STRESSED SKIN INSULATING CORE PANEL DEMONSTRATION HOUSE PHASE III — DESIGN DEVELOPMENT AND CONSTRUCTION

ENERGY EFFICIENT INDUSTRIALIZED HOUSING RESEARCH PROGRAM

CENTER FOR HOUSING INNOVATION
UNIVERSITY OF OREGON

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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.
Elk Corporation
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Forbo Industries, Inc.
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Jerry's Home Improvement Center
Lane Community College
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Viscor, Inc.
Wasco Products, Inc.
Western Red Cedar Lumber Association
Weyerhaeuser Co.
Willamette Industries
Wirecon

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1.0 EXECUTIVE SUMMARY

The Stressed Skin Insulating Core Panel Demonstration House project seeks to show that a house built of Stressed Skin Insulated 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 7.0; details of the Bonneville Power Administration Super Good Cents Program are given in Appendix 8.1).

This report describes the completion of the design phase, and the entirety of the construction phase, of the Stressed Skin Insulating Core Panel Demonstration House project. Design work prior to May 1993 is described in another ESBL report, *SSIC Panel Demonstration House, Phase I — First Design; Phase II — Second Design*. Energy and structural tests of the completed house are described in subsequent reports.

As a result of this comparison, the "long ridge" design emerged as the most promising design. The work which forms the first focus of this report includes the design development, energy and cost analyses, preparation of construction documents and builder selection as preconstruction tasks needed to prepare this design for construction; the second focus is on the construction process itself. The simultaneous activities of design and analysis (of energy performance and comparative cost) guided the evolution of the house prior to its construction. Monitoring the construction process and costs likewise paralleled the work on the job site.

The prototype project designed and built in Springfield, Oregon in 1994 has from its initial tests met the energy goal, although complete confirmation will come after energy monitoring provides more data.

It is in this last area, that of locating problems and opportunities, that the prototype Demonstration House has most clearly succeeded. Many previously identified problems such as air sealing and joint detailing have been clarified and even quantified for their impact on house costs. New approaches such as the shiplap joint, perimeter wiring chase and integral-siding panel were utilized and their impacts documented, and opportunities for further development (alternate panel materials and simplified air sealing, for example) were identified.

Achievement of the second goal, of reduced cost, is described in a separate study, *Cost Analysis, – Stressed Skin Insulating Core Panel Demonstration House.* This study examines cost records for the project plus video records of the actual construction process to determine a fair and accurate assessment of the "average" house cost distilled from its prototype costs. This study will also identify problems and opportunities revealed in the Springfield project.

2.0 INTRODUCTION

The Stressed Skin Insulating Core Panel Demonstration House project seeks to show that a house built of Stressed Skin Insulated 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 9.0).

This report describes the completion of the design phase, and the entirety of the construction phase, of the SSIC Panel Demonstration House project. Design work prior to May 1993 is described in ESBL report: *SSIC Panel Demonstration House, Phase I — First Design; Phase II — Second Design.* Energy and structural tests of the completed house are described in subsequent reports.

2.1 SCOPE OF THIS REPORT

Throughout the project, simultaneous and overlapping tasks have influenced each other; consequently the "single track" chronology suggested by the organization of this report only approximates the history of the actual work. Section 3 describes the latter portion of the preconstruction work for the Demonstration House project: site and house design, as well as development of the testing program; specification of energy goals and details; determination of cost goals and related efforts; project documentation such as plans and contracts; and the builder selection process. Section 4 covers construction of the house including panel fabrication, site work, panel assembly on site, non-panel structural component assembly, doors and windows, utilities, sealing and insulation, roofing and finishes.

Section 5 describes the project team's conclusions from the work. Section 6 lists references, Section 7 lists bibliographic references for the report, Section 8 provides a glossary of project terms, and Section 9 includes the report appendices.

2.2 TESTING

While a description of the test instrumentation built into the Demonstration House is given in Section 3.1, the details and results of the structural and energy tests themselves will be given in *Stressed Skin Insulating Core Panel Demonstration House Thermal Testing Report*.

3.0 DESIGN DEVELOPMENT

By May of 1993 the Demonstration House had undergone two cycles of preliminary design and cost analysis of the Demonstration and Reference versions, resulting in selection of a 1-1/2 story, 1260 sf design as being the most cost-competitive type examined. Once this basic house design was confirmed as the final choice, work proceeded on site design, building design development (including foundation, panels, electrical, plumbing, HVAC, windows and doors, and finishes), the energy testing program and its equipment, refinement of the cost goals and their means of achievement, development of project documentation, and selection of the Demonstration House builder.

3.1 SITE DESIGN

The building site for the Demonstration House project was confirmed in June of 1992. The building lot was one of four adjacent sites owned by the St. Vincent dePaul Society (the project developer) on M Street in Springfield, Oregon. Lot 1562 was a south-facing, flat, poorly drained site in an existing residential neighborhood (Figure 3-1).

With the general building configuration and location of the project established, site planning began. The basic requirements for the specific site design were outlined, combining the requirements of the City, the project client/developer, and the ESBL design team. From the developer came requirements for budget limits, compatibility with other nearby projects and responsiveness to the needs of a prospective tenant family: garage, outside supervised play area, and potential garden space. From the project team came priorities of controllable solar access and effective microclimate management of summer and winter winds (using site design to help accomplish project energy objectives), and overall architectural design quality.

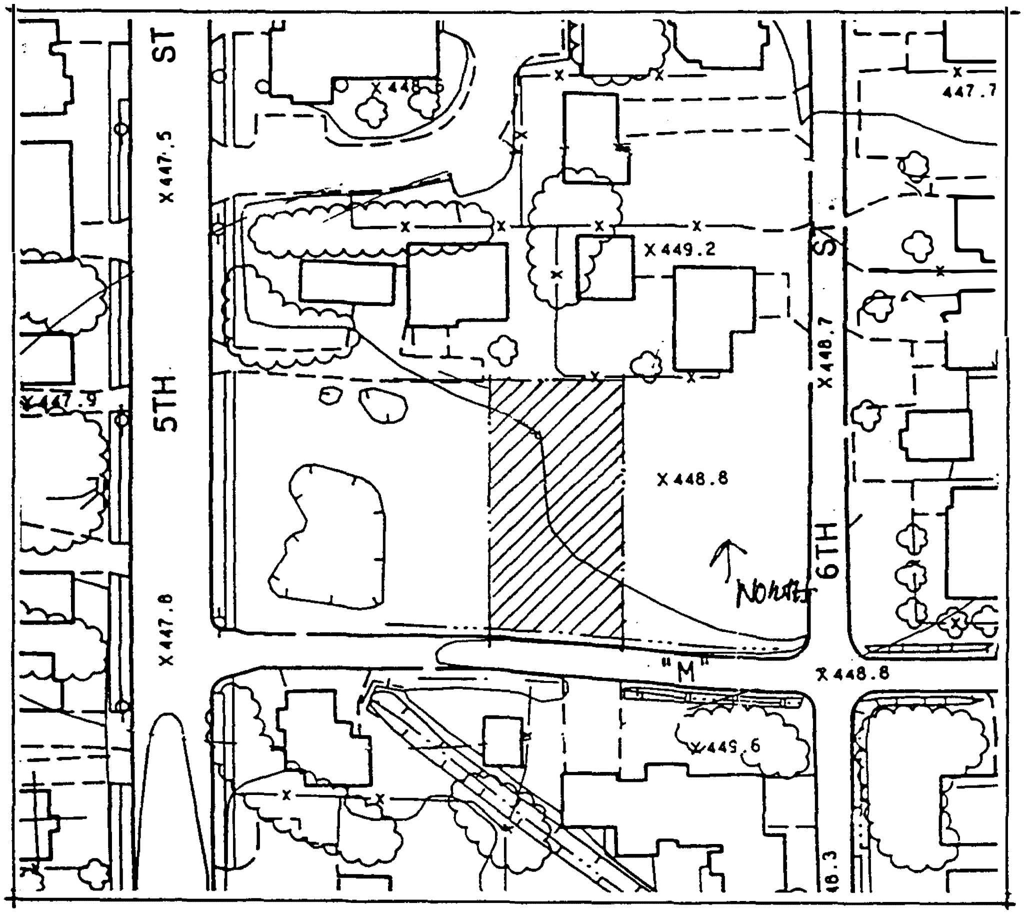

Figure 3-1
Location Plan

Also from the design team came an underlying goal that the Demonstration House be a flexible, adaptable product with potential application to other sites. Appropriateness to the Springfield site should not mean that the house would have to be fundamentally redesigned to be used elsewhere.

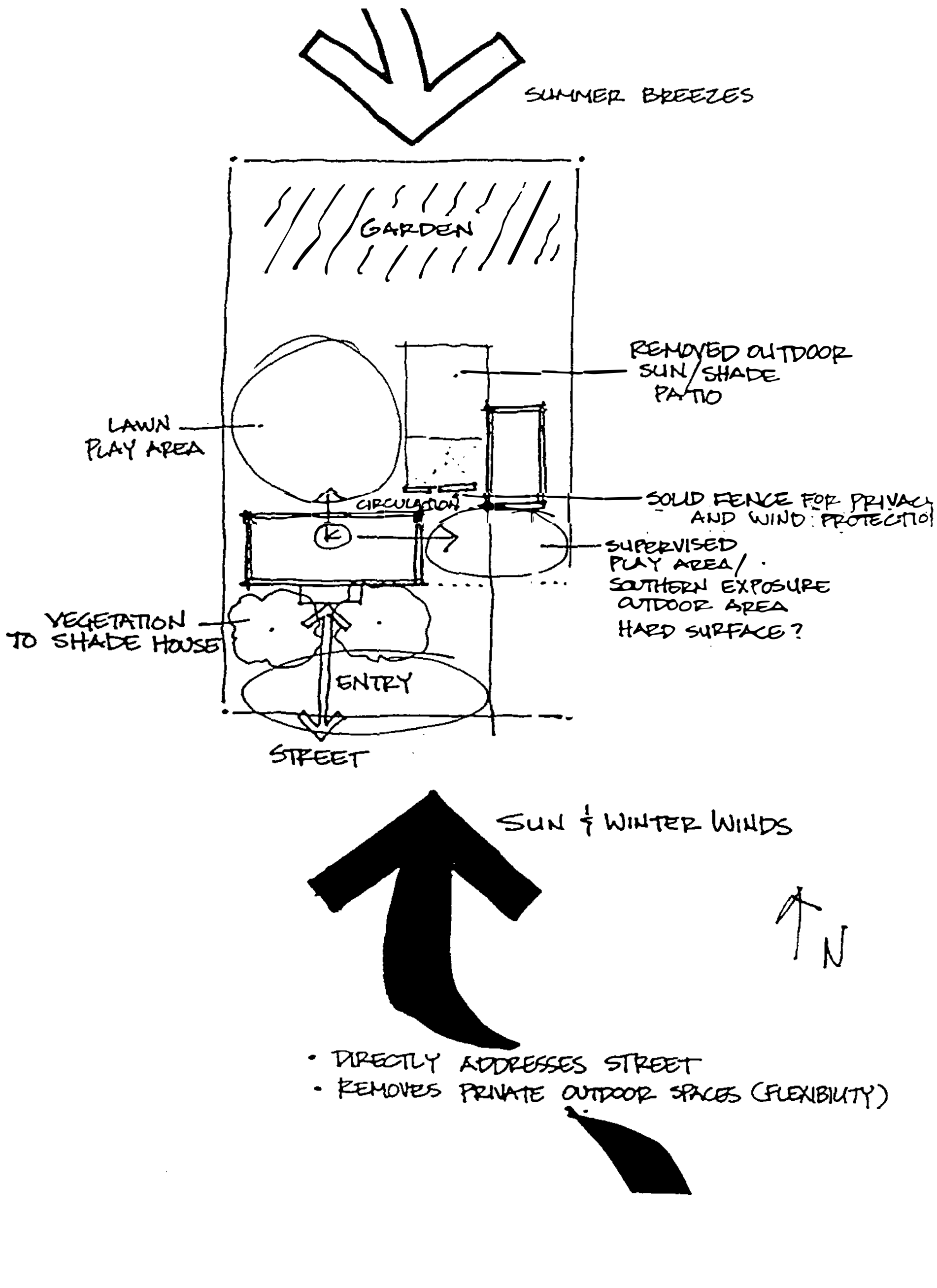

Figure 3-2
Preliminary Site Plan

Previous design work had developed a small 1-1/2 story house with a 12/12 roof. Adding to the site plan a detached garage and two street trees provided opportunities to use these ingredients to help shape outside spaces. After exploration of several alternatives with the help of landscape architect Cynthia Girling a general site plan emerged (Figure 3-2).

A small-scale massing model of this design, along with existing and planned nearby buildings and trees, was assembled. Solar studies (Figure 3-3) showed the seasonal patterns of sun and shade, revealing best locations for the required street trees.

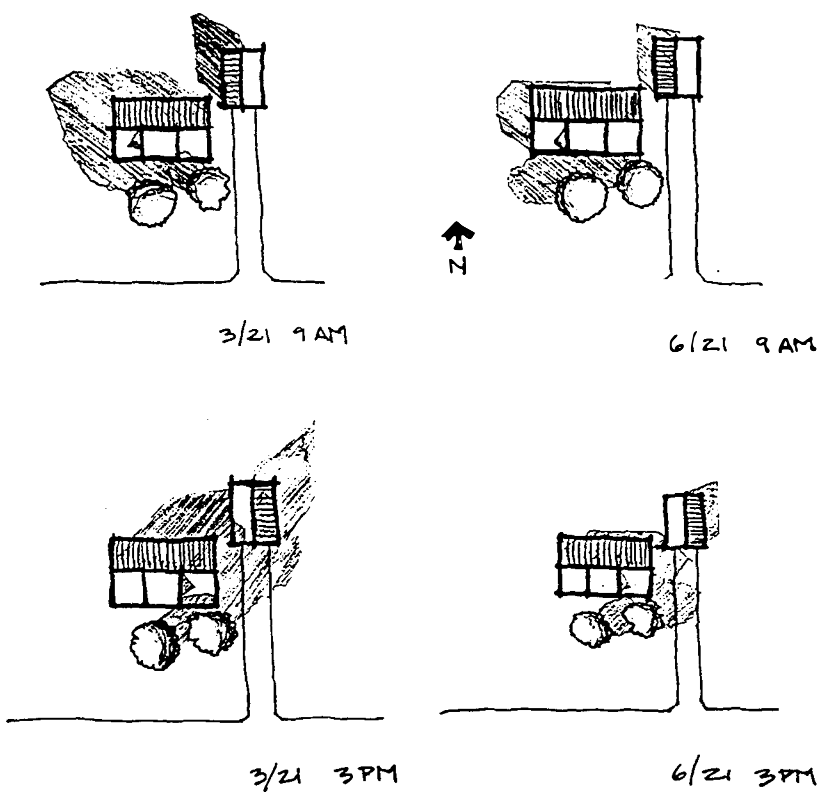

Figure 3-3
Solar Site Studies

In the Laboratory wind tunnel, the same model revealed the design's response to seasonal winds (prevailing southwesterly winter winds could be either focused or blocked, for example, depending on the size and arrangement of shrubs or fences between the house and garage). Figure 3-4 shows typical wind tunnel site studies for five wind directions from north to south. Lightweight foam plastic beads poured onto the model settle into pockets of low wind speed; their absence indicates areas of wind scouring that might be welcome in summer but uncomfortable in winter.

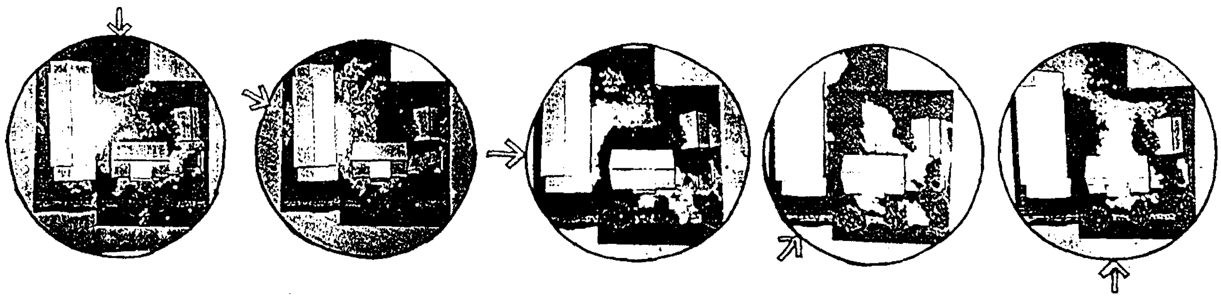

Figure 3-4
Wind Tunnel Site Studies:
Wind Eddy Patterns for 5 ~~Wind Directions~~ from North (L) to South (R)

In keeping with the goal that the Demonstration House be adaptable to other sites, studies such as Figure 3-5 below examined how other site and solar orientations might work.

With the addition of fences, paving and shrubs, plus determination of utility locations and finish site grades necessary to meet drainage requirements, the site plan was completed as shown in Figure 3-6.

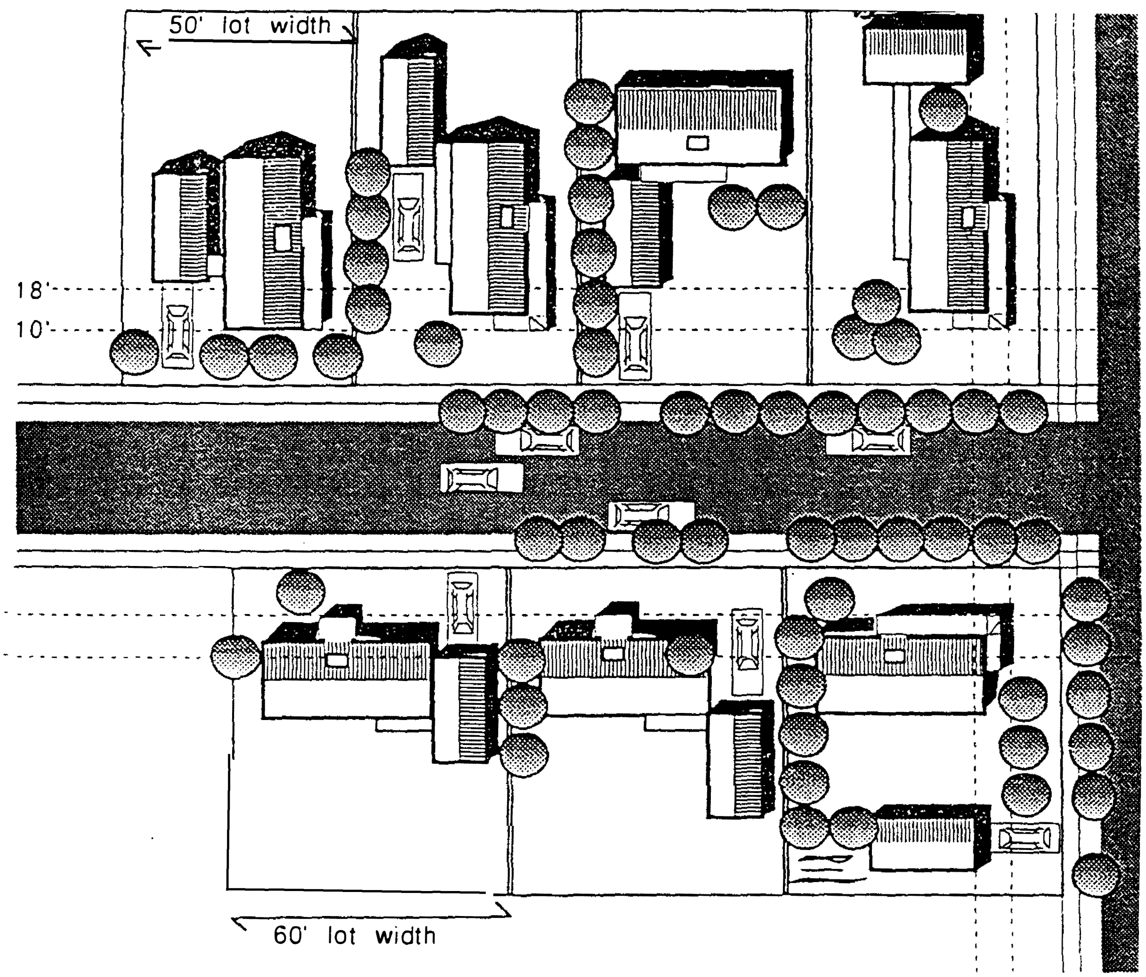

Figure 3-5
Alternate Site Plans

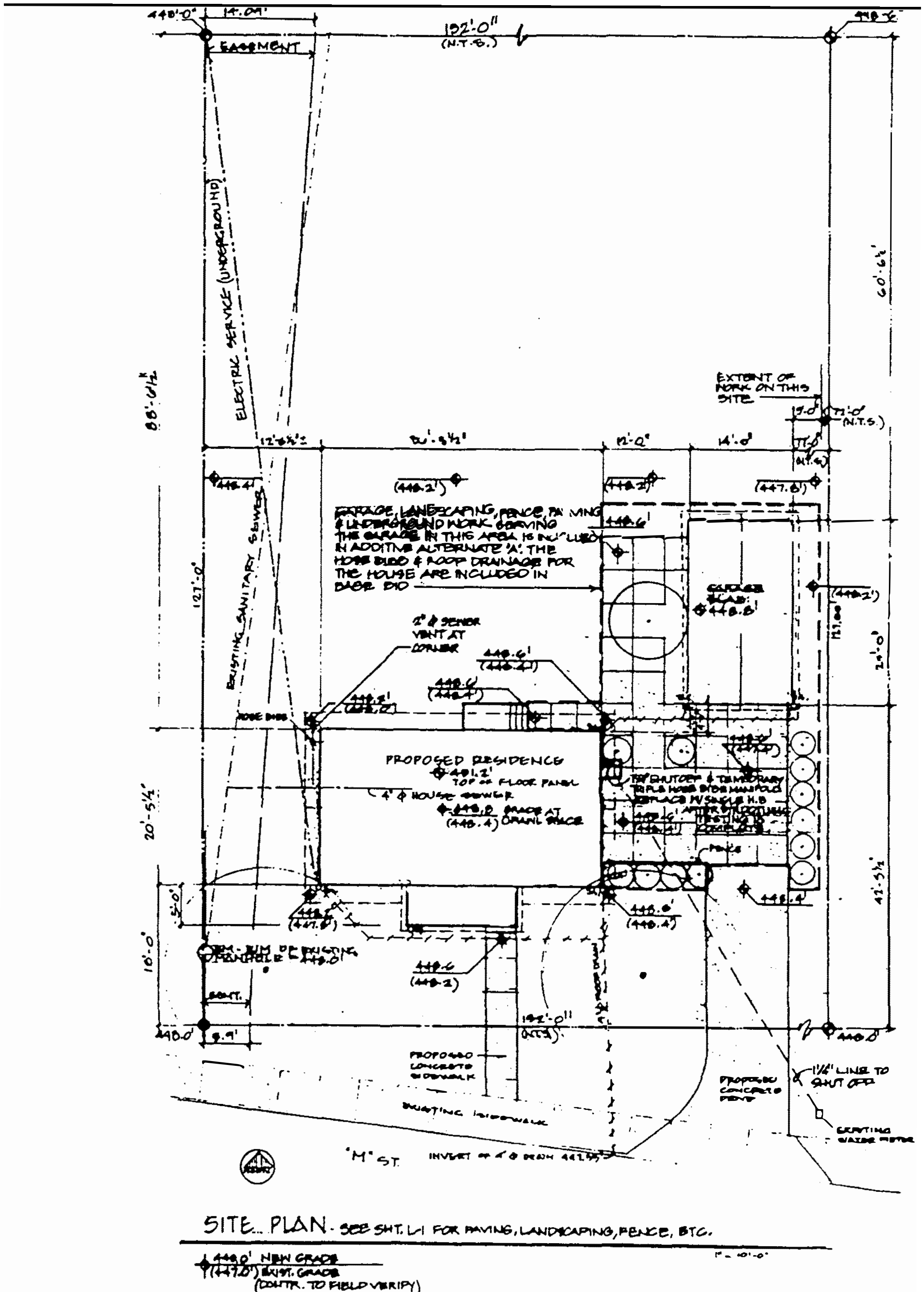

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Figure 3-6
Final Site Plan

3.2 BUILDING DESIGN

Foundation Design

Initial cost comparisons showed that the SSIC panel floor was not a cost-competitive element of the building envelope (see Table 3-1). Attempts to find cost savings through redesign of the floor itself showed little promise; however, a another strategy was to examine the floor and foundation as a unit, and see what cost savings might result from an integrated approach.

HOUSE ENVELOPE COST BY COMPONENT

	Roof	Walls	Floors	Int. Floor	Int. Walls	Misc.	Total
Demo	5,540	6,226	4,011	2,848	1,925	11,339	31,889
Ref	4,694	4,235	3,219	2,88	1,839	11,339	28,209

Table 3-1
Building Shell Cost Comparison Summary

Additionally, an effort was made to see what opportunities might lie in the distinctive properties of the SSIC panels, compared to conventional construction. One difference is that lumber "sticks" are structurally one-dimensional, linear elements which rest on linear support systems such as perimeter foundation walls or beams; panels, however, provide stiffness in two dimensions. A two-way span — in this case, a floor slab — can be carried on point supports. Two-way spanning strategies are often employed in concrete buildings. Perhaps SSIC panels could be used in some similar way.

For the Demonstration House, consequently, an integrated floor/foundation was developed which used floor panels coupled to a simplified pier foundation system in such a way that the panels act as two-way spanning elements. In effect, the floor panels were made to work harder, permitting cost savings in the foundation. The pier foundation could reduce or eliminate the need for form construction and stripping, saving time and costs.

Computer modeling of the building shell energy performance established that 6" nominal core floor panels would provide sufficient thermal insulation. Rated span capacity of these panels required that the floor have two rows of supports besides those under the perimeter walls. Thus the general arrangement of support piers was determined, and from this configuration and Building Code derived floor design loads (40 psf live + 13 psf dead), plus wind loads on the building, foundation point loads were established.

Soils at the building site appeared poorly drained and unimpressive. Expansive clays are locally common. Using a conservative estimated soil bearing capacity of 1500 psf, a first estimate of the pier sizes showed that the largest would be 4' in diameter. An initial foundation plan was derived (Figure 3-7).

Because frost depth in this area is shallow, footings need to be only 12" deep. As the diameter and depth requirements for the piers were determined, it appeared that some inexpensive way to dig large diameter, shallow holes would be desirable. The estimated pier diameters were beyond the range of locally available earth augers, and the augers' capacity to dig deep holes would be poorly used.

The "Turnip" Foundation

One possibility was the tree spade — the hydraulic digger used to dig up, move, and replant trees. Such machines were locally available with hole diameter capacities to 80". They produce a characteristic conical hole — whose structural implications, unfortunately, were unknown. However, cost estimates from local contractors (as low as $10/hole) showed that the tree spade might be a cost effective foundation excavator. A test excavation was made to observe the machine and the resulting excavation (Figure 3-8).

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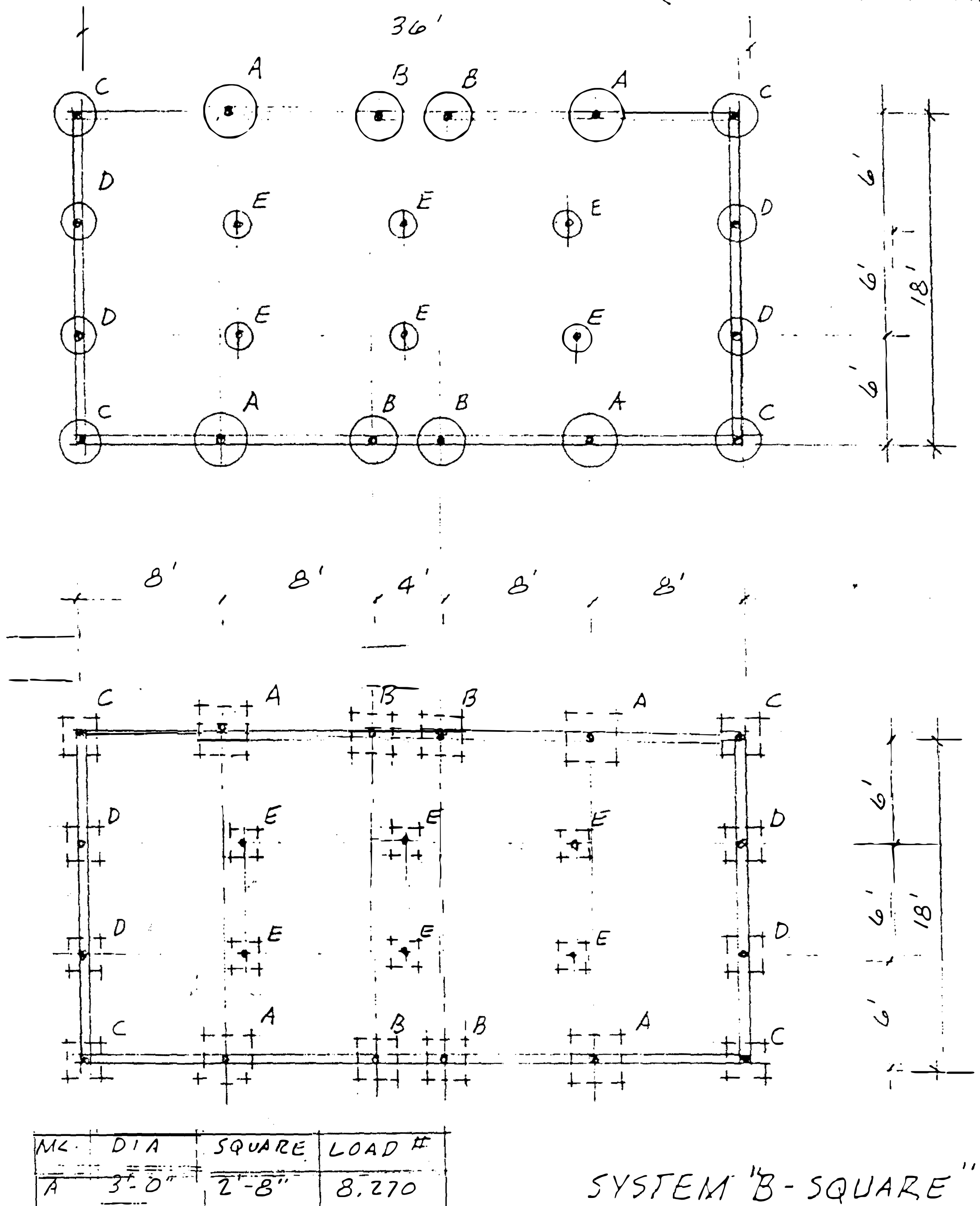
FOOTINGS - TENTATIVE SIZES (SYSTEM "B-ROUND")



MK	DIA	SQUARE	LOAD #
A	3'-0"	2'-8"	8,270
B	2'-6"	2'-4"	6,200
C	2'-4"	2'-0"	4,950
D	2'-0"	1'-10"	3,930
E	1'-10"	1'-6"	3,020

Figure 3-7
Initial Foundation Plan

Figure 3-8
Tree Spade Test

The questions of site soil and conical foundation behavior and conical foundation were referred to Foundation Engineering, geotechnical consultants. The firm dug test holes at the site and submitted their report, excerpted below (the complete report is given in Appendix 9.3).

"The soils at the site consist primarily of brown, stiff silts and clays to a depth of 5 or 6 feet followed by shallow gravels. We have concluded that

the proposed foundations should be adequate to support the required loads. However, the unusual shape of the footings made conventional analysis of the foundations difficult and there are some potential disadvantages with the proposed type of foundation. Some of the values presented herein are presumptive based on the foundation conditions encountered. We are recommending that a program consisting of field testing be implemented prior to using this type of foundation at other sites."

James K. Maitland, P.E., Foundation Engineering

Auger Drilled Foundation

Because of the consultants' concerns, the tree spade approach appeared problematic. Foundation Engineering's finding of a high-bearing-capacity gravel stratum roughly 5' below grade, however, suggested that a deeper, smaller diameter piers would be a better choice, so conventional auger equipment might be used after all. Cost estimates from local contractors – as low as $250 for 20 holes 6' deep – confirmed that auger excavation could also be economical. The foundation was consequently redesigned and submitted to Foundation Engineering for review. Their report follows:

"We have reviewed the revised foundation system proposed for the Demonstration House Project. This letter summarizes our findings.

The revised foundation consists of auger piers, 18 inches in diameter and 5 feet deep. As indicated by phone, we believe that the behavior of short piers would be similar to spread footings (shallow foundations), rather than true piers or deep foundations. As a result, the "piers" would be resisted by end bearing only and significant shaft resistance would probably not develop. We have provided the following guidelines to design the pier foundations:

1. Perform the earthwork during dry weather only. The site is relatively flat and water will tend to accumulate on the property. Excessive ponding may make foundation construction difficult.

2. Design the piers as spread footings assuming that the native gravels could support an allowable bearing pressure of 4000 psf. Therefore, an 18-inch diameter pier could support a maximum vertical load of approximately 7 kips. The diameter of the pier should be increased, or additional piers constructed, to provide the required end area for larger loads. The bearing pressure recommended above may be increased by 1/3 for the analysis of temporary live loads (wind, earthquakes, etc.).

3. Auger the piers a minimum of 1 foot into the gravels. The hole should be inspected to insure that the bottom is founded in gravels and not merely a layer of dense sand. Clean out the hole and remove all slough to promote an intimate contact between the concrete and soil.

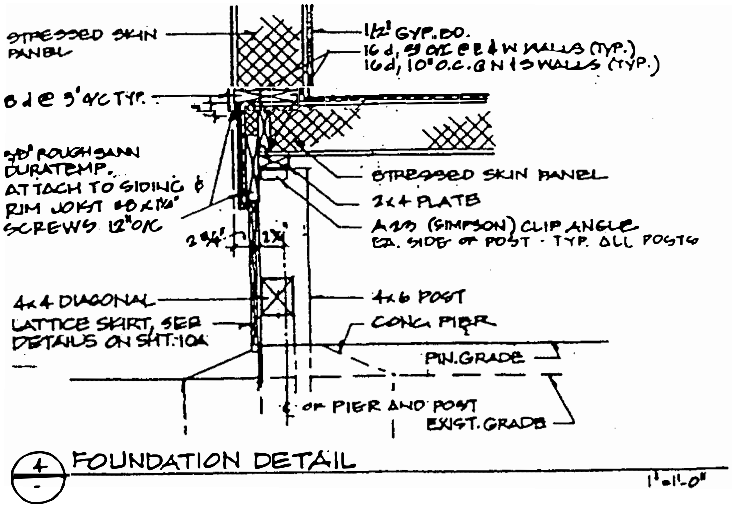
4. Construct the concrete piers with steel rebar, as required, to resist a maximum moment of approximately 0.8 kip-foot. Our analysis indicates that the maximum moment will occur in the pier at a depth of approximately 1 1/2 feet. We assumed a lateral load of approximately 1100 pounds and a 5-foot pier for this analysis. A shear strength of approximately 1.5 ksf was assumed for the surficial clays based on the Torvane measurements obtained in the field. ø-values of 35° and 42° were assumed for the sands and gravels, respectively. These strength parameters were used to calculate a modulus of subgrade reaction for the lateral pier analysis. Piers should be at least 5 feet deep (even if shallow gravels are encountered) to provide the required lateral capacity.

5. Provide crawl space drainage as indicated in our original report. Otherwise, water could pond in the crawl space and potentially affect the forms of the foundations."

M. Todd Boire and James K. Maitland, P.E.,
Foundation Engineering

The auger excavated foundation was refined further into the final design shown in Figure 3-9.

The importance of verifying the constructability of this novel foundation led to a proposed construction sequence described in Figure 3-10.



FOOTING SCHEDULE

		LOAD	AREA	Ø PIER	DEPTH
(A)		7750		24"	6'±
(B)		14,220		[illegible]	6'±
(C)		3,720		18"	6'±
(D)		17,160		30"	6'±
(E)		4,470		18"	6'±
* (F)		1,990		18"	2'

* BASED ON MOST HEAVILY LOADED PORCH FOOTING.

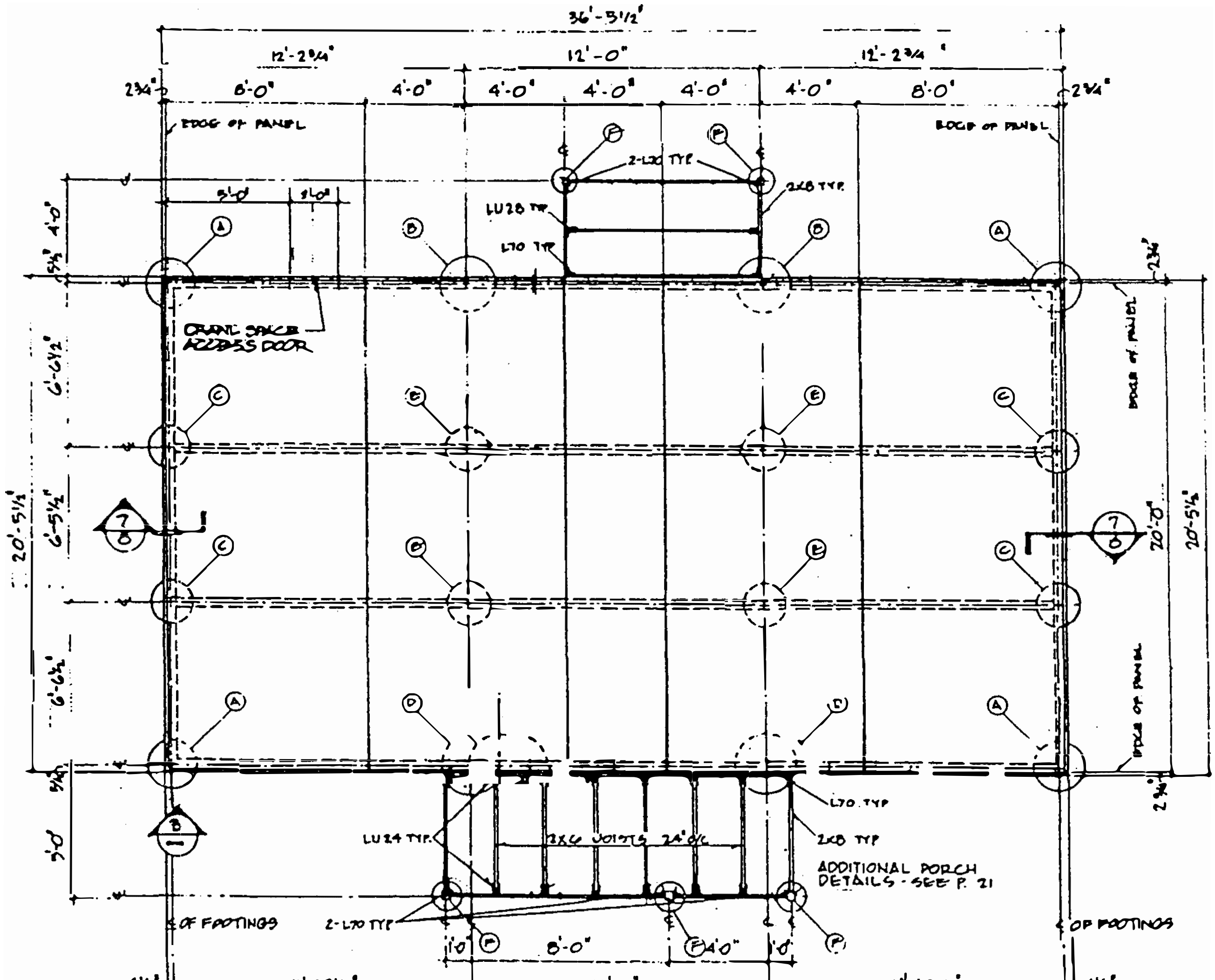


Figure 3-9
Foundation Plans

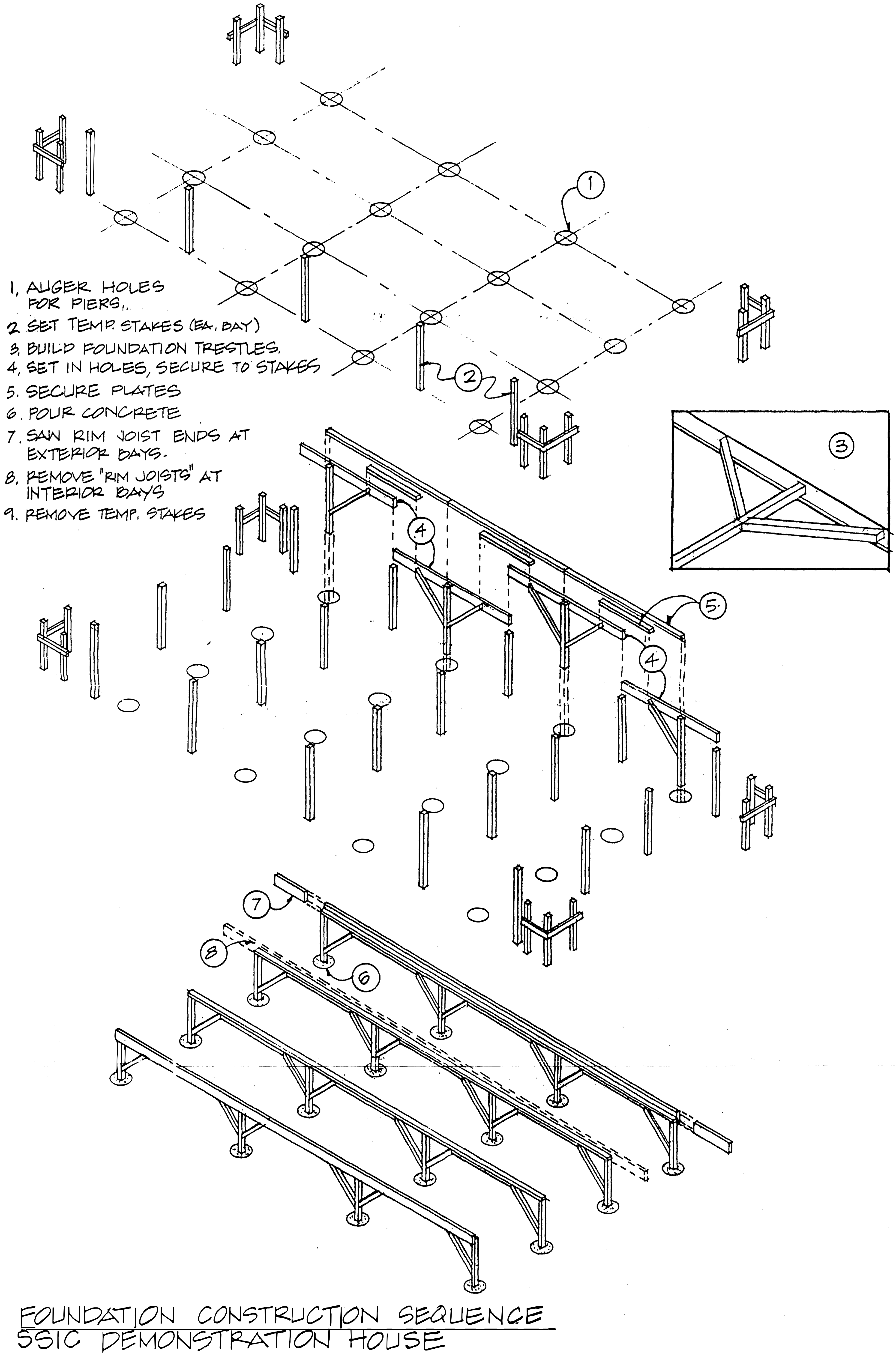


Figure 3-10
Foundation Construction Sequence

Panel Design
The SSIC panel Demonstration House project applied a high performance, premium quality product/technology to a low-budget project. The basic strategy used was to minimize panel waste and redundancy, expand and exploit the unique design capabilities of the panel system, and wherever possible shift construction operations into the panel factory for improved quality control and cost savings.

Based on this strategy, several specific innovations were developed: the pier-type foundation just described, which exploited the floor panels' two-way spanning capability; a shiplap panel joint (Figure 3-11) developed to make large floor and roof panels easier to install and connect; a peripheral wiring chase (Figure 3-12) beneath the exterior panel walls to simplify wiring in the walls and around corners; and wall panels with integrated siding (using Duratemp, a newly developed structural panel siding) for economy.

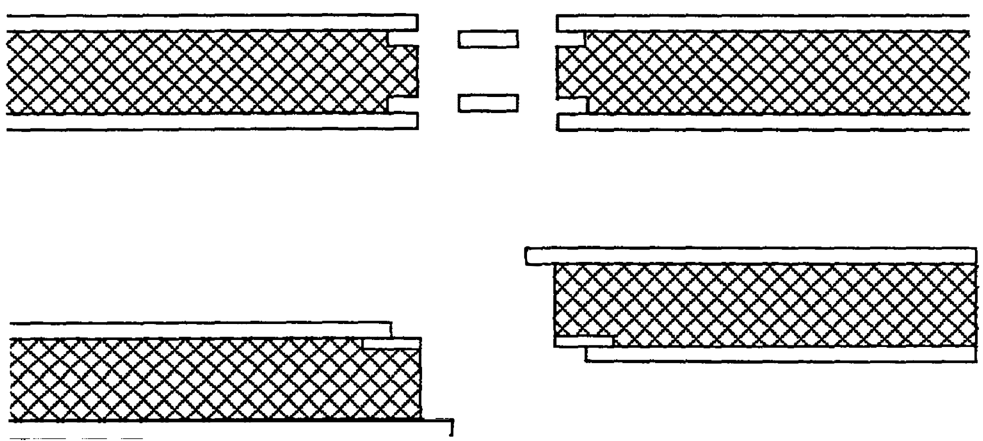


Figure 3-11
Shiplap Panel Joint

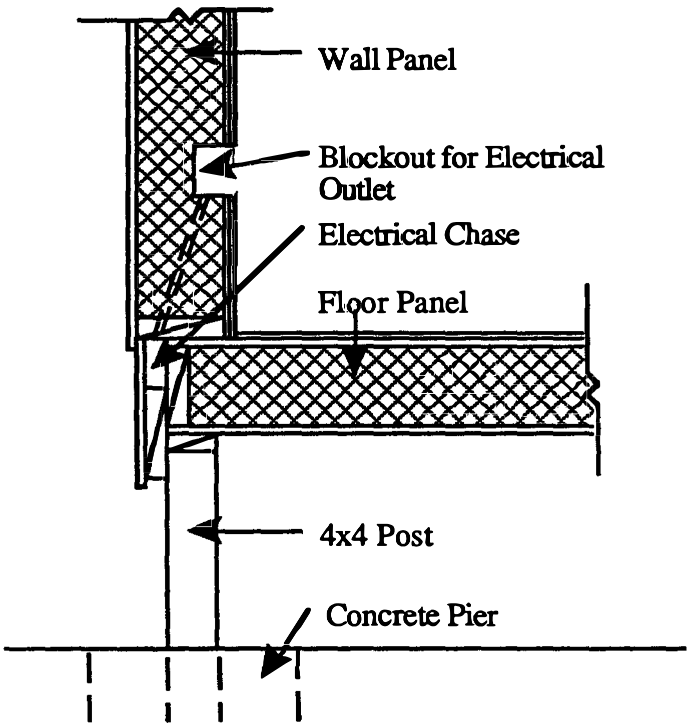


Figure 3-12
Peripheral Wiring Chase

HVAC System Design
Design of the Demonstration House HVAC system began from these premises: the site climate is mild (about 4500 heating degree days — base 65°F; about 250 cooling degree days — base 78°F), and (because Northwest electric rates are low and the Super Good Cents incentive program is tailored to electrically heated homes) the house would have an electric space conditioning system. Additionally, because of the small size and low projected energy budget for the house, heating could be provided by a low-capacity system or systems, and cooling should be provided as completely as possible by natural ventilation.

The Super Good Cents requirements called for continuous ventilation of 30 cfm in the master bedroom, 15 cfm for each additional bedroom, plus 15 cfm for main living area (100 cfm total for the three bedroom Demonstration House), or intermittent ventilation at 0.35 ACH minimum (BPA, 1992).

A survey of available candidate systems found that a ventilating heat pump provided a good match for the Demonstration House needs: it provided reliable ventilation, high overall efficiency and compactness (such a unit provide ventilation, water heating and space conditioning in one package), but it was rather expensive. Only one such unit, the Envirovent, was currently being marketed in the U.S. Fortunately, the manufacturer (DEC International) was interested in the Demonstration House project, and agreed to supply such a unit at a price within the project budget.

The Envirovent provides space and water heating capacity of a nominal of 7,200 BTU/hr with a COP of 3.0. Cooling capacity is 3/4 ton. Integral to the unit is an 80 gal. water heater with a 4500 W resistance element to supply hot water beyond the capacity of the heat pump.

As a space conditioning system for the Demonstration House, the Envirovent would need backup heating capacity. A newly introduced “Advantage” resistance heater from Cadet Manufacturing Company offered more sensitive room temperature control, variable output and a programmable thermostat — providing improved overall performance and comfort from previous resistance heaters. This unit is also compact and wall mounted, so several such heaters could provided for a certain measure of zoning in the heating system. Cadet heaters totaling 5000W were therefore distributed through the house as shown in Figure 3-13.

Ducts for the ventilating heat pump could be kept to simple U-shaped configuration (Figure 3-14), taking advantage of the compact Demonstration House plan and the likelihood that the intermediate floor would be conventionally framed (to provide such utility chase spaces, and clear span capability across the house so that interior walls could be relocated freely, and no point loads would bear on the SSIC panel first floor).

A small 2” diameter duct was added to the system to pull warm air from behind the refrigerator, to improve refrigerator efficiency and provide additional heated air for the heat pump.

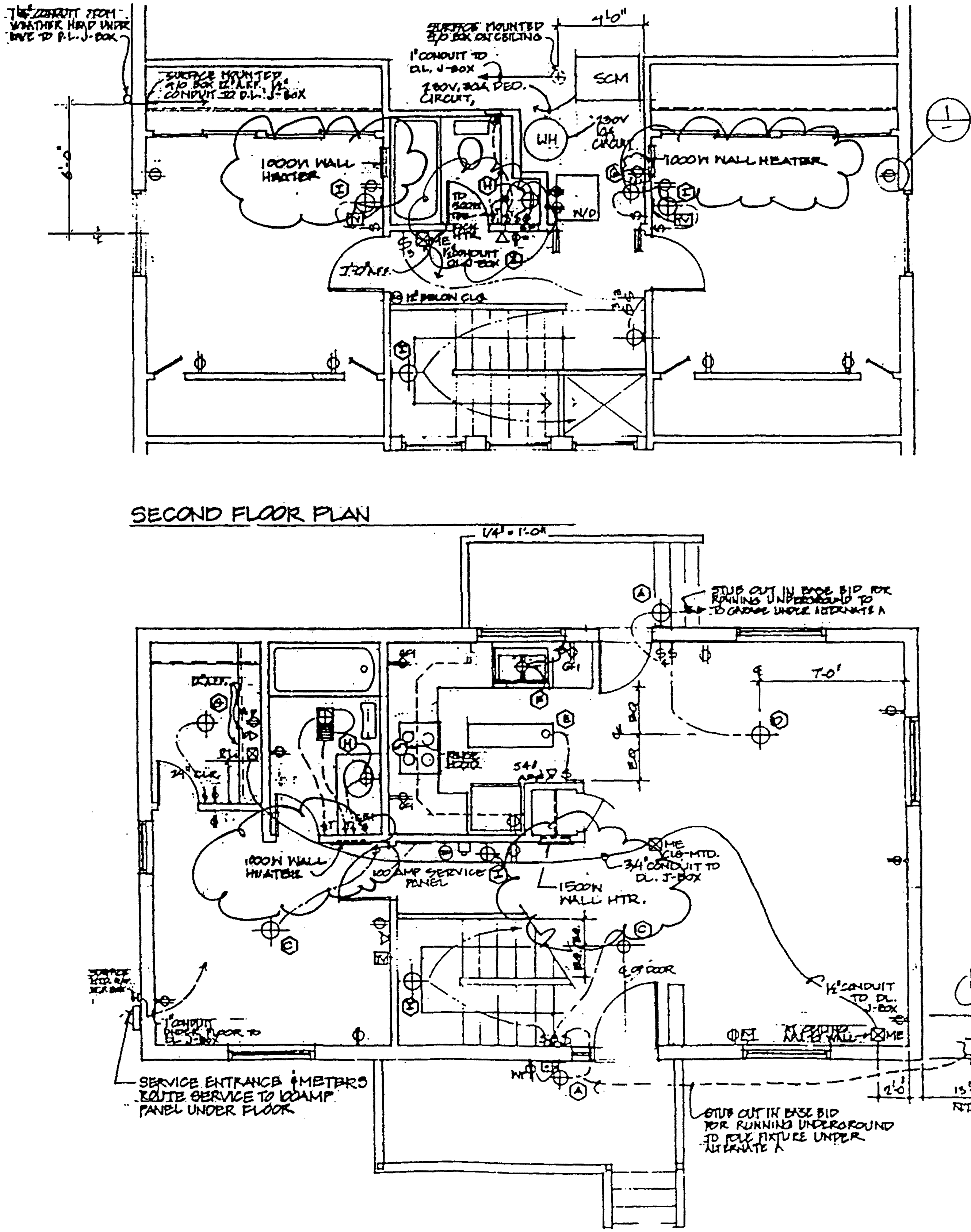


Figure 3-13
Distribution of Electric Heaters

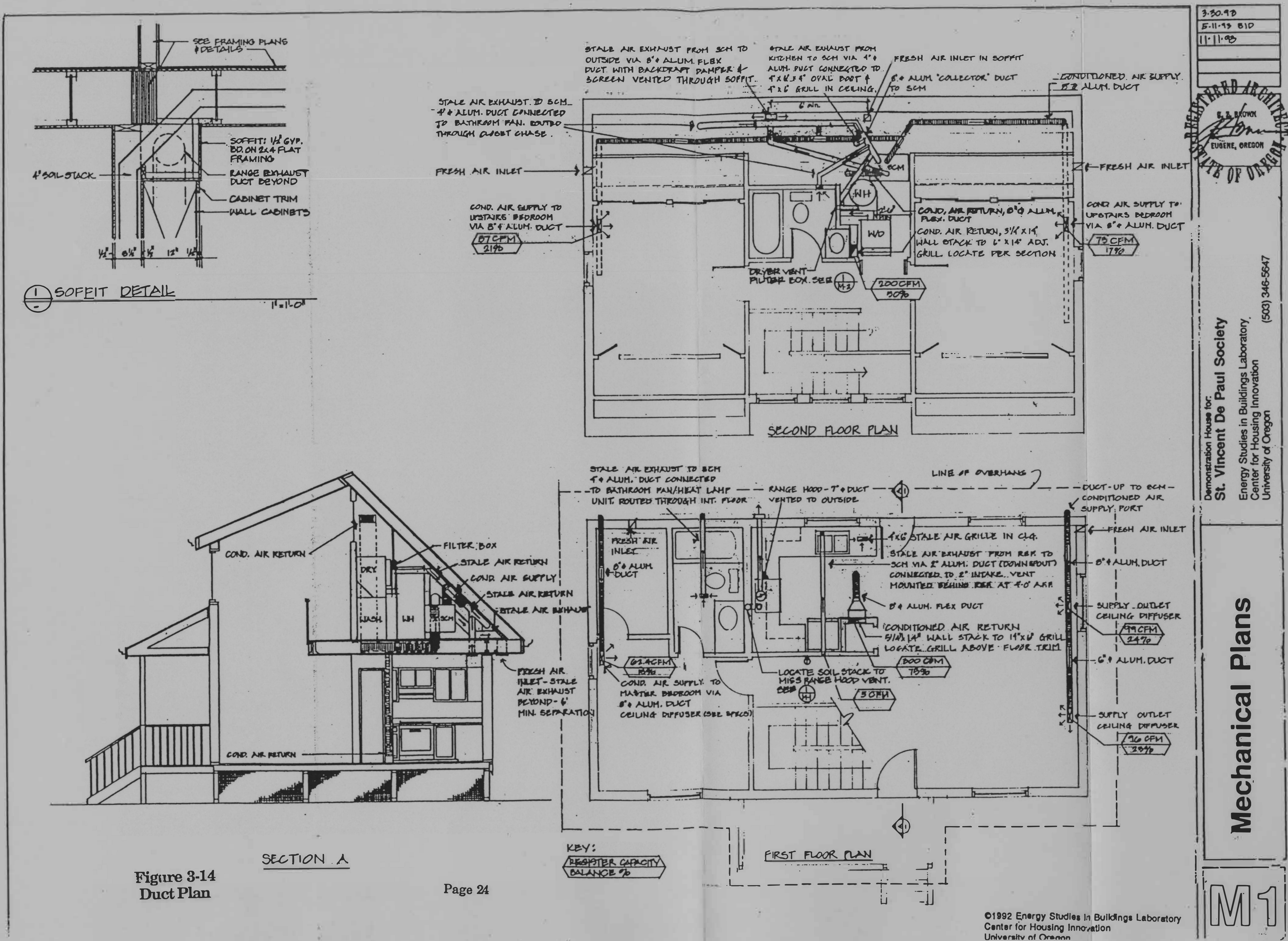


Figure 3-14
Duct Plan

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Electrical System Design

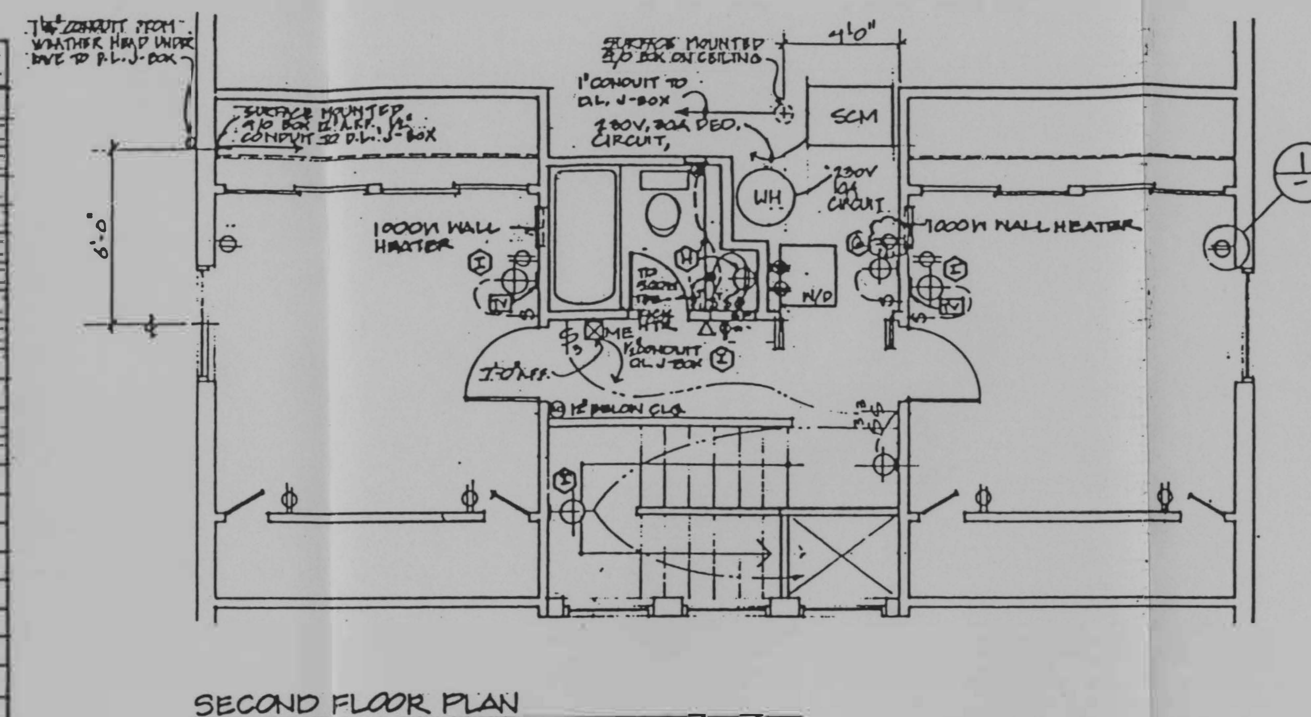
Design of the Demonstration House electrical system aimed to support the twin project goals of energy efficiency and affordability. To enhance energy efficiency, penetrations of the building envelope were minimized and chase cavities in envelope panels were avoided where possible to maintain high insulation levels.

Minimizing chases in the exterior panels was also hoped to reduce wiring costs, since the process of wiring through precut chases in the panels — as supplied by AFM and many other panel manufacturers — has been reported to be more costly than wiring through conventional framing (Andrews, 1988, p. 50). Consequently the Demonstration House wiring plan sought to use interior partition walls, and especially the framed intermediate floor, to carry the bulk of the house wiring and the circuit breaker panel (Figure 3-15).

As another strategy to deal with the problem of wiring in panel walls, the perimeter wiring chase mentioned earlier was designed below the exterior walls (Figures 3-12, 3-16). With this chase, electrical outlets could be located before or after the walls were erected , their holes routed into the panels, connecting holes to the perimeter chase drilled by the electrician (as in conventional construction — eliminating the need for the framers to drill vertical chases in the wall bottom plate as they assemble the panel wall), perimeter wiring wrapped around the edge of the floor deck by the electrician and loops pushed up to the outlet locations, expanding foam sealant injected into the wiring holes, a flexible foam gasket installed atop the perimeter wiring, and an apron panel installed to cover the wiring chase.

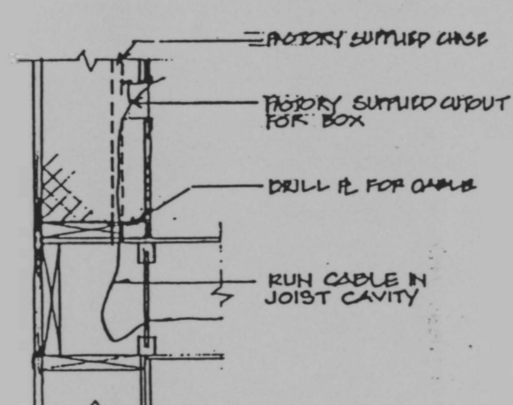
ELECTRICAL SCHEDULE

SYMBOL	DESCRIPTION
	120 V. DUPLEX OUTLET
	220 V. OUTLET
	120 V. DUPLEX OUTLET, GROUND FAULT INTERRUPTER
	120 V. DUPLEX OUTLET, DEDICATED CIRCUIT
	RANGE HOOD
	TELEPHONE JACK
	120 VOLT JUNCTION BOX W/BLANK COVER FOR MONITORING EQUIPMENT
	120 VOLT JUNCTION BOX W/BLANK COVER FOR DATALOGGER
	SMOKE DETECTOR, WALL-MOUNTED
	HEAT LAMP W/ FAN
	WALL-MOUNTED LIGHT FIXTURE
	CEILING-MOUNTED LIGHT FIXTURE
	RECESSED LIGHT FIXTURE
	1'x4' FLUORESCENT LIGHT FIXTURE
	SINGLE POLE SWITCH
	3-WAY SWITCH
	4-WAY SWITCH
	SWITCH WITH SPRING TIMER
	DOOR CHIME
	DOORBELL
	TELEVISION OUTLET
	JUNCTION BOX
	THERMOSTAT

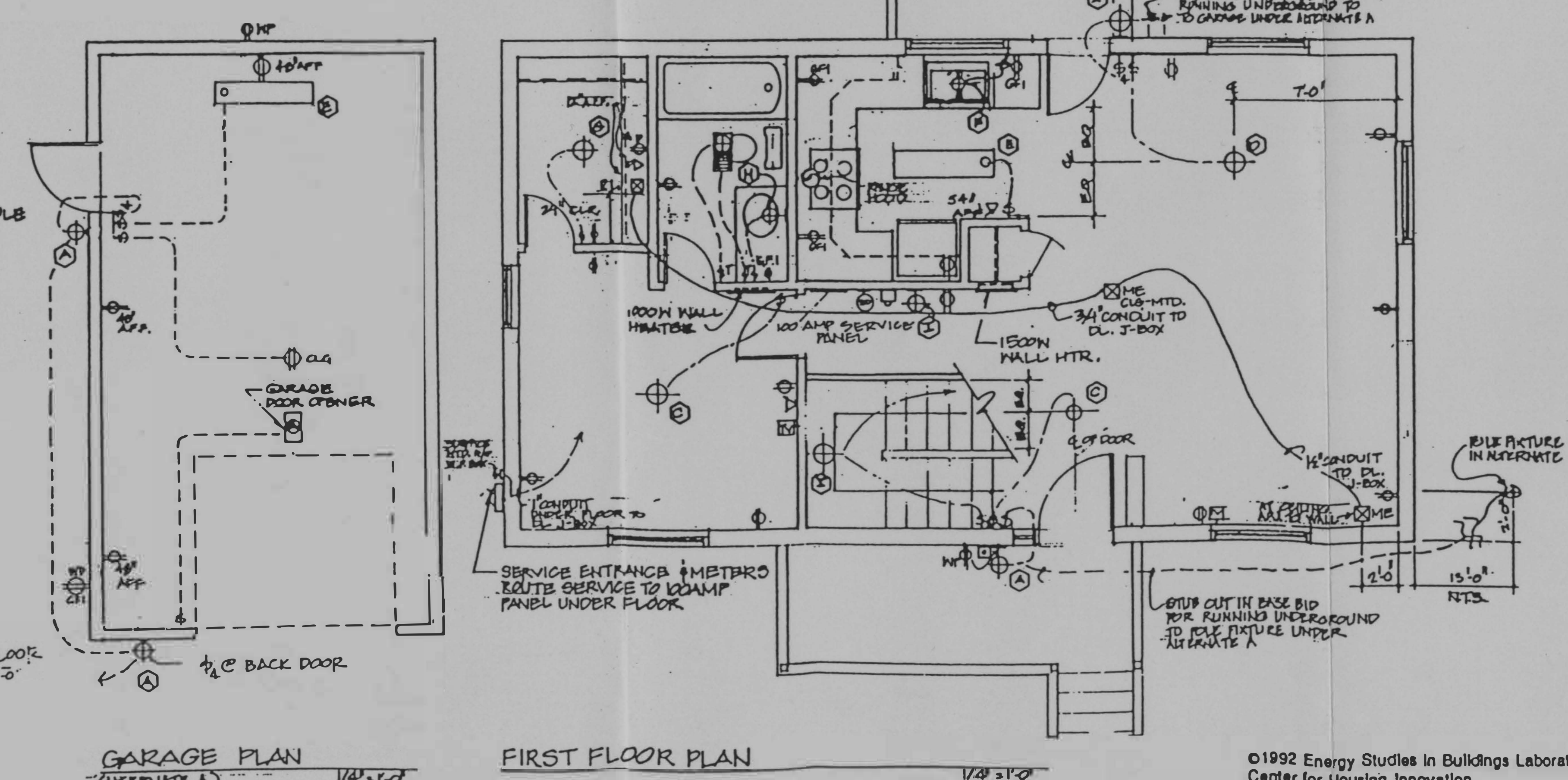


NOTES:

1. ALL OUTLETS TO BE MOUNTED 12" AFF UNLESS NOTED OTHERWISE
2. ALL SWITCHES TO BE MOUNTED 48" AFF UNLESS NOTED OTHERWISE.
3. SEE INTERIOR ELEVATIONS FOR ADDITIONAL MOUNTING HEIGHTS.
4. SEE SHEET 12 FOR LIGHT FIXTURE SCHEDULE



OUTLET @ EXTERIOR WALL - 2ND FLOOR 1" = 1'-0"



4.25.92	PERMIT
3.30.93	
5.11.93	BID
5.26.93	REVISED
1.11.93	

REGISTERED ARCHITECT — R. L. BROWN — EUGENE, OREGON — STATE OF OREGON

Demonstration House for:
St. Vincent De Paul Society

Energy Studies in Buildings Laboratory
Center for Housing Innovation
University of Oregon
(503) 346-5647

Electrical Plan

SHEET E 1

Figure 3-15
Electrical Plan

10/3/9 5

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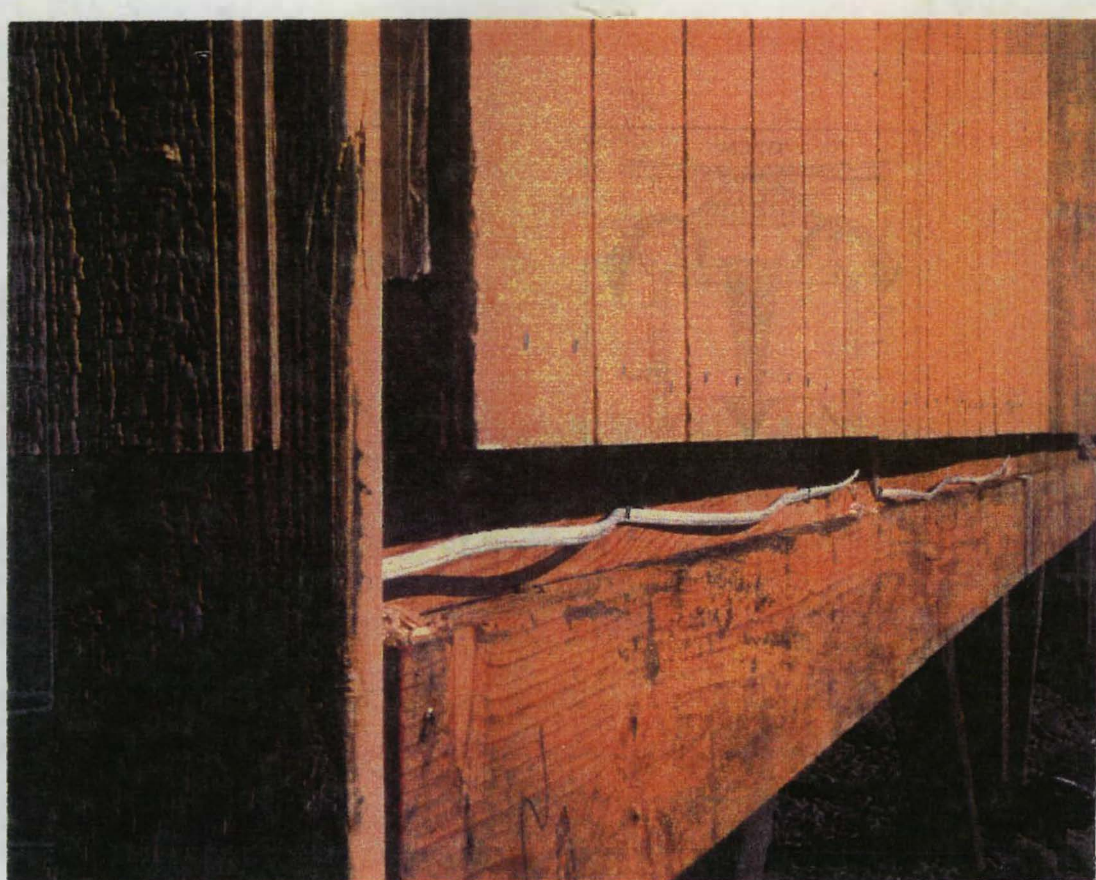


Figure 3-16
Perimeter Electrical Chase

An analogous detail served to feed outlets in the upstairs panel walls, where a keyhole-shaped slot would be routed to bring outlet wiring up from the floor framing cavity to each outlet location.

Plumbing System Design

As with the electrical system, the Demonstration House plumbing was designed to help improve energy performance and reduce costs. Similar strategies were used: minimizing envelope penetrations and localizing the plumbing components in non-panel structures. To minimize envelope penetrations, air admittance valves were used instead of exterior plumbing vents; the single atmospheric vent required by the Springfield building department was coupled to the house waste line en route to the sewer (outside the building shell) and attached to the exterior of the Demonstration House west wall (Figures 3-17, 18, 19).

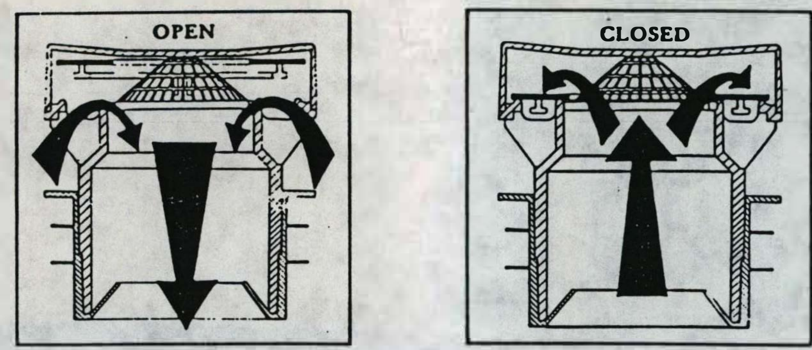


Figure 3-17
Air Admittance Valve

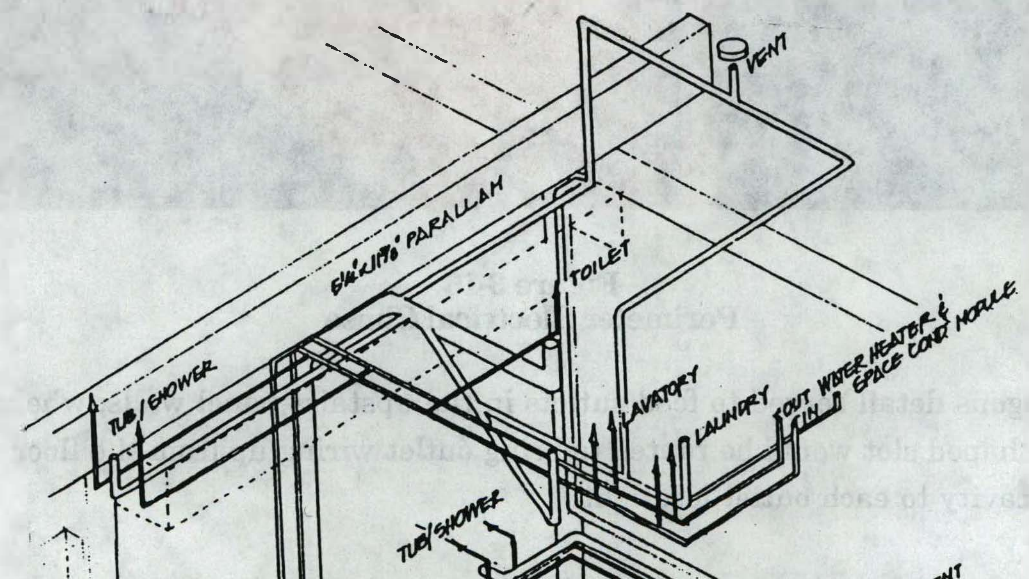


Figure 3-18
Plumbing Schematic

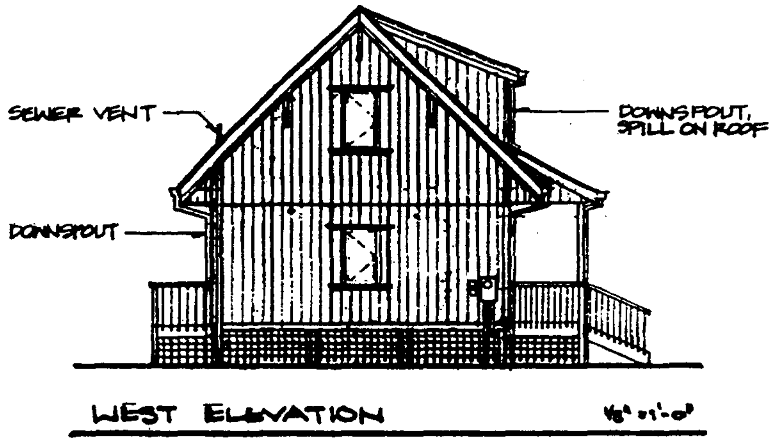


Figure 3-19
External Atmospheric Vent

The downstairs bathtub waste trap was specified to be imbedded in the floor panel and insulated with expanding foam sealant, and the waste stack and water supply were also designed to be clustered at their point of entry into the floor panel, and carefully insulated with foam sealant.

Test Instrumentation Design

Energy tests for the Demonstration House would consist of energy performance tests — unoccupied house blower door, coheating and thermographic tests, plus simulated occupancy testing — and energy monitoring of the occupied house for one year.

Most of the instruments used for the energy testing phase were portable tools such as a blower door and thermographic camera. These will be described in a later report on the testing and monitoring program. The instruments built into the Demonstration House for the energy monitoring program, however, were part of the overall design and construction process; in addition, several tests specific to the Demonstration House were added, with specialized instrumentation as required. These instruments will be described below.

Energy Monitoring Instrumentation

The monitoring program uses an array of sensors (Table 3-2) installed in the

Demonstration House to keep track of total electrical energy use, space and water heating energy consumption (space heating via heat pump and electrical resistance heat; water heating via heat pump and electrical resistance), air temperature at two locations in the house, mean radiant temperature and south wall interior surface temperature in the main living space, and relative humidity at one location in the house.

Number	Type	Location	Function
1	thermocouple	south wall interior	surface temperature
2	thermocouple	living room 7' a.f.f.	air temperature
3	thermocouple	living room 7' a.f.f.	mean radiant temperature
4	humidity sensor	living room 7' a.f.f.	relative humidity
5	thermocouple	upstairs landing	air temperature
6	IR optical counter	kWh meter	whole house electrical
7	IR optical counter	kWh submeter	resistance heat circuit 1
8	IR optical counter	kWh submeter	resistance heat circuit 2
9	IR optical counter	kWh submeter	heat pump
10	IR optical counter	kWh submeter	resistance H_2O heat
11	thermocouple	panel roof	shingle temperature 1
12	thermocouple	panel roof	shingle temperature 2
13	thermocouple	porch roof	shingle temperature 3
14	thermocouple	porch roof	shingle temperature 4
15	thermocouple	Envirovent	air inlet temperature
16	thermocouple	Envirovent	supply outlet temperature
17	thermocouple	Envirovent	exhaust inlet temperature
18	thermocouple	Envirovent	exhaust outlet temperature
19	thermocouple	H_20 heater inlet	water temperature
20	thermocouple	H_20 heater outlet	water temperature
21	flow meter	H_20 heater inlet	water flow rate
22	moisture sensor	east wall panel spline 1	joint moisture
23	moisture sensor	east wall panel spline 2	joint moisture
24	moisture sensor	west wall panel spline 1	joint moisture

Table 3- 2
Demonstration House Energy Monitoring Instrumentation

These instruments are wired into a Campbell Scientific CR10 data logger, AM416 multiplexer and DC112 modem in a locked case in the master bedroom closet; they are served by a dedicated electrical power circuit and a dedicated phone line. The modem connects them to an IBM 386 computer using PC 208 software at the Energy Studies in Buildings Laboratory, which is similarly connected to a meteorological station nearby (Figure 3-20). Thus instantaneous and summary data can be acquired remotely and correlated to local weather conditions.

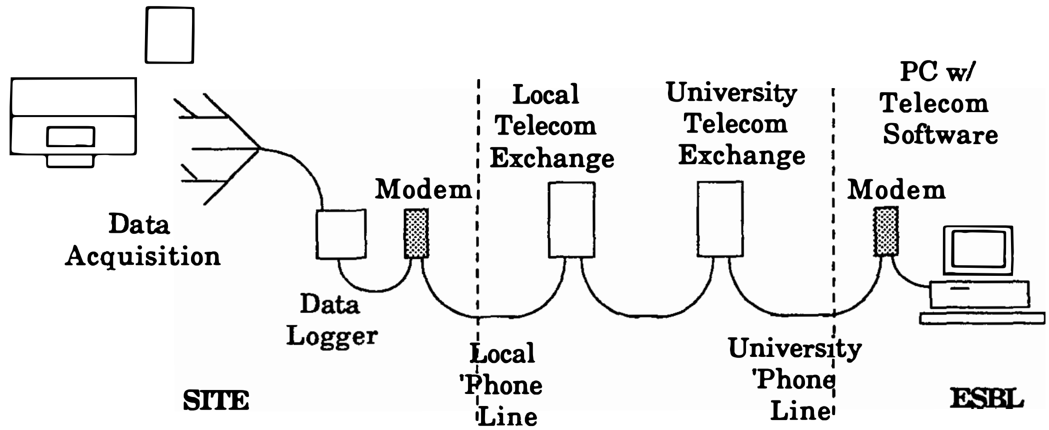
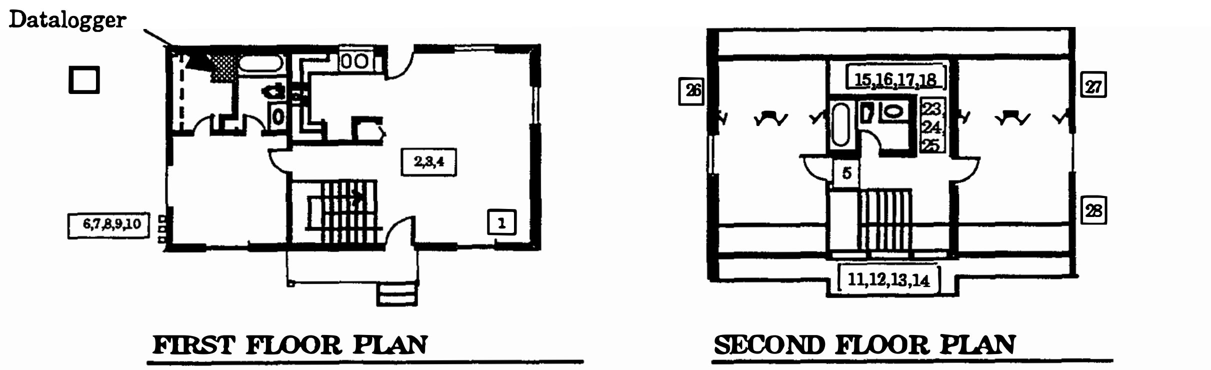


Figure 3-20
Data Acquisition System

A plan of instrument locations is provided in Figure 3-21.



SENSOR	LOCATION	SENSOR	LOCATION
1	South Wall Temperature	13	Roof Shingle Temperature
2	Ambient Air Temperature	14	Roof Shingle Temperature
3	Mean Radiant Temperature	15	Envirovent, Return Inlet
4	Relative Humidity	16	Envirovent, Supply Outlet
5	Upstairs Ambient Air	17	Envirovent, Exhaust Inlet
6	Meter (main)	18	Envirovent, Exhaust Outlet
7	Meter (downstairs space heaters)	23	Hot Water Inlet Temperature
8	Meter (upstairs space heaters)	24	Hot Water Outlet Temperature
9	Meter (heat pump)	25	Water Flow
10	Meter (water heating)	26	Wood Moisture Sensor (Northwest)
11	Roof Shingle Temperature	27	Wood Moisture Sensor (Northeast)
12	Roof Shingle Temperature	28	Wood Moisture Sensor (Southeast)

Figure 3-21
Instrumentation Plan

Conduits for low-voltage instrument wiring, along with power supply wiring and phone (modem) wiring were installed by the Demonstration House project electrical contractor during construction, and the work billed separately from the house work proper. The plumbing and mechanical subcontractors were also involved in arranging for thermocouples and other instrumentation in the water supply and HVAC systems; again, the work was done simultaneously with, but billed separately from, the house construction.

Other Test Instrumentation

The Demonstration House project offered opportunities to perform some tests collateral to the main energy conservation focus, but still pertinent to the overall goal of improving the performance of residential construction. Two questions have emerged regarding SIP panel homes: does moisture accumulate in panel joints, and are roof shingle temperatures higher on panel than on conventionally built roofs?

The first question derives from the occasional occurrence of "shingle ridging" on some SIP panel home roofs — places where panel joints become conspicuous because shingles form a bump or ridge over the joint (Andrews, 1988, p. 47). The Structural Insulated Panel Association formed a technical subcommittee to examine this phenomenon, and initial theories centered on moisture migrating into the panel joint from inside the home, causing swelling of the outer OSB panel skin or a bubble in the damp roofing felt over the panel joint.

The second phenomenon appeared as accelerated aging of asphalt roof shingles on some SIP panel roofs, as noted by the Asphalt Roofing Manufacturers Association, SIPA and others (Andrews, 1992, p.74).

Both of these problems occur rarely, and are subjects of some debate. To gather data on moisture in panel joints, the Demonstration House was fitted with moisture sensors in upstairs panel joints (Figure 3-22). These consist of electrodes screwed into the panel splines at specified spacings, and monitored electrical resistance measurements through the OSB splines compared to similar samples of material at known moisture levels.

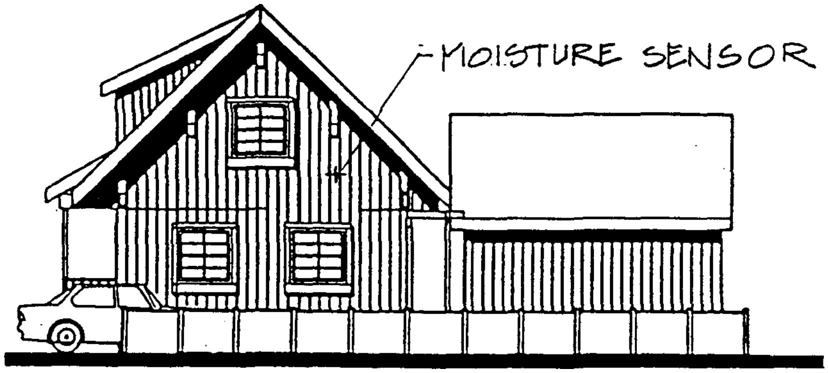


Figure 3-22
Panel Joint Moisture Sensor Locations

Roof shingle temperatures are likewise measured with four thermocouples installed under shingles on adjacent dormer (SSIC panel) and porch (conventionally framed) roof pitches (Figure 3-23 and Table 3-3).

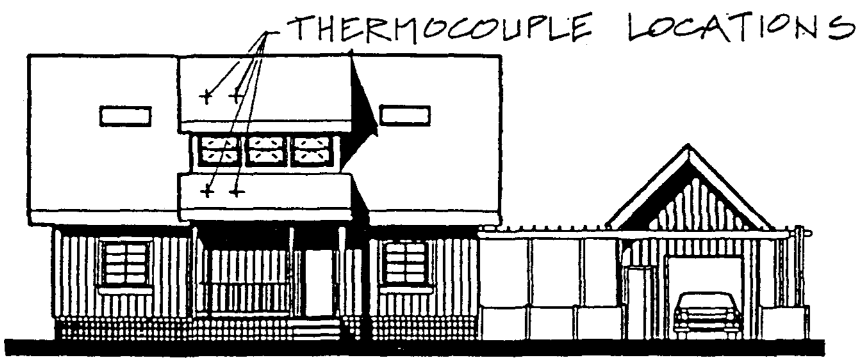


Figure 3- 23
Shingle Temperature Sensor Locations

3.3 ENERGY

Goals

As stated earlier, the Demonstration House project seeks to show that a house built of SSIC panel construction can provide energy performance equal to an "architecturally equivalent" conventionally framed Reference House which meets Long Term Super Good Cents energy standards (details of the Bonneville Power Adminstration Super Good Cents Program are given in Appendix 8.1).

The general procedure for assessing Demonstration House energy performance was to develop the house design fully enough to describe its conventionally framed Reference House version in detail, and use that description to model Reference House energy performance with DOE 2 and other software as appropriate. The resulting energy budget formed the performance target for the SSIC panel Demonstration House.

Modeling

The energy modeling process proceeded as shown in Figure 3.24. The general process was as follows: staff engineers first used a heat loss spreadsheet to model the impacts of several significant design varibles — envelope R value (panel thickness) options, presence or absence of skylights, and glazing U values, for example — and then employed WATTSUN to verify Super Good Cents compliance of the Reference House and comparative energy performance (UA) for the Demonstration House. DOE 2 was finally used to provide more detailed modeling of the energy performance of the two versions of the house. These simulations were repeated as the design developed. Each type of simulation is described in more detail below.

This iterative design process involved many specific backgroung studies, for example: to find the minimum uniform insulation thickness, to find the minimum net insulation volume, to optimize R value per dollar vs. panel core thickness, to determine R values for alternative panel core compositions, to examine the energy inpacts of dormers and skylights, and determine envelope vs. window R value energy tradeoffs. Through such comparisons the building design was optimized for cost energy performance.

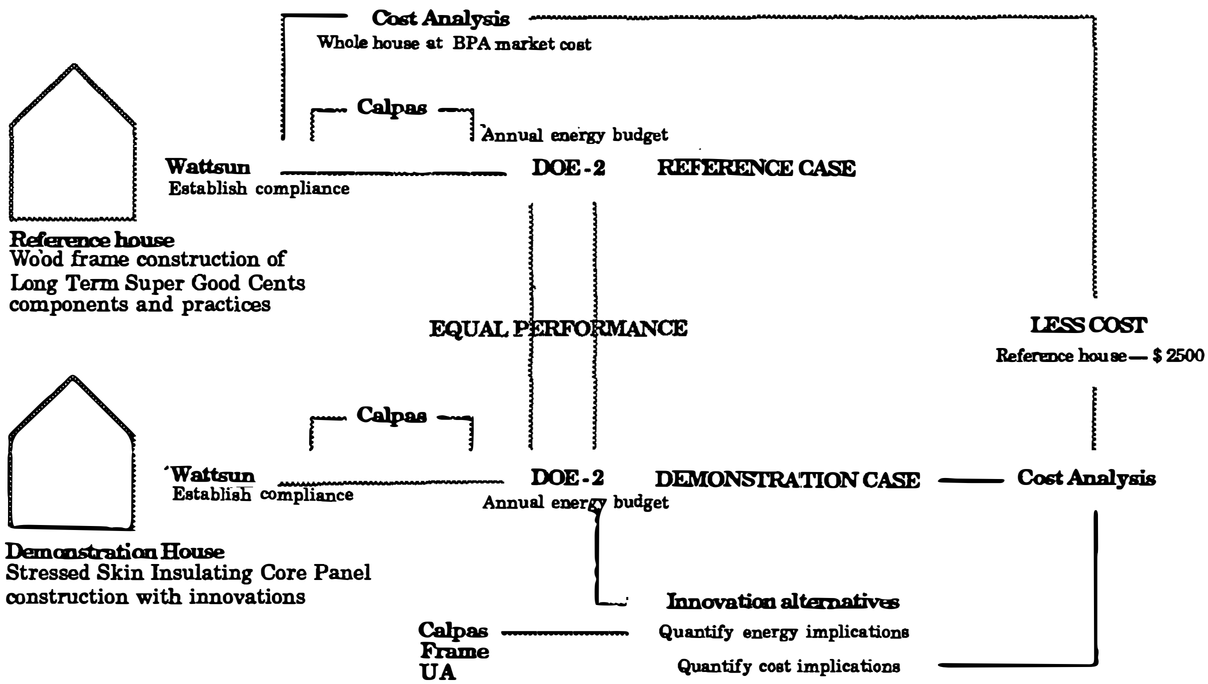


Figure 3-24
Demonstration House Energy Design Process

Heat Loss Spread Sheets

A typical heat loss spread sheet is given in Tables 3-3 and 3-4. The goal in this case is to find the optimal net insulation (foam) volume, as a step toward minimizing the envelope cost at a given energy performance level. Table 3-3 details the heat loss of the house under the stated ambient conditions and assumptions, with a building envelope consisting of 6" nominal floor, 8" nominal walls and 10" nominal roof panels. The net heat flow Q derived is 6400 Btu/hr.

Table 3-4 then examines how variations from these base panel thicknesses interact, with first the wall, then the floor, and finally the roof panel thickness held constant as the other two items are varied. Highlighted areas indicate the most economical ranges of ceiling, floor and wall insulation thicknesses which provide net heat flows below the target value of 7400 Btu/hr. This target was selected to allow for cost optimization within an acceptable range of thermal performance.

	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			

Table 3-3
Demonstration House Envelope Heat Loss

Note that panel core thicknesses considered are not simply the "stock" thicknesses offered by panel manufacturers, which (3-1/2", 5-1/2", 7-1/4", etc.) match common lumber sizes — rather, this analysis explores a variety of possible thicknesses in 1/2" increments, to reveal optimization opportunities that might be masked by conventional practice. Several such analyses made it possible to optimize the distribution of insulation volume for maximum cost effectiveness. The resulting indicated panel thicknesses were permitted small adjustments where necessary to accommodate standard lumber dimensions. The final panel thicknesses derived from this process were floor 5-1/2" nominal core thickness (R=25 total), walls 7-1/4" core (R=32 total) and roof 9-1/4"core (R=38 total).

WATTSUN Simulations

Table 3-5 Summarizes the Super Good Cents prescriptive standards applicable to the SSIC Demonstration House (climate Zone 1<6000 heating degree days).

Table 3.6 shows a WATTSUN output — component performance UA of 235 vs. 243 Btu/hr-°F for the Reference and Demonstration Houses, respectively; and annual energy budgets of 1.30 vs. 1.43 kWh/ft^2-yr, equivalent to roughly 5.0 MBtu/yr.

	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	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
7	3.00	7344	7229	7130	7043	6967	6899	6838	6784	6735	6690
8	3.50	7249	7134	7035	6948	6872	6804	6743	6689	6640	6595
9	4.00	7170	7055	6956	6869	6793	6725	6664	6610	6561	6516
10	4.50	7103	6989	6889	6802	6726	6658	6598	6543	6494	6449
11	5.00	7046	6931	6832	6745	6669	6601	6540	6486	6437	6392
12	5.50	6997	6882	6783	6696	6619	6551	6491	6436	6387	6342
13	6.00	6954	6839	6739	6653	6576	6508	6448	6393	6344	6299
14	6.50	6915	6800	6701	6614	6538	6470	6409	6355	6306	6261
15	7.00	6881	6767	6667	6580	6504	6436	6376	6321	6272	6227
16	7.50	6851	6736	6637	6550	6474	6406	6345	6291	6242	6197
17	8.00	6824	6709	6610	6523	6446	6379	6318	6264	6214	6170
18	8.50	6799	6684	6585	6498	6422	6354	6293	6239	6190	6145
19	9.00	6777	6662	6563	6476	6399	6332	6271	6216	6167	6122
20	9.50	6756	6642	6542	6455	6379	6311	6251	6196	6147	6102
21	10.00	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											

tables, ins thickness 4/9/92

	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			Floor: AP12 (row)			Ceiling = 9.375					
25			Wall: R8 (column)			Glazing = .35					
26						Q target ≤ 7400 btu/hr					
27			Floor insulation thickness (inches) vs. wall ins thickness								
28	6399	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00
29	5.50	8104	7456	7021	6709	6473	6289	6141	6020	5919	5833
30	6.00	8061	7413	6978	6665	6430	6246	6098	5977	5876	5790
31	6.50	8022	7375	6940	6627	6392	6208	6060	5939	5838	5752
32	7.00	7989	7341	6906	6593	6358	6174	6026	5905	5804	5718
33	7.50	7958	7311	6876	6563	6327	6144	5996	5875	5774	5688
34	8.00	7931	7283	6848	6536	6300	6116	5969	5848	5746	5661
35	8.50	7906	7259	6824	6511	6276	6092	5944	5823	5722	5636
36	9.00	7884	7236	6801	6489	6253	6069	5922	5800	5699	5613
37	9.50	7864	7216	6781	6468	6233	6049	5901	5780	5679	5593
38	10.00	7845	7197	6762	6449	6214	6030	5882	5761	5660	5574
39	10.50	7828	7180	6745	6432	6197	6013	5865	5744	5643	5557
40	11.00	7812	7164	6729	6416	6181	5997	5849	5728	5627	5541
41	11.50	7797	7149	6714	6402	6166	5982	5835	5713	5612	5526
42	12.00	7783	7136	6701	6388	6152	5969	5821	5700	5599	5513
43											
44											
45											

Table 3-4
Demonstration House Envelope Thickness Optimization Process

Insulation Requirement	Envelope Component
R=49	Advanced Attic
R=38	Vaulted Ceiling
R=26	Advanced Walls
R=30	Under Floor
R=15	Slab-on-grade Edge
R=21	Basement Wall (slab edge R=5)
U=0.35	Windows

Table 3-5
Super Good Cents Program Standards Summary
(Climate Zone I — source: BPA, 1988)

DOE 2 Modeling

Relatively simple energy performance simulations such as those described above were iterated until the the ESBL researchers were satisfied that a promising building envelope had been achieved; then the greater sophistication of the DOE 2 program was employed to give a more precise estimate of comparative Reference and Demonstration House performance. Table 3.7 excerpts a report from consulting engineer Michael Hatten summarizing the input information and DOE 2 results — 45.63 MBtu vs. 45.50 MBtu total energy required for the Reference and Demonstration Houses, respectively, or about 8.34 MBtu/yr for heating the Demonstration House.

TTSUN 5.2 SUPER GOOD CENTS (1991 MCS) COMPLIANCE REPORT 04/24/92

FILE: C:WATTSUN5DH 1.WS HOUSE ID:

Site:		Analyst:	
		Jurisdiction:	
		Utility:	
Homeowner:		House Type:	Single Family/Duplex
		Floor Area:	1296 ft2
Builder:		Weather Data:	Salem, OR
		Climate Zone:	1

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

	REFERENCE	PROPOSED	
COMPONENT PERFORMANCE	235	243	Btu/hr-F
ENERGY BUDGET	1.30	1.48	kWh/ft2-yr

REFERENCE DESIGN

Component	Description	Reference Value	X	Area =	UA
Floor	R30 vented joist	U-0.029		648	18.8
Glazing @15%	0.35 U-value	U-0.350		194.4	68.0
Doors	Metal R5 base case	U-0.190		42.0	8.0
AG Wall	R21+R5 ADV	U-0.041		1250	51.2
Ceiling, Attic	R49 blown Attic ADV	U-0.020		818	16.4
Infiltration	Standard air sealing	ACH-0.350		11335ft3	72.6
		Reference UA			235

PROPOSED DESIGN COMPONENTS

Component	Description	Value	X	Area =	UA
Floor	**R-CONTROL 5.625"	U-0.044		648	28.5
Glazing @10%	3Gl Vinyl 1/2"	U-0.400		136.0	53.0*
Doors	Metal R-5 base case	U-0.190		42.0	8.0*
AG Wall	**R-CONTROL 7.375"	U-0.036		1308	47.1
Skylights @2%	3Gl Vinyl 1/2" w/low-E	U-0.420		24.0	9.6*
Ceiling	9.25" Core Stress Skin Panel	U-0.030		794	23.8
Infiltration	Standard Air Sealing	ACH-0.350		11335ft3	72.6
		Proposed UA			243

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.

Page 1

Table 3-6
WATTSUN Super Good Cents Compliance Report

Input Assumptions

Input assumptions of note include: (1) building envelope thermal performance values, (2) peak internal loads, (3) load schedule definitions, (4) hot water load and schedule, and (5) heating system efficiencies and schedules.

Building Envelope Thermal Performance. The input for the building envelope components for the reference and demonstration house was calculated to account for the effects of the framing. The following inputs were used:

Reference House

Effective R-values and U-coefficients

Walls:	R-26 nominal insulation with advanced framing:	R-23.01
Roof:	R-38 nominal insulation between rafters:	R-37.38
Floor:	R-30 nominal insulation between joists:	R-26.4
Windows:	Vinyl frame, low-E, argon fill	U=0.35
Skylights:		U=0.286

DOE2 input

Walls:	THICKNESS=0.5833 ft. DENSITY=6.3 lb/cf	CONDUCTIVITY=0.02535 Btu/hr-ft-F SPECIFIC-HEAT=0.24 Btu/lb-F
Roof:	THICKNESS=1.125 ft. DENSITY=4.73 lb/cf	CONDUCTIVITY=0.03009 Btu/hr-ft-F SPECIFIC-HEAT=0.23 Btu/lb-F
Floor:	THICKNESS=0.625 ft. DENSITY=5.49 lb/cf	CONDUCTIVITY=0.02367 Btu/hr-ft-F SPECIFIC-HEAT=0.24 Btu/lb-F
Windows:	GLASS-CONDUCTANCE=0.39	SHADING-COEF=0.75
Skylights:	GLASS-CONDUCTANCE=0.312	SHADING-COEF=0.75

Table 3-7
<u>Summary</u> of DOE 2 Inputs and Results

Demonstration House

Effective R-values and U-coefficients

Walls:	7-3/8" polystyrene panel:	R-29.47
Roof:	9-3/8" polystyrene panel:	R-37.17
Floor:	5-1/2" polystyrene panel:	R-22.25
Windows:	Vinyl frame, low-E, argon fill	U=0.35
Skylights:		U=0.286

DOE2 input

Walls:	THICKNESS=0.58333 ft. DENSITY=3.5 lb/cf	CONDUCTIVITY=0.0198 Btu/hr-ft-F SPECIFIC-HEAT=0.29 Btu/lb-F
Roof:	THICKNESS=0.84375 ft. DENSITY=3.5 lb/cf	CONDUCTIVITY=0.0227 Btu/hr-ft-F SPECIFIC-HEAT=0.29 Btu/lb-F
Floor:	THICKNESS=0.4583 ft. DENSITY=3.5 lb/cf	CONDUCTIVITY=0.0206 Btu/hr-ft-F SPECIFIC-HEAT=0.29 Btu/lb-F
Windows:	GLASS-CONDUCTANCE=0.39	SHADING-COEF=0.75
Skylights:	GLASS-CONDUCTANCE=0.312	SHADING-COEF=0.75

Peak Internal Loads. Peak internal loads include maximum occupants per zone, peak lighting per zone, and peak miscellaneous electric use per zone. The following table summarizes input assumptions made for peak internal loads.

Table 3-7 (continued)
Summary of DOE 2 Inputs and Results

Zone/space	Occupants	Lighting	Electrical
Living Room/ Entry Way	2	75 watts	250 watts
Kitchen	1	88 watts	17,750 watts
Bath/Laundry (dwnstrs)	1	272 watts	9,750 watts
Bedrm (dwnstrs)	1	22 watts	50 watts
Bath (upstairs)	1	272 watts	0 watts
E.Bedrm (upstrs)	1	22 watts	50 watts
W.Bedrm (upstrs)	1	22 watts	50 watts

Load Schedules. In DOE2, all peak load inputs are modified by schedule inputs. The following schedules were defined to approximate occupancy, lighting diversity, and equipment use diversity in the zones described above.

Occupancy Schedules

Schedule	Hours	Percent Occupancy
Living Room:	1 - 7	0%
	8	75%
	9 - 12	25%
	13 - 16	0%
	17	75%
	18 - 20	100%
	21 - 24	25%
Bath Room:	1 - 7	0%
	8	100%
	9 - 19	0%
	20	100%
	21 - 24	0%

Table 3-7 (continued)
Summary of DOE 2 Inputs and Results

Bed Room:	1 - 7	100%
	8 - 20	0%
	21 - 24	100%

Lighting Schedules

Schedule	Hours	Percent Occupancy
Bath Room:	1 - 5	0%
	6 - 8	50%
	9 - 20	5%
	21	100%
	22 - 24	20%
Other Rooms:	1 - 5	0%
	6 - 8	20%
	9 - 10	90%
	11 - 17	10%
	18 - 20	60%
	21 - 24	20%

Equipment Schedules

Schedule	Hours	Percent Occupancy
Kitchen:	1 - 6	0.1%
	7 - 8	5%
	9 - 17	0.1%
	18 - 19	17.5%
	20 - 24	0.1%
Laundry:	1 - 9	0%
	10	12.5%
	11 - 20	0%
	21	12.5%
	22 - 24	0%
Other Rooms:	1 - 24	10%

Table 3-7 (continued)
Summary of DOE 2 Inputs and Results

Hot Water Load and Schedule. The peak hot water load was input at 35,000 Btu/hour. This is approximately 50 gallons per hour. The peak load was adjusted by the following diversity schedule.

Schedule	Hours	Percent Occupancy
DHW	1 - 6	1%
	7 - 9	20%
	10 - 16	1%
	17 - 20	12%
	21	20%
	22 - 24	2%

Heating System Efficiencies and Schedules. The heating (and ventilating) systems were modeled as a mix of a heat recovery heat pump system and baseboard heaters. The domestic water heater was modeled as a heat pump water heater with electric resistance backup. The following input summaries describe the systems, as modeled:

System Name: LIVE-SYST

System Type: Heat pump with integrated heat recovery from exhaust-air stream

Serves: Living Room/Entry
Kitchen
Bath (downstrs)
Bath (upstrs)

Heating Capacity: 7,200 Btu/hr at a constant C.O.P. of 3.1
2 kw backup heating elements

Cooling Capacity: 9,000 Btu/hr at a constant C.O.P. of 2.0

Fan Inputs:
Supply kw: 0.074 kw
Exhaust kw: 0.046 kw
Vent Rate: 95 cfm

Table 3-7 (continued)
Summary of DOE 2 Inputs and Results

System Name: MASTBED-SYST

System Type:	Baseboard heater
Serves:	Bedroom (downstairs)
Heating Capacity:	2,559 Btu/hr (electric resistance)
Cooling Capacity:	No cooling
Fan Inputs:	No fans

System Name: EASTBED-SYST

System Type:	Baseboard heater
Serves:	Bedroom (downstairs)
Heating Capacity:	2,559 Btu/hr (electric resistance)
Cooling Capacity:	No cooling
Fan Inputs:	No fans

System Name: WESTBED-SYST

System Type:	Baseboard heater
Serves:	Bedroom (downstairs)
Heating Capacity:	2,559 Btu/hr (electric resistance)
Cooling Capacity:	No cooling
Fan Inputs:	No fans

System Name: DHW Heater

System Type:	Electric Water Heater
Efficiency:	Ave. C.O.P. of 1.41 (assumes 50% heat pump operation & 50% backup heat operation)
Capacity:	23,000 Btu/hr

The following schedules were input to control the heating (and ventilating) systems:

Schedule	Hours	Percent Occupancy
Fans	1 - 5	off
	6 - 24	on
Heating	1 - 24	65 deg F
Cooling	1 - 24	78 deg F

Table 3-7 (continued)
Summary of DOE 2 Inputs and Results

With these schedules, the heat pump fans operate continuously when the fans are scheduled on. The compressor will cycle as necessary to meet space heating or cooling load. The fans and compressor will cycle as needed to meet load when the fans are scheduled off.

The baseboard heaters cycle as needed to maintain 65 degrees F in the zones in which they are located.

Updated Results of the Models

Attached to this letter report are complete DOE2 output reports for the updated models of the Reference House and Demonstration House. The updated results are summarized in the tables below.

Building Energy Performance Summary

Energy Use Category	Reference (no skylights)	Reference (skylights)	Demonstration (skylights)
Heating	9.39 MBtu	8.59 MBtu	8.34 MBtu
Cooling	0.72 MBtu	1.22 MBtu	1.26 MBtu
Fans	2.85 MBtu	3.05 MBtu	3.12 MBtu
Dom. Hot Water	13.30 MBtu	13.30 MBtu	13.30 MBtu
Lights	4.84 MBtu	4.84 MBtu	4.84 MBtu
Misc. Equip.	14.62 MBtu	14.62 MBtu	14.62 MBtu
TOTAL	45.73 MBtu	45.63 MBtu	45.50 MBtu

Table 3-7 (continued)
Summary of DOE 2 Inputs and Results

3.4 BUILDING ENVELOPE

Integral with the energy simulation activity was the process of designing the Demonstration House building envelope. While the basic configuration of the house had been established by earlier design cycles, decisions regarding panel thickness, window details, etc. brequired design studies to explore their implications. Typically, cost and energy implications of each idea were examined simultaneously, reflecting the dual goals of the Demonstration House project. The DOE 2 report summarized in Table 3-7, for instance, includes both skylight and non-skylight design versions of the Reference House; this option was studied for its impact on daylighting and cross ventilation in the upstairs bedrooms.

Both daylighting and natural ventilation design studies involved ESBL test facilities — daylighting using the Mirror Box Artificial Sky instrument, and cross ventilation using the Low Speed Boundary Layer Wind Tunnel. The design studies are summarized below; the facilities and the complete test details will be described in subsequent ESBL reports.

Daylighting Tests

A complex set of variables affected the initial sizing of windows. Cost was a prime influence; for example, all opening widths were kept to the four foot horizontal panel module, eliminating costly discarded panel window cutouts. Thermal performance was another consideration, and when this was coupled with emergency egress requirements for bedrooms, 4'- 0" x 4'- 6" casement windows were chosen. Finally, architectural considerations suggested limiting the variety of window types used in the house. As a result, the 4'-0" x 4'-6" window was used in 8 of the house's 13 window locations. Structural considerations led to elimination of a planned downstairs bathroom window, and at this point daylight testing began. The initial design is shown in Figure 3-25.

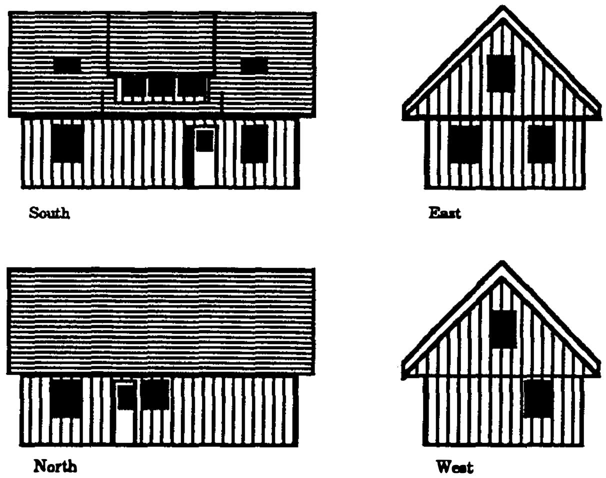


Figure 3-25
Initial Window Design

The daylighting tests involved construction of a 1/2" = 1'-0" scale model of the house shell. All windows were modeled at their net glazing sizes. Doors were modeled in the open position. Skylights were given slats installed at a 22° angle (normal to horizontal) to exclude midsummer and admit midwinter direct sunlight (Figure 3-26).

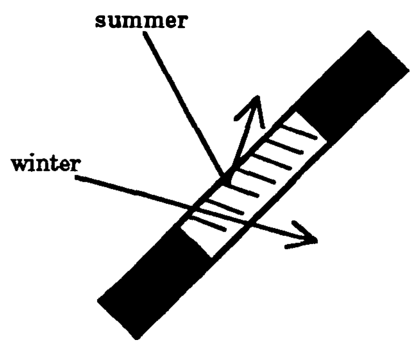


Figure 3-26
Skylight Shading Detail

These slats simulated a shading device under consideration in the early stages of design which was eventually abandoned because of its incompatibility with operable skylights. Interior doors were ommitted (open position) in the model except in the upstairs bathroom, which is daylit only from the stair hall (Figure 3-27).

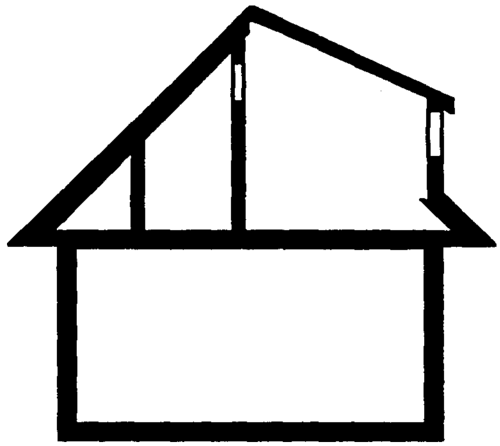


Figure 3-27
Relight From Stair Hall To Bath

A reduction factor was applied to the data to account for the light transmittance of the glass, plus insect screening over the entire net window opening, as follows: typical low-e, argon-filled, double glazing -- transmittance = .78; 10% insect screening -- transmittance = .90; net reduction factor = .78 x .90 = .70.

The model was placed inside the Artificial Sky instrument (Figure 3-28), which provides a lighting distribution approximating an idealized overcast sky.

An array of photocells inside the model (Figure 3-29) compared light levels at various inside locations to the outside overhead brightness, and expressed inside light levels as "daylight factors." These were translated into Springfield daylight conditions and compared to light levels recommended in *Sun, Wind, and Light* and the *IES Lighting Handbook*, 1987.

When initial results indicated that daylighting greatly exceeded the proposed goals, strategies for reducing non south-facing glazing were investigated, including ideas on ways to use windows narrower than the panel module without waste of panel material. During this process other factors besides daylighting came increasingly into play: thermal performance, cross ventilation, opportunities for furniture placement, emergency egress requirements, view lines from within the house, and appearance issues.

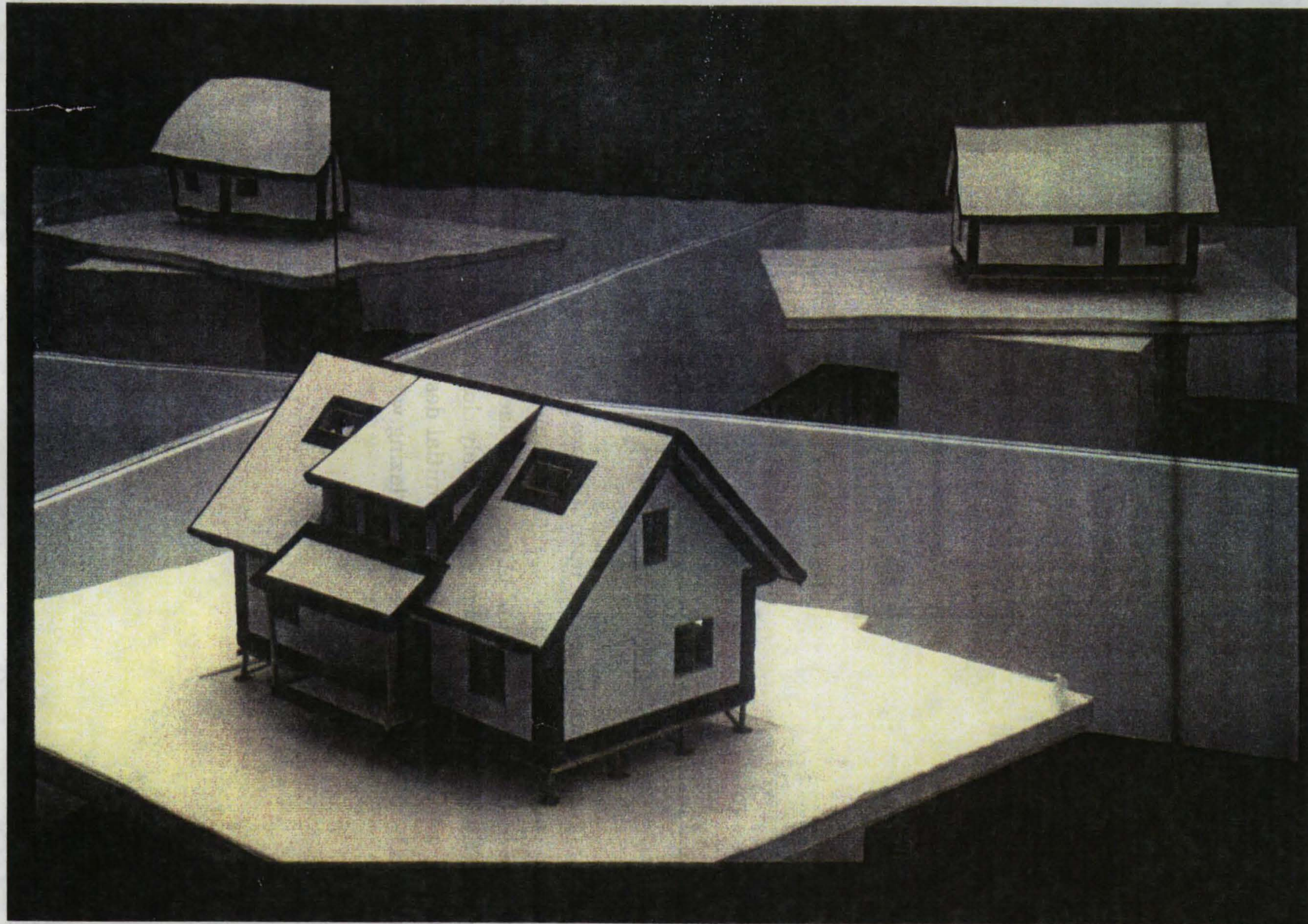
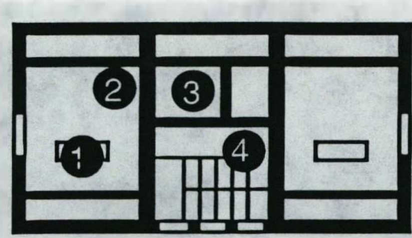
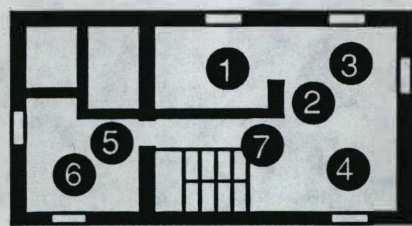


Figure 3-28
Daylighting Model in Mirror Box Artificial Sky



Upstairs



Downstairs

Figure 3-29
Lighting Sensor Locations

Data from tests during this process are reported in Table 3-8. The results are listed in terms of daylighting factors (df).

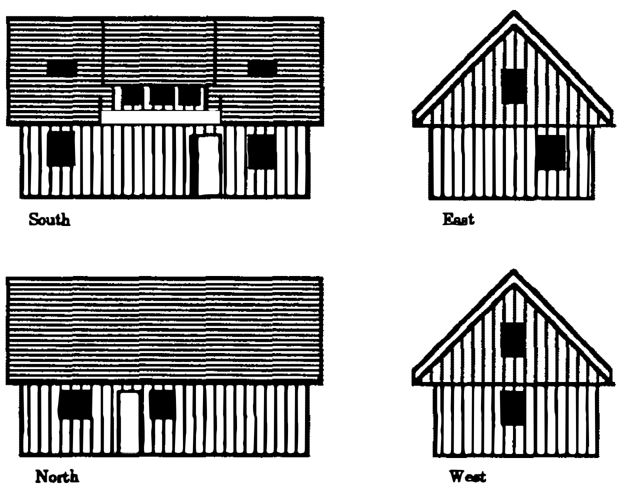
The compromise finally settled upon (Figure 3-30) included a shift from single-hung to casement type windows, rearrangement of some window locations, and a large reduction in the amount of non south-facing glazing. While still somewhat overlit, the design results come considerably closer to the intended goals. Overall glazing was reduced by 29% from the initial design; south-facing glazing was reduced by 5%; and non south-facing glazing was reduced by 46%.

Downstairs:	Test 1	Test 2	Test 3	Goal
sensor/location				
1 Kitchen	4.6	5.7 [1]		2
2 Closet	4.1	3.5		1
3 Dining	6.8	6.0		1+
4 Living	6.5	4.6		1
5 Bed (corner)	3.4	2.2	2.4	.5
6 Bed (center)	5.3	4.8	3.8	.5
7 Hall	1.8	1.7		.5 -

Upstairs:	Test 1	Test 2	Test 3	Test 4	Test 5	Goal
skylight blind	open	open	closed	open	closed	
sensor/location						
1 Bed (corner)	3.6	2.3	0.7	3.1	1.3	.5
2 Bed (center)	5.5	3.8	0.9	5.0	1.7	.5
3 Bathroom	0.1	0.1 [2]				.5
4 Landing	2.3					.5 -

1. Sensor height raised to counter level in model - 1.5" = 3'.
2. Bathroom door closed during this test

Table 3-8
Demonstration House Daylighting Test Results
(daylight factors)



run.

Figure 3-30
Final Window Design

Wind Tunnel Tests

Concurrent with the daylighting tests were wind tunnel tests to ensure that the window design would provide adequate natural ventilation to cool the house — following the energy design strategy described in Section 3-3 to meet the small Springfield cooling load of 250 degree days (base 78°F). The configuration of openings in most of the rooms of the house followed established guidelines to promote good air flow; for each the upstairs bedrooms, however,the ventilation openings consisted of a window in the gable end wall and an opening skylight, a configuration unusual enough to merit performance testing.

Consequently a 1/4" = 1'-0" scale model of the house was built, minus both upstairs bedrooms. A separate upstairs bedroom model was built which could be attached at either the east or west position, and a similar movable transparent plastic bedroom model was also constructed. By interchanging these "plugs," both east and west bedrooms could be simulated with the transparent model. Figure 3-31 shows the transparent plastic model, which permitted visualization of air flows through the bedroom as well as internal air speed measurements.

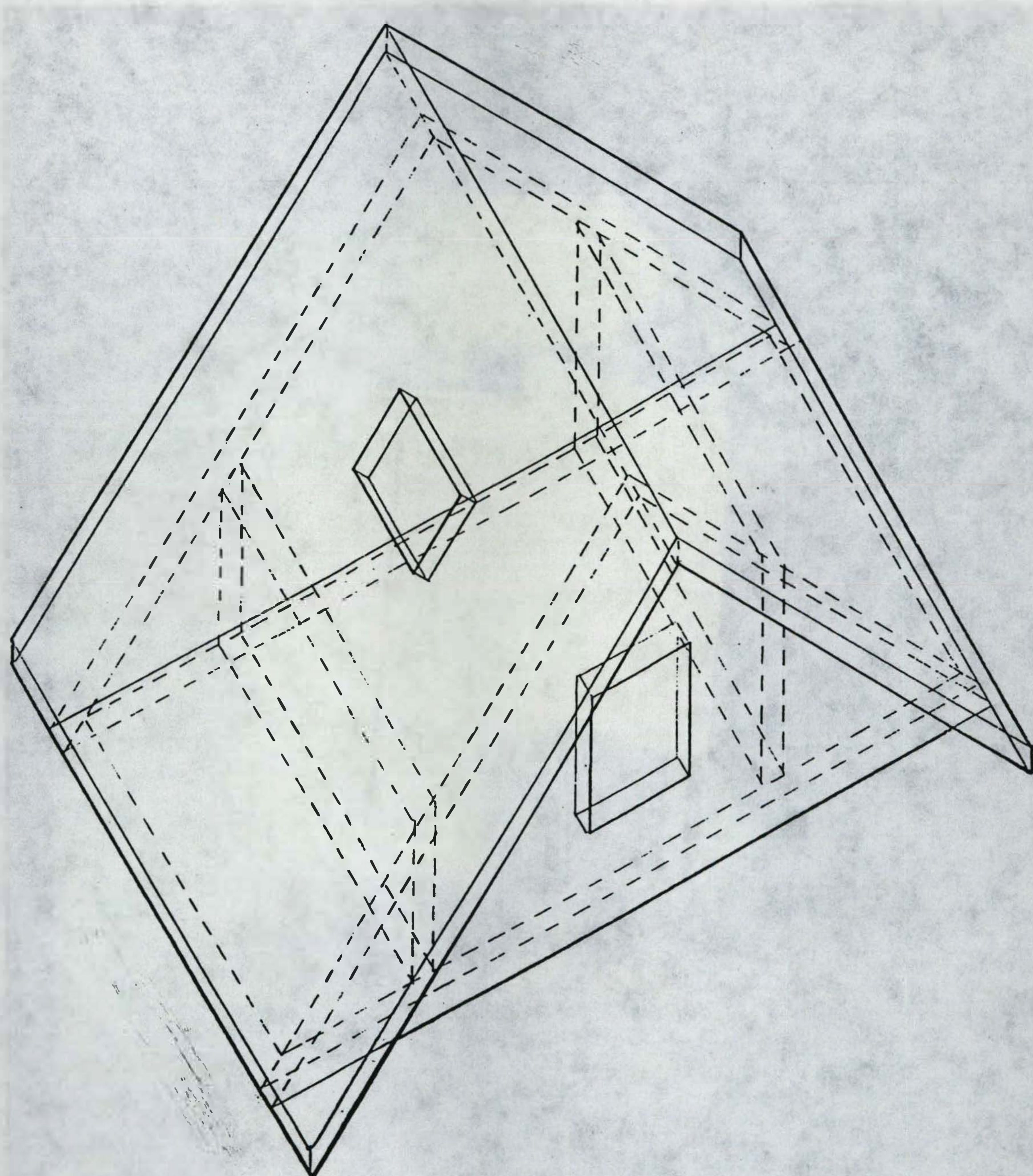


Figure 3-31
Upstairs Bedroom Air Flow Model

The assembled wind tunnel model, complete with its surroundings and an air speed probe, is shown in Figure 3-32.

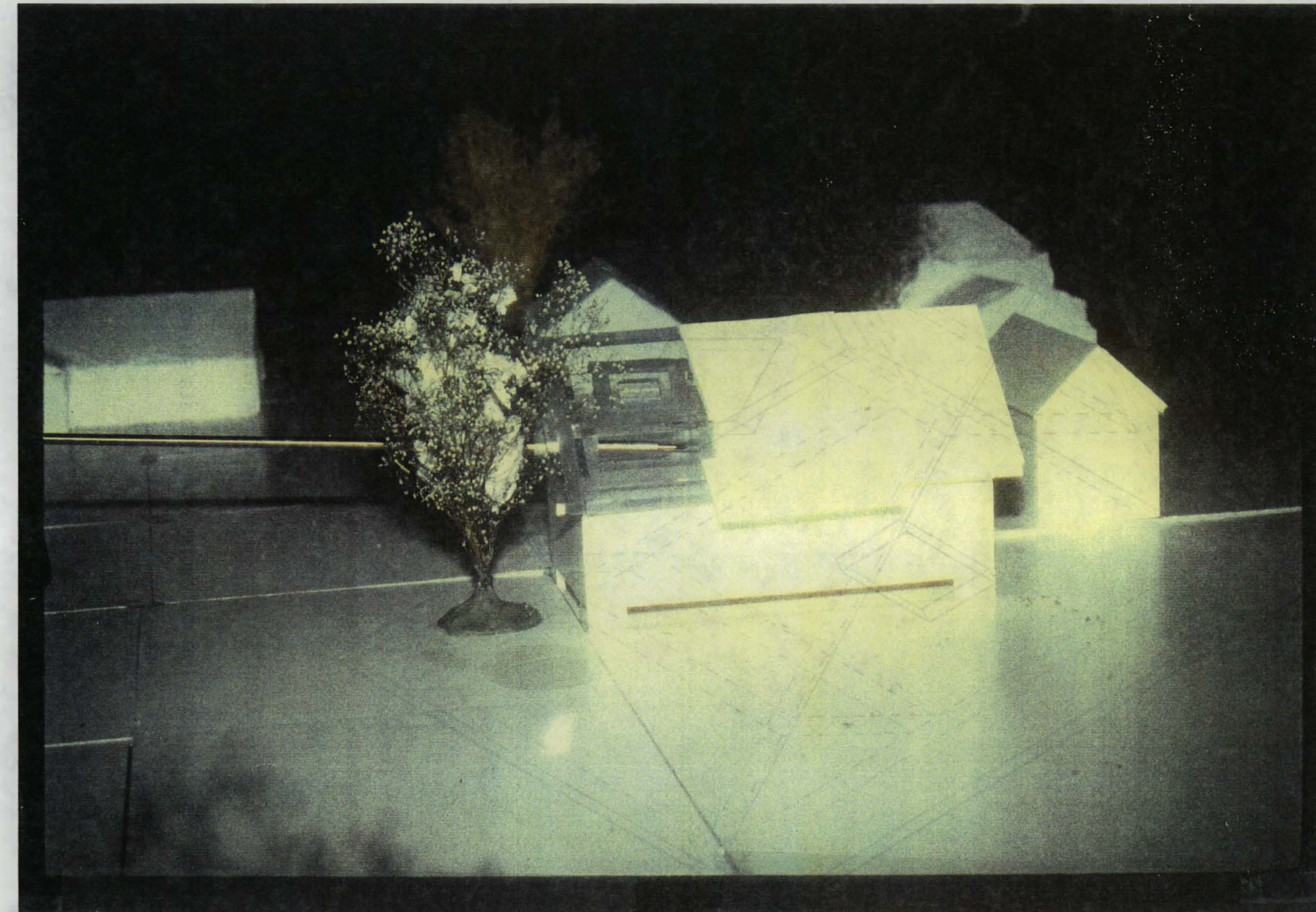
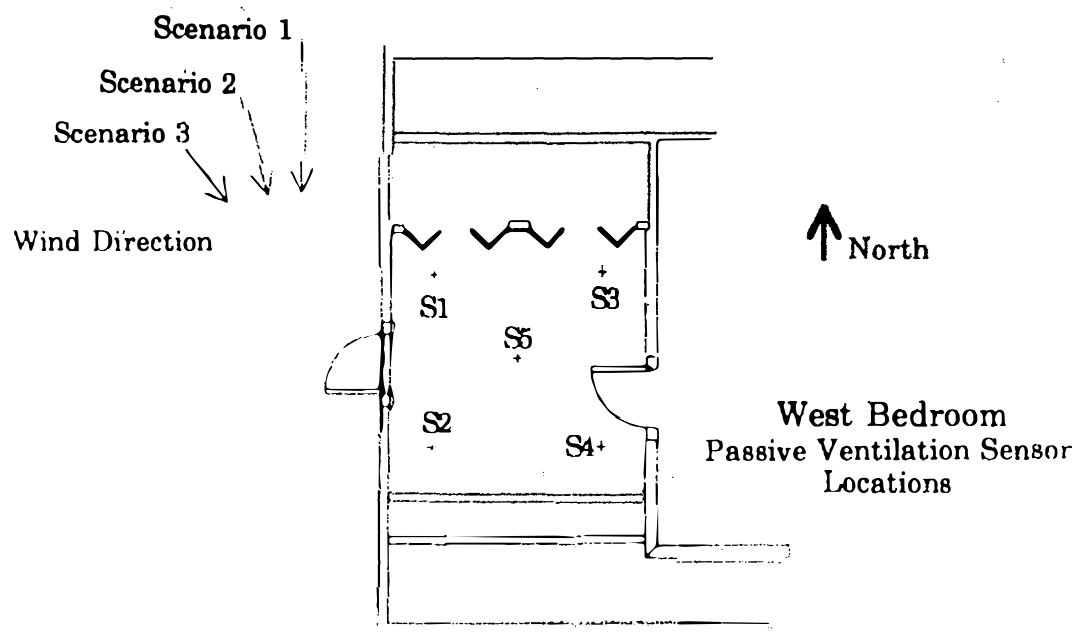


Figure 3-32
Demonstration House Air Flow Model in Boundary Layer Wind Tunnel

Figure 3-33 shows the result of tests of the west upstairs bedroom, for three wind directions ranging from north to north-northwest, at five probe locations in the bedroom. Such tests helped establish the importance of several factors: the direction of casement window opening relative to the prevailing Springfield winds, the degree of skylight opening, and the impact of open bedroom doors for greatest cooling effect. A series of such tests confirmed that the chosen design strategy would work — essentially all the cooling load could be provided for through natural ventilation.



VENTILATION STUDIES

Scenario	Wind Direction	Ambient v (Wind Velocity)	Velocity at Sensor Location: ft/sec (%/ambient) S1	S2	S3	S4	S5
1. N wind	North (0°)	9.25 ft/sec	0.03 (0.32%)	0.04 (0.43%)	0.007 (0.76%)	0.007 (0.76%)	–
2. NW wind	15° W of N	9.25 ft/sec	–	–	0.03 (0.32%)	0.04 (0.43%)	0.10 (1.08%)
3. NW wind	22.5° W of N	9.25 ft/sec	–	–	0.32 (3.46%)	0.17 (1.84%)	0.14 (1.51%)

Figure 3-33
Upstairs Bedroom Air Flow Probe Locations and Test Results

3.5 COST

The Demonstration House project sought to achieve twin goals of energy performance and cost competitiveness. Throughout the design process each step was measured against these standards, as illustrated in Figure 3-34.

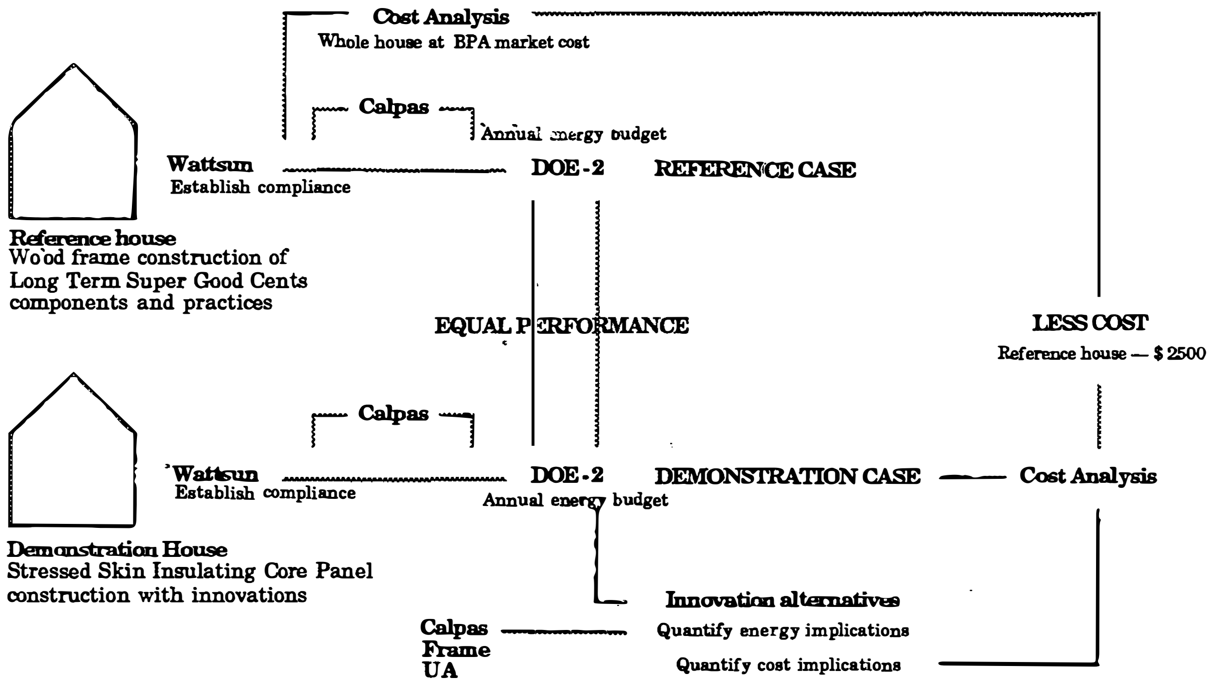


Figure 3-34
Demonstration House Cost and Energy Analysis
Design Process

Because of its cost competitiveness a 1-1/2 story design was developed, from among five designs examined, as the final Demonstration House. An important part of the design development work was the elimination of the projected $3682 cost disadvantage of the this best design, plus finding an additional $2000 in savings to offset the Long Term Super Good Cents rebate.

As in the case of energy performance, the cost reduction effort consisted of a series of background studies. First a survey of industry panel prices was conducted, to develop a current sense of the average and range of this basic information. This was elaborated to determine panel labor and materials costs.

Price data were also processed to permit comparisons of building envelope R value vs. cost.

For design optimization purposes, costs of various dormer and skylight configurations were developed. Other studies compared panel size vs. waste costs, cost effectiveness of various floor spans, comparative costs of caulks vs. gaskets, and alternative costs of several window installation details. All such studies were used to optimize the Demonstration House design.

As a first estimate of total project costs, the building shell costs derived in earlier Demonstration vs. Reference House studies were expanded to include the non-shell costs such as plumbing, electrical, roofing and finishes — plus soft costs — which had been assumed to be equal between the Demonstration and Reference houses. The first such whole building estimate is given in Table 3-9.

Cost Estimate Confirmation

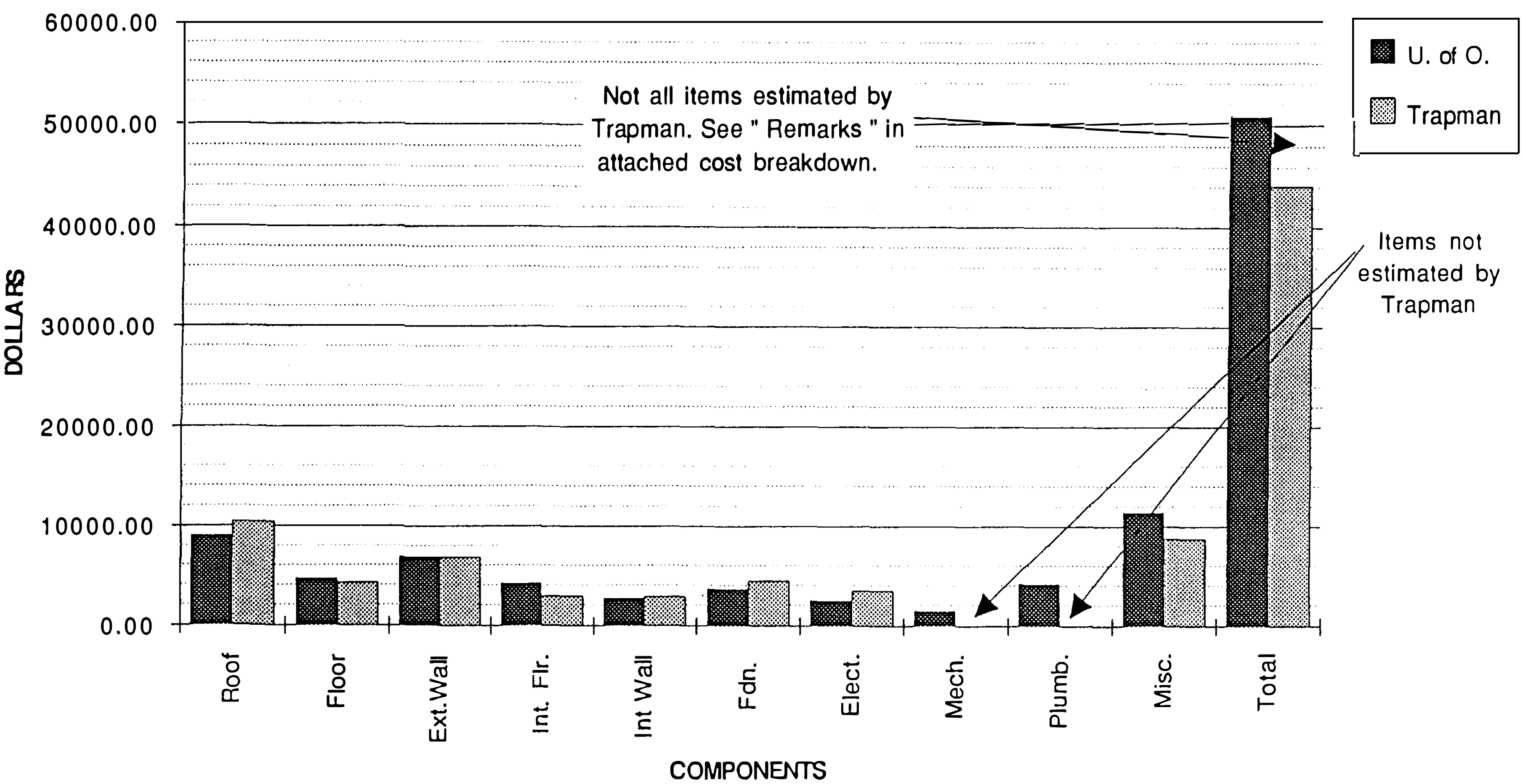
To check ESBL's cost estimates, construction cost estimates for the Reference and Demonstration House were sought from other sources. Plans and specifications for the Reference House were sent to a local builder, Rod Ruhoff, and to Tom Giesen, a professional estimator. Similarly, plans and specifications for the Demonstration House were sent to Mark Trapman, one of the few nearby building contractors with SSIC panel experience (this factor — lack of local panel builders — is discussed further in Section 3-7, Builder Selection). Their estimates are compared to those of ESBL in Figures 3-35 and 3-36, respectively.

	A	B	C	D	E	F	G	H	I	J
1	Component	Qty.	Unit	Adj. Mat. $	Mat. Tot $	Adj. Lab. $	Lab. Tot.$	Lab. W/O&P	Bare Total	Adj. Total
2	Roof; 9 3/8" R-control Panel									
9	PANEL TOTAL				4096.00					5700.62
10	15# Felt	1600	sf	0.02	39.09	0.04	61.77	104.39	100.86	147.92
11	Roofing,(Asphalt Shingles)	1600	sf	0.31	501.57	0.19	301.96	510.32	803.53	1062.57
12	2x8-Fascia	152	lf	0.51	77.08	0.89	135.28	228.62	212.36	320.10
13	Gutters	80	lf	0.89	71.55	1.07	85.84	145.06	157.38	227.29
14	Downspouts	56	lf	0.48	26.85	0.68	38.09	64.37	64.94	96.37
15	Nails/Glue			0.00	50.00	0.00	0.00	0.00	50.00	55.00
16	Porch Sheathing-5/8"	80	sf	0.37	29.50	0.15	12.26	20.72	41.77	54.06
17	Porch Soffit-1/2"	64	sf	0.30	18.88	0.14	9.20	15.54	28.08	37.02
18	Soffit-1/2"	130	sf	0.30	38.36	0.14	18.68	31.57	57.04	75.19
19	Additional Roof Sheathing	180	sf	0.30	53.11	0.14	25.87	43.71	78.97	104.11
20	Caulk(1/2 tube per 80 sf)	9	ea	3.54	31.86	0.00	0.00	0.00	31.86	35.05
21	Knee Braces	10	ea	9.17	91.74	14.85	148.50	250.97	240.24	352.32
22										
23	~~R-Control~~ Roof Totals				5125.58		1327.94	2244.22	6453.53	8267.61
24										
25	Floor; 5 1/2" R-Control Panels									
28	PANEL TOTAL				2072.00					2756.07
29	Rim Joist-2x8	112	lf	0.51	56.80	0.18	20.39	34.45	77.18	98.16
30	Underlayment-1/2" Part. Bd.	736	sf	0.33	244.29	0.13	98.71	166.82	343.01	443.64
31	Caulk (1/2 tube per 80sf)	5	ea	3.54	17.70	0.00	0.00		17.70	19.77
32	***Floor Finishes:***									
33	***Sponge Rubber Pad***	*575*	*sf*	*0.31*	*176.96*	*0.08*	*47.45*	*80.20*	*224.41*	*274.85*
34	***Nylon, plush, 20 oz.***	*575*	*sf*	*1.17*	*672.43*	*0.25*	*142.36*	*240.60*	*814.80*	*999.25*
35	***Vinyl***	*100*	*sf*	*1.82*	*182.19*	*0.22*	*22.01*	*37.19*	*204.20*	*240.90*
36	Nails	1	ea	32.27	32.27				32.27	35.56
37										
38	~~R-30~~ Floor Sub-Total				3454.64		524.06	885.66	3978.69	4868.20
39										
40	Walls, (7 3/8") R-Control Panel									
53	PANEL TOTAL				4388.00					5823.10
54	Plate-2x8	274	lf	0.51	138.95	0.48	131.25	221.81	270.19	380.67
55	Staples			0.00	25.00	0.00	0.00		25.00	27.50
56	Caulk (1/2 tube per 80 sf)	7	ea	3.54	24.78	0.00	0.00		24.78	27.26
57	Screw fasteners	50	ea	1.00	50.00	0.00	0.00		50.00	55.00
58	Ext. Window Trim, (1x4)	186	lf	0.16	29.15	0.57	105.13	177.67	134.28	217.92
59	Baseboards	0	sf	0.12	0.00	0.07	0.00	0.00	0.00	0.00
60										
61	~~R-26~~ Wall Sub-Total				4655.88		640.27	1082.06	5296.15	6531.45
62										
63	*PANEL TOTAL*				*10556.00*					
64										
65	Total Adj. Shell Cost				13236.10		2492.27	4211.94	15728.37	19667.27
66	Adj. Shell Cost $/sf		1259	sf	10.51		1.98		12.49	15.62
67	Component	Qty.	Unit	Adj. Mat. $	Mat. Tot $	Adj. Lab. $	Lab. Tot.$	Lab. W/O&P	Bare Total	Adj. Total
68	~~Interior~~ Floor Framing									
69	***11 7/8" TJI***	*596*	*lf*	*1.43*	*851.74*	*0.24*	*142.74*	*241.23*	*994.49*	*1191.26*
70	***11 7/8" LVL***	*104*	*lf*	*1.43*	*148.63*	*0.24*	*24.91*	*42.09*	*173.53*	*207.87*
72	Blocking,(2x12)	64	lf	0.93	59.60	0.76	48.44	81.86	108.03	148.82
73	3/4" Decking	636	sf	0.42	269.74	0.16	103.58	175.05	373.32	478.76
74	3/8" Plywd. Soffit	144	sf	0.52	74.35	0.38	55.18	93.26	129.53	179.79
75	***Sponge Rubber Pad***	*590*	*sf*	*0.31*	*181.57*	*0.08*	*48.69*	*82.29*	*230.27*	*282.02*
76	***Nylon, plush, 20 oz.***	*590*	*sf*	*1.17*	*689.98*	*0.25*	*146.08*	*246.87*	*836.05*	*1005.85*
77	***Vinyl***	*50*	*sf*	*1.82*	*91.09*	*0.22*	*11.00*	*18.60*	*102.10*	*120.45*
78	Caulk/Glue	1	ea	23.05	23.05	0.00	0.00	0.00	23.05	25.36
79	Nails/Screws	1	ea	36.88	36.88	0.00	0.00	0.00	36.88	40.57
80	Vapor Barrier	200	sq	0.03	6.00	0.09	18.00	30.42	24.00	43.62
81										
82										
83										
84	~~Int.~~ Floor Total				2442.31		604.79	1022.10	3047.10	3745.44
85			*TJI TOTAL*		*1000.37*					
86			*FLOORING COVERING*		*1994.22*					
87										
88										

*Estimate for wood I-beam interior floor w/ tree spade foundation. Page1 11/19/92 ; M. Elliot

Table 3-9
SSIC Panel Demonstration House Whole House Cost Estimate

Demo House Estimate											
	Roof	Floor	Ext.Wall	Int. Flr.	Int Wall	Fdn.	Elect.	Mech.	Plumb.	Misc.	Total
U. of O.	9052.17	4685.81	6913.99	4174.17	2738.16	3633.14	2495.31	1566.27	4200.00	11458.53	50917.55
Trapman	10488.98	4232.43	6831.47	2960.11	2905.26	4456.20	3490.25	0.00	0.00	8817.10	44181.80



M. Elliot

Figure 3-35
Reference House Cost Estimate Comparison

Ref. House Estimate											
		18974.63									
	Roof	Floor	Ext.Wall	Int. Flr.	Int Wall	Fdn.	Elect.	Mech.	Plumb.	Misc.	Total
U. of O.	8344.11	3955.05	6675.47	4174.17	2738.16	3633.14	2495.31	1566.27	4190.00	11356.66	49128.34
Giesen	9332.60	3818.18	9742.12	5283.00	1859.50	3864.36	4400.00	1785.00	5985.00	13335.51	59405.27
Ruhoff	7303.92	2842.66	6517.50	2823.49	6925.82	1585.79	3459.90	0.00	4776.60	10047.32	46283.00

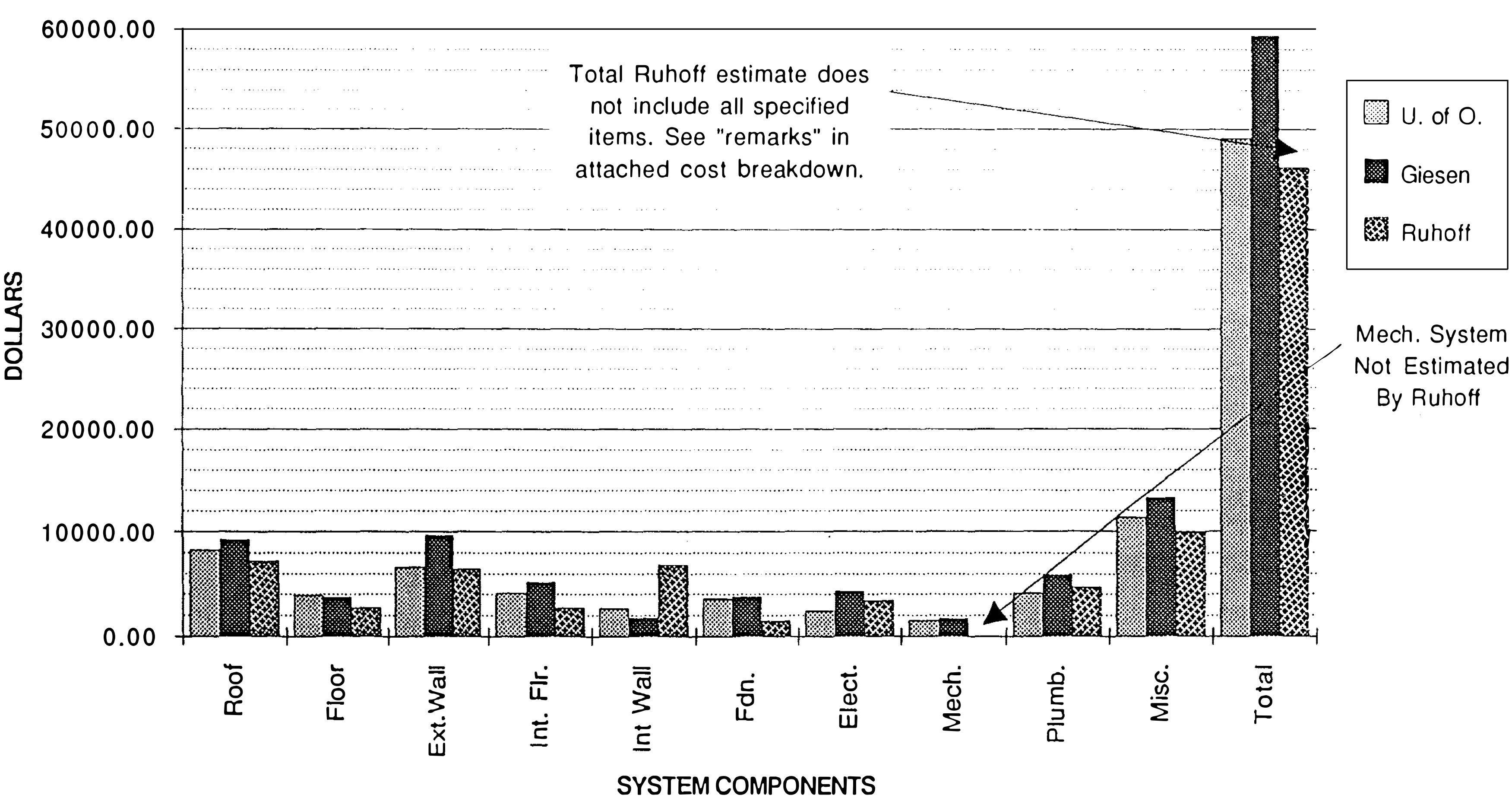


Figure 3-36
Demonstration House Cost Estimate Comparison

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As the figures show, there was good overall agreement. As the project proceeded, similar comparisons were obtained from time to time as confirming data.

Industry Support

Industry support was sought from suppliers whose products reflected the cost-effective approach to energy efficiency characteristic of the Demonstration House itself. High quality, innovation and local sourcing were also factors in identifying potential industry partners. The industry response was very positive. By the time the Demonstration House was completed, the list of partners had grown to forty-six:

Source	Materials
AFM Corporation	SSIC panels and technical expertise
American Standard	plumbing fixtures
Ashland Chemical	structural adhesive
BASF Corp.	EPS source resin
Bonneville Power Administration	$5000 economic assistance
Brownlee Lighting	compact fluorescent lighting fixtures
Cadet Manufacturing Co.	electric resistance heaters
Challenger Electrical Equipment Corp.	electrical equipment
DEC International	ventilating heat pump (at cost)
Dura Undercushions, Ltd.	recycled rubber carpet pad
Elk Corporation	roof shingles
Eugene Sand and Gravel	concrete
Forbo Industries, Inc.	linoleum floor covering
The Glidden Company	paint
Image Carpets Inc./Sound Floor Coverings	recycled PET carpet (at cost)
Jerry's Home Improvement Center	framing lumber
Lane Community College	construction assistance
Levolor Corp.	window blinds
Lights of America	compact fluorescent lighting fixtures
Louisiana-Pacific Corporation	wallboard/underlayment
Masonite Corporation	interior doors
Morse Bros. Prestressed Concrete Group	concrete

Oregon Strand Board	roof sheathing/ subfloor
OrePac Building Products	trim and decking lumber
Owens Brockway Corp.	"gravel" (recycled glass cullet)
Sea Gull Lighting Products, Inc.	compact fluorescent lighting
Simpson Strong-Tie	building connectors
Springfield Utility Board	electric submeters (loan)
Stimson Trading Company	siding panels
Gene Stringfield Building Materials Co.	lumber (reduced price)
Studor Inc.	interior plumbing vents
St. Vincent dePaul Society of Lane County	land/const. costs/appliances
Super Struct Systems	interior honeycomb core wall panels
Temperate Forest Foundation	wood products/project funding
Therma-Tru Corporation	fiberglas exterior doors
Trus Joist MacMillan	engineered wood framing materials
Viking Industries, Inc.	windows
Viscor, Inc.	building gaskets
Wasco Products, Inc.	skylights
Western Red Cedar Lumber Association/ Tumac Lumber Company	trim and deck lumber
Weyerhaeuser Co.	oriented strand board
Willamette Industries	underlayment plywood
Wirecon	integrated electrical outlets/switches

Bid Solicitation

The processes of design development, cost estimating and gathering support for the project were focused on and motivated by the question of what the actual construction costs would be for the Demonstration House. The Demonstration House project had some specific requirements:

- Quality construction — for achieving desired energy performance and durability, and providing a fair test of materials and methods.
- Input from the builder — for comments regarding buildability and feedback on materials and methods.
- Construction data — documentation of time, cost, problems, etc.
- Cost information — actual detailed construction cost of the prototype, separate from testing and other associated costs; credible data on projected

"typical" costs for a similar non-prototype house; and clues about potential cost reduction strategies.

The Demonstration House project also involved some novel circumstances:

- Use of donated materials obscured costs — realistic costs including builder or subcontractor markups would have to be extrapolated.
- Some items might not be locally available or even commonly used in this application; again, estimates would be required for costing.
- Novel methods and materials would add an unknown "learning curve" factor to the construction process. The absence of local builders with SSIC panel experience (see Section 3.6) would amplify this aspect.

These and other issues were considered in assessing how to engage a builder. Three approaches were examined, along with their positive and negative aspects:

- **Bid**

Positive: the bid indicates builder interest, clearly tells the project cost less change orders and contingencies, provides cost information early to confirm the budget, and is credible. Negative: the project novelty may discourage desirable bidders, the potential for publicity might attract artificially low bids, innovations increase the error potential of a bid, the bid process works against careful construction and open communication, and bidding complicates accounting for donated materials.

- **Construction manager**

Positive: a manager could be an experienced panel expert from elsewhere using local subcontractors, or a seasoned local builder employing an experienced panel builder as a subcontractor (balance of panel expertise and local connections). Negative: this type of organization would add a layer in the communication process, and might drive up total costs.

- **Time and materials**

Positive: with a stipulated maximum this approach would create a budget ceiling and possibly provide a balance between flexibility and control; with no ceiling it permits changes, new donations and open communication, without intimidating builders. Negative: it can encourage delays and increase costs, and might discourage a lender.

After some discussion it was decided that the bid approach would be used, because of its credibility and straightforwardness. The construction manager approach was rejected as being inappropriate for such a small project, and the time and materials approach seemed to invite cost overruns and unreliable cost data.

3.6 DOCUMENTATION

As the method for engaging a builder was determined, the construction documents needed for bidding and building the project were prepared. Documentation for the Demonstration House consisted of a Project Manual, Construction Drawings and Specifications (including Addenda). These are given below. Because funding for the entire project — house, garage and site — was still uncertain, it was decided to split the project into a "Base Bid" portion (house and essential site work) and "Additive Alternate A" (remaining work).

3.7 BUILDER SELECTION

As with other aspects of the Demonstration House project, selection of a builder was not a simple conventional process. When the project began, no structural panel homes had been built in the area; consequently there was no pool of local builders experienced in SSIC panel construction from which to draw. Consequently the search began with calls to regional panel suppliers and utilities' energy offices for the names of the nearest panel builders and conventional builders known for their dedication to energy efficient construction.

Through this process an initial list of ten builders was assembled; five were local and the remainder included builders from as far away as Washington and California. These were sent a preliminary information package, and five responded that they were interested in the project. These were invited to interviews with an ESBL selection panel; four of the five came to interview, including the Washington builder. These four builders were given the project documentation package and asked to bid the project. Two bids were received, one from a highly regarded local builder with no SSIC panel experience and the other from the Washington panel builder. The experienced California panel builder expressed continued interest in the project but declined to bid it, offering instead to act as project manager.

The two bids received were higher than project estimates had foreseen. It was clear that further cost reduction efforts would be needed, as well as additional donated materials. The cost reduction effort would need to involve the potential builder, so his availability was important. It was also clear that a local builder might be better able to elicit low bids from local subcontractors, and maximum cooperation from local building departments. The local builder expressed willingness to work with the developer and ESBL to find project cost reductions. It was decided to work with him in hopes that an acceptable price could be achieved.

After a series of meetings, changes in the design and specifications for the house, and further efforts to find funding and additional materials for the project, a compromise was achieved. A second bid was submitted, with the project amended as described in Addendum 1 above, and several potentially highly variable costs reidentified as allowances rather than bid items. The new bid, more than $20,000 lower than the the initial bid, was accepted.

4.0 CONSTRUCTION PHASE

As bid negotiations proceeded, details of the panels were developed at ESBL and discussed with their manufacturer, Premier Building Systems in Kent, Washington, as well as with AFM Corporation. The specific goals of the Demonstration House project — and particularly the focus on maximum cost effectiveness — departed from the suppliers' customary marketing emphasis, but all parties were dedicated to producing a successful house. When the project developer issued a Notice to Proceed with construction, the panel fabrication began.

4.1 PANEL FABRICATION

Duratemp siding materials were shipped to the Premier plant. The wall, roof and floor panels were laminated and, after adhesive curing, shaped into the component panels for the Demonstration House. The ESBL designers had planned to employ 8'x 18' roof and 8'x 20' floor panels, respectively; however, during fabrication it became clear that the the extra net panel width required for the shiplap joint could not be accommodated in Premier's press. Consequently these panels were redesigned as 4' wide units with a resulting increase in fabrication and handling effort. The reduced size and weight, however, made it possible for the builder to manhandle these panels even with a small crew — an impossibility with the panels as originally planned.

Originally, too, it was envisioned that the shiplap joint (Figure 4-1) would be manufactured with an embedded spline built into the panel at the pressing stage, attached to its "host" panel skin only with the adhesive used for the panel itself. Premier felt that without test pressings and structural tests of the resulting joint they could not verify the strength of the resulting joint, so the shiplap joints actually produced used separate splines, field installed with the adhesives and fasteners typical of the R-Control system. Again, the consequence was more field assembly than originally planned.

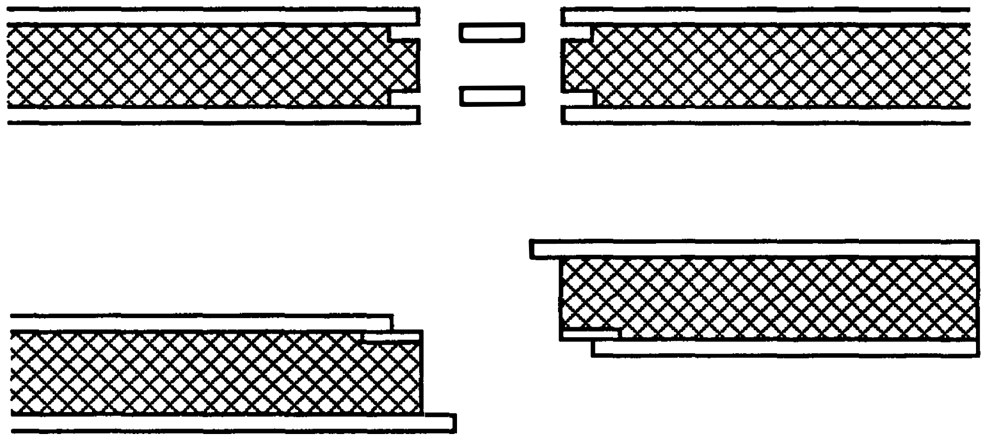

Figure 4-1
Conventional and Shiplap Spline Panel Joints

Aside from the shiplap joint, which Premier regarded as structurally equivalent to the standard R-Control double spline joint, the floor and roof panels for the Demonstration House followed standard R-Control materials and standards, and were provided the ICBO stamp.

The custom (Duratemp outer skins) wall panels, however, were regarded as experimental and not certifiable as R-Control panels. Subsequently, after ESBL and Premier provided evidence that Duratemp met structural performance standards (NER-108, PRP-108, NER-QA 397, and ICBO No. 4856) equal to the OSB skins standard on R-Control panels, the special Duratemp-faced panels were approved for use by Dave Puent, Springfield Building Official, under City Code Section 106 as an approved alternate material for use in the Demonstration House project.

Premier declined to extend any warranties regarding the custom panels, and the owner/developer, St. Vincent dePaul Society of Lane County, agreed to accept these panels on this basis. The completed panels were shipped to the job site in Springfield.

4.2 SITE WORK

As the panels were being fabricated, basic site work began. Utility locations were identified, temporary electric power was installed and the house located. The foundation piers were laid out and a truck-mounted auger (Figure 4-2) drilled the pier holes.

Foundation "trestles" were assembled from treated lumber and temporarily staked into position in their holes, then embedded in concrete (Figure 4-3). Dirt from the holes was spread throughout the foundation, raising the grade to prevent water from ponding under the house, and covered with poly film. This was covered with pea gravel to hold it in place.

The driveway and garage slab locations were graded free of sod and spread with recycled glass "cullet" (crushed green glass bottles, supplied by the recycler, for which there was essentially no Oregon market). The cullet served as structural sub-base for these areas which would later receive concrete slabs.

Figure 4-2
Foundation Pier Drilling

Figure 4-3
Foundation Trestles

4.3 SSIC PANEL ASSEMBLY

The panel assembly process had been planned around use of a backhoe-mounted boom capable of lifting 1000 lb. to reaches sufficient for the Demonstration House. Joints for the roof and floor panels, as well as sizes of the panels themselves, had been based on this strategy. Immediately prior to construction, however, it became evident that such a boom would not be available; consequently panel lifting and staging of the panels was performed with a large-tired extended reach fork lift (Figure 4-4). Lifting the panels from beneath, rather than slinging them from above, sometimes required extra effort to maneuver the panels into place.

Floor

Panel assembly began with attachment of the nominal 6" floor panels to the foundation trestles (Figure 4-5). The builder chose to use a small crew (himself and one carpenter) to minimize the "down time" impact of coping with the many novel aspects of the project. Consequently the largest (4' x 20') floor panels were nearly beyond what could be manhandled into place.

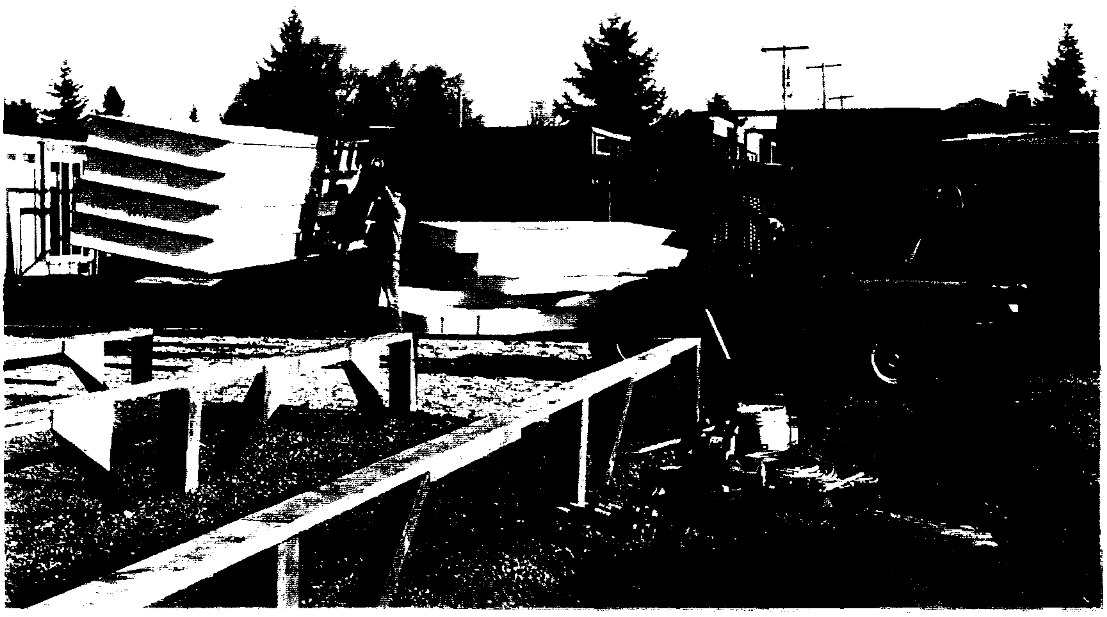

Figure 4-4
Panel Delivery

The shiplap panel joint, however, seemed to ease the task of joining large, heavy panels. The shiplap joint was designed to eliminate the need for loose separate splines, and would have eliminated half the field-applied adhesive and fasteners. Since for the Demonstration House project, however, the splines were installed conventionally, the full impact of this joint remains unexplored.

Use of large floor panels brought with it greater sensitivity to dimensional variations in the panels, particularly from moisture-induced OSB elongation. The measured lengths of the 4' x 20' floor panels upon installation, one day after December delivery to the damp Oregon job site, varied from +1/8" to + 5/16". No data were obtained regarding subsequent dimensional changes.

Walls

Wall panel erection began next (Figures 4-6 and 4-7). The 8" nominal panels were numbered on their ends corresponding to the construction drawings. One consequence of the builder's inexperience and the large number of unique panels

— particularly coupled with the directional nature of the Duratemp-faced panels — was some confusion regarding their placement and orientation. This confusion led to extra handling and consequent delays. For projects using uncut panels, orientation and sequence are less important issues, but of course the greater the degree of off-site preparation a project undergoes, the greater the value of clear, conspicuous panel labeling.

Figure 4-5
Floor Assembly

The issue of employing large vs. small panels is significant and should reflect a strategic designer/builder choice. The Demonstration House project used both large and small panels; consequently, the rented forklift sometimes sat idle while small panels were manhandled into place. The two-man crew was also at times overextended in its efforts to manually move larger wall panels once they were off the forklift.

Figure 4-6
Wall Assembly

Use of structural panel siding in the custom panels was a mixed success. The siding's precise groove patterning and shiplap joint alignments were meant for tighter assembly tolerances than SSIC panels may commonly achieve. Table 4-1 lists APA standards for plywood siding products such as Duratemp:

Dimension	Tolerance
Length/width	+ 0", -1/8"
Out of square	± 1/10"
Thickness	± 1/32"

Table 4-1
APA Rated Siding Dimensional Standards
(Source: American Plywood Association)

Figure 4-7
First Floor Assembly Complete

Consequently the builder had to trim several wall panels in order to achieve acceptable siding/siding fits. During these and other trim operations the hot foam cutting tool supplied was only marginally effective, and on at least one occasion the molten EPS core material caught fire. Once assembled on site, however, the siding-faced panels seem to perform well.

Through a clerical error the initial supply of sawn lumber ordered for the Demonstration House was undried ("green"), and consequently oversize for the recesses in the panel edges, which are sized for lumber in its dry (19% or less moisture content) condition. A brief period of struggling to remedy this misfit was sufficient to convince the builder to work only with dry lumber thenceforth.

Roof

The roof panel system, like that of the floor, was designed to use the fewest, largest pieces possible. It was assumed that the 10" nominal roof panels (up to 18' in length) would be installed from overhead, and overlap joints were detailed accordingly.

Like the floor panels, however, the roof panels ultimately had to be reduced from 8' to 4' in width because of press limitations; consequently the number of panels nearly doubled. The maximum panel weight was about 300 lb. To avoid the high hourly crane cost (with licensed operator), the builder chose to use the extended reach forklift to stage the panels onto the second floor deck. From there they were manually lifted into final position.

The consequence of these changes was that the roof panel installation was more complicated and took longer than originally envisioned. As with the floor panels, fitting the roof panels required all the strength the two-man crew could summon. It seems likely that the net installed cost was greater than if the original strategy had been followed.

4.4 OTHER STRUCTURAL COMPONENTS

Sawn Lumber

As was mentioned earlier, the initial supply of sawn lumber received for the Demonstration House was mistakenly ordered undried ("green"), and consequently was oversize for the recesses in the panel edges, which are sized for lumber in its dry (19% or less moisture content) condition. Once this stock was replaced with dry lumber, no particular lumber-related problems were encountered.

Engineered Wood Products

For the intermediate floor, full (20') span 11-7/8" TJI/35 DF joists were used, along with 2.0E DF Parallam PSL beams to frame the opening around the stair well. The TJI joists' light weight was advantageous for a two person crew, as was their straightness (no need to crown joists). The bottom flange provided convenient nailing to the wall plate, and knockouts worked well for subsequent utilities.

Each Parallam weighed 440 lbs. (5-1/4" x 11-7/8" beams, 24' 5-1/2" long). A 3-1/2" x 11-7/8" header completed the stair opening.

Blocking and stiffeners (Figure 4-8) between TJI joists added substantially to installation labor. The joist profile complicated insulation/ vapor barrier installation; however, "vapor dams" (Figure 4-9) were devised to complete the wall insulation and vapor barrier in the TJI floor. These were cut from foil-faced (low vapor permeability) foam insulation and caulked after installation.

Wood Panel Products

The Demonstration House incorporated a variety of contemporary wood-based panel products: oriented strand board (Weyerhauser) structural insulated building panel skins; Duratemp plywood structural siding with a tempered hardboard outer ply (Stimson Trading Company); Comply (strand board/wood veneer composite from Oregon Strand Board) intermediate floor sheathing; plywood structural underlayment on the first floor (Willamette Industries); and Fiberbond (gypsum bonded wood fiber board from Louisiana-Pacific) underlayment upstairs. All these products performed very well, and none required any unusual care or techniques.

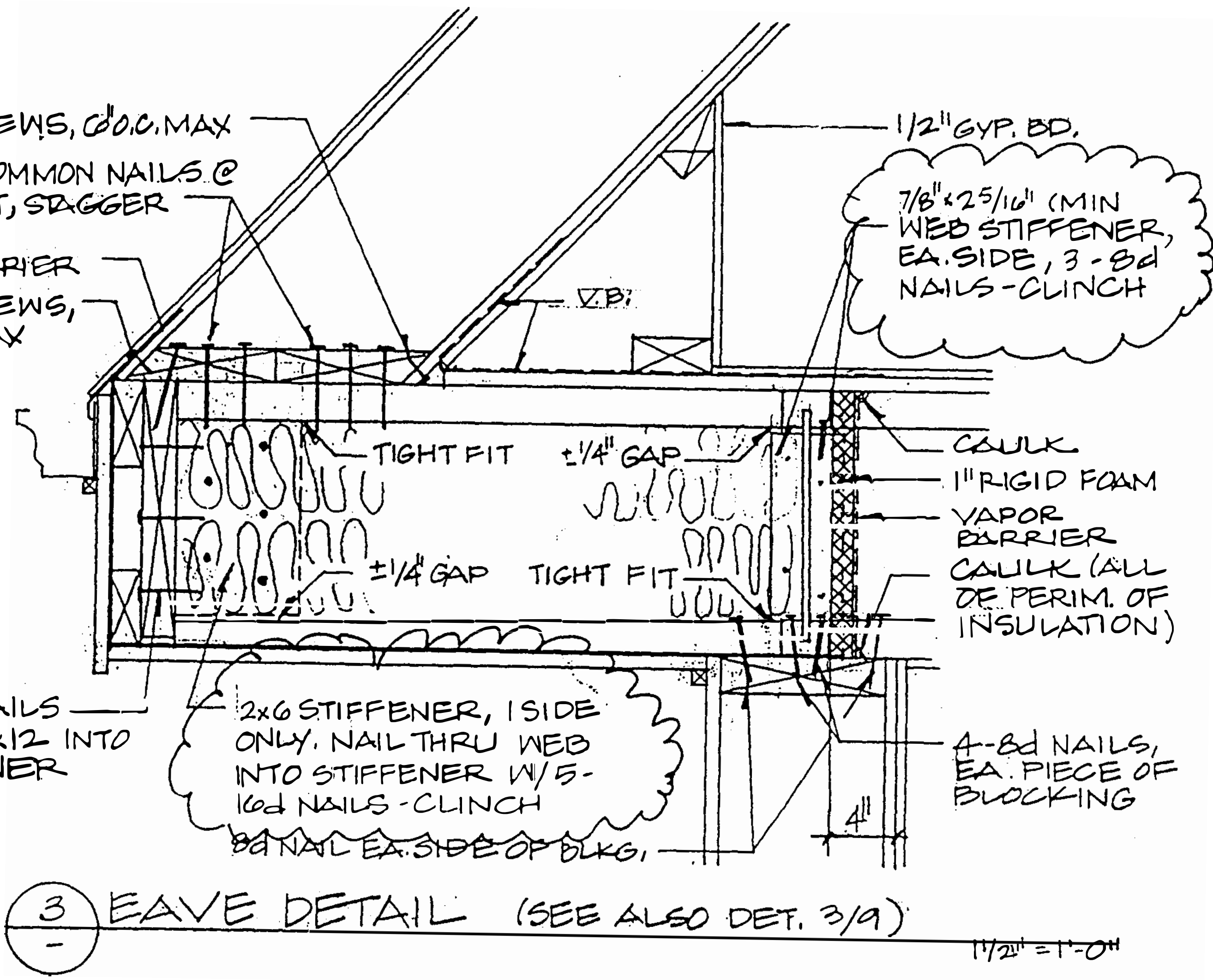

Figure 4-8
Intermediate Floor Framing

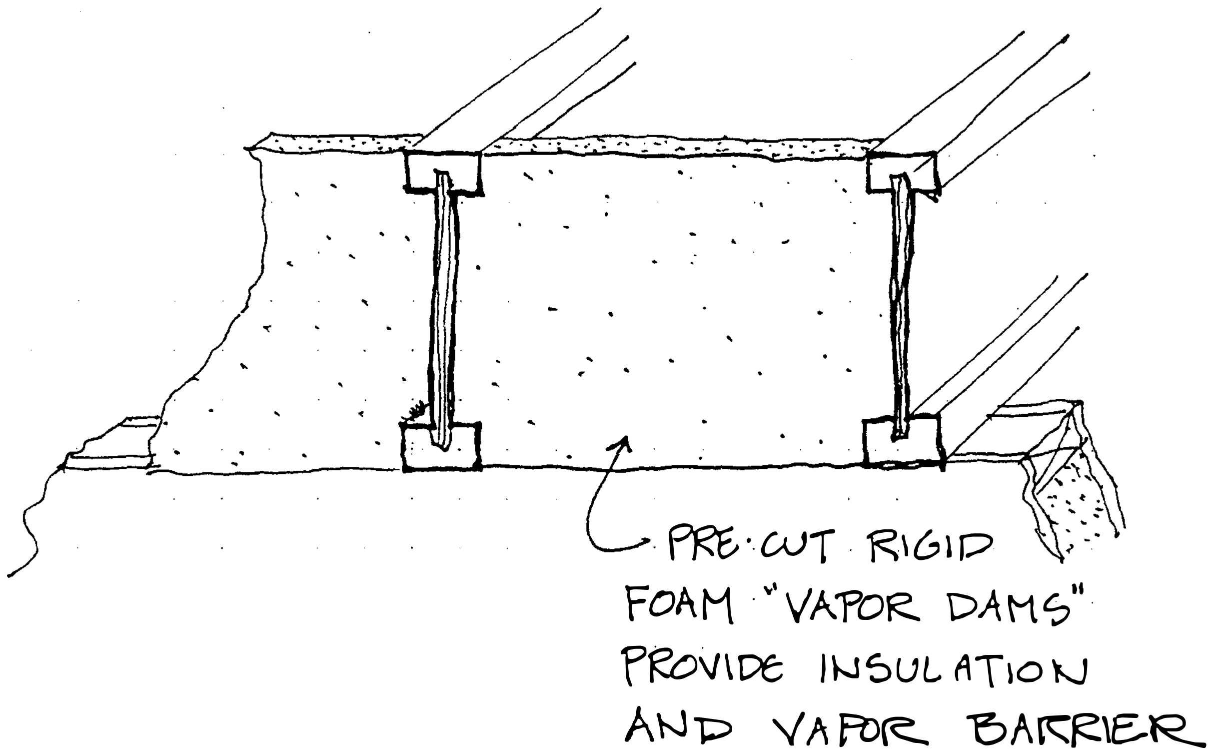

Figure 4-9
Vapor Dam

Connectors

A variety of Simpson Strong-Tie building connectors saw use throughout the Demonstration House, chiefly in the intermediate floor, and also as reinforcement at highly loaded points in the panel structure. These performed well in generally typical applications. In some cases (notably the attachment of a stair landing beam to the face of a wall panel — Figure 4-10) connectors found new uses specific to SSIC panel construction. It appears that more such uses exist, and that perhaps specialized connectors could be developed.

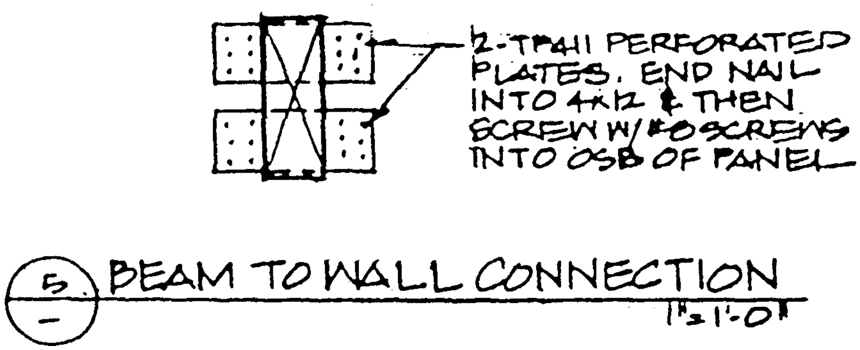

Figure 4-10
Beam-Panel Connection

4.5 DOORS AND WINDOWS

Panel Openings

The placement and details of openings for doors and windows in the panel structure received considerable attention. Due to the cost (approximately $3/sf) of the panels, waste was avoided wherever possible. Door and window locations were planned to align with panel joints. The comparative cost of producing an opening by cutting a hole in a large panel vs. assembling smaller panel pieces around an opening was examined, and ultimately the latter approach seemed most advantageous.

Design Details

Details of a typical window opening are given in Figure 4-11. One consequence of integrating the siding into the wall panel was the problem of how to provide flashing for the window head; this was achieved by removing the window upper nailing flange and capturing the window head between an inserted Z flashing and the interior finish as shown. Remaining window nailing flanges were fastened to the outer panel skin and covered with applied trim. Door installation, except for the deep jambs and threshold to accommodate the 8" walls, was conventional.

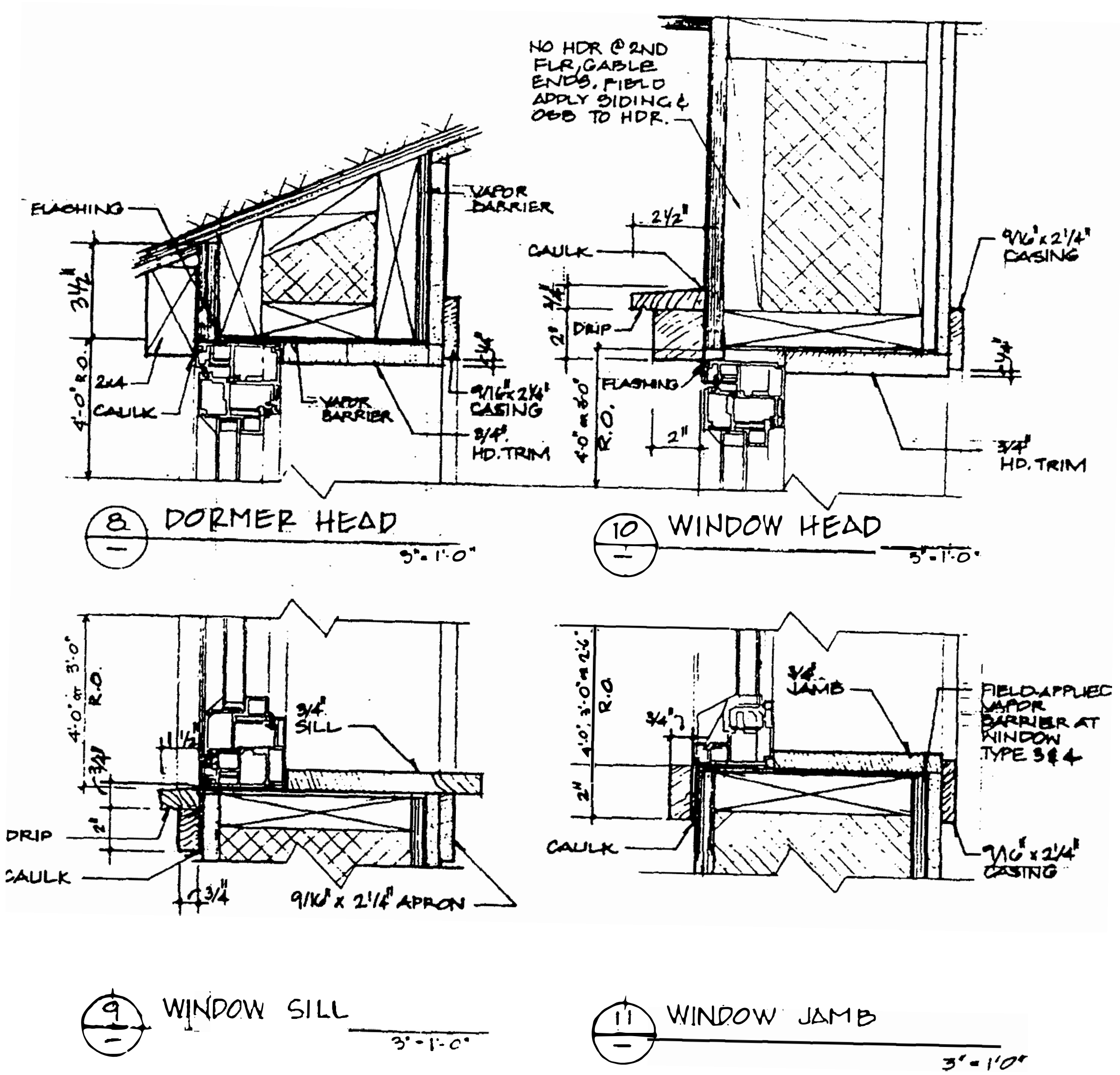

Figure 4-11
Window Details

4.6 UTILITIES

Layout

As was described in Section 3.1, the general design strategy in utility layout was to minimize wiring and plumbing in the outside (panel) walls and keep services clustered for economy. Consequently, virtually all plumbing is housed in one interior stud wall, exterior plumbing vents are replaced by air admittance valves, and most wiring occurs in interior stud walls and the intermediate floor (plan sheets E1 and M2, Section 3.4).

Installation

Installation of utilities was routine except for wiring in the exterior panel walls, where a perimeter wiring chase (Figure 4-12) seemed to make the task simpler than it would have been in conventional construction. In any case the electrician (this was his first experience with SSIC panels) proceeded with at least customary speed.

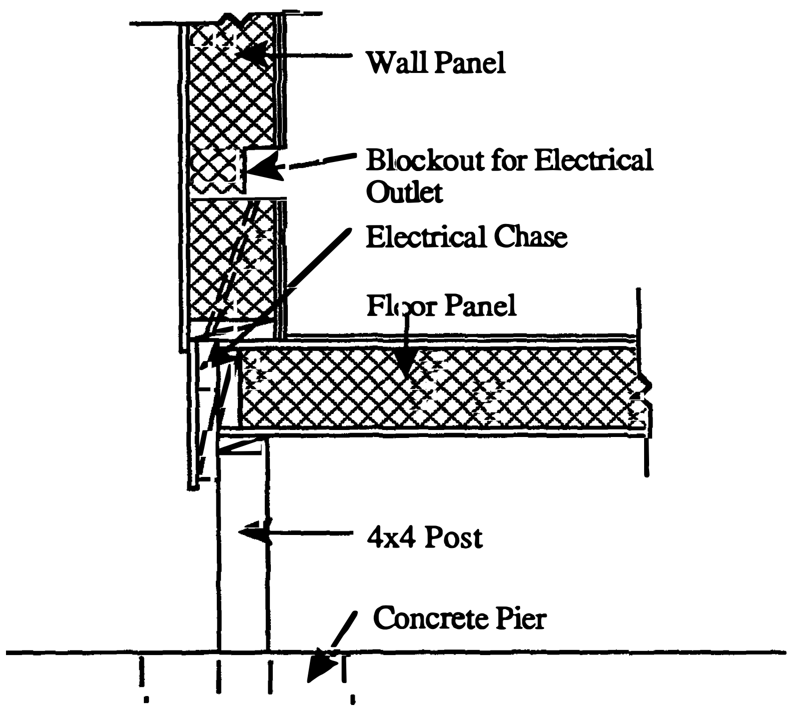

Figure 4-12
Perimeter Electrical Chase

4.7 SEALING AND INSULATION

Details

One objective of the Demonstration House project was to achieve an air tightness of 0.20 ACH, according to the Long Term Super Good Cents standards on which the energy goals were based. In support of this target, envelope penetrations were minimized as noted in Section 3-1. Holes for wiring and plumbing were filled with expanding foam sealant. Panel joints were treated with latex sealant and panel adhesive per R-Control procedures.

The application of four beads of adhesive and one bead of sealant per splined panel joint (Figure 4-13) consumed over 30% of the panel assembly time, yet the benefit of this process — particularly during rainy weather, when the adhesive commonly failed to grab wet OSB surfaces, and the water-based sealant obviously washed out of the joint — seemed doubtful.

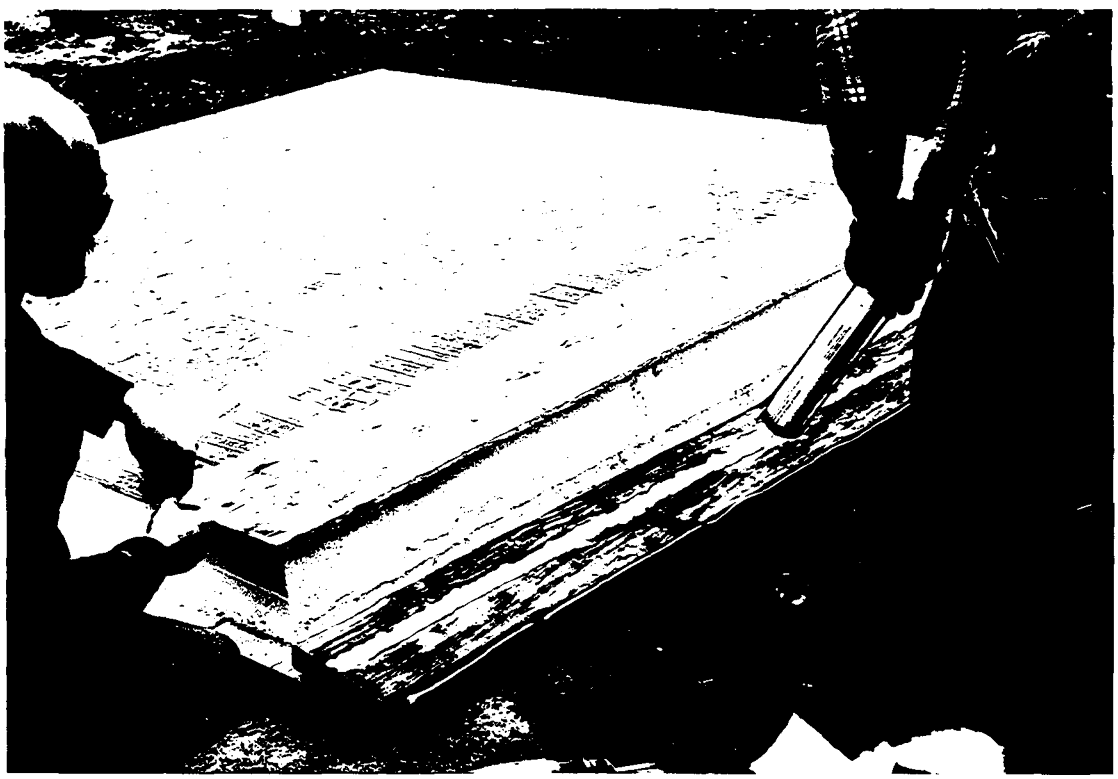

Figure 4-13
Sealant Installation

The Demonstration House builder consequently chose to apply a final bead of sealant to all interior panel joints after the shell was dried in, and it seemed likely that this relatively quick step probably contributed substantially to the air tightness of the house (subsequently measured at 0.07 ACH).

A related minor point is the mess associated with omnipresent sealant and adhesive, which seemed to find its way via electrical cords and air hoses to hands, tools and clothing — a powerful enough nuisance to perhaps discourage a first-time panel user from being a repeat customer. Again, a one-time sealant application after basic construction is finished might minimize this problem.

The intermediate floor presented some of the most difficult air sealing challenges. The outside edge (cantilevered joist ends and rim joist) was wrapped with air barrier material (details 2/9 and 3/9 in the building drawings, Section 3.4) and vapor dams were installed and caulked between the wood I-joists as described in Section 4-4.

4.8 ROOFING

As was noted in Section 3-2, SSIC panel roof construction has met some questions regarding asphalt shingle durability. One of the relatively few shingle manufacturers to maintain full warranty coverage for panel roofs is Elk Corporation. They supplied laminated Prestique Plus shingles for the project, and no problems have been encountered. As was noted in Section 3-2, shingle temperatures are being monitored.

4.9 INTERIOR AND FINISHES

The Demonstration House project provided an opportunity to showcase some products and techniques which supported overall goals of resource (including energy) efficiency. One of these was Louisiana-Pacific Fiberbond gypsum bonded fiberboard. This product combines recycled newsprint with gypsum binders to make a high-strength gypsum board used as interior wall board (and in a slightly different formulation as underlayment) in the Demonstration House.

Another product employed was Super Struct interior wall panels, gypsum board/paper honeycomb partition panels which reduce the wood stud requirements of the project.

The interior finishes are Glidden Spred 2000 low-VOC latex paints, chosen because they help ensure high air quality in the exceptionally tight Demonstration House. Similarly, Forbo linoleum floor coverings were used in the kitchen and baths, to help preserve air quality (via all natural ingredients) and provide durability.

Bedroom and living room floors are covered with Wearlon Royal Tex carpet, whose fiber is derived from recycled PET soft drink bottles; the Duralux carpet pad is likewise made from recycled tire rubber.

5.0 CONCLUSIONS

The Stressed Skin Insulating Core (SSIC) panel Demonstration House project seeks to show that a house built of 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.

The house has from its initial tests met the energy goal, saving approximately 40% of the space heating energy of a comparable new Code-compliant house (Brown *et al*, 1995, p. 8); complete confirmation will come after energy monitoring provides more data. Through blower door testing the house infiltration (closed mode) ACH_{50}/N was measured at 0.053 ACH.

A detailed cost study (Aires *et al,* 1995) has established that the total cost savings for the Demo House over its unbuilt Reference House counterpart are roughly $900, based on present Eugene, Oregon conditions. This study was based on cost records for the project plus video records of the construction process.

Problems such as air sealing and joint detailing were clarified and quantified for their impact on house costs. Several innovations were employed including the shiplap panel joint, two-way spanning floor panels with pier foundation, perimeter wiring chase, integrated second floor/roof assembly, and integral-siding panel. Their impacts were documented, and were rated as follows.

Most successful: The shiplap joint worked well, permitting the two-man crew to join large panels with relative ease. The builder clearly preferred the shiplap joints over the spline joints on equal sized panels. Early estimates that this approach would save 20% in installation time seem realistic.

The perimeter electrical chase also worked well, providing the electrician with a roomy, accessible chase around the building at a comfortable working height. While it impacted only a fraction of the total wiring, this feature seemed to offer a speed, hence cost, advantage over both conventional SSIC panel and frame construction. Again, our estimate that this approach might save 5% in installation costs still seems plausible.

Somewhat successful: Offsetting the wall panels to provide this chase added to the usable building floor area, and our structural tests found no notable adverse effect on the racking strength of the wall/floor connection. Offsets at the building corners proved useful for accommodating dimensional variations but could have been more fully exploited.

The 2-way span, integrated floor/foundation system seems from our tests to provide a satisfactorily stiff floor, and was relatively (given its novelty compared to a conventional floor) straightforward to build.

The integrated roof and second floor remains conceptually attractive, but the difficulty of manually placing large panels (4' x 18', based on limits in the panel fabricator's press size) suggests that using larger panels (8' x 18') hoisted by a crane or boom truck might work better.

Least successful: The incorporation of siding into the wall panels in this instance may have cost more than it saved, because of two factors. First, the siding materials (and their joints) are made to tighter tolerances than either the other panel components or the completed panel assemblies, so that consistently tight siding joints are inherently problematic. Second, the use of small (4' x 10' maximum) sheets of siding to produce SSIC panels as large as 8' x 12' creates significant fabrication, quality control and weather sealing problems. Changing the siding joinery, and matching the siding to SSIC panel size might ease these problems. The siding used in our project proved relatively tolerant of handling and transportation abuse.

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8.0 GLOSSARY

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

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.

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.

9.0 APPENDICES

9.1 BONNEVILLE POWER ADMINISTRATION LONG TERM SUPER GOOD CENTS SPECIFICATIONS

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
WATTSUN 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:

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 Telefax (206) 753-2397

ADDITIONAL NEW RESIDENTIAL MEASURES

Energy Efficient Heat Pumps

HSPF's	7.2 KWH	7.2 PAYMENT	7.4 KWH	7.4 PAYMENT	8.5 KWH	8.5 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.

9403r 08/20/91

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

9.2 ENGINEERING REPORTS

GEOTECHNICAL INVESTIGATION
DEMONSTRATION HOUSE FOR THE
ST. VINCENT DE PAUL SOCIETY
SPRINGFIELD, OREGON

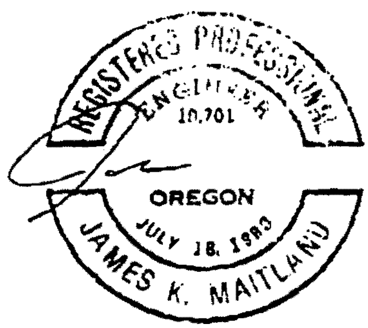
Prepared for

ENERGY STUDIES AND BUILDING LABORATORY

CENTER FOR HOUSING INNOVATION

UNIVERSITY OF OREGON

EUGENE, OREGON



Prepared by

FOUNDATION ENGINEERING

AUGUST 1992

Foundation Engineering
Professional Geotechnical Services

Soil

August 31, 1992

University of Oregon
Department of Architecture
Eugene, Oregon 97403

Attn: Rudy Berg

Project P-897
Demonstration House Project

Dear Mr. Berg:

We have completed the geotechnical investigation for the University of Oregon Demonstration House for the St. Vincent de Paul Society in Springfield, Oregon. This report contains a description of our work, a discussion of site conditions, and recommendations for design and for construction of conical-shaped foundations.

The soils at the site consist primarily of brown, stiff silts and clays to a depth of 5 or 6 feet followed by shallow gravels. We have concluded that the proposed foundations should be adequate to support the required loads. However, the unusual shape of the footings made conventional analysis of the foundations difficult and there are some potential disadvantages with the proposed type of foundation. Some of the values presented herein are presumptive, based on the foundation conditions encountered. We are recommending that a program consisting of field testing be implemented prior to using this type of foundation at other sites.

It has been a pleasure assisting you with this phase of your project. Please do not hesitate to call if you have any questions or if we can be of further assistance.

Sincerely,

FOUNDATION ENGINEERING

M. Todd Boire

James K. Maitland, P.E.

MTB/ap

GEOTECHNICAL INVESTIGATION
DEMONSTRATION HOUSE FOR THE
ST. VINCENT DE PAUL SOCIETY
SPRINGFIELD, OREGON

Background

The University of Oregon, Center for Housing Innovation plans to build a demonstration house in Springfield, Oregon. The new house is a prototype designed to be cost-efficient and easy to construct and maintain. It is our understanding that the new home will be a single-family dwelling. The foundations will be shallow, conical-shaped spread footings, several feet in diameter at the surface. The conical-shaped footings are constructed with a tree spade that are easy to excavate.

Foundation Engineering was retained by Mr. Rudy Berg (University of Oregon Department of Architecture) in mid-July 1992 to perform the investigation for the project. Our scope of work was outlined in a letter proposal dated July 16, 1992 and authorized by a Personal/Professional Services Contract dated August 5.

Field Exploration

We dug two exploratory test pits at the site on August 14 using a rubber-tired backhoe. The exploration was performed to examine the subsurface conditions and to establish a general soil profile for the foundation design. The test pits were logged and representative soil samples were obtained for further identification and possible laboratory testing. Torvane measurements were made periodically on the test pit side walls to measure the undrained shear strengths of the undisturbed native soils. The soil profiles, sampling depths, and Torvane measurements are summarized on the appended test pit logs. The locations of the test pits are shown in Figure 1.

Laboratory Testing

Laboratory testing was limited to natural water contents and Atterberg limits tests. These tests were performed to classify the foundation soils. Table 1 provides a summary of these test results.

Table 1. Natural Water Content and Atterberg Limits

Sample Number	Sample Depth (ft.)	Natural Water Content (%)	LL	PL	PI	USCS Classification
SS-1-1	2.0	30.5	75	32	43	CH
SS-2-1	1.5	26.9				
SS-2-2	3.5	33.7				

Foundation Engineering

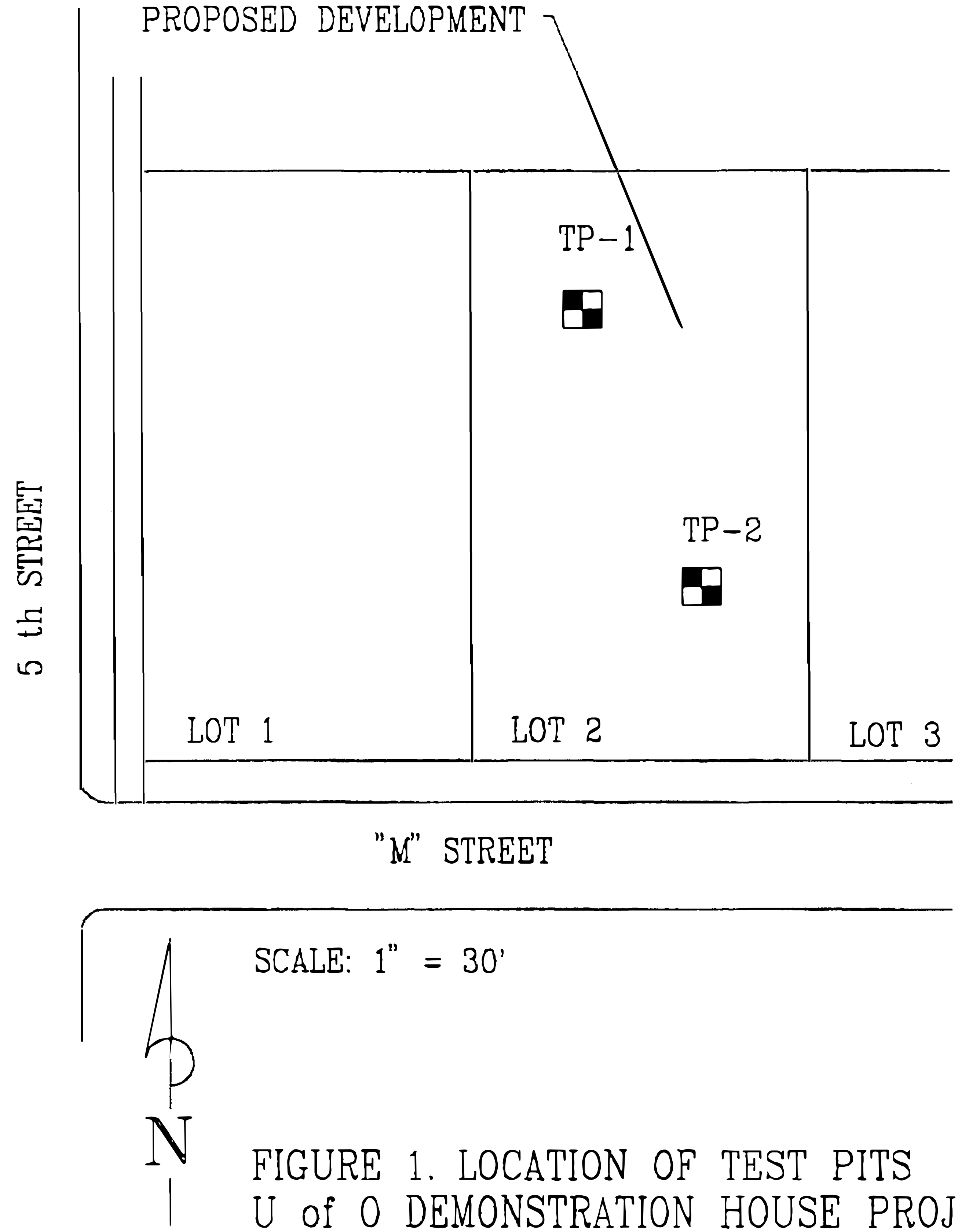


FIGURE 1. LOCATION OF TEST PITS
U of O DEMONSTRATION HOUSE PROJECT
EUGENE, OREGON

Site Conditions

The site is located in Springfield, north of M Street, between 5th and 6th Streets. The property is the second parcel east of 5th Street. The proposed construction area is approximately 70 feet wide by 127 feet long. Generally, the site is relatively flat and vegetation is restricted to tall grass. There are no trees or brush on the property.

The surficial soil consists of 1 foot of dark brown, dry, friable, clayey silt or silty clay. The soil is stiff, but relatively loose due to roots. This layer is underlain by approximately 1 foot of dark brown and grey, slightly moist, very stiff to hard, plastic clay containing light brown, tuffaceous, coarse sand and pebbles. The clay is very stiff to hard with average Torvane measurements greater than 2.5 tsf.

The surficial plastic clay is underlain by brown, moist, sandy, silty clay below about 2 feet, which is followed by a brown, moist, dense, sandy, cobbly gravel at approximately 5 feet. The gravels extend to a depth of approximately 6½ feet (the limits of our exploration).

Ground Water. No ground water was encountered in any of the test pits. The soils, however, did contain a substantial amount of iron-staining and oxidation which suggests that ground water can rise seasonally near the ground surface.

Engineering Analysis and Discussion

We examined one hole during our site investigation that had been dug with a tree spade. The hole measured approximately 42 inches in diameter and about 28 inches deep. Therefore, the conical-shaped footing has a side wall slope slightly greater than 1:1. It is our understanding that a larger tree spade can be used, but the slope or angle of the cone cannot be varied. Therefore, for a tree spade with a specific size, a hole must be made deeper to increase its diameter.

Mr. Rudy Berg provided us with an estimate of the foundation loads. The foundations will consist of individual footings supporting post-and-beam construction. The individual footings will have applied loads ranging from 1640 lbs to a maximum of 16,508 lbs. The average lateral (wind) load will be approximately 1050 pounds per footing.

We performed a variety of analyses to estimate the bearing capacity of a footing with this shape. The foundations were analyzed as a conventional spread footing placed on an inclined slope and as a pier with only frictional resistance. A computer program and a variety of assumed failure surfaces were also used to estimate an allowable bearing pressure for design.

Our analysis suggests that bearing capacity at this site would not be critical because the soils are stiff and shallow gravels are present. We recommend using a presumptive bearing pressure of 2500 psf for design. This bearing pressure should be calculated using the vertically projected area of the footing.

It is critical that the bearing pressure provided herein not be extrapolated, or used for other sites without additional, site specific analysis. We found it very difficult to calculate a meaningful allowable bearing pressure for this shape of footing because the mode of failure is complex and because the footing can come into contact with several soil layers. We expect that for softer soils the lower portion of the footing would "punch" and the rest of the footing would fail in shear. We recommend that load tests be performed to establish a correlation between soil strength and bearing capacity if this type of foundation is to be used at other sites.

No settlement estimates were made since the foundation soils are very stiff and bearing pressures should be modest. In addition, shallow gravels were exposed and therefore, the thickness of the compressible layer is relatively thin. The design team should assume that foundation settlements will be negligible (i.e., less than ½ inch).

We analyzed the lateral capacity assuming the footing would rotate about the top and "kick out" toward the surface. The horizontal projection of the footing was used in the area and a reduced undrained shear strength was assumed to act over a potential failure wedge extending from the tip of the footing to the ground surface along a 1:1 slope. Our analysis indicates that a passive earth pressure of approximately 1000 psf should be used for design. This value could be used as a uniform pressure over the vertically projected area of the footing. No increase in lateral capacity with depth is recommended.

You indicated that a building official from the City of Springfield, Mr. Don Moore, is concerned about several issues related to the performance of conical-shaped foundations. His primary concern seems to be related to seismic performance and how the foundations would perform (i.e., "would they sink") under earthquake conditions. We have not performed a rigorous analysis to estimate the seismic performance of these footings; however we do have some concerns with regard to the seismic performance of conical-shaped footings.

It is our opinion that the conical-shaped footings may be susceptible to tilting or rocking during an earthquake, or any other condition such as strong wind gusts that produces large or sustained lateral loads. It would be very difficult to analyze rocking or tilting since several variables are involved. We understand that lateral bracing will be provided so that no net moment will be applied to the footing. However, we recommend that the proposed foundations be tested in the field to establish a correlation between the potential failure by rocking or tilting and the soil's shear strength. The potential for rocking or tilting may reduce the allowable lateral capacity of the footings. The problem or rocking of tilting may be amplified by eccentrically loaded footings and may not be totally corrected with the use of bracing. Therefore, it is critical that all posts be located at the centers of the footings.

Shrinkage and swelling of the soils are also major concerns with respect to the performance of the foundations. We typically recommend that conventional (spread) footings be built 1½ to 2 feet below the ground surface in order to bypass the surficial soils that are subject to seasonal variations in moisture content. These variations can produce volume changes in the soil and lead to heaving or excessive settlement. It is recommended that the top of the foundations be placed a minimum of 18 inches below the ground surface to avoid these potential problems. This is especially critical since the area of the conical footings is greatest at the top where it would be most affected by shrinking and swelling soils. The requirement of placing the footings below the ground surface will require construction of a formed pedestal to avoid placing the post below the crawl space surface (see Figure 2).

Recommendations for Site Preparation and Foundation Construction

1. Design conical-shaped foundations using an allowable bearing pressure of 2500 psf. We recommend assuming that only the upper 2/3 of the footing would contribute area for soil bearing. This value may be increased by 1/3 for analysis of temporary live loads (i.e., wind and earthquakes).

2. Dig the footings using the tree spade, as proposed. Trim the sides of the excavation as required to create a smooth, undisturbed surface. Remove all sloughed soil from the bottom of the hole.

3. Place the concrete in the hole, making sure that the top of footing is a minimum of 18 inches below the ground surface. Install a sonotube or another suitable form to insure that the upper portion of the foundation does not come in contact with the sides of the sloping excavation. The formed portion of the footing should extend above the ground surface.

4. Use only pressure-treated wood for posts that are connected to the foundations. Care should be taken during construction to insure that the post are placed at the center of the footing. Otherwise, eccentrically loaded footings could tend to rock or tilt.

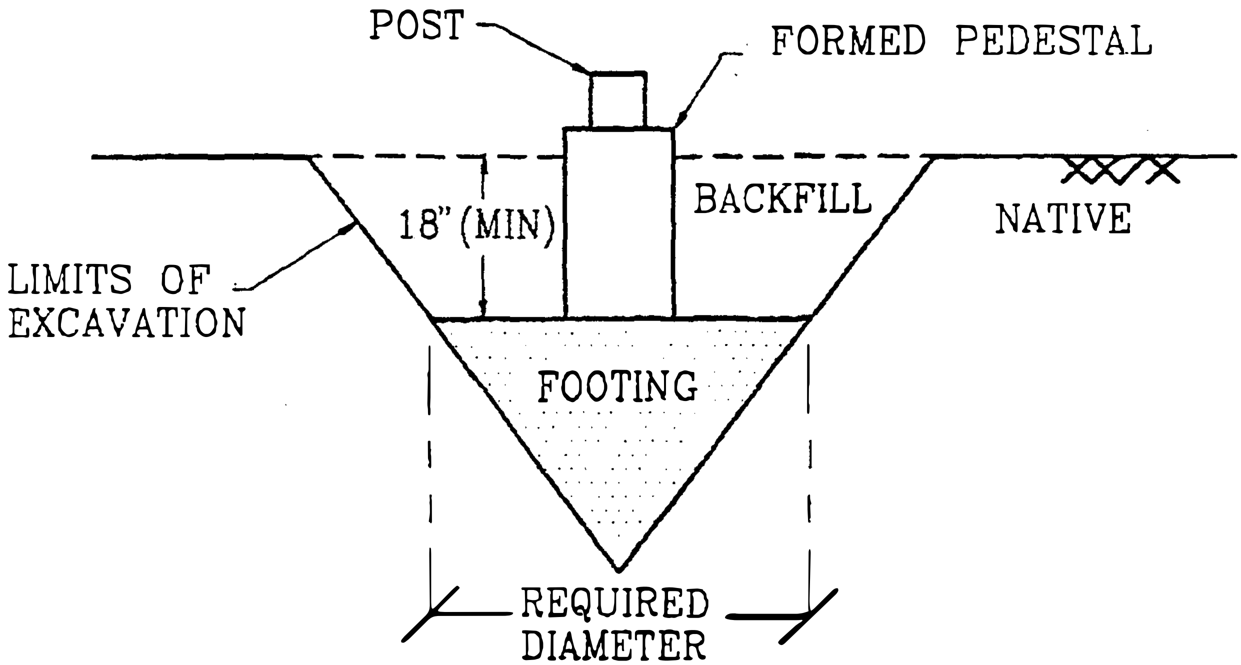
Drainage

The site for the demonstration house is relatively level, but seasonally perched water could accumulate in the crawl space. Several options for draining the crawl space are discussed below.

Option 1. Grade the site so that runoff flows away from the house. This could be accomplished by making the elevation of the ground surface slightly higher under the house and building it on the center of the mound.

Option 2. Create a drainage blanket by overexcavating a nominal 1 foot under the entire house, and backfilling the excavation with a pervious granular fill. The excavation should be graded such that any water passing through the granular fill or accumulating in the bottom is collected at a common point and drained to a storm sewer.

Option 3. Provide ditching or a conventional curtain drain around the perimeter of the house to intercept surface water before it flows under the house. The curtain drain would consist of a 2 to 3-foot deep trench, lined with a geotextile and backfilled with pervious rock or gravel and drained by a perforated or slotted, PVC pipe.



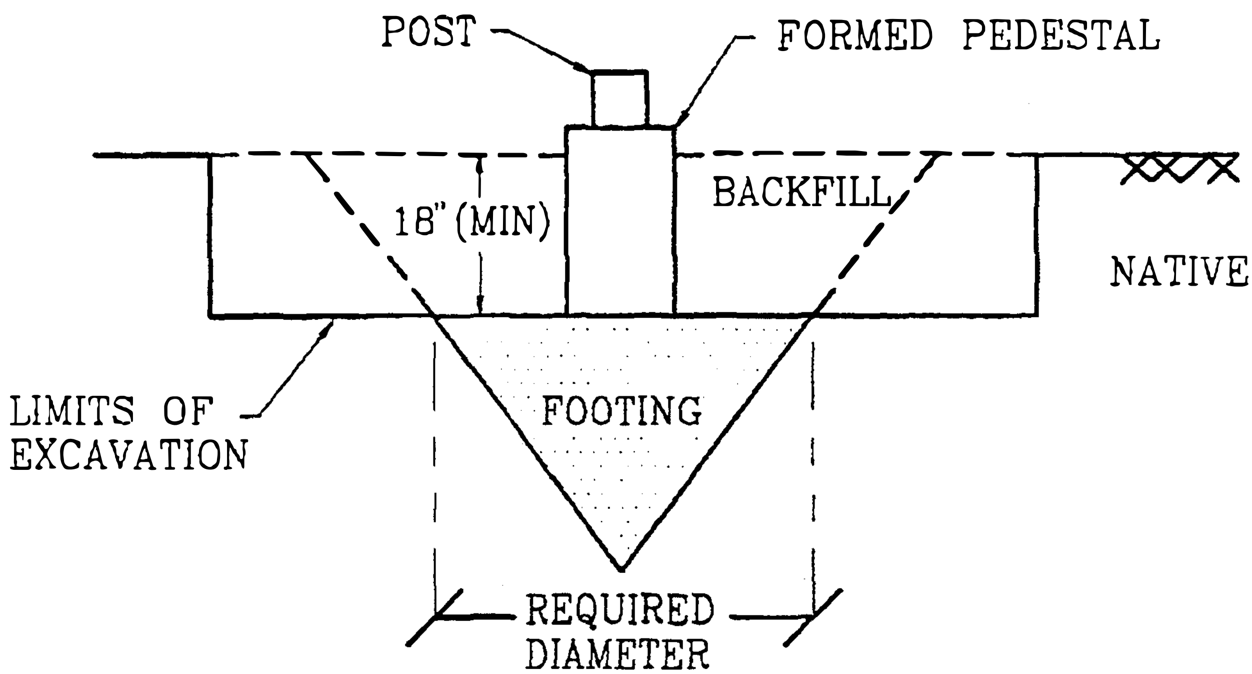


FIGURE 2. FOOTING DETAILS
U of O DEMONSTRATION HOUSE
SPRINGFIELD, OREGON

Conclusions

We have concluded that the proposed footings offer a practical advantage only because they are quick and easy to construct. However, it is our opinion that, while the actual construction may be simple, the size and shape of the footing pose several possible disadvantages. We have identified several items that should be addressed as feasibility issues before construction proceeds on other projects.

1. Bearing capacity. We have estimated that there could be several possible modes of failure, depending on the type and strength of the soil. Modeling each possible failure mode, or a combination thereof is a complicated problem.

2. Shrink/Swell. Frequently, the upper 1 to 2 feet of soil is affected by changes in moisture content and therefore is subject to changes in volume. This is very important where the foundation soils are plastic (such as the present one). The footings must be placed below the ground surface to mitigate this problem. This may make footing construction with a tree spade cost prohibitive.

3. Drainage. Residential construction typically requires foundation drainage. Perimeter foundation drains could be installed, but they will be more difficult and/or expensive to install since additional trenching and excavation would be required.

4. Lateral Capacity. Typically, the lateral capacity of footings is not critical (except in the case of sliding) since continuous perimeter footings usually provide sufficient resistance. We found that the soils at this site are relatively stiff and therefore can develop a relatively high passive resistance. This may not be the case at other sites, where the lateral area of the footings required for passive resistance could be the governing factor for design.

5. Rotation or Tilting. The footings could fail by rocking even if no moment is applied. This is because the center of the projected area is located at the upper 1/3 of the footing, not at the middle as in the case of a conventional square footing.

6. Construction. The angle the tree spade excavates cannot be varied. As a result, a relatively deep hole must be constructed to increase the effective bearing area of the footing. Constructing a hole with a specified diameter and a minimum embedment depth would require pre-digging the foundation area (see Figure 2) or using a substantially larger tree spade. Pre-excavation would increase the costs and may make it impractical to build large diameter footings.

Load Tests

We recommend that a modest test program be implemented to establish correlations between bearing capacity and lateral capacity with the soil's strength. A field test program would also confirm the mode of failure, i.e., whether the footings punches into the soil, tilts or rocks.

The test program could consist of building two series of three, small diameter footings. One series would be loaded vertically to failure, the second would be loaded laterally. A site with fine-grained soils (silts or clays) should be selected and the strength of the soil established in the field. In this manner correlations between undrained shear strengths obtained with a Torvane or a pocket penetrometer could be established with bearing capacity and lateral loads. The observed deflections could be used to determine the critical mode of failure.

Design Review/Field Inspection/Testing

We should be provided the opportunity to review all drawings and specifications that pertain to earthwork, foundations, and pavements or slabs prior to construction. Site preparation will require field confirmation of foundation conditions and footing excavations. That judgement should be provided by one of our representatives. Periodic field density tests should be run on all base rock or engineered fill placed beneath pavements and slabs, or in footing excavations, if placed. We recommend that we be retained to provide the field inspection and testing.

Variation of Subsurface Conditions and Warranty

The analysis, conclusions, and recommendations contained herein are based on the assumption that the soil profiles and the absence of ground water encountered in the test pits are representative of overall site conditions. The above recommendations assume that we will have the opportunity to review final drawings and be present during construction to confirm assumed foundation conditions. No changes in the enclosed recommendations should be made without our approval. We will assume no responsibility or liability for any engineering judgement, inspection or testing performed by others.

This report was prepared for the exclusive use of the University of Oregon and their design consultants for the Demonstration House for the St. Vincent de Paul Society in Springfield, Oregon. Information contained herein should not be used for other sites or for unanticipated construction without our written consent. A program of field testing is recommended before these footings are used extensively.

Our work was done in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made.

SYMBOL KEY
FOR
BORING AND TEST PIT LOGS

DISTINCTION BETWEEN FIELD LOGS AND FINAL LOGS

A field log is prepared for each boring or test pit by our field representative. The log contains information concerning sampling depths, and the presence of various materials such as gravel, cobbles and fill, and observations of ground water. It also contains our interpretation of the soil conditions between samples. The final logs presented in this report represent our interpretation of the contents of the field logs and the results of the laboratory examinations and tests. Our recommendations are based on the contents of the final logs and the information contained therein and not on the field logs.

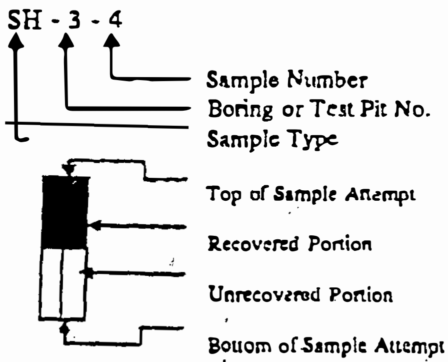
VARIATION IN SOILS BETWEEN TEST PITS AND BORINGS

The final log and related information depict subsurface conditions only at the specific location and on the date indicated. Those using the information contained herein should be aware that soil conditions at other locations or on other dates may differ. Actual foundation or subgrade conditions should be confirmed by us during construction.

TRANSITION BETWEEN SOIL OR ROCK TYPES

The lines designating the interface between soil, fill or rock on the final logs and on subsurface profiles presented in the report are determined by interpolation and are therefore approximate. The transition between the materials may be abrupt or gradual. Only at boring or test pit locations should profiles be considered as reasonably accurate and then only to the degree implied by the notes thereon.

SAMPLE OR TEST SYMBOLS



SS - Standard Penetration Test Sample (split-spoon)
SH - Thin-walled Shelby Tube Sample
C - Core Sample
CS - Continuous sample

▲ Standard Penetration Test Resistance equals the number of blows a 140-lb weight falling 30 in. required to drive a standard split-spoon sampler 1 ft. Practical refusal = 50 or more blows per 6 in. of sampler penetration.

● Water content (%).

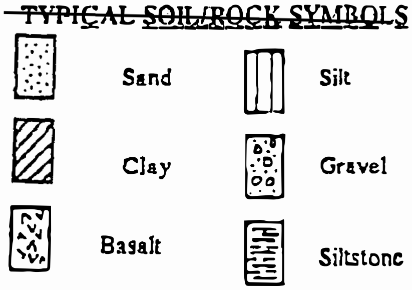
~~UNIFIED SOIL CLASSIFICATION SYMBOLS~~

G - Gravel	W - Well Graded
S - Sand	P - Poorly Graded
M - Silt	L - Low Plasticity
C - Clay	H - High Plasticity
Pt - Peat	O - Organic

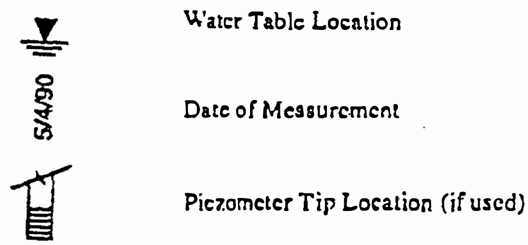
FIELD SHEAR STRENGTH TEST

Shear strength measurements on test pit sidewalls, blocks of soil or Shelby tube samples are typically made with Torvane or pocket penetrometer devices.

~~TYPICAL SOIL/ROCK SYMBOLS~~



WATER TABLE



9.3 PROJECT MANUAL

Project Manual

DEMONSTRATION HOUSE PROJECT

for

ST. VINCENT DE PAUL SOCIETY
OF LANE COUNTY, INC.

Energy Studies in Buildings Laboratory
Center for Housing Innovation

University of Oregon

Date: Number:

CONTENTS

INSTRUCTION TO BIDDERS

Bids from pri e contractors invited by the owner will be received by:

The office of Energy Studies in Buildings Laboratory
Center for Housing Innovation
Room 102/103 Pacific Hall
University of Oregon
Eugene, Oregon 97403

until 5:00 p.m. June 1, 1993 for the construction of :

Demonstration House Project for
ST. VINCENT DE PAUL SOCIETY OF LANE COUNTY, INC.

PROJECT DESCRIPTION:
In general the project comprises a house, garage, paving and landscape work included in the plans and specifications and project manual titled as above. The garage and some of the paving and landscape work is included in Additive Alternate "A"; all other work is included in the Base Bid.

SUBMISSION OF BIDS:
Enclose bid (and bid guarantee) to the address above in a sealed envelope marked:

Proposal for Demonstration House Project

The bids will be opened at the above stated time and place and read aloud in the presence of the invited prime bidders present.

RIGHT TO REJECT BIDS:
The owner reserves the right to reject any or all bids and to waive informalities.

BID GUARANTEE:
Each bidder is required to submit a $500.00 bid guarantee, in the form of a certified check, with the bid.

Make payable to: St. Vincent de Paul Society

DISPOSITION OF BID GUARANTEE:
Bid guarantees will be returned by mail to bidders whose bids are not accepted within 30 days after bids are opened.

FORFEITURE OF BID GUARANTEE:
The bid guarantee of a bidder whose bid is accepted will be retained by the owner until the contract is completed, at which time it will be returned to the bidder. In the event that the bidder fails to undertake the project or perform the work required in these documents, the guarantee will be forfeited by the bidder and will become the property of the owner.

BID FORM

From (Contractor)____

To: St. Vincent De Paul Society of Lane County, Inc.
705 S. Seneca
Eugene, Oregon 97402

Having examined the Drawings and Specifications, and Project Manual entitled:

Demonstration House Project for
St. Vincent De Paul Society

and the premises and conditions affecting the work, the undersigned proposes to furnish all labor and materials to perform the work required with the above documents for the following sums:

Base Bid:____

______________________________________Dollars ($_____________)

Alternate "A" (for garage, etc. as shown): Add to the Base Bid the sum of

______________________________________Dollars ($_____________)

CONTRACT:
If the bidder be notified of the acceptance of this bid within 30 days of the time set for receipt of bids the bidder agrees to execute a contract for the work in AIA Document A 107 Abbreviated form of Agreement between Owner and Contractor.

TIME OF COMPLETION:
The undersigned agrees, if awarded the contract, to substantially complete within ___________ calendar days from the date Contract is awarded, and to fully complete as soon as practicable thereafter.

ADDENDA:
Receipt of Addenda numbered ___________is hereby acknowledged.

____
Bidder

____
Address

__________ ______________________________________
Telephone Signature

SUPPLEMENTARY CONDITIONS

GENERAL CONDITIONS:
AIA Document A107 is the form of agreement that will be used for the Contract between the Owner and Contractor. The General Conditions included as a part of AIA Document A107 is a part of the Contract. In case of a conflict between the Supplementary Conditions and the General Conditions, the Supplementary Conditions will govern.

OWNER:
The Owner is St. Vincent de Paul Society of Lane County, Inc. This name is intended where it is used in the documents as St. Vincent de Paul or St. Vincent de Paul Society.

BUILDING PERMIT:
The building permit from the City of Springfield has been obtained by the Owner; the amount of the permit is not a part of the contract sum.

INSURANCE:
Contractor shall provide proof of liability insurance as required by law, and fire insurance with extended coverage for the replacement cost of the demonstration house for the duration of the construction. Contractor shall also provide proof of workmen's compensation insurance coverage for all subcontractors.

PERFORMANCE BOND:
Contractor shall show proof of performance bond as required by Oregon law.

CONSTRUCTION SCHEDULE/SEQUENCE OF WORK:
Contractor shall provide a detailed construction schedule as soon as possible after award of the Contract.

RECORD DRAWINGS:
Contractor shall assist the Architect in compiling information for "As Built" drawings which will record deviations from contract drawings including dimensioning of all permanently concealed items. The Architect will be responsible for recording the information on the drawings.

OWNER'S OPERATIONS & MAINTENANCE DATA:
Contractor shall assist the Architect in compiling two hardbound loose leaf binders including:

1. Copies of all guarantees, certificates, etc.
2. Installation instructions accompanying all equipment and fixtures.
3. Operation and maintenance instructions for all equipment and fixtures.
4. Maintenance instructions for finishes.

EXTRAS AND CHANGE ORDERS:
The Contractor and Architect may agree verbally on minor changes in details or

methods to expedite the work if such changes do not involve extra costs to the Owner; such changes must carry out the overall intent of the drawings and specifications, and must not reduce the value or effectiveness of the completed work. Should changes be discussed which involve extra cost, it is the responsibility of the Contractor to state that an extra cost is involved so that no agreement can be reached until the cost for the change is determined and a change order is issued.

STRUCTURAL TESTING:
The Contractor shall stop construction for any four consecutive calendar days to allow for structural testing of the building shell. This shall be done when the shell of the building is complete and the shingles or other protective roof covering is in place and before any interior partitions are installed.

Part of the testing will involve loading the floors with water bladders on the east side of the building for an area of approximately 12' x 20' on each floor and includes rooms 101 and 204. The projection of pipes or conduit through the floor for the interior partitions in these locations must not occur before the testing. Clean floors in this area of rubbish and stored materials.

Another part of the testing will require application of lateral forces to the exterior of the building from the north and west. Consequently the Contractor shall maintain a 12' clear area adjacent to the northwest quadrant of the house until this testing is complete.

Notify Architect at least five days before the testing can start. The Contractor is not required to be present during the testing.

BLOWER DOOR AND THERMOGRAPHIC TESTS:
The Contractor shall stop construction for two calendar days to allow for blower door and thermographic testing after the house construction is completed, but prior to interior finish painting and floor finishes.

Notify Architect at least five days in advance before the testing can start. The Contractor is not required to be present during the testing.

Blower door testing for air tightness of the demonstration house will be performed and paid for by the Energy Studies in Buildings Laboratory. The house is required to meet a Long Term Super Good Cents standard for Advanced Air-Leakage Control of 0.1 ACH as established by the blower door test performed per Appendix C of the Long Term Super Good Cents Technical Specifications for Site-built and Multifamily Homes, and shall have 1.8 air changes per hour or less at 50 pascals. If blower door testing indicates that further air tightening is necessary to meet this standard, the Contractor will caulk and otherwise seal the house as needed until this standard is met at no additional charge to the Owner.

Thermographic testing is to be performed and paid for by the Energy Studies in Buildings Laboratory. These tests will use infrared examination of the building to identify possible defects in the thermal envelope as determined by the Architect. If defects are found, the Contractor will repair these defects according to the instructions of the Architect at no additional charge to the Owner.

ROOFING INSTRUMENTATION:
The Contractor shall oversee the installation of six thermocouples (low-voltage wires to be laid under the shingles during roofing, with loose ends coiled for connection later) supplied by the Energy Studies in Buildings Laboratory, during the roofing of the house for subsequent measurement of roof temperatures. Other test instruments will be installed by the Energy Studies in Buildings Laboratory after the house is completed.

PROJECT SIGN: At the start of construction the Contractor shall provide and maintain a 4' x 8' construction sign in a prominent location on the site. The layout and text of the sign will be provided by the Architect. The sign will remain in place until completion of the contract.

TEMPORARY FACILITIES: The Contractor shall provide a construction office, toilet, water and telephone on the site. Electric power is available from the adjacent site to the west.

SOILS INVESTIGATION:
Test pits were dug by a backhoe on the site immediately east of the building site. A copy of this report is available for inspection in the Architect's office.

SPECIAL REQUIREMENTS FOR RECORD KEEPING:
The Contractor shall each day maintain records of the time and materials required for specific portions of the construction work, broken down in time periods of 1/10 hour and by materials unit and total cost, by operation to include but not be limited to the following:

- foundation excavation
- foundation framing
- foundation concrete
- first floor framing
- exterior wall framing
- second floor wall framing
- roof framing
- interior panel wall framing
- interior stud wall framing
- window installation
- rough plumbing
- HVAC installation
- rough wiring
- dry wall installation and finishing
- porches and exterior trim
- finish carpentry
- finish wiring

finish plumbing

ARCHITECT'S ACCESS TO THE SITE:
The Contractor shall provide the Architect free access to the building site for the purpose of observing, photographing, videotaping or otherwise recording the construction process. In the event that this recording process impedes the progress of the contruction work, the Contractor shall promptly advise the Architect of the nature and extent of the impediment, and its projected impact on the cost of the project. The Architect shall determine whether the impediment is necessary; if so, the Contractor will record the cost addition in such a way that it can be identified in the project records.

CONFERENCES WITH THE ARCHITECT:
Throughout the construction process, conferences between the Contractor and Architect will be required. These will be at the end of each work day during construction of the building shell (foundation, floor, exterior wall and roof) and less frequently thereafter, as determined by the Architect. The time required for these conferences will be logged in such a way as to distinguish it from other construction work.

DONATED MATERIALS (NOT IN CONTRACT):
Donated materials include the foam panels as shown on drawings sheets 15 through 18 and as included in the specifications. In addition to the panels the materials listed below will be donated to the project. The contract amount is not to include the costs of these materials. These materials will be delivered to the site as they are required to expedite construction. Delivery times will be coordinated with the Architect. Contractor shall provide all other materials required.

Materials	Source
land, const. costs, appliances, direct burial grade 4x lumber	St. Vincent dePaul, Eugene, OR
siding, soffitt, porch ceiling panels	Stimson Lumber Co., Portland, OR
TJI's, Parallam beams	Trus Joist MacMillan
interior honeycomb panels	Super Struct Systems, Rialto, CA
windows	Viking Industries, Portland, OR
window gasket mat'l	Viscor, Inc., Dallas, TX
all building connectors	Simpson Strong-Tie, Brea, CA
all lighting fixtures	Lights of America, Walnut, CA Seagull Lighting, Riverside, NJ
all "gravel" (glass cullet)	Owens Brockway, Portland, OR
interior plumbing vents	Studor International, Dunedin, FL
all makeup heaters	Cadet Mfg. Co., Vancouver, WA

9.4 SPECIFICATIONS AND ADDENDA

May 7, 1993

SPECIFICATIONS

DIVISION 1 - GENERAL REQUIREMENTS:

1. The work specified herein applies to both the Base Bid and Additive Alternate "A." See drawings and Project Manual to determine the extent of each.

2. Work and installation materials shall be approved by the manufacturer of the product being installed and shall conform to all applicable building codes.

3. Substitutions for specified items to be submitted for architect to approval.

DIVISION 2 - SITE WORK

1. Soil excavated for pier footings of house shall be spread evenly over crawl space area and covered with 6 mil polyethylene for vegetation control. Lap joints 12" minimum. Tape all joints and tape to the interior posts. Apply gravel to hold in place. Tuck outer edge under lattice framing.

2. Strip minimum of top 6" of soil under garage slab and all pavement. Stockpile for use in final grading.

3. Piers to be drilled a minimum of 12" into gravel stratum.

4. All footings to bear on undisturbed soil.

5. Finish grade to drain positively away from building. Avoid ponding.

6. Concrete slabs on grade on 6" minimum glass cullet with vibrator type compactor (no earth fill) compacted in 6" maximum layers. Slope all paving as necessary for positive drainage.

7. Provide additional clean fill as required to meet finish grades indicated on plan. In all disturbed areas which are to receive lawns replace 6" of topsoil as necessary to meet finish grades indicated on plan.

8. All grading is to be completed with hand raking to spread soil evenly.

9. Spread grass seed at wholesaler's recommended rate over the portion of the site indicated as lawn on plan. Spread 1/2" rotten sawdust over this area and water one time.

10. Plant new trees as indicated on landscaping plan as recommended by plant supplier/wholesaler. Furnish owner with two copies of wholesaler's planting and maintenance instructions.

DIVISION 3 - CONCRETE

1. House and porch footings: air-entrained concrete between 5 and 7 percent, 3000 psi compressive strength at 28 days.

2. Turned-down slab at garage: air-entrained concrete between 5 and 7 percent, 3500 psi compressive strength at 28 days, 6 x 6 W1.4 x W1.4 wire mesh in middle of slab, 6 mil black polyethylene over compacted base. Provide 1-#4 bar at top of and 1-#4 bar at bottom of perimeter foundation. Reinforcing bars shall conform to ASTM A305, Grade 60. Light broom finish. One coat of sealer.

3. Driveway: Air-entrained concrete, 3500 psi compressive strength at 28 days, 6 x 6 W1.4 x W1.4 wire mesh in middle of slab over compacted base, heavy broom finish on driveway. Sawn joints as indicated on plan. One coat of sealer.

4. Sidewalks and paved play area: air entrained concrete, 3500 psi compressive strength at 28 days, exposed aggregate finish. One coat of sealer.

DIVISION 5 - METALS

1. All fasteners exposed to weather to be hot-dip galvanized.

2. All connector numbers refer to Simpson except as noted. Use nails recommended by manufacturer except where otherwise noted.

DIVISION 6 - WOOD AND PLASTIC

1. Wood framing standards: NFPA House Framing Manual except as noted. Interior partitions on first floor shall be spaced below joists with roof truss clips to prevent deflected joists from bearing on partitions. See details. Nails shown in details are common or galvanized box; not sinkers.

2. Framing lumber: #2 DF-L except as noted, 19% maximum moisture content (except for pressure treated lumber). Wood studs: "stud" grade.

3. 2x10 stringers in main roof panel adjacent to stairwell and adjacent to skylight openings: #1 DF-L.

4. 4x6 posts embedded in concrete: select structural DF-L.

5. Flat 2x6 and 2x4 glued and screwed to bottom of first floor panels (interior bays only): select structural DF-L. Splice 2x6 over posts.

6. Exposed framing members selected for appearance for paint finish.

7. 4 inch thick framing members (4x4, 4x6, 4x8, & 4x12) shall be free of heart center.

8. Preservative treatment with waterborne salts:
Wood partially embedded in concrete: AWPB FDN, .60 pcf retention. Treat all cut or drilled surfaces near or below ground: AWPA M-4.
Wood in contact with concrete: AWPB LP-22, .40 pcf retention.
Above ground wood in decks and porch construction (below 4x8 beam): pressure treated, "Sunwood," Wolmanized, or equal without incisions.

9. Roof sheathing for garage, porch, and end wall overhangs: 5/8" OSB rated 40/20. Nail with #8 nails 6" o.c. at edges and 10" o.c. intermediate. Stagger joints.

10. Floor sheathing for second floor: 3/4" OSB, 40/20 or 3/4" plywood, exposure 1, touch sanded, 40/20, glued and nailed. Use continuous bead of construction adhesive along joists and two beads at end of panels spliced on joists. Nail 6" o.c. at edges, 10" o.c. field. Decrease nail spacing to 4" at the three joists nearest each end of building. Add 2 nails at edge of sheathing near end of joists at overhang. Triple nail around stairwell. Nails: 8d deformed shank.

11. Underlayment for second floor: 3/8" underlayment plywood, sanded, exposure 1. Lay in same direction as subfloor; stagger joints 16" minimum. Nail with 3d ring shanked nails 6" o.c. all edges, 8" o.c. in field.

12. Underlayment for first floor: 1/2" underlayment plywood, sanded, exposure 1, nailed and glued. Lay panels perpendicular to floor panels; stagger joints. Apply glue as recommended by manufacturer, 16" o.c. minimum. Nail same as 2nd floor. The underlayment on this floor is to be applied continuously over the floor before any interior partitions are framed.

13. All finish interior grade carpentry to be AWI Custom grade except as specified otherwise.

14. All finish exterior carpentry to be AWI Custom grade.

15. Soffits: 5/8" rough sawn "Duratemp"; 8d nails 6" o.c. all edges and on all joists.

16. Fascias: Western Red Cedar "A" grade, surfaced, KD 12%, long

lengths. Scarf splices; scarf to weather on rake.

17. Wall skirt: 5/8" rough sawn "Duratemp." Lattice: privacy grade unsurfaced cedar.

18. Siding for garage and side panels of dormer to match siding on house wall panels: 5/8" "Duratemp," RB&B, 8". 8d HD galvanized nails.

19. Wood I joists: 11-7/8" TJI-35/DF or equal with web stiffeners. Provide shop drawings.

20. Parallam beams: 2.0E DF Parallam PSL or equal. Provide shop drawings.

21. Prefabricated wood trusses (garage) designed for following loads:

Snow:	25 psf
Wind:	18 psf
Roofing & sheathing:	7 psf

Provide shop drawings.

22. Pre-manufactured interior partitions: 3-1/2" paper honeycomb core panels with factory-laminated 1/2" gypsum board faces by Super-Struct Building System.

23. Kitchen cabinets and bathroom lavatories: 5/8" melamine-faced particle board to be supplied by owner for drawers, doors and interiors of cabinets. 3/4" wood face frame to be painted to match melamine. Countertop surface to be preformed laminated faced with integral backsplash. Provide shop drawings.

DIVISION 7 - THERMAL AND MOISTURE PROTECTION

1. Building panels: R-Control or equivalent. 1 pcf expanded polystyrene core with 7/16" OSB skins ("Structurwood" or equivalent stiffness) except 5/8" Duratemp for outside face of wall as noted. The finished panel thickness shall not vary by more than 1/4" for panels of the same nominal thickness.

The lengths, widths and out of square tolerances of the completed panels shall not be more than one and one half times the tolerance allowed for either panel face.

Installation and connections with nails, construction adhesive, and sealant as recommended by manufacturer except as noted. Provide splines. At contractor's option 14 gage 1-1/2" staples or screws of equal or greater bearing strength may be used instead of nails in concealed locations.

The orientation of the OSB is parallel to the long panel dimension in floors and roof; it is vertical in the walls . For east and west walls below second floor use 3" spacing (instead of 6") for all connections. Reinforce each corner of these two window openings by connecting the 2x8 horizontal framing members to the 2x8 vertical members at panel joints with H2.5 and N10 nails.

2. Wall Panels: exterior face shall be 5/8" "Duratemp" RB&B, 8". Change nail spacing at top, bottom, and at building corners to 3".

3. Roof Panels: Connections at support at second floor shall be with 1-5/8" #8 screws, 6" o.c. maximum spacing and construction adhesive.

4. Flashing: pre-painted 26 gauge galvanized steel.

5. Gutters (4" continuous) and downspouts(2"x3"): pre-painted (white) 26 gage galvanized steel. Gutters to be seamless. Provide basket strainers at each downspout.

6. Roof shingles: Malarkey Roofing Alaskan SBS Modified Polyglass Shingles or approved equal with manufacturer's warranty for installation over stressed-skin insulated panels. Install over 15# asphalt saturated felt. Color to be selected by architect. Leave one unopened bundle with owner. Provide zinc moss control strip at ridge on north side of roof below ridge shingles.

7. Garage roof vent: Air Vent Inc. steep pitch filter vent or equal for ridge.

8. Air infiltration barrier: Tyvek or equal.

9. Batt or blanket insulation: fiberglass; install with vapor barrier on warm side.

10. Vapor barrier: 4 mil polyethylene.

11. Rigid insulation (at eave): 1" Celotex "Thermax" Insulation Board 610 series with reflective foil face both sides. Cut to force fit in the TJI space. Continuous caulk on all edges.

12. Caulking: Paintable 25-year acrylic latex plus silicone. Apply at all exterior fixed joints and other noted locations to provide water and airtight seal.

DIVISION 8 - DOORS AND WINDOWS

1. Exterior doors at house: R-5 insulated steel or fiberglass, simulated-panel, pre-hung. Sidelight: insulated, tempered, low-E glazing. Exterior swinging door at garage: solid-core wood door with single glass light, pre-

hung AWI custom grade.

2. Overhead garage door: Clad wood door by Overhead Doors or equal with glass lights, low headroom hardware, and automatic door opener.

3. Interior doors (including bifold): flush, paint-grade birch, pre-hung except as noted on plans, AWI custom grade.

4. Hardware manufacturers:
   a. Locks and latches by Kwikset
   b. Butts by Stanley (3 per door)
   c. Thresholds and door bottoms by Pemko

   Butts for exterior doors: RDF 179 4"
   Butts for interior doors: RDF 758 3-1/2"
   Stops, except as noted: Flex stop

Type 1:
Entrance w/ push button lock 401P3
Single cylinder deadbolt 660x3
Threshold w/ extender: 85518DV w/ 5EXT3D
Door bottom 216DV
Weatherstripping

Type 2:
Entrance w/ push button lock 401P3

Type 3:
Bathroom privacy lock 300P3
Stop for Door 202: Ives 407, mount on door

Type 4:
Passage latch 200P3
Stop for Door 104: Hinge stop

Type 5:
Entrance w/ push button lock: 401P3
Threshold: 170D
Door Bottom: 216DV

Type 6:
Bi-Fold Doors Ball knob US3

5. Keying: Doors 100, 101 and G1 keyed alike; furnish 6 keys total. Door 102 keyed differently; furnish 3 keys.

6. Attic storage access doors: 3/4" birch ply, back-beveled, finished similar to adjacent wall.

7. Windows: Viking Model 9700 with 1" insulated, low E glazing, argon filled, with flush fin adapters and insect screens. Awning windows to be pole operated. Provide one 3' or 4' pole. Provide egress hardware for single casements. Provide standard hardware for other casements. Install Viscor 3/4" x 3" window wrap (self-adhesive foam gasket) per manufacturer's instructions.

8. Skylights: Crestline, model no. 4630TVGS with step flashing kits, model no. 4630L, pole operated or approved equal. Provide a pole for each skylight. Provide insect screens.

9. Relight glazing: 1/8" single glazed.

DIVISION 9 - FINISHES

1. Gypsum board: 5/8" on first floor ceiling only; 1/2" thick elsewhere. Light texture finish throughout. Gypsum board applied to OSB on exterior walls and second floor ceiling shall have joints staggered from OSB joints 12" minimum. Gypsum board to be water-resistant around tubs; protect joints, cut edges and pipe openings with sealant. Secure all gypsum board with screws. Use metal trim for external corners and exposed edges.

2. Carpet: Atlas, Oxford Place 26 oz., level loop, minimum number of seams. Pad to be 5 lb., 1/2" Rebound foam, FHA approved.

3. Sheet vinyl: Tarkett "Coordinates," .080; 12 ft where required to reduce number of seams.

4. Vinyl base: Flexco 4" cove rubber base, 1/8".

5. Metal edge strips: Naplock.

6. Primers, fillers, adhesives, and cleaners approved by floor manufacturers. Leave floor covering remnants over 5 sf on job site. Flooring and base colors to be selected by architect.

7. Paint: Finish all exterior and interior surfaces unless specifically excepted. Prepare surfaces per manufacturer's instructions. Color schedules to be provided by Architect.

Interior:

All gypsum board surfaces to be primed with Glidden Insul-Aid latex primer. Finish coat to be flat Glidden Spred 2000 except at bathrooms which shall be semi-gloss Glidden Spred 2000. All trim to be primed with latex wood primer and finished with semi-gloss enamel Glidden Spred 2000.

Oak stair landing and treads to be sanded and filled with paste wood filler per manufacturer's instructions. Finish with three coats of Flecto Diamond Varathane gloss finish per manufacturer's instructions.

Parallam at stair opening to be filled, sanded, primed and painted to match adjacent wood trim.

Paint out duct openings visible through grilles and registers. Ductwork, piping, etc. in unfinished areas shall receive no finish.

Exterior:

Walking surfaces of porches to be painted and primed with Glidden Spred Floor Polyurethane Enamel No. 800.

All other wood surfaces to be primed with Glidden Oil/Alkyd No. 3651. Unprimed metal surfaces to be primed with Glid-Guard All Purpose Metal Primer No. 5229. Top coat to be Glidden Spred House Paint, Dura-Satin Finish No. 2900 except doors and all trim which shall be Glidden Spred House Dura-Gloss Finish No. 3900.

Paint lattice prior to installation. All under-floor lumber that is visible within four feet from exterior walls of the house shall also be painted.

8. Closets to be finished similar to adjacent room.

9. Acoustical tile (Room 205): Mineral fissured tile, NRC Range .65-.75 or greater. USG Acoustone or equal. Apply over gypsum board before installation of mechanical equipment.

10. Garage to have no interior finish except for painted doors and door trim. Color to be selected by Architect.

DIVISION 10 - SPECIALITIES

1. Medicine cabinets: white, with frameless mirrors; flush mounted at first floor; surface mounted at second floor.

DIVISION 11 - EQUIPMENT

1. Washer/dryer, refrigerator and range provided by Owner.

2. Range Hood: by Broan, 190 CFM, 75W bulb, ducted, white.

DIVISION 12 - FURNISHINGS

1. Window blinds: Ovation line by Levolor. Color to be selected by

architect.

DIVISION 15 - MECHANICAL

1. House Supply: 1-1/4" galvanized steel supply line from meter to 1-1/4" shutoff in utility box. Install temporary manifold with three 3/4" hose bibbs at location indicated on plan until structural testing is complete; afterward replace with single permanent hose bibb.

2. Fixture Supply: Minimum 1/2" copper, soldered with lead-free solder, galvanic protection at joint to steel supply line, shutoff in utility box at house and stops at all fixtures.

3. Waste: Schedule 40 ABS plastic.

4. Water Heater: To be part of Envirovent HPVAC-80 ventilating heat pump unit by Therma-Stor Products Group. Provide with overflow pan. Install on 2" noncompressible foam bottom board.

5. Interior vent: Studor Mini-Vent air admittance valves per manufacturer's instructions.
Exterior vent: 2" Schedule 40 ABS plastic.

6. Provide R-11 insulation with protective covering at exposed water supply lines and any traps below floor level to prevent freezing. Make airtight seals around supply and waste penetrations through floor.

7. Hose bibbs: Merrill Manufacturing frostproof yard hydrant no. C75015 except three temporary hose bibbs installed for duration of structural testing.

8. HVAC system: Envirovent HPVAC-80 by Therma-Stor Products Group. Use resilient mounts to dampen vibrations.

9. Locate fresh air intake 6'-0" minimum away from kitchen exhaust vent.

10. Fresh air intakes: Fresh 80 ventilators by Therma-Stor Products Group as located on plan.

DIVISION 16 - ELECTRICAL WORK

1. Connect smoke detectors to house power and locate a minimum of 5'-0" upstream from any return air grille.

2. Bathroom fan: Broan Model No. S130 at second floor bath. Broan Model No. 162 with heat lamp at first floor bathroom. Wire fan and heat lamp separately.

3. Wall heaters: by Cadet. 1000W Advantage at bedrooms, 1500W Advantage at living room, and 500W Hidden Heat TK-051T at second floor bathroom. Advantage heaters to be controlled by integral thermostats; Hidden Heat TK-051T to be connected to spring timer switch per plan.

4. Test equipment: install only conduit and junction boxes as indicated on the electrical plan. Instruments and related low voltage wiring will be installed prior to testing by research technicians.

Addenda to Specifications

ADDENDUM 1. September 20, 1993

Specification Changes for Bid Revision
Note: all numbers refer to original (5/7/93) specifications. Items marked* to be donated; supplied on site as needed.

Division 2 — Site Work

6. By others.
8. By others.
9. By others.
10. Plant two street trees as required by City, per revised landscape plan, as recommended by plant supplier/wholesaler. Furnish owner with two copies of wholesaler's planting and maintenance instructions.

Division 3 — Concrete

2. By others.
3. By others.
4. By others.

Division 6 — Wood and Plastic

7. Omit
9. Substitute 19/32" T & G Comply* rated 40/20.
10. Substitute 3/4" T & G Comply Sturd-I-Floor*.
11. Substitute 3/8" Fiberbond* underlayment. Install per manufacturer's instructions.
12. Substitute 1/2" underlayment grade plywood C-C PTS or approved equivalent*.
16. Substitute Western Red Cedar "B" grade or approved equivalent.

Division 7 — Thermal and Moisture Protection

4. Omit "pre-painted"
6. Substitute Elk Prestique Plus* shingles.

Division 8 — Doors and Windows

1. Exterior doors at house: R-5 Therma-Tru insulated fiberglas doors*, pre-hung. Omit sidelight. Exterior swinging door at garage: R-5 insulated Therma-Tru door*.
3. Interior doors (including bifold): Masonite CraftMaster Coventry*, pre-hung except as noted on plans.
8. Skylights: Wasco Genra-I Self-Flashing Venting Units, Model GVI 4630, with SPW 4630 Skyshades, a Skyshade Pole, and a Skywindow Venting Pole*.

Division 9 — Finishes

1. Substitute 1/2" Louisiana-Pacific Fiberbond* wallboard throughout. Install per manufacturer's instructions.
2. Substitute "Phoenix" carpet from Image Carpets. Substitute Duralux poly 7mm carpet pad*. Install per manufacturer's instructions.
3. Substitute Marmoleum linoleum, 2.5mm*. Install with supplied adhesive per manufacturer's instructions.
7. Exterior: omit painting of porch walking surfaces. Omit painting of lattice and under-floor lumber.

Division 15 — Mechanical

1. Substitute PVC supply line.
2. Omit galvanic protection at supply line.
7. Hose bibbs: add "or approved equivalent."

Division 16 — Electrical

4. Instruments and related low voltage wiring will be installed prior to testing by others.
5. (add) Stub out conduit only to garage slab and optional light pole location per plan.

ADDENDUM 2. date: June 11, 1993

Sign copy for Demonstration House project:

Affordable Energy Efficient Demonstration House Project for St. Vincent de Paul Society of Lane County Inc.
Designed by Energy Studies in Buildings Laboratory, University of Oregon
U. S. Department of Energy, research sponsor
with help from these industry partners:

AFM Corp.	foam core exterior building panels
Bonneville Power Administration	funding
Cadet Mfg. Co., Vancouver, WA	heaters
DEC International, Madison, WI	exhaust air heat pump
Lights of America, Walnut, CA	lighting fixtures
Levolor Corp., Sunnyvale, CA	window coverings
Owens Brockway, Portland, OR	glass "gravel" (cullet)
Seagull Lighting	lighting fixtures
Simpson Strong-Tie, Brea, CA	building connectors
Stimson Lumber Co., Portland, OR	siding panels
St. Vincent dePaul, Eugene, OR	land, construction costs, appliances

Studor International, Dunedin, FL	interior plumbing vents
Super Struct Systems, Rialto, CA	honeycomb core interior building panels
Trus Joist MacMillan	engineered framing materials
Viking Industries, Portland, OR	windows
Viscor, Inc., Dallas, TX	window and building gaskets

ADDENDUM 3. Date: September 20, 1993

Addendum to Project Documents

DEMONSTRATION HOUSE PROJECT FOR ST. VINCENT DE PAUL SOCIETY OF LANE COUNTY, INC.

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

Date:________ Number: _____ Refer to drawings sheet number:_________

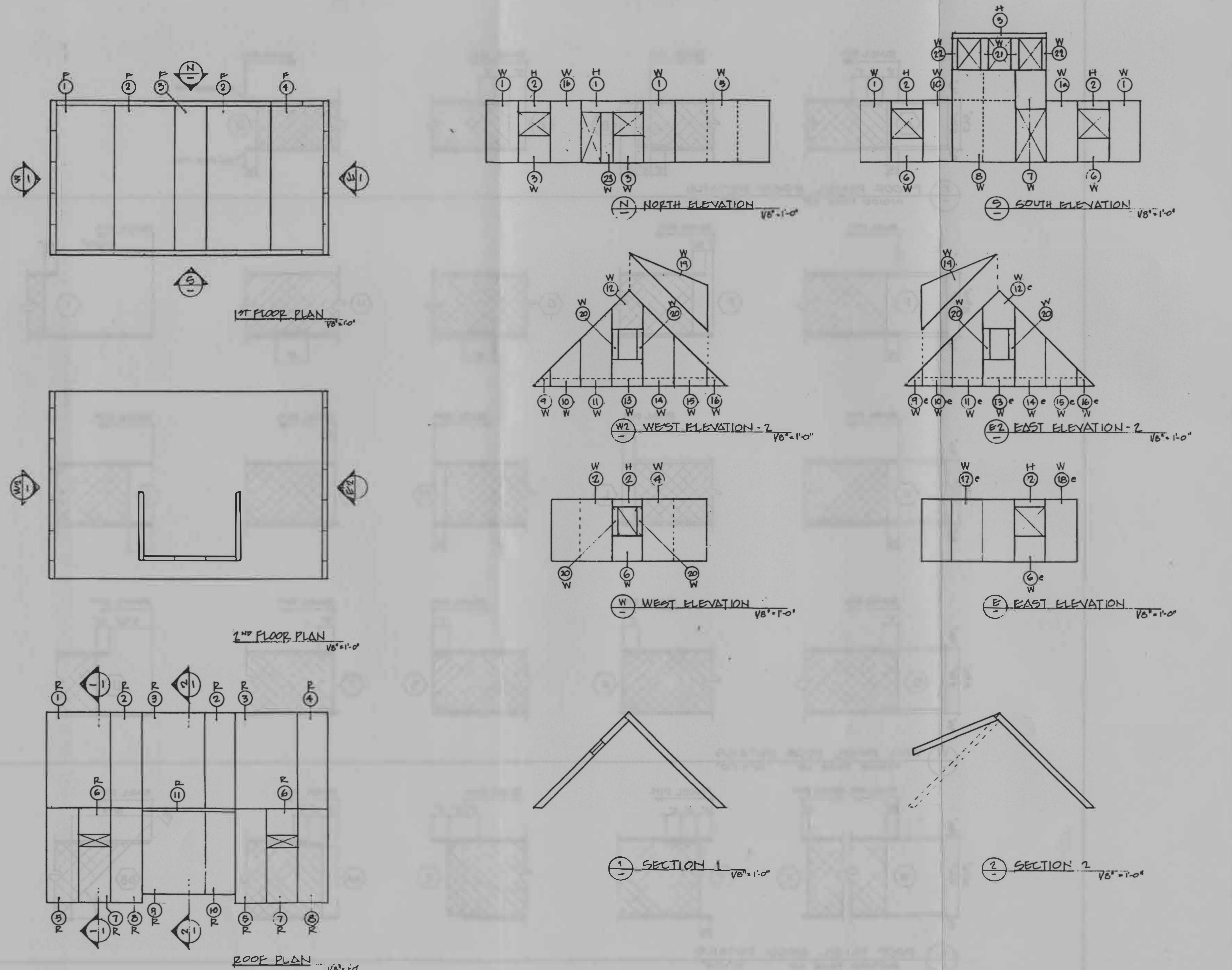
1. Delete the following items from the scope of work:

   concrete flatwork (driveway, garage slab and walkways)
   final clean up
   base boards
   paint on lattice and porch decks

2. Revise interior window trim as follows: wallboard wrap head and jamb, install wood sill per drawings

3. Electrical work to include stub out conduit to garage slab and outside light pole location per drawings

9.5 PANEL SHOP DRAWINGS

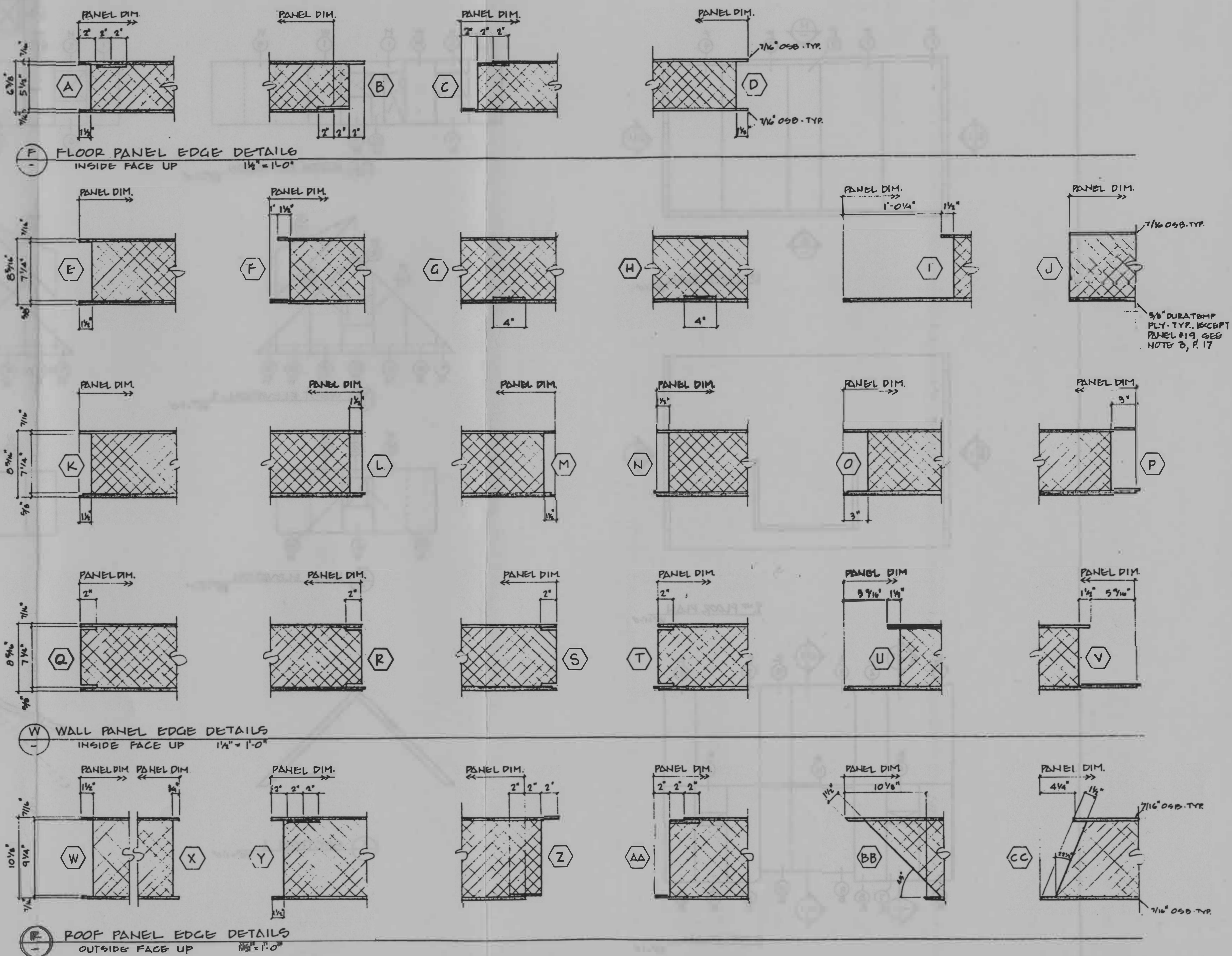


3-30-93
5-11-93 BID
11-11-93

Demonstration House for:
St. Vincent De Paul Society

Energy Studies in Buildings Laboratory
Center for Housing Innovation
University of Oregon
(503) 346-5647

Panel Locations



NOT FOR CONSTRUCTION

3.30.93
5.11.93 BID
11.11.93

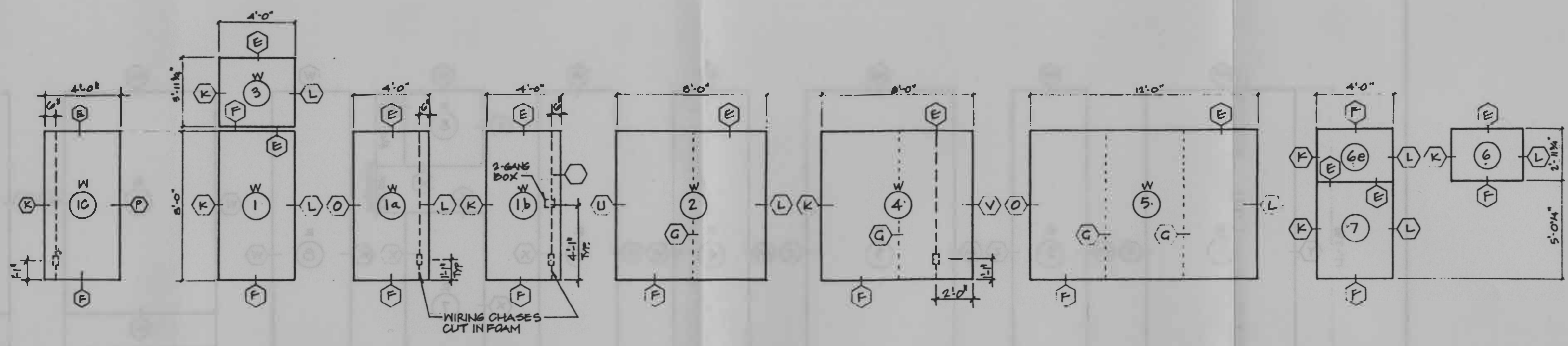
REGISTERED ARCHITECT
G. Z. BROWN
EUGENE, OREGON
STATE OF OREGON

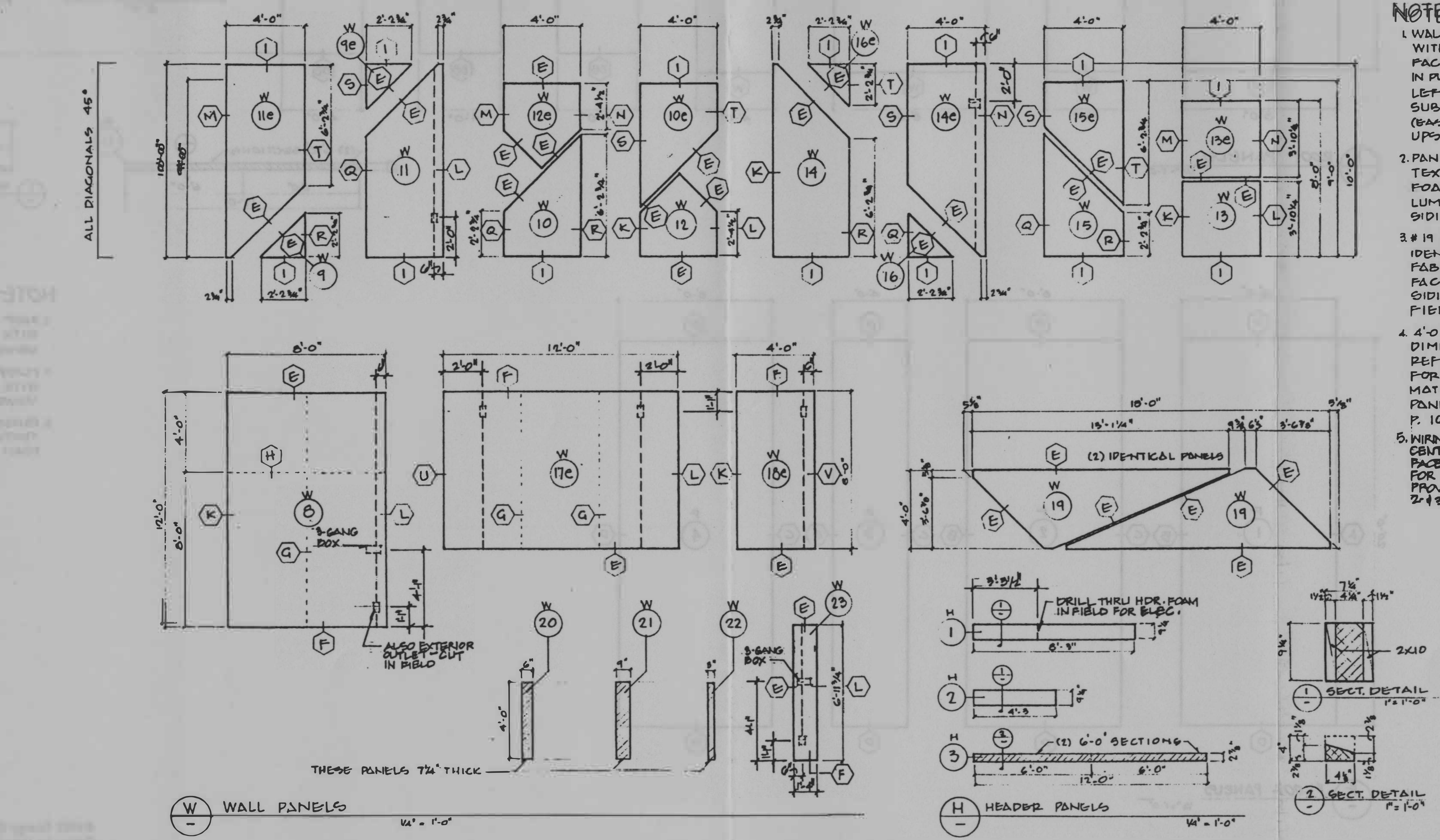
Demonstration House for:
St. Vincent De Paul Society

Energy Studies in Buildings Laboratory
Center for Housing Innovation
University of Oregon
(503) 346-5647

Panel Edge Details

16





NOTES: THIS PAGE

1. WALL PANELS ARE SHOWN WITH OUTSIDE (PLYWOOD) FACE TO VIEWER. GROOVE IN PLY IS AT RIGHT; LAP IS AT LEFT. PANELS WITH "e" SUBSCRIPT DESIGNATION (EAST ELEV.) ARE SHOWN UPSIDE DOWN.
2. PANELS WITH HATCHED TEXTURE ▨▨▨ ARE EPS FOAM ONLY; TO HAVE OSB, LUMBER, AND/OR PLYWOOD SIDING APPLIED IN FIELD.
3. # 19 PANELS ONLY - (TWO IDENTICAL PIECES) - TO BE FABRICATED WITH BOTH FACES OF 7/16" OSB. PLYWOOD SIDING TO BE APPLIED IN FIELD, OVER OSB.
4. 4'-0", 8'-0", AND 12'-0" HORIZ. DIMENSIONS ON THIS PAGE REFER TO PANEL MODULE. FOR MORE PRECISE INFORMATION, SEE SPECIFIC PANEL EDGE DETAILS ON P. 16.
5. WIRING CHASES CUT IN FOAM CENTERED 2½" FROM INSIDE FACE OF PANEL (OSB). OUTOUTS FOR INTERIOR ELEC. BOXES PROVIDED IN FACTORY; 3" DEEP 2- & 3-GANG BOXES ARE NOTED.

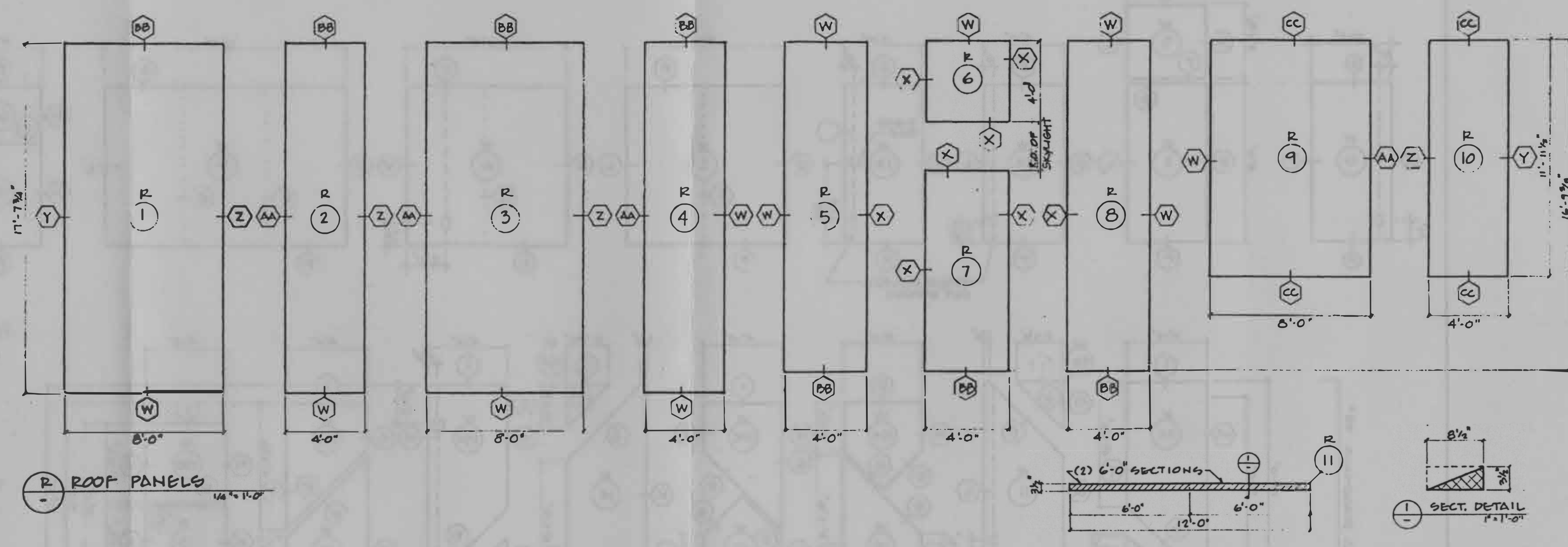
5.30.93
5.11.93 BID
11.11.93

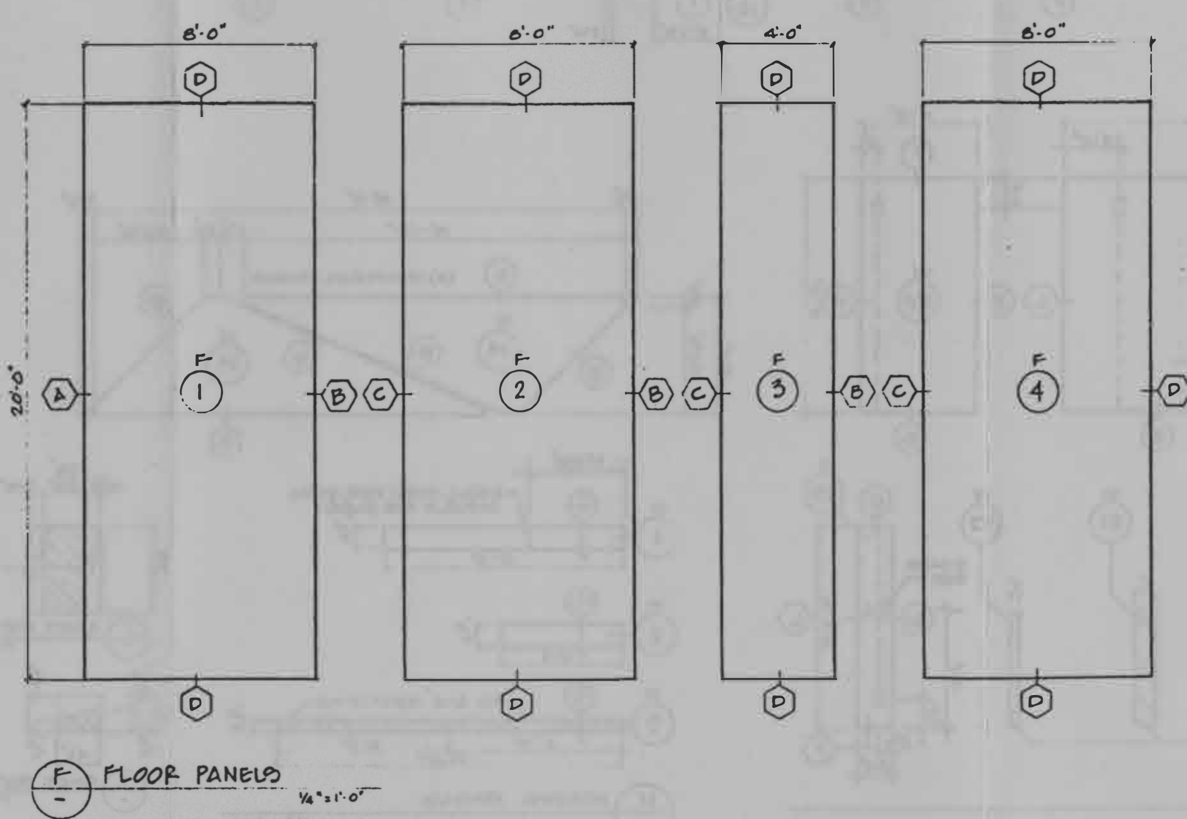
REGISTERED ARCHITECT G. Z. BROWN EUGENE, OREGON STATE OF OREGON

Demonstration House for:
St. Vincent De Paul Society

Energy Studies in Buildings Laboratory
Center for Housing Innovation
University of Oregon
(503) 346-5647

Wall Panels





NOTES: THIS PAGE

1. ROOF PANELS ARE SHOWN WITH OUTSIDE FACE TO VIEWER
2. FLOOR PANELS ARE SHOWN WITH INSIDE FACE TO VIEWER.
3. PANELS WITH HATCHED TEXTURE ARE EPS FOAM ONLY.

3-30-93
5-11-93 BID
11-11-93

REGISTERED ARCHITECT
G. Z. BROWN
EUGENE, OREGON
STATE OF OREGON

Demonstration House for:
St. Vincent De Paul Society

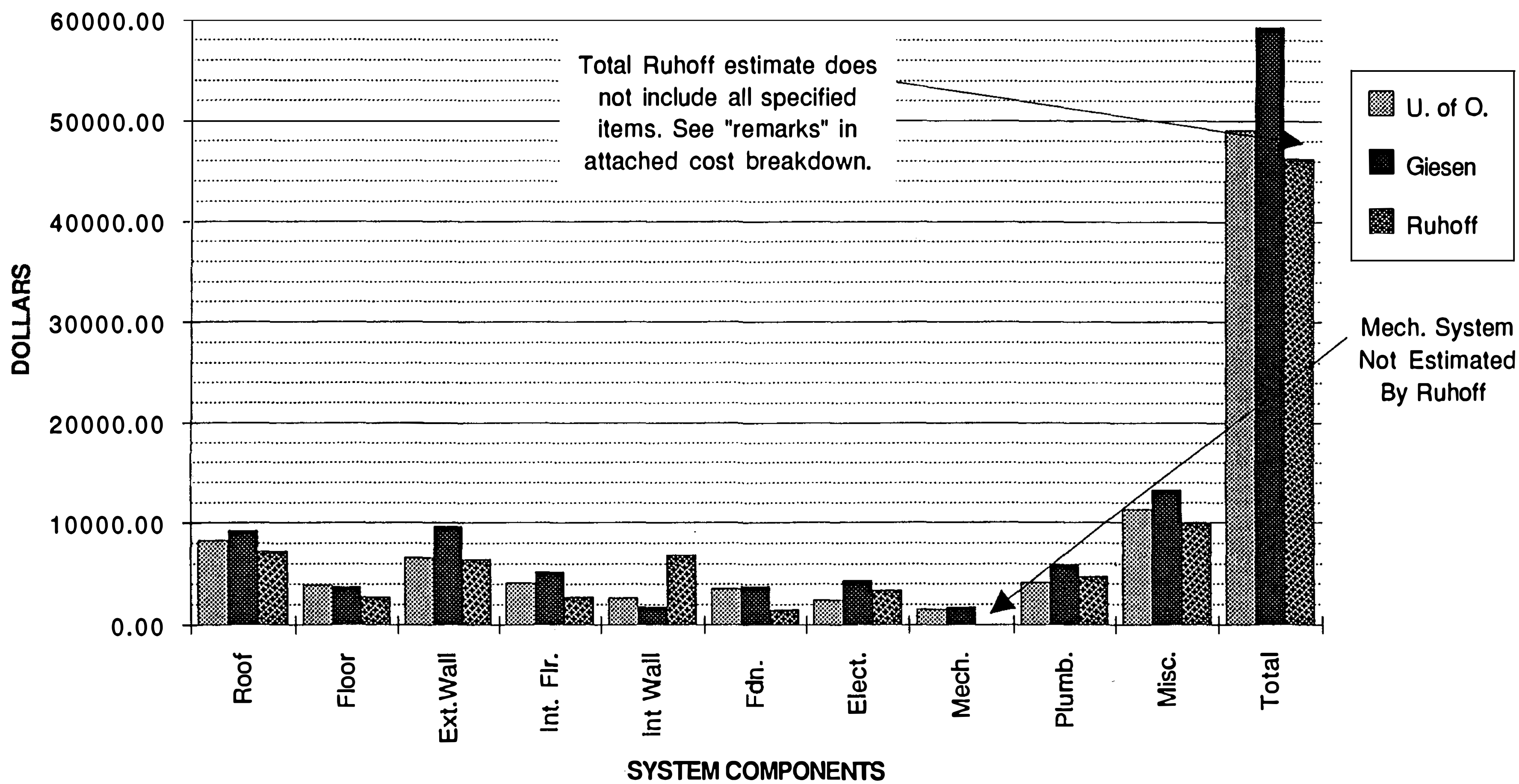
Energy Studies in Buildings Laboratory
Center for Housing Innovation
University of Oregon
(503) 346-5647

Floor and Roof Panels

9.6 COST SPREAD SHEETS

Estimate Comparison

Ref. House Estimate											
		18974.63									
	Roof	Floor	Ext.Wall	Int. Flr.	Int Wall	Fdn.	Elect.	Mech.	Plumb.	Misc.	Total
U. of O.	8344.11	3955.05	6675.47	4174.17	2738.16	3633.14	2495.31	1566.27	4190.00	11356.66	**49128.34**
Giesen	9332.60	3818.18	9742.12	5283.00	1859.50	3864.36	4400.00	1785.00	5985.00	13335.51	**59405.27**
Ruhoff	7303.92	2842.66	6517.50	2823.49	6925.82	1585.79	3459.90	0.00	4776.60	10047.32	**46283.00**



 7/7/92 M. Elliot

Estimate Comparison

Reference House Estimate-Ruhoff								
Roof								
		Material	**Labor**	**Bare Tot.**	**O. & P.**	**Total**	**Remarks**	
Framing		1315.09	1500.00	2815.09	1.14	3209.20		* No estimate for vents
R-38 insulation		750.00		750.00	1.14	855.00		* No Estimate for knee braces
Roofing		1994.00		1994.00	1.14	2273.16		
Gutters		260.00		260.00	1.14	296.40		
Sheetrock		587.86		587.86	1.14	670.16		
Totals		**4906.95**		**6406.95**		**7303.923**		
Floor								
		Material	**Labor**	**Bare Tot.**	**O. & P.**	**Total**	**Remarks**	
Framing		613.60	458.96	1072.56	1.14	1222.72		* No estimate for 1/2" underlayment
R-30 Insulation		525.00		525.00	1.14	598.50		
Flooring		896.00		896.00	1.14	1021.44		
Totals		**2034.60**		**2493.56**		**2842.66**		
Exterior Walls								
		Material	**Labor**	**Bare Tot.**	**O. & P.**	**Total**	**Remarks**	
Framing		1578.83	921.50	2500.33	1.14	2850.38		* No estimate for 2" insulation
R-26 Insulation		1125.00		1125.00	1.14	1282.50		
Sheetrock		835.38		835.38	1.14	952.33		
Painting		1256.40		1256.40	1.14	1432.30		
Totals		**4795.61**		**5717.11**		**6517.505**		
Total Shell Cost				14617.6		16664.09		
Shell Cost $/SF	1259					13.23597		

Estimate Comparison

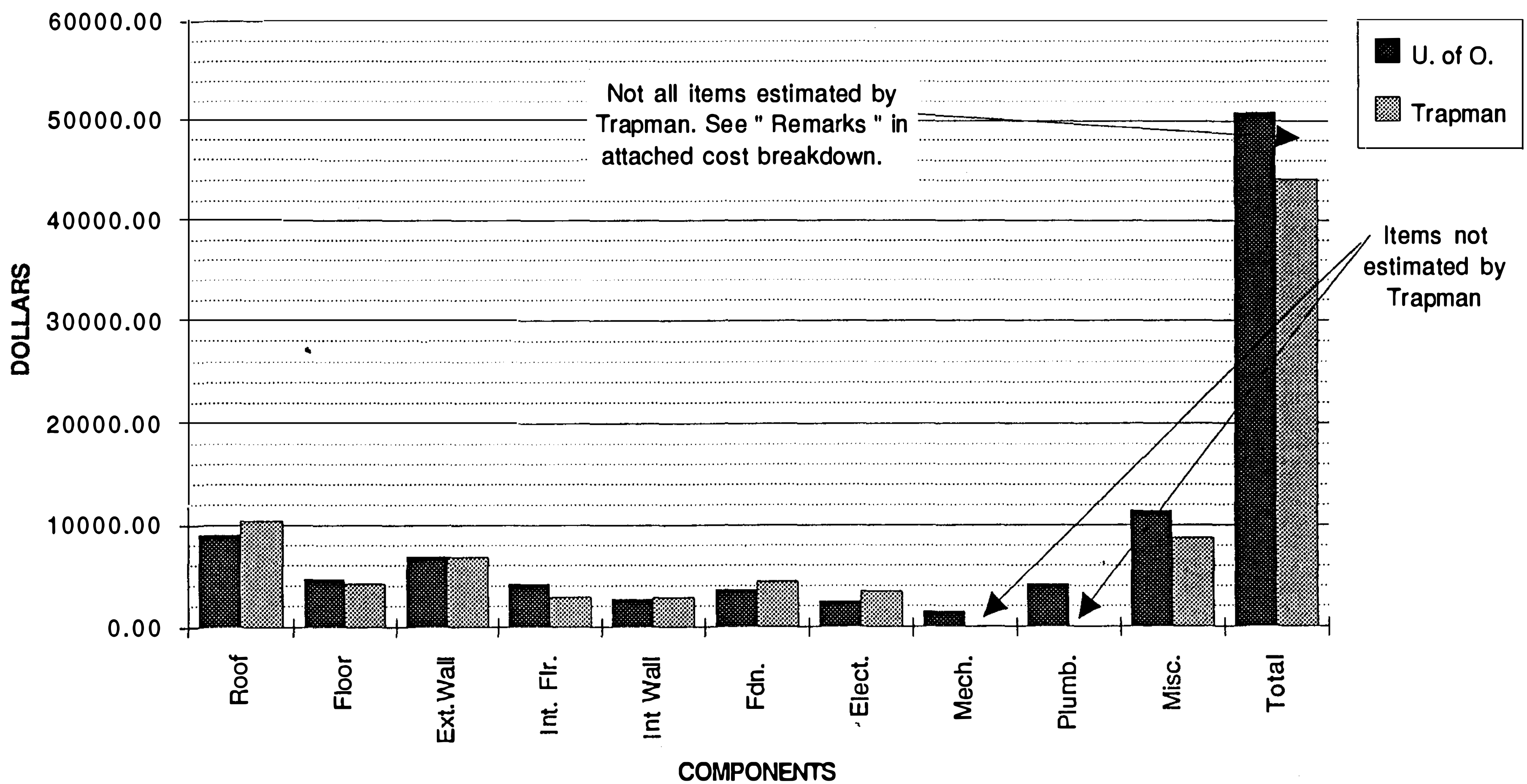
Interior Floor							
	Material	**Labor**	**Bare Tot.**	**O. & P.**	**Total**	**Remarks**	
Framing	780.35	398.39	1178.74	1.14	1343.77		* Floor take-off consists of old 4x8 system
Sheetrock	402.00		402.00	1.14	458.28		* No Estimate for 1/2" underlayment
Flooring	896.00		896.00	1.14	1021.44		
Totals	**2078.35**		**2476.74**		**2823.49**		
Interior Walls							
	Material	**Labor**	**Bare Tot.**	**O. & P.**	**Total**	**Remarks**	
Framing	798.14	604.00	1402.14	1.14	1598.44		* Price includes finish carpentry.
Finish Carp.	1869.00		1869.00	1.14	2130.66		
Sheetrock	1268.54		1268.54	1.14	1446.14		
Painting	1535.60		1535.60	1.14	1750.58		
Totals	**5471.28**		**6075.28**		**6925.82**		
Foundation							
	Material	**Labor**	**Bare Tot.**	**O. & P.**	**Total**	**Remarks**	
Concrete	358.00	420.00	778.00	1.14	886.92		* No estimate for:
Hardware	100.00		100.00	1.14	114.00		Grading
Survey	240.00		240.00	1.14	273.60		Excavation
Framing	156.21	116.83	273.04	1.14	311.27		P.V.C. drain
							Vapor barrior
Totals	854.21		**1391.04**		**1585.79**		
Electrical							
	Material	**Labor**	**Bare Tot.**	**O. & P.**	**Total**	**Remarks**	
Electrical	**3035.00**		**3035.00**	1.14	**3459.90**		

Estimate Comparison

Mechanical											
		Material	**Labor**	**Bare Tot.**	**O. & P.**	**Total**	**Remarks**				
Mech.		**0.00**		**0.00**	1.14	**0.00**		* No estimate for mech.			
Plumbing											
		Material	**Labor**	**Bare Tot.**	**O. & P.**	**Total**	**Remarks**				
Plumbing		**4190.00**		**4190.00**	1.14	**4776.60**					
Miscellaneous											
		Material	**Labor**	**Bare Tot.**	**O. & P.**	**Total**	**Remarks**				
Skylites		0.00		0.00	1.14	0.00		* No estimate for skylites			
Windows		1221.54		1221.54	1.14	1392.56					
Doors		1148.12		1148.12	1.14	1308.86					
Finish Lumber		767.70		767.70	1.14	875.18					
Finish Hardware		611.20		611.20	1.14	696.77					
Range w/ Hood		473.00		473.00	1.14	539.22					
Washer/Dryer		853.00		853.00	1.14	972.42					
Light Fixtures		500.00		500.00	1.14	570.00					
Cabinets		2022.88		2022.88	1.14	2306.08					
Clean Up		450.00		450.00	1.14	513.00					
Insurance		271.00		271.00	1.14	308.94					
Utilites		220.00		220.00	1.14	250.80					
Other Labor		275.00		275.00	1.14	313.50					
		0.00		0.00	1.14	0.00					
		0.00		0.00	1.14	0.00					
Total		8813.44		8813.44		**10047.32**					
Ref. House Total Costs						46283.00					
Ref. House Total Costs $/sf		1259			$	36.76					

Estimate Comparison #2

Demo House Estimate	Roof	Floor	Ext.Wall	Int. Flr.	Int Wall	Fdn.	Elect.	Mech.	Plumb.	Misc.	Total
U. of O.	9052.17	4685.81	6913.99	4174.17	2738.16	3633.14	2495.31	1566.27	4200.00	11458.53	50917.55
Trapman	10488.98	4232.43	6831.47	2960.11	2905.26	4456.20	3490.25	0.00	0.00	8817.10	44181.80



Estimate Comparison #2

Demonstration House Estimate-Trapman

NOTE :All material & labor items not included by Trapman were taken from the U. of O. cost estimate and multiplied by 1.15

Roof								
		Material	**Labor**	**Bare Tot.**	**O. & P.**	**Total**	**Remarks**	
Framing		1179.98	1050.00	2229.98	1.15	2564.48		* Estimate includes additional items not in
9 3/8" Panels		4147.20	720.00	4867.20	1.15	5597.28		U of O roof cost analysis:
Roofing		904.39	363.73	1268.12	1.15	1458.34		Truck rental
Gutters		98.40		98.40	1.15	113.16		Interior roof stringers
Sheetrock		242.57	214.58	457.15	1.15	525.72		Full porch cost
Truck Rental		200.00		200.00	1.15	230.00		
Totals		**6572.54**		**8920.85**		**10488.98**		
Floor								
		Material	**Labor**	**Bare Tot.**	**O. & P.**	**Total**	**Remarks**	
Framing		112.00	324.00	436.00	1.15	501.40		* No estimate for 1/2" underlayment
5 1/2" Panel		1944.00		1944.00	1.15	2235.60		
Flooring		956.50		956.50	1.15	1099.98		
Sub-Floor		244.29	99.58	343.87	1.15	395.45		
Totals		**3012.50**		**3336.50**		**4232.426**		
Exterior Walls								
		Material	**Labor**	**Bare Tot.**	**O. & P.**	**Total**	**Remarks**	
Framing		434.60	818.80	1253.40	1.15	1441.41		
7 3/8" Panel		3920.00		3920.00	1.15	4508.00		
Sheetrock		314.44	218.56	533.00	1.15	612.95		
Painting		181.13	52.88	234.01	1.15	269.11		
Totals		**4850.17**		**5940.41**		**6831.472**		
Total Shell Cost				18197.76		21552.87		
Shell Cost $/SF	1259					17.12		

Estimate Comparison #2

Interior Floor

	Material	Labor	Bare Tot.	O. & P.	Total	Remarks	
Framing	780.35	398.39	1178.74	1.15	1343.77		* Floor take-off consists of old 4x8 system
Sheetrock	196.96	52.82	249.78	1.15	287.25		* No Estimate for 1/2" underlayment
Flooring	944.45	211.28	1155.73	1.15	1329.09		
	0.00	0.00	0.00	1.15	0.00		
Totals	**1921.76**		**2584.25**		**2960.11**		

Interior Walls

	Material	Labor	Bare Tot.	O. & P.	Total	Remarks
Framing	559.40	700.00	1259.40	1.15	1448.31	
Sheetrock	546.90	380.13	927.03	1.15	1066.08	
Painting	215.46	124.42	339.88	1.15	390.86	
Totals	**1321.76**		**2526.31**		**2905.26**	

Foundation

	Material	Labor	Bare Tot.	O. & P.	Total	Remarks	
Concrete	900.00	450.00	1350.00	1.00	1350.00		* No estimate for:
Foundation Skirting	1848.00	400.00	2248.00	1.00	2248.00		Grading
4x4 Posts	43.20		43.20	1.00	43.20		Excavation
Simpson Brackets	20.00		20.00	1.00	20.00		P.V.C. drain
Rebar	12.00	125.00	137.00	1.00	137.00		
4x8 Girders	158.00	200.00	358.00	1.00	358.00		
Shipping Costs	300.00	0.00	300.00	1.00	300.00		
							Vapor barrior
Totals	**3281.20**		**4456.20**		**4456.20**		

Electrical

	Material	Labor	Bare Tot.	O. & P.	Total	Remarks
Electrical	**3035.00**		**3035.00**	1.15	**3490.25**	

Estimate Comparison #2

Mechanical								
		Material	**Labor**	**Bare Tot.**	**O. & P.**	**Total**	**Remarks**	
Mech.		**0.00**		**0.00**	1.15	**0.00**		* No estimate for mech.
Plumbing								
		Material	**Labor**	**Bare Tot.**	**O. & P.**	**Total**	**Remarks**	
Plumbing		**0.00**		**0.00**	1.15	**0.00**		* No estimate for plumbing
Miscellaneous								
		Material	**Labor**	**Bare Tot.**	**O. & P.**	**Total**	**Remarks**	
Skylites		0.00		0.00	1.15	0.00		* No estimate for skylites
Windows		1551.27	71.11	1622.38	1.15	1865.74		* No estimate for stair railing
Doors		1278.82	78.12	1356.94	1.15	1560.48		
Door trimwork		116.17	268.24	384.41	1.15	442.07		
Range w/ Hood		473.00	39.78	512.78	1.15	589.70		
Washer/Dryer		666.23	80.44	746.67	1.15	858.67		
Cabinets		1303.89	676.44	1980.33	1.15	2277.38		
Vanities		477.60	85.93	563.53	1.15	648.06		
Stairs		500.00	0	500.00	1.15	575.00		
		0.00	0	0.00	1.15	0.00		
		0.00	0	0.00	1.15	0.00		
		0.00	0	0.00	1.15	0.00		
Total		6366.98		7667.04		8817.10		
Ref. House Total Costs						44181.78		
Ref. House Total Costs $/sf		1259			$	35.09		

Costs

20'x36' Demo House Estimate#4a

	A	B	C	D	E	F	G	H	I	J
1	Component	Qty.	Unit	Adj. Mat. $	Mat. Tot $	Adj. Lab. $	Lab. Tot.$	Lab. W/O&P	Bare Total	Adj. Total
2	Roof; 9 3/8" R-control Panel									
9	PANEL TOTAL				4096.00					5700.62
10	15# Felt	1600	sf	0.02	39.09	0.04	61.77	104.39	100.86	147.92
11	Roofing,(Asphalt Shingles)	1600	sf	0.31	501.57	0.19	301.96	510.32	803.53	1062.57
12	2x8-Fascia	152	lf	0.51	77.08	0.89	135.28	228.62	212.36	320.10
13	Gutters	80	lf	0.89	71.55	1.07	85.84	145.06	157.38	227.29
14	Downspouts	56	lf	0.48	26.85	0.68	38.09	64.37	64.94	96.37
15	Nails/Glue			0.00	50.00	0.00	0.00	0.00	50.00	55.00
16	Porch Sheathing-5/8"	80	sf	0.37	29.50	0.15	12.26	20.72	41.77	54.06
17	Porch Soffit-1/2"	64	sf	0.30	18.88	0.14	9.20	15.54	28.08	37.02
18	Soffit-1/2"	130	sf	0.30	38.36	0.14	18.68	31.57	57.04	75.19
19	Additional Roof Sheathing	180	sf	0.30	53.11	0.14	25.87	43.71	78.97	104.11
20	Caulk(1/2 tube per 80 sf)	9	ea	3.54	31.86	0.00	0.00	0.00	31.86	35.05
21	Knee Braces	10	ea	9.17	91.74	14.85	148.50	250.97	240.24	352.32
22	Sub-									
23	~~R-Control~~ Roof Totals				5125.58		1327.94	2244.22	6453.53	8267.61
24										
25	Floor; 5 1/2" R-Control Panels									
28	PANEL TOTAL				2072.00					2756.07
29	Rim Joist-2x8	112	lf	0.51	56.80	0.18	20.39	34.45	77.18	98.16
30	Underlayment-1/2" Part. Bd.	736	sf	0.33	244.29	0.13	98.71	166.82	343.01	443.64
31	Caulk (1/2 tube per 80sf)	5	ea	3.54	17.70	0.00	0.00		17.70	19.77
32	***Floor Finishes:***									
33	***Sponge Rubber Pad***	***575***	***sf***	***0.31***	***176.96***	***0.08***	***47.45***	***80.20***	***224.41***	***274.85***
34	***Nylon, plush, 20 oz.***	***575***	***sf***	***1.17***	***672.43***	***0.25***	***142.36***	***240.60***	***814.80***	***999.25***
35	***Vinyl***	***100***	***sf***	***1.82***	***182.19***	***0.22***	***22.01***	***37.19***	***204.20***	***240.90***
36	Nails	1	ea	32.27	32.27				32.27	35.56
37										
38	~~R-30~~ Floor Sub-Total				3454.64		524.06	885.66	3978.69	4868.20
39										
40	Walls, (7 3/8") R-Control Panel									
53	PANEL TOTAL				4388.00					5823.10
54	Plate-2x8	274	lf	0.51	138.95	0.48	131.25	221.81	270.19	380.67
55	Staples			0.00	25.00	0.00	0.00		25.00	27.50
56	Caulk (1/2 tube per 80 sf)	7	ea	3.54	24.78	0.00	0.00		24.78	27.26
57	Screw fasteners	50	ea	1.00	50.00	0.00	0.00		50.00	55.00
58	Ext. Window Trim, (1x4)	186	lf	0.16	29.15	0.57	105.13	177.67	134.28	217.92
59	Baseboards	0	sf	0.12	0.00	0.07	0.00	0.00	0.00	0.00
60										
61	~~R-26~~ Wall Sub-Total				4655.88		640.27	1082.06	5296.15	6531.45
62										
63	***PANEL TOTAL***				***10556.00***					
64										
65	Total Adj. Shell Cost				13236.10		2492.27	4211.94	15728.37	19667.27
66	Adj. Shell Cost $/sf		1259	sf	10.51		1.98		12.49	15.62
67	Component	Qty.	Unit	Adj. Mat. $	Mat. Tot $	Adj. Lab. $	Lab. Tot.$	Lab. W/O&P	Bare Total	Adj. Total
68	~~Interior~~ Floor Framing									
69	***11 7/8" TJI***	***596***	***lf***	***1.43***	***851.74***	***0.24***	***142.74***	***241.23***	***994.49***	***1191.26***
70	***11 7/8" LVL***	***104***	***lf***	***1.43***	***148.63***	***0.24***	***24.91***	***42.09***	***173.53***	***207.87***
72	Blocking,(2x12)	64	lf	0.93	59.60	0.76	48.44	81.86	108.03	148.82
73	3/4" Decking	636	sf	0.42	269.74	0.16	103.58	175.05	373.32	478.76
74	3/8" Plywd. Soffit	144	sf	0.52	74.35	0.38	55.18	93.26	129.53	179.79
75	***Sponge Rubber Pad***	***590***	***sf***	***0.31***	***181.57***	***0.08***	***48.69***	***82.29***	***230.27***	***282.02***
76	***Nylon, plush, 20 oz.***	***590***	***sf***	***1.17***	***689.98***	***0.25***	***146.08***	***246.87***	***836.05***	***1005.85***
77	***Vinyl***	***50***	***sf***	***1.82***	***91.09***	***0.22***	***11.00***	***18.60***	***102.10***	***120.45***
78	Caulk/Glue	1	ea	23.05	23.05	0.00	0.00	0.00	23.05	25.36
79	Nails/Screws	1	ea	36.88	36.88	0.00	0.00	0.00	36.88	40.57
80	Vapor Barrier	200	sq	0.03	6.00	0.09	18.00	30.42	24.00	43.62
81										
82										
83	Sub-									
84	~~Int.~~ Floor Total				2442.31		604.79	1022.10	3047.10	3745.44
85			***TJI TOTAL***		***1000.37***					
86			***FLOORING COVERINK***		***1994.22***					
87										
88										

Intermediate

*Estimate for wood I-beam interior floor w/ tree spade foundation.

11/19/92 ; M. Elliot

separate panel walls / stud walls see ...

20'x36' Demo House Estimate#4a

— add panel walls (...) to deleted list

	A	B	C	D	E	F	G	H	I	J
89	Component	Qty.	Unit	Adj. Mat. $	Mat. Tot $	Adj. Lab. $	Lab. Tot.$	Lab. W/O&P	Bare Total	Adj. Total
90	Int. Wall- Standard Framing									
91	Studs 2x4x8	757	lf	0.25	188.45	0.18	137.79	232.86	326.24	456.81
92	Studs 2x6x8	96	lf	0.37	35.40	0.20	19.31	32.64	54.72	73.70
93	Plates 2x4	440	lf	0.25	109.53	0.20	88.52	149.60	198.05	279.76
94	Plates 2x6	80	lf	0.37	29.50	0.27	21.46	36.27	50.96	70.48
95	2x8 Header	48	lf	0.51	24.34	0.59	28.51	48.18	52.85	77.60
96	Screws/Nails			50.00	50.00	0.00	0.00	0.00	50.00	55.00
97	Glue/Caulk			0.00	35.00	0.00	0.00	0.00	35.00	38.50
98	Baseboards	105	lf	0.78	82.29	0.48	50.30	85.00	132.58	173.50
99										
100	Std. Framing Int Wall Total				554.52		345.89	584.55	900.41	1225.35
101										
102										
103	Miscellaneous									
104	*Skylites*	*2*	*ea*	*137.91*	*275.82*	*30.26*	*60.51*	*102.27*	*336.33*	*406.09*
105	Windows:									
106	*4'x4" Class 35 H. Slider*	*3*	*ea*	*185.28*	*555.83*	*29.76*	*89.28*	*150.88*	*645.11*	*762.29*
107	*2'-6"x4" Class 35 Casemer*	*3*	*ea*	*169.70*	*509.10*	*29.76*	*89.28*	*150.88*	*598.38*	*710.90*
108	*3'-6"x4" Class 35 H. Slider*	*1*	*ea*	*185.28*	*185.28*	*29.76*	*29.76*	*50.29*	*215.04*	*254.10*
109	*3'-6"x3' Class 35 Casemen*	*3*	*ea*	*132.34*	*397.02*	*18.15*	*54.46*	*92.04*	*451.48*	*528.76*
110	Window trimwork	12	opn'g	13.83	165.96	11.40	136.80	231.20	302.76	414.02
111	Interior doors:									
112	*2'-6"x6'-8" Bi-fold*	*3*	*ea*	*47.02*	*141.07*	*15.47*	*46.42*	*78.44*	*187.48*	*233.61*
113	*5'-0"x6'-8" Bi-fold*	*4*	*ea*	*79.29*	*317.17*	*18.30*	*73.19*	*123.69*	*390.36*	*472.58*
114	*2'-6"x6'-8" Hollow Core*	*3*	*ea*	*80.00*	*240.00*	*11.16*	*33.48*	*56.58*	*273.48*	*320.58*
115	*2'-4"x6'-8" Hollow Core*	*2*	*ea*	*78.00*	*156.00*	*11.16*	*22.32*	*37.72*	*178.32*	*209.32*
116	Exterior doors	2	ea	165.96	331.92	22.03	44.07	74.47	375.99	439.59
117	Door Trimwork"Molding"	14	ea	8.30	116.17	19.16	268.24	453.33	384.41	581.11
118	*Cabinets*	*1*	*total*	*1303.89*	*1303.89*	*676.44*	*676.44*	*1143.19*	*1980.34*	*2577.47*
119	*Vanities*	*2*	*ea*	*238.80*	*477.60*	*42.97*	*85.93*	*145.23*	*563.53*	*670.58*
120	Appliances:									
121	*Washer/Dryer" Stacked"*	*1*	*ea*	*666.23*	*666.23*	*80.44*	*80.44*	*131.12*	*746.67*	*865.58*
122	*Oven*	*1*	*ea*	*473.76*	*473.76*	*39.78*	*39.78*	*64.84*	*513.54*	*586.77*
123	Stairs, (Including Railing)	1	ea	776.32	776.32	271.11	271.11	458.18	1047.44	1301.29
124										
125										
126			*MISC. SUBTOTAL*		*5698.75*					
127										
128										
129	Miscellaneous Total				7089.13		2101.53	3544.37	9190.66	11334.65
130										
131										
132	*POTENTIAL*									
133	*DONATION TOTAL*				*8693.343*					
134										
135										
136										
137										
138	Foundation									
139	Concrete	5.25	cy	53.65	281.66	8.15	42.79	69.74	324.45	413.51
140	Holes	16	ea	0.00	0.00	10.00	160.00	176.00	160.00	160.00
141	Grub/Grading	1	ea	12.80	12.80	195.00	195.00	214.50	207.80	228.58
142	4x6 PT Posts	80	lf	1.28	102.40	0.76	60.80	98.50	163.20	220.67
143	4x4x4.5' PT	54	lf	0.85	45.90	0.48	25.92	41.99	71.82	96.08
144	2x4x4.5' PT	54	lf	0.33	17.82	0.48	25.92	41.99	43.74	65.19
145	2x4 Upper Cord	88	lf	0.27	23.76	0.33	29.04	47.04	55.44	76.08
146	2x4 Bottom Cord	112	lf	0.27	30.24	0.33	36.96	35.00	67.20	99.42
147	2x4 Plates	72	lf	0.27	19.44	0.26	18.72	30.33	38.16	55.40
148	2x6 Plates	72	lf	0.40	28.80	0.28	20.16	32.66	50.40	67.33
149	2x4 Studs	116	lf	0.27	31.32	0.33	38.28	62.01	69.60	102.97
150	6 mil. V.B.	720	sf	0.03	21.60	0.03	21.60	34.99	43.20	60.26
151	Nails and caulk	1		35.00	35.00	0.00	0.00	0.00	35.00	38.50
152	1/2" treated Plywd.	96	sf	0.26	24.96	0.23	22.08	35.77	47.04	65.83
153										
154										
155	Foundaton Totals				675.70		697.27	920.53	1377.05	1749.83

*Estimate for wood I-beam interior floor w/ tree spade foundation. ?

20'x36' Demo House Estimate#4a

	A	B	C	D	E	F	G	H	I	J
156	Component	Qty.	Unit	Adj. Mat. $	Mat. Tot $	Adj. Lab. $	Lab. Tot.$	Lab. W/O&P	Bare Total	Adj. Total
157	Contingency									
158										
159										
160	Total Hard Costs				23997.76		6241.74	10283.47	30243.58	37722.54
161	Hard Cost : $/sf		1259	sf	19.06		4.96	8.17	24.02	29.96
162										
163										
164	SUBCONTRACT BIDS									
165	Sheetrock									
166	Gyp. Bd.-1/2"	860	sf	0.29	251.10	0.25	213.59	360.97	464.69	675.02
167	Gyp. Bd.-1/2""	1260	sf	0.28	353.75	0.20	245.88	415.53	599.62	860.09
168	1/2" Gyp. Bd.	608	sf	0.28	170.70	0.20	118.65	200.51	289.34	388.28
169	1/2" Gyp. Bd.	1948	sf	0.28	546.90	0.20	380.13	642.42	927.03	1244.02
170										
171	Totals				1322.44		958.24	1619.43	2280.69	3167.40
172										
173	Painting									
174	Interior Painting	900	sf	0.12	107.73	0.07	62.21	105.13	169.94	221.15
175	2x8-Fascia-Painting	152	sf	0.12	18.19	0.07	10.51	17.76	28.70	37.35
176	Exterior Painting	1377	sf	0.13	181.31	0.04	52.88	89.36	234.19	349.39
177	Interior Painting	1260	sf	0.12	150.82	0.07	87.09	147.18	237.91	309.60
178	Painting	608	sf	0.12	72.78	0.07	42.02	71.02	114.80	149.40
179	Painting-Doors	10	ea	1.70	17.00	5.34	53.38	90.21	70.37	106.77
180	Painting-Windows	11	ea	1.34	14.75	4.99	54.91	92.80	69.66	106.83
181	Painting	1800	sf	0.12	215.46	0.07	124.42	210.26	339.88	442.29
182										
183	Totals				778.04		487.41	823.72	1265.45	1722.77
184										
185	Electrical									
186	Elect Panel	1	ea	292.41	292.41	93.50	93.50	152.40	385.91	474.05
187	Conduit in Trench	40	lf	3.74	149.80	0.73	29.27	47.71	179.06	212.48
188	Single pole	10	ea	6.16	61.56	6.46	64.63	105.35	126.19	173.07
189	3-way	5	ea	10.21	51.04	7.56	37.80	61.62	88.85	117.77
190	4-way	1	ea	20.01	20.01	7.56	7.56	12.32	27.57	34.33
191	Typ. Duplex Outlet	16	ea	1.59	25.44	5.71	91.32	148.85	116.76	176.83
192	G.F.I. Outlet	3	ea	34.42	103.27	10.33	30.98	50.49	134.24	164.08
193	Dryer Outlet	1	ea	45.50	45.50	17.07	17.07	27.83	62.58	77.88
194	Oven Outlet	1	ea	76.59	76.59	26.02	26.02	42.41	102.61	126.66
195	Hot Water Hook-Up	1	ea	12.77	12.77	21.95	21.95	35.78	34.72	49.83
196	Diningroom Light	1	ea	62.59	62.59	6.10	6.10	9.94	68.68	78.78
197	~~Recessed Downlight~~	~~4~~	~~ea~~	~~28.73~~	~~114.91~~	5.65	22.60	36.84	137.51	163.24
198	~~Kitchen Vent~~	1	ea	48.99	48.99	7.36	7.36	11.99	56.35	65.88
199	~~36"~~ B.B.H.	3	ea	40.01	120.04	13.78	41.34	67.39	161.38	199.43
200	~~48"~~ B.B.H.	1	ea	49.25	49.25	16.26	16.26	26.50	65.51	80.68
201	T.V. Antenna System	1	ea	29.75	29.75	18.70	18.70	30.48	48.45	63.21
202	Telephone Wiring	2	ea	10.69	21.38	4.84	9.67	15.77	31.06	39.29
203										
204	Electrical Total				1285.31		542.12	883.66	1827.44	2297.51
205										
206	Plumbing									
207	"Hytec" Tub&Shower	2			0.00	1254.40	0.00		0.00	4190.00
208	"Briggs"Oval Steel Lav.	2		0.00	0.00	0.00	0.00		0.00	0.00
209	"Kilgore" Plain W.C.	2		0.00	0.00	0.00	0.00		0.00	0.00
210	"Dayton" Kitchen Sink			0.00	0.00	0.00	0.00		0.00	0.00
211	Auto Washer W/ Box			0.00	0.00	0.00	0.00		0.00	0.00
212	"Badger" Dishwasher Conn.			0.00	0.00	0.00	0.00		0.00	0.00
213	Frostproof Hose Bibbs			0.00	0.00	0.00	0.00		0.00	0.00
214	Plumbing Total				0.00		0.00	0.00	0.00	4190.00
215										
216	AAHX-Mech									
217		1		2483.00	2483.00	770.37	770.37	1271.11	3253.37	3879.15
218				0.00	0.00	0.00	0.00	0.00	0.00	0.00
219	AAHX-Mech Total				2483.00		770.37	1255.70	3253.37	3879.15
220										
221	SUBCONTRACT TOTALS				5868.79		2758.15	4582.52	8626.94	15256.83
222										

	A	B	C	D	E	F	G	H	I	J
223	Component	Qty.	Unit	Adj. Mat. $	Mat. Tot $	Adj. Lab. $	Lab. Tot.$	Lab. W/O&P	Bare Total	Adj. Total
224	GARAGE									
225	Foundation									
226	Concrete (incl. slab)	11.5	cy	56.28	647.22	0.00	0.00	0.00	647.22	712.32
227	Excavation	13	cy	0.00	0.00	11.50	149.50	243.69	149.50	242.62
228	Pea gravel	286	site	0.48	137.28	0.00	0.00	0.00	137.28	160.45
229	Formwork	344	sf ca	0.41	141.04	1.02	350.88	571.93	491.92	734.92
230	2"x6" mudsill	70	lf	0.95	66.50	0.42	29.40	47.92	95.90	123.09
231	Rebar	245	lf	0.19	46.55	0.15	36.75	59.90	83.30	118.83
232	P.V.C. drain	170	lf	1.73	294.10	0.65	110.50	180.12	404.60	508.13
233	1/2" dia. A.B.	19	unit	0.37	7.03	1.32	25.08	40.88	32.11	48.99
234	6 mil. vapor barrier	720	sy	0.07	50.40	0.03	21.60	35.21	72.00	92.81
235	Walls									
236	2"x4" studs -16" o.c.	420	lf	0.25	104.55	0.22	92.54	156.40	197.10	280.65
237	2"x4" plates	210	lf	0.25	52.28	0.29	60.35	102.00	112.63	164.12
238	Bracing	80	lf	0.50	39.83	0.24	19.16	32.38	58.99	77.95
239	Vapor barrier	456	sf	0.06	25.23	0.03	13.11	22.15	38.33	59.93
240	Sheathing T-111	456	sf	0.48	218.62 [circled]	0.55	249.00	420.82	467.63	671.33
241	Roof				DONATED					
242	Trusses	8	unit	25.82	206.53	0.22	1.76	2.98	208.29	230.34
243	Fascia board	62	sf	0.25	15.43	2.02	125.33	211.80	140.76	230.14
244	Sheathing	400	sf	0.30	118.02	0.67	268.24	453.33	386.26	591.94
245	Felt	400	sf	0.03	11.06	0.04	15.33	25.90	26.39	46.87
246	Shingles	400	sf	0.31	125.39	0.18	72.81	123.05	198.20	269.78
247	Garage door	1	unit	262.77	262.77 [circled]	38.32	38.32	64.76	301.09	353.83
248	Side door	1	unit	122.63	122.63 [circled]	23.95	23.95	40.48	146.58	175.39
249	Garage Total				POTENTIAL DONATIONS					5894.43
250										
251	Site Improvements									
252	Landscaping	1	site	691.50	691.50	327.20	327.20	552.98	1018.70	1313.65 [circled]
253				0.00	0.00	0.00	0.00	0.00	0.00	0.00
254	Base, stone	400	sf	0.22	88.51	0.00	0.00	0.00	88.51	106.16
255	Concrete	6.5	cy	49.47	321.52	1.07	6.97	11.79	328.50	365.61
256	Formwork	400	lf	0.22	88.51	0.98	390.86	660.56	479.38	766.72
257	Expansion joint	100	lf	0.45	45.18	0.17	17.24	29.14	62.42	81.04
258	#10/10 mesh	250	sf	0.06	16.14	0.24	59.88	101.19	76.01	124.44
259	Covered Walk			0.00	0.00	0.00	0.00	0.00	0.00	450.00
260										
261	Site Improvement Total									3207.62
262										
263	SOFT COSTS									
264	Plans,survey,engineering &specs								700.00	
265	Initial Lot Costs							$2000	~~10000.00~~	
266	Initial Financing Cost								1500.00	POTENTIAL DONATION
267	Equipment Rental								1730.00 [circled]	
268	Builder's profit								4996.75	
269	Builder's Administration								1556.62	
270	Utility Connection								30.00	
271	Site Insurance								145.21	
272	Holding Cost								874.13	DONATED?
273	Title Insurance								395.00	
274	House Sales Commission								2594.09	
275	Permits and Development Fees								1150.00 [circled]	
276	Additional Fees									
277	Apprasial								450.00	
278	Credit Report								65.00	
279	Underwriter								200.00	
280	Escrow								150.00	
281	Builder Credit Report								130.00	
282	Draw Inspections								300.00	
283	Final Appraiser Inspections								75.00	
284	Recording Fees								75.00	
285	Taxe Service Fee								62.00	
286	Total Soft Costs								27208.80	
287										
288	R-Control Total House Cost									81811.26
289	R-Control Total $/sf		1259	sf						64.98

*Estimate for wood I-beam interior floor w/ tree spade foundation. 11/19/92 ; M. Elliot