



HOUSING

The Sun-Tempered Superinsulated House no. 9.936

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Quick Facts...

A sun-tempered, superinsulated house combines passive solar and super-insulation.

It features solar orientation, increased insulation, effective air/vapor barriers, controlled ventilation and improved windows.

Design is flexible and fits a variety of architectural styles.

It does not require attention for its operation, but is automatically controlled and self-regulating.

Over its life, considerable savings in monthly operating costs will result.

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One result of rising energy costs is the evolution of energy-efficient house designs based on two distinct concepts: passive solar and superinsulation. Passive solar emphasizes orienting the house to the sun. Superinsulation emphasizes improving the thermal efficiency of the structure.

Both concepts involve greater integration of the house with its climatic environment, use of improved construction materials, and appropriate construction methods. Depending on the climate of an area, one approach is favored over the other.

For Colorado, with its cold but sunny climate, the sun-tempered superinsulated (STS) house, which combines both concepts, is an appropriate design. Elements in the STS house include:

- solar orientation,
- increased insulation levels,
- an effective air/vapor barrier,
- controlled ventilation, and
- improved windows.

Solar Orientation

Colorado's excellent solar environment can be effectively used in the STS house as a source of supplemental heat. This requires opening the house to the south through room orientation and window placement. The STS house is designed around a floor plan like that shown in Figure 1. The key principles are:

- Rooms most frequently occupied (living room and family room) face south to make the most effective use of solar energy.
- Storage rooms, utility rooms, bathrooms, bedrooms and other less frequently occupied rooms are located on the north and west to serve as a thermal buffer.
- Attached garage or unheated storage areas are located on the north and west.

This floor plan fits well with a landscape plan that has outside activity areas (patios and decks) on the south side of the house. Patios and decks can be used more of the year because of their sunny, protected location.

Solar orientation also relies on proper window placement. The STS house minimizes window openings in order to reduce energy use. Generally, window area should be no more than 8 percent of the total floor area. Locate as many windows as possible on the south side of the house. This provides solar heat as well as light to create a comfortable, well-lit environment.

To prevent overheating in the summer, shade the south windows by a roof overhang. A roof overhang of about 2 feet adequately shades an 8-foot wall. While south facing windows are encouraged, the STS house is a flexible

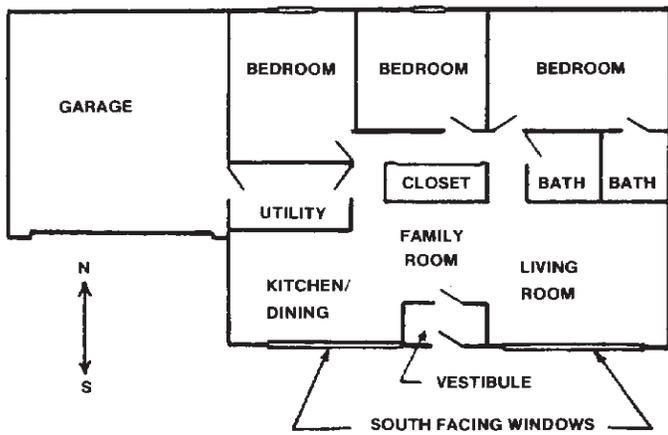


Figure 1: Floor plan for an STS house.

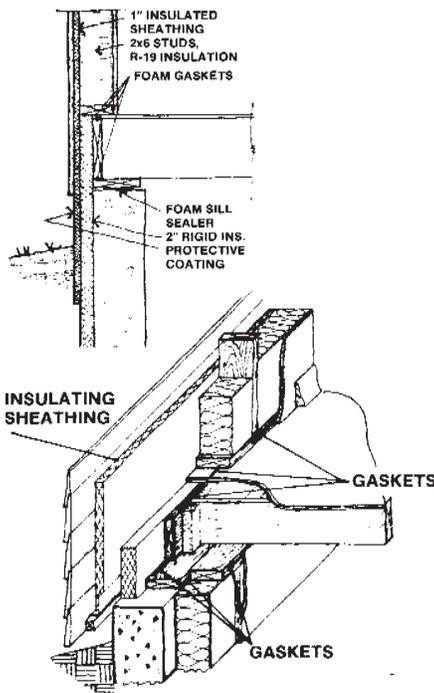


Figure 2: Wall construction in the STS house (use a combination of these diagrams).

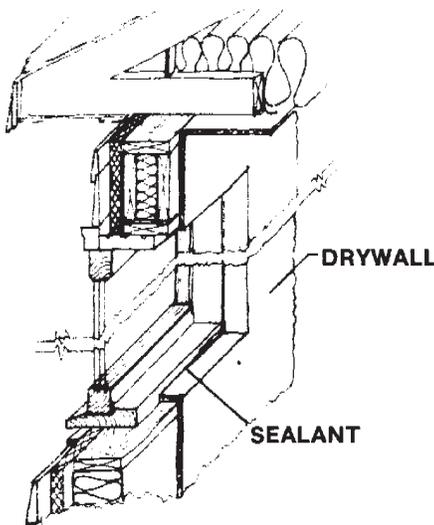


Figure 3: Sealing window openings using the ADA method.

design in that windows can be placed as needed. However, the overriding principle favors south-oriented window placement.

Increased Insulation Levels

The STS house achieves increased insulation levels without making the construction method overly costly or complex. The main departure from conventional techniques is in wall construction. The wall is framed with 2 inch by 6 inch studs placed on 24-inch centers. This allows placement of a standard 6-inch insulating batt with an R-19 rating. A layer of rigid insulation is applied over the exterior wall framework.

The rigid insulation serves several important purposes:

- It increases the R rating of the wall.
- It reduces thermal bridging whereby heat is conducted through the studs.
- It forms a continuous blanket around the house exterior, thus reducing air infiltration.

Rigid insulation should be 1 inch thick in homes at lower elevations or 2 inches thick for homes in mountainous locations. This provides an R-25 to R-30 wall for the STS house. Apply either siding or a stucco-like finish over the rigid insulation. Figure 2 illustrates the wall construction.

Ceilings in the STS house are insulated to R-40. This can be done with conventional roof framing trusses and 12 inches of loose fill insulation.

Foundation walls are insulated to R-20 down to the frostline and to R-10 below the frostline to the footing. One easy method for insulating foundation walls is to apply rigid insulation to the outside of the wall. The concrete slab in a basement should have R-5 insulation (achieved with 1 inch of rigid insulation) beneath it. Rigid insulation in contact with the ground must be able to withstand moisture contact. Extruded polystyrene is suitable for this purpose.

Air/Vapor Barrier

An effective air/vapor barrier is an important feature. Studies show that in well insulated houses, air infiltration can account for up to 40 percent of the heat lost. Also, moisture must be kept out of wall cavities to prevent deterioration of framing members. The perfect air/vapor barrier is an impervious membrane installed on the inside of the exterior-facing surfaces with no breaks. In the STS house, the air-tight drywall approach (ADA) is used to produce an effective air/vapor barrier.

The principle of ADA is to apply drywall in a continuous layer on the interior walls and ceilings. Use compressible gaskets to seal the tops and bottoms of the walls and any joints between plates, rim joist, and subfloor or foundation. Note the placement of gaskets in Figure 2.

Install the drywall as closely as possible to window and door openings, and caulk the gap (see Figure 3). Tape the drywall and finish and paint it in the usual manner. A primer coat of vapor barrier paint will enhance the air- and vapor-tight seal. Keep electrical wiring out of the outside walls as much as possible. Seal any electrical boxes installed in the outside walls with gaskets. Caulk holes in the plates for wiring runs. Also seal plumbing penetrations in the ceiling.

The advantage of ADA is that it uses conventional construction techniques and materials. It requires extra care for detail and some construction rescheduling, in that the exterior drywall is put in place before the interior walls are installed. By having the air/vapor barrier visible, minor problems are easily detected and repaired.

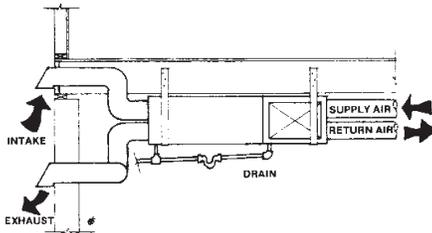
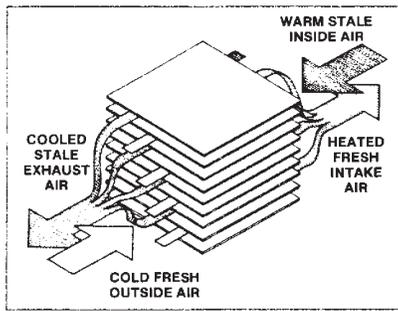


Figure 4: An air-to-air heat exchanger.

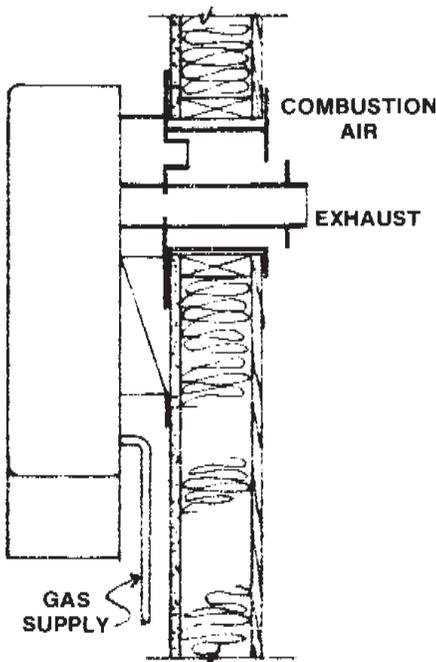


Figure 5: Sealed combustion unit heater.

Controlled Ventilation

Since the STS house is well sealed, controlled ventilation is necessary to prevent indoor air pollution problems. The recommended rate of air exchange in a house is 0.5 air changes per hour (ACH). This means that one-half of the volume of air in the house is changed every hour. In conventional houses, this recommended rate is easily met (and often exceeded) through air infiltration. In the STS house using the airtight drywall approach to sealing the structure, the rate of air exchange can be as low as 0.1 ACH. At such a low rate, indoor air pollution caused by cigarette smoke, radon gas, formaldehyde gas, combustion gases from stoves and heating systems, and cooking odors can be a health problem.

The STS house uses an air-to-air heat exchanger to control the ventilation rate at 0.5 ACH and thus maintains adequate indoor air quality. An air-to-air heat exchanger is slightly larger than a window air conditioner. The unit is connected through ducts to all rooms in the house. Two continuously running small capacity (80 to 300 cubic feet per minute) blowers expel stale house air to the outdoors, bring in an equal amount of fresh air, and transfer the heat in the outgoing warm air to the incoming cold air (see Figure 4). About 70 percent of the heat contained in the outgoing air is recycled by the heat exchanger.

Preheated fresh air is supplied to bedrooms, the living room, and family room. Stale air is removed from kitchen, bathrooms, and laundry areas. Locate both supply and exhaust vents in or near the ceiling of each room. Undercut doors about 1 inch to provide circulation between rooms when doors are closed. In addition to continuous low speed operation, blowers are controlled by variable speed control switches located in the kitchen and bathrooms to provide increased ventilation rates when cooking or after showering.

Ventilation also includes the type of heating system installed. In the STS house, electricity, natural gas, or propane can be used for supplemental heating. Electric heat can be supplied by baseboard units or radiant panels. Natural gas or propane heaters must be chosen with greater care since they require air for combustion. In a conventional house, this air is supplied through infiltration. However, in the STS house where infiltration is minimized, a different method must be used.

A preferred method is a sealed combustion unit heater. These heaters have low rated output (15,000 to 35,000 Btu/hour) to match the small heating needs of the STS house. They are space heaters mounted on outside walls. Combustion air is drawn directly from the outside (see Figure 5). Using space heaters eliminates the cost of a distribution network in the house. Due to the well-insulated structure and air movement created by the air-to-air heat exchanger, even temperatures are maintained throughout the STS house when using space heaters. Sealed combustion water heaters also are used in the house.

Improved Windows

Windows represent the weakest energy defense in any house. Double-paned windows have, at best, an R-2 rating. The STS house uses several methods to strengthen this weak point.

Keep windows to a minimum. Avoid locating windows on the north and west walls as much as possible. The window area should not exceed 8 percent of the floor area of the house. This will provide enough windows for light and ventilation and avoid a closed-in feeling. Window frames are made from solid wood, vinyl-clad wood, or metal with a thermal break. Thus, heat losses through the frame are reduced. The operable windows in the house are casement or awning types because they create a better seal when closed.

All windows are double paned and treated with "low E" (low emissivity)

Sources:

Amann, J.T., Wilson, A., & Ackerly, K. (2007). Consumer guide to home energy savings. Gabriola Island, Canada: New Society Publishers.

Consumer Reports. (2006). Reducing energy costs. Washington, DC: Consumers Union.

Energy Star, www.energystar.gov

U.S. Department of Energy, www.energy.gov/energyefficiency/buildings.htm

Xcel, www.xcelenergy.com/residential/saveenergy_money

coatings. “Low E” coatings are made from a metal oxide deposited in a thin layer on the glass or a suspended plastic film between the two panes. The coating must be on the inside of the sealed window unit in order to protect it from degradation by moisture. “Low E” coatings allow visible light and solar energy into the house, but greatly reduce heat radiation through the glass. Thus, heat flowing out of the house in winter or into the house in summer is reduced.

The R-value for a double pane, “low E” coated window is 3.1 for coated glass and 4.3 for a coating on a suspended plastic film. This represents a reduction of heat loss of 40 to 50 percent over a conventional double paned window. “Low E” glass has the following additional advantages:

- greater occupant comfort due to warmer glass surfaces,
- reduced condensation, and
- reduced fabric fading from ultraviolet light.

In colder parts of the state, insulating shutters or shades can be added to the windows to further increase their effective R value.

Living With an STS House

The STS house combines the latest building materials and construction techniques with effective use of the solar environment. The design of the STS house is flexible. It can be built in a variety of architectural styles. The five elements mentioned above can be applied with great flexibility in order to accommodate a particular site or the preferences of the owner.

The STS house is comfortable for the occupants. Such a well-sealed, heavily-insulated house shields residents from outside noise, provides even temperatures and humidity levels, and minimizes drafts. The controlled ventilation ensures excellent indoor air quality. The solar orientation provides a link to the natural environment, which is a psychological boost for the occupants.

Finally, the STS house does not require special attention by the occupants for its operation. Automatic controls on the heating and ventilation system and built-in design features allow the house to be self-regulating.

Economic considerations are one of the most favorable aspects of living with an STS house. Over the life of the house, a considerable savings in monthly operating costs will result. These savings will quickly pay for the added costs of the energy efficient features incorporated into the house. Such features will add 5 percent to 8 percent to the cost of the house.

A final economic advantage of the STS house to a prospective buyer is the economics of the mortgage. Some lenders will allow a higher mortgage loan limit because of the low annual energy operating costs. Thus, the STS house may be open to more potential home buyers.