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INDUSTRY NEWS

Urbana Gets Another Passivhaus

The first house in the US designed according to Passivhaus principles -- a strict European specification for energy-efficient buildings -- was built in Urbana, Illinois, in 2003 (see ***EDU***, May 2004). After designing the house, architect Katrin Klingenberg founded a nonprofit organization, the Ecological Construction Laboratory (E-co Lab), to promote the design and construction of energy-efficient buildings for low-income and middle-income families.

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In October 2006, E-co Lab completed construction of Urbana's second Passivhaus building, a 1,300-square-foot affordable home (see Figure 1). In November, homeowner Beth Simpson moved in.

Figure 1. Most of the windows at the second Passivhaus in Urbana, Illinois, face south. This photo shows the ventilation system's intake and exhaust ducts.

The new house has many specifications in common with Klingenberg's own home, the first Urbana Passivhaus. Both houses have a simple design with a rectilinear footprint. Both have TJI-framed walls. (TJIs are engineered-wood framing members usually used as joists). Both houses have tight building envelopes and high levels of insulation: except for the walls and doors, the envelope components have a minimum R-value of 56. Both houses are all-electric. Neither house includes a photovoltaic array or a solar thermal system.

A Simplified Foundation

The second Urbana Passivhaus has a simpler foundation than its predecessor: instead of a frost-wall foundation surrounding a slab, the second house sits on a frost-protected thickened-edge slab (see Figure 2, page 2). The slabs at both houses were poured over 14 inches of expanded polystyrene (see Table 1, page 3).

The slab perimeter is insulated with only 3 inches of vertical insulation (R-15 extruded polystyrene foam). Klingenberg would have preferred to include more insulation at the slab perimeter, but was constrained by the fact that the TimberStrand wall plates have a maximum allowable cantilever of 2 ½ inches.

Framing Thick Walls

Like all builders of energy-efficient homes, Klingenberg had a variety of options to choose from when designing the home's high-R walls. She decided to stick with the TJI studs used on the first Passivhaus, but to eliminate the foam sheathing (see Figure 3, page 3). The second Passivhaus has 14-inch-deep studs (rather than the 12-inch-deep studs used for the first house) filled with blown-in fiberglass insulation. Once sheathed with R-1.28 asphalt-impregnated fiberboard, the walls have an R-value of about 60.

To improve the structural characteristics of the TJI walls, the studs are sheathed on the interior with OSB; the OSB also acts as a vapor retarder and contributes to the walls' airtightness.

Klingenberg insists that exterior walls include no electrical wiring. While this requirement improves a building's airtightness, it complicates life for electricians. Klingenberg told ***EDU*** that if she gets an opportunity to build another Passivhaus, she may specify the inclusion of a 2x3 stud wall inside of the TJI-stud wall; the 2x3 wall would provide room for wiring, inboard of the vapor retarder and air barrier.

Duncan Prahl, the research manager at Integrated Building And Construction Solutions (IBACOS) in Pittsburgh, Pennsylvania, is now monitoring the energy performance of the second Urbana Passivhaus. "If you run the modeling for a zero-energy house, or a Passivhaus, then this is it for a cold climate -- these are the levels of insulation and the types of windows you need," Prahl told ***EDU***. "But whether the walls should be framed with 14-inch TJIs is another question. Maybe we should do double-stud walls, or 2x6 walls with 2 inches of foam on the outside. What we really need to do is find the most cost-effective way for a production builder to build these high-R walls."

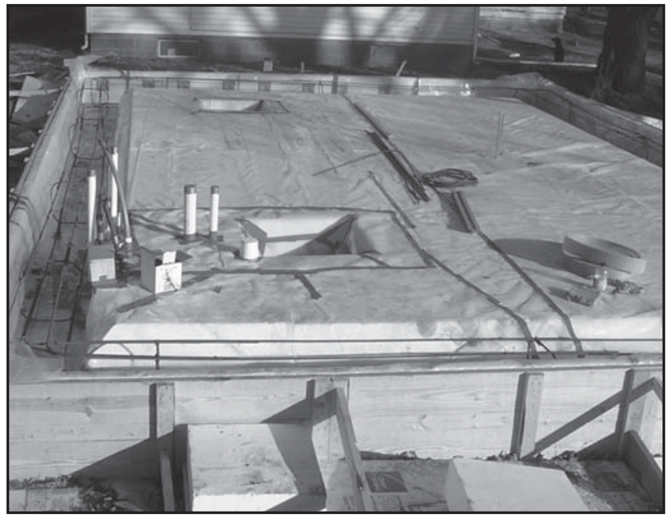

Figure 2. The frost-protected thickened-edge slab was poured over 14 inches of expanded polystyrene foam; the perimeter of the slab is insulated with 3 inches of vertical extruded polystyrene foam.

Triple-Glazed Windows

The windows at the second Urbana Passivhaus are triple-glazed fiberglass-framed windows with a whole-window U-factor of 0.20. "The windows are from Fibertec Windows in Canada, and we had a terrible time with them," Klingenberg wrote in an e-mail to ***EDU***. "I wish we had gone with Thermotech again. Fibertec was 12 weeks late, customer service was terrible, and the quality is far below that of the Thermotech windows. We had broken seals between

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window and brickmold extension and significant leakage after installation. The hardware is very flimsy compared to Thermotech, and one window already needs repair -- it does not close anymore."

Klingenberg's first Passivhaus had extensive south glazing; after the house was built, an energy modeling program suggested that the house might be susceptible to summer overheating. "I have a trellis now on the south side of my house," Klingenberg told ***EDU***. "In the summer it is overgrown with vines, and it works just about perfectly to shade the south windows. By the time the weather gets cold, the leaves have dropped."

A blower-door test performed at the second Passivhaus showed 0.25 air changes per hour at 50 Pascals; as Prahl notes, "It's a way tight house."

Figure 3. The Passivhaus walls were framed with 14-inch TJIs and sheathed with ½-inch asphalt-impregnated fiberboard.

HVAC for a Thrifty House

Like many energy-efficient houses, the second Urbana Passivhaus has such a low heating load -- about 11,000 Btuh at the outdoor design temperature of -6°F -- that even a small furnace would be oversized. In Germany, equipment manufacturers have developed new HVAC appliances to serve the Passivhaus market. "In Europe, they have their 'magic boxes,'" says Prahl. "A number of manufac-

Table 1—Second Urbana Passivhaus Specifications

Location	1005 W. Fairview Ave., Urbana, Illinois
Completion date	October 2006
Size	1,300 sq. ft. (3 bedrooms, 2 baths)
Foundation	Frost-protected thickened-edge concrete slab
Under-slab insulation	14" expanded polystyrene (R-56)
Slab perimeter insulation	3" extruded polystyrene (R-15)
Wall construction	14" TJI studs, 24" o.c., TimberStrand plates, ½" asphalt-impregnated fiberboard sheathing covered with Tyvek and rainscreen strapping
Wall insulation	14" blown-in fiberglass (R-60)
Roof framing	16" TJI rafters, 24" o.c., sheathed with ½" asphalt-impregnated fiberboard topped with Tyvek, 2x4 strapping, and plywood over the air channel
Roof/ceiling insulation	16" blown-in fiberglass (R-60)
Roofing	Standing-seam galvanized steel roofing
Siding	Fiber-cement siding
Windows	Fibertec fiberglass-framed U-0.20 windows with triple-pane, argon-filled, low-e glazing; SHGC varies by orientation
Blower-door results	0.25 ACH @ 50 Pa; about 0.01 ACH_{nat}
Heat load calculation	10,996 Btuh per Manual J (outdoor design temp., -6°F)
Space heating	3,000 watts electric resistance baseboards
Cooling	None; window air conditioner may be added later
Mechanical ventilation	Stirling RecoupAerator ERV
Domestic hot water	Stiebel Eltron instantaneous electric water heater

Table 1. The house at 1005 West Fairview Avenue in Urbana, Illinois, was designed according to principles established by the Passivhaus Institut in Darmstadt, Germany. The house shares many features with a similar house built in Urbana in 2003 (see ***EDU***, May 2004).

turers are making integrated appliances combining a heat pump, water heater, and HRV -- but without cooling, at this point."

Since the second Urbana Passivhaus has such a low heating load, Klingenberg could not justify the expense of a ground-source heat pump. Lacking easy access to a European "magic box," she specified 3,000 watts of electric resistance baseboard. Domestic hot water is supplied by a wall-mounted electric instantaneous water heater; mechanical ventilation is provided by an energy-recovery ventilator from Stirling (the RecoupAerator).

The ventilation system at the second Urbana house, unlike the one at the first house, has no buried earth tube. "We have evaluated the effectiveness of the earth tube at my house," Klingenberg told ***EDU***. "It was only of limited usefulness. In some conditions, it starts warming the incoming air when it should be cooling it. Temperature changes occur not just between winter and summer, but also on a daily basis, so at night during the summer, the earth tube can warm the air when it should be cooling."

Prahl concurs with Klingenberg's conclusions. "I was at the Passivhaus conference in Germany, and it seemed that a lot of people in Europe are moving away from the earth tubes," said Prahl. "They're not sure they are really doing what they are supposed to."

Cost and Performance

The total construction budget for the second Urbana Passivhaus was $148,000, not including land and donated labor.

According to Prahl's energy modeling, the house is designed to use 5,353 kWh of electricity per year for space heating and 15,750 kWh per year for all purposes. The home's energy use is expected to be 55% less than the Building America benchmark (that is, a "code minimum" house, circa 2000, equipped with an air-source heat pump). Ongoing energy use monitoring, begun by Prahl in November 2006, will eventually provide more data on the home's performance.

Even though energy modeling pegs the house as an energy miser, the net-zero-energy goal remains elusive. Prahl calculates that the house would require a 12-kW photovoltaic (PV) system to balance its energy use -- in other words, a PV system costing over $100,000.

Klingenberg is already tweaking specifications for a third Urbana Passivhaus. "The energy savings are phenomenal," says Klingenberg. "These houses are pointing in the direction of carbon-neutral homes."

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$364 a Year For Zero Energy

The latest monitoring data from the Habitat for Humanity house in Wheat Ridge, Colorado, shows that the homeowners made it through a very cloudy winter season without jeopardizing the home's zero-energy status (see ***EDU***, February 2007). Paul Norton, a senior engineer at the National Renewable Energy Laboratory, reports that monitoring data through the end of March 2007 confirm that the Wheat Ridge homeowners continue to use less energy than is produced by the solar equipment installed on the home's roof.

Norton also released an interesting table (see Table 2) detailing how the homeowners ended up with an annual utility bill of $364, in spite of the fact that they used less energy than their home produced. The cost is attributable to the Achilles' heel of grid-connected zero-energy homes: monthly connection and meter-reading fees set by electric and gas utilities -- fees that remain fixed regardless of the homeowners' level of energy use.

Table 2—Annual Utility Bills, Wheat Ridge House

	Fixed charge	Use charge	Total charge
Total annual electricity bill	$95.11	$69.58	$164.69
Reimbursement from electric utility for net PV production			-$108.00
Total annual natural gas bill	$119.87	$187.51	$307.38
Total annual net energy bill			$364.07

Table 2. Although the PV array on the roof of the Wheat Ridge house produced more energy on an annual basis than the homeowners used, they were still obligated to pay $364 in meter-reading fees.