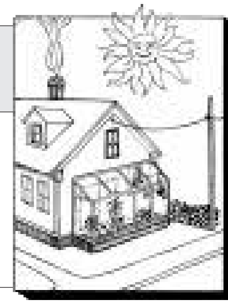


Wall Details for Cooling Climates

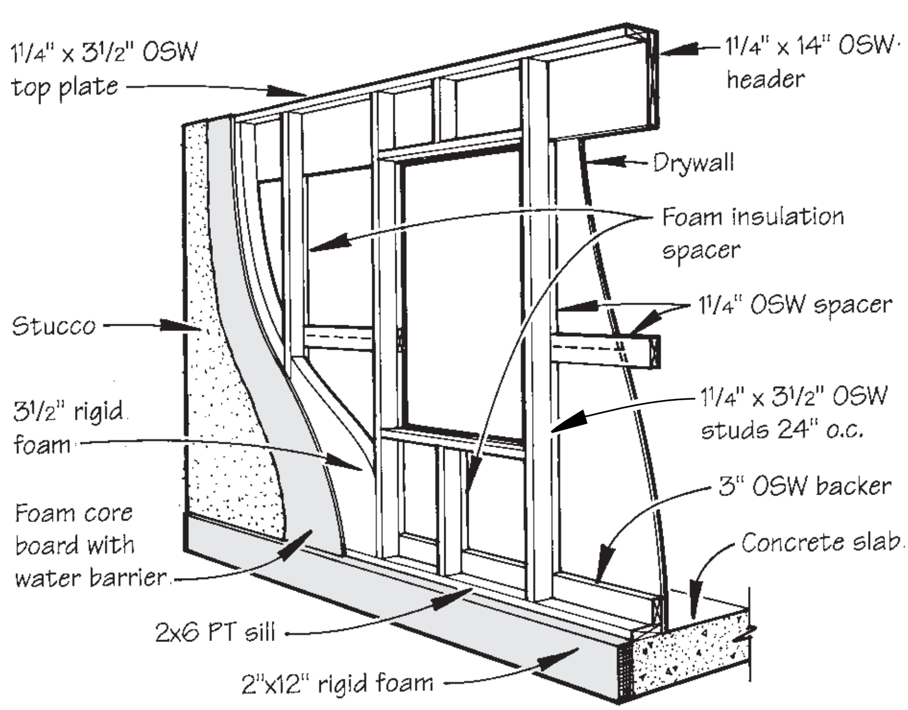
by Bruce Sullivan

Davis, California, is hot — its summer design temperature is 103°F. So it was a bold move when researchers at Pacific Gas & Electric Co. (PG&E) proposed to build an experimental house with no air conditioning. The project was called ACT2, and according to Lance Elberling, research associate at PG&E, the goal was to put an integrated package of the latest energy-saving technologies into a marketable house design. Together with designers at the Davis Energy Group, a local energy consulting firm, PG&E staff analyzed the building as a system, rather than as a set of discrete components. The end result was a building shell that was remarkably effective at resisting summer heat gain.

The designers looked at 86 possible energy-saving measures, including multiple ceiling fans, a whole-house attic fan for nighttime ventilation, tile floors and double-drywall ceilings for thermal mass, insulated doors, and low-e, gas-filled windows. They eventually incorporated 27 of these into the experimental buildings. The first demonstration house was built in Davis in 1993; another was completed in Rockland, Calif., early in 1994.

To arrive at the final design, PG&E looked at the estimated energy use of four separate plans. The complicated “base case” design had a perimeter measuring 260 linear feet, with 260 square feet of window glazing and lots of heat-losing corners. Nearly three-quarters of the windows were on the south and north sides; the rest were split between the east and west walls. The design that was finally built offered the best balance between energy efficiency and marketability — four bedrooms and a family room in only 1,656 square feet, with nearly equal daylighting in most rooms. This final plan reduced the exterior wall perimeter to 178 linear feet, and window area to only 11% of floor area. Most of the window area (73%) ended up on the long south-facing wall to improve wintertime solar heat gain, yet the windows were shaded by the roof overhangs in summer. These changes alone reduced estimated energy use by 23% from the base-case plan.

Innovative Wall System



The ACT2 home’s innovative wall system uses engineered studs and rigid foam to achieve overall insulating values from R-25 to R-30.

The backbone of the ACT2 homes is an innovative high-insulating wall system (see illustration, left). The studs were made from a new engineered product called Oriented Strand Wood, or OSW, manufactured by Trus Joist MacMillan. Though OSW has yet to hit the market, it’s a variation on the company’s Timberstrand header material (see *For What It’s Worth*, 6/93). The manufacturer claims that OSW is stronger than pine or fir framing lumber. In fact, the 2x4 OSW studs were strong enough to be spaced 24 inches on-center, which reduced the amount of framing in the wall and left room for more insulation.

Single header. Instead of separate door and window headers, the plans for the Davis house called for a continuous header to be mounted to the inside face of the studs, supported by jacks at door and window openings, and at the corners. Drywall was screwed to these, as well as to horizontal OSW furring strips along the floor and at the mid-point of the wall. The space between the strips was filled with strips of foam insulation to create a thermal break between the drywall and the studs. The framing-to-wall ratio for the engineered wall was only 9% — compared with a range of 15% to 30% for a typical wall — but structural tests showed it to be stronger.

Foam in the bays. Instead of placing foam insulation on the outside of the frame, the ACT2 builders put 3 1/2-inch rigid foam between the wall studs. The foam boards were installed as the wall was assembled, which helped maintain stud spacing and reduced wall layout time. The wall had an overall insulating value of R-25.6, compared with R-13.7 for a typical house in the same area. According to PG&E, the wall will cost about the same as a conventional wall system when the market matures for all the components.

Learning curve. The framing crew struggled with the unfamiliar system on the Davis house, so designers simplified plans for the Rockland project. The continuous header was replaced by standard window and door headers. This time the walls were tipped up first and insulated later. Each piece of rigid insulation was cut to fit, and sealed in place with expanding foam. And instead of using strapping and foam spacers on the face of the studs, a single-coat stucco system with 1 inch of rigid insulation was added to the outside. Together these changes increased the insulating value of the new wall by R-3.9, to a total of R-29.5.

Space Conditioning

The base-case design would have required a central air conditioner to keep it comfortable in summer. In the Davis test house, the air conditioner was replaced by a whole-house fan that flushed the house out with cool air at night, a change that lowered construction costs by $1,500. Energy savings were estimated to be 3,200 kWh of electricity and 370 therms of natural gas — a reduction of 62% over the original design.

The Rockland house had different requirements. Because the site doesn't cool off at night, ventilation wouldn't be enough; mechanical cooling was needed. Instead of a traditional air conditioner, however, PG&E used a roof-mounted evaporative cooler. The typical system is fairly simple in concept: As water in the device evaporates, the surrounding air becomes cooler and heavier, and drops into the building. The hotter and drier the weather, the faster this happens. In the Rockland house, however, PG&E used the evaporative cooler's output to cool water instead of air. The water then circulates through 1,000 feet of thick-wall, 2-inch-diameter plastic tubing under the concrete slab floor. The slab is cooled at night; during the day, its thermal mass helps keep the house cool. This floor delivery system alone can maintain the house temperature below 78°F, a typical energy-saving setpoint for an air conditioner. Electronic temperature controls prevent the slab from dipping below 60°F, reducing the chance that condensation will form.

If daytime cooling becomes necessary, water from the tubing circulates through a fan coil and blows into the house. The evaporative cooler's fan also provides night ventilation when needed. No installation costs are available for the custom-made evaporative cooler, but PG&E projected that the Rockland house would save 5,200 kWh of electricity and 330 therms of natural gas compared with a typical house.