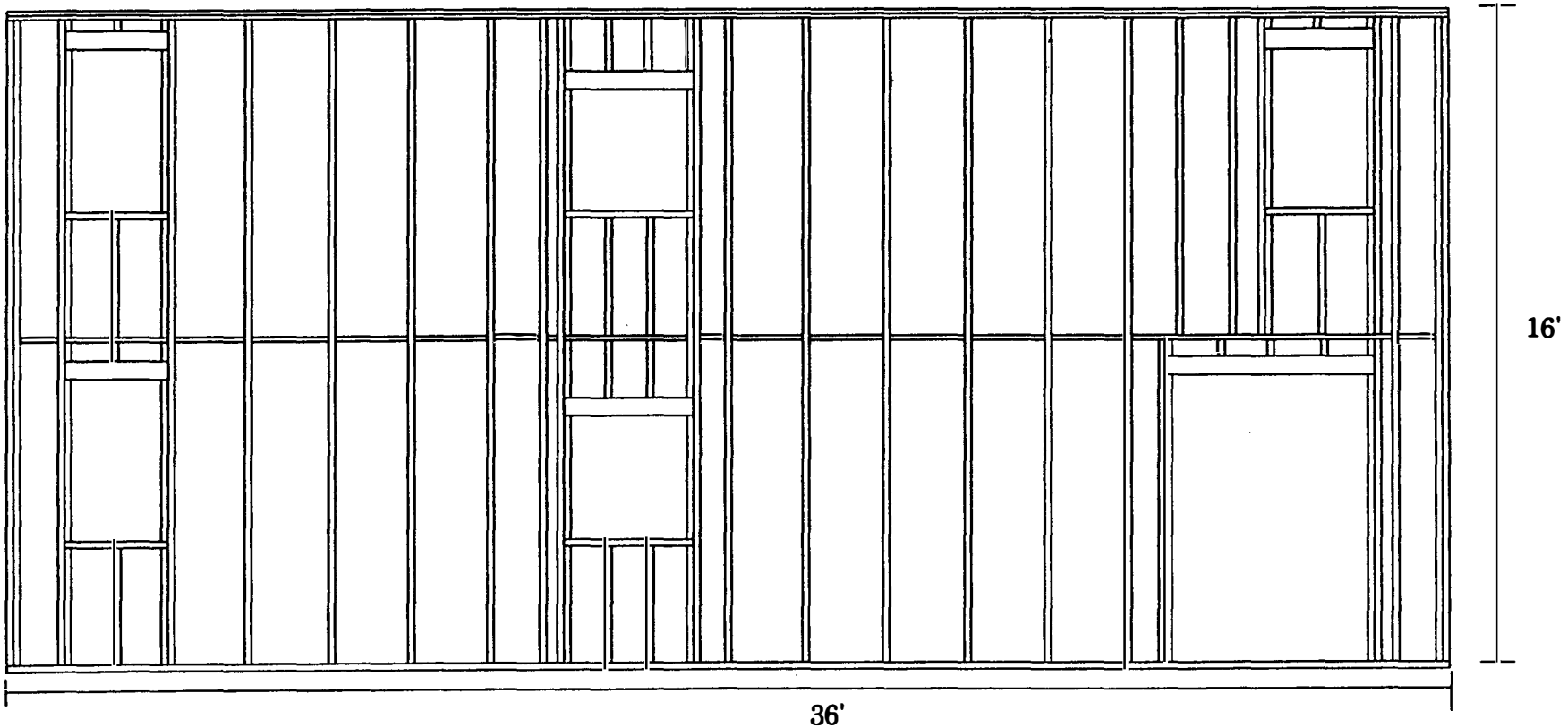






R-26 Wall (Advanced Framing)

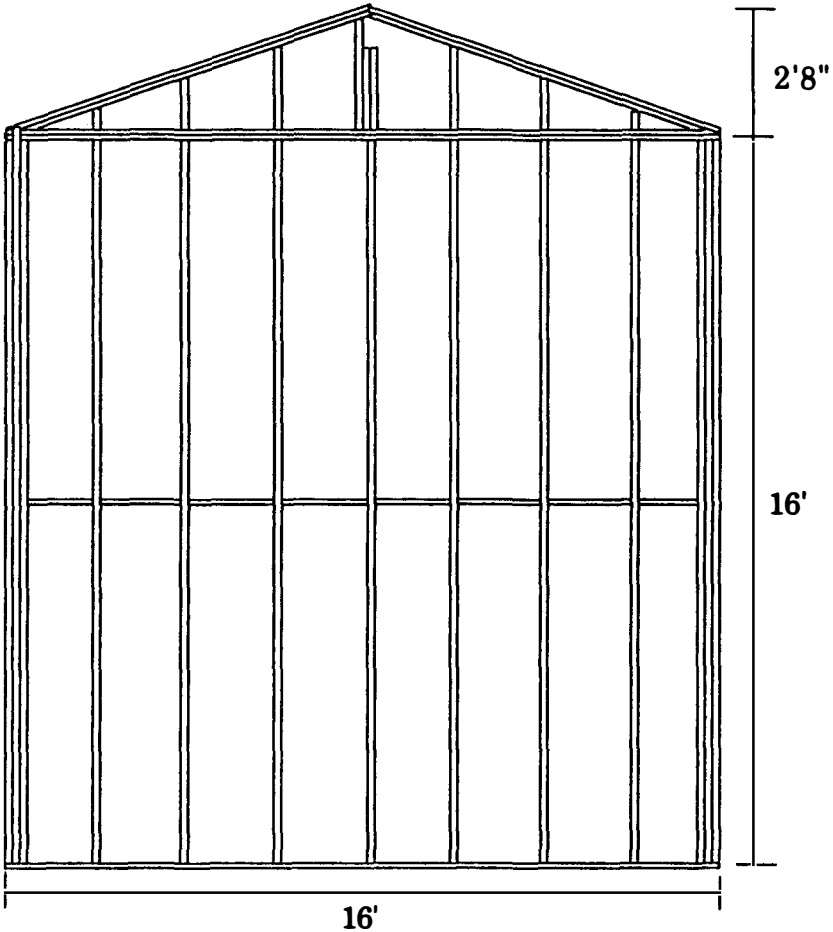
2" X 6" Studs
2" X 6" Cripples
2" X 6" Plates
4" X 8" Headers
R-21 Batt Insulation
2" Rigid Insulation
1" Rigid Insulation
5/8" Sheathing
Nails



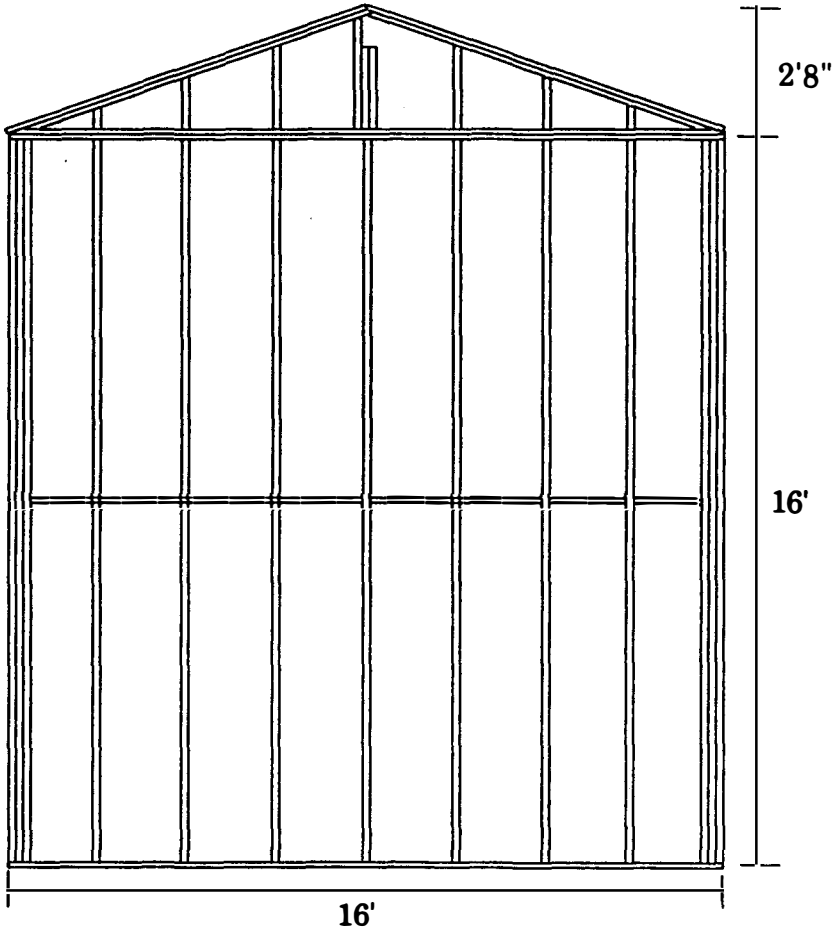
South Wall

R-26 Wall (Advanced Framing)

2" X 6" Studs
2" X 6" Cripples
2" X 6" Plates
4" X 8" Headers
R-21 Batt Insulation
2" Rigid Insulation
1" Rigid Insulation
5/8" Sheathing

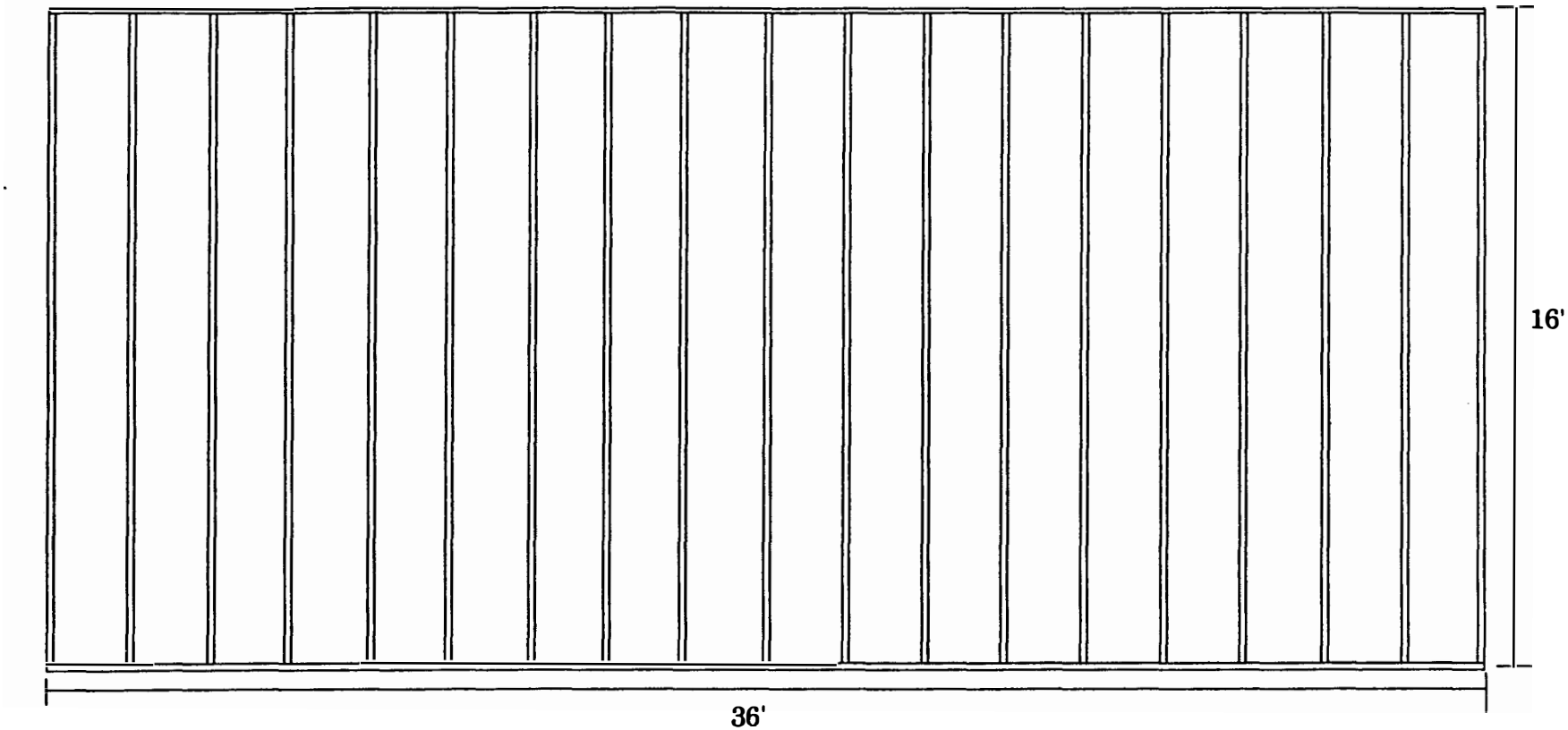


East Exterior Wall
(2 X 6's)

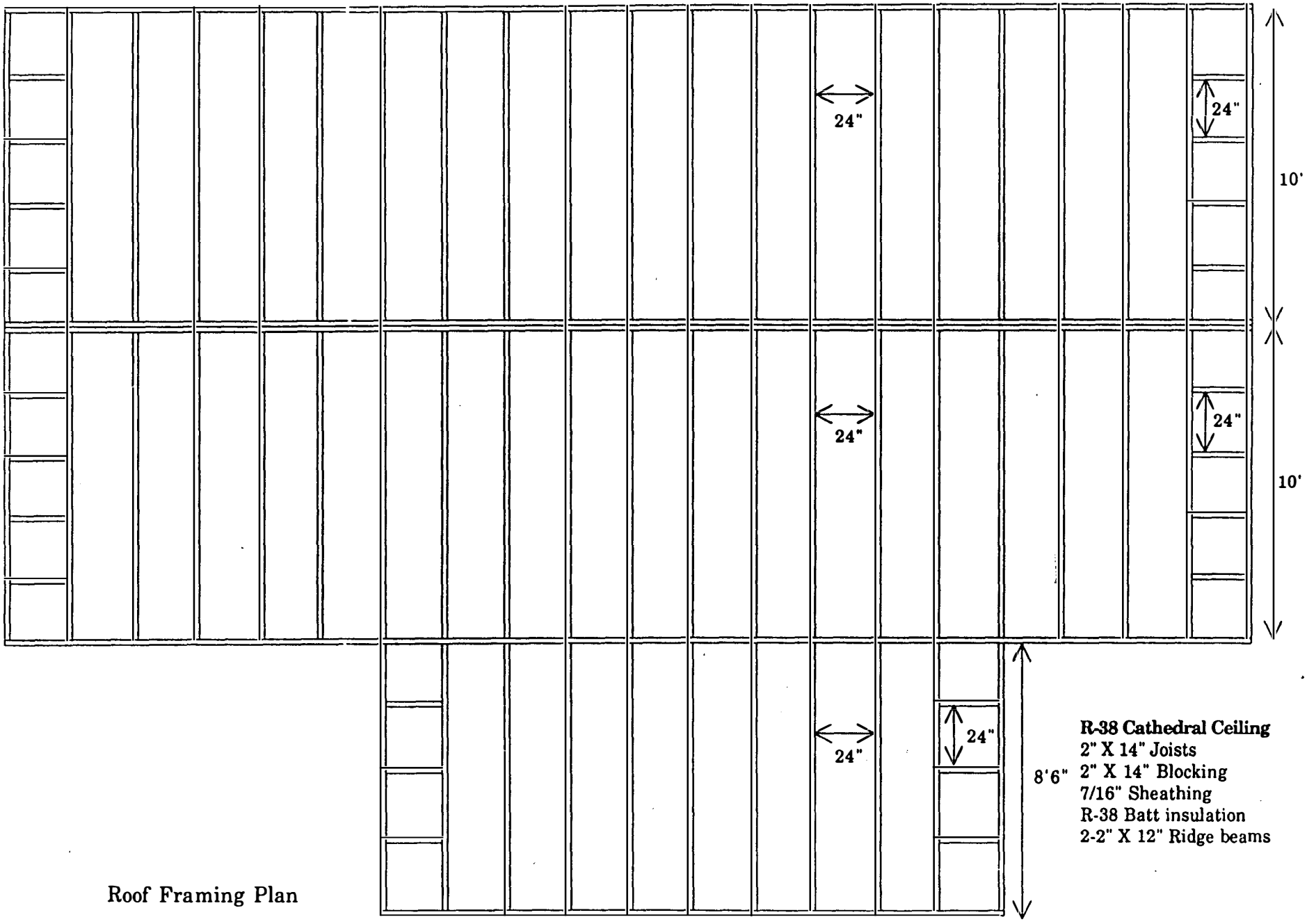


West Exterior Wall
(2 X 6's)

First Floor
2" X 10" Joists @ 24" O.C.
2" X 10" Header Joists
2" X 10" Solid Blocking
R-30 Batt Insulation
3/4" Floor Sheathing



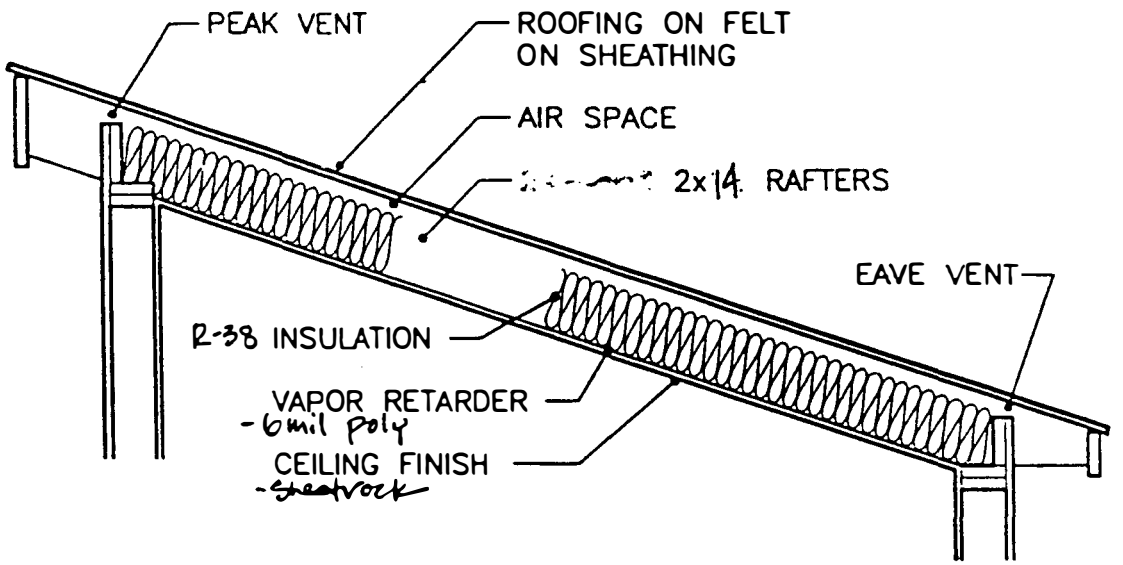
First Floor Framing Plan



Roof Framing Plan

Figure 9K:
Ventilated Vault vs Closed Cavity Vault

VENTILATED VAULT



CLOSED CAVITY VAULT

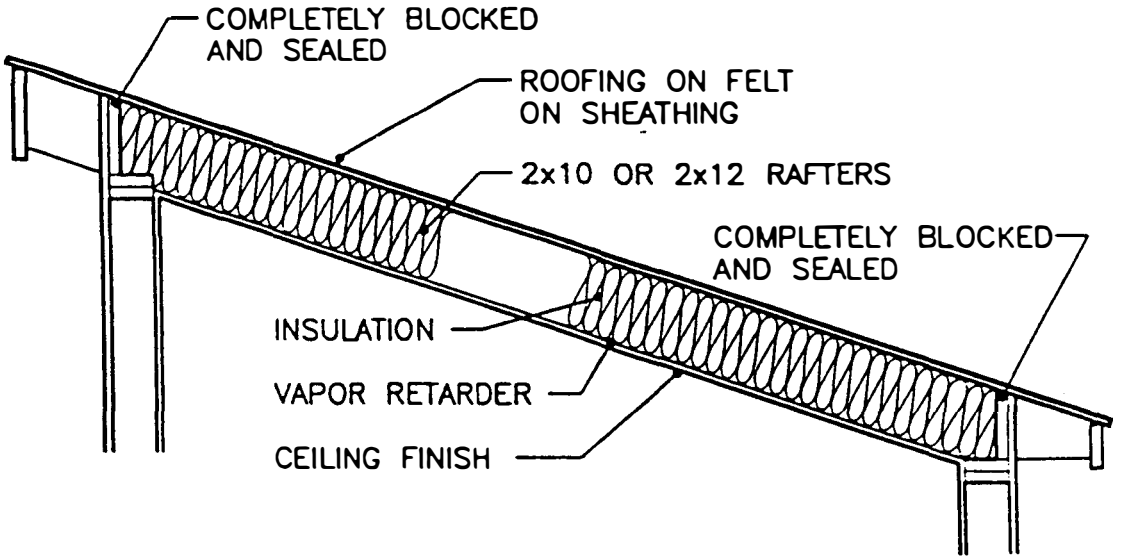


Figure 9A:
Joisted Floor System w/R-30

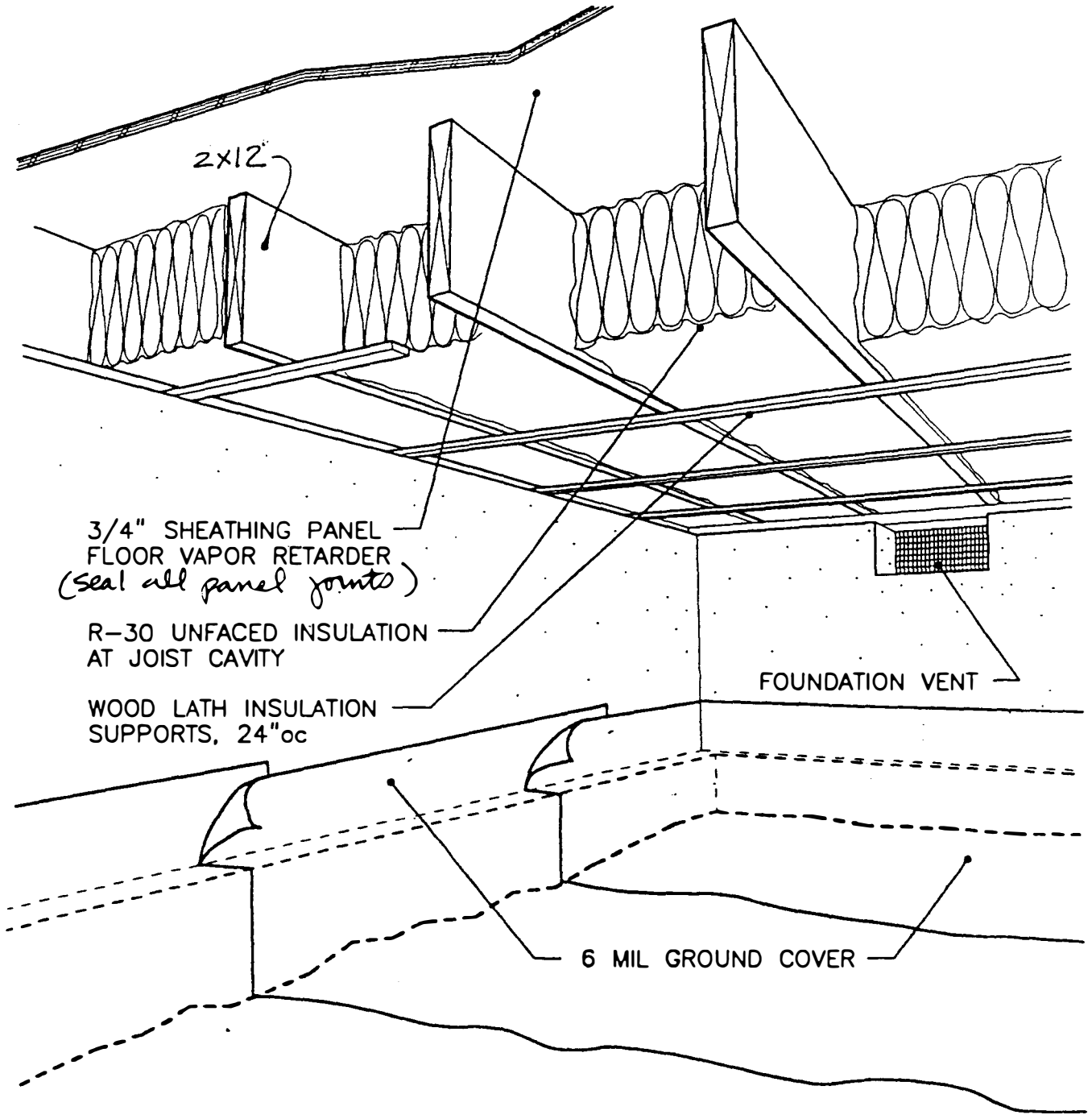
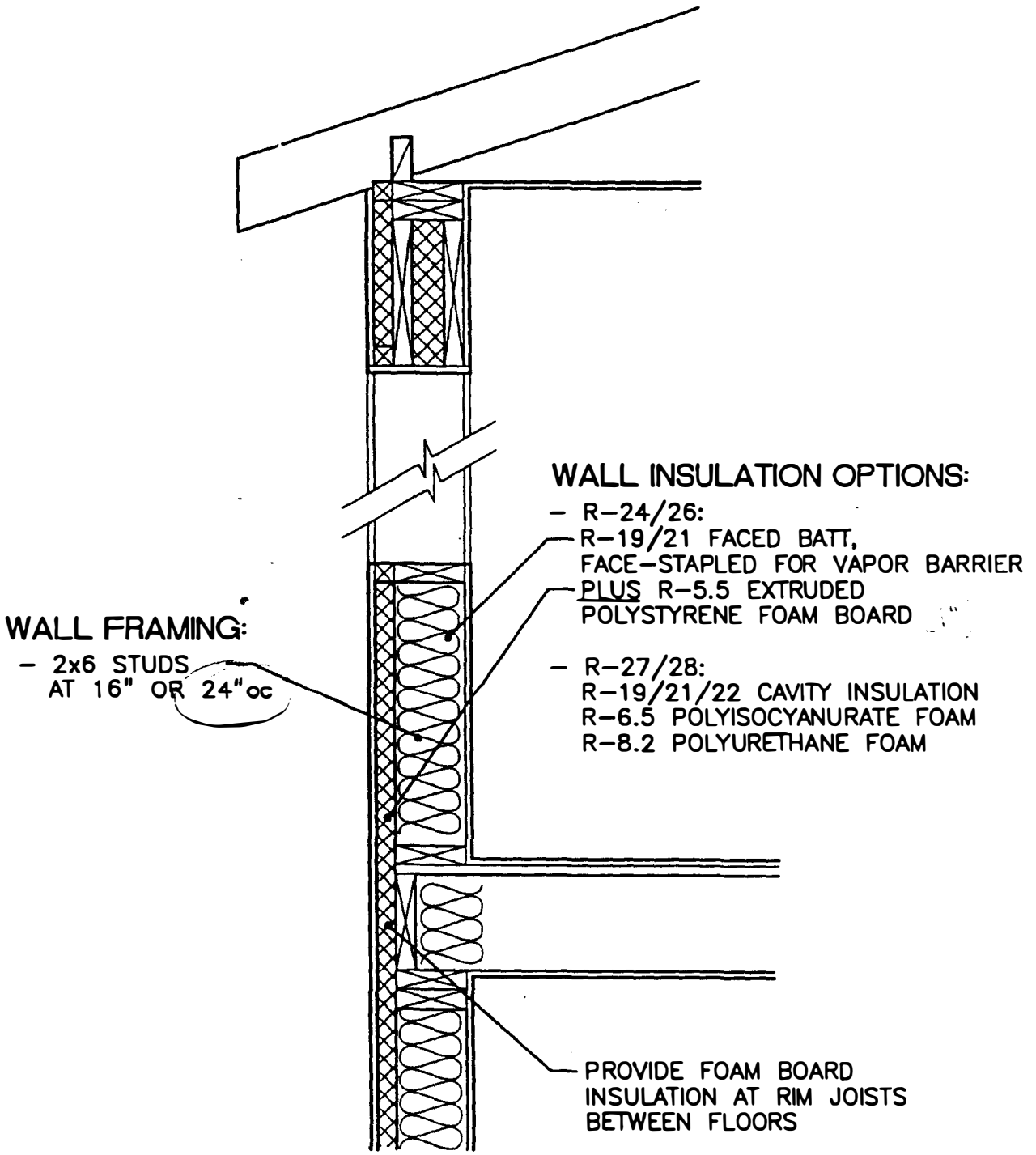
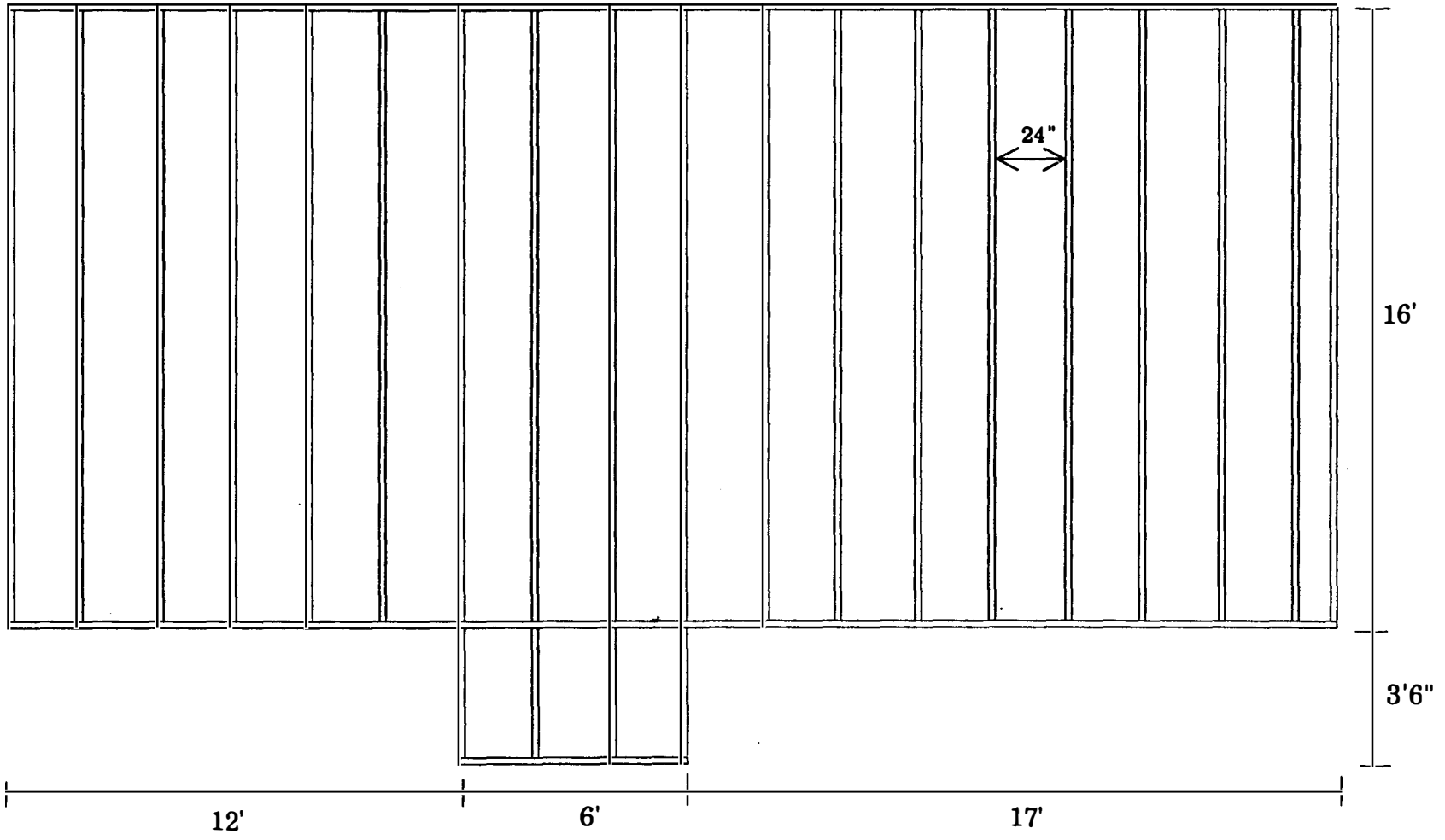


Figure 9E:
R-24/26 Wall

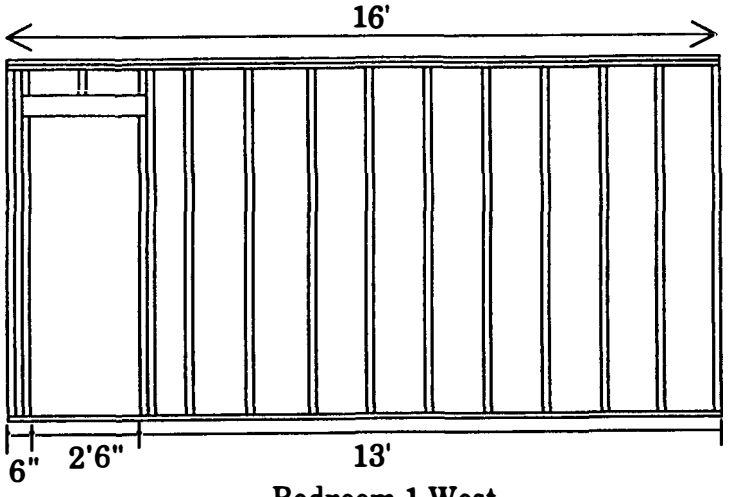


Intermediate Floor (Option II)
2" X 10" Joists @ 24" O.C.
2" X 10" Header Joists
3/4" Floor Sheathing

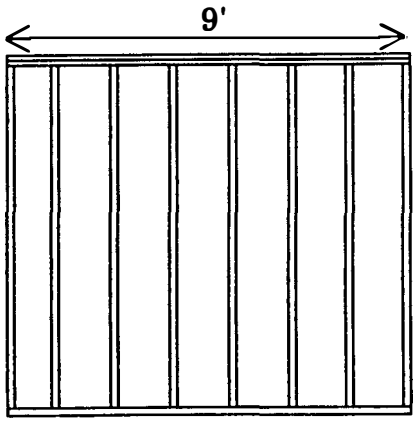


Intermediate Floor Framing Plan

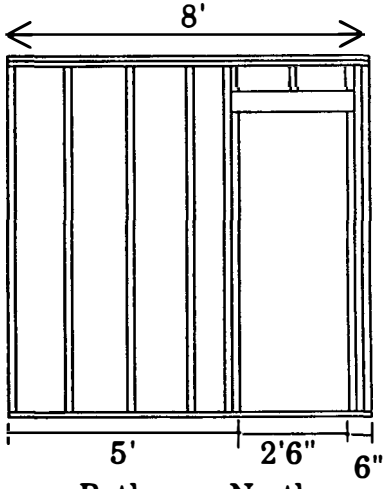
Interior Partitions
2" X 4" Studs @ 16" O.C. unless otherwise noted
2" X 4" Plates
4" X 8" Headers



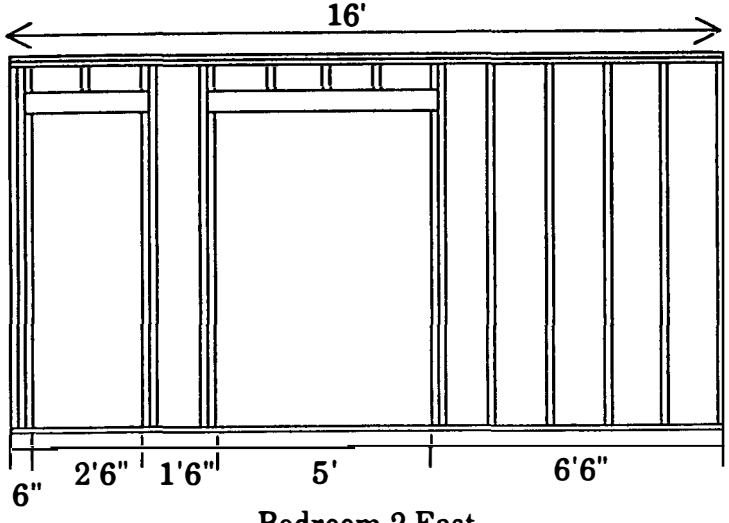
Bedroom 1 West



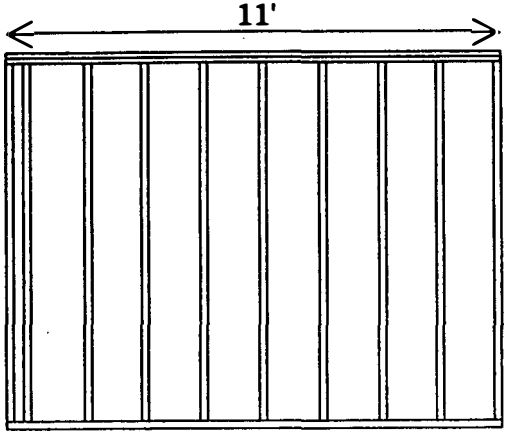
Living Room West



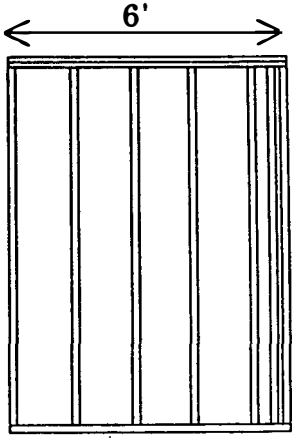
Bathroom North



Bedroom 2 East

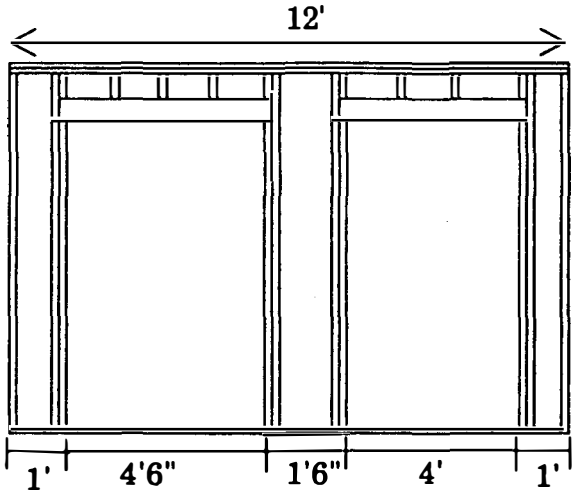


Kitchen North
(2 X 6's)

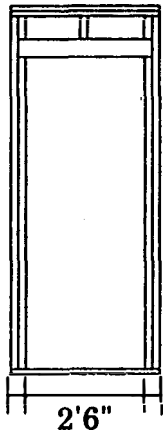


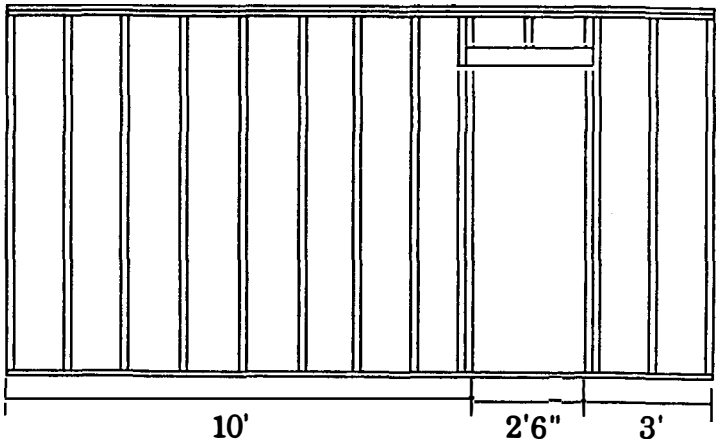
Bathroom East
(2 X 6's)

Interior Partitions
2" X 4" Studs @ 16" O.C. unless otherwise noted
2" X 4" Plates
4" X 8" Headers

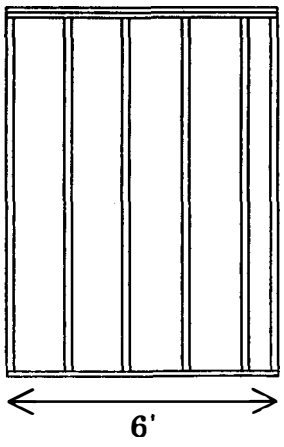


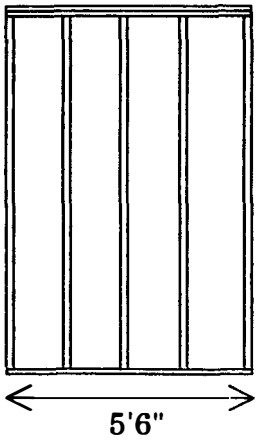
Master Bedroom West



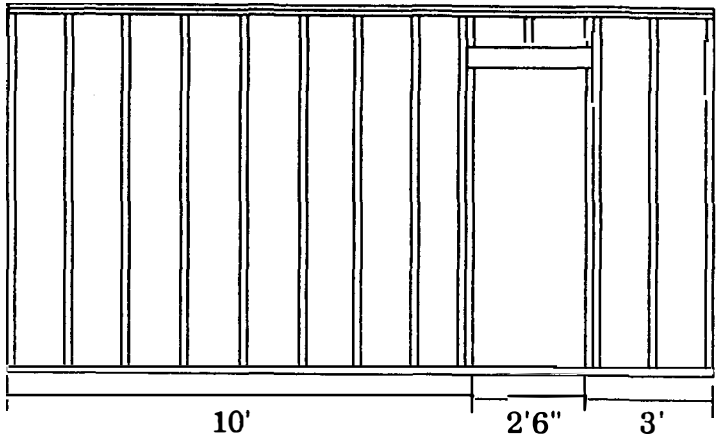


Hall





Plumbing Walls (2 X 6's)



Bathroom North (2 X 6's)

9.5 Energy Analysis Data

PROPOSED 1-22-92

WATTSUN 5.2 SUPER GOOD CENTS (1991 MCS) COMPLIANCE REPORT 01/22/92

FILE: C:WATTSUN5DH1219 R.WS HOUSE ID:

Site:

Analyst:
Jurisdiction:
Utility:

Homeowner:

House Type: Single Family/Duplex
Floor Area: 1300 ft2

Builder:

Weather Data: Portland, OR
Climate Zone: 1

The PROPOSED design *COMPLIES* with Super Good Cents (1991 MCS).

	REFERENCE	PROPOSED
~~COMPONENT PERFORMANCE~~	316	291 Btu/hr-F
ENERGY BUDGET	2.93	2.23 kWh/ft2-yr

PROPOSED DESIGN COMPONENTS

Component	Description	Value	X Area =	UA
On Grade Slab	R15 2' horizontal w/TB	F-0.520	119ft	61.9
* Floor	**R-CONTROL 7.25	U-0.032	592	18.9
Glazing @15%	**VINYL	U-0.350	191.0	64.9*
Doors	Metal R-5 base case	U-0.190	21.0	4.0*
* AG Wall	**R-CONTROL 5.25	U-0.043	1811	77.9
* Ceiling	**R-CONTROL 9.25	U-0.025	884	22.1
Infiltration	Advanced Air Sealing w/HRV	ACH-0.200	11335ft3	41.5
		Proposed UA		291

Items in parentheses not included in COMPONENT PERFORMANCE totals.
** Denotes non-standard values - check calculation of thermal value.
* Denotes adjusted UA to reflect 7-1/2 mph wind speed.

REFFRENCE 1·22·92

WATTSUN 5.2 SUPER GOOD CENTS (1991 MCS) COMPLIANCE REPORT 01/22/92

FILE: C:WATTSUN5DH1219.WS HOUSE ID:

Site: Analyst:
Jurisdiction:
Utility:

Homeowner: House Type: Single Family/Duplex
Floor Area: 1300 ft2

Builder: Weather Data: Portland, OR
Climate Zone: 1

The PROPOSED design *COMPLIES* with Super Good Cents (1991 MCS).

	REFERENCE @.35 ACH	~~PROPOSED~~ REFERENCE @ .20 ACH	
COMPONENT PERFORMANCE	322	288	Btu/hr-F
ENERGY BUDGET	3.06	2.16	kWh/ft2-yr

~~REFERENCE DESIGN~~ REFERENCE @ .35 ACH

Component	Description	Reference Value	X	Area =	UA
On Grade Slab	R15 2' horizontal w/TB	F-0.520		119ft	61.9
Floor	R30 vented joist	U-0.029		592	17.2
Glazing @15%	0.35 U-value	U-0.350		195.0	68.3
Doors	Metal R5 base case	U-0.190		21.0	4.0
AG Wall	R21+R5 ADV	U-0.041		1807	74.1
Ceiling, Vault	R38 batt vault vented	U-0.027		884	23.9
Infiltration	Standard air sealing	ACH-0.350		11335ft3	72.6
		Reference UA			322

~~PROPOSED DESIGN COMPONENTS~~ REFERENCE @ ~~.35~~ 0.20 ACH

Component	Description	Value	X	Area =	UA
On Grade Slab	R15 2' horizontal w/TB	F-0.520		119ft	61.9
Floor	R30 unvented Joist 16oc	U-0.029		592	17.2
Glazing @15%	**VINYL	U-0.350		191.0	64.9*
Doors	Metal R-5 base case	U-0.190		21.0	4.0*
AG Wall	R21 + R5 ADV T1-11	U-0.041		1811	74.3
Ceiling	R38 batt Vault vented 2x14 16oc	U-0.027		884	23.9
Infiltration	Advanced Air Sealing w/HRV	ACH-0.200		11335ft3	41.5
		Proposed UA			288

Items in parentheses not included in COMPONENT PERFORMANCE totals.
** Denotes non-standard values - check calculation of thermal value.
* Denotes adjusted UA to reflect 7-1/2 mph wind speed.

9.6 Cost Analysis Spread Sheets

COST SHEET 1-8

DEMONSTRATION HOUSE (PHASE I DESIGN)

COST SHEET 1-8

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB $	LAB TOT $	TOTAL $	ADJ TOTAL $	MAT.INDEX	ADJ. MAT.$	LAB. INDEX	ADJ. LAB.$	NOTES
2	ROOF: R-Control 9 3/8"													
3	6@8x10 panel	480	sf	3.35	1608.00	0.59	283.20	1891.20	1915.16	1.000	1608.00	0.922	307.16	MEANS 4X8' ROOF PANEL INSTALLATION Labor, R-Contr
4	2@8x18 panel	288	sf	3.35	964.80	0.59	169.92	1134.72	1149.10	1.000	964.80	0.922	184.30	"
5	2@4x10 panel	80	sf	3.20	256.00	0.59	47.20	303.20	307.19	1.000	256.00	0.922	51.19	"
6	**Panel Sub-Total**	**848**	**sf**		**2828.80**		**500.32**	**3329.12**	**3371.45**					
7														
8	Rafter 9@2x10x10	90	lf	0.74	66.60	0.35	31.50	98.10	108.00	0.902	73.84	0.922	34.16	MEANS 2X8 RAFTER FRAMIN G
9	Overhang 2X6	276	lf	0.30	82.80	0.33	91.08	173.88						2 LF SHEATHING AROUND 92 FT ROOF PERIMETER
10	Ridge Beam 2@2x12	80	lf	1.07	85.60	0.30	24.00	109.60	104.42	1.092	78.39	0.922	26.03	Jerry's 12/16/91
11	Staples				25.00		0.00	25.00	25.00	1.000	25.00	1.000	0.00	Allowance
12	Screw Fasteners(1/2 lf)	54	ea	1.00	54.00		0.00	54.00	54.00	1.000	54.00	1.000	0.00	R-Control Cost Data 1-91
13	ST 12 straps	10	ea	0.55	5.50		0.00	5.50	5.50	1.000	5.50	1.000	0.00	"
14	L-70(1/2 lf)	42	ea	0.75	31.50		0.00	31.50	31.50	1.000	31.50	1.000	0.00	"
15	Sealant(1/2 per 80sf)	6	ea	3.54	21.24		0.00	21.24	21.24	1.000	21.24	1.000	0.00	"
16	1/2" sheetrock	848	sf	0.08	67.84	0.41	347.68	415.52	548.33	0.444	152.79	0.879	395.54	MEANS- TAPED AND FINISHED
17	Sheathing 1/2" Plywood	184	sf	0.25	46.00	0.24	44.16	90.16	90.02	1.092	42.12	0.922	47.90	2 FT OVERHANG AROUND ROOF PERIMETER WITH RAFTER
18	Roofing (Felt,flash,vent	1032	sf	0.42	433.44	0.52	536.64	970.08	1121.62	0.866	500.51	0.864	621.11	MEANS- STND STRIP, ASP. SHINGLES, ORG. CLASS C,075 10
19														
20	**Roof Sub-Total**				**3748.32**		**1575.38**	**5323.70**	**5481.08**					
21														
22														
23	FLOOR:R-Control 7 3/8"													
24	9@4x16 panel	576	sf	2.95	1699.20	0.59	339.84	2039.04	2067.79	1.000	1699.20	0.922	368.59	MEANS- 4X8 FLOOR PANEL Labor, R-Control Materials
25	**Panel Sub Total**	**576**	**sf**		**1699.20**		**339.84**	**2039.04**	**2067.79**					
26														
27	Joist 8@2x8x16	128	lf	0.42	53.76	0.30	38.40	92.16	109.53	0.792	67.88	0.922	41.65	Means Labor, R-Control Materials
28	Treated Plate-2x8	106	lf	0.47	49.82	0.73	77.38	127.20	158.62	0.667	74.69	0.922	83.93	"
29	Rim Joist - 2x8	106	lf	0.42	44.52	0.30	31.80	76.32	90.70	0.792	56.21	0.922	34.49	"
30	Anchor bolts	28	ea	0.25	7.00	1.88	52.64	59.64	61.56	1.207	5.80	0.944	55.76	"
31	Staples				25.00		0.00	25.00	25.00	1.000	25.00	1.000	0.00	Allowance
32	Sealant	4.5	ea	3.54	15.93		0.00	15.93	15.93	1.000	15.93	1.000	0.00	R-Control
33	Slab				114.68		97.71	212.39	192.62	1.007	113.88	1.241	78.73	MEANS-46 LF EDGE WORK FORMS TO 6", 119 SF 4" SLAE
34	Slab insulation	45	sf	0.35	15.75	0.23	10.35	26.10	30.17	0.866	18.19	0.864	11.98	MEANS- 2" EPS
35														
36	**Floor Sub-Total**				**2025.66**		**648.12**	**2673.78**	**2751.91**					

* Adj. Total Cost is Total Cost adjusted to Means National Averages for Labor and Materials

DEMONSTRATION HOUSE (PHASE I DESIGN)

COST SHEET 1-8

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
37	COMPONENT	QTY	UNIT	MAT UNIT $	MAT COST	UNIT LAB. $	LABOR COS	TOTAL COST	ADJ TOTAL $	MAT.INDEX	ADJ. MAT.$	LAB. INDEX	ADJ. LAB.$	
38	WALL:R-Control 5 1/2"													
39	14@8x16 panel	1792	sf	2.90	5196.80	0.56	1003.52	6200.32	6285.22	1.000	5196.80	0.922	1088.42	R-Control materials, Means Labor
40	2@4x16 panel	128	sf	2.70	345.60	0.56	71.68	417.28	423.34	1.000	345.60	0.922	77.74	"
41	3@4x8 panel	96	sf	2.70	259.20	0.56	53.76	312.96	317.51	1.000	259.20	0.922	58.31	"
42	**Panel Sub Total**	**2016**	**sf**		**5801.60**		**1128.96**	**6930.56**	**7026.07**					
43														
44	Plates 2x6	305	lf	0.30	91.50	0.60	183.00	274.50	317.47	0.769	118.99	0.922	198.48	MEANS-SILL PLATES Labor, Jerry's Materials 12/16/91
45	Staples				35.00		0.00	35.00	35.00	1.000	35.00	1.000	0.00	Allowance
46	Sealant	12	ea	3.54	42.48		0.00	42.48	42.48	1.000	42.48	1.000	0.00	R-Control
47	Screw Fasteners	50	ea		50.00		0.00	50.00	50.00	1.000	50.00	1.000	0.00	R-Control
48	1/2" sheetrock	1768	sf	0.08	141.44	0.33	583.44	724.88	982.31	0.444	318.56	0.879	663.75	Means Labor, Jerry's Materials 12/16/91
49	Siding (T1-11 5/8")	1768	sf	0.47	830.96	0.49	866.32	1697.28	1894.74	0.870	955.13	0.922	939.61	MEANS- FIR Labor, Jerry's Materials 12/16/91
50														
51	**Wall Sub Total**				**6992.98**		**2761.72**	**9754.70**	**10340.06**					
52														
53														
54	**R-Control Shell Total**				**12766.96**		**4985.22**	**17752.18**	**18581.06**					
55	**R-Control Shell $/sf**	**1268**	**sf**		**10.07**		**3.93**	**14.00**	**14.65**					
56														
57														
58														
59	ROOF-Advanced Framing													
60	Rafters 53@2x14x10	530	lf	1.46	773.80	0.50	265.00	1038.80	907.45	1.248	620.03	0.922	287.42	MEANS- 2X14 JOIST (PLUS .07) Labor, Hammer Lumbe
61	Sub Fascia 2x14	196	lf	1.46	286.16	0.50	98.00	384.16	335.59	1.248	229.29	0.922	106.29	MEANS- 2X14 JOIST (PLUS .07) Labor, Hammer Lumbe
62	Blocking 22@2x14x2	44	lf	1.46	64.24	0.82	36.08	100.32	90.61	1.248	51.47	0.922	39.13	MEANS- 2X8 Labor,
63	Ridge Beam 2@2x12x40	80	lf	1.07	85.60	0.30	24.00	109.60	104.42	1.092	78.39	0.922	26.03	Means Labor, Jerry's Materials 12/16/91
64	Sheathing 1/2" Plywood	1032	sf	0.25	258.00	0.24	247.68	505.68	567.94	0.862	299.30	0.922	268.63	"
65	R-38 batt Insulation	848	sf	0.67	568.16	0.12	101.76	669.92	813.20	0.817	695.42	0.864	117.78	"
66	Vapor Barrier/ Air Barr.	848	sf	0.07	59.36	0.04	33.92	93.28	116.35	0.770	77.09	0.864	39.26	"
67	Nails/Screws				30.00		0.00	30.00	30.00	1.000	30.00	1.000	0.00	Allowance
68	Glue/Caulk				30.00		30.00	60.00	60.00	1.000	30.00	1.000	30.00	Allowance
69	1/2" sheetrock	848	sf	0.08	67.84	0.41	347.68	415.52	548.33	0.444	152.79	0.879	395.54	Means Labor, Jerry's Materials 12/16/91
70	Roofing (Felt, etc.)	1032	sf	0.42	433.44	0.52	536.64	970.08	1121.62	0.866	500.51	0.864	621.11	see #18
71														
72	**Roof Adv. Frm. Sub-Total**				**2656.60**		**1720.76**	**4377.36**	**4695.50**					

REFERENCE HOUSE (PHASE I DESIGN)

* Adj. Total Cost is Total Cost adjusted to Means National Averages for Labor and Materials

REFERENCE HOUSE (PHASE I DESIGN)

COST SHEET 1-8

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
73	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST	ADJ TOTAL $	MAT.INDEX	ADJ. MAT.$	LAB. INDEX	ADJ. LAB.$	
74	FLOOR: Advanced Framing													
75	Joist-19@2x12x16	304	l f	1.07	325.28	0.37	112.48	437.76	419.87	1.092	297.88	0.922	122.00	MEANS-2X12 JOIST Labor, Jerry's Materials 12/16/91
76	Rim Joist-2x12	78	l f	1.07	83.46	0.37	28.86	112.32	107.73	1.092	76.43	0.922	31.30	"
77	Blocking- 2x12	36	l f	1.07	38.52	0.82	29.52	68.04	67.29	1.092	35.27	0.922	32.02	MEANS- 2X8 BLOCKING Labor, Jerry's Materials 12/16/
78	R-30 batt insulation	560	s f	0.36	201.60	0.12	67.20	268.80	391.31	0.643	313.53	0.864	77.78	Means Labor, Jerry's Materials 12/16/91
79	3/4" floor decking	560	s f	0.43	243.04	0.31	173.60	416.64	451.89	0.922	263.60	0.922	188.29	"
80	Vapor Barrier/Air Barr.	0	s f	0.07	0.00	0.04	0.00	0.00	0.00	0.770	0.00	0.864	0.00	
81	Nails/Screws				30.00		0.00	30.00	30.00	1.000	30.00	1.000	0.00	Allowance
82	Glue/Caulk				30.00		30.00	60.00	60.00	1.000	30.00	1.000	30.00	"
83	Joist hangers	38	ea	0.99	37.62	1.04	39.52	77.14	57.02	1.736	21.67	1.118	35.35	Means Labor, Homeclub Materials 12/16/91
84	Slab				114.68		97.71	212.39	193.41	1.000	114.68	1.241	78.73	SEE # 34
85	Slab insulation	45	s f	0.35	15.75	0.23	10.35	26.10	30.17	0.866	18.19	0.864	11.98	SEE # 35
86														
87	Floor Adv. Frm. Sub Total				1119.95		589.24	1709.19	1808.69					
88														
89	WALL: Advanced Framing													
90	Studs 101@2x6x16	1616	l f	0.30	484.80	0.35	565.60	1050.40	1243.88	0.769	630.43	0.922	613.45	MEANS- 2 STORY FRM. Labor, Jerry's Materials 12/16/
91	Plates 2x6	458	l f	0.30	137.40	0.44	201.52	338.92	397.24	0.769	178.67	0.922	218.57	Means Labor, Jerry's Materials 12/16/91
92	Firestop/blk/crip 2x6	554	l f	0.30	166.20	0.55	304.70	470.90	546.60	0.769	216.12	0.922	330.48	MEANS- FIRESTOP DATA Labor, Jerry's Materials 12/1
93	Header 2x8	1034	l f	0.42	434.28	0.74	765.16	1199.44	1378.22	0.792	548.33	0.922	829.89	Means Labor, Jerry's Materials
94	R-21 batt insulation	1768	s f	0.26	459.68	0.11	194.48	654.16	932.29	0.650	707.20	0.864	225.09	Means Labor, HomeClub Materials 12/16/91
95	2" rigid insulation	172	s f	0.66	113.52	0.22	37.84	151.36	222.57	0.635	178.77	0.864	43.80	Means Labor, Jerry's Materials 12/16/91
96	1" rigid Insulation	1596	s f	0.41	654.36	0.21	335.16	989.52	1218.32	0.788	830.41	0.864	387.92	"
97	5/8" sheathing	1768	s f	0.41	724.88	0.32	565.76	1290.64	1214.68	1.206	601.06	0.922	613.62	"
98	Vapor Barrier	1768	s f	0.07	123.76	0.04	70.72	194.48	242.58	0.770	160.73	0.864	81.85	"
99	Screws/Nails				45.00		0.00	45.00	45.00	1.000	45.00	1.000	0.00	Allowance
100	Anchor bolts	36	ea	0.25	9.00	1.88	67.68	76.68	61.99	1.207	7.46	1.241	54.54	Means Labor, Jerry's Materials 12/16/91
101	Glue/Caulk				30.00		100.00	130.00	130.00	1.000	30.00	1.000	100.00	Allowance
102	1/2" sheetrock	1768	s f	0.08	141.44	0.33	583.44	724.88	982.31	0.444	318.56	0.879	663.75	Means Labor, Jerry's Materials 12/16/91
103	Siding(T1-11 5/8")	1768	s f	0.47	830.96	0.49	866.32	1697.28	1894.74	0.870	955.13	0.922	939.61	"
104														
105	Wall Adv. Frm. Sub Total				4355.28		4658.38	9013.66	10510.44					
106														
107	Total Advanced Framing Shell				8131.83		6968.38	15100.21	17014.63					
108	Adv Frm Shell $/sf	1268	s f		6.41		5.50	11.91	13.42					

* Adj. Total Cost is Total Cost adjusted to Means National Averages for Labor and Materials

COST SHEET 1-8

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
109	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST	ADJ TOTAL $	MAT.INDEX	ADJ. MAT.$	LAB. INDEX	ADJ. LAB.$	
110	INT.FLOOR: Conv. Frm.													
111	Joist-19@2x12x16	304	l f	1.07	325.28	0.37	112.48	437.76	419.87	1.092	297.88	0.922	122.00	Jerry's Materials 12/16/91, Means Labor
112	Rim Joist-2x12	78	l f	1.07	83.46	0.37	28.86	112.32	107.73	1.092	76.43	0.922	31.30	"
113	Blocking- 2x12	72	l f	1.07	77.04	0.82	59.04	136.08	134.58	1.092	70.55	0.922	64.03	"
114	3/4" floor decking	581	s f	0.43	252.15	0.31	180.11	432.26	468.83	0.922	273.49	0.922	195.35	"
115	Nails/Screws				25.00		0.00	25.00	25.00	1.000	25.00	1.000	0.00	Allowance
116	Glue/Caulk				10.00		0.00	10.00	10.00	1.000	10.00	1.000	0.00	Allowance
117	Joist hangers	38	ea	0.99	37.62	1.04	39.52	77.14	57.02	1.736	21.67	1.118	35.35	HomeClub Materials 12/16/91, Means Labor
118	1/2" sheetrock	581	s f	0.08	46.48	0.41	238.21	284.69	375.69	0.444	104.68	0.879	271.00	Jerry's Materials 12/16/91,Means Labor
119	Painting	581	s f	0.44	255.64	0.09	52.29	307.93	276.85	1.198	213.39	0.824	63.46	Means Labor and Materials
120	Floor Finishes	581	s f	1.92	1115.52	0.42	244.02	1359.54	1249.46	1.152	968.33	0.868	281.13	"
121														
122	Int.Floor Frm. Sub Total				2228.19		954.53	3182.72	3125.03					
123														
124	INT. WALL: Standard Framing													
125	Studs 2x4x8	592	l f	0.16	94.72	0.24	142.08	236.80	308.12	0.615	154.02	0.922	154.10	Jerry's Materials 12/16/91
126	Studs 101@2x6x8	326	l f	0.30	97.80	0.31	101.06	198.86	236.79	0.769	127.18	0.922	109.61	"
127	Plates 2x4	237	l f	0.16	37.92	0.41	97.17	135.09	167.05	0.615	61.66	0.922	105.39	"
128	Plates 2x6	132	l f	0.30	39.60	0.44	58.08	97.68	114.49	0.769	51.50	0.922	62.99	"
129	Firestop/blk/crip 2x4	13	l f	0.16	2.08	0.43	5.59	7.67	9.45	0.615	3.38	0.922	6.06	"
130	Firestop/blk/crip 2x6	1	l f	0.30	0.30	0.55	0.55	0.85	0.99	0.769	0.39	0.922	0.60	"
131	2x4 Header	33	l f	1.58	52.14	0.65	21.45	73.59	108.05	0.615	84.78	0.922	23.26	"
132	1/2" sheetrock	1585	s f	0.08	126.80	0.33	523.05	649.85	880.64	0.444	285.59	0.879	595.05	"
133	Screws/Nails				25.00		0.00	25.00	25.00	1.000	25.00	1.000	0.00	Allowance
134	Glue/Caulk				10.00		0.00	10.00	10.00	1.000	10.00	1.000	0.00	Allowance
135	Painting	1585	s f	0.13	206.05	0.09	142.65	348.70	345.11	1.198	171.99	0.824	173.12	Means Labor and Materials
136														
137	Wall Std. Frm. Sub Total				692.41		1091.68	1784.09	2205.67					
138														
139														
140														
141														
142														
143														
144														

* Adj. Total Cost is Total Cost adjusted to Means National Averages for Labor and Materials

COST SHEET 1-8

COST SHEET 1-8

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
145	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST	ADJ TOTAL $	MAT.INDEX	ADJ. MAT.$	LAB. INDEX	ADJ. LAB.$	
146	MISCELLANEOUS													
147	Windows	191	sf	19.07	3642.37	16.57	3164.87	6807.24	6891.93	1.019	3574.46	0.954	3317.47	JERRY'S VIKING VINYL CASEMENT AVG. 2X3@127.99 & 2'
148	Window trimwork	20	opng	10.04	200.80	12.74	254.80	455.60	464.14	1.019	197.06	0.954	267.09	MEANS- STOOL AND APRON ONLY
149	Interior doors				878.00		307.05	1185.05	1183.48	1.019	861.63	0.954	321.86	MEANS BIRCH 2'6" HC & LOUVERED PINE
150	Exterior doors				73.96		22.75	96.71	96.43	1.019	72.58	0.954	23.85	MEANS EXCLUDES SLIDING GLASS DOOR
151	Light fixtures				300.00		200.00	500.00	500.00	1.000	300.00	1.000	200.00	ESTIMATE
152	Cabinets				1500.00		150.00	1650.00	1650.00	1.000	1500.00	1.000	150.00	ESTIMATE BASED ON SVDP NUMBERS
153	Appliances				1250.00		0.00	1250.00	1250.00	1.000	1250.00	1.000	0.00	ESTIMATE
154	Stairs	2	ea	134.00	268.00	82.22	164.44	432.44	469.02	0.922	290.67	0.922	178.35	MEANS PINE BOX 4'
155	Interior Painting	2738	sf	0.13	355.94	0.09	246.42	602.36	596.17	1.198	297.11	0.824	299.05	MEANS- 2 COATS, SMOOTH FINISH, SPRAYED
156	Floor finishes	672	sf	1.92	1290.24	0.42	282.24	1572.48	1445.16	1.152	1120.00	0.868	325.16	MEANS- PLUSH NYLON MED. USE
157	Gutters and Downspouts				107.04		222.02	329.06	380.57	0.866	123.60	0.864	256.97	MEANS- 64 LF ALUM. 2X3 .O20 DWN. SPT., 80 LF ALUM. 5'
158	Exterior Painting	1768	sf	0.08	141.44	0.06	106.08	247.52	246.80	1.198	118.06	0.824	128.74	MEANS-2 COAT SPRAY
159	**Miscellaneous Sub-Total**				**10007.79**		**5120.67**	**15128.46**	**15173.71**					
160														
161	SERVICES													ESTIMATE BASED ON SVDP NUMBERS
162	Plumbing				4300.00		0.00	4300.00	4300.00	1.000	4300.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS + $1500
163	Electrical				3925.00		0.00	3925.00	3925.00	1.000	3925.00	1.000	0.00	
164	AAHX- Mech.				1200.00		200.00	1400.00	1400.00	1.000	1200.00	1.000	200.00	UNIT BASED ON BPA MODEL, ALLOWANCE FOR LABOR
165	**Total Services Costs**				**9425.00**		**200.00**	**9625.00**	**9625.00**					
166														
167	SITE WORK													
168	Excv.,backfill,grade,gravel,sewer				3284.00		0.00	3284.00	3284.00	1.000	3284.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
169	Foundation				1404.00		0.00	1404.00	1404.00	1.000	1404.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
170	Landscape				1000.00		0.00	1000.00	1000.00	1.000	1000.00	1.000		
171	**Total Sitework Costs**				**5688.00**		**0.00**	**5688.00**	**5688.00**					
172														
173	Contingency				0.00		0.00	2000.00	2000.00	1.000	0.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
174														
175														
176	**Adv Frm Total Hard Costs**				**36173.22**		**14335.26**	**52508.48**	**54832.03**					
177	**Adv Frm Hard $/sf**	**1268**	**sf**		**28.53**		**11.31**	**41.41**	**43.24**					
178														
179	**R-Control Total Hard Costs**				**40808.35**		**12352.10**	**55160.45**	**56398.47**					
180	**R-Control Hard $/sf**	**1268**	**sf**		**32.18**		**9.74**	**43.50**	**44.48**					

* Adj. Total Cost is Total Cost adjusted to Means National Averages for Labor and Materials

COST SHEET 1-8

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
181	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST	ADJ TOTAL $	MAT.INDEX	ADJ. MAT.$	LAB. INDEX	ADJ. LAB.$	
182	SOFT COSTS													
183	Plans,survey,specs							0.00	0.00	1.000	0.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
184	Survey							1950.00	1950.00	1.000	0.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
185	Design and Engineering Fees							0.00	0.00	1.000	0.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
186	Raw land							0.00	0.00	1.000	0.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
187	Land Sales Commission							6000.00	6000.00	1.000	0.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
188	Site Planning and engineering							0.00	0.00	1.000	0.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
189	Closing Costs							0.00	0.00	1.000	0.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
190	Builder's Administration and profit							500.00	500.00	1.000	0.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
191	Warranty expenses							0.00	0.00	1.000	0.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
192	Temporary Utilities							0.00	0.00	1.000	0.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
193	Streets, Curbs, and grading							0.00	0.00	1.000	0.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
194	Construction loan interest							0.00	0.00	1.000	0.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
195	Construction Loan Fees							600.00	600.00	1.000	0.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
196	Insurance							500.00	500.00	1.000	0.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
197	House Sales Commission							0.00	0.00	1.000	0.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
198	Permits and Development Fees							0.00	0.00	1.000	0.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
199	Taxes							0.00	0.00	1.000	0.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
200	Construction Overhead							0.00	0.00	1.000	0.00	1.000	0.00	ESTIMATE BASED ON SVDP NUMBERS
201														
202	**Total Soft Costs**							**9550.00**	**9550.00**					
203														
204														
205	**Adv Frm Total House Costs**							**62058.48**	**64382.03**					
206	**R-Control Total House Costs**							**64710.45**	**65948.47**					
207														
208	**Adv Frm Total $/sf**	**1268 sf**						**48.94**	**50.77**					
209	**R-Control Total $/sf**	**1268 sf**						**51.03**	**52.01**					
210	GARAGE													

* Adj. Total Cost is Total Cost adjusted to Means National Averages for Labor and Materials

9.7 Structural Analysis Data

Discussion of Proposed Panel Thicknesses for Two-Story House Design

Dimensions of House: Height = 16'
Length = 36'
Width = 16'

Floor Design: 7-1/4" EPS core with 7/16" waferboard

Live Load (LL) = 40 psf
Dead Load (DL) = 20 psf

Assuming 16' span: Allowable LL = 46 psf (OK)
All. DL + LL = 68 psf (OK)
(Deflection controls)

So, the floor appears to be slightly overdesigned for structural needs.

Checking 5-1/2" EPS core with 7/16" waferboard

Assuming 8' span: Allowable LL = 40 psf (OK)
(deflection controls)
All. DL + LL = 61 psf (OK)
(strength controls)

Therefore, the 5-1/2" panels would appear to be adequate structurally if the span is reduced to 8' by a floor girder .

Roof Design: 9-1/4" EPS core with 7/16" waferboard

Snow Load (SL) = 25 psf
Roof Live Load = 20 psf
Dead Load (DL) = 8 psf

DL + SL = 33 psf (controls)

The 9-1/4" panel appears overdesigned for structural loads.

Checking 3-1/2" EPS core with 7/16" waferboard

Assuming 8' span: Allowable SL = 25 psf (OK)
All. DL + SL = 39 psf (OK)
(Deflection controls)

So, the 3-1/2" panel appears to be adequate for the structural needs.

Wall Design: 5-1/2" EPS core with 7/16" waferboard

Wind Load (WL) = 25 psf
(Seismic loads do not control.)

Assuming 8' span: Allowable WL = 40 psf (OK)
(deflection controls)
(axial + bending OK)

So, the 5-1/2" panel appears to be overdesigned for the structural needs.

Checking 3-1/2" EPS core with 7/16" waferboard

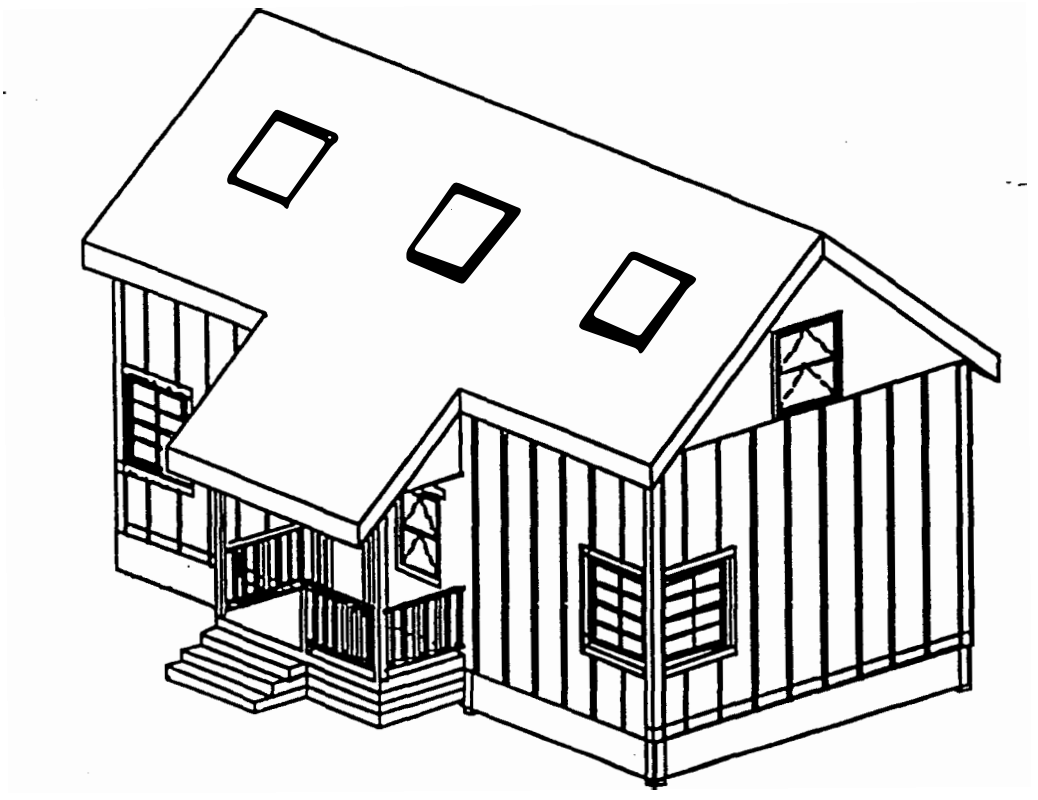
Assuming 8' span: Allowable WL = 25 psf (OK)
(deflection controls)
(axial + bending OK)

So, the 3-1/2" panel appears adequate for structural needs .

Note: These are very rough calculations for preliminary design purposes as you requested. Final design calculations checking each failure mode based on the actual configuration and details need to be performed by a structural engineer experienced in wood design and familiar with the R-Control product and its testing.

10.0 APPENDIX — PHASE II DATA

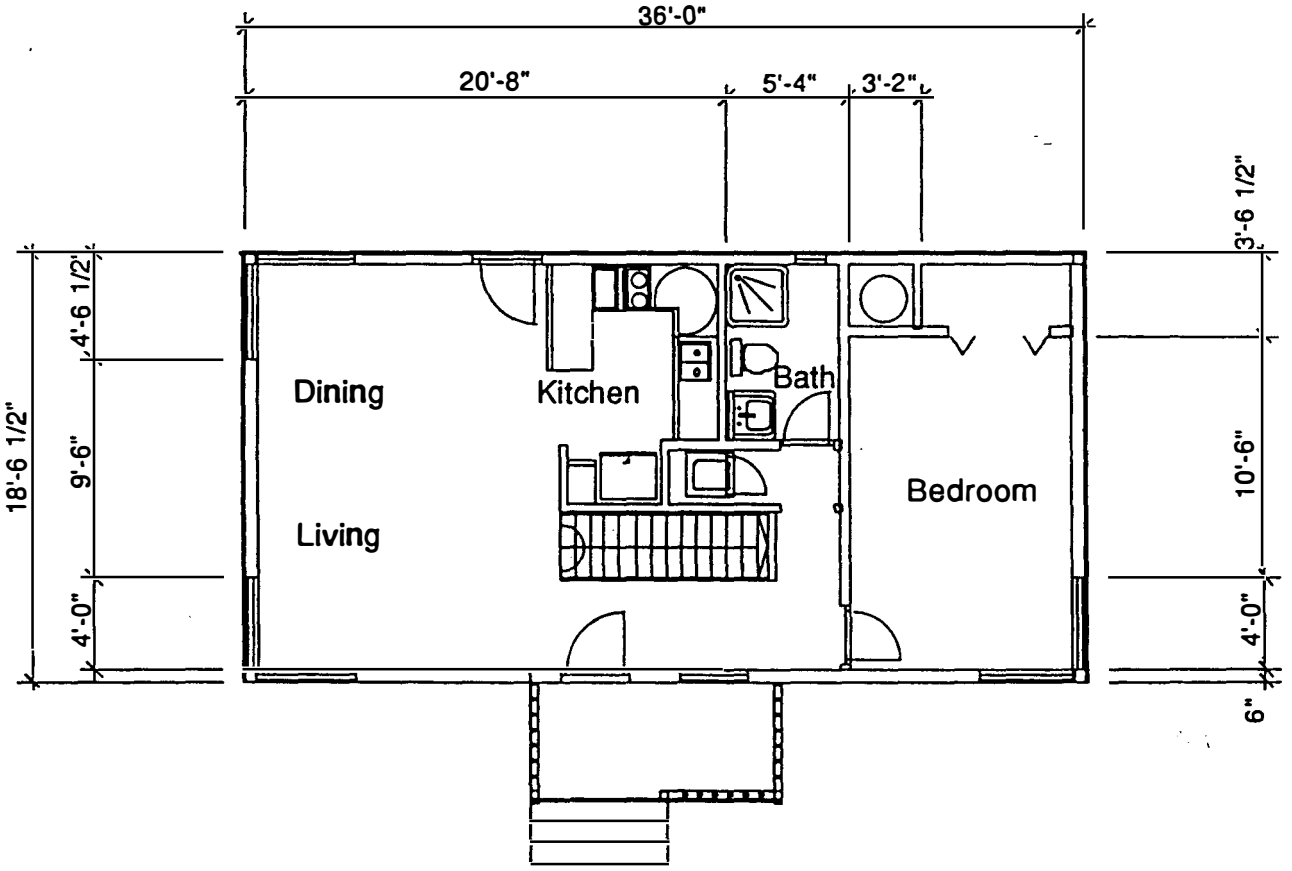
10.1 1-1/2 Story "Long Ridge" Design



1 1/2- Story House " Long "
Plan Views
Cost Estimates:
Demonstration House & Reference House

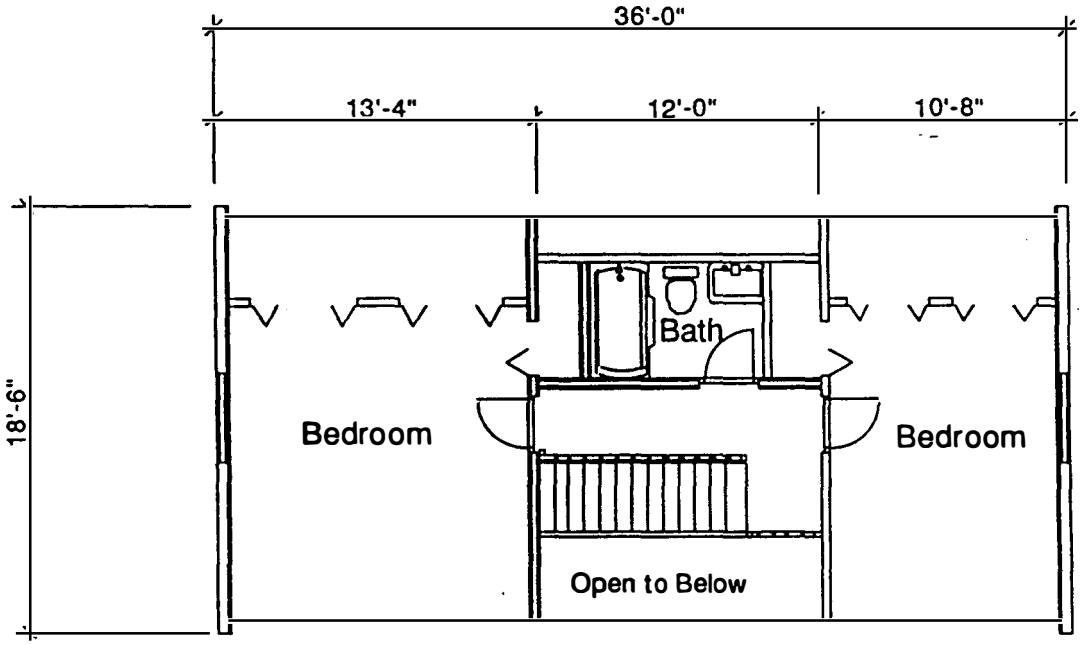
Energy Efficient Industrlized Housing
Center for Housing Innovation
University of Oregon

***Cost estimates based on 1992 Means Estimating Guide**



FIRST FLOOR PLAN

1 1/2 Story " Long "



SECOND FLOOR PLAN

1 1/2 Story "

	A	B	C	D	E	F	G	H
1	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB $	LAB TOT $	TOTAL $
2	ROOF: R-38							
3	2x12 Ridge	44	lf	0.85	37.40	0.90	39.60	77.00
4	2x12x18' Rafters	560	lf	0.85	476.00	0.45	252.00	728.00
5	2x12 Blocking	72	lf	0.85	61.20	0.82	59.04	120.24
6	Engr'd Trusses#1	6	ea	21.30	127.80	6.24	37.44	165.24
7	Engr'd Trusses#2	17	ea	42.00	714.00	10.67	181.39	895.39
8	Sheathing 7/16" Plywood	1780	sf	0.27	480.60	0.23	409.40	890.00
9	2x6 Fascia	264	lf	0.34	89.76	1.36	359.04	448.80
10	R-38 batt Insulation	712	sf	0.71	505.52	0.14	99.68	605.20
11	Vapor Barrier/ Air Barr.	1212	sf	0.07	84.84	0.04	52.12	136.96
12	Na./Sc./Gl./Ca.				40.00	0.00	0.00	40.00
13	1/2" sheetrock-ceiling	608	sf	0.10	60.80	0.34	206.72	267.52
14	Roofing	1780	sf	0.29	516.20	0.30	534.00	1050.20
15	15 # Felt	1780	sf	0.05	89.00	0.05	89.00	178.00
16	Gutters/Downspouts	134	lf	0.60	80.40	1.12	150.08	230.48
17	Vents	10		15.00	150.00	20.00	200.00	350.00
18	Glue/Caulk				0.00		0.00	0.00
19	R-21 Insulation	426	sf	0.38	161.88	0.15	63.90	225.78
20	Flr. Ins. R-38	404	sf	0.71	286.84	0.11	44.44	331.28
21								
22	R-38 Roof Sub-Total				3962.24		2777.85	6740.09
23								
24	FLOOR: R-30 Std. Framing							
25	Joist-27@2x8x20	486	lf	0.47	228.42	0.36	174.96	403.38
26	Rim Joist-2x8	120	lf	0.47	56.40	0.36	43.20	99.60
27	Blocking- 2x8	69	lf	0.47	32.43	0.80	55.20	87.63
28	R-30 batt Insulation	741	sf	0.50	370.50	0.12	88.92	459.42
29	3/4" floor decking	800	sf	0.37	296.00	0.32	256.00	552.00
30	Vapor Barrier/Air Barr.	741	sf	0.07	51.87	0.04	31.86	83.73
31	Na./Sc./Gl./Ca.				40.00		0.00	40.00
32	Floor Finish	719	sf	1.92	1380.48	0.42	301.98	1682.46
33								
34								
35	R-30Floor Sub Total				2456.10		952.12	3408.22
36	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COST	TOTAL COST
37								
38	WALL: R-21 Adv. Framing							
39	Studs 122 @ 2x6x8'	1104	lf	0.34	375.36	0.33	364.32	739.68
40	Studs 9@2x6x10	90	lf	0.34	30.60	0.33	29.70	60.30
41	Plates 2x6	480	lf	0.34	163.20	0.43	206.40	369.60
42	Header 2x8	90	lf	0.47	42.30	0.97	87.30	129.60
43	R-21 batt Insulation	928	sf	0.38	352.64	0.12	111.36	464.00
44	2" rigid Insulation	30	sf	0.78	23.40	0.21	6.30	29.70
45	Vapor Barrier	928	sf	0.07	64.96	0.04	39.90	104.86
46	Screws/Nails				45.00		0.00	45.00
47	Glue/Caulk				10.00		0.00	10.00
48	1/2" sheetrock	928	sf	0.10	92.80	0.33	306.24	399.04
49	Siding(T1-11 5/8")	1120	sf	0.47	526.40	0.49	548.80	1075.20
50	Painting - Ext.	1120	sf	0.14	156.80	0.18	201.60	358.40
51								
52	R-21 Wall Sub Total				1883.46		1901.92	3785.38
53								
54	Total Base Case Shell				8301.80		5631.89	13933.69
55	Base Case Shell $/sf	1257	sf		6.60		4.48	11.08
56								
57	INT.FLOOR: Conv. Frm.							
58	Beam 6x12x16'	1	ea	33.25	33.25	28.50	28.50	61.75
59	Blocking- 2x10	76	lf	0.71	53.96	1.20	91.20	145.16
60	Nails/Screws				25.00		0.00	25.00

	A	B	C	D	E	F	G	H
61	Glue/Caulk				10.00		0.00	10.00
62	Joist hangers	10	ea	0.99	9.90	1.04	10.40	20.30
63	1/2" sheetrock	649	sf	0.10	64.90	0.34	220.66	285.56
64	Floor Finishes	400	sf	1.92	768.00	0.42	168.00	936.00
65								
66								
67								
68								
69								
70	Int.Floor Frm. Sub Total				965.01		518.76	1483.77
71	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COST	TOTAL COST
72								
73	INT. WALL: Standard Framing							
74	Studs 2x4x8	1367	lf	0.23	314.41	0.24	328.08	642.49
75	Studs 2x6x8	177	lf	0.34	60.18	0.33	58.41	118.59
76	Plates 2x4	259	lf	0.23	59.57	0.41	106.19	165.76
77	Plates 2x6	89	lf	0.34	30.26	0.43	38.27	68.53
78	2x8 Header	78	lf	0.47	36.66	0.90	70.20	106.86
79	1/2" sheetrock	2186	sf	0.10	218.60	0.34	743.24	961.84
80	Screws/Nails				25.00		0.00	25.00
81	Glue/Caulk				10.00		0.00	10.00
82	Painting	1947	sf	0.12	233.64	0.09	175.23	408.87
83								
84	Wall Std. Frm. Sub Total				988.32		1518.62	2507.94
85								
86								
87								
88	MISCELLANEOUS							
89	Skylites	24	sf	18.94	454.56	16.74	401.76	856.32
90	Windows	125	sf	20.13	2516.25	16.74	2092.50	4608.75
91	Window trimwork	10	opng	10.60	106.00	12.87	128.70	234.70
92	Interior doors				861.63		307.05	1168.68
93	Exterior doors				72.58		22.75	95.33
94	Light fixtures				300.00		200.00	500.00
95	Cabinets				1500.00		150.00	1650.00
96	Appliances				1250.00		0.00	1250.00
97	Stairs	2	ea	129.54	259.08	84.18	168.36	427.44
98								
99	Miscellaneous Sub-Total				6865.54		3069.36	10791.22
100								
101								
102								
103								
104								
105								
106	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COST	TOTAL COST
107								
108	SERVICES							
109	Plumbing				0.00		0.00	0.00
110	Electrical				0.00		0.00	0.00
111	AAHX- Mech.				0.00		0.00	0.00
112								
113	Total Services Costs				0.00		0.00	0.00
114	Excav.	22	cy		0.00		0.00	250.00
115	Grading				0.00		0.00	100.00
116	Formwork	600	sf ca	0.87	522.00	1.61	966.00	1488.00
117	2x6 Mudsill	120	lf	0.61	73.20	0.84	100.80	174.00
118	4x8 Int Bm.	40	lf	1.42	56.80	0.81	32.40	89.20
119	4x4 P.T. Posts	16	lf	0.70	11.20	0.81	12.96	24.16
120	Concrete	11	cy	51.64	568.04		0.00	568.04

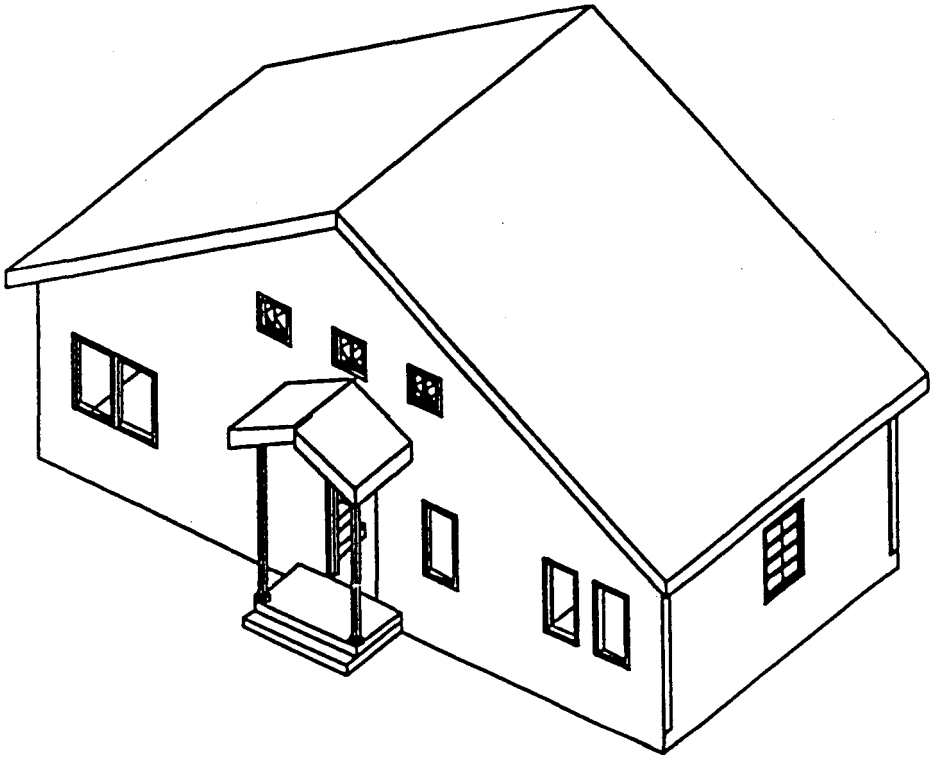
	A	B	C	D	E	F	G	H
121	Rebar				0.00		0.00	290.00
122	P.V.C. Drain	130	lf	1.47	191.10	1.35	175.50	290.00
123					0.00		0.00	0.00
124	Total Sitework Costs				1422.34		1287.66	3273.40
125								
126	Contingency				0.00		0.00	0.00
127								
128								
129	Base Case Total Hard Costs				18543.01		12027.29	31990.02
130	Base Case Hard $/sf	1257	sf		14.75		9.57	25.45
131	SOFT COSTS							
132	Plans,survey,specs							0.00
133	Survey							0.00
134	Design and Engineering Fees							0.00
135	Raw land							0.00
136	Land Sales Commission							0.00
137	Site Planning and engineering							0.00
138	Closing Costs							0.00
139	Builder's Administration and profit							0.00
140	Warranty expenses							0.00
141	Temporary Utilities							0.00
142	Streets, Curbs, and grading							0.00
143	Construction loan interest							0.00
144	Construction Loan Fees							0.00
145	Insurance							0.00
146	House Sales Commission							0.00
147	Permits and Development Fees							0.00
148	Taxes							0.00
149	Construction Overhead							0.00
150								
151	Total Soft Costs							0.00
152	Base Case Total House Costs							31990.02
153	Base Case Total $/sf	1257	sf					25.45
154								
155								
156							*Floor/Fdn. Total=	5249.54
157								
158								

	A	B	C	D	E	F	G	H
1	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB $	LAB TOT $	TOTAL $
2	ROOF: R-Control 9 3/8"							
3	16@4x8 Panel	512	sf	3.15	1612.80	0.55	281.60	1894.40
4	4@4x14 Panel	224	sf	3.15	705.60	0.55	123.20	828.80
5	Panel Sub-Total	736	sf		2318.40		404.80	2723.20
6	Engr'd Trusses #1	6	ea	21.30	127.80	6.24	37.44	165.24
7	Engr'd Trusses #2	17	ea	42.00	714.00	10.67	181.39	895.39
8	3/4" Decking	400	sf	0.37	148.00	0.32	128.00	276.00
9	Ridge Stringer-2x10	44	lf	0.73	32.12	0.53	23.32	55.44
10	7/16" Sheathing	928	sf	0.27	250.56	0.24	222.72	473.28
11	2x6 Fascia	264	lf	0.34	89.76	1.36	359.04	448.80
12	Staples				25.00		0.00	25.00
13	Screw Fasteners(1/2 lf)	148	ea	1.00	148.00		0.00	148.00
14	ST 12 straps	148	ea	0.55	81.40		0.00	81.40
15	L-70(1/2 lf)	74	ea	0.75	55.50		0.00	55.50
16	Sealant(1/2 per 80sf)	10	ea	3.54	35.40		0.00	35.40
17	1/2" sheetrock	608	sf	0.10	60.80	0.34	206.72	267.52
18	Roofing	1780	sf	0.29	516.20	0.30	534.00	1050.20
19	15 # Felt	1780	sf	0.05	89.00	0.05	89.00	178.00
20	Gutters/Downspouts	134	lf	0.60	80.40	1.12	150.08	230.48
21	Roof Sub-Total				4772.34		2336.51	7108.85
22								
23	FLOOR:R-Control 5 1/2"(System E)							
24	4@8x20	640	sf	2.90	1856.00	0.55	246.40	2102.40
25	1@4x20	80	sf	2.70	216.00	0.55	30.80	246.80
26	Panel Sub Total	720	sf		2072		277.2	2349.2
27	Rim Stringer- 2x6	120	lf	0.33	39.60		0.00	39.60
28	Staples				25.00		0.00	25.00
29	Sealant	4.5	ea	3.54	15.93		0.00	15.93
30	Floof Finishes	719	sf	1.92	1380.48	0.42	301.98	1682.46
31	Wood Screws	2	box	23.50	47.00		0.00	47.00
32	3/4" Plywood	3	sht.	12.69	38.07		0.00	38.07
33								
34								
35	Floor Sub-Total				3616.08		579.18	4197.26
36	COMPONENT	QTY	UNIT	MAT UNIT $	MAT COST	UNIT LAB. $	LABOR COS	TOTAL COST
37	WALL:R-Control 5 1/2"							
38	35@4x8 panel	1024	sf	2.90	2969.60	0.55	563.20	3532.80
39	Panel Sub Total	1024	sf		2969.60		563.20	3532.80
40	Plates 2x6	322	lf	0.34	109.48	0.86	276.92	386.40
41	Staples				35.00		0.00	35.00
42	Sealant	12	ea	3.54	42.48		0.00	42.48
43	Screw Fasteners	50	ea		50.00		0.00	50.00
44	1/2" sheetrock	928	sf	0.10	92.80	0.33	306.24	399.04
45	Siding (T1-11 5/8")	1120	sf	0.47	526.40	0.49	548.80	1075.20
46	Painting - Ext.	1120	sf	0.14	156.80	0.18	201.60	358.40
47								
48								
49								
50					0.00		0.00	0.00
51					0.00		0.00	0.00
52	Wall Sub Total				3982.55		1896.76	5879.32
53								
54								
55	R-Control Shell Total				12372.98		4812.45	17185.43
56	R-Control Shell $/sf	1259	sf		9.83		3.82	13.65
57	INT.FLOOR: Conv. Frm.							
58	Beam-2@6x10x16	1	ea	33.25	33.25	28.50	28.50	61.75
59	Blocking- 2x12	76	lf	0.85	64.60	1.20	91.20	155.80
60	Nails/Screws				25.00		0.00	25.00

	A	B	C	D	E	F	G	H
61	Glue/Caulk				10.00		0.00	10.00
62	Joist hangers	10	ea	0.99	9.90	1.04	10.40	20.30
63	1/2" sheetrock	649	sf	0.10	64.90	0.34	220.66	285.56
64	Floor Finishes	400	sf	1.92	768.00	0.42	168.00	936.00
65								
66								
67								
68								
69								
70	Int.Floor Frm. Sub Total				975.65		518.76	1494.41
71	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST
72								
73	INT. WALL: Standard Framing							
74	Studs 2x4x8	1367	lf	0.23	314.41	0.24	328.08	642.49
75	Studs 2x6x8	177	lf	0.34	60.18	0.33	58.41	118.59
76	Plates 2x4	259	lf	0.23	59.57	0.41	106.19	165.76
77	Plates 2x6	89	lf	0.34	30.26	0.43	38.27	68.53
78	2x4 Header	78	lf	1.58	123.24	0.90	70.20	193.44
79	1/2" sheetrock	2186	sf	0.10	218.60	0.34	743.24	961.84
80	Screws/Nails				25.00		0.00	25.00
81	Glue/Caulk				10.00		0.00	10.00
82	Painting	1947	sf	0.12	233.64	0.09	175.23	408.87
83								
84	Wall Std. Frm. Sub Total				1074.90		1519.62	2594.52
85								
86								
87								
88								
89								
90								
91	MISCELLANEOUS							
92	Skylites	24	sf	18.94	454.56	16.74	401.76	856.32
93	Windows	125	sf	20.13	2516.25	16.74	2092.50	4608.75
94	Window trimwork	10	opng	10.60	106.00	12.87	128.70	234.70
95	Interior doors				861.63		307.05	1168.68
96	Exterior doors				72.58		22.75	95.33
97	Light fixtures				300.00		200.00	500.00
98	Cabinets				1500.00		150.00	1650.00
99	Appliances				1250.00		0.00	1250.00
100	Stairs	2	ea	129.54	259.08	84.18	168.36	427.44
101								
102								
103								
104	Miscellaneous Sub-Total				7320.10		3471.12	10791.22
105								
106	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST
107								
108								
109								
110								
111								
112	SERVICES							
113	Plumbing				0.00		0.00	0.00
114	Electrical				0.00		0.00	0.00
115	AAHX- Mech.				0.00		0.00	0.00
116	Total Services Costs				0.00		0.00	0.00
117								
118	Foundation							
119	Holes & Conc.	20	ea		0.00	20.00	400.00	400.00
120	Grading				0.00		200.00	200.00

	A	B	C	D	E	F	G	H
121	Fdn. Trusses (L-1)	2	ea	176.80	353.60	44.20	88.40	442.00
122	Fdn. Trusses (S-1)	2	ea	87.05	174.10	21.75	43.50	217.60
123	4x8 Beams	80	lf	1.42	113.60		0.00	113.60
124	4x4 Posts	32	lf	0.87	27.84		0.00	27.84
125	6 Mil. V.B.	720	sf	0.07	50.40	0.04	28.80	79.20
126	Simp. Post Caps	8	ea	2.50	20.00	2.50	20.00	40.00
127	Nails & Adheasive				0.00		0.00	55.00
128					0.00		0.00	0.00
129								
130	Total Foundation Costs				739.54		760.70	1575.24
131								
132	Contingency				0.00		0.00	0.00
133								
134								
135								
136	R-Control Total Hard Costs				22483.17		11102.65	33640.82
137	R-Control Hard $/sf	1259	sf		17.86		8.82	26.72
138								
139								
140								
141	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST
142								
143	SOFT COSTS							
144	Plans,survey,specs							0.00
145	Survey							0.00
146	Design and Engineering Fees							0.00
147	Raw land							0.00
148	Land Sales Commission							0.00
149	Site Planning and engineering							0.00
150	Closing Costs							0.00
151	Builder's Administration and profit							0.00
152	Warranty expenses							0.00
153	Temporary Utilities							0.00
154	Streets, Curbs, and grading							0.00
155	Construction loan Interest							0.00
156	Construction Loan Fees							0.00
157	Insurance							0.00
158	House Sales Commission							0.00
159	Permits and Development Fees							0.00
160	Taxes							0.00
161	Construction Overhead							0.00
162								
163	Total Soft Costs							0.00
164								
165	R-Control Total House Costs							33640.82
166	R-Control Total $/sf	1259	sf					26.72
167								
168						*Flr./Fdn. Total=		4090.04

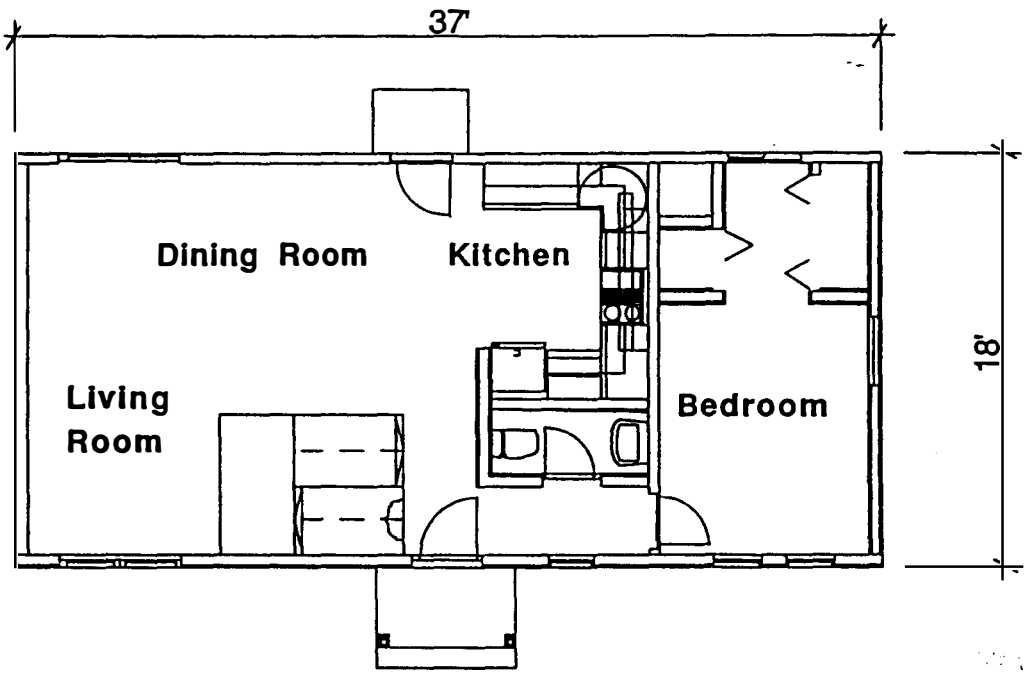
10.2 1-1/2 Story "Short Ridge" Design



1 1/2- Story House "Short "
Plan Views
Cost Estimates:
Demonstration House & Reference House

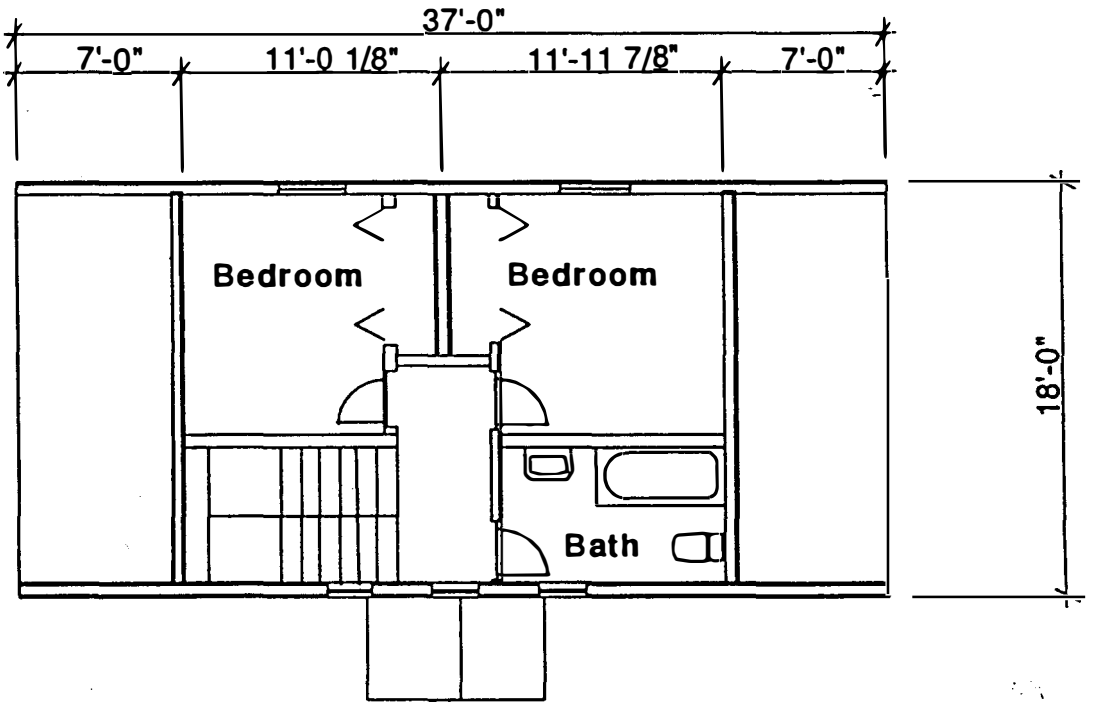
Energy Efficient Industrlized Housing
Center for Housing Innovation
University of Oregon

***Cost estimates based on 1992 Means Estimating Guide**



FIRST FLOOR PLAN

1 1/2 Story "Short"



SECOND FLOOR PLAN

1 1/2 Story "Short"

	A	B	C	D	E	F	G	H
1	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB $	LAB TOT $	TOTAL $
2								
3	ROOF: R-38							
4	2x12 Ridge(Dbl.)	42	lf	0.85	35.70	0.90	37.80	73.50
5	2x12 Ridge (Dormer)	21	lf	0.85	17.85	0.90	18.90	36.75
6	2x12 Rafters	250	lf	0.85	212.50	0.45	112.50	325.00
7	2x12 Valley Rafter	52	lf	0.85	44.20	0.72	37.44	81.64
8	2x12 Blocking	42	lf	0.85	35.70	0.82	34.44	70.14
9	Sheathing 7/16" Plywood	693	sf	0.27	187.11	0.23	159.39	346.50
10	2x6 Fascia	161	lf	0.34	54.74	1.36	218.96	273.70
11	R-38 batt Insulation	525	sf	0.71	372.75	0.14	73.50	446.25
12	Vapor Barrier/ Air Barr.	814	sf	0.07	56.98	0.04	35.00	91.98
13	Nails/Screws				30.00	0.00	0.00	30.00
14	Glue/Caulk				10.00	0.00	0.00	10.00
15	1/2" sheetrock	525	sf	0.10	52.50	0.34	178.50	231.00
16	Roofing	972	sf	0.29	281.88	0.30	291.60	573.48
17	15 # Felt	972	sf	0.05	48.60	0.05	48.60	97.20
18	Gutters/Downspouts	156	lf	0.60	93.60	1.12	174.72	268.32
19	Vents	10		15.00	150.00	20.00	200.00	350.00
20	Glue/Caulk				0.00		0.00	0.00
21	2x6 Dormer Wall	73	lf	0.34	24.82	0.40	29.20	54.02
22	2x8 Header	8	lf	0.47	3.76	0.94	7.52	11.28
23	R-21 Insulation	216	sf	0.38	82.08	0.15	32.40	114.48
24	2x6 Int. Wall	194	lf	0.34	65.96	0.48	93.12	159.08
25	Dormer Sheathing	297	sf	0.27	80.19	0.35	103.95	184.14
26	Flr. Ins. R-38	288	sf	0.71	204.48	0.11	31.68	236.16
27	2x6 Rafters	216	lf	0.34	73.44	0.45	97.20	170.64
28	2x6 Blocking	32	lf	0.34	10.88	0.81	25.92	36.80
29								
30								
31	R-38 Roof Sub-Total				2229.72		2042.34	4272.06
32								
33								
34								
35								
36	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB $	LAB TOT $	TOTAL $
37								
38	FLOOR: R-30 Std. Framing							
39	Joist-28@2x12x18	504	lf	0.85	428.40	0.36	181.44	609.84
40	Rim Joist-2x12	110	lf	0.85	93.50	0.36	39.60	133.10
41	Blocking- 2x12	34.5	lf	0.85	29.33	0.80	27.60	56.93
42	R-30 batt Insulation	648	sf	0.50	324.00	0.12	77.76	401.76
43	3/4" floor decking	666	sf	0.37	246.42	0.32	213.12	459.54
44	Vapor Barrier/Air Barr.	666	sf	0.07	46.62	0.04	28.64	75.26
45	Nails/Screws				30.00		0.00	30.00
46	Glue/Caulk				10.00		0.00	10.00
47	Anchor bolts	20	ea	0.34	6.80	1.88	37.60	44.40
48	Floor Finish	612	sf	1.92	1175.04	0.42	257.04	1432.08
49								
50	R-30Floor Sub-Total				2390.11		862.80	3252.90
51								
52								
53	WALL: R-21 Adv. Framing							
54	Studs 130 @ 2x6x8'	1040	lf	0.34	353.60	0.33	343.20	696.80
55	Plates 2x6	525	lf	0.34	178.50	0.43	225.75	404.25
56	Firestop/blk/crip 2x6	370	lf	0.34	125.80	0.55	203.50	329.30
57	Header 2x8	90	lf	0.47	42.30	0.97	87.30	129.60
58	R-21 batt insulation	1280	sf	0.38	486.40	0.12	153.60	640.00
59	2" rigid insulation	30	sf	0.78	23.40	0.21	6.30	29.70
60	Vapor Barrier	1444	sf	0.07	101.08	0.04	62.09	163.17

	A	B	C	D	E	F	G	H
61	Screws/Nails				45.00		0.00	45.00
62	Glue/Caulk				10.00		0.00	10.00
63	1/2" sheetrock	1532	sf	0.10	153.20	0.33	505.56	658.76
64	Siding(T1-11 5/8")	1444	sf	0.47	678.68	0.49	707.56	1386.24
65	Painting - Ext.	1444	sf	0.14	202.16	0.18	259.92	462.08
66								
67	R-21 Wall Sub Total				2400.12		2654.78	4954.90
68								
69	Total Base Case Shell				7019.94		5459.92	12479.87
70	Base Case Shell $/sf	1152	sf		6.09		4.74	10.83
71	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COST	TOTAL COST
72								
73								
74	INT.FLOOR: Conv. Frm.							
75	Glulam Beam	2	ea	89.10	178.20	44.64	89.28	267.48
76	Joist-24@2x12x18'	432	lf	0.85	367.20	0.37	159.84	527.04
77	Rim Joist-2x12	84	lf	0.85	71.40	0.37	31.08	102.48
78	Blocking- 2x12	2	lf	0.85	1.70	1.20	2.40	4.10
79	3/4" floor decking	380	sf	0.37	140.60	0.26	98.80	239.40
80	Nails/Screws				25.00		0.00	25.00
81	Glue/Caulk				10.00		0.00	10.00
82	Joist hangers	10	ea	0.99	9.90	1.04	10.40	20.30
83	1/2" sheetrock	747	sf	0.10	74.70	0.34	253.98	328.68
84	Floor Finishes	380	sf	1.92	729.60	0.42	159.60	889.20
85	2x6 Ceiling Joists	288	lf	0.34	97.92	0.26	74.88	172.80
86	Int.Floor Frm. Sub Total							86.48
87								
88								
89	INT. WALL: Standard Framing							
90	Studs 2x4x8	521	lf	0.23	119.83	0.24	125.04	244.87
91	Studs 27@2x6x8	216	lf	0.34	73.44	0.33	71.28	144.72
92	Plates 2x4	260	lf	0.23	59.80	0.41	106.60	166.40
93	Plates 2x6	92	lf	0.34	31.28	0.43	39.56	70.84
94	Firestop/blk/crip 2x4	13	lf	0.23	2.99	0.43	5.59	8.58
95	Firestop/blk/crip 2x6	1	lf	0.34	0.34	0.53	0.53	0.87
96	2x4 Header	33	lf	1.58	52.14	0.90	29.70	81.84
97	1/2" sheetrock	1366	sf	0.10	136.60	0.34	464.44	601.04
98	Screws/Nails				25.00		0.00	25.00
99	Glue/Caulk				10.00		0.00	10.00
100	Painting	1366	sf	0.12	163.92	0.09	122.94	286.86
101								
102	Wall Std. Frm. Sub Total				675.34		965.68	1641.02
103								
104								
105								
106	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COST	TOTAL COST
107								
108	MISCELLANEOUS							
109	Windows	119	sf	20.13	2395.47	16.74	1992.06	4387.53
110	Window trimwork	20	opng	10.60	212.00	12.87	257.40	469.40
111	Interior doors				861.63		307.05	1168.68
112	Exterior doors				72.58		22.75	95.33
113	Light fixtures				300.00		200.00	500.00
114	Cabinets				1500.00		150.00	1650.00
115	Appliances				1250.00		0.00	1250.00
116	Stairs	2	ea	129.54	259.08	84.18	168.36	427.44
117								
118	Miscellaneous Sub-Total				6850.76		3097.62	9948.38
119								
120								

#3410-1 1/2 Story Ref.*

	A	B	C	D	E	F	G	H
121								
122								
123	SERVICES							
124	Plumbing				0.00		0.00	0.00
125	Electrical				0.00		0.00	0.00
126	AAHX- Mech.				0.00		0.00	0.00
127								
128	Total Services Costs				0.00		0.00	0.00
129								
130	SITE WORK							
131	Excv.,backfill,grade,gravel,sewer				0.00		0.00	0.00
132	Foundation				0.00		0.00	0.00
133	Landscape				0.00		0.00	0.00
134	Total Sitework Costs				0.00		0.00	0.00
135								
136	Contingency				0.00		0.00	0.00
137								
138								
139	Base Case Total Hard Costs				16252.27		10403.48	26655.75
140	Base Case Hard $/sf	1152 sf			14.11		9.03	23.14
141	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COST	TOTAL COST
142								
143								
144	SOFT COSTS							
145	Plans,survey,specs							0.00
146	Survey							0.00
147	Design and Engineering Fees							0.00
148	Raw land							0.00
149	Land Sales Commission							0.00
150	Site Planning and engineering							0.00
151	Closing Costs							0.00
152	Builder's Administration and profit							0.00
153	Warranty expenses							0.00
154	Temporary Utilities							0.00
155	Streets, Curbs, and grading							0.00
156	Construction loan interest							0.00
157	Construction Loan Fees							0.00
158	Insurance							0.00
159	House Sales Commission							0.00
160	Permits and Development Fees							0.00
161	Taxes							0.00
162	Construction Overhead							0.00
163								
164	Total Soft Costs							0.00
165	Base Case Total House Costs							26655.75
166	Base Case Total $/sf	1152 sf						23.14

#3411-1 1/2 Story Demo.*

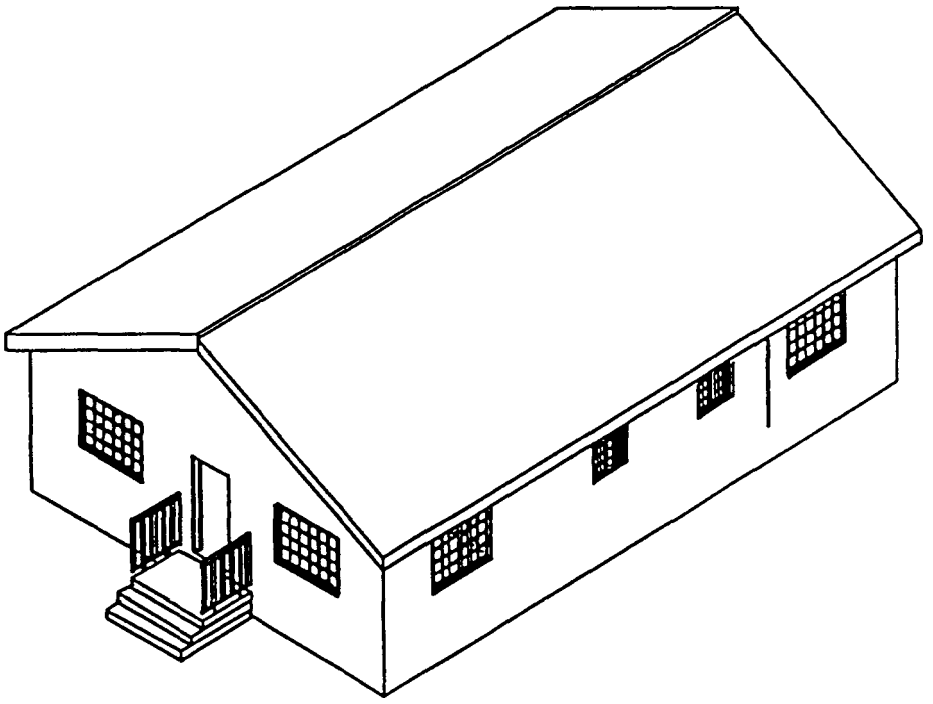
	A	B	C	D	E	F	G	H
1	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB $	LAB TOT $	TOTAL $
2	ROOF: R-Control 9 3/8"							
3	5@8x12 panel	480	sf	3.30	1584.00	0.55	264.00	1848.00
4	1@4x12 panel	48	sf	3.05	146.40	0.55	26.40	172.80
5	Panel Sub-Total	528	sf		1730.40		290.40	2020.80
6	Stringer@2 x10 x 12'	96	lf	0.73	70.08	0.35	33.60	103.68
7	Valley Stringer 2x10	52	lf	0.73	37.96	0.48	24.96	62.92
8	Ridge Stringer-2x10	42	lf	0.73	30.66	0.53	22.26	52.92
9	7/16" Sheathing	446	sf	0.27	120.42	0.24	107.04	227.46
10	2x6 Rafters	216	lf	0.34	73.44	0.45	97.20	170.64
11	2x6 Fascia	161	lf	0.34	54.74	1.36	218.96	273.70
12	Staples				25.00		0.00	25.00
13	Screw Fasteners(1/2 lf)	148	ea	1.00	148.00		0.00	148.00
14	ST 12 straps	148	ea	0.55	81.40		0.00	81.40
15	L-70(1/2 lf)	74	ea	0.75	55.50		0.00	55.50
16	Sealant(1/2 per 80sf)	4.25	ea	3.54	15.05		0.00	15.05
17	1/2" sheetrock	562	sf	0.10	56.20	0.34	191.08	247.28
18	Roofing	972	sf	0.29	281.88	0.30	291.60	573.48
19	15 # Felt	972	sf	0.05	48.60	0.05	48.60	97.20
20	Gutters/Downspouts	156	lf	0.60	93.60	1.12	174.72	268.32
21	Dormer Wall							
22	3@4x8	96	sf	2.70	259.20	0.55	52.80	312.00
23	1@4x12	48	sf	2.70	129.60	0.55	26.40	156.00
24	2@4x18	144	sf	2.70	388.80	0.55	79.20	468.00
25	Flr. Ins. R-38	288	sf	0.71	204.48	0.11	31.68	236.16
26	2x4 Plate	68	lf	0.23	15.64	0.34	23.12	38.76
27	Vents	6	ea	15.00	90.00	20.00	120.00	210.00
28	6 Mil. V.B.	288	sf	0.07	20.16	0.04	11.52	31.68
29	2x4 Soffit Framing	90	lf	0.23	20.70	0.33	29.70	50.40
30					0.00		0.00	0.00
31					0.00		0.00	0.00
32	Roof Sub-Total				4061.51		1874.84	5926.35
33								
34								
35								
36								
37	FLOOR:R-Control 7 3/8"							
38	10@4x18 panel	720	sf	2.90	2088.00	0.55	396.00	2484.00
39	Panel Sub Total	720	sf		2088.00		396.00	2484.00
40	Spline 8@ 7 3/8" TJI	10	ea	32.83	328.30	8.76	87.60	415.90
41	Rim Joist - 2x8	122	lf	0.46	56.12	0.29	35.38	91.50
42	Anchor bolts	28	ea	0.34	9.52	1.88	52.64	62.16
43	Staples				25.00		0.00	25.00
44	Sealant	4.5	ea	3.54	15.93		0.00	15.93
45	Floof Finishes	586	sf	1.92	1125.12	0.42	246.12	1371.24
46								
47								
48	Floor Sub-Total				3647.99		817.74	4465.73
49	COMPONENT	QTY	UNIT	MAT UNIT $	MAT COST	UNIT LAB. $	LABOR COS	TOTAL COST
50	WALL:R-Control 5 1/2"							
51	5@8x16 panel	640	sf	2.85	1824.00	0.55	352.00	2176.00
52	2@8x18 panel	288	sf	2.65	763.20	0.55	158.40	921.60
53	2@8x10 panel	160	sf	2.65	424.00	0.55	88.00	512.00
54	2@ 4x18 Panel	144	sf	2.70	388.80	0.55	79.20	468.00
55	Panel Sub Total	1088	sf		3011.20		598.40	3609.60
56	2x6 Framing	80		0.34	27.20	0.33	26.40	53.60
57	Plates 2x6	405	lf	0.34	137.70	0.86	348.30	486.00
58	Staples				35.00		0.00	35.00
59	Sealant	12	ea	3.54	42.48		0.00	42.48
60	Screw Fasteners	50	ea		50.00		0.00	50.00

	A	B	C	D	E	F	G	H
61	1/2" sheetrock	1532	sf	0.10	153.20	0.33	505.56	658.76
62	Siding (T1-11 5/8")	1444	sf	0.47	678.68	0.49	707.56	1386.24
63	Painting - Ext.	1444	sf	0.14	202.16	0.18	259.92	462.08
64					0.00		0.00	0.00
65					0.00		0.00	0.00
66	Wall Sub Total				4337.62		2446.14	6783.76
67								
68								
69	R-Control Shell Total				12037.11		5138.72	17175.84
70	R-Control Shell $/sf	1152	sf		10.45		4.46	
71								
72								
73	INT.FLOOR: Conv. Frm.							
74	Joist-24@2x12x18	432	lf	0.85	367.20	0.37	159.84	527.04
75	Rim Joist-2x12	84	lf	0.85	71.40	0.37	31.08	102.48
76	Blocking- 2x12	22	lf	0.85	18.70	1.20	26.40	45.10
77	3/4" floor decking	380	sf	0.37	140.60	0.26	98.80	239.40
78	Nails/Screws				25.00		0.00	25.00
79	Glue/Caulk				10.00		0.00	10.00
80	Joist hangers	10	ea	0.99	9.90	1.04	10.40	20.30
81	1/2" sheetrock	747	sf	0.10	74.70	0.34	253.98	328.68
82	Floor Finishes	380	sf	1.92	729.60	0.42	159.60	889.20
83	2x6 Ceiling Joist	288	lf	0.34	97.92		0.00	97.92
84								
85	Int.Floor Frm. Sub Total				1545.02		740.10	2285.12
86								
87	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST
88								
89	INT. WALL: Standard Framing							
90	Studs 2x4x8	521	lf	0.23	119.83	0.24	125.04	244.87
91	Studs 101@2x6x8	215	lf	0.34	73.10	0.33	70.95	144.05
92	Plates 2x4	260	lf	0.23	59.80	0.41	106.60	166.40
93	Plates 2x6	92	lf	0.34	31.28	0.43	39.56	70.84
94	Firestop/blk/crip 2x4	13	lf	0.23	2.99	0.43	5.59	8.58
95	Firestop/blk/crip 2x6	1	lf	0.34	0.34	0.53	0.53	0.87
96	2x4 Header	33	lf	1.58	52.14	0.90	29.70	81.84
97	1/2" sheetrock	1366	sf	0.10	136.60	0.34	464.44	601.04
98	Screws/Nails				25.00		0.00	25.00
99	Glue/Caulk				10.00		0.00	10.00
100	Painting	1366	sf	0.12	163.92	0.09	122.94	286.86
101								
102	Wall Std. Frm. Sub Total				675.00		965.35	1640.35
103								
104								
105								
106	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST
107								
108	MISCELLANEOUS							
109	Windows	119	sf	20.13	2395.47	16.74	1992.06	4387.53
110	Window trimwork	10	opng	10.60	106.00	12.87	128.70	234.70
111	Interior doors				861.63		307.05	1168.68
112	Exterior doors				72.58		22.75	95.33
113	Light fixtures				300.00		200.00	500.00
114	Cabinets				1500.00		150.00	1650.00
115	Appliances				1250.00		0.00	1250.00
116	Stairs	2	ea	129.54	259.08	84.18	168.36	427.44
117								
118	Miscellaneous Sub-Total				6744.76		2968.92	9713.68
119								
120	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST

#3411-1 1/2 Story Demo.*

	A	B	C	D	E	F	G	H
121								
122	SERVICES							
123	Plumbing				0.00		0.00	0.00
124	Electrical				0.00		0.00	0.00
125	AAHX- Mech.				0.00		0.00	0.00
126	Total Services Costs				0.00		0.00	0.00
127								
128	SITE WORK							
129	Excv.,backfill,grade,gravel,sewer				0.00		0.00	0.00
130	Foundation				0.00		0.00	0.00
131	Landscape				0.00		0.00	0.00
132	Total Sitework Costs				0.00		0.00	0.00
133								
134	Contingency				0.00		0.00	0.00
135								
136								
137								
138	R-Control Total Hard Costs				21001.90		9813.09	30814.99
139	R-Control Hard $/sf	1152 sf			18.23		8.52	26.76
140								
141	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST
142	SOFT COSTS							
143	Plans,survey,specs							0.00
144	Survey							0.00
145	Design and Engineering Fees							0.00
146	Raw land							0.00
147	Land Sales Commission							0.00
148	Site Planning and engineering							0.00
149	Closing Costs							0.00
150	Builder's Administration and profit							0.00
151	Warranty expenses							0.00
152	Temporary Utilities							0.00
153	Streets, Curbs, and grading							0.00
154	Construction loan interest							0.00
155	Construction Loan Fees							0.00
156	Insurance							0.00
157	House Sales Commission							0.00
158	Permits and Development Fees							0.00
159	Taxes							0.00
160	Construction Overhead							0.00
161								
162	Total Soft Costs							0.00
163								
164	R-Control Total House Costs							30814.99
165	R-Control Total $/sf	1152 sf						26.76
166								

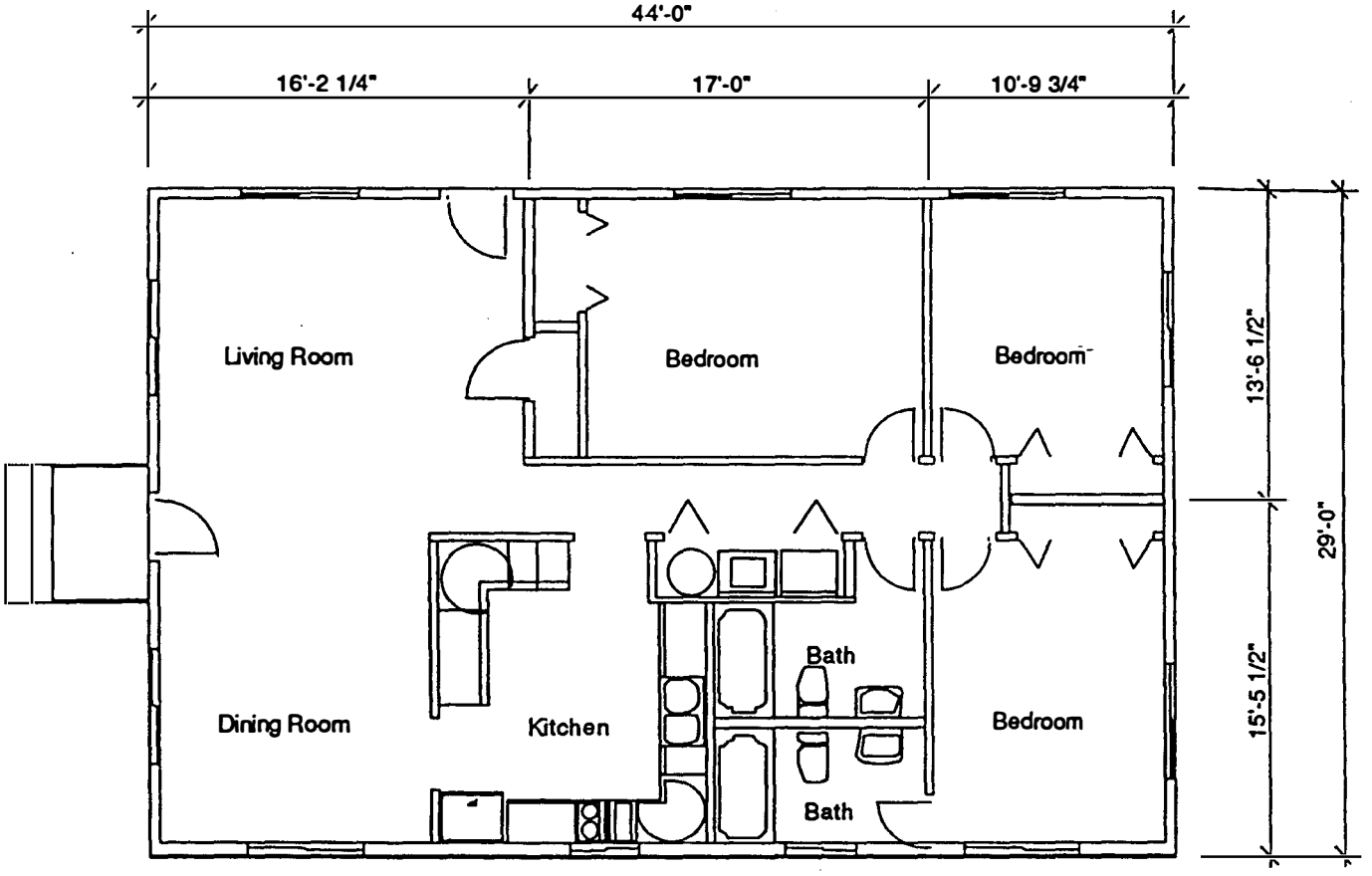
10.3 One Story Design



1 -Story House
Plan Views
Cost Estimates:
Demonstration House & Reference House

Energy Efficient Industrlized Housing
Center for Housing Innovation
University of Oregon

***Cost estimates based on 1992 Means Estimating Guide**



FIRST FLOOR

1 Story Plan

1 Story Ref House "1990 Cost"

	A	B	C	D	E	F	G	H
1	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB $	LAB TOT $	TOTAL $
2								
3	ROOF: R-38							
4	Std. Flat Cord Trusses	22	ea	27.20	598.40	8.96	197.12	795.52
5	Sub Fascia 2x8x47	94	lf	0.47	44.18	1.36	127.84	172.02
6	Blocking@2x6x2'	0	lf	0.34	0.00	0.82	0.00	0.00
7	Ridge blocking 2x4	47	lf	0.23	10.81	0.80	37.60	48.41
8	Sheathing 7/16" Plywood	1579	sf	0.26	410.54	0.23	363.17	773.71
9	R-38 batt Insulation	1579	sf	0.71	1121.09	0.14	221.06	1342.15
10	Vapor Barrier/ Air Barr.	1579	sf	0.07	110.53	0.04	67.90	178.43
11	Nails/Screws				30.00	0.00	0.00	30.00
12	Glue/Caulk				10.00	0.00	0.00	10.00
13	1/2" sheetrock	1273	sf	0.10	127.30	0.34	432.82	560.12
14	Roofing	1579	sf	0.29	457.91	0.30	473.70	931.61
15	15 # Felt	1579	sf	0.05	78.95	0.05	78.95	157.90
16	Vents	6		15.00	90.00	20.00	120.00	210.00
17	Rafters 2x12	70	lf	0.85	59.50	0.52	36.40	95.90
18	Beam 5.125" x 12"	17	lf	6.20	105.40	0.95	16.15	121.55
19	Gutters/Downspouts	110	lf	0.60	66.00	1.12	123.20	189.20
20								
21	R-38 Roof Sub-Total				3320.61		2295.91	6616.52
22								
23	FLOOR: R-30 Std. Framing							
24	Joist-40@2x10x14	560	lf	0.73	408.80	0.36	201.60	610.40
25	Rim Joist-2x10	142	lf	0.73	103.66	0.36	51.12	154.78
26	Blocking- 2x10	0	lf	0.73	0.00	0.80	0.00	0.00
27	R-30 batt Insulation	1204	sf	0.50	602.00	0.12	144.48	746.48
28	3/4" floor decking	1204	sf	0.37	445.48	0.26	313.04	758.52
29	Vapor Barrier/Air Barr.	1204	sf	0.07	84.28	0.04	51.77	136.05
30	Nails/Screws				30.00		0.00	30.00
31	Glue/Caulk				10.00		0.00	10.00
32	Anchor bolts	24	ea	0.34	8.16	1.88	45.12	53.28
33	Floor Finish	1161	sf	1.92	2229.12	0.42	487.62	2716.74
34								
35	R-30 Floor Sub Total				3921.50		1294.75	5216.25
36								
37								
38	WALL: R-21 Adv. Framing							
39	Studs 98@2x6x8	784	lf	0.34	266.56	0.33	258.72	525.28
40	Plates 2x6	432	lf	0.34	146.88	0.43	185.76	332.64
41	Firestop/blk/crip 2x6	85	lf	0.34	28.90	0.55	46.75	75.65
42	Header 2x8	63.5	lf	0.47	29.85	0.97	61.60	91.44
43	R-21 batt Insulation	1881	sf	0.38	714.78	0.12	225.72	940.50
44	2" rigid Insulation	40	sf	0.78	31.20	0.21	8.40	39.60
45	Vapor Barrier	1881	sf	0.07	131.67	0.04	80.88	212.55
46	Screws/Nails				45.00		0.00	45.00
47	Glue/Caulk				10.00		0.00	10.00
48	1/2" sheetrock	1264	sf	0.10	126.40	0.34	429.76	556.16
49	Siding(T1-11 5/8")	1282	sf	0.47	602.54	0.49	628.18	1230.72
50	Painting - Ext.	1282	sf	0.14	179.48	0.18	230.76	410.24
51								
52								
53								
54								
55								
56								
57	R-21 Wall Sub Total				2313.26		2156.53	4469.78
58								
59	Total Base Case Shell				9555.37		5747.19	15302.55
60	Base Case Shell $/sf	1232 sf			7.76		4.66	12.42

1 Story Ref House "1990 Cost"

	A	B	C	D	E	F	G	H
61	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COST	TOTAL COST
62	INT.FLOOR: Conv. Frm.							
63	Joist-19@2x12x16	304	lf	0.85	258.40	0.37	112.48	370.88
64	Rim Joist-2x12	78	lf	0.85	66.30	0.37	28.86	95.16
65	Blocking- 2x12	36	lf	0.85	30.60	1.20	43.20	73.80
66	3/4" floor decking	1282	sf	0.37	474.34	0.26	333.32	807.66
67	Nails/Screws				25.00		0.00	25.00
68	Glue/Caulk				10.00		0.00	10.00
69	Joist hangers	44	ea	0.99	43.56	1.04	45.76	89.32
70	1/2" sheetrock	1161	sf	0.10	116.10	0.34	394.74	510.84
71	Floor Finishes	1161	sf	1.92	2229.12	0.42	487.62	2716.74
72								
73								
74	Int.Floor Frm. Sub Total				3253.42		1445.98	4699.40
75								
76								
77	INT. WALL: Standard Framing							
78	Studs 2x4x8	0	lf	0.23	0.00	0.24	0.00	0.00
79	Studs 101@2x6x8	0	lf	0.34	0.00	0.33	0.00	0.00
80	Plates 2x4	0	lf	0.23	0.00	0.41	0.00	0.00
81	Plates 2x6	0	lf	0.34	0.00	0.43	0.00	0.00
82	Firestop/blk/crip 2x4	0	lf	0.23	0.00	0.43	0.00	0.00
83	Firestop/blk/crip 2x6	0	lf	0.34	0.00	0.53	0.00	0.00
84	2x4 Header	0	lf	1.58	0.00	0.90	0.00	0.00
85	1/2" sheetrock	0	sf	0.10	0.00	0.34	0.00	0.00
86	Screws/Nails				25.00		0.00	25.00
87	Glue/Caulk				10.00		0.00	10.00
88	Painting	0	sf	0.12	0.00	0.09	0.00	0.00
89								
90	Wall Sub Total	2383	sf	0.50	1179.66	0.71	1692.04	2871.71
91								
92	MISCELLANEOUS							
93	Windows	191	sf	20.13	3844.83	16.74	3197.34	7042.17
94	Window trimwork	20	opng	10.60	212.00	12.87	257.40	469.40
95	Interior doors				861.63		307.05	1168.68
96	Exterior doors				72.58		22.75	95.33
97	Light fixtures				300.00		200.00	500.00
98	Cabinets				1500.00		150.00	1650.00
99	Appliances				1250.00		0.00	1250.00
100	Stairs	2	ea	129.54	259.08	84.18	168.36	427.44
101								
102	Miscellaneous Sub-Total				8300.12		4302.90	12603.02
103								
104								
105								
106								
107								
108								
109								
110								
111								
112	SERVICES							
113	Plumbing				0.00		0.00	0.00
114	Electrical				0.00		0.00	0.00
115	AAHX- Mech.				0.00		0.00	0.00
116								
117								
118								
119								
120	Total Services Costs				0.00		0.00	0.00

	A	B	C	D	E	F	G	H
121	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COST	TOTAL COST
122	SITE WORK							
123	Excv.,backfill,grade,gravel,sewer				0.00		0.00	0.00
124	Foundation				0.00		0.00	0.00
125	Landscape				0.00		0.00	0.00
126	Total Sitework Costs				0.00		0.00	0.00
127								
128	Contingency				0.00		0.00	0.00
129								
130								
131	Base Case Total Hard Costs				22289.57		13186.11	35476.68
132	Base Case Hard $/sf	1232 sf			18.09		10.70	28.80
133								
134	SOFT COSTS							
135	Plans,survey,specs							0.00
136	Survey							0.00
137	Design and Engineering Fees							0.00
138	Raw land							0.00
139	Land Sales Commission							0.00
140	Site Planning and engineering							0.00
141	Closing Costs							0.00
142	Builder's Administration and profit							0.00
143	Warranty expenses							0.00
144	Temporary Utilities							0.00
145	Streets, Curbs, and grading							0.00
146	Construction loan interest							0.00
147	Construction Loan Fees							0.00
148	Insurance							0.00
149	House Sales Commission							0.00
150	Permits and Development Fees							0.00
151	Taxes							0.00
152	Construction Overhead							0.00
153								
154	Total Soft Costs							0.00
155	Base Case Total House Costs							35476.68
156	Base Case Total $/sf	1232 sf						28.80

1 Story Demo House "1990 Cost"

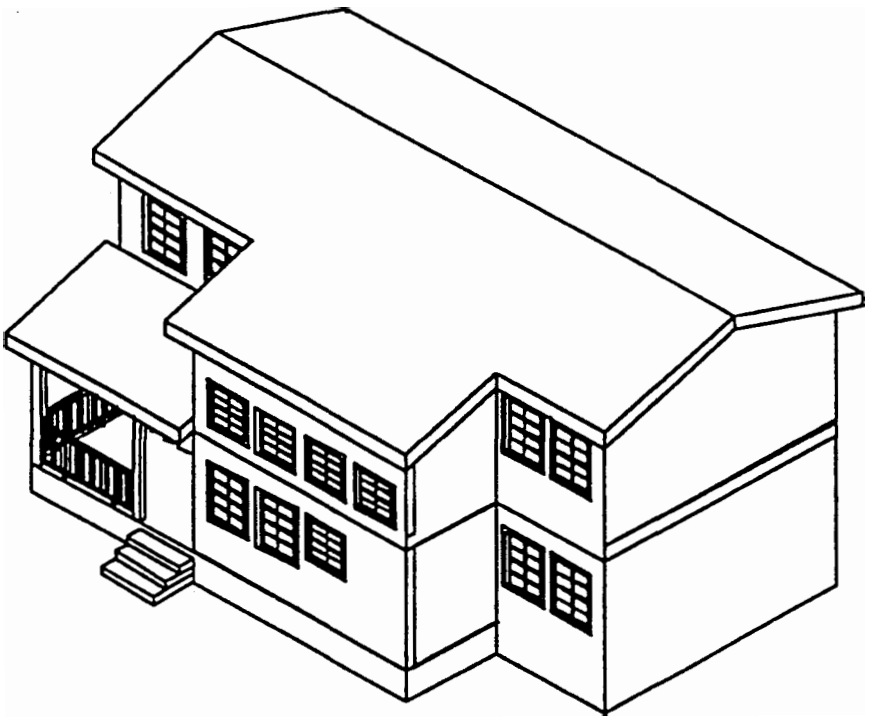
	A	B	C	D	E	F	G	H
1	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB $	LAB TOT $	TOTAL $
2	ROOF: R-Control 9 3/8"							
3	10@8x16 panel	1280	sf	3.30	4224.00	0.55	704.00	4928.00
4	2@4x16 panel	128	sf	3.30	422.40	0.55	70.40	492.80
5								
6	Panel Sub-Total	1408	sf		4646.40		774.40	5420.80
7	Spline 20@2 x10 x 18'	360	lf	0.70	252.00	0.35	126.00	378.00
8	Overhang 2X6	0	lf	0.34	0.00	0.33	0.00	0.00
9	Ridge Beam 2@2x12	88	lf	0.85	74.80	0.82	72.16	146.96
10	Staples				25.00		0.00	25.00
11	Screw Fasteners(1/2 lf)	176	ea	1.00	176.00		0.00	176.00
12	ST 12 straps	264	ea	0.55	145.20		0.00	145.20
13	L-70(1/2 lf)	176	ea	0.75	132.00		0.00	132.00
14	Sealant(1/2 per 80sf)	9	ea	3.54	31.86		0.00	31.86
15	1/2" sheetrock	1273	sf	0.10	127.30	0.37	471.01	598.31
16	Sheathing 1/2" Plywood	0	sf	0.25	0.00	0.24	0.00	0.00
17	Roofing	1579	sf	0.29	457.91	0.30	473.70	931.61
18	15 # Felt	1579	sf	0.05	78.95	0.05	78.95	157.90
19	Gutters/Downspouts	110	lf	0.60	66.00	1.12	123.20	189.20
20								
21	Roof Sub-Total				6213.42		2119.42	8332.84
22								
23	FLOOR:R-Control 7 3/8"							
24	22@4x14 panel	1232	sf	2.90	3572.80	0.55	677.60	4250.40
25								
26	Panel Sub Total	1232	sf		3572.80		677.60	4250.40
27	Spline 20@ 7 3/8" TJI	20	ea	32.83	656.60	8.76	175.20	831.80
28	Rim Joist - 2x8	142	lf	0.46	65.32	0.29	41.18	106.50
29	Anchor bolts	24	ea	0.34	8.16	1.88	45.12	53.28
30	Staples				25.00		0.00	25.00
31	Sealant	7.5	ea	3.54	26.55		0.00	26.55
32	Floor Finishes	1161	sf	1.92	2229.12	0.42	487.62	2716.74
33								
34								
35	Floor Sub-Total				6583.55		1426.72	8010.27
36								
37	WALL:R-Control 5 1/2"							
38	16@8x8 panel	1024	sf	2.85	2918.40	0.55	563.20	3481.60
39	4@4x8 panel	128	sf	2.65	339.20	0.55	70.40	409.60
40	2@8x14 panel	224	sf	2.85	638.40	0.55	123.20	761.60
41	Panel Sub Total	1376	sf		3896.00		756.80	4652.80
42	Plates 2x6	292	lf	0.34	99.28	0.86	251.12	350.40
43	Spline	260	lf	0.70	182.00	0.35	91.00	273.00
44	Staples				35.00		0.00	35.00
45	Sealant	8	ea	3.54	28.32		0.00	28.32
46	Screw Fasteners	16	ea		50.00		0.00	50.00
47	1/2" sheetrock	1264	sf	0.10	126.40	0.33	417.12	543.52
48	Siding (T1-11 5/8")	1282	sf	0.47	602.54	0.49	628.18	1230.72
49	Painting - Ext.	1282	sf	0.14	179.48	0.18	230.76	410.24
50								
51								
52	Wall Sub Total				5199.02		2374.98	7574.00
53								
54								
55								
56								
57								
58								
59	R-Control Shell Total				17995.99		5921.12	23917.11
60	R-Control Shell $/sf	1232	sf		14.61		4.81	19.41

	A	B	C	D	E	F	G	H
61	COMPONENT	QTY	UNIT	MAT UNIT $	MAT COST	UNIT LAB. $	LABOR COST	TOTAL COST
62	INT.FLOOR: Conv. Frm.							
63	Joist-19@2x12x16	304	lf	0.85	258.40	0.37	112.48	370.88
64	Rim Joist-2x12	78	lf	0.85	66.30	0.37	28.86	95.16
65	Blocking- 2x12	36	lf	0.85	30.60	1.20	43.20	73.80
66	3/4" floor decking	1282	sf	0.37	474.34	0.26	333.32	807.66
67	Nails/Screws				25.00		0.00	25.00
68	Glue/Caulk				10.00		0.00	10.00
69	Joist hangers	44	ea	0.99	43.56	1.04	45.76	89.32
70	1/2" sheetrock	1161	sf	0.10	116.10	0.34	394.74	510.84
71	Floor Finishes	1161	sf	1.92	2229.12	0.42	487.62	2716.74
72								
73								
74	Int.Floor Frm. Sub Total				3253.42		1445.88	4699.40
75								
76	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COST	TOTAL COST
77								
78	INT. WALL: Standard Framing							
79	Studs 2x4x8	0	lf	0.23	0.00	0.24	0.00	0.00
80	Studs 101@2x6x8	0	lf	0.34	0.00	0.33	0.00	0.00
81	Plates 2x4	0	lf	0.23	0.00	0.41	0.00	0.00
82	Plates 2x6	0	lf	0.34	0.00	0.43	0.00	0.00
83	Firestop/blk/crip 2x4	0	lf	0.23	0.00	0.43	0.00	0.00
84	Firestop/blk/crip 2x6	0	lf	0.34	0.00	0.53	0.00	0.00
85	2x4 Header	0	lf	1.58	0.00	0.90	0.00	0.00
86	1/2" sheetrock	0	sf	0.10	0.00	0.34	0.00	0.00
87	Screws/Nails	0			25.00		0.00	25.00
88	Glue/Caulk	0			10.00		0.00	10.00
89	Painting	0	sf	0.12	0.00	0.09	0.00	0.00
90								
91	Wall Sub Total	2303	sf	0.50	1129.66	0.71	1692.04	2821.71
92								
93								
94								
95								
96								
97								
98								
99	MISCELLANEOUS							
100	Windows	191	sf	20.13	3844.83	16.74	3197.34	7042.17
101	Window trimwork	20	opng	10.60	212.00	12.87	257.40	469.40
102	Interior doors				861.63		307.05	1168.68
103	Exterior doors				72.58		22.75	95.33
104	Light fixtures				300.00		200.00	500.00
105	Cabinets				1500.00		150.00	1650.00
106	Appliances				1250.00		0.00	1250.00
107	Stairs	2	ea	129.54	259.08	84.18	168.36	427.44
108								
109	Miscellaneous Sub-Total				8300.12		4302.90	12603.02
110								
111								
112								
113	SERVICES							
114	Plumbing				0.00		0.00	0.00
115	Electrical				0.00		0.00	0.00
116	AAHX- Mech.				0.00		0.00	0.00
117								
118								
119								
120	Total Services Costs				0.00		0.00	0.00

1 Story Demo House "1990 Cost"

	A	B	C	D	E	F	G	H
121	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COST	TOTAL COST
122	SITE WORK							
123	Excv.,backfill,grade,gravel,sewer				0.00		0.00	0.00
124	Foundation				0.00		0.00	0.00
125	Landscape				0.00		0.00	0.00
126	Total Sitework Costs				0.00		0.00	0.00
127								
128	Contingency				0.00		0.00	0.00
129								
130								
131								
132	R-Control Total Hard Costs				30729.19		13362.04	44091.24
133	R-Control Hard $/sf	1232 sf			24.94		10.85	35.79
134								
135								
136	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COST	TOTAL COST
137	SOFT COSTS							
138	Plans,survey,specs							0.00
139	Survey							0.00
140	Design and Engineering Fees							0.00
141	Raw land							0.00
142	Land Sales Commission							0.00
143	Site Planning and engineering							0.00
144	Closing Costs							0.00
145	Builder's Administration and profit							0.00
146	Warranty expenses							0.00
147	Temporary Utilities							0.00
148	Streets, Curbs, and grading							0.00
149	Construction loan interest							0.00
150	Construction Loan Fees							0.00
151	Insurance							0.00
152	House Sales Commission							0.00
153	Permits and Development Fees							0.00
154	Taxes							0.00
155	Construction Overhead							0.00
156								
157	Total Soft Costs							0.00
158								
159	R-Control Total House Costs							44091.24
160	R-Control Total $/sf	1232 sf						35.79

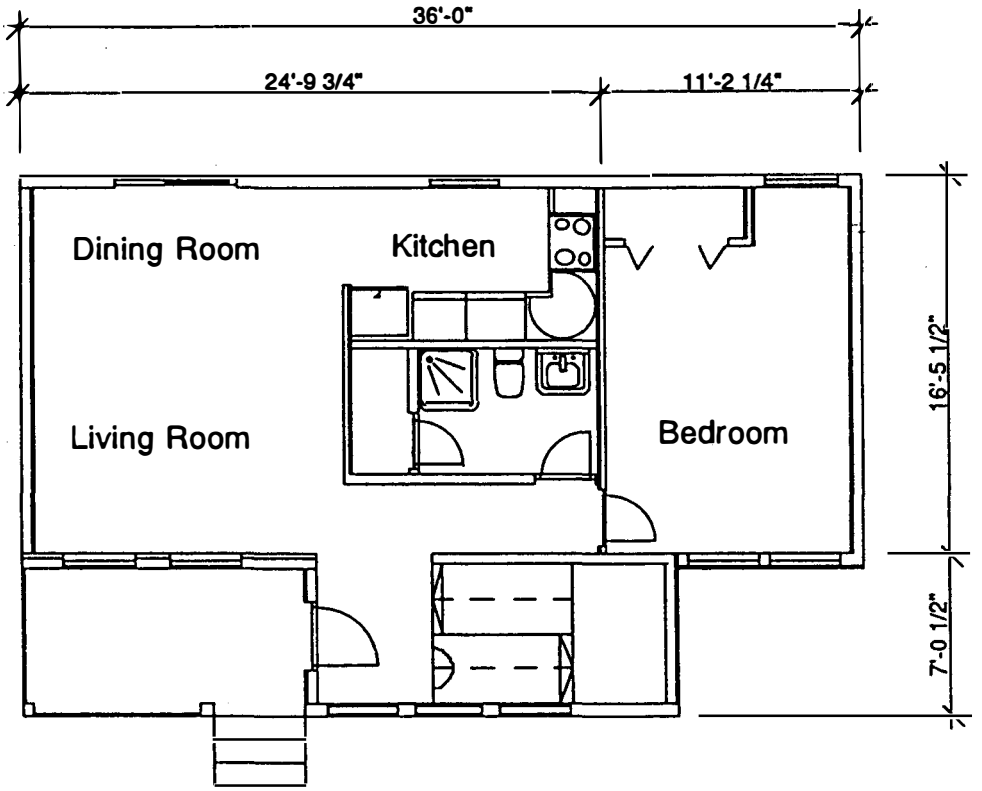
10.4 Two Story Design



2- Story House
Plan Views
Cost Estimates:
Demonstration House & Reference House

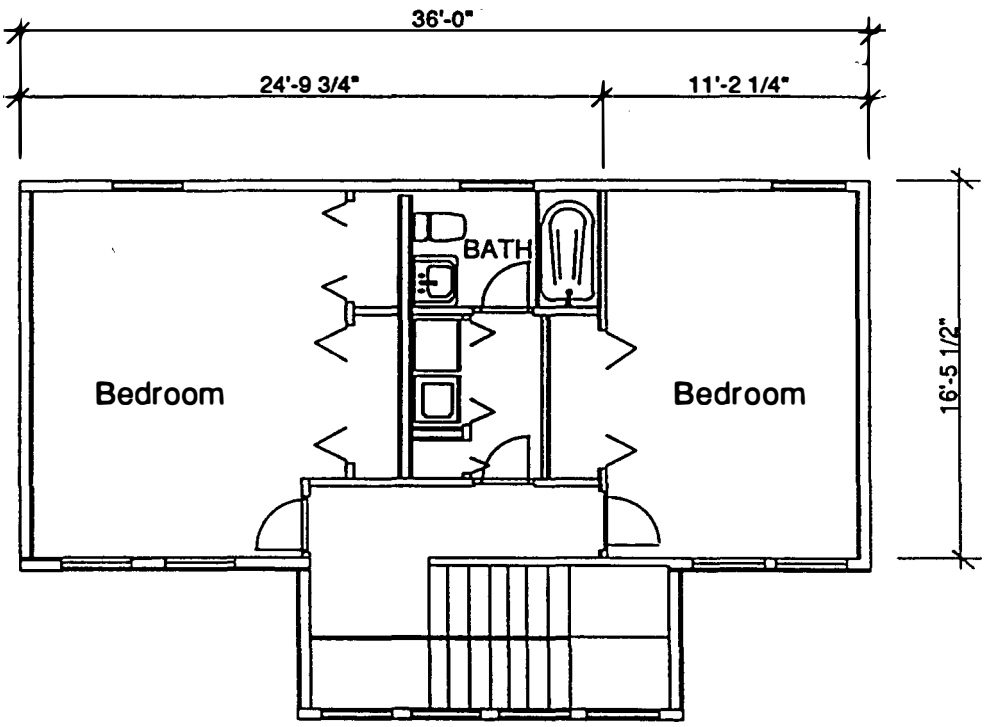
Energy Efficient Industrlized Housing
Center for Housing Innovation
University of Oregon

***Cost estimates based on 1992 Means Estimating Guide**



FIRST FLOOR

1st Flr. Plan



SECOND FLOOR PLAN

2 Story House Plan

	A	B	C	D	E	F	G	H
1	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB $	LAB TOT $	TOTAL $
2								
3	ROOF: R-38							
4	Std. Flat Cord Trusses	19	ea	27.20	516.80	8.96	170.24	687.04
5	Blocking 2x6	72	lf	0.34	24.48	0.82	59.04	83.52
6	Ridge Blocking 2x4	34	lf	0.23	7.82	0.80	27.20	35.02
7	Sheathing 7/16" Plywood	940	sf	0.27	253.80	0.23	216.20	470.00
8	2x6 Fascia	140	lf	0.34	47.60	1.36	190.40	238.00
9	R-38 batt Insulation	702	sf	0.71	498.42	0.14	98.28	596.70
10	Vapor Barrier/ Air Barr.	702	sf	0.07	49.14	0.04	30.19	79.33
11	Nails/Screws				30.00	0.00	0.00	30.00
12	Glue/Caulk				10.00	0.00	0.00	10.00
13	1/2" sheetrock	679	sf	0.10	67.90	0.34	230.86	298.76
14	Roofing	972	sf	0.29	281.88	0.30	291.60	573.48
15	15 # Felt	972	sf	0.05	48.60	0.05	48.60	97.20
16	Gutters/Downspouts	152	lf	0.60	91.20	1.12	170.24	261.44
17	Vents	6	ea	15.00	90.00	20.00	120.00	210.00
18	Rafters 2x12	70	lf	0.85	59.50	0.52	36.40	95.90
19	Beam 5.125"x12"	17	lf	6.20	105.40	0.95	16.15	121.55
20								0.00
21	R-38 Roof Sub-Total				2182.54		1705.40	3887.94
22								
23	FLOOR: R-30 Std. Framing							
24	Joist-19@2x10x16	304	lf	0.73	221.92	0.36	109.44	331.36
25	Rim Joist-2x10	119	lf	0.73	86.87	0.36	42.84	129.71
26	Blocking- 2x10	50	lf	0.73	36.50	0.80	40.00	76.50
27	R-30 batt Insulation	687	sf	0.50	343.50	0.12	82.44	425.94
28	3/4" floor decking	702.5	sf	0.37	259.93	0.32	224.80	484.73
29	Vapor Barrier/Air Barr.	702.5	sf	0.07	49.18	0.04	30.21	79.38
30	Nails/Screws				30.00		0.00	30.00
31	Glue/Caulk				10.00		0.00	10.00
32	Anchor bolts	36	ea	0.34	12.24	1.88	67.68	79.92
33	Floor Finish	586	sf	1.92	1125.12	0.42	246.12	1371.24
34								
35	R-30Floor Sub Total				2175.25		843.53	3018.78
36	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COST	TOTAL COST
37								
38	WALL: R-21 Adv. Framing							
39	Studs 101@2x6x16	1340	lf	0.34	455.60	0.33	442.20	897.80
40	Plates 2x6	724	lf	0.34	246.16	0.43	311.32	557.48
41	Firestop/blk/crip 2x6	459	lf	0.34	156.06	0.55	252.45	408.51
42	Header 2x8	140	lf	0.47	65.80	0.97	135.80	201.60
43	R-21 batt Insulation	1881	sf	0.38	714.78	0.12	225.72	940.50
44	2" rigid Insulation	40	sf	0.78	31.20	0.21	8.40	39.60
45	Vapor Barrier	1881	sf	0.07	131.67	0.04	80.88	212.55
46	Screws/Nails				45.00		0.00	45.00
47	Glue/Caulk				10.00		0.00	10.00
48	1/2" sheetrock	1722	sf	0.10	172.20	0.34	585.48	757.68
49	Siding(T1-11 5/8")	1960	sf	0.47	921.20	0.49	960.40	1881.60
50	Painting - Ext.	1960	sf	0.14	274.40	0.18	352.80	627.20
51								
52								
53	R-21 Wall Sub Total				3224.07		3355.45	6579.52
54								
55	Total Base Case Shell				7581.86		5904.38	13486.24
56	Base Case Shell $/sf	1268	sf		5.98		4.66	10.64
57								
58	INT.FLOOR: Conv. Frm.							
59	Joist-19@2x12x16	320	lf	0.85	272.00	0.37	118.40	390.40
60	Rim Joist-2x12	125	lf	0.85	106.25	0.37	46.25	152.50

#3414 -2 Story Ref House *

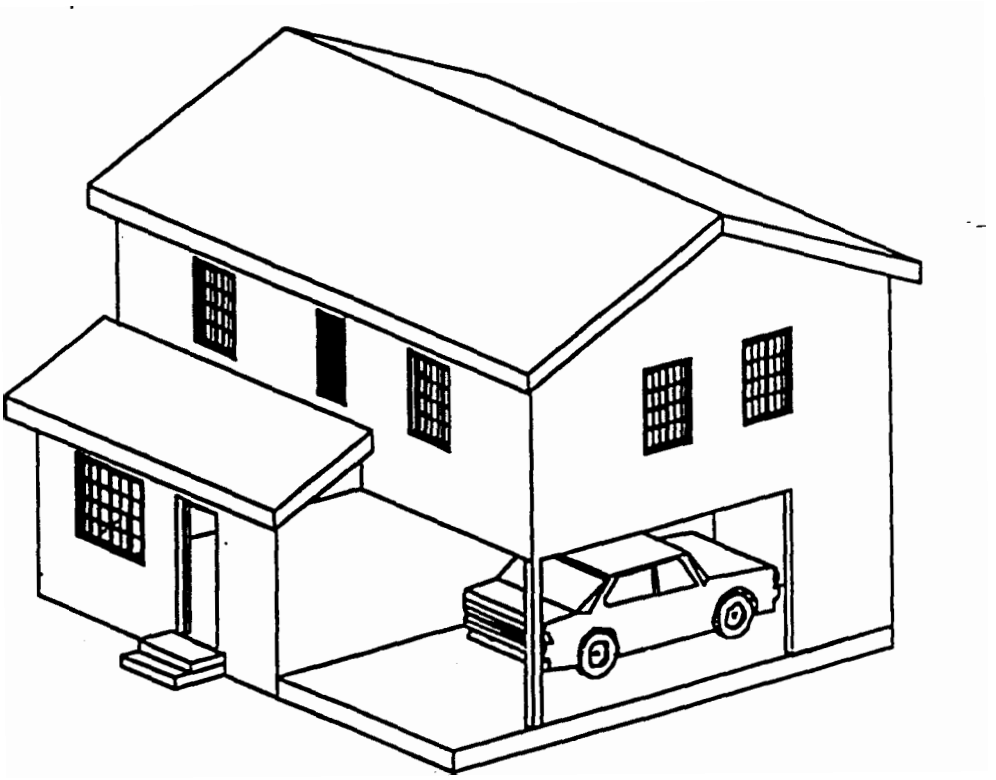
	A	B	C	D	E	F	G	H
121	Contingency				0.00		0.00	0.00
122								
123								
124	Base Case Total Hard Costs				18488.82		12136.87	30625.69
125	Base Case Hard $/sf	1268 sf			14.58		9.57	24.15
126								
127	SOFT COSTS							
128	Plans,survey,specs							0.00
129	Survey							0.00
130	Design and Engineering Fees							0.00
131	Raw land							0.00
132	Land Sales Commission							0.00
133	Site Planning and engineering							0.00
134	Closing Costs							0.00
135	Builder's Administration and profit							0.00
136	Warranty expenses							0.00
137	Temporary Utilities							0.00
138	Streets, Curbs, and grading							0.00
139	Construction loan interest							0.00
140	Construction Loan Fees							0.00
141	Insurance							0.00
142	House Sales Commission							0.00
143	Permits and Development Fees							0.00
144	Taxes							0.00
145	Construction Overhead							0.00
146								
147	Total Soft Costs							0.00
148	Base Case Total House Costs							30625.69
149	Base Case Total $/sf	1268 sf						24.15
150								

	A	B	C	D	E	F	G	H
1	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB $	LAB TOT $	TOTAL $
2	ROOF: R-Control 9 3/8"							
3	6@8x10 panel	480	sf	3.30	1584.00	0.55	264.00	1848.00
4	2@8x18 panel	288	sf	3.30	950.40	0.55	158.40	1108.80
5	2@4x10 panel	80	sf	3.15	252.00	0.55	44.00	296.00
6	Panel Sub-Total	848	sf		2786.40		466.40	3252.80
7	Spline 9@2 x10 x 12'	108	lf	0.70	75.60	0.35	37.80	113.40
8	Overhang 2X6	276	lf	0.34	93.84	0.33	91.08	184.92
9	Ridge Beam 2@2x12	80	lf	0.85	68.00	0.82	65.60	133.60
10	Staples				25.00		0.00	25.00
11	Screw Fasteners(1/2 lf)	54	ea	1.00	54.00		0.00	54.00
12	ST 12 straps	144	ea	0.55	79.20		0.00	79.20
13	L-70(1/2 lf)	72	ea	0.75	54.00		0.00	54.00
14	Sealant(1/2 per 80sf)	6	ea	3.54	21.24		0.00	21.24
15	1/2" sheetrock	679	sf	0.10	67.90	0.37	251.23	319.13
16	Sheathing 1/2" Plywood	184	sf	0.25	46.00	0.24	44.16	90.16
17	Roofing	940	sf	0.29	272.60	0.30	282.00	554.60
18	15 # Felt	940	sf	0.05	47.00	0.05	47.00	94.00
19	Gutters/Downspouts	152	lf	0.60	91.20	1.12	170.24	261.44
20								
21	Roof Sub-Total				3781.98		1455.51	5237.49
22								
23	FLOOR:R-Control 7 3/8"							
24	9@4x16 panel	576	sf	2.90	1670.40	0.55	316.80	1987.20
25	1@8x18 panel	144	sf	3.05	439.20	0.55	79.20	518.40
26	Panel Sub Total	720	sf		2109.60		396.00	2505.60
27	Spline 8@ 7 3/8" TJI	10	ea	32.83	328.30	8.76	87.60	415.90
28	Rim Joist - 2x8	122	lf	0.46	56.12	0.29	35.38	91.50
29	Anchor bolts	28	ea	0.34	9.52	1.88	52.64	62.16
30	Staples				25.00		0.00	25.00
31	Sealant	4.5	ea	3.54	15.93		0.00	15.93
32	Floof Finishes	586	sf	1.92	1125.12	0.42	246.12	1371.24
33								
34								
35	Floor Sub-Total				3669.59		817.74	4487.33
36	COMPONENT	QTY	UNIT	MAT UNIT $	MAT COST	UNIT LAB. $	LABOR COS	TOTAL COST
37	WALL:R-Control 5 1/2"							
38	14@8x16 panel	1792	sf	2.85	5107.20	0.55	985.60	6092.80
39	2@4x16 panel	128	sf	2.65	339.20	0.55	70.40	409.60
40	2@4x8 panel	64	sf	2.65	169.60	0.55	35.20	204.80
41	Panel Sub Total	1984	sf		5616.00		1091.20	6707.20
42	Plates 2x6	242	lf	0.34	82.28	0.86	208.12	290.40
43	Staples				35.00		0.00	35.00
44	Sealant	12	ea	3.54	42.48		0.00	42.48
45	Screw Fasteners	50	ea		50.00		0.00	50.00
46	1/2" sheetrock	1574	sf	0.10	157.40	0.33	519.42	676.82
47	Siding (T1-11 5/8")	1693	sf	0.47	795.71	0.49	829.57	1625.28
48	Painting - Ext.	1693	sf	0.14	237.02	0.18	304.74	541.76
49	Splines-2x6							
50	Wall Sub Total				7015.89		2953.05	9968.94
51								
52								
53	R-Control Shell Total				14467.46		5226.30	19693.76
54	R-Control Shell $/sf	1268	sf		11.41		4.12	15.53
55								
56								
57	INT.FLOOR: Conv. Frm.							
58	Joist-19@2x12x16	304	lf	0.85	258.40	0.37	112.48	370.88
59	Rim Joist-2x12	78	lf	0.85	66.30	0.37	28.86	95.16
60	Blocking- 2x12	36	lf	0.85	30.60	1.20	43.20	73.80

	A	B	C	D	E	F	G	H
61	3/4" floor decking	617	sf	0.37	228.29	0.26	160.42	388.71
62	Nails/Screws				25.00		0.00	25.00
63	Glue/Caulk				10.00		0.00	10.00
64	Joist hangers	34	ea	0.99	33.66	1.04	35.36	69.02
65	1/2" sheetrock	563	sf	0.10	56.30	0.34	191.42	247.72
66	Floor Finishes	563	sf	1.92	1080.96	0.42	236.46	1317.42
67								
68								
69	Int.Floor. Frm. Sub Total				1769.51		1008.20	2597.71
70								
71	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST
72								
73	INT. WALL: Standard Framing							
74	Studs 2x4x8	592	lf	0.23	136.16	0.24	142.08	278.24
75	Studs 101@2x6x8	326	lf	0.34	110.84	0.33	107.58	218.42
76	Plates 2x4	237	lf	0.23	54.51	0.41	97.17	151.68
77	Plates 2x6	132	lf	0.34	44.88	0.43	56.76	101.64
78	Firestop/blk/crip 2x4	13	lf	0.23	2.99	0.43	5.59	8.58
79	Firestop/blk/crip 2x6	1	lf	0.34	0.34	0.53	0.53	0.87
80	2x4 Header	33	lf	1.58	52.14	0.90	29.70	81.84
81	1/2" sheetrock	1585	sf	0.10	158.50	0.34	538.90	697.40
82	Screws/Nails				25.00		0.00	25.00
83	Glue/Caulk				10.00		0.00	10.00
84	Painting	1585	sf	0.12	190.20	0.09	142.65	332.85
85								
86	Wall Std. Frm. Sub Total				785.56		1120.96	1906.52
87								
88								
89								
90								
91								
92	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST
93								
94	MISCELLANEOUS							
95	Windows	191	sf	20.13	3844.83	16.74	3197.34	7042.17
96	Window trimwork	20	opng	10.60	212.00	12.87	257.40	469.40
97	Interior doors				861.63		307.05	1168.68
98	Exterior doors				72.58		22.75	95.33
99	Light fixtures				300.00		200.00	500.00
100	Cabinets				1500.00		150.00	1650.00
101	Appliances				1250.00		0.00	1250.00
102	Stairs	2	ea	129.54	259.08	84.18	168.36	427.44
103								
104	Miscellaneous Sub-Total				8300.12		4302.00	12603.02
105								
106	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST
107								
108	SERVICES							
109	Plumbing				0.00		0.00	0.00
110	Electrical				0.00		0.00	0.00
111	AAHX- Mech.				0.00		0.00	0.00
112	Total Services Costs				0.00		0.00	0.00
113								
114	SITE WORK							
115	Excv.,backfill,grade,gravel,sewer				0.00		0.00	0.00
116	Foundation				0.00		0.00	0.00
117	Landscape				0.00		0.00	0.00
118	Total Sitework Costs				0.00		0.00	0.00
119								
120	Contingency				0.00		0.00	0.00

	A	B	C	D	E	F	G	H
121								
122								
123								
124	R-Control Total Hard Costs				25342.65		11458.36	36801.01
125	R-Control Hard $/sf	1268 sf			19.99		9.04	29.02
126								
127								
128	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST
129	SOFT COSTS							
130	Plans,survey,specs							0.00
131	Survey							0.00
132	Design and Engineering Fees							0.00
133	Raw land							0.00
134	Land Sales Commission							0.00
135	Site Planning and engineering							0.00
136	Closing Costs							0.00
137	Builder's Administration and profit							0.00
138	Warranty expenses							0.00
139	Temporary Utilities							0.00
140	Streets, Curbs, and grading							0.00
141	Construction loan interest							0.00
142	Construction Loan Fees							0.00
143	Insurance							0.00
144	House Sales Commission							0.00
145	Permits and Development Fees							0.00
146	Taxes							0.00
147	Construction Overhead							0.00
148								
149	Total Soft Costs							0.00
150								
151	R-Control Total House Costs							36801.01
152	R-Control Total $/sf	1265 sf						29.02
153								

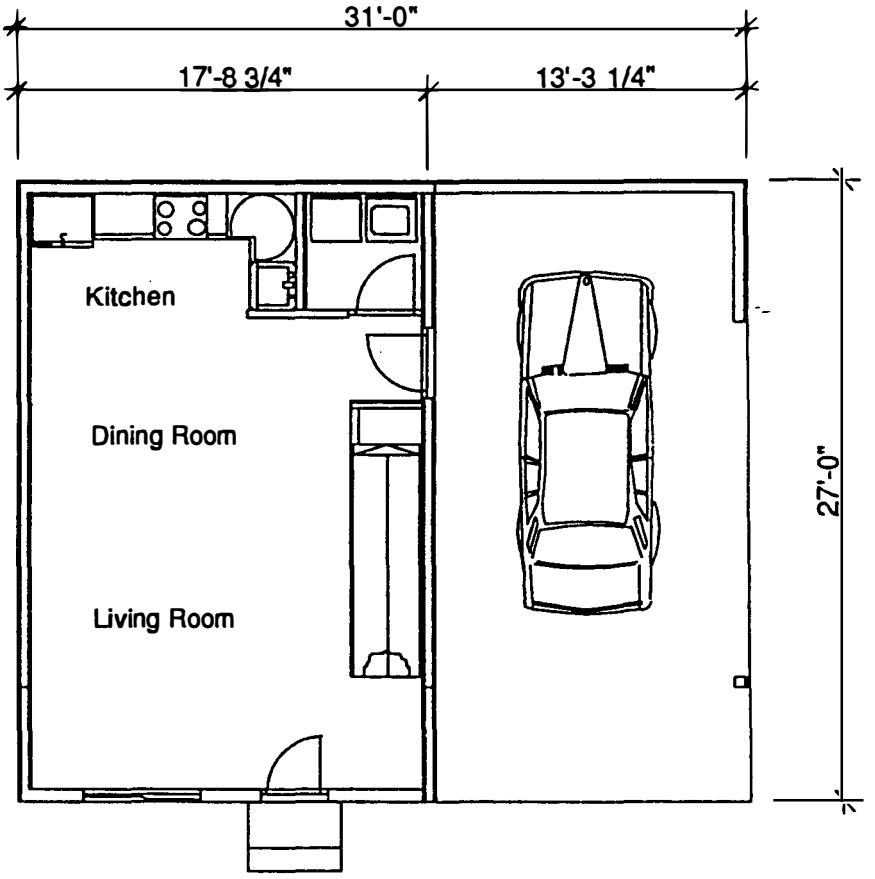
10.5 Two Story "Crosswise" Design



2- Story House "Crosswise "
Plan Views
Cost Estimates:
Demonstration House & Reference House

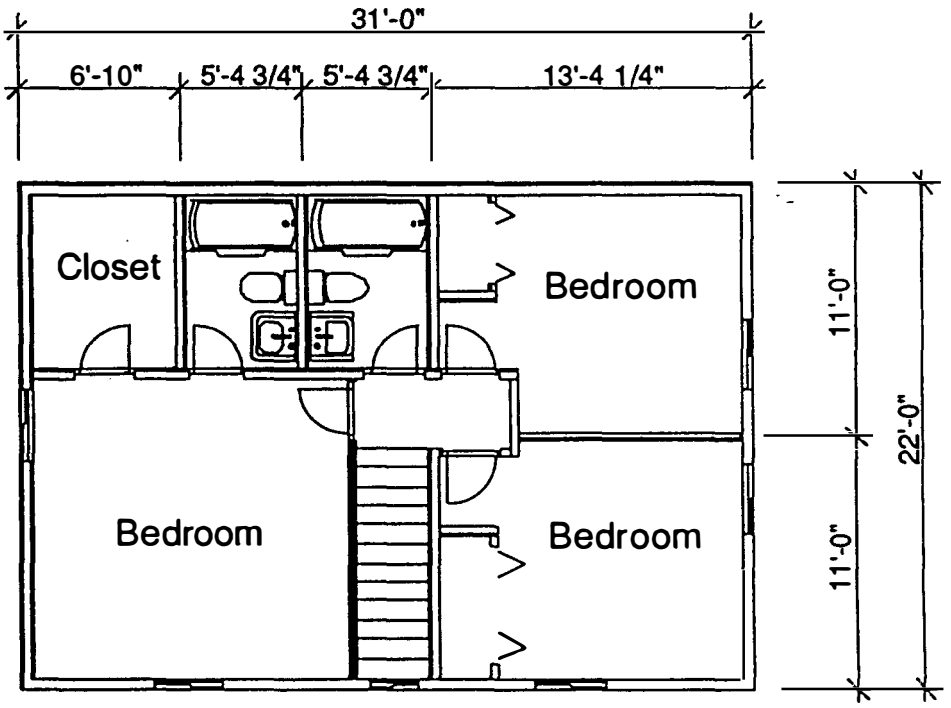
Energy Efficient Industrlized Housing
Center for Housing Innovation
University of Oregon

***Cost estimates based on 1992 Means Estimating Guide**



FIRST FLOOR PLAN

2 Story "Crosswise"



SECOND FLOOR PLAN

2nd Flr. Plan

2 Story Ref. " Crosswise"

	A	B	C	D	E	F	G	H
1	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB $	LAB TOT $	TOTAL $
2	ROOF: R-38							
3	Roof Trusses	17	ea	37.40	635.80	12.76	216.92	852.72
4	R-38 Insulation	682	sf	0.71	484.22	0.14	95.48	579.70
5	6 Mil. V.B.	682	sf	0.07	47.74	0.04	27.28	75.02
6	Nails/Screws				30.00		0.00	30.00
7	1/2" sheetrock	630	sf	0.10	63.00	0.37	233.10	296.10
8	Sheathing 1/2" Plywood	0	sf	0.25	0.00	0.24	0.00	0.00
9	Roofing	952	sf	0.29	276.08	0.30	285.60	561.68
10	15 # Felt	952	sf	0.05	47.60	0.05	47.60	95.20
11	Gutters/Downspouts	100	lf	0.60	60.00	1.12	112.00	172.00
12	Glue/Caulk				10.00			10.00
13	2x4 Blocking	56	lf	0.34	19.04	0.81	45.36	64.40
14	2x4 Ridge Blocking	28	lf	0.34	9.52	0.45	12.60	22.12
15	Vents	5	ea	15	75.00	20	100.00	175.00
16	Fascia	68	lf	0.34	23.12	1.36	92.48	115.60
17	Roof Sub-Total				1781.12		1268.42	3049.54
18								
19	FLOOR:R-30 Std. Floor							
20	Floor Joist-2x12x18'	342	lf	0.85	290.70	0.36	123.12	413.82
21	Rim Joist - 2x12	90	lf	0.85	76.50	0.29	26.10	102.60
22	Sheathing-3/4"	486	sf	0.37	179.82	0.32	155.52	335.34
23	R-30 Insulation	473	sf	0.50	236.50	0.12	56.76	293.26
24	6 Mil. V.B.	486	sf	0.07	34.02	0.04	19.44	53.46
25	Anchor bolts	15	ea	0.34	5.10	1.88	28.20	33.30
26	Glue/Caulk				10.00		0.00	10.00
27	Nails/Screws				30.00		0.00	30.00
28	Floor Finishes	442	sf	1.92	848.64	0.42	185.64	1034.28
29	Blocking	25	lf	0.85	21.25	0.80	20.00	41.25
30					0.00		0.00	0.00
31	Floor Sub-Total				1732.55		614.78	2347.31
32								
33								
34								
35								
36	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB $	LAB TOT $	TOTAL $
37	WALL:R-21 Ins.							
38	Studs 2x6	1315		0.34	447.10	0.33	433.95	881.05
39	Plates 2x6	588	lf	0.34	199.92	0.86	505.68	705.60
40	Blk./Crip.	131	lf	0.34	44.54	0.55	72.05	116.59
41	Header 2x8	82	lf	0.47	38.54	0.97	79.54	118.08
42	R-21 Insulation	1594	sf	0.38	605.72	0.12	191.28	797.00
43	2" Rigid Ins.	27	sf	0.78	21.06	0.21	5.67	26.73
44	6 Mil. V.B.	1594	sf	0.07	111.58	0.04	63.76	175.34
45	Sealant	12	ea	3.54	42.48		0.00	42.48
46	Screw Fasteners	50	ea		50.00		0.00	50.00
47	1/2" sheetrock	1488	sf	0.10	148.80	0.33	491.04	639.84
48	Siding (T1-11 5/8")	1794	sf	0.47	843.18	0.49	879.06	1722.24
49	Painting - Ext.	1594	sf	0.14	223.16	0.18	286.92	510.08
50								
51								
52	Wall Sub Total				2776.08		3008.95	5785.03
53								
54								
55	R-Control Shell Total				6289.73		4892.15	11181.88
56	R-Control Shell $/sf	1268	sf		4.96		3.86	8.82
57								
58	INT.FLOOR: Conv. Frm.							
59	Joist-34@2x12x12	546	lf	0.85	464.10	0.37	202.02	666.12
60	Rim Joist-2x12	116	lf	0.85	98.60	0.37	42.92	141.52

	A	B	C	D	E	F	G	H
61	Blocking- 2x12	31	lf	0.85	26.35	1.20	37.20	63.55
62	3/4" floor decking	772	sf	0.37	285.64	0.26	200.72	486.36
63	Nails/Screws				25.00		0.00	25.00
64	Glue/Caulk				10.00		0.00	10.00
65	Joist hangers	34	ea	0.99	33.66	1.04	35.36	69.02
66	1/2" sheetrock	630	sf	0.10	63.00	0.34	214.20	277.20
67	Floor Finishes	714	sf	1.92	1370.88	0.42	299.88	1670.76
68	R-30 Ins.	286	sf	0.50	143.00	0.12	34.32	177.32
69	Sheathing-3/8"	286	sf	0.23	65.78	0.23	65.78	131.56
70	Int.Floor Frm. Sub Total				2586.01		1132.40	3718.41
71	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST
72								
73	INT. WALL: Standard Framing							
74	Studs 2x4x8	592	lf	0.23	136.16	0.24	142.08	278.24
75	Studs 101@2x6x8	326	lf	0.34	110.84	0.33	107.58	218.42
76	Plates 2x4	237	lf	0.23	54.51	0.41	97.17	151.68
77	Plates 2x6	132	lf	0.34	44.88	0.43	56.76	101.64
78	Firestop/blk/crip 2x4	13	lf	0.23	2.99	0.43	5.59	8.58
79	Firestop/blk/crip 2x6	1	lf	0.34	0.34	0.53	0.53	0.87
80	2x4 Header	33	lf	1.58	52.14	0.90	29.70	81.84
81	1/2" sheetrock	1585	sf	0.10	158.50	0.34	538.90	697.40
82	Screws/Nails				25.00		0.00	25.00
83	Glue/Caulk				10.00		0.00	10.00
84	Painting	1585	sf	0.12	190.20	0.09	142.65	332.85
85								
86	Wall Std. Frm. Sub Total				785.56		1120.96	1906.52
87								
88								
89								
90								
91								
92								
93	MISCELLANEOUS							
94	Windows	200	sf	20.13	4026.00	16.74	3348.00	7374.00
95	Window trimwork	13	opng	10.60	137.80	12.87	167.31	305.11
96	Interior doors				861.63		307.05	1168.68
97	Exterior doors				72.58		22.75	95.33
98	Light fixtures				300.00		200.00	500.00
99	Cabinets				1500.00		150.00	1650.00
100	Appliances				1250.00		0.00	1250.00
101	Stairs	1	ea	129.54	129.54	84.18	84.18	213.72
102								
103	Miscellaneous Sub-Total				8277.55		4279.29	12556.84
104								
105								
106	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST
107								
108	SERVICES							
109	Plumbing				0.00		0.00	0.00
110	Electrical				0.00		0.00	0.00
111	AAHX- Mech.				0.00		0.00	0.00
112	Total Services Costs				0.00		0.00	0.00
113								
114	SITE WORK							
115	Excv.,backfill,grade,gravel,sewer				0.00		0.00	0.00
116	Foundation				0.00		0.00	0.00
117	Landscape				0.00		0.00	0.00
118	Total Sitework Costs				0.00		0.00	0.00
119								
120	Contingency				0.00		0.00	0.00

	A	B	C	D	E	F	G	H
121								
122								
123								
124	R-Control Total Hard Costs				17938.85		11424.80	29363.65
125	R-Control Hard $/sf	1268 sf			14.15		9.01	23.16
126								
127								
128	SOFT COSTS							
129	Plans,survey,specs							0.00
130	Survey							0.00
131	Design and Engineering Fees							0.00
132	Raw land							0.00
133	Land Sales Commission							0.00
134	Site Planning and engineering							0.00
135	Closing Costs							0.00
136	Builder's Administration and profit							0.00
137	Warranty expenses							0.00
138	Temporary Utilities							0.00
139	Streets, Curbs, and grading							0.00
140	Construction loan interest							0.00
141	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST
142								
143	Construction Loan Fees							0.00
144	Insurance							0.00
145	House Sales Commission							0.00
146	Permits and Development Fees							0.00
147	Taxes							0.00
148	Construction Overhead							0.00
149								
150	Total Soft Costs							0.00
151								
152	R-Control Total House Costs							29363.65
153	R-Control Total $/sf	1268 sf						23.16

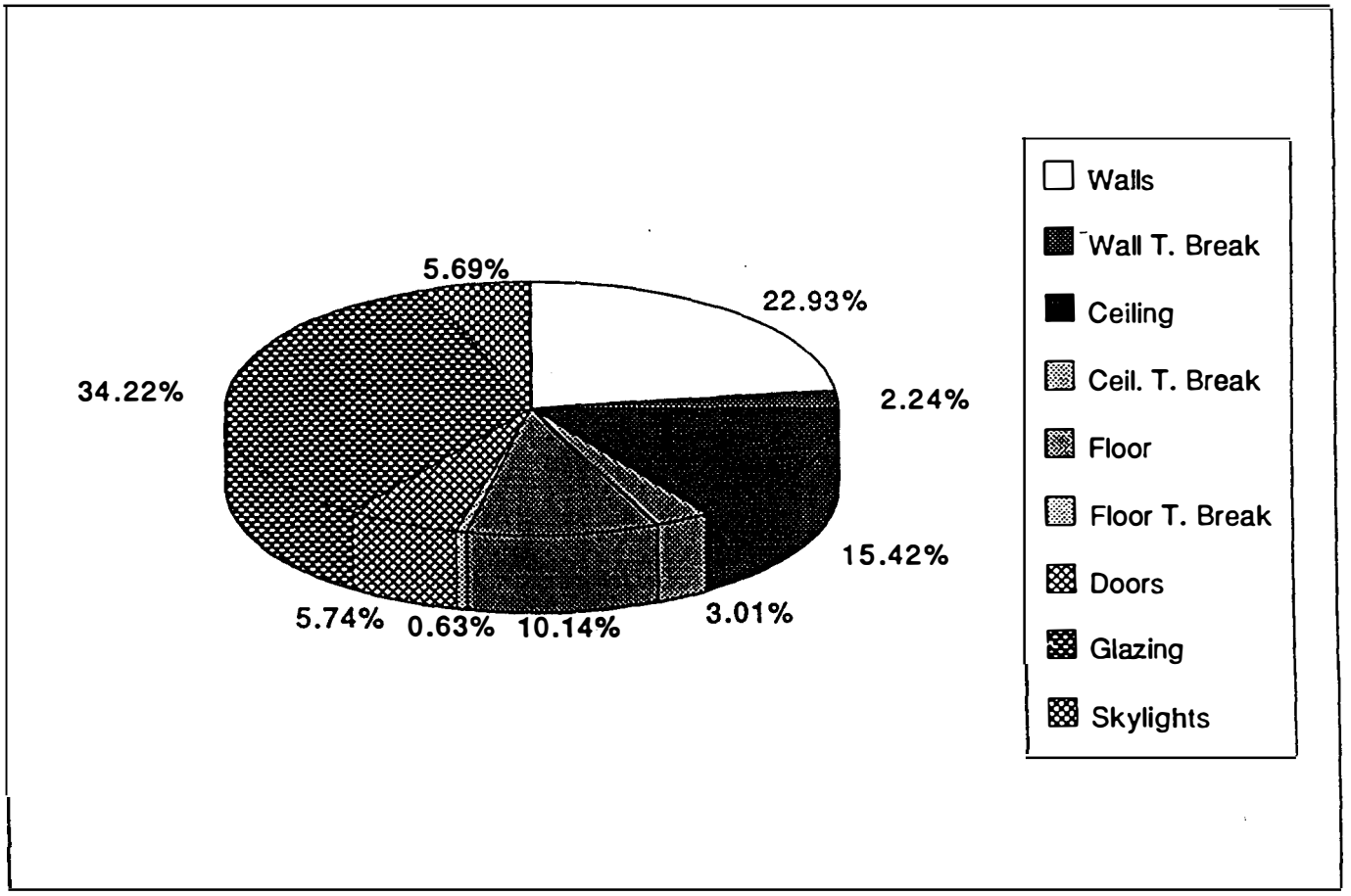
	A	B	C	D	E	F	G	H
1	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB $	LAB TOT $	TOTAL $
2	ROOF: R-Control 9 3/8"							
3	16@4x12 panel	768	sf	3.15	2419.20	0.55	422.40	2841.60
4	4@4x8 panel	0	sf	3.15	0.00	0.55	0.00	0.00
5	Panel Sub-Total	768	sf		2419.20		422.40	2841.60
6	Spline 28@2 x10 x 10'	280	lf	0.70	196.00	0.35	98.00	294.00
7	Spline 6@2 x10 x 7'	0	lf	0.70	0.00	0.35	0.00	0.00
8	Overhang 2X6	0	lf	0.34	0.00	0.33	0.00	0.00
9	Ridge Beam 2@2x12	62	lf	0.85	52.70	0.82	50.84	103.54
10	Staples				25.00		0.00	25.00
11	Screw Fasteners(1/2 lf)	54	ea	1.00	54.00		0.00	54.00
12	ST 12 straps	10	ea	0.55	5.50		0.00	5.50
13	L-70(1/2 lf)	42	ea	0.75	31.50		0.00	31.50
14	Sealant(1/2 per 80sf)	6	ea	3.54	21.24		0.00	21.24
15	1/2" sheetrock	688	sf	0.10	68.80	0.37	254.56	323.36
16	Sheathing 1/2" Plywood	0	sf	0.25	0.00	0.24	0.00	0.00
17	Roofing	768	sf	0.29	222.72	0.30	230.40	453.12
18	15 # Felt	768	sf	0.05	38.40	0.05	38.40	76.80
19	Gutters/Downspouts	100	lf	0.60	60.00	1.12	112.00	172.00
20								
21	Roof Sub-Total				3195.06		1206.60	4401.66
22								
23	FLOOR:R-Control 7 3/8"							
24	7@4x18 panel	504	sf	2.90	1461.60	0.55	277.20	1738.80
25			sf	3.05	0.00	0.55	0.00	0.00
26	Panel Sub Total	504	sf		1461.60		277.20	1738.80
27	Spline 6@ 7 3/8" TJI	6	ea	32.83	196.98	8.76	52.56	249.54
28	Rim Joist - 2x8	90	lf	0.46	41.40	0.29	26.10	67.50
29	Anchor bolts	16	ea	0.34	5.44	1.88	30.08	35.52
30	Staples				25.00		0.00	25.00
31	Sealant	4.5	ea	3.54	15.93		0.00	15.93
32	Floor Finishes	442	sf	1.92	848.64	0.42	185.64	1034.28
33								
34								
35	Floor Sub-Total				2594.99		571.58	3166.57
36	COMPONENT	QTY	UNIT	MAT UNIT $	MAT COST	UNIT LAB. $	LABOR COS	TOTAL COST
37	WALL:R-Control 5 1/2"							
38	panel	1730	sf	2.65	4584.50	0.55	951.50	5536.00
39	panel		sf	2.65	0.00	0.55	0.00	0.00
40	panel	0	sf	2.65	0.00	0.55	0.00	0.00
41	Panel Sub Total	1730	sf		4584.50		951.50	5536.00
42	Plates 2x6	392	lf	0.34	133.28	0.86	337.12	470.40
43	Splines 2x4	418	lf	0.23	96.14	0.86	359.48	455.62
44	Splines 2x8	168	lf	0.46	77.28	0.86	144.48	221.76
45	Staples				35.00		0.00	35.00
46	Sealant	12	ea	3.54	42.48		0.00	42.48
47	Screw Fasteners	50	ea		50.00		0.00	50.00
48	1/2" sheetrock	1645	sf	0.10	164.50	0.33	542.85	707.35
49	Siding (T1-11 5/8")	1645	sf	0.47	773.15	0.49	806.05	1579.20
50	Painting - Ext.	1645	sf	0.14	230.30	0.18	296.10	526.40
51								
52	Wall Sub Total				6186.63		3437.58	9624.21
53								
54								
55	R-Control Shell Total				11976.68		5215.76	17192.44
56	R-Control Shell $/sf	1268	sf		9.45		4.11	13.56
57								
58								
59	INT.FLOOR: Conv. Frm.							
60	Joist-34@2x12x12	408	lf	0.85	346.80	0.37	150.96	497.76

	A	B	C	D	E	F	G	H
61	Rim Joist-2x12	62	lf	0.85	52.70	0.37	22.94	75.64
62	Blocking- 2x12	31	lf	0.85	26.35	1.20	37.20	63.55
63	3/4" floor decking	682	sf	0.37	252.34	0.26	177.32	429.66
64	Nails/Screws				25.00		0.00	25.00
65	Glue/Caulk				10.00		0.00	10.00
66	Joist hangers	34	ea	0.99	33.66	1.04	35.36	69.02
67	1/2" sheetrock	630	sf	0.10	63.00	0.34	214.20	277.20
68	Floor Finishes	630	sf	1.92	1209.60	0.42	264.60	1474.20
69								
70	Int.Floor Frm. Sub Total				2019.45		902.56	2922.03
71	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST
72								
73	INT. WALL: Standard Framing							
74	Studs 2x4x8	592	lf	0.23	136.16	0.24	142.08	278.24
75	Studs 101@2x6x8	326	lf	0.34	110.84	0.33	107.58	218.42
76	Plates 2x4	237	lf	0.23	54.51	0.41	97.17	151.68
77	Plates 2x6	132	lf	0.34	44.88	0.43	56.76	101.64
78	Firestop/blk/crip 2x4	13	lf	0.23	2.99	0.43	5.59	8.58
79	Firestop/blk/crip 2x6	1	lf	0.34	0.34	0.53	0.53	0.87
80	2x4 Header	33	lf	1.58	52.14	0.90	29.70	81.84
81	1/2" sheetrock	1585	sf	0.10	158.50	0.34	538.90	697.40
82	Screws/Nails				25.00		0.00	25.00
83	Glue/Caulk				10.00		0.00	10.00
84	Painting	1585	sf	0.12	190.20	0.09	142.65	332.85
85								
86	Wall Std. Frm. Sub Total				785.56		1120.96	1906.52
87								
88								
89								
90								
91								
92								
93	MISCELLANEOUS							
94	Windows	191	sf	20.13	3844.83	16.74	3197.34	7042.17
95	Window trimwork	20	opng	10.60	212.00	12.87	257.40	469.40
96	Interior doors				861.63		307.05	1168.68
97	Exterior doors				72.58		22.75	95.33
98	Light fixtures				300.00		200.00	500.00
99	Cabinets				1500.00		150.00	1650.00
100	Appliances				1250.00		0.00	1250.00
101	Stairs	2	ea	129.54	259.08	84.18	168.36	427.44
102								
103	Miscellaneous Sub-Total				8300.12		4302.90	12603.02
104								
105								
106	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST
107								
108	SERVICES							
109	Plumbing				0.00		0.00	0.00
110	Electrical				0.00		0.00	0.00
111	AAHX- Mech.				0.00		0.00	0.00
112	Total Services Costs				0.00		0.00	0.00
113								
114	SITE WORK							
115	Excv.,backfill,grade,gravel,sewer				0.00		0.00	0.00
116	Foundation				0.00		0.00	0.00
117	Landscape				0.00		0.00	0.00
118	Total Sitework Costs				0.00		0.00	0.00
119								
120	Contingency				0.00		0.00	0.00

	A	B	C	D	E	F	G	H
121								
122								
123								
124	R-Control Total Hard Costs				23081.81		11542.20	34624.01
125	R-Control Hard $/sf	1268 sf			18.20		9.10	27.31
126								
127								
128	SOFT COSTS							
129	Plans,survey,specs							0.00
130	Survey							0.00
131	Design and Engineering Fees							0.00
132	Raw land							0.00
133	Land Sales Commission							0.00
134	Site Planning and engineering							0.00
135	Closing Costs							0.00
136	Builder's Administration and profit							0.00
137	Warranty expenses							0.00
138	Temporary Utilities							0.00
139	Streets, Curbs, and grading							0.00
140	Construction loan interest							0.00
141	COMPONENT	QTY	UNIT	MAT UNIT $	MAT TOT $	UNIT LAB. $	LABOR COS	TOTAL COST
142								
143	Construction Loan Fees							0.00
144	Insurance							0.00
145	House Sales Commission							0.00
146	Permits and Development Fees							0.00
147	Taxes							0.00
148	Construction Overhead							0.00
149								
150	Total Soft Costs							0.00
151								
152	R-Control Total House Costs							34624.01
153	R-Control Total $/sf	1268 sf						27.31

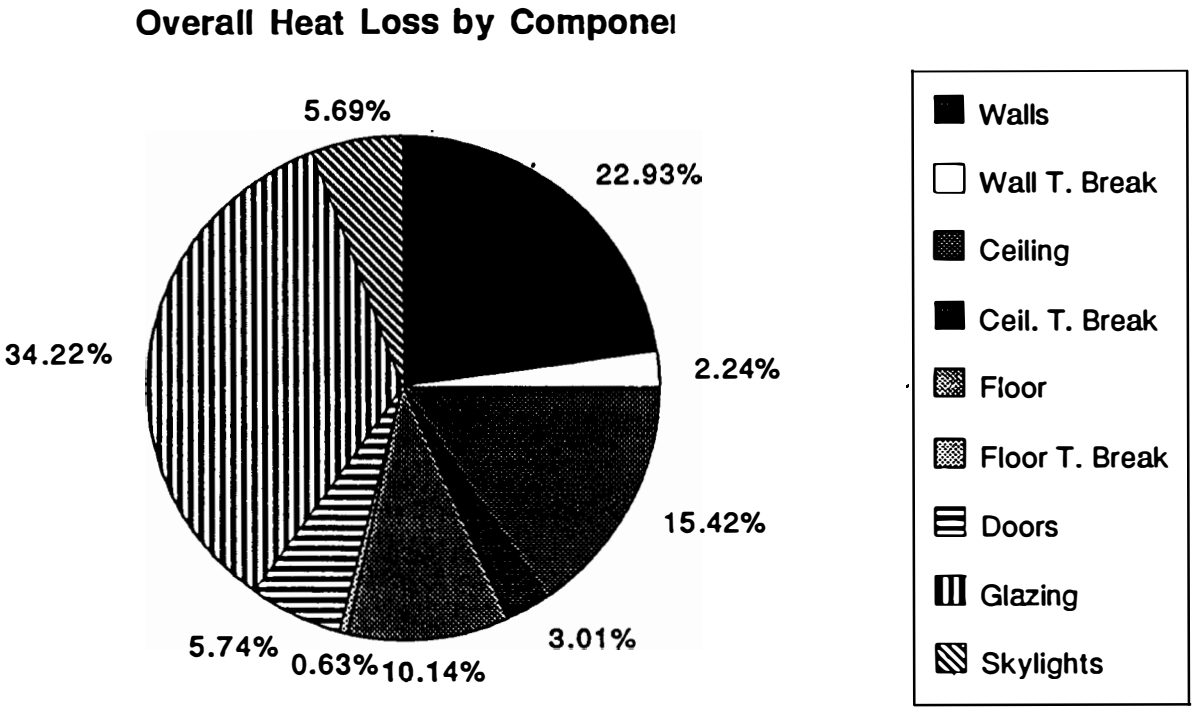
10.6 Energy Analysis Data

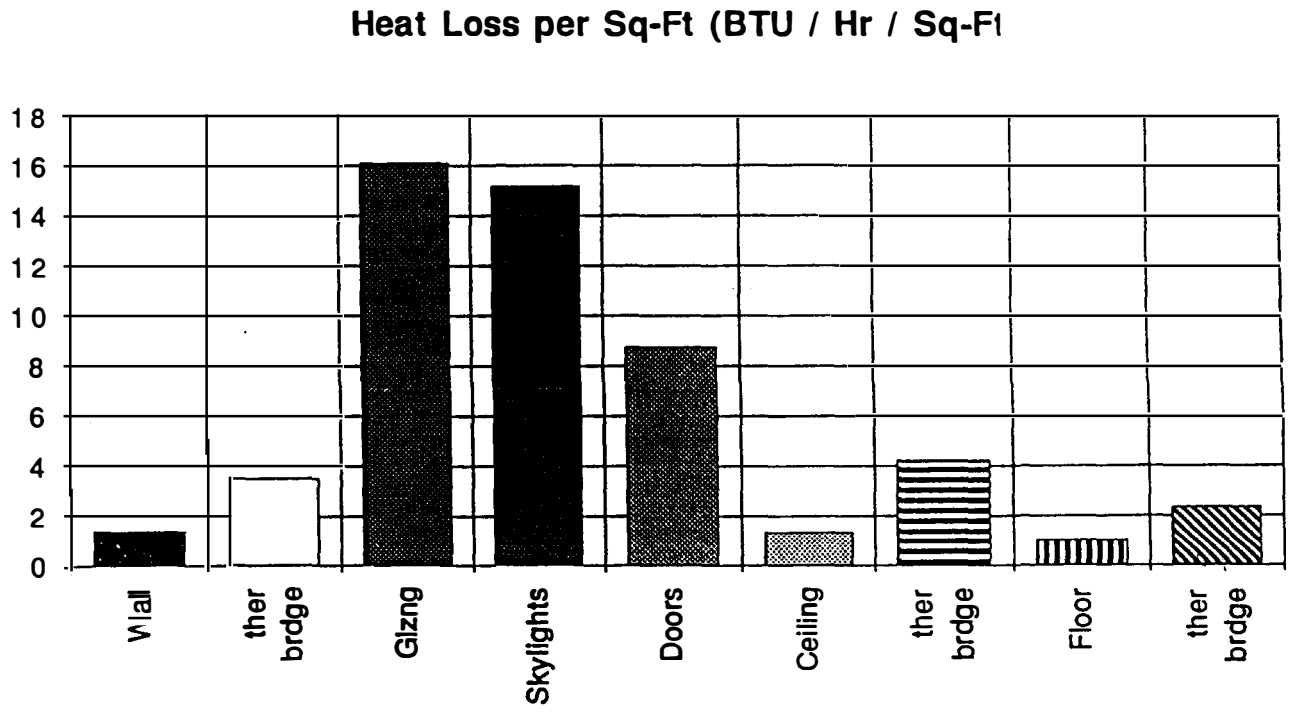
Demonstration House Project



Energy Analysis:
1 1/2 Story " Long" Demonstration House
Graphical Summary of Energy Performance
Energy Analysis Data

Energy Efficient Industrlized Housing
Center for Housing Innovation
University of Oregon


Overall Heat Loss by Componel
5.69%
22.93%
34.22%
2.24%
15.42%
5.74%
0.63%
10.14%
3.01%
Walls
Wall T. Break
Ceiling
Ceil. T. Break
Floor
Floor T. Break
Doors
Glazing
Skylights


Heat Loss per Sq-Ft (BTU / Hr / Sq-Ft
18
16
14
12
10
8
6
4
2
0
Wall
ther brdge
Glzng
Skylights
Doors
Ceiling
ther brdge
Floor
ther brdge

	A	B	C	D	E	F
1						
2	Heat loss spreadsheet considering:			OPTIMAL INSULATION VOLUME		
3		•Composite wall section				
4		•Air film resistence				
5		•Air temperature stratification (inside)				
6		•Elevated crawlspace temperature				
7		•No infiltration				
8		•No Solar Gain				
9		•No thermal breaks at the panel joints				
10						
11						
12	UA TEST FORMAT					
13						
14		Q (=UA dT)	Q/A	UA	U	R
15		BTU/Hr	BTU/Hr Sq-Ft	BTU/Hr F	UA/Sq-Ft	1/U
16	Wall	1467.2	1.426	31.897	0.031	32.268
17	ther brdge	143.2	3.513	3.112	0.076	13.094
18	Glzng	2189.6	16.100	47.600	0.350	2.857
19	Skylights	364.3	15.180	7.920	0.330	3.030
20	Doors	367.1	8.740	7.980	0.168	5.935
21	Ceiling	986.6	1.361	18.330	0.025	39.539
22	ther brdge	192.3	4.250	3.573	0.079	12.664
23	Floor	648.6	1.028	24.914	0.039	25.327
24	ther brdge	40.1	2.361	1.542	0.091	11.027
25						
26	Total	6399.0		146.867		
27						
28	R=(1/f in) +R1+R2+R3+(1/f out); Hr Sq-Ft F / BTU					
29	R=t/k, t =thickness (Ft), k=conductance BTU Ft / Hr Sq-Ft F					
30	Q = (UAdT)1 + (UAdT)2 + (UAdT)3 +•••					
31	T(actual) = T(bl) +(1 + 0.02(h))					
32	T(bl) = Temp @ breathing line, h= Ft from breathing line to centerline of surface (+ or -).					
33						
34	Variation Tables					
35						
36	Insulation volume					
37		thcknss (in)	area (Sq-ft)	volume (ft3)		
38	Walls	7.375	1029.250	632.560		
39	Ceiling	9.375	724.750	566.211		
40	Floor	5.500	631.000	289.208		
41						
42	Total Volume			1487.979		
43						
44	Glazing 'U' =.35					
45	Heat Loss	6398.99	Btu/Hr			

	G	H	I	J	K	L
1	Wall Area Sq-Ft (gross)		Area			
2	Wall 1 (N)		395.000			
3	Wall 2 (S)		377.000			
4	Wall 3 (E)		246.000			
5	Wall 4 (W)		230.000			
6				Angle	Width	Length
7	Ceiling area Sq-Ft (gross)		794.000	37.500		
8	Floor area Sq-Ft (gross)		648.000			
9	Temperatures		T (in) =	68.000	T (out) =	22.000
10	Windows Sq-Ft					
11	Wall 1		22.000		Condctnce=BTU Ft/Hr Sq-Ft F	
12	Wall 2		34.000		R=Hr Sq-Ft F/BTU	
13	Wall 3		32.000		Air Film:f =BTU/Hr Sq-Ft F	
14	Wall 4		48.000		U=BTU/Hr Sq-Ft F	
15	Total		136.000			
16	Skylights		24.000			
17	Doors Sq-Ft	Total	Type 1	Type 2	Type 3	
18	Wall 1	21.000	21.000			
19	Wall 2	21.000	21.000			
20	Wall 3	0.000	0.000	0.000		
21	Wall 4	0.000	0.000	0.000		
22	Total	42.000	42.000	0.000	0.000	
23						
24	Thermal bridge		Area (Sq-Ft)	Length (Ft)	Width (in)	Note: includes
25	Wall 1		9.000	72.000	1.500	framed
26	Wall 2		9.000	72.000	1.500	openings
27	Wall 3		11.375	91.000	1.500	
28	Wall 4		11.375	91.000	1.500	
29	Total		40.750			
30						
31	Thermal Bridge		Area (Sq-Ft)	Length (Ft)	Width (in)	
32	Ceiling		45.250	362.000	1.500	
33	Thermal Bridge					
34	Floor		17.000	136.000	1.500	
35						
36	Wall net 1		343.000		Q / ΔT =(ACH)(Vol)(C)	
37	Wall net 2		313.000		ACH (infil)	0.200
38	Wall net 3		202.625		C (Spec Ht)	0.018
39	Wall net 4		170.625		Vol (Ft 3)	12308.000
40			Sq-FT	Sq-FT		
41	Wall area net total		1029.250		ACH =	Cubic Feet
42	Floor area net total		631.000		C =	BTU / Ft3 F
43	Ceiling area net total		724.750		Vol =	Ft 3
44	Glazing area		136.000			
45	Door area		42.000	0.000		

	M	N	O	P	Q	R
1	Heat loss Walls					
2		Area =	1029.250			
3		T (in) =	68.000	T (out) =	22.000	
4						
5		Component	Material	R value	R / in	Thcknss (in)
6		Int surface	gypsun t=.5	0.450		
7		R2 (OSB)		0.810	1.850	0.438
8		R3	INS	28.394	3.850	7.375
9		R4 (OSB)	OSB	0.809	1.850	0.438
10		R5	build. paper	0.060		
11		ext surface	.5 Lapp Sidng	0.810		
12		Sum R =		31.333		
13				R value	f (BTU/Hr Sq-Ft F)	
14		air film (in)	xxxxx	0.685	1.460	
15		air film (out)	xxxxx	0.250	4.000	
16		Sum R (flm)=		0.935		
17		Total R =		32.268		
18		Wall U =1/R	Wall U value =	0.031		
19		Heat loss	Q = UA dT =	1467.242		
20						
21	Wall Thermal Bridge					
22		Area (Sq-Ft)=	40.750			
23		T(in) =	68.000	T(out) =	22.000	
24		Component	Material	R value	R / in	Thickness (in)
25		Int surface	gypsum t=.5	0.450		
26		C2	OSB	0.810	1.850	0.438
27		C3	Stud	9.219	1.250	7.375
28		C4	OSB	0.810	1.850	0.438
29		C5	Building pap.	0.060		
30		ext surface	.5 Lapp Sidng	0.810		
31		Sum R=		12.159		
32						
33				R value	'f' (BTU/Hr Sq-Ft F)	
34		air film (in)		0.685	1.460	
35		air film (out)		0.250	4.000	
36		Sum R (flm)		0.935		
37						
38		Total R		13.094		
39						
40		Wall U= 1/R	Wall U =	0.076	BTU/hr Sq-Ft F	
41		Heat loss / Sq-Ft =	UA =	3.112	BTU/hr F	
42		Heat loss	Q=UAdt	143.154	BTU/hr	
43						
44						
45						

	S	T	U	V	W	X
1						
2	Glazing					
3		Area(Sq-Ft)=	136.000			
4		T (in) =	68.000	T(out) =	22.000	
5		Component	Discription	R value	U value	(Tested)
6		glazing U			0.350	
7						
8		Total U =	0.350			
9						
10		Glzng U =1/R	Glzng U value=	0.350	BTU/HR Sq-Ft F	
11		BTU/Hr F =	UA =	47.600	BTU/Hr F	
12		Heat loss	Q = UA dT =	2189.600	BTU/Hr	
13						
14	SKYLIGHTS					
15		Area(Sq-Ft)=	24.000			
16		T (in) =	68.000	T(out) =	22.000	
17		Component	Discription	R value	U value	(Tested)
18		glazing U			0.330	
19						
20		Total U =	0.330			
21						
22		Glzng U =1/R	Glzng U value=	0.330	BTU/HR Sq-Ft F	
23		BTU/Hr F =	UA =	7.920	BTU/Hr F	
24		Heat loss	Q = UA dT =	364.320	BTU/Hr	
25						
26	TOTAL GLAZING					
27		Heat loss	Q = UA dT =	2553.92		
28						
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						
40						
41						
42						
43						
44						
45						

	Y	Z	AA	AB	AC	AD
1						
2	Door 1	Area (Sq-Ft)=	42.000			
3		T (in) =	68.000	T (out) =	22.000	
4						
5		Component	Material	R value		
6		C1	wood	5.000		
7						
8		Air Film (in)		0.685		
9		Air Film (out)		0.250		
10		Sum R (film)=		0.935		
11						
12		Total R =		5.935		
13						
14		Door U=1/R	Door U value=	0.190	BTU/HR Sq-Ft F	Set Value
15		BTU/Hr F =	UA =	7.980	BTU/Hr F	
16		Heat loss	Q = UA dT =	367.080	BTU/Hr	
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						
40						
41						
42						
43						
44						
45						

	AE	AF	AG	AH	AI	AJ
1	Ceiling		Pitched area	Angle	Width	Length
2			724.750	37.500	18.000	36.000
3		T (actual) =	75.824	T (out) =	22.000	
4		T (bl) =	68.000	T (actual) =	75.824	
5		h mid (Ft) =	6.753			
6		Component	Material	R value	R / in	Thckness in
7		Int surface	gypsun t=.5	0.450		
8		R2 (OSB)	OSB	0.810	1.850	0.438
9		R3 (foam)	Exp Polys	36.094	3.850	9.375
10		R4 (OSB)	OSB	0.810	1.850	0.438
11		R5	build. paper	0.060		
12		ext surface	asphault shngl	0.440		
13		Sum R =		38.664		
14				R value	f (BTU/Hr Sq-Ft F)	
15		air film (in)		0.625	1.600	
16		air film (out)		0.250	4.000	
17		Sum R (flm)=		0.875		
18						
19		Total R =		39.539		
20						
21		Wall U =1/R	Wall U value =	0.025		
22			UA=	18.330		
23		Heat loss	Q = UA dT =	986.586		
24						
25	Ceiling Thermal Bridge					
26		Area (Sq-Ft)=	45.250			
27		T(in) =	75.824	T(out) =	22.000	
28						
29		Component	Material	R value	R /in	Thcknss in
30		Int surface	gypsum t=.5	0.450		
31		C2	OSB	0.810	1.850	0.438
32		C3	Stud	9.219	1.250	7.375
33		C4	OSB	0.810	1.850	0.438
34		C5	Building pap.	0.060		
35		ext surface	asphault shngl	0.440		
36		Sum R=		11.789		
37						
38		air film (in)	R=	0.625		
39		air film (out)	R=	0.250		
40		Sum R (flm)	R=	0.875		
41		Total R		12.664		
42						
43		Ceil U= 1/R	Ceil U =	0.079		
44		Heat loss / Sq-Ft = UA =		3.573		
45		Heat loss	Q=UAdT=	192.314		

	AK	AL	AM	AN	AO	AP
1						
2	Heat loss Floor					
3		Area =	631.000			
4		T (bl) =	68.000	T (in) =	61.200	
5		h (dist to flr)	5.000			
6						
7		T (in) =	61.200	T (out) =	35.168	
8						
9		Component	Material	R value	R / in	Thcknss (in)
10		Int surface	hardwood	0.680		
11		R2 (OSB)	OSB	0.810	1.850	0.438
12		R3 (foam)	Exp Polys	21.175	3.850	5.500
13		R4 (OSB)		0.810	1.850	0.438
14		Sum R =		23.476		
15				R value	f (BTU/Hr Sq-Ft F)	
16		air film (in)	xxxxx	0.926	1.080	
17		air film (out)	xxxxx	0.926	1.080	
18		Sum R (flm)=		1.852		
19						
20		Total R =		25.327		
21						
22		Wall U =1/R	Wall U value =	0.039		
23			UA=	24.914		
24		Heat loss	Q = UA dT =	648.561		
25	Floor thermal bridge					
26		Area	17.000			
27		T (in) =	61.200	T (out) =	35.168	
28						
29		Component	Material	R value	R / in	Thckness (in)
30		Int surface	hardwood	0.680		
31		R2 (OSB)	OSB	0.810	1.850	0.438
32		Stud	wood	6.875	1.250	5.500
33		R4 (OSB)	OSB	0.810	1.850	0.438
34		Sum R =		9.176		
35				R value	f (BTU/Hr Sq-Ft F)	
36		air film (in)	xxxxx	0.926	1.080	
37		air film (out)	xxxxx	0.926	1.080	
38		Sum R (flm)=		1.852		
39						
40		Total R =		11.027		
41						
42		Wall U =1/R	Wall U value =	0.091		
43			UA =	1.542		
44		Heat loss	Q = UA dT =	40.132		
45						

	AQ	AR	AS	AT	AU	AV
1	Chart 1: Overall heat loss distribution					
2						
3	Walls	1610.396				
4	Ceiling	1178.901				
5	Floor	688.693				
6	Doors	367.080				
7	Glazing	2189.600				
8	Skylights	364.320				
9						
10						
11	Chart 2: Overall including thermal breaks					
12						
13	Walls	1467.242				
14	Wall T. Break	143.154				
15	Ceiling	986.586				
16	Ceil. T. Break	192.314				
17	Floor	648.561				
18	Floor T. Break	40.132				
19	Doors	367.080				
20	Glazing	2189.600				
21	Skylights	364.320				
22						
23						
24	Chart 3: Thermal resistance component contributions (wall)					
25						
26	Inside air film	0.685				
27	Gypsum	0.450				
28	OSB	0.810				
29	Foam	28.394				
30	OSB	0.809				
31	Build Paper	0.060				
32	Alum Siding	0.000				
33	Outside air flm	0.250				
34						
35	Chart 4: Q/A Heat loss per sq-foot					
36						
37	Wall	1.426				
38	ther brdge	3.513				
39	Glzng	16.100				
40	Skylights	15.180				
41	Doors	8.740				
42	Ceiling	1.361				
43	ther brdge	4.250				
44	Floor	1.028				
45	ther brdge	2.361				

	AW	AX	AY	AZ	BA	BB
1	Crawlspace	Q in = Q out	Q floor + Q grnd= Q wall+ Q infl			
2		Q floor = U floor A floor (T in - T crawl)			T in =	68.000
3		Q grnd = U grnd A grnd (T grnd - T crawl)			T out =	22.000
4		Q wall = U wall A wall (T crawl - T out)				
5		Q infil = (ACH) (Vol) (Cp) (D) (T crawl -T out)				C=Cp*D
6		UA wall=	69.80	(report)	Ground	
7		UA floor=	26.46		depth const T	8.000
8		UA grnd=	82.93		T grnd @ 8'=	58.000
9		Infiltration=	139.97		R grnd / in=	10.076
10		ACH=	4.00		R total=	7.200
11		Vol=	1944.00			
12		C=	0.0180		air film=	1.630
13		(SGC)			R air	0.613
14						
15					R total=	7.813
16		Temp crawl=	35.17		U grnd=	0.128
17						
18						
19						
20						
21						
22						
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25						
26						
27						
28						
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45						

	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM
1	Ceiling / Floor Relationships										
2			Ceiling : Variable = AJ 9 (columns)					Wall = 7.375" (constant)			
3			Floor: Variable = AP 12 (rows)					Glazing = .35 (constant)			
4								Q target ≤ 7400 btu/ hr			
5		Ceiling insulation thickness (inches) vs Floor ins thickness									
6	6399	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
7	3	7344	7229	7130	7043	6967	6899	6838	6784	6735	6690
8	3.5	7249	7134	7035	6948	6872	6804	6743	6689	6640	6595
9	4	7170	7055	6956	6869	6793	6725	6664	6610	6561	6516
10	4.5	7103	6989	6889	6802	6726	6658	6598	6543	6494	6449
11	5	7046	6931	6832	6745	6669	6601	6540	6486	6437	6392
12	5.5	6997	6882	6783	6696	6619	6551	6491	6436	6387	6342
13	6	6954	6839	6739	6653	6576	6508	6448	6393	6344	6299
14	6.5	6915	6800	6701	6614	6538	6470	6409	6355	6306	6261
15	7	6881	6767	6667	6580	6504	6436	6376	6321	6272	6227
16	7.5	6851	6736	6637	6550	6474	6406	6345	6291	6242	6197
17	8	6824	6709	6610	6523	6446	6379	6318	6264	6214	6170
18	8.5	6799	6684	6585	6498	6422	6354	6293	6239	6190	6145
19	9	6777	6662	6563	6476	6399	6332	6271	6216	6167	6122
20	9.5	6756	6642	6542	6455	6379	6311	6251	6196	6147	6102
21	10	6738	6623	6523	6437	6360	6292	6232	6177	6128	6083
22											
23	Ceiling / Wall			Ceiling : Varible = AJ9 (rows)					Floor = 5.50" (constan		
24				Wall: Varible = R8 (columns)					Glazing = .35 (constant		
25									Q target ≤ 7400 btu/hr		
26			Wall insulation thickness (inches) vs. ceiling insulation thickness								
27	6399	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00
28	3.50	8172	8027	7902	7792	7695	7608	7530	7460	7397	7339
29	4.00	7936	7792	7666	7556	7459	7372	7295	7225	7161	7104
30	4.50	7745	7600	7475	7365	7267	7181	7103	7033	6970	6912
31	5.00	7585	7441	7315	7205	7108	7021	6944	6874	6810	6753
32	5.50	7451	7306	7181	7071	6974	6887	6809	6739	6676	6618
33	6.00	7336	7191	7066	6956	6859	6772	6694	6624	6561	6503
34	6.50	7237	7092	6967	6857	6759	6673	6595	6525	6462	6404
35	7.00	7150	7005	6880	6770	6673	6586	6508	6438	6375	6317
36	7.50	7073	6929	6803	6693	6596	6509	6432	6362	6298	6241
37	8.00	7006	6861	6736	6626	6528	6442	6364	6294	6231	6173
38	8.50	6945	6800	6675	6565	6468	6381	6303	6233	6170	6112
39	9.00	6890	6746	6620	6510	6413	6327	6249	6179	6115	6058
40	9.50	6841	6697	6571	6461	6364	6277	6200	6130	6066	6009
41	10.00	6796	6652	6526	6416	6319	6233	6155	6085	6021	5964
42											
43											
44											
45											

	BN	BO	BP	BQ	BR	BS	BT	BU	BV	BW	BX
1	Floor / wall										
2			Floor: AP 12 (row)			Ceiling = 9.375"					
3			Wall: R8 (column)			Glazing =.35					
4						Q target ≤ 7400 btu/hr					
5						Floor ins thickness vs. wall ins thickness					
6	6399	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00
7	3.00	8451	7804	7369	7056	6821	6637	6489	6368	6267	6181
8	3.50	8356	7709	7274	6961	6726	6542	6394	6273	6172	6086
9	4.00	8277	7630	7195	6882	6646	6463	6315	6194	6093	6007
10	4.50	8211	7563	7128	6815	6580	6396	6248	6127	6026	5940
11	5.00	8153	7506	7071	6758	6523	6339	6191	6070	5969	5883
12	5.50	8104	7456	7021	6709	6473	6289	6141	6020	5919	5833
13	6.00	8061	7413	6978	6665	6430	6246	6098	5977	5876	5790
14	6.50	8022	7375	6940	6627	6392	6208	6060	5939	5838	5752
15	7.00	7989	7341	6906	6593	6358	6174	6026	5905	5804	5718
16	7.50	7958	7311	6876	6563	6327	6144	5996	5875	5774	5688
17	8.00	7931	7283	6848	6536	6300	6116	5969	5848	5746	5661
18	8.50	7906	7259	6824	6511	6276	6092	5944	5823	5722	5636
19	9.00	7884	7236	6801	6489	6253	6069	5922	5800	5699	5613
20	9.50	7864	7216	6781	6468	6233	6049	5901	5780	5679	5593
21	10.00	7845	7197	6762	6449	6214	6030	5882	5761	5660	5574
22											
23	Glazing / Wall										
24	)		Glazing W6 (column)			Ceiling = 9.375					
25			Wall: R8 (row)			Floor = 5.5"					
26						Q target ≤ 7400 btu/hr					
27			Wall insulation thickness (inches) vs. Glazing "U" value								
28	6399	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	
29	3.5	6806	7119	7432	7745	8058	8370	8683	8996	9309	
30	4.5	6281	6594	6906	7219	7532	7845	8158	8470	8783	
31	5.5	5915	6227	6540	6853	7166	7479	7791	8104	8417	
32	6.5	5645	5957	6270	6583	6896	7209	7521	7834	8147	
33	7.25	5485	5797	6110	6423	6736	7049	7361	7674	7987	
34	8.25	5311	5624	5936	6249	6562	6875	7188	7500	7813	
35	9.25	5171	5483	5796	6109	6422	6735	7047	7360	7673	
36	10.25	5055	5368	5681	5993	6306	6619	6932	7245	7557	
37	11.25	4958	5271	5584	5896	6209	6522	6835	7148	7460	
38	12.25	4876	5188	5501	5814	6127	6440	6752	7065	7378	
39	13.25	4805	5117	5430	5743	6056	6369	6681	6994	7307	
40	14.25	4743	5055	5368	5681	5994	6307	6619	6932	7245	
41	15.25	4688	5001	5314	5627	5940	6252	6565	6878	7191	
42											
43											
44											
45											

	BY	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI
1	Glazing / Ceiling										
2		Glazing: W6 (columns)				Floor = 5.625" (constant)					
3		Ceiling: AJ9 (rows)				Wall = 7.375" (constant)					
4						Q target ≤ 7400 btu/hr					
5		Ceiling insulation thickness vs. galzing ins thkness									
6	6399	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55		
7	3.5	6779	7092	7405	7718	8031	8343	8656	8969		
8	4.5	6352	6665	6978	7290	7603	7916	8229	8542		
9	5.5	6058	6371	6684	6997	7310	7622	7935	8248		
10	6.5	5844	6157	6470	6783	7095	7408	7721	8034		
11	7.25	5718	6031	6344	6656	6969	7282	7595	7908		
12	8.25	5582	5895	6208	6520	6833	7146	7459	7772		
13	9.25	5473	5786	6098	6411	6724	7037	7350	7662		
14	10.25	5383	5696	6009	6322	6634	6947	7260	7573		
15	11.25	5308	5621	5934	6247	6559	6872	7185	7498		
16	12.25	5245	5558	5870	6183	6496	6809	7122	7434		
17	13.25	5190	5503	5816	6129	6442	6754	7067	7380		
18											
19											
20											
21											
22											
23	Glazing / Floor										
24		Floor: AP12 (row)				Ceiling = 9.375" (constant)					
25		Glazing: W6 (column)				Wall = 7.375" (constant)					
26						Q target ≤ 7400 btu/hr					
27		Floor insulation thickness (inches) vs. glazing 'U' value									
28	6399	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55		
29	3.5	6713	6026	6339	6652	6964	7277	7590	7903		
30	4.5	5567	5880	6193	6506	6818	7131	7444	7757		
31	5.5	5461	5773	6086	6399	6712	7025	7337	7650		
32	6.5	5379	5692	6005	6318	6630	6943	7256	7569		
33	7.25	5330	5643	5955	6268	6581	6894	7207	7519		
34	8.25	5275	5588	5901	6213	6526	6839	7152	7465		
35	9.25	5230	5543	5856	6169	6481	6794	7107	7420		
36	10.25	5193	5506	5818	6131	6444	6757	7070	7382		
37	11.25	5161	5474	5786	6099	6412	6725	7038	7350		
38	12.25	5134	5446	5759	6072	6385	6698	7010	7323		
39	13.25	5110	5423	5735	6048	6361	6674	6987	7299		
40	14.25	5089	5402	5715	6027	6340	6653	6966	7279		
41											
42											
43											
44											
45											

	CJ	CK	CL	CM	CN	CO	CP	CQ
1								
2	FOAM DENSITY FLOOR /			Floor = 5.5"				
3		GLAZNG= W6 (C		Ceiling = 9.375"				
4		DENSITY= AO1;		Wall = 7.375"				
5								
6	Density	6399	0.2	0.25	0.3	0.35	0.4	0.45
7	1# =	3.85	5461	5773	6086	6399	6712	7025
8	1.25# =	3.92	5452	5765	6077	6390	6703	7016
9	1.5# =	4.17	5423	5735	6048	6361	6674	6987
10	2# =	4.35	5403	5716	6029	6342	6654	6967
11								
12								
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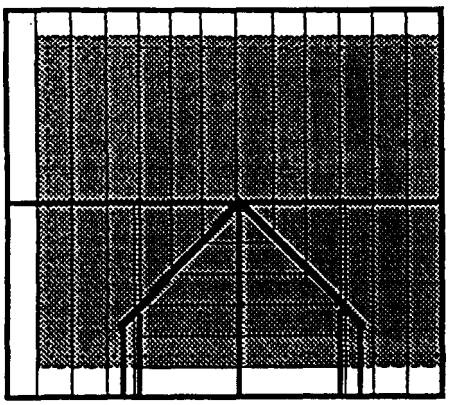
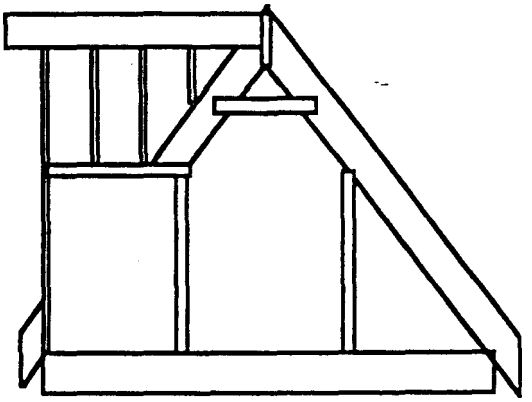
10.7 Cost Analysis Spread Sheets

Demonstration House Project

Building Systems Cost Estimates and Comparisons





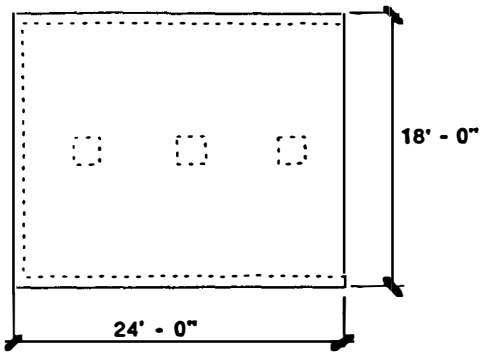
R-Control vs. Conventional "Stick" Framing-

*** Foundation Systems**
*** Conventional Roofs**
*** Roofs with Dormers**
*** Roofs using Trusses**
*** Roofs with Panel and Conventional Framing**

Energy Studies of Buildings Laboratory
Center for Housing Innovation
University of Oregon

***Cost estimates based on 1992 Means Estimating Guide**

CONVENTIONAL FRAMING FLOOR SYSTEM

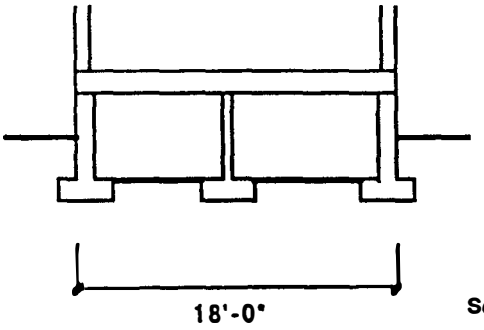


Floor Area: 432sf

Dollars per s.f. =	7.19

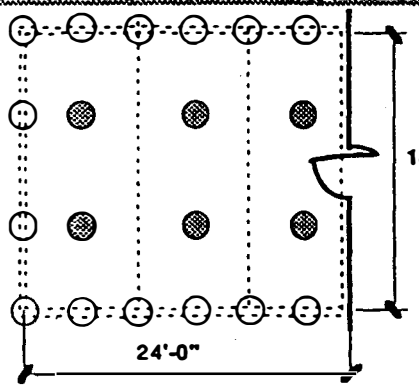
Conventional Floor/Foundation System

Component	Qty.	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
2x8 Joist	306	lf.	0.47	143.82	0.36	110.16	253.98
2x8 Blocking	22.5	lf.	0.47	10.58	0.80	18.00	28.58
2x8 Rim Joist	66	lf	0.47	31.02		0.00	31.02
2x6 P.T. Mudsill	66	lf.	0.61	40.26	0.84	55.44	95.70
3/4" Decking	432	sf.	0.37	159.84	0.26	112.32	272.16
6 Mil. V.B.	432	sf.	0.07	30.24	0.04	17.28	47.52
R-30 Insulation	432	sf	0.50	216.00	0.14	60.48	276.48
4x8 Int. Bm.	24	lf.	1.42	34.08	0.81	19.44	53.52
4x4 P.T. Posts	10	lf.	0.70	7.00	0.81	8.10	15.10
Na./Sc./Gl./Ca.				20.00		0.00	20.00
Anchor Bolts	11	ea.	0.34	3.74	1.88	20.68	24.42
#4 Rebar	227.5	lf.		200.00		0.00	200.00
Concrete	9	cy	51.64	464.76		0.00	464.76
P.V.C. Pipe	66	lf.	1.47	97.02	1.35	89.10	186.12
Excav.	14.67	cy		0.00		220.00	220.00
Grading				0.00		100.00	100.00
Formwork	432	sf ca.	0.87	375.84	1.61	695.52	1071.36
TOTALS				1690.38		1416.36	3106.74



Section Diagram

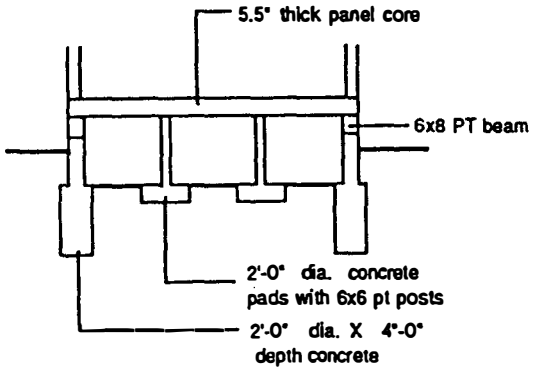
R-CONTROL FLOOR SYSTEM Type 1



Dollars per sf =	6.33

R-Control Floor/Foundation System-5 1/2" Core

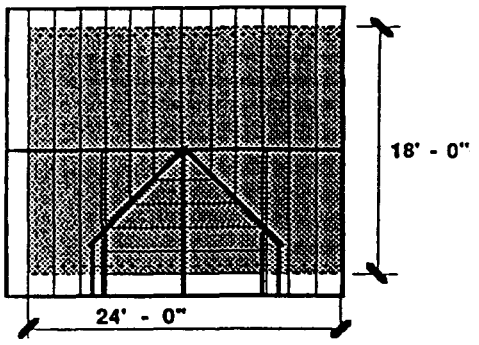
Component	Qty.	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
R-Control Panel	432	sf	2.90	1252.80	0.55	237.60	1490.40
Spline 2x6	54	lf	0.34	18.36	0.85	45.90	64.26
Rim Joist 2x6	66	lf	0.34	22.44	0.29	19.14	41.58
6x8 P.T. Beam	66	lf	1.84	121.44	0.51	33.66	155.10
6x6 Posts	144	ea	1.20	172.80	1.46	210.24	383.04
Concrete	1.67	cy	51.64	86.24	19.35	32.31	118.55
Po./Bm. Connector	28	ea	1.50	42.00	2.50	70.00	112.00
24" Dia. Holes	24	ea	10.00	240.00		0.00	240.00
Staples/Sealant			30.00	30.00	0.00	0.00	30.00
Grading			0.00			100.00	100.00
TOTALS				1986.08		648.85	2734.93



R- Control Floor System Discription

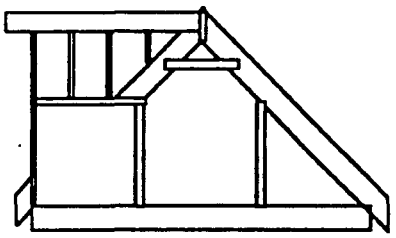
R-Control Panel	5 1/2" core with (2) layers of 3/4" OSB on each side.
Stringer 2x6	(2) 2x6 Stringers running full length of panel
Rim Joist 2x6	Continuous rim joist at edge of panels.
6x8 P.T. Beam	Load bearing at edge of building footprint.
6x6 P.T. Posts	Continuous post from conc. pad to panel capital.
Concrete	Concrete pads placed at bottom of holes for load bearing.
Po./Bm. Conn.	Mech. connection for post and beam.
24" Dia. Holes	24"x 5'-0" deep hole required for pole foundation.
Staples/Sealant	Panel fastening system.
Grading	Site grading as required.
Capitals	Factory applied 3/4" thick OSB panels for point loading.

CONVENTIONAL ROOF FRAMING SYSTEM - 1 1/2 Story



12:12 Slope

Dollars per sf = 7.94

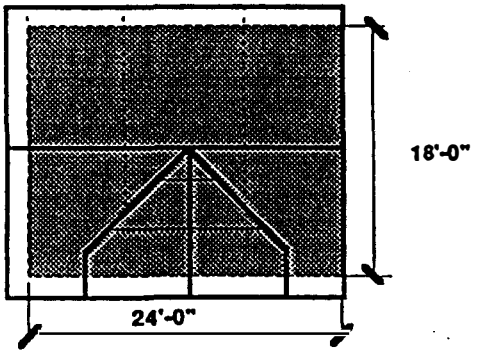


Section Diagram

Conventional Roof System R-38

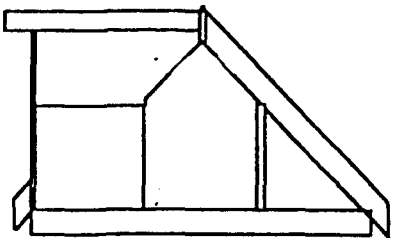
Component	Qty	Unit	Mat. Unit	Mat. Tot.	Unit Lab	Lab. Tot.	Total $'s
2x12 Ridge (Dbl.)	51	lf	0.85	43.35	0.90	45.90	89.25
2x10 Ridge	12	lf	0.72	8.64	0.80	9.60	18.24
2x12 Rafters	440	lf	0.85	374.00	0.53	233.20	607.20
2x12 V. Rafters	24	lf	0.85	20.40	0.72	17.28	37.68
2x6 Jack Rafters	48	lf	0.34	16.32	0.80	38.40	54.72
2x12 Blocking	42	lf	0.85	35.70	0.81	34.02	69.72
7/16" Sheathing	617	sf	0.27	163.51	0.36	222.12	385.63
2x6 Fascia	89	lf	0.34	30.26	1.36	121.04	151.30
R-38 Insulation	320	sf	0.71	227.20	0.14	44.80	272.00
6 Mil. V.B.	320	sf	0.07	22.40	0.04	12.80	35.20
1/2" Gyp. Bd.	320	sf	0.10	32.00	0.34	108.80	140.80
2x6 Ceiling Joists	116	lf	0.34	39.44	0.39	45.24	84.68
Roofing	830	sf	0.29	240.70	0.39	323.70	564.40
15# Felt	830	sf	0.05	41.50	0.08	66.40	107.90
Gutters/D.S.	89	lf	0.60	53.40	1.20	106.80	160.20
Vents	4	ea	15.00	60.00	20.00	80.00	140.00
Glue/Caulk				0.00	20.00	0.00	20.00
R-21 Insulation	233	sf	0.38	88.54	0.12	27.96	116.50
2x6 Dormer Wall	100	lf	0.34	34.00	0.40	40.00	74.00
2x6 Stub Wall	35	lf	0.34	11.90	0.48	16.80	28.70
2x8 Header	4	lf	0.47	1.88	0.94	3.76	5.64
Dormer Sheathing	213	sf	0.27	57.51	0.35	74.55	132.06
Dormer Ins. R-21	93	sf	0.38	35.34	0.15	13.95	49.29
Flr. Ins. R-19	183	sf	0.35	64.05	0.11	20.13	84.18
Totals				1702.04		1707.25	3429.28

R-CONTROL ROOF SYSTEM 1 1/2 Story W/DORMER



12:12 Slope

Dollars per sf = 11.99

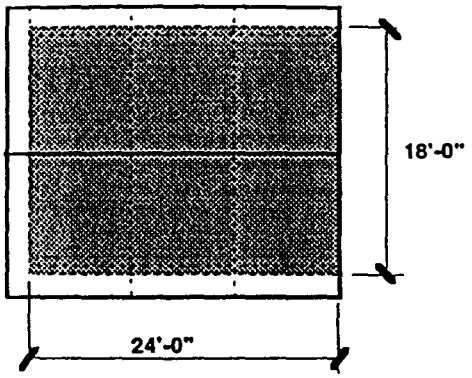


Section Diagram

R-Control Roof System-9 3/8" Core

Component	Qty	Unit	Mat. Unit	Mat. Tot.	Unit Lab	Lab. Tot.	Total $'s
5@8x14 Panels	560	sf	3.30	1848.00	0.55	308.00	2156.00
4@4x10 Panels	160	sf	3.15	504.00	0.55	88.00	592.00
2x10 Stringer	174	lf	0.73	127.02	0.53	92.22	219.24
R. Stringer 2x10	40	lf	0.73	29.20	0.63	25.20	54.40
V. Stringer 2x10	23	lf	0.73	16.79	0.80	18.40	35.19
7/16" Sheathing	151	sf	0.27	40.77	0.36	54.36	95.13
2x4 Sft. Framing	80	lf	0.23	18.40	0.36	28.80	47.20
2x6 Fascia	89	lf	0.34	30.26	1.36	121.04	151.30
Simp. L-70	74	ea	0.75	55.50		0.00	55.50
Simp. ST 12	148	ea	0.55	81.40		0.00	81.40
1/2" Gyp.Bd.	460	sf	0.10	46.00	0.34	156.40	202.40
Roofing	830	sf	0.29	240.70	0.45	373.50	614.20
Felt	830	sf	0.05	41.50	0.08	66.40	107.90
Gutters/D.S.	89	lf	0.60	53.40	1.12	99.68	153.08
Sealant	3.25	ea	3.54	11.51		0.00	11.51
Staples				0.00		0.00	0.00
Screws/Fasteners	148	ea	0.75	111.00		0.00	111.00
3/4" CDX Soffit	96	sf	0.34	32.64	0.36	34.56	67.20
2@4x12 Panels	96	sf	2.65	254.40	0.55	52.80	307.20
1@4x8 Panels	32	sf	2.65	84.80	0.55	32.55	117.35
Totals				3542.49		1519.36	5179.20

R-CONTROL ROOF SYSTEM

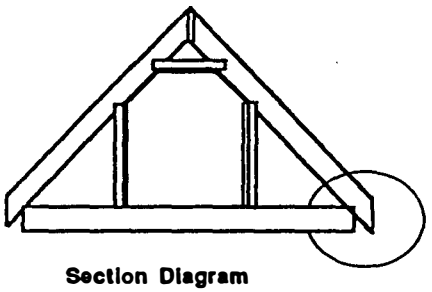


12:12 Slope

Dollars per sf = 9.96

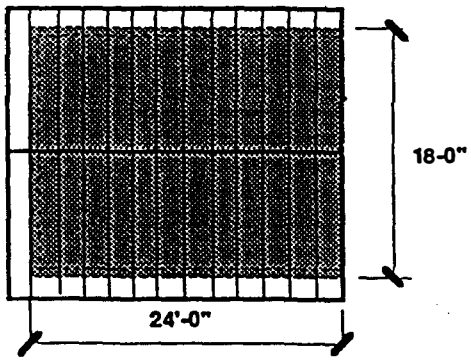
R-Control Roof System-9 3/8" Core

Component	Qty.	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
6@8x14	672	sf	3.30	2217.60	0:55	369.60	2587.20
2x10 Stringer	168	lf	0.73	122.64	0.53	89.04	211.68
R. Stringer 2x10	26	lf	0.73	18.98	0.53	13.78	32.76
7/16" Sheathing	72	sf	0.27	19.44	0.24	17.28	36.72
3/4" CDX Soffit	96	sf	0.36	34.56	0.36	34.56	69.12
2x4 Sft. Framing	100	lf	0.23	23.00	0.36	36.00	59.00
2x6 Fascia	80	lf	0.34	27.20	1.36	108.80	136.00
Simp. L-70	43	ea	0.75	32.25		0.00	32.25
Simp. ST 12	96	ea	0.55	52.80		0.00	52.80
1/2" Gyp.Bd.	388	sf	0.10	38.80	0.34	131.92	170.72
Roofing	757	sf	0.29	219.53	0.45	340.65	560.18
Felt	757	sf	0.05	37.85	0.08	60.56	98.41
Gutters/D.S.	86	lf	0.60	51.60	1.12	96.32	147.92
Sealant	3.25	ea	3.54	11.51		0.00	11.51
Staples				0.00			0.00
Screws/Fasteners	96	ea	1.00	96.00		0.00	96.00
Totals				3003.76		1298.51	4302.27



Section Diagram

CONVENTIONAL ROOF FRAMING SYSTEM 1 1/2 Story



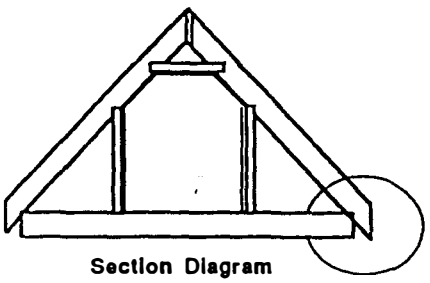
12:12 Slope

Dollars per sf = 6.95

12:12 R-Control

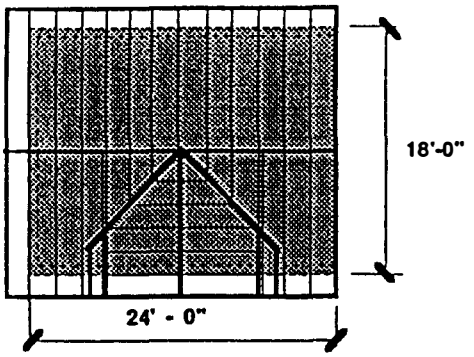
Conventional Roof System R-38

Component	Qty.	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
2x12 Ridge (Dbl.)	51	lf	0.85	43.35	0.90	45.90	89.25
2x12 Rafters	416	lf	0.85	353.60	0.53	220.48	574.08
2x12 Blocking	42	lf	0.85	35.70	0.81	34.02	69.72
7/16" Sheathing	757	sf	0.27	200.61	0.35	264.95	465.56
2x6 Fascia	80	lf	0.36	28.80	1.36	108.80	137.60
R-38 Insulation	270	sf	0.71	191.70	0.14	37.80	229.50
6 Mil. V.B.	270	sf	0.07	18.90	0.04	10.80	29.70
1/2" Gyp. Bd.	270	sf	0.10	27.00	0.34	91.80	118.80
2x6 Celling Joists	116	lf	0.34	39.44	0.39	45.24	84.68
Roofing	757	sf	0.29	219.53	0.45	340.65	560.18
15# Felt	757	sf	0.05	37.85	0.08	60.56	98.41
Gutters/D.S.	86	lf	0.60	51.60	1.20	103.20	154.80
Vents	4	ea	15.00	60.00	20.00	80.00	140.00
Glue/Caulk				0.00	20.00	0.00	20.00
R-21 Insulation	233	sf	0.38	88.54	0.15	34.95	123.49
Flr. Ins. R-19	235	sf	0.35	82.25	0.11	25.85	108.10
				0.00		0.00	0.00
Totals				1478.87		1505	3003.87



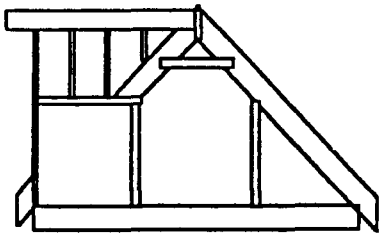
Section Diagram

CONVENTIONAL FRAMED ROOF 1 1/2 STORY W/DORMER (1992 Cost)



12:12 Slope

Dollars per sf = 8.75

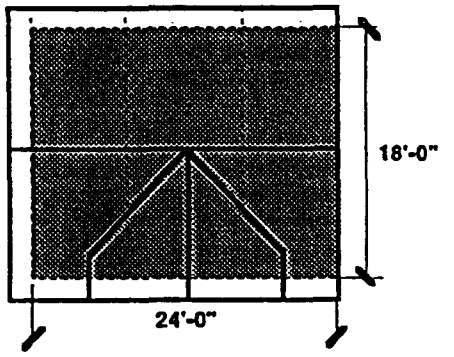


Section Diagram

Conventional Roof System /R-38

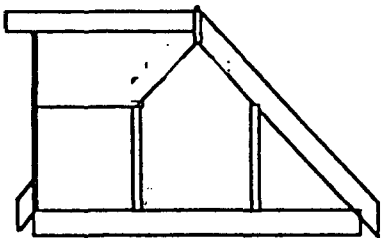
Component	Qty	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
2x12 Ridge (Dbl.)	51	lf	1.05	53.55	0.95	48.45	102.00
2x10 Ridge	12	lf	0.87	10.44	0.85	10.20	20.64
2x12 Rafters	428	lf	1.05	449.40	0.53	226.84	676.24
2x12 V. Rafters	24	lf	1.05	25.20	0.72	17.28	42.48
2x6 Jack Rafters	48	lf	0.38	18.24	0.80	38.40	56.64
2x12 Blocking	42	lf	1.05	44.10	0.81	34.02	78.12
7/16" Sheathing	830	sf	0.29	240.70	0.36	298.80	539.50
2x6 Fascia	89	lf	0.34	30.26	1.44	128.16	158.42
R-38 Insulation	320	sf	0.71	227.20	0.15	48.00	275.20
6 Mil. V.B.	320	sf	0.07	22.40	0.04	12.80	35.20
1/2" Gyp. Bd.	320	sf	0.10	32.00	0.36	115.20	147.20
2x6 Ceiling Joists	130	lf	0.38	49.40	0.41	53.30	102.70
Roofing	830	sf	0.29	240.70	0.45	373.50	614.20
15# Felt	830	sf	0.05	41.50	0.08	66.40	107.90
Gutters/D.S.	89	lf	0.60	53.40	1.27	113.03	166.43
Vents	4	ea	15.00	60.00	21.20	84.80	144.80
Glue/Caulk				0.00	21.20	0.00	20.00
R-21 Insulation	233	sf	0.38	88.54	0.12	27.96	116.50
2x6 Dormer Wall	100	lf	0.34	34.00	0.40	40.00	74.00
2x6 Stub Wall	35	lf	0.34	11.90	0.48	16.80	28.70
2x8 Header	4	lf	0.47	1.88	0.94	3.76	5.64
Dormer Sheathing	213	sf	0.27	57.51	0.35	74.55	132.06
Dormer Ins. R-21	93	sf	0.38	35.34	0.15	13.95	49.29
Flr. Ins. R-19	183	sf	0.35	64.05	0.11	20.13	84.18
Totals				1891.71		1866.33	3778.04

R-CONTROL ROOF SYSTEM 1 1/2 Story W/DORMER



9:12 Slope

Dollars Per sf = 10.15

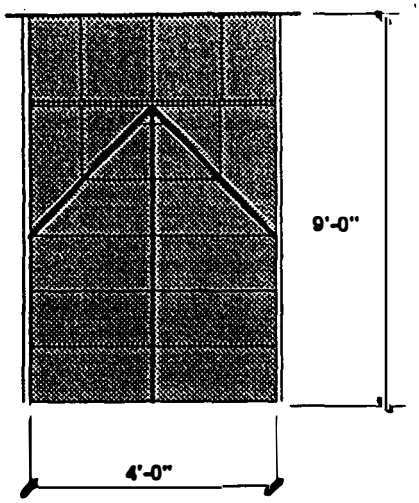


Section Diagram

R-Control Roof System-9 3/8" Core

Component	Qty	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
5@8x12	480	sf	3.30	1584.00	0.55	264.00	1848.00
1@8x10	80	sf	3.15	252.00	0.55	44.00	296.00
Ra. Stringer 2x10	108	lf	0.73	78.84	0.53	57.24	136.08
Rl. Stringer 2x10	40	lf	0.73	29.20	0.63	25.20	54.40
V. Stringer 2x10	23	lf	0.73	16.79	0.80	18.40	35.19
7/16" Sheathing	133	sf	0.27	35.91	0.36	47.88	83.79
2x4 Sft. Framing	80	lf	0.23	18.40	0.36	28.80	47.20
2x6 Fascia	84	lf	0.34	28.56	1.36	114.24	142.80
Simp. L-70	74	ea	0.75	55.50		0.00	55.50
Simp. ST 12	148	ea	0.55	81.40		0.00	81.40
1/2" Gyp.Bd.	460	sf	0.10	46.00	0.34	156.40	202.40
Roofing	732	sf	0.29	212.28	0.45	329.40	541.68
Felt	732	sf	0.05	36.60	0.08	58.56	95.16
Gutters/D.S.	87	lf	0.60	52.20	1.12	97.44	149.64
Sealant	3.25	ea	3.54	11.51		0.00	11.51
Staples				0.00		0.00	0.00
Screws/Fasteners	148	ea	0.75	111.00		0.00	111.00
3/4" CDX Soffit	96	sf	0.34	32.64	0.36	34.56	67.20
2@4x12	96	sf	2.65	254.40	0.55	52.80	307.20
1@4x8	32	sf	2.65	84.80	0.55	32.55	117.35
Totals				2937.23		1328.92	4383.50

CONVENTIONAL ROOF FRAMING SYSTEM - 1 1/2 Story w/Dormer

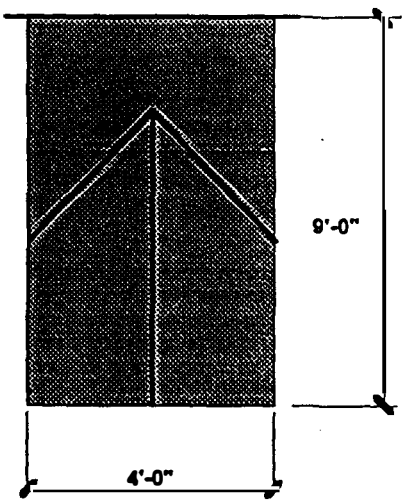


Plan View

Conventional Roof System R-38

Component	Qty.	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
2x12 Ridge (Dbl.)	10	lf	0.85	8.50	0.90	9.00	17.50
2x12 Rafters	66	lf	0.85	56.10	0.40	26.40	82.50
2x12 V. Rafters	9	lf	0.85	7.65	0.72	6.48	14.13
2x6 Jack Rafters	9	lf	0.34	3.06	0.80	7.20	10.26
2x12 Ridge Board	6.5	lf	0.85	5.53	0.80	5.20	10.73
7/16" Sheathing	108.5	sf	0.27	28.75	0.23	24.96	53.71
2x6 Fascia	20	lf	0.34	6.80	1.36	27.20	34.00
R-38 Insulation	59	sf	0.71	41.89	0.14	8.26	50.15
6 Mil. V.B.	108.5	sf	0.07	7.60	0.04	4.34	11.94
1/2" Gyp. Bd.	108.5	sf	0.10	10.85	0.34	36.89	47.74
2x6 Side Studs	15	lf	0.34	5.10	0.40	6.00	11.10
Roofing	59	sf	0.29	17.11	0.39	23.01	40.12
15# Felt	59	sf	0.05	2.95	0.08	4.72	7.67
2x6 Studs	12	lf	0.34	4.08	0.40	4.80	8.88
2X6 Cripples	5	lf	0.34	1.70	0.40	2.00	3.70
Glue/Caulk	2	ea		0.00	20.00	40.00	40.00
R-21 Insulation	15	sf	0.38	5.70	0.15	2.25	7.95
2x6 Sill	3	lf	0.34	1.02	0.40	1.20	2.22
2x6 plates	18	lf	0.34	6.12	0.40	7.20	13.32
2x6 Header	4	lf	0.34	1.36	0.94	3.76	5.12
Totals	8.012			221.86		250.87	472.73

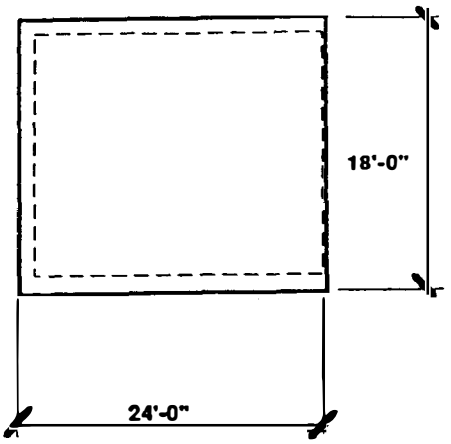
R-CONTROL ROOF SYSTEM 1 1/2 Story W/DORMER



Plan View

R-Control Roof System-9 3/8" Core

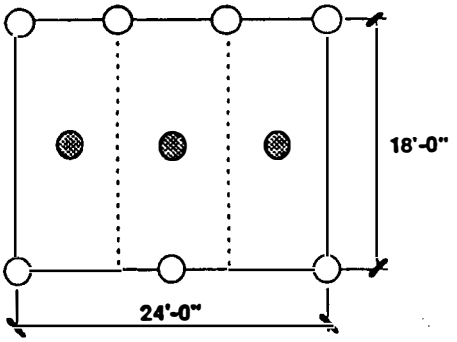
Component	Qty.	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
9-3/8" Panels	72	sf	3.30	237.60	0.55	39.60	277.20
5-1/2" Panels	40	sf	3.15	126.00	0.55	22.00	148.00
V. Stringer 2x6	10	lf	0.34	3.40	0.48	4.80	8.20
R. Stringer 2x10	13	lf	0.73	9.49	0.53	6.89	16.38
V. Stringer 2x10	9	lf	0.73	6.57	0.48	4.32	10.89
Other 2x6	32	lf	0.34	10.88	0.40	12.80	23.68
Other 2x10	15	lf	0.73	10.95	0.40	6.00	16.95
2x4 Sft. Framing	0	lf	0.23	0.00	0.36	0.00	0.00
2x6 Fascia	0	lf	0.34	0.00	1.36	0.00	0.00
Simp. L-70	12	ea	0.75	9.00		0.00	9.00
Simp. ST 12	22	ea	0.55	12.10		0.00	12.10
1/2" Gyp.Bd.	108.5	sf	0.10	10.85	0.34	36.89	47.74
Roofing	59	sf	0.29	17.11	0.39	23.01	40.12
Felt	59	sf	0.05	2.95	0.08	4.72	7.67
Gutters/D.S.	0	lf	0.60	0.00	1.12	0.00	0.00
Sealant	1	ea	3.54	3.54		0.00	3.54
Staples/Screws	136	ea	0.01	1.36		0.00	1.36
Screws/Fasteners	4	ea	0.66	2.64		0.00	2.64
Totals	10.60			464.44		161.03	625.47



Concrete Slab on Grade

Concrete Slab

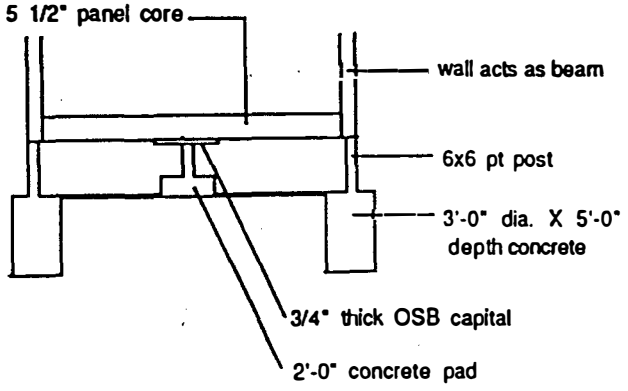
Component	Qty.	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
Concrete Slab	10.8	cy	65.00	702.00	25.00	270.00	972.00
Wire Mesh	6.48	csf	7.60	49.25	10.65	69.01	118.26
2x6 P.T. Mudsill	108	lf.	0.76	82.08	0.41	44.28	126.36
6 Mil. V.B.	684	sf.	0.07	47.88	0.04	27.36	75.24
Na./Sc./Gl./Ca.				20.00		0.00	20.00
Anchor Bolts	18	ea.	0.60	10.80	2.03	36.54	47.34
#4 Rebar	216	lf.	0.12	25.92	0.10	21.60	47.52
P.V.C. Pipe	110	lf.	1.47	161.70	1.35	148.50	310.20
Excav.	14.67	cy		0.00		220.00	220.00
Grading				0.00		100.00	100.00
Formwork	110	sf ca.	0.68	74.80	1.51	166.10	240.90
TOTALS				1174.43		1103.39	2277.82



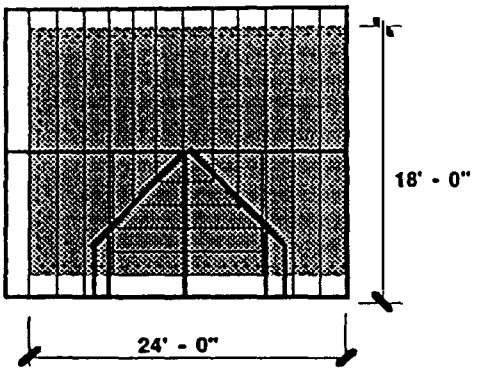
Dollars per sf = 4.94

R-Control Floor/Foundation System

Component	Qty.	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
R-Control Panel	432	sf	2.90	1252.80	0.55	237.60	1490.40
Spline 2x6	54	lf	0.34	18.36	0.85	45.90	64.26
Rim Joist 2x6	66	lf	0.34	22.44	0.29	19.14	41.58
6x6 Posts	46		1.20	55.20	1.46	67.16	122.36
Concrete	3	cy	51.64	154.92	19.35	58.05	212.97
Po./Bm. Connector	28	ea	1.50	42.00	2.50	70.00	112.00
36" Dia. Holes	6	ea	10.00	60.00		0.00	60.00
Staples/Sealant			30.00	30.00	0.00	0.00	30.00
Grading			0.00			100.00	100.00
							0.00
							0.00
TOTALS				1635.72		497.85	2133.57



CONVENTIONAL ROOF FRAMING SYSTEM - 1 1/2 STORY



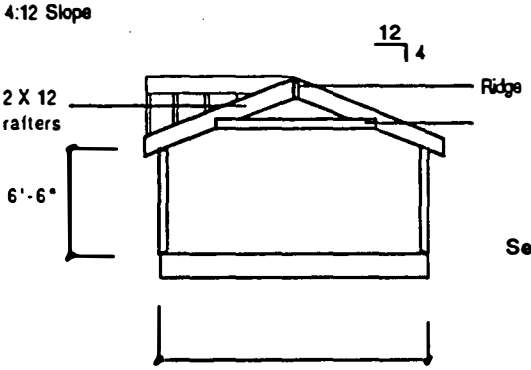
4:12 Slope

Dollars per sf = $ 6.51

Conventional Roof System R-38

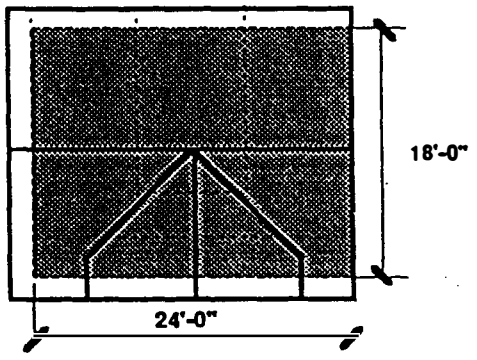
Component	Qty.	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
2x12 Ridge (Dbl.)	51	lf	0.85	43.35	0.90	45.90	89.25
2x10 Ridge	12	lf	0.72	8.64	0.80	9.60	18.24
2x12 Rafters	324	lf	0.85	275.40	0.45	145.80	421.20
2x12 V. Rafters	20	lf	0.85	17.00	0.72	14.40	31.40
2x6 Jack Rafters	40	lf	0.34	13.60	0.80	32.00	45.60
2x12 Blocking	42	lf	0.85	35.70	0.81	34.02	69.72
7/16" Sheathing	467	sf	0.27	123.76	0.23	107.41	231.17
2x6 Fascia	86	lf	0.34	29.24	1.36	116.96	146.20
R-38 Insulation	260	sf	0.71	184.60	0.14	36.40	221.00
6 Mil. V.B.	260	sf	0.07	18.20	0.04	10.40	28.60
1/2" Gyp. Bd.	260	sf	0.10	26.00	0.34	88.40	114.40
2x6 Celling Joists	230	lf	0.34	78.20	0.39	89.70	167.90
Roofing	583	sf	0.29	169.07	0.20	116.60	285.67
15# Felt	583	sf	0.05	29.15	0.05	29.15	58.30
Gutters/D.S.	80	lf	0.60	48.00	1.20	96.00	144.00
Vents	4	ea	15.00	60.00	20.00	80.00	140.00
Glue/Caulk	4			0.00	20.00	80.00	80.00
2x6 Dormer Wall	115	lf	0.34	39.10	0.40	46.00	85.10
2x6 Stub Wall	50	lf	0.34	17.00	0.48	24.00	41.00
2x8 Header	12	lf	0.47	5.64	0.94	0.94	6.58
R-21 Insulation	305	sf	0.38	115.90	0.15	45.75	161.65
Dormer Sheathing	133	sf.	0.27	35.91	0.35	46.55	82.46
Dormer Ins. R-19	110	sf	0.38	41.80	0.15	16.50	58.30
Flr. Ins. R-19	182.5		0.35	63.88	0.11	20.08	83.95
Totals				1479.13		1332.56	2811.69

4:12 Slope



Section Diagram

R-CONTROL ROOF SYSTEM

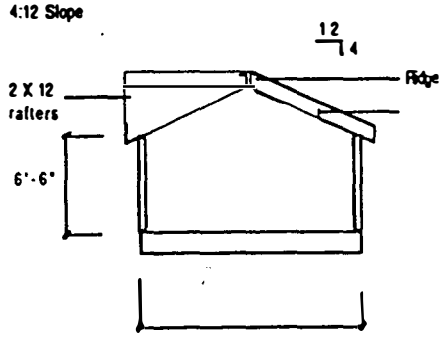


Dollars per sf = $ 9.63

R- Control Roof - 9 3/8" Core

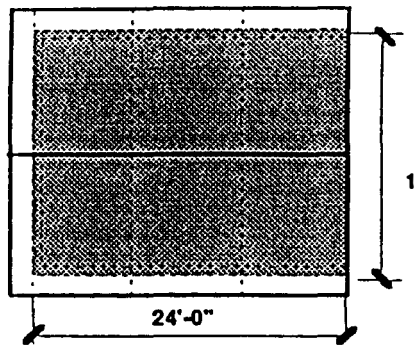
Component	Qty.	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
6@8x10	480	sf	3.30	1584.00	0.55	264.00	1848.00
2@4x14 Panel	112	sf	3.15	352.80	0.55	61.60	414.40
Stringer-2x10	96	lf	0.73	70.08	0.36	34.56	104.64
Ridge Stringer 2x1(	40	lf	0.73	29.20	0.53	21.20	50.40
V. Rafter Stringer	20	lf	0.73	14.60	0.48	9.60	24.20
7/16" Sheathing	77.5	sf	0.27	20.93	0.24	18.60	39.53
2x4 Sft. Framing	80	lf	0.23	18.40	0.36	28.80	47.20
3/4" CDX Soffit	96	sf	0.34	32.64	0.36	34.56	67.2
2x6 Fascia	73	lf	0.34	24.82	1.36	99.28	124.10
Simp. L-70	74	ea	0.75	55.50		0.00	55.50
Simp. ST 12	148	ea	0.55	81.40		0.00	81.40
1/2" Gyp.Bd.	400	sf	0.10	40.00	0.34	136.00	176.00
Roofing	583	sf	0.29	169.07	0.30	174.90	343.97
Felt	583	sf	0.05	29.15	0.05	29.15	58.30
Gutters/D.S.	75	lf	0.60	45.00	1.12	84.00	129.00
Sealant	3.25	ea	3.54	11.51		0.00	11.51
Staples				0.00		0.00	0.00
Screws/Fasteners	148	ea	1.00	148.00		0.00	148.00
Dormer Wall							
2@4x10 Panel	80	sf	2.65	212.00	0.55	44.00	256
1@4x14 Panel	56	sf	2.65	148.40	0.55	30.80	179.2
Totals		sf		3087.49		1071.05	4158.54

4:12 Slope



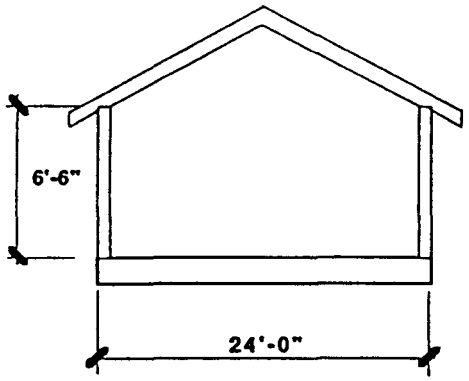
Section Diagram

R-CONTROL ROOF SYSTEM



4:12 Slope

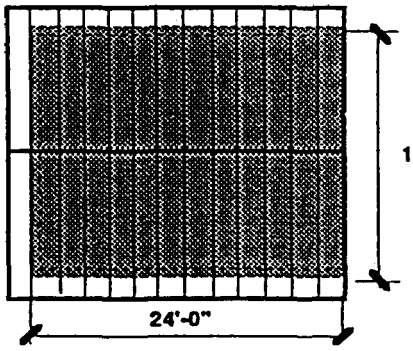
Dollars per sf = $7.40



R-Control Roof System-9 3/8" Core

Component	Qty.	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
6@8x10	480	sf	3.30	1584.00	0.55	264.00	1848
Stringer-2x10	120	lf	0.73	87.60	0.36	43.20	130.8
R. Stringer 2x10	26	lf	0.73	18.98	0.53	13.78	32.76
7/16" Sheathing	96	sf	0.27	25.92	0.24	23.04	48.96
3/4" CDX Soffit	96	sf	0.34	32.64	0.36	34.56	67.2
2x4 Sft. Framing	100	lf	0.23	23.00	0.36	36.00	59
2x6 Fascia	80	lf	0.34	27.20	1.36	108.80	136
Simp. L-70	43	ea	0.75	32.25		0.00	32.25
Simp. ST 12	96	ea	0.55	52.80		0.00	52.8
1/2" Gyp.Bd.	400	sf	0.10	40.00	0.34	136.00	176
Roofing	561	sf	0.29	162.69	0.30	168.30	330.99
Felt	561	sf	0.05	28.05	0.05	28.05	56.1
Gutters/D.S.	70	lf	0.60	42.00	1.12	78.40	120.4
Sealant	3.25	ea	3.54	11.51		0.00	11.505
Staples				0.00		0.00	0
Screws/Fasteners	96	ea	1.00	96.00		0.00	96
				0.00		0.00	0
				0.00		0.00	0
Totals				2264.64		934.13	3198.77

CONVENTIONAL ROOF W/TRUSSES

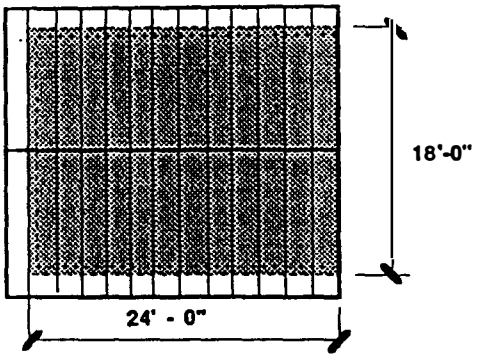


4:12 Slope

Dollars per sf = 5.18

Conventional Roof System / Trusses

Component	Qty.	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
Roof Trusses	13	ea	30.6	397.80	8.96	116.48	514.28
7/16" Sheathing	561	sf	0.27	148.67	0.23	129.03	277.70
2x6 Fascia	73	lf	0.34	24.82	1.36	99.28	124.10
R-38 Insulation	400	sf	0.71	284.00	0.14	56.00	340.00
6 Mil. V.B.	400	sf	0.07	28.00	0.04	16.00	44.00
1/2" Gyp. Bd.	400	sf	0.10	40.00	0.34	136.00	176.00
Roofing	561	sf	0.29	162.69	0.30	168.30	330.99
15# Felt	561	sf	0.05	28.05	0.05	28.05	56.10
Gutters/D.S.	70	lf	0.60	42.00	1.12	78.40	120.40
Vents	4	ea	15.00	60.00	20.00	80.00	140.00
Glue/Caulk				0.00	7.50	0.00	20.00
Nails/Screws					20.00		20.00
2x4 Blocking	48	lf	0.23	11.04	0.82	39.36	50.40
2x4 Ridge Blocking	22.5	lf	0.23	5.18	0.80	18.00	23.18
				0.00		0.00	0.00
Totals				1216.03		907.54	2237.14

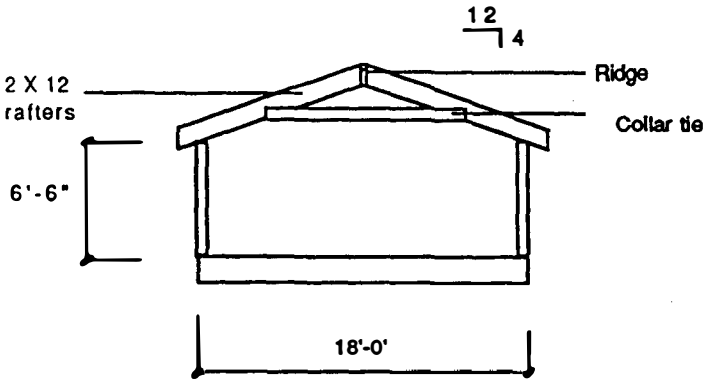


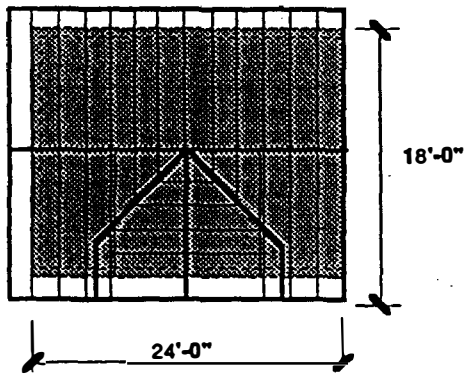
4:12 Slope

Dollars per sf = 5.60

Conventional Framed Roof/R-38

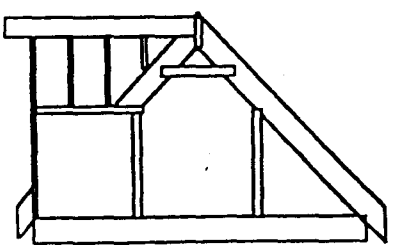
Component	Qty.	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
2x12 Ridge (Dbl.)	51	lf	0.85	43.35	1.17	59.67	103.02
2x12 Rafters	312	lf	0.85	265.20	0.46	143.52	408.72
2x12 Blocking	42	lf	0.85	35.70	0.81	34.02	69.72
7/16" Sheathing	561	sf	0.27	148.67	0.30	168.30	316.97
2x6 Fascia	73	lf	0.34	24.82	1.36	99.28	124.10
R-38 Insulation	400	sf	0.71	284.00	0.14	56.00	340.00
6 Mil. V.B.	400	sf	0.07	28.00	0.04	16.00	44.00
1/2" Gyp. Bd.	400	sf	0.10	40.00	0.34	136.00	176.00
2x6 Ceiling Joists	216	lf	0.34	73.44	0.39	84.24	157.68
Roofing	561	sf	0.29	162.69	0.30	168.30	330.99
15# Felt	561	sf	0.05	28.05	0.05	28.05	56.10
Gutters/D.S.	73	lf	0.60	43.80	1.20	87.60	131.40
Vents	4	ea	15.00	60.00	20.00	80.00	140.00
Glue/Caulk	4				20.00	80.00	20.00
				0.00		0.00	0.00
				0.00		0.00	0.00
				0.00		0.00	0.00
Totals				1237.72		1240.98	2418.7





9:12 Slope

Dollars per sf = $ 7.05

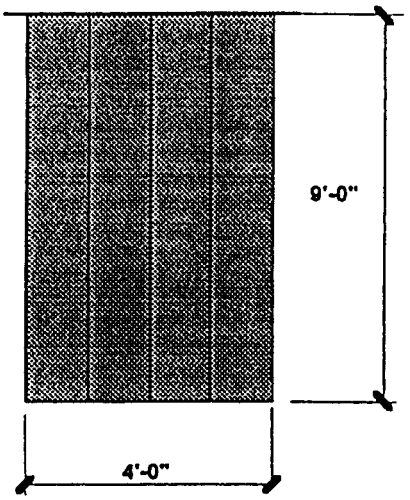


Section Diagram

Conventional Roof System R-38

Component	Qty.	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
2x12 Ridge (Dbl.)	51	lf	0.85	43.35	0.90	45.90	89.25
2x10 Ridge	12	lf	0.72	8.64	0.80	9.60	18.24
2x12 Rafters	382	lf	0.85	324.70	0.45	171.90	496.60
2x12 V. Rafters	22	lf	0.85	18.70	0.72	15.84	34.54
2x6 Jack Rafters	46	lf	0.34	15.64	0.80	36.80	52.44
2x12 Blocking	42	lf	0.85	35.70	0.81	34.02	69.72
7/16" Sheathing	557	sf	0.27	147.61	0.23	128.11	275.72
2x6 Fascia	86	lf	0.34	29.24	1.36	116.96	146.20
R-38 Insulation	300	sf	0.71	213.00	0.14	42.00	255.00
6 Mil. V.B.	300	sf	0.07	21.00	0.04	12.00	33.00
1/2" Gyp. Bd.	300	sf	0.10	30.00	0.34	102.00	132.00
2x6 Ceiling Joists	230	lf	0.34	78.20	0.39	89.70	167.90
Roofing	702	sf	0.29	203.58	0.20	140.40	343.98
15# Felt	706	sf	0.05	35.30	0.05	35.30	70.60
Gutters/D.S.	84	lf	0.60	50.40	1.20	100.80	151.20
Vents	4	ea	15.00	60.00	20.00	80.00	140.00
Glue/Caulk	4			0.00	20.00	80.00	80.00
2x6 Dormer Wall	107	lf	0.34	36.38	0.40	42.80	79.18
2x6 Stub Wall	42	lf	0.34	14.28	0.48	20.16	34.44
2x8 Header	4	lf	0.47	1.88	0.94	0.94	2.82
R-21 Insulation	265	sf	0.38	100.70	0.15	39.75	140.45
Dormer Sheathing	149	sf.	0.27	40.23	0.35	52.15	92.38
Dormer Ins. R-19	102	sf	0.38	38.76	0.15	15.30	54.06
Flr. Ins. R-19	182.5		0.35	63.88	0.11	20.08	83.95
Totals				1611.16		1432.51	3043.66

Conventional Roof Framing System w/No Dormer

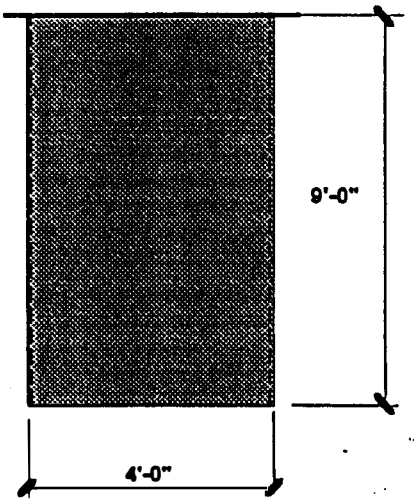


Plan View

Conventional Roof System R-38

Component	Qty.	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
Conventional Roof Framing							
2x12 Ridge beam	4	lf	0.85	3.40	0.90	3.60	7.00
2x12 Rafters	39	lf	0.85	33.15	0.40	15.60	48.75
7/16" Sheathing	52	sf	0.27	14.04	0.23	11.96	26.00
2x6 Fascia	4	lf	0.34	1.36	1.36	5.44	6.80
R-38 Insulation	45	sf	0.71	31.95	0.14	6.30	38.25
6 Mil V.B.	52	sf	0.07	3.64	0.04	2.08	5.72
1/2" Gyp. Board	45	sf	0.10	4.50	0.34	15.30	19.80
Roofing	52	sf	0.29	15.08	0.39	20.28	35.36
15# Felt	52	sf	0.05	2.60	0.08	4.16	6.76
Glue Caulk	1	ea	10.00	10.00	0.00	0.00	10.00
Gutters/Downspou	4	lf	0.60	2.40	1.12	4.48	6.88
Soffit	4	lf	0.34	1.36	0.36	1.44	2.80
Total	4.12			123.48		90.64	214.12

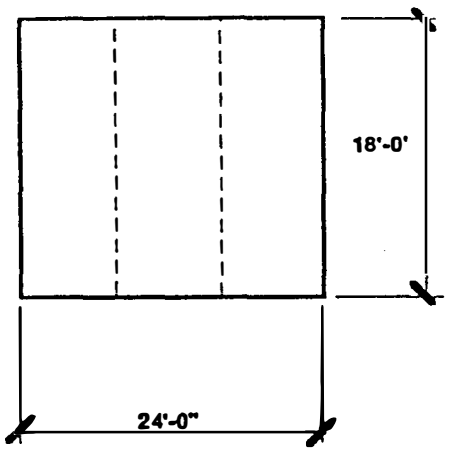
R-Control System 1 1/2 Story w/ No Dormer



Plan View

R-Control Roof Framing

Component	Qty.	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
4x12-9 3/8" Panel	48	sf	3.30	158.40	0.55	26.40	184.80
2x12 Ridge beam	4	lf	0.85	3.40	0.90	3.60	7.00
2x10x14' Stringer	28	lf	0.73	20.44	0.36	10.08	30.52
Add'l 2x10	5.5	lf	0.73	4.02	0.36	1.98	6.00
7/16" Sheathing	6	sf	0.27	1.62	0.23	1.38	3.00
2x6 Fascia	4	lf	0.34	1.36	1.36	5.44	6.80
6 Mil V.B.	52	sf	0.07	3.64	0.04	2.08	5.72
1/2" Gyp. Board	45	sf	0.10	4.50	0.34	15.30	19.80
Roofing	52	sf	0.29	15.08	0.39	20.28	35.36
15# Felt	52	sf	0.05	2.60	0.08	4.16	6.76
Glue Caulk	1	ea	3.54	3.54	0.00	0.00	3.54
Gutters/Downspou	4	lf	0.60	2.40	1.12	4.48	6.88
Soffit	4	lf	0.34	1.36	0.36	1.44	2.80
Total	6.13			222.36		96.62	318.98



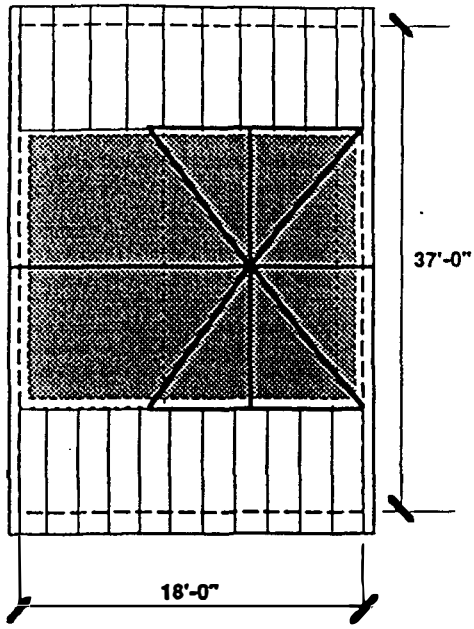
R-Control Panels on Grade

R-Control Floor/Foundation System-3 5/8" Core

Component	Qty.	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
R-Control Panel	648	sf	2.00	1296.00	0.55	356.40	1652.40
6 Mil. V.B.	648	lf	0.07	45.36	0.04	25.92	71.28
Staples/Sealant			30.00	0.00	0.00	0.00	30.00
Grading			0.00	0.00		0.00	100.00
Excavation	9.2			0.00		0.00	125.00
P.T. 2x10	110		1.10	121.00		0.00	121.00
P.T. 2x4	220		0.30	66.00		0.00	66.00
P.T. 3/4" Ply. Wd.	5		34.99	174.95		0.00	174.95
6" P.V.C. Drain	110		1.47	161.70	1.35	148.50	310.20
TOTALS				1865.01		530.82	2650.83

R-Control Panel Floor

R-CONTROL ROOF SYSTEM *



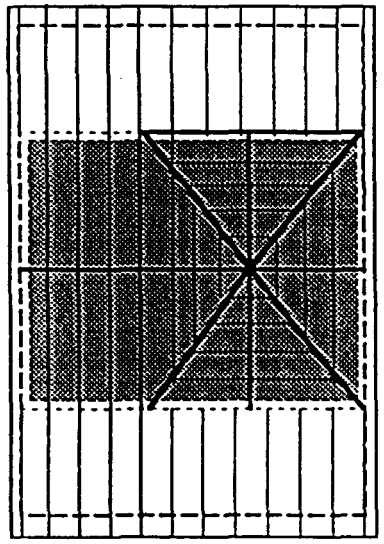
Dollars per sf = $ 8.32

R- Control Roof - 9 3/8" Core

Component	Qty.	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
5@8x12	480	sf	3.30	1584.00	0.55	264.00	1848.00
1@4x12	48	sf	3.05	146.40	0.55	26.40	172.80
Stringer-2x10	44	lf	0.73	32.12	0.36	15.84	47.96
Ridge Stringer 2x1(	42	lf	0.73	30.66	0.53	22.26	52.92
V. Rafter Stringer	52	lf	0.73	37.96	0.48	24.96	62.92
7/16" Sheathing	446	sf	0.27	120.42	0.24	107.04	227.46
2x6 Rafters	216		0.34	73.44	0.45	97.20	170.64
2x6 Fascia	161	lf	0.34	54.74	1.36	218.96	273.70
Simp. L-70	74	ea	0.75	55.50		0.00	55.50
Simp. ST 12	148	ea	0.55	81.40		0.00	81.40
1/2" Gyp.Bd.	562	sf	0.10	56.20	0.34	191.08	247.28
Roofing	972	sf	0.29	281.88	0.30	291.60	573.48
Felt	972	sf	0.05	48.60	0.05	48.60	97.20
Gutters/D.S.	156	lf	0.60	93.60	1.12	174.72	268.32
Sealant	3.25	ea	3.54	11.51		0.00	11.51
Staples				0.00		0.00	0.00
Screws/Fasteners	148	ea	1.00	148.00		0.00	148.00
Dormer Wall							
2@4x10 Panel	80	sf	2.65	212.00	0.55	44.00	256
2@4x18 Panel	144	sf	2.65	381.60	0.55	79.20	460.8
Flr. Ins. (R-38)	288	sf	0.71	204.48	0.11	31.68	236.16
2x4 Plate	68	lf	0.23	15.64		0.00	15.64
2x8Header	8	lf	0.47	3.76	0.94	7.52	11.28
Vents	4	ea	15.00	60.00	20.00	80.00	140.00
6 Mil V.B.	288	sf	0.07	20.16	0.04	11.52	31.68
2x4 Rafter Tails	90	lf	0.23	20.70	0.33	29.70	50.40
Totals		sf		3774.77		1766.28	5541.05

* Combination R-Control roof and conventional "stick" framing.

CONVENTIONAL ROOF FRAMING SYSTEM



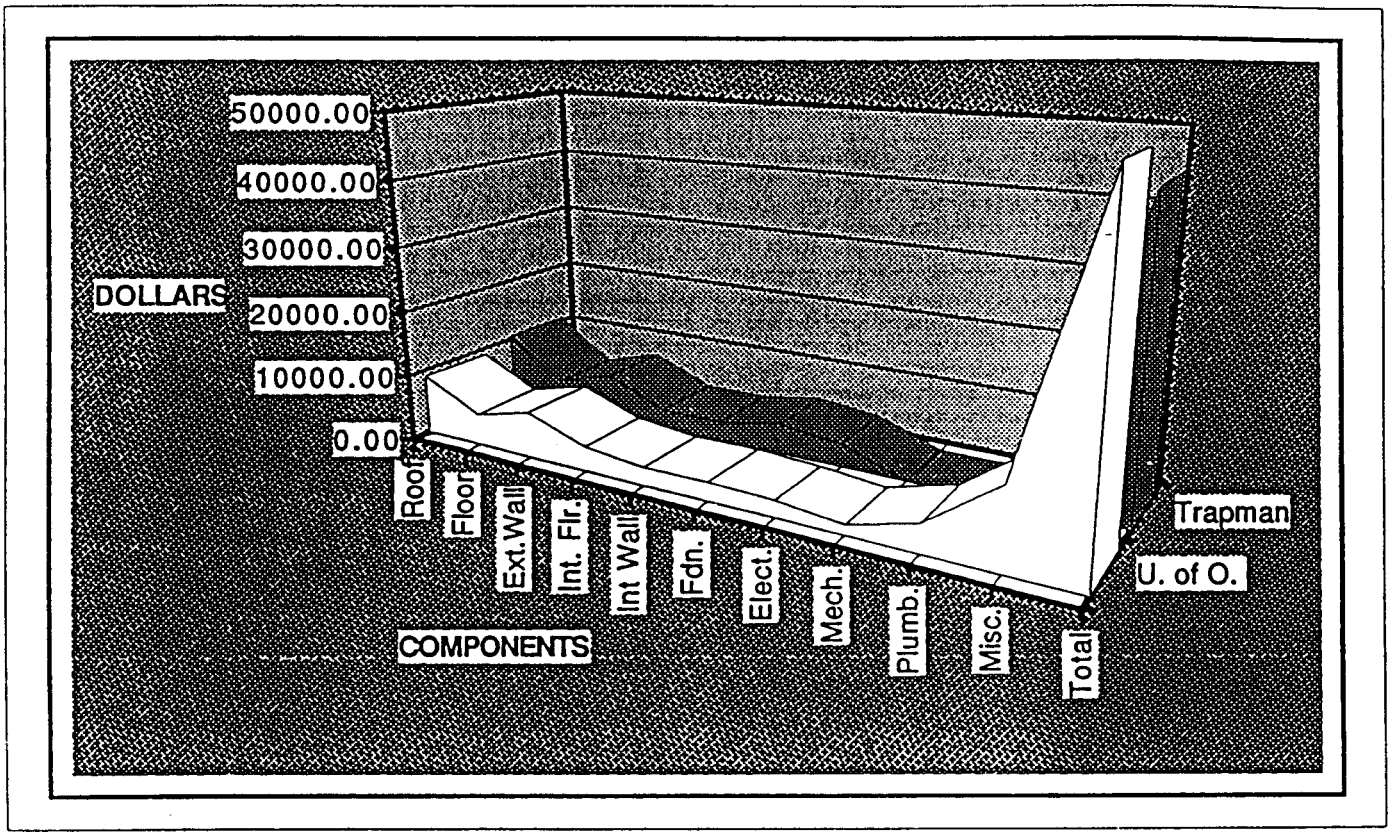
Dollars per sf $ 6.38

Conventional Roof System R-38

Component	Qty.	Unit	Mat. Unit	Mat. Tot.	Unit Lab.	Lab. Tot.	Total $
2x12 Ridge (Dbl.)	42	lf	0.85	35.70	0.90	37.80	73.50
2x10 Ridge	21	lf	0.72	15.12	0.80	16.80	31.92
2x12 Rafters	250	lf	0.85	212.50	0.45	112.50	325.00
2x12 V. Rafters	52	lf	0.85	44.20	0.72	37.44	81.64
2x12 Blocking	42	lf	0.85	35.70	0.81	34.02	69.72
7/16" Sheathing	693	sf	0.27	183.65	0.23	159.39	343.04
2x6 Fascia	161	lf	0.34	54.74	1.36	218.96	273.70
R-38 Ins.(Roof)	526	sf	0.71	373.46	0.14	73.64	447.10
6 Mil. V.B.	814	sf	0.07	56.98	0.04	32.56	89.54
1/2" Gyp. Bd.	526	sf	0.10	52.60	0.34	178.84	231.44
Roofing	972	sf	0.29	281.88	0.20	194.40	476.28
15# Felt	972	sf	0.05	48.60	0.05	48.60	97.20
Gutters/D.S.	156	lf	0.60	93.60	1.20	187.20	280.80
Vents	10	ea	15.00	150.00	20.00	200.00	350.00
Glue/Caulk	6			.0.00	20.00	120.00	120.00
2x6 Dormer Wall	73	lf	0.34	24.82	0.40	29.20	54.02
2x8 Header	8	lf	0.47	3.76	0.94	0.94	4.70
R-21 Insulation	216	sf	0.38	82.08	0.15	32.40	114.48
Int. Wall 2x6	194	lf	0.34	65.96	0.48	93.12	159.08
Dormer Sheathing	297	sf.	0.27	80.19	0.35	103.95	184.14
Flr. Ins. R-38	288	sf	0.71	204.48	0.11	31.68	236.16
2x6 Rafters	216	lf	0.34	73.44	0.45	97.20	170.64
2x6 Blocking	32	lf	0.34	10.88	0.81	25.92	36.80
				0.00		0.00	0.00
Totals				2100.02		1943.44	4250.9

10.8 Graphical Analysis

Graphical Analysis of Proposed Building Design

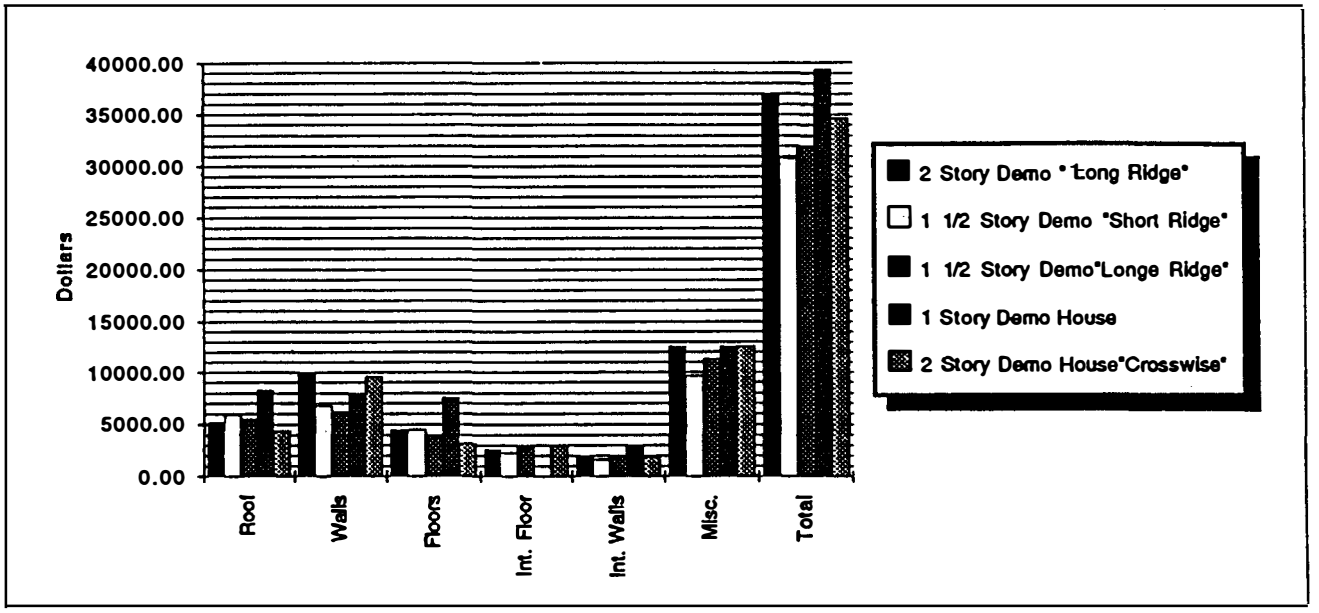


* House "Type" Cost Comparison
* Materials and Labor Analysis
* Panel Dollar to Span Ratio
* R- Value / Core Thickness

Energy Efficient Industrlized Housing
Center for Housing Innovation
University of Oregon

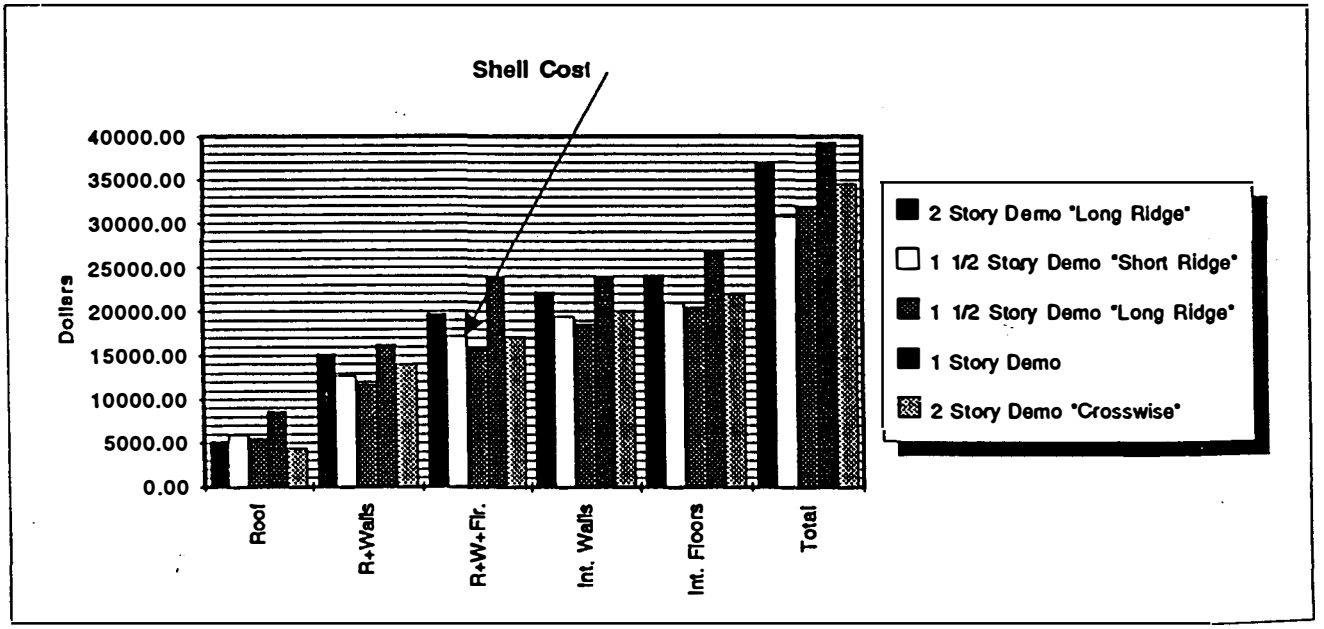
Ref./Demo Cost Comparison

	Roof	Walls	Floors	Int. Floor	Int. Walls	Misc.	Total	$ Difference
2 Story Demo " Long Ridge"	5237.49	9968.94	4487.33	2597.71	1906.52	12603.02	36801.01	5791.20
	4272.06	*6579.52*	*3018.78*	*2629.91*	*1906.52*	*12603.02*	*31009.81*	
1 1/2 Story Demo "Short Ridge"	5926.35	6783.76	4465.73	2285.12	1640.35	9713.68	30814.99	4393.95
	4272.06	*4954.90*	*3252.90*	*2586.48*	*1641.02*	*9713.68*	*26421.04*	
1 1/2 Story Demo"Long Ridge"	5540.79	6226.64	4011.34	2848.02	1925.74	11339.18	31891.71	3682.27
	4694.98	*4235.42*	*3219.29*	*2881.41*	*1839.16*	*11339.18*	*28209.44*	
1 Story Demo House	8332.84	7574.00	8010.27	0.00	2871.71	12603.02	39391.84	8614.56
	5616.52	*4469.78*	*5216.25*	*0.00*	*2871.71*	*12603.02*	*30777.28*	
2 Story Demo House"Crosswise"	4401.66	9624.21	3166.57	2922.03	1906.52	12603.02	*34624.01*	4860.36
	3449.54	*5785.03*	*2347.31*	*3718.41*	*1906.52*	*12556.84*	*29763.65*	

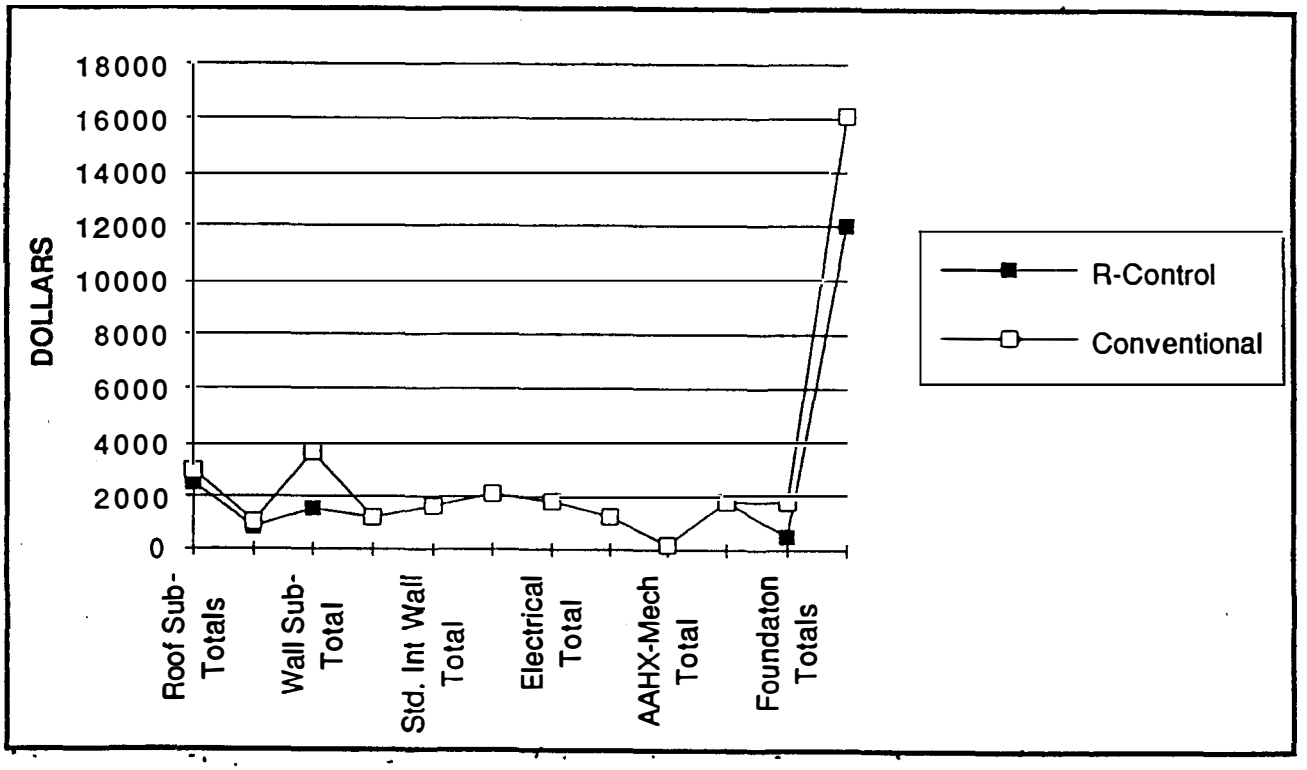


Cumulative Totals

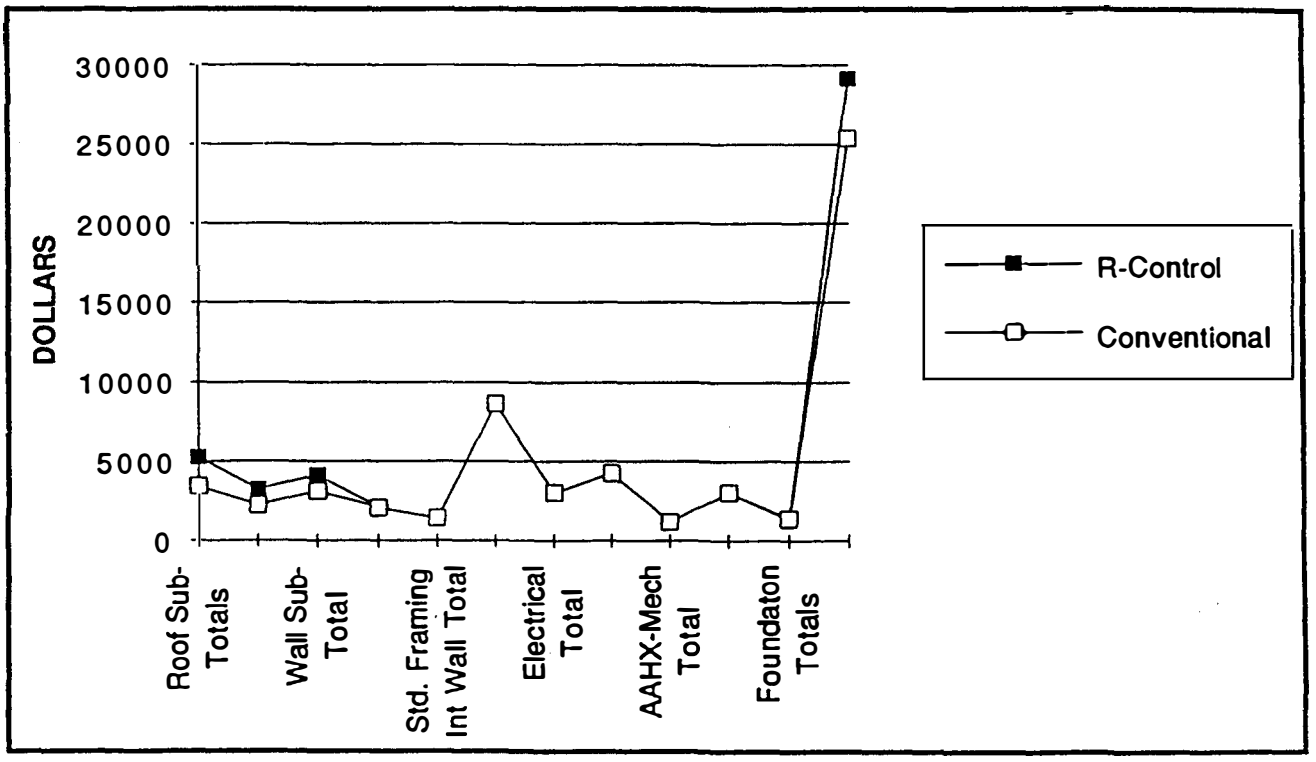
	Roof	R+Walls	R+W+Flr.	Int. Walls	Int. Floors	Total
2 Story Demo "Long Ridge"	5237.49	15206.43	19693.76	22291.47	24197.99	36801.01
1 1/2 Story Demo "Short Ridge"	5926.35	12710.11	17175.84	19460.96	21101.31	30814.99
1 1/2 Story Demo "Long Ridge"	5540.79	11767.43	15778.77	18626.79	20552.53	31891.71
1 Story Demo	8714.68	16343.11	23917.11	23917.11	26788.82	39391.84
2 Story Demo "Crosswise"	4401.66	14025.87	17192.44	20114.47	22020.99	34624.01



Reference House vs. Demonstration House : Labor Analysis



Reference House vs. Demonstration House : Materials Analysis



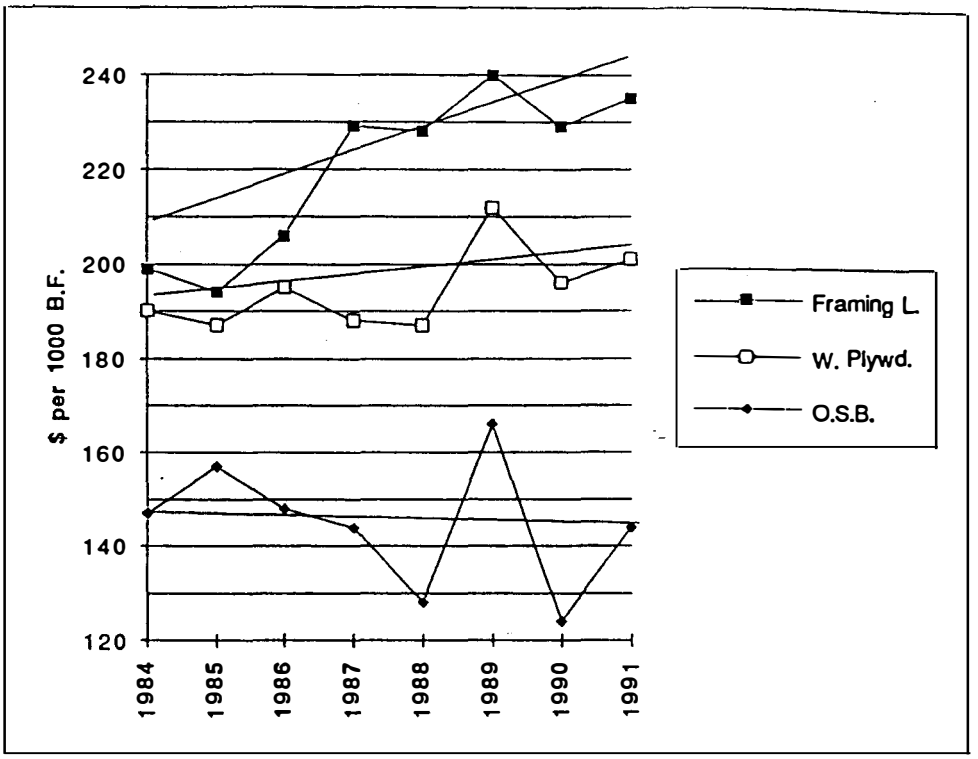
OSB/Waferboard
7/16", 24/16
Prices Net f.o.b. Mill, Northeast

Year	$/1000 BF
1984	147
1985	157
1986	148
1987	144
1988	128
1989	166
1990	124
1991	144

Western Plywood
1/2", CD Exterior (3-ply)
Prices Net f.o.b. Mill

Year	$/1000 BF
1981	184
1982	167
1983	192
1984	190
1985	187
1986	195
1987	188
1988	187
1989	212
1990	196
1991	201

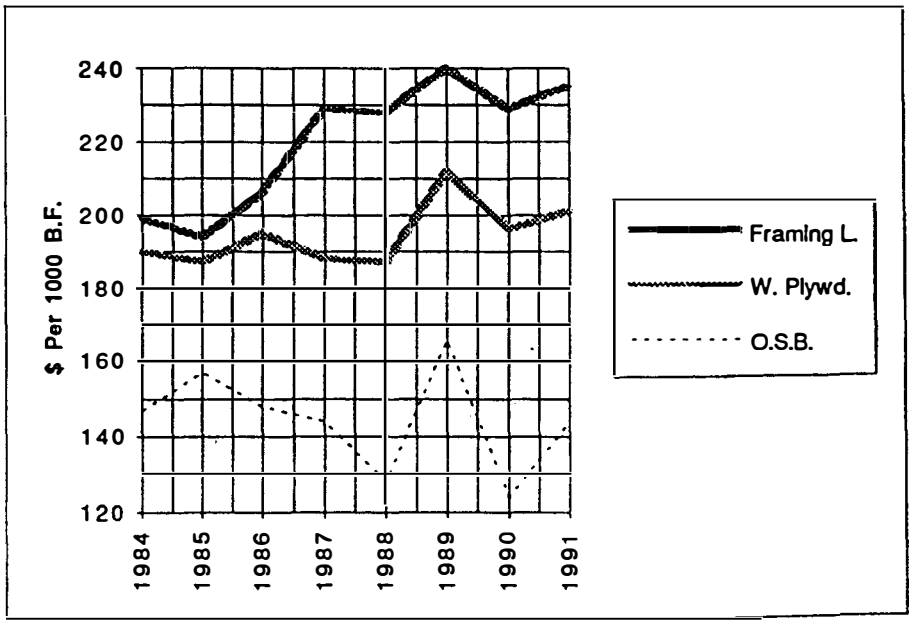
Plywood / OSB Cost Trends



Source: Random Lengths

Wood Framing Cost Trends

Year	Framing L.	W. Plywd.	O.S.B.
1984	199	190	147
1985	194	187	157
1986	206	195	148
1987	229	188	144
1988	228	187	128
1989	240	212	166
1990	229	196	124
1991	235	201	144



10.9 Structural Test Data

ICBO Evaluation Service, Inc.
A subsidiary corporation of the International Conference of Building Officials

EVALUATION REPORT

Report No. PFC-4645
July, 1991

Filing Category: ROOF, WALL AND FLOOR PANELS—Sandwich Panels (216)

THERMASAVE BUILDING PANELS
HSN
POST OFFICE BOX 340
PUYALLUP, WASHINGTON 98371

THERMASAVE PACIFIC NORTHWEST, INC.
239 WEST STEWART AVENUE
PUYALLUP, WASHINGTON 98371

I. **Subject:** ThermaSave Building Panels.

II. **Description:** A. **General:** ThermaSave panels are factory-assembled sandwich panels consisting of oriented strandboard or plywood facings with expanded polystyrene (EPS) cores. The panels are used as load-bearing wall, roof and floor components. Panels are produced in lengths up to 28 feet. Typical width is 4 feet, although greater or lesser widths can be produced. Core thicknesses range from $3^1/_2$ inches to $11^1/_4$ inches. Nominal core density is typically 1.0 pcf. Greater densities, up to 2.0 pcf, may be used when required by the design.

Panels facings range from $^7/_{16}$-inch to $^3/_4$-inch thick depending on design requirements. Panel facings are recognized in NER-108. The bond between the facings and the EPS core is made with a one-part urethane adhesive cured under pressure. A Type II, Class 2 adhesive recognized under ICBO ES Evaluation Report No. 3462 is used. The EPS core is recognized under ICBO ES Evaluation Report No. 4169. The in-service temperature of the foam core shall not be subjected to temperatures in excess of 180°F.

B. **Installation:** ThermaSave panels are connected to each other with factory cut splines of the same material as the facings. Prior to installation, splines may be coated with a bead of wood-to-wood construction adhesive. Facings are attached to the splines with No. 6, $1^1/_4$-inch-long, Type S or W drywall screws spaced 6 inches on center.

Top and bottom plates are dimensional lumber, sized to match the core thickness and secured to the panel facings with common nails spaced 6 inches on center. Nail size is 6d for facings $^1/_2$-inch thick and less and 8d for facing thicknesses through $^3/_4$ inch.

Typical installation details are in Figures Nos. 1, 2 and 3. Hold-down devices may be required for shear walls, depending on the actual loading conditions.

C. **Loading:** Allowable transverse, axial, combined transverse and axial loads, and racking shear loads are noted in Tables Nos. I, II, III and IV.

D. **Openings:** Where openings created in the panel configurations occur, headers consist of lumber headers and framing designed in accordance with the code.

E. **Thermal Barrier:** One-half-inch regular gypsum wallboard is fastened to the interior surface of the ThermaSave panels with $1^1/_4$ inch or longer No. 6 Type S or W gypsum wallboard screws in accordance with Table No. 47-G of the code, using 16-inches-on-center framing spacing guidelines.

F. **Panel Cladding:** 1. **Roof covering:** The roof covering must comply with Chapter 32 of the code except that hot-asphalt or hot-coal tar pitch is prohibited. Underlayment and flashings are installed in accordance with the code.

G. **Wall Covering:** Wall coverings may be any recognized in the code. Panels are considered weather-resistive barriers and do not require building paper except where cementitious plaster is used. See Section 4706 (d) of the code. All exterior panel joints must be sealed with a compatible acrylic latex caulk.

H. **1990 Accumulative Supplement to the U.B.C.:** This report is unaffected by the Supplement.

I. **Identification:** Each sandwich panel bears a stamp noting the product name, identification of the fabricator, evaluation report number, and the label of the inspection agency (PFS Corporation, NER-QA251).

III. **Evidence Submitted:** Data in accordance with the ICBO ES Acceptance Criteria for Sandwich Panels, dated April 1977.

Findings

IV. Findings: That the ThermaSave Building Panels described in this report comply with the 1988 Uniform Building Code, subject to the following conditions:

1. **The panels are fabricated and erected in accordance with this report and the manufacturer's instructions.**
2. **The panels and their attachments are subject to inspection by the building official prior to covering with an approved weather-resistive barrier.**
3. **Other portions of the structure are designed and constructed in accordance with the code or other applicable ICBO ES or NER reports.**
4. **Calculations for actual loading conditions and construction plans are submitted to the building official for approval.**
5. **Panels are limited to loads in Tables Nos. I through IV.**
6. **A $^1/_2$-inch-thick gypsum wallboard thermal barrier is applied to interior exposed panel facings.**
7. **The panels are only used in buildings of Type V-N construction and are nonfire-resistive.**
8. **The panels are fabricated at 239 West Stewart Avenue, Puyallup, Washington, with quality control inspections by PFS Corporation (NER-QA251).**
9. **Floor panels are limited to Group R Occupancies.**

This report is subject to re-examination in one year.

TABLE NO. I—ROOF, LL: L/240, DL: L/180[1,2]

FACING THICKNESS (inches)		CORE Thickness (inches)	CORE Density (pcf)	DESIGN LOADS FOR TRANSVERLY LOAOES SPANS[1,2] (psf)																	
				LL 8'	DL 8'	LL 10'	DL 10'	LL 12'	DL 12'	LL 14'	DL 14'	LL 16'	DL 16'	LL 18'	DL 18'	LL 20'	DL 20'	LL 22'	DL 22'	LL 24'	DL 24'
7/16	7/16	3.50	1.0	40.4	13.5	27.4	9.1														
7/16	5/8	3.50	1.0	42.3	14.1	28.9	9.6	20.5	6.8												
5/8	5/8	3.50	1.0	44.2	14.7	30.5	10.2	21.7	7.2												
7/16	3/4	3.50	1.0	44.5	14.8	31.2	10.4	22.4	7.5												
3/4	5/8	3.50	1.0	44.5	14.8	32.9	11.0	23.8	7.9												
3/4	3/4	3.50	1.0	44.5	14.8	35.5	11.8	26.1	8.7												
7/16	7/16	3.50	2.0	44.5	14.8	35.6	11.9	25.6	8.5												
7/16	5/8	3.50	2.0	44.5	14.8	35.6	11.9	27.5	9.2												
7/16	3/4	3.50	2.0	44.5	14.8	35.6	11.9	29.7	9.9	21.6	7.2										
5/8	5/8	3.50	2.0	44.5	14.8	35.6	11.9	29.5	9.8	20.5	6.8										
3/4	5/8	3.50	2.0	44.5	14.8	35.6	11.9	29.7	9.9	23.4	7.8										
3/4	3/4	3.50	2.0	44.5	14.8	35.6	11.9	29.7	9.9	25.4	8.5										
7/16	7/16	5.50	1.0	60.0	20.0	48.0	16.0	35.1	11.7	26.2	8.7	20.0	6.7								
7/16	5/8	5.50	1.0	60.0	20.0	48.0	16.0	36.6	12.2	27.5	9.2	21.0	7.0								
7/16	3/4	5.50	1.0	60.0	20.0	48.0	16.0	39.2	13.1	29.8	9.9	23.0	7.7								
5/8	5/8	5.50	1.0	60.0	20.0	48.0	16.0	38.1	12.7	28.8	9.6	22.1	7.4								
3/4	5/8	5.50	1.0	60.0	20.0	48.0	16.0	40.0	13.3	31.2	10.4	24.2	8.1								
3/4	3/4	5.50	1.0	60.0	20.0	48.0	16.0	40.0	13.3	33.9	11.3	26.7	8.9	21.3	7.1						
7/16	7/16	5.50	2.0	60.0	20.0	48.0	16.0	40.0	13.3	34.3	11.4	25.8	8.6								
7/16	5/8	5.50	2.0	60.0	20.0	48.0	16.0	40.0	13.3	34.3	11.4	27.4	9.1	20.6	6.9						
7/16	3/4	5.50	2.0	60.0	20.0	48.0	16.0	40.0	13.3	34.3	11.4	30.0	10.0	23.2	7.7						
5/8	5/8	5.50	2.0	60.0	20.0	48.0	16.0	40.0	13.3	34.3	11.4	29.1	9.7	21.9	7.3						
3/4	5/8	5.50	2.0	60.0	20.0	48.0	16.0	40.0	13.3	34.3	11.4	30.0	10.0	24.9	8.3						
3/4	3/4	5.50	2.0	60.0	20.0	48.0	16.0	40.0	13.3	34.3	11.4	30.0	10.0	26.7	8.9	22.3	7.4				
7/16	7/16	7.25	1.0	71.2	23.8	57.0	19.0	47.5	15.8	38.2	12.7	29.6	9.9	23.3	7.8						
7/16	5/8	7.25	1.0	71.2	23.8	57.0	19.0	47.5	15.8	39.6	13.2	30.8	10.3	24.4	8.1						
7/16	3/4	7.25	1.0	71.3	23.7	57.0	19.0	47.5	15.8	40.7	13.6	33.3	11.1	26.6	8.9	21.4	7.1				
5/8	5/8	7.25	1.0	71.2	23.8	57.0	19.0	47.5	15.8	40.7	13.6	32.1	10.7	25.5	8.5	20.5	6.8				
3/4	5/8	7.25	1.0	71.2	23.8	57.0	19.0	47.5	15.8	40.7	13.6	34.7	11.6	27.8	9.3	22.5	7.5				
3/4	3/4	7.25	1.0	71.2	23.8	57.0	19.0	47.5	15.8	40.7	13.6	35.6	11.9	30.5	10.2	24.9	8.3	20.6	6.9		
7/16	7/16	9.25	1.0	71.2	23.8	57.0	19.0	47.5	15.8	40.7	13.6	35.6	11.9	31.7	10.6	26.7	8.9	21.8	7.3		
7/16	5/8	9.25	1.0	71.2	23.8	57.0	19.0	47.5	15.8	40.7	13.6	35.6	11.9	31.7	10.6	27.8	9.3	22.8	7.6		
7/16	3/4	9.25	1.0	71.2	23.8	57.0	19.0	47.5	15.8	40.7	13.6	35.6	11.9	31.7	10.6	28.5	9.5	24.9	8.3	20.7	6.9
5/8	5/8	9.25	1.0	71.3	23.7	57.0	19.0	47.5	15.8	40.7	13.6	35.6	11.9	31.7	10.6	28.5	9.5	23.8	7.9		
3/4	5/8	9.25	1.0	71.3	23.7	57.0	19.0	47.5	15.8	40.7	13.6	35.6	11.9	31.7	10.6	28.5	9.5	25.9	8.6	21.8	7.3
3/4	3/4	9.25	1.0	71.2	23.8	57.0	19.0	47.5	15.8	40.7	13.6	35.6	11.9	31.7	10.6	28.5	9.5	25.9	8.6	23.8	7.9
7/16	7/16	11.25	1.0	87.7	29.2	70.1	23.4	58.4	19.5	50.1	16.7	43.8	14.6	39.0	13.0	35.1	11.7	29.3	9.8	24.3	8.1
7/16	5/8	11.25	1.0	87.7	29.2	70.1	23.4	58.4	19.5	50.1	16.7	43.8	14.6	39.0	13.0	35.1	11.7	30.4	10.1	25.3	8.4
7/16	3/4	11.25	1.0	87.7	29.2	70.1	23.4	58.4	19.5	50.1	16.7	43.8	14.6	39.0	13.0	35.1	11.7	31.9	10.6	27.7	9.2
5/8	5/8	11.25	1.0	87.7	29.2	70.1	23.4	58.4	19.5	50.1	16.7	43.8	14.6	39.0	13.0	35.1	11.7	31.6	10.5	26.4	8.8
3/4	5/8	11.25	1.0	87.7	29.2	70.1	23.4	58.4	19.5	50.1	16.7	43.8	14.6	39.0	13.0	35.1	11.7	31.9	10.6	28.9	9.6
3/4	3/4	11.25	1.0	87.7	29.2	70.1	23.4	58.4	19.5	50.1	16.7	43.8	14.6	39.0	13.0	35.1	11.7	31.9	10.6	29.2	9.7
7/16	7/16	11.25	2.0	87.7	29.2	70.1	23.4	58.4	19.5	50.1	16.7	43.8	14.6	39.0	13.0	35.1	11.7	31.9	10.6	29.2	9.7
7/16	5/8	11.25	2.0	87.7	29.2	70.1	23.4	58.4	19.5	50.1	16.7	43.8	14.6	39.0	13.0	35.1	11.7	31.9	10.6	29.2	9.7
7/16	3/4	11.25	2.0	87.7	29.2	70.1	23.4	58.4	19.5	50.1	16.7	43.8	14.6	39.0	13.0	35.1	11.7	31.9	10.6	29.2	9.7
5/8	5/8	11.25	2.0	87.7	29.2	70.1	23.4	58.4	19.5	50.1	16.7	43.8	14.6	39.0	13.0	35.1	11.7	31.9	10.6	29.2	9.7
3/4	5/8	11.25	2.0	87.7	29.2	70.1	23.4	58.4	19.5	50.1	16.7	43.8	14.6	39.0	13.0	35.1	11.7	31.9	10.6	29.2	9.7
3/4	3/4	11.25	2.0	87.7	29.2	70.1	23.4	58.4	19.5	50.1	16.7	43.8	14.6	39.0	13.0	35.1	11.7	31.9	10.6	29.2	9.7
7/16	7/16	7.25	2.0	103.1	34.4	82.5	27.5	68.8	22.9	53.8	17.9	39.8	13.3	30.2	10.2	23.3	7.8				
7/16	5/8	7.25	2.0	103.1	34.4	82.5	27.5	68.8	22.9	56.4	18.8	41.9	14.0	31.9	10.6	24.7	8.2				
7/16	3/4	7.25	2.0	103.1	34.4	82.5	27.5	68.8	22.9	58.9	19.6	46.5	15.5	35.6	11.9	27.7	9.2	22.0	7.3		
5/8	5/8	7.25	2.0	103.1	34.4	82.5	27.5	68.8	22.9	58.9	19.6	44.2	14.7	33.7	11.2	26.1	8.7	20.6	6.9		
3/4	5/8	7.25	2.0	103.1	34.4	82.5	27.5	68.8	22.9	58.9	19.6	49.1	16.4	37.7	12.6	29.5	9.8	23.4	7.8		
3/4	3/4	7.25	2.0	103.1	34.4	82.5	27.5	68.8	22.9	58.9	19.6	51.6	17.2	42.7	14.2	33.7	11.2	27.0	9.0	21.8	7.3
7/16	7/16	9.25	2.0	103.1	34.4	82.5	27.5	68.8	22.9	58.9	19.6	51.6	17.2	44.5	14.8	34.7	11.6	27.5	9.2	22.1	7.4
7/16	5/8	9.25	2.0	103.1	34.4	82.5	27.5	68.8	22.9	58.9	19.6	51.6	17.2	45.8	15.3	36.5	12.2	29.0	9.7	23.3	7.8
7/16	3/4	9.25	2.0	103.1	34.4	82.5	27.5	68.8	22.9	58.9	19.6	51.6	17.2	45.8	15.3	40.6	13.5	32.5	10.8	26.3	8.8
5/8	5/8	9.25	2.0	103.1	34.4	82.5	27.5	68.8	22.9	58.9	19.6	51.6	17.2	45.8	15.3	38.4	12.8	30.6	10.2	24.7	8.2
3/4	5/8	9.25	2.0	103.1	34.4	82.5	27.5	68.8	22.9	58.9	19.6	51.6	17.2	45.8	15.3	41.3	13.7	34.4	11.5	27.9	9.3
3/4	3/4	9.25	2.0	103.1	34.4	82.5	27.5	68.8	22.9	58.9	19.6	51.6	17.2	45.8	15.3	41.2	13.8	37.5	12.5	31.9	10.6

[1]Either facing thickness may be in compression or tension.

[2]Loads are for single spans.

TABLE NO. II—FLOOR, LL: L/360, DL: L/240[1,2,3,4]

FACING THICKNESS (inches)		CORE		DESIGN LOADS FOR TRANSVERSELY LOADED SPANS (psf)											
		Thickness (inches)	Density (pcf)	LL 8'	DL 8'	LL 10'	DL 10'	LL 12'	DL 12'	LL 14'	DL 14'	LL 16'	DL 16'	LL 18'	DL 18'
7/16	7/16	5.50	1.0	45.4	22.7										
7/16	5/8	5.50	1.0	46.8	23.4										
7/16	3/4	5.50	1.0	48.9	24.4										
5/8	5/8	5.50	1.0	48.3	24.1										
3/4	5/8	5.50	1.0	50.4	25.2										
3/4	3/4	5.50	1.0	52.6	26.3										
7/16	7/16	5.50	2.0	53.3	26.7	42.7	21.3								
7/16	7/16	7.25	1.0	62.2	31.1	44.9	22.4								
7/16	5/8	7.25	1.0	63.3	31.7	46.2	23.1								
5/8	5/8	7.25	1.0	63.3	31.7	47.5	23.7								
7/16	3/4	7.25	1.0	63.3	31.7	48.3	24.1								
3/4	5/8	7.25	1.0	63.3	31.7	49.7	24.8								
3/4	3/4	7.25	1.0	63.3	31.7	50.7	25.3	40.0	20.0						
7/16	7/16	9.25	1.0	63.3	31.7	50.7	25.3	42.2	21.1						
7/16	7/16	11.25	1.0	77.9	39.0	62.3	31.2	51.9	26.0	44.5	22.3				
7/16	7/16	7.25	2.0	91.7	45.8	70.7	35.3	49.6	24.8						
7/16	5/8	7.25	2.0	91.7	45.8	73.3	36.7	51.8	25.9						
7/16	3/4	7.25	2.0	91.7	45.8	73.3	36.7	56.2	28.1	41.3	20.6				
5/8	5/8	7.25	2.0	91.7	45.8	73.3	36.7	54.1	27.0						
3/4	5/8	7.25	2.0	91.7	45.8	73.3	36.7	58.7	29.4	43.3	21.7				
3/4	3/4	7.25	2.0	91.7	45.8	73.3	36.7	61.1	30.6	48.0	24.0				
7/16	7/16	9.25	2.0	91.7	45.8	73.3	36.7	61.1	30.6	51.5	25.7				
7/16	5/8	9.25	2.0	91.7	45.8	73.3	36.7	61.1	30.6	52.4	26.2	40.4	20.2		
7/16	3/4	9.25	2.0	91.7	45.8	73.3	36.7	61.1	30.6	52.4	26.2	44.3	22.2		
5/8	5/8	9.25	2.0	91.7	45.8	73.3	36.7	61.1	30.6	52.4	26.2	42.3	21.1		
3/4	5/8	9.25	2.0	91.7	45.8	73.3	36.7	61.1	30.6	52.4	26.2	45.8	22.9		
3/4	3/4	9.25	2.0	91.7	45.8	73.3	36.7	61.1	30.6	52.4	26.2	45.8	22.9	40.4	20.2

[1]Either face may be in compression or tension.

[2]Loads are for single spans.

[3]The tabulated loadings also apply to panels under the following conditions:

a) Facing thickness increased; core density as tabulated or greater.

b) Core density increased; facing thickness as tabulated or greater.

c) Core density and facing thickness increased.

[4]The floor panels are limited to use in Group R Occupancies.

TABLE NO. III—W = 25 PSF WIND LOAD

FACING THICKNESS (Inches)		CORE		WALL DESIGN LOADS PER FOOT OF PANEL WIDTH BASED ON TRANSVERSE/AXIAL LOADING[1] (plf)								
		Thickness (Inches)	Density (pcf)	Load 8'	Load 10'	Load 12'	Load 14'	Load 16'	Load 18'	Load 20'	Load 22'	Load 24'
7/16	7/16	3.50	1.0	2000	737							
7/16	7/16	3.50	2.0	2000	2000	205						
7/16	7/16	5.50	1.0	2000	2000	2000	529					
7/16	7/16	5.50	2.0	2000	2000	2000	2000	386				
7/16	7/16	7.25	1.0	2000	2000	2000	2000	2000				
7/16	7/16	7.25	2.0	2000	2000	2000	2000	2000	2000			
7/16	7/16	9.25	1.0	2000	2000	2000	2000	2000	2000	1051		
7/16	7/16	9.25	2.0	2000	2000	2000	2000	2000	2000	2000	1684	
7/16	7/16	11.25	1.0	2000	2000	2000	2000	2000	2000	2000	2000	
7/16	7/16	11.25	2.0	2000	2000	2000	2000	2000	2000	2000	2000	2000
7/16	5/8	3.50	1.0	2000	2000							
7/16	5/8	3.50	2.0	2000	2000	900						
7/16	5/8	5.50	1.0	2000	2000	2000	1057					
7/16	5/8	5.50	2.0	2000	2000	2000	2000	1177				
7/16	5/8	7.25	1.0	2000	2000	2000	2000	2000				
7/16	5/8	7.25	2.0	2000	2000	2000	2000	2000	2000			
7/16	5/8	9.25	1.0	2000	2000	2000	2000	2000	2000	1725		
7/16	5/8	9.25	2.0	2000	2000	2000	2000	2000	2000	2000	2000	
7/16	5/8	11.25	1.0	2000	2000	2000	2000	2000	2000	2000	2000	244
7/16	5/8	11.25	2.0	2000	2000	2000	2000	2000	2000	2000	2000	2000
7/16	3/4	3.50	1.0	2000	2000							
7/16	3/4	3.50	2.0	2000	2000	2000						
7/16	3/4	5.50	1.0	2000	2000	2000	2000					
7/16	3/4	5.50	2.0	2000	2000	2000	2000	2000				
7/16	3/4	7.25	1.0	2000	2000	2000	2000	2000	2000			
7/16	3/4	7.25	2.0	2000	2000	2000	2000	2000	2000	1672		
7/16	3/4	9.25	1.0	2000	2000	2000	2000	2000	2000	2000		
7/16	3/4	9.25	2.0	2000	2000	2000	2000	2000	2000	2000	2000	935
7/16	3/4	11.25	1.0	2000	2000	2000	2000	2000	2000	2000	2000	1938
7/16	3/4	11.25	2.0	2000	2000	2000	2000	2000	2000	2000	2000	2000
5/8	5/8	3.50	1.0	2000	1659							
5/8	5/8	3.50	2.0	2000	2000	1642						
5/8	5/8	5.50	1.0	2000	2000	2000	1606					
5/8	5/8	5.50	2.0	2000	2000	2000	2000	2000				
5/8	5/8	7.25	1.0	2000	2000	2000	2000	2000	267			
5/8	5/8	7.25	2.0	2000	2000	2000	2000	2000	2000	690		
5/8	5/8	9.25	1.0	2000	2000	2000	2000	2000	2000	2000		
5/8	5/8	9.25	2.0	2000	2000	2000	2000	2000	2000	2000	2000	
5/8	5/8	11.25	1.0	2000	2000	2000	2000	2000	2000	2000	2000	1020
5/8	5/8	11.25	2.0	2000	2000	2000	2000	2000	2000	2000	2000	2000
3/4	5/8	3.50	1.0	2000	2000							
3/4	5/8	3.50	2.0	2000	2000	2000						
3/4	5/8	5.50	1.0	2000	2000	2000	2000					
3/4	5/8	5.50	2.0	2000	2000	2000	2000	3805				
3/4	5/8	7.25	1.0	2000	2000	2000	2000	2000	1535			
3/4	5/8	7.25	2.0	2000	2000	2000	2000	2000	2000	2000		
3/4	5/8	9.25	1.0	2000	2000	2000	2000	2000	2000	2000	730	
3/4	5/8	9.25	2.0	2000	2000	2000	2000	2000	2000	2000	2000	2000
3/4	5/8	11.25	1.0	2000	2000	2000	2000	2000	2000	2000	2000	2000
3/4	5/8	11.25	2.0	2000	2000	2000		2000	2000	2000	2000	2000
3/4	3/4	3.50	1.0	2000	2000	411						
3/4	3/4	3.50	2.0	2000	2000	2000	825					
3/4	3/4	5.50	1.0	2000	2000	2000	2000	813				
3/4	3/4	5.50	2.0	2000	2000	2000	2000	2000	1962			
3/4	3/4	7.25	1.0	2000	2000	2000	2000	2000	2000			
3/4	3/4	7.25	2.0	2000	2000	2000	2000	2000	2000	2000	1318	
3/4	3/4	9.25	1.0	2000	2000	2000	2000	2000	2000	2000	2000	
3/4	3/4	9.25	2.0	2000	2000	2000	2000	2000	2000	2000	2000	2000
3/4	3/4	11.25	1.0	2000	2000	2000	2000	2000	2000	2000	2000	2000
3/4	3/4	11.25	2.0	2000	2000	2000	2000	2000	2000	2000	2000	2000

[1]Either face may be in compression or tension.

TABLE NO. IV—SANDWICH PANEL SHEAR WALLS WITH FRAMING OF DOUGLAS FIR, LARCH OR SOUTHERN PINE[1,2]

MINIMUM FACE THICKNESS (Inches)	COMMON NAILS (Into Lumber Framing)		DRYWALL SCREWS (Into Splines)		SHEAR (plf) (Both Faces)
	Nail Size	Spacing (Inches)	Screw Size (Inches)	Spacing (Inches)	
7/16	8d	3	1 1/4 Type S or W	2 1/2	490[3]
	8d	6	1 1/4 Type S or W	4 1/2	260

[1]Panels with 7/16 inch and thicker faces fastened with 6d common nails at 6 inches o.c. and 1 1/4-inch Type S or W drywall screws at 6 inches o.c. are satisfactory alternate to the plywood bracing specified in U.B.C. Section 2517 (g) 3.

[2]Minimum panel width is four feet. The maximum panel height-width ratio is 3 1/2:1. facings nailed at all edges.

[3]Two top plates are required.

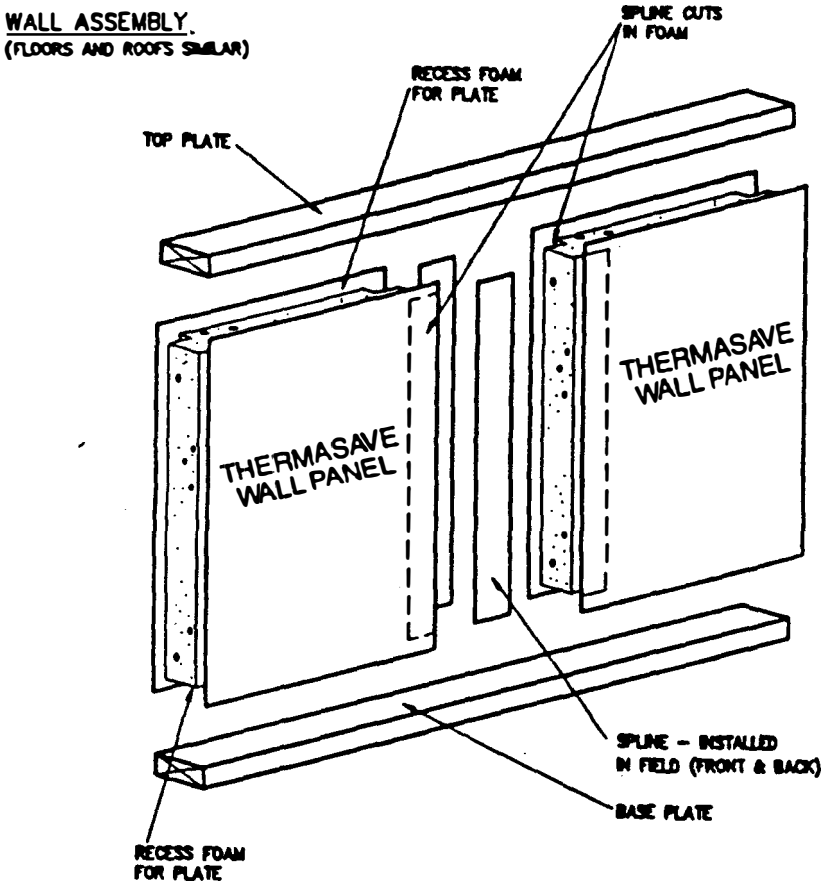
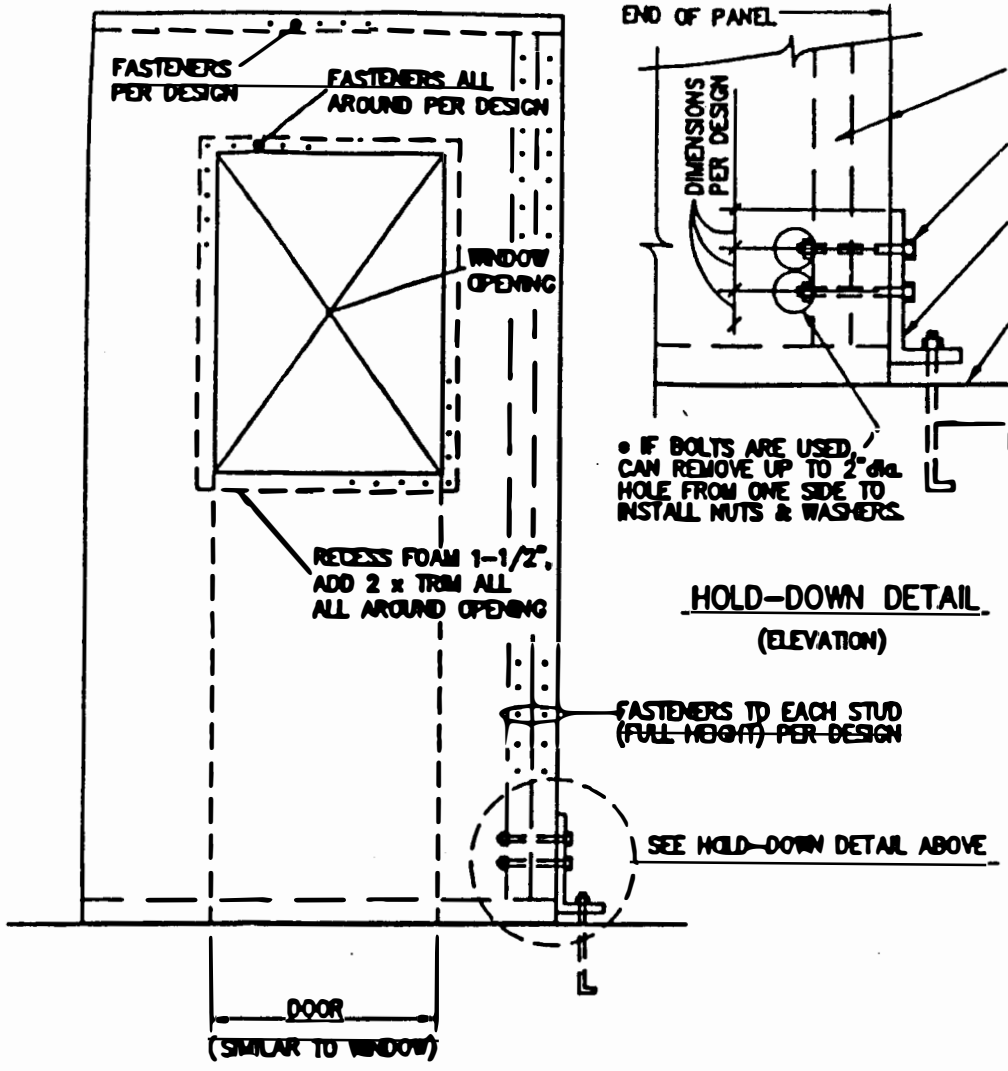


FIGURE NO. 1

ASSEMBLY DESCRIPTION: ADJACENT THERMASAVE PANELS ARE CONNECTED BY MEANS OF 4" WIDE SPLINES WHICH ARE INSERTED INTO NOTCHES IN THE FOAM CORE AND ATTACHED TO THE FACING MATERIAL EACH SIDE OF THE PANEL JOINT WITH SCREWS. WALL PANELS WILL HAVE SPLINES AT BOTH INTERIOR AND EXTERIOR FACES, WHEREAS FLOOR AND ROOF PANELS WILL NORMALLY HAVE SPLINES AT THE TOP FACE ONLY. DETAILS OF SPECIFIC CONDITIONS ARE SHOWN ON THE FOLLOWING PAGES.

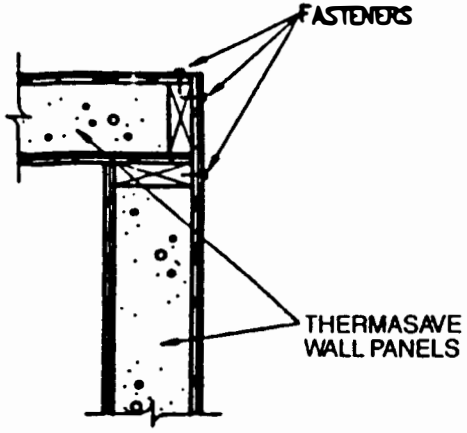


WINDOW/DOOR OPENINGS, HOLD-DOWNS

(PANEL ELEVATION)

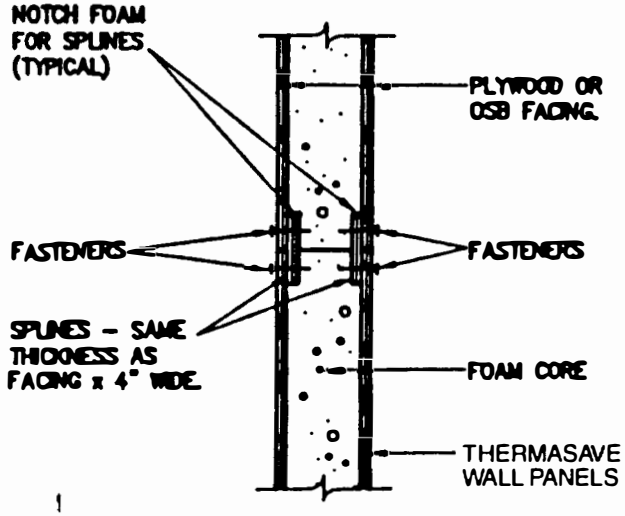
HOLD-DOWN DETAIL

(ELEVATION)



WALL PANEL CORNER

(PLAN VIEW)



WALL PANEL JOINT

(PLAN VIEW)

NOTE: SPECIAL FASTENERS OR ADDED MEMBERS AT WINDOWS OR DOOR HEADS MAY BE REQUIRED. SPECIFICS TO BE DETERMINED BY DESIGN.

FIGURE NO. 2