STRESSED SKIN INSULATING CORE PANEL DEMONSTRATION HOUSE -- DESIGN PHASE

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ABSTRACT

In 1992/93, the Center for Housing Innovation will design, build, and test a prototype house which showcases energy efficient technology, demonstrating that stressed skin panel construction delivers good quality with high energy performance at lower first cost than conventional construction. The project -- a 1300 sf, three bedroom house -- is designed to match the annual energy performance of a similar conventional construction home which meets the Bonneville Power Administration's advanced Long Term Super Good Cents standards but can be built at a lower first cost.

1. INTRODUCTION

The purpose of this project is to demonstrate that stressed skin insulating core panel construction can reach high levels of energy performance at a lower first cost than conventional construction.

Panelized construction is the strongest housing industrialization trend in the U.S. Panelizers increased their market share from 29% in 1980 to 36% in 1989. We expect this trend to continue, making panelized construction potentially an important source of energy savings. We believe that the increase in market share is in part due to cost savings when compared to conventional framing techniques. The Swedish housing industry has proven that very high shell performance can be achieved using panelized construction.

Within panelized construction, there are two approaches to transferring loads -- one uses a combination of studs and sheathing and the other sheathing and a core material. The later, called stressed skin panels, are inherently energy efficient when the core is made of insulating material. Because of this characteristic, stressed skin insulating core (SSIC) panel manufacturers aggressively market energy efficiency as a product feature. However, there are a number of factors which have reduced penetration of these panels into the market place. The unique structural characteristics of the panels have not been fully exploited because contractors and designers are used to using planning modules related to conventional framing. Therefore, the cost of SSIC panel houses is higher than necessary. The thickness of the SSIC panels have not been optimized for the combination of structural *and* thermal performance, resulting in energy overkill and excess cost. The SSIC panels are "closed" by virtue of their construction making wiring and plumbing in exterior walls problematic. The area around window and door openings is less thermal efficient than the opaque wall, as a result of the framing required for conventional windows and doors. Current details rely more heavily than necessary on 2 x 4 material to transfer loads at wall/roof and wall/floor connections, resulting in a less thermally efficient envelope.

2. PROJECT GOAL

The goal of this project was to build a house to Bonneville Power Administration's (BPA) Long Term Supergood Cents standards of an R49 roof, R26 wall, R30 floors, and UO.35 windows at $2000 less cost than a house of architectural equivalent design built conventionally. The Long Term Supergood Cents standard house will use about 40% less energy for heating and cooling than a house built to the current Oregon code of R 38 roof, R21 wall, R25 floor and UO .35 windows. The $2000 is equal to the incentive that BPA currently pays contractors to build houses to Long Term Supergood Cents standards.

3. DESIGN PROCESS

Schematic design studies were completed for five candidates for the demonstration house, including construction cost estimates for panel and conventional versions of these designs. These designs and costs are outlined in figures 1 to 5.

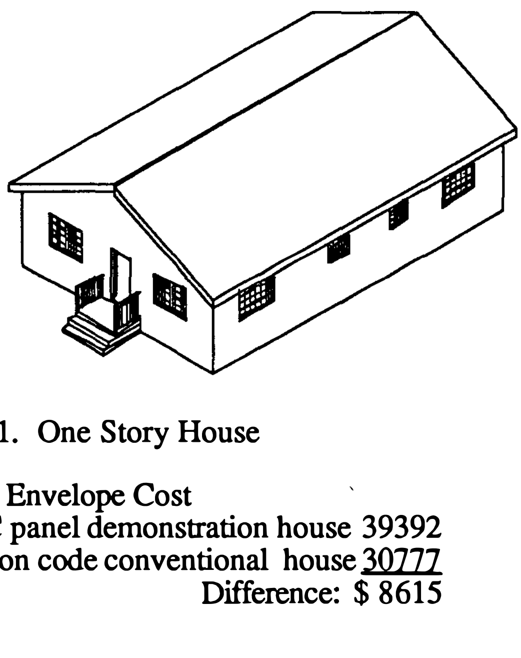

Fig. 1. One Story House

Total Envelope Cost	
SSIC panel demonstration house	39392
Oregon code conventional house	30777
Difference:	$ 8615

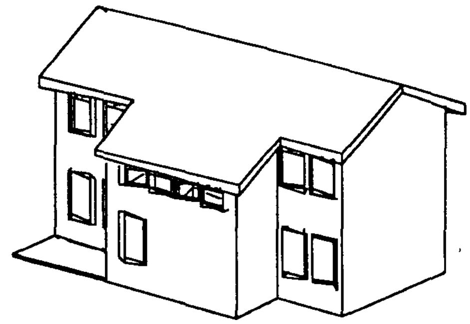

Fig. 2. Two Story Long Ridge House

Total Envelope Cost	
SSIC panel demonstration house	36801
Oregon code conventional house	31010
Difference:	$ 5791

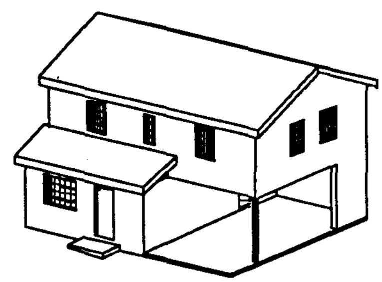

Fig. 3. Two Story "Crosswise" House

Total Envelope Cost	
SSIC panel demonstration house	34624
Oregon code conventional house	29364
Difference:	$ 5260

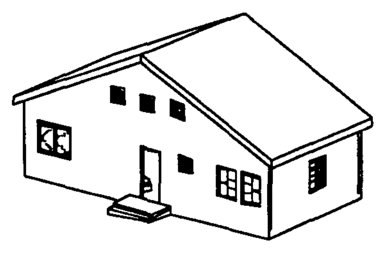

Fig. 4. 1-1/2 Story Short Ridge House

Total Envelope Cost	
SSIC panel demonstration house	30815
Oregon code conventional house	26421
Difference:	$ 4394

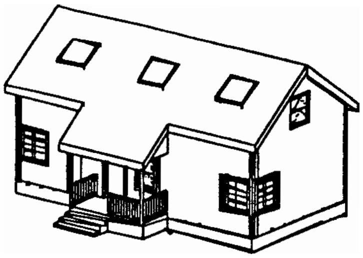

Fig. 5. 1-1/2 Story Long Ridge House

Total Envelope Cost
SSIC panel demonstration house 32737
Oregon code conventional house 29191
Difference: $ 3546

Other studies (see Table 1) examined foundations, panel configurations and sizes, joinery and roof alternatives for ways to improve cost effectiveness. These studies have led us to focus on the 1 - 1/2 story "long ridge" design. The "long ridge" design was carefully scrutinized in an attempt to reduce its cost by $5546 ($3546 over the conventional house and the $2000 incentive).

TABLE 1. SUMMARY OF BACKGROUND STUDIES

Structure

Compare pier vs. strip foundations
Examine panel wall as beam in bending
Examine panel wall as beam in shear
Examine folded plate roof
Compare different floor spans

Cost

Perform industry price survey
Determine labor costs
Compare cost of floor span variants
Cost different Panel compositions
Compare envelope R-value vs. cost
Determine small dormer costs
Determine large dormer costs
Cost surface mounted windows
Find skylight comparative costs
Study panel size vs. waste costs
Envelope vs. window R-value costs
Compare cost of caulks vs. gaskets
Compare cost of panel joint variants

Energy

Find minimum uniform panel thickness
Find minimum insulation volume
R-value per dollar vs. core thickness
R-value vs. core composition
Examine dormer energy impacts
Examine skylight energy impacts
Envelope vs. window R-value tradeoffs

As the design currently stands the conventional house (6.6 KBtu/sf, yr) and the demonstration house (6.3 KBtu/sf,yr) have nearly identical heating loads according to DOE-2 simulations. Cooling loads are met by shading and by cross ventilation.

The 1 1/2 story long ridge design (see figures 6-9) has a number of innovations when compared to both conventional and other SSIC panel designs (see tables 2, 3 and 4). The 1 1/2 story long ridge design also has a number of features which make it energy efficient and livable.

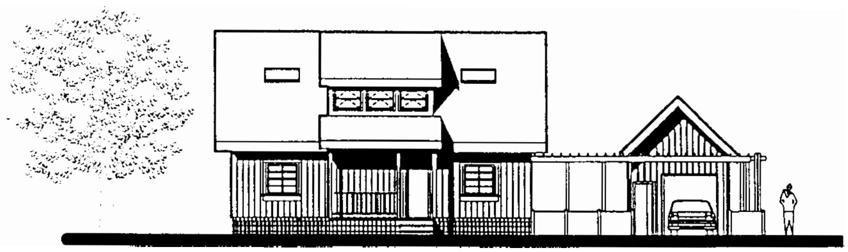

Fig. 6. South Elevation

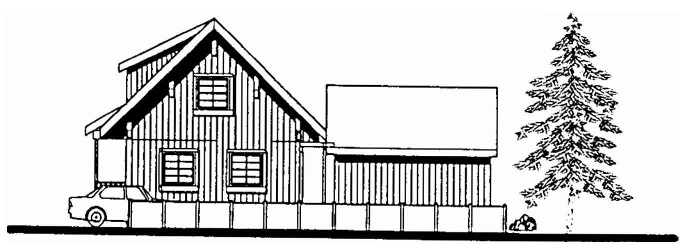

Fig. 7. East Elevation

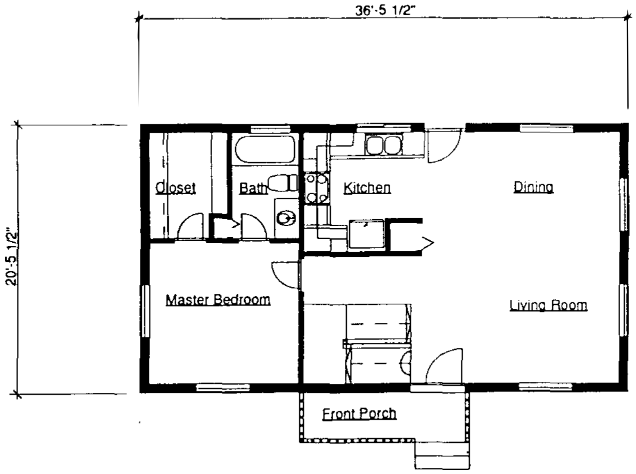

Fig. 8. First Floor Plan

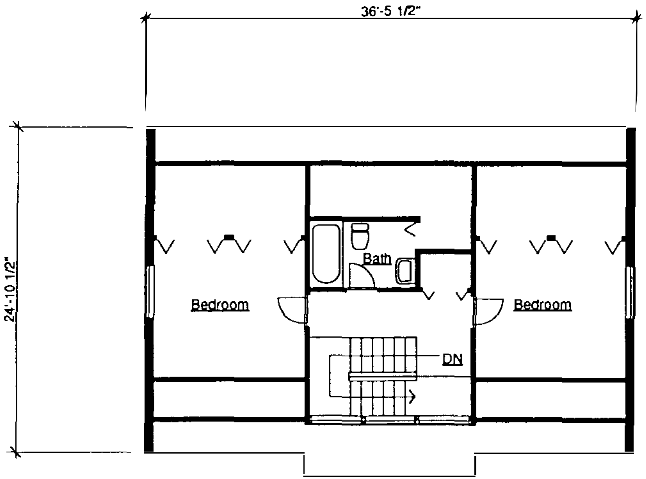

Fig. 9. Second Floor Plan

TABLE 2. FEATURES THAT DISTINGUISH THE DEMONSTRATION HOUSE FROM CONVENTIONAL CONSTRUCTION

- The structurally integrated roof and second floor system eliminate the ridge beam and the need for internal supports.
- The integrated floor and foundation system, using the 2-way spanning capability of the SSIC panels, distributes the floor loads evenly and reduces the size of the horizontal members, reducing costs.
- Offsetting the wall-to-wall and floor-to-wall connections provides an increase of 28 square feet (2% of floor area).
- The panel system replaces sawn lumber with a variety of plentiful wood resources.
- Site labor is reduced by half.
- Project length is reduced by one week.
- Because only three consecutive days are required for shell construction, this system extends the building season.

TABLE 3. FEATURES THAT DISTINGUISH THE DEMONSTRATION HOUSE CONSTRUCTION FROM STANDARD SSIC PANEL CONSTRUCTION

- Internal plumbing vents minimize envelope penetrations reducing energy transfer through the shell.
- The design optimizes the skin area for structural, thermal, and cost performance.
- Structural siding laminated directly to the insulation core eliminates a layer of OSB.
- Panel cutoffs at gable ends are reused at the opposite end of the building to reduce waste.
- The house plan is based on the panel module to reduce waste.
- Shiplap joints reduce installation by 20%, improve air tightness and reduce fasteners by 50%.
- Offsetting building corners reduces the impact of dimensional variations in long walls and floor panels.
- Eliminated dimensional lumber in the floor and roof that produced thermal bridges.
- Located panel joints at the exterior openings to reduce panel waste.
- Overlapping ridge joint improves R-values, reduces infiltration and improves the thermal performance.
- Exterior electrical chases minimize wiring in the panel and increase R-value. Reduces installation cost by 5%.

TABLE 4. FEATURES OF THE 1 1/2 STORY DESIGN

- The master bedroom is usable as a separate rental or office space

- The use of an open stair and kitchen provides long sight lines for spaciousness.
- Free span structural design allows for maximum flexibility in arrangement of interior partitions.
- A minimum of two windows or skylights in all major rooms facilitates cross ventilation and quality daylighting.
- Flush mounted skylights eliminate thermal bridging due to curbs.
- Heat pump water heater uses exhaust air as energy source.
- Eave overhangs shade south-facing glazing and shutters shade east/west glazing.

4. CONCLUSION

The cost estimates for the demonstration and reference house shells are shown in table 5. As would be expected materials are a larger percentage of the total house cost in the demonstration house than in the reference house and the labor percentage is larger in the reference house than in the demonstration house. As we move from low cost labor markets like Eugene towards high cost markets like Los Angeles, the cost of the reference house increases faster than the demonstration house, thereby making the difference between the two greater. Cleveland is a moderately high priced labor market (more than Seattle, less than Sacramento) which has a very competitive panel market. In Cleveland the labor cost goes up faster for the reference house than the demonstration house. In addition the demonstration house and reference house are nearly identical in material cost. Therefore there is a large difference between the costs of the two houses.

TABLE 5. SHELL COSTS–as of November 1992

	Demonstration	Reference	Difference
Eugene, OR	$50260	$50360	$100
Seattle, WA	$52505	$52926	$421
Sacramento, CA	$53912	$54971	$1059
Los Angeles, CA	$54862	$56363	$1501
Cleveland, OH	$50350	$54035	$3685

As of March 1993 the cost of the complete house including the land in Eugene is $91,487 for the demonstration house and $92,354 for the reference house, a difference of $867 in favor of the demonstration house. The project is currently out to bid and construction is scheduled to start in June 1993.

In terms of reaching our goal of $2000 reduction in the first cost, we fall $1100 short in high-labor, high-panel cost markets like Eugene, Oregon, but surpassed our goal by $2000 in high-labor, low-panel cost metropolitan markets like Cleveland, Ohio. Since most housing in the United States is built in high-labor cost metropolitan markets we feel we have reached our objective for a large percentage of new housing construction.

We have identified several innovations that will be used in the next prototype which should further reduce the cost of the demonstration house by $1700, and we will reach our objective of a $2000 reduction in first cost throughout the United States.

5. PROJECT SPONSORS

The design and analysis work on this project was funded by the United States Department of Energy. A large share of the cost for site improvements and building construction, was provided by St. Vincent DePaul, a social service agency in Eugene, Oregon. St. Vincent DePaul secured funds from the City of Springfield to purchase the property, from the Oregon Housing Trust fund for street and site improvements, consulting from Springfield Utility Board regarding the Supergood Cents program, and closing and escrow services from the Title Insurance and Escrow Services company.

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