system matches the combined luminous output of a 300-watt halogen lamp and a 150-watt incandescent table lamp while using only one-quarter of the energy. The new lamp uses two independently controllable and fully dimmable compact fluorescent lamps. One lamp's light is directed downward, illuminating the table or desk. The other directs light up toward the ceiling, providing high-quality indirect lighting. For additional information, visit www.lbl.gov/Science-Articles/archive/cfl-tablelamp.html.

RESEARCH AND IDEAS

Crazy Like A Fox

Wisdom and Innovation Play Equal Parts in Randy Voss' New Home

As a seasoned building inspector for the town of Reedsburg, Wisconsin, Randy Voss has seen almost everything that can go right or wrong in a new home. He's also a keen student of building science and a strong advocate for the environment. It's no wonder then that when Voss set out to build his own home, builders and contractors from miles around tuned in to see what kinds of designs and materials he would use. And so did we.

The result of his effort is a stunning four-bedroom, 3,500-ft² (326-m²) home that combines a lot of practical experience, meticulous attention to detail, and some truly remarkable design innovations. "Overall, I would say that five years of hard thought went into the design before we broke ground," Voss says. "I know that some home builders and contractors will say I'm crazy with some of these ideas — and I concede that I may be 5 or 10 years out with some of them — but I believe that all of the home's features will show their merit over time." (See Spec Sheet on page 10.)

Voss tells ***EDU*** that he already has strong evidence that the design works well. "The basement is delightfully warm and as dry as the Sahara Desert," he says. "Over this past winter — one of the coldest in Wisconsin history — we were heating the whole house for about $35 a month."

Buffered Basement

One of the most interesting features on the house is the 6-foot wide by 8-foot deep concrete buffer that wraps around the north side of the basement, creating, in effect, a double envelope. The exterior wall of the buffer, which is shown on the right in Figure 2, was poured on top of an extra wide footing and is 3 feet thick at its base. Voss insisted that his foundation contractor build special, one-sided forms so that the concrete could be poured tight into virgin soil.

"I wanted to add mass to that exterior wall and to have it well-coupled to the earth," Voss explains. "Experience has taught me that you can't get good conduction with backfill. I've seen a lot of double-envelope houses that underperformed because they used gravel and sand and construction debris as backfill and so failed to really couple with the earth. I'm convinced the concrete should be set tight against undisturbed soil and that it's worth the extra money to do it right."

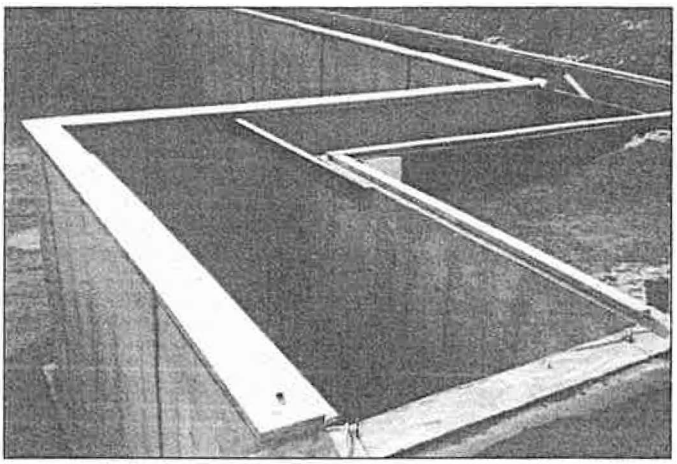

Figure 2 — The north side of the basement is thermally buffered by a 6-foot wide by 8-foot deep by 100-foot long double envelope. This view shows the space before it was capped with Flexcore pre-stressed concrete slabs (see Figure 3). The finished buffer, accessible through doors from the basement, serves as a wine cellar and general storage area.

The 100-foot long buffer space is capped with Flexcore pre-stressed concrete slabs, which are insulated underneath with 2 inches of Styrofoam rigid insulation. The Flexcore slabs do double duty, serving as the roof to the buffer space below and creating a solid, rot-proof floor for the home's wraparound porch above (see Figure 3).

The basement has two doors that open into the buffer space, so that Voss can use it for storage. The home's air-to-air heat exchanger provides fresh air to the buffer space on a timed sequence. "Apart from the thermal advantages we get from the buffer space, it also provides us with more storage than you can imagine and creates space for a fantastic wine cellar."

Four-Ply Exterior Skin

Voss, once a die-hard proponent of 2x6 framing because of the extra cavity insulation it allows, now declares it to be one of the worst mistakes the building industry has ever made. "You may be able to get away with 2x6 framing down South," he says, "but in this climate we are seeing serious moisture and rot problems inside 2x6 walls, because we have basically moved the dew point

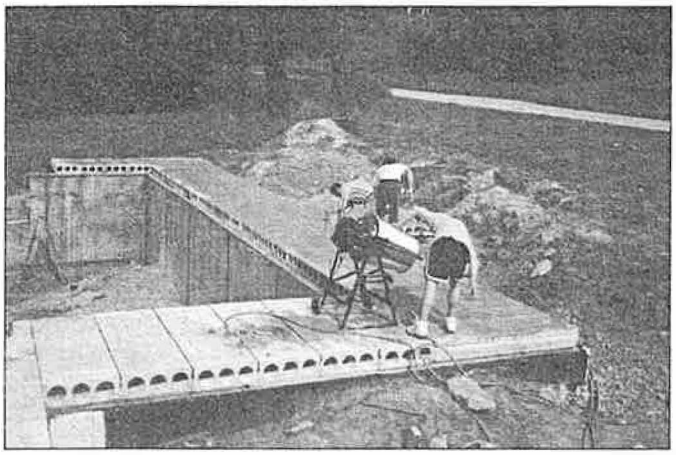

Figure 3 — The buffer is capped with Flexcore pre-stressed concrete slabs and insulated underneath with 2 inches of Styrofoam rigid insulation. The Flexcore slabs, grouted between the seams and topped with a 3-inch slab, serve as the solid, rot-proof floor for the wraparound porch.

right inside the cavity. The lawsuits are already starting to make news, and I think it's going to be 10 or 15 years before we can reeducate builders, solve existing or developing moisture problems, and put this bad chapter behind us."

Voss' new house exemplifies his conviction that the best envelope design in cold climates is to use conventional 2x4 framing with cavity insulation but to move the dew point outside the sheathing by wrapping the home with a thick sheet of rigid insulation. Thus, from inside to out, the envelope components in the Voss home include:

- Sheetrock
- 0.5 inches of Styrofoam (carefully taped to create a moisture barrier)
- 2x4 framing @ 16 inches o.c. with R-13 batt insulation
- OSB sheathing
- Tyvek housewrap
- 1 inch of Styrofoam
- 0.5 inches of Styrofoam (carefully taped)

The wall assembly, which has a total R-value of about 28, prompts two immediate questions: Why use OSB when you could brace the frame and get by with just the Styrofoam sheathing? And why go to the trouble of installing two separate layers of Styrofoam sheathing on the outside, when one thick sheet could have been used?

To the first question, Voss answers: "I've inspected some of these homes that were built using just rigid insulation as sheathing, and they have serious vibration problems. When you slam the front door, the kitchen cabinets shake. So the OSB gives the frame strength and eliminates those vibration problems."

As for the second question, Voss says double sheets of Styrofoam were used to produce a better mounting detail around windows and doors (see Figure 4). "Contractors do not like to mount windows though a thick piece of foam," Voss explains. "So we installed 1 x 1.5 inch furring strips around all the window and door rough openings. We then installed the 1-inch Styrofoam sheathing, which comes in flush to the furring. We then installed the half-inch-thick Styrofoam, which laps all of the seams on the inner sheet of Styrofoam and comes in right to the edge of the rough opening. Now your window installer is only mounting through a half inch of foam. It's really a beautiful detail."

Early on, Voss decided that wherever rigid insulation was used, inside or out, he would tape every seam. Over the course of the construction, he used more than 200 rolls of tape and experimented with many different types (Scott, Nashua, United Tape, Manco, etc.) before he settled on AC64, manufactured by Intertape (Bradington, Florida). "The stuff really sticks great to wood and concrete and other surfaces," Voss says. "It costs $2 more per roll, but the quality is incredible."

Completing the envelope are Heat Mirror triple-glazed windows, which have a low-e coated film suspended in the middle of the insulated glass unit. Voss' meticulous attention to detail is further illustrated in the way he sealed and insulated the box sills (see Figure 5) and in the way he designed his cathedral ceilings (see Figure 6).

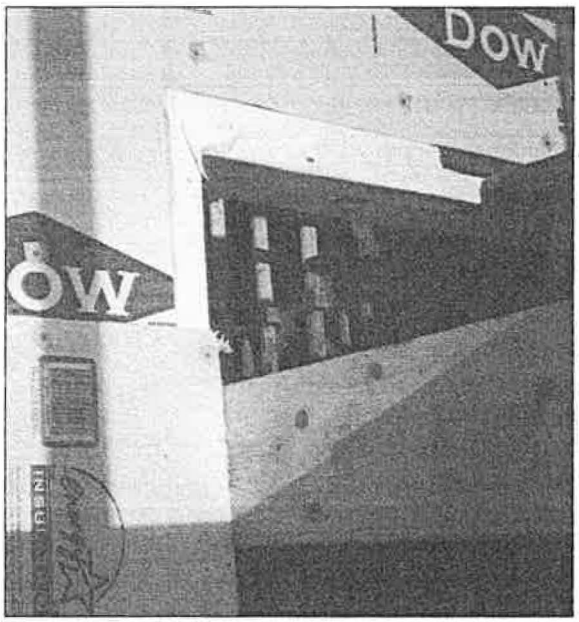

Figure 4 — Insulation detail at rough window opening. The 1-inch thick Styrofoam (exposed top) butts up flush against the 1 x 1.5 inch furring strip that was nailed around the perimeter of the rough window opening. The half-inch Styrofoam (bottom) then laps over both. Voss says the detail provides a very tight assembly and gives the window installer a nice solid surface to screw into.

Spec Sheet: Voss Home

GENERAL

Size: 3,600 ft² (335 m²) (conditioned basement adds 1,884 ft² [175 m²])

Garage: Double

Style: One-and-a-half story country estate

Location: Reedsburg, Wisconsin

Lot Size: 160-acre farm

Price: $200,000

ENVELOPE

Basement: Poured 8-inch concrete walls sheeted with 2 inches of rigid insulation wrapped in a geotextile. North side of basement has buffer space that works as a double envelope (see main story and Figures 2 and 3).

Floor system: 16-inch open-web truss joists; HVAC, electrical, and plumbing routed through open webs.

Walls: 2x4 framing @ 16 inches o.c. with R-13 batt insulation. OSB sheathing covered with Tyvek housewrap. Half-inch rigid insulation (Styrofoam) on the inboard side of the framing, taped to create a moisture barrier. 1.5 inches of Styrofoam on the exterior of the OSB, taped.

Attic: 2x12 rafters @ 16 inches o.c. Cathedral ceiling combines fiberglass batt and rigid insulation to attain R-98 (see Figure 6).

Roof: OSB sheathing, rolled underlayment, asphalt shingles.

Attic venting: 429-cfm Fantech blower draws outdoor air into the attic and distributes it through a standard 8-inch furnace duct. Design intent is to keep the attic cool in the summer and reduce infiltration from the rooms below. (See main story and Figure 8.)

Windows: Heat Mirror triple pane.

Siding: Vinyl with aluminum soffits and fascia.

Exterior doors: Kolby & Kolby insulated fiberglass.

Air sealing details: Taped Styrofoam inside and out. Tyvek housewrap.

Interior partitions: 2x4s @ 24 inches o.c. with 5/8-inch gypsum board.

HVAC

Heating: Delta-Therm electric heat bank system stores off-peak electric heat in a 12-inch-thick layer of compacted sand underneath the slab. WaterFurnace Premier 2 ground-source heat pump (open loop) with 4.8 coefficient of performance. A high-efficiency 90+ Ruud LP gas furnace serves as a backup source of heat in case of power outage and provides fuel flexibility for the future.

Cooling: 5-ton WaterFurnace Premier 2 ground-source heat pump (open loop) with 4.8 coefficient of performance.

Ductwork: Insulated ductboard. Four-zone system designed by heating engineer.

Water heating: Desuperheater directs "waste heat" from the heat pump into a hot water storage tank that serves as a tempering tank to a conventional State electric water heater.

Spot ventilation: Each bathroom and laundry room has an 80-cfm exhaust fan.

Whole-house mechanical ventilation: Air Research energy recovery ventilator removes heat and humidity. Supply and return are ducted into the forced-air system.

OTHER FEATURES

- Communications system includes two Category 5 cables, two coaxial cables, and a fiber-optic pair originating at a cabinet interface, serving 10 locations.
- Groundwater infiltration system designed to allow slow absorption of rainwater on-site. Sized to allow reabsorption of a 1-inch rainfall over a 24-hour period (see main story).
- Deck supports are cantilevered steel beams, which eliminate the need for pressure-treated wood posts.