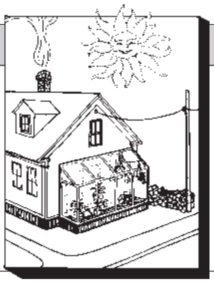
Stressed-Skin Panels



by Alex Wilson

Few building products introduced in the past 50 years have had the impact of stressed-skin panels. They may very well revolutionize the way we build houses. Already, they've made dramatic inroads into the relatively small timber-framing industry.

Most timber-frame houses built today are clad with four- to six-inch-thick stressed-skin panels—a core of rigid insulation sandwiched between an inner skin of drywall and an outer skin of waferboard or oriented-strand board (OSB). Timber-framers have found that it makes more sense to enclose their frames with these panels than to frame-in separate 2x4 or 2x6 walls and/or sheathe with rigid insulation.

Stressed-skin panels are also starting to be used in conventional houses to replace frame-wall and roof systems—and even foundation walls. Unlike the stressed-skin panels that are used on timber-frame houses and have drywall on one side and waferboard on the other, these "structural panels" have waferboard on both sides. This combination creates an extremely strong wall system—typically, about three times as strong as a conventional 2x4 stud wall.

In this column, I will address one aspect of stressed-skin panels—their insulation. Currently, two primary types are being used: isocyanurate (a formulation of polyurethane), and expanded polystyrene (EPS). Let's discuss the pros and cons of each, and look at alternatives that may come up in the next few years.

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EPS-Core Panels

EPS, or beadboard, is used by the majority of manufacturers of stressed-skin panels. The basic advantages of EPS are lower-cost panels and less complex manufacturing.

Large sheets of EPS, usually four feet wide and up to 16 feet long, are glued to the drywall or waferboard skins. Because of the ease of manufacturing, even one- or two-person companies operating out of a garage can produce them, and can turn out fairly good-quality panels. Larger firms typically manufacture their own EPS, while smaller companies purchase EPS board stock.

The cost of EPS stressed-skin panels runs from $1.50 to $2 per square foot. A wide range of thicknesses is available, allowing designers to choose the best R-value for different parts of the building shell.

On the downside, EPS has a lower R-value per inch than isocyanurate. Thicker panels are therefore required to achieve comparable insulation levels. EPS has lower density and compressive strength, so it does not offer the same structural properties (particularly important in structural panels). And, perhaps most significant, EPS is not as safe in the event of a fire.

Isocyanurate-Core Panels

With isocyanurate panels, the manufacturing method affects the finished product. Some isocyanurate panels are made in much the same way as EPS panels: large sheets of the insulation are glued to the drywall or waferboard skins. There may be problems with delamination, however, because the surfaces of the isocyanurate sheets deteriorate somewhat when exposed to air, and the glue does not always bond well.

The preferred manufacturing technique is a continuous-lamination process. In this process, the foam is laid down between the skins and allowed to rise, thereby filling the core. This produces a far stronger bond between the insulation and the drywall or waferboard.

Isocyanurate has a higher R-value per inch than EPS—an average of about R-7 versus R-4. Isocyanurate achieves a higher R-value because it is denser, and because Freon (rather than air) fills the tiny cells of insulation. The R-value of isocyanurate drops over time, however, as air molecules slowly diffuse into the insulation and Freon escapes.

In some cases, with either isocyanurate or polyurethane, the R-value can drop to R-5.6 to R-6, although that low a level is unlikely in stressed-skin panels because of their thickness. If all the Freon were replaced with air—which is probably not possible—the R-value could theoretically drop to as low as R-5 per inch (the same as *extruded* polystyrene). For stressed-skin panels, a safe estimate for an aged R-value (after, say, ten years) is about R-6.5 per inch.

The R-value of EPS depends on its density. The low-density EPS typically used in stressed-skin panels (about one pound per cubic foot) has an R-value of 3.6 per inch.

The strength of stressed-skin panels is determined largely by the density and compressive strength of the insulation. Isocyanurate has a density of about 2 lb/ft^3 and a compressive strength of about 33 lb/in^2. EPS, with a density of 1 lb/ft^3, has a compressive strength of 10 to 12 lb/in^2. A panel's thickness also affects its strength, however: what the EPS panels lose by virtue of the weaker foam, they partially make up for due to thickness.

In terms of fire safety, isocyanurate-core panels are much safer than EPS-core panels. EPS begins melting at temperatures of around 170°F. By 300 degrees, it becomes a low-viscosity liquid that is highly flammable. Isocyanurate, on the other hand, is a "thermoset" plastic: it does not melt when exposed to high temperatures. Like wood, it burns—but it maintains its structural properties until consumed by fire.

As an EPS panel is heated, the insulation melts and the skins fall off—contributing tremendous quantities of fuel to a fire.

With stressed-skin panels, this is a key difference. Recent fire testing by a manufacturer of stressed-skin panels* showed that, as an EPS panel is heated, the insulation melts and the skins fall off—contributing tremendous quantities of fuel to the fire all at once. This delamination can occur even *before* the 15-minute finish rating of the drywall is reached. Furthermore, as melting occurs, an open channel is created within the panel, allowing fire to spread rapidly. The isocyanurate panels tested did not have these problems.

Both types of panels give off harmful gases—including carbon monoxide—as they burn, so don't plan to use stressed-skin panels in buildings that might be exposed to above-average fire hazards.

On the downside for isocyanurate panels, the continuous-lamination process requires expensive and precisely controlled equipment, so the panels are more expensive—typically $2 to $2.85 per square foot. The proper mixing of chemicals is almost an art, I am told, and slight differences in formulation can affect foam quality. These difficulties have kept most companies out of the isocyanurate-panel market.

It is more difficult to produce panels of differing thickness with the continuous-lamination manufacturing process, so manufacturers often offer only one thickness—typically, 4½ inches. With EPS panels, you can economize by using thinner panels where the heat loss is expected to be less, and thicker panels where greater heat loss is expected.

Other Alternatives

While EPS and isocyanurate are the only insulation materials currently used in stressed-skin panels, other types of foam may soon be available. Extruded polystyrene, with its higher density, greater compressive strength, and higher R-value, would offer some benefits over EPS. It would, however, have to be produced by the continuous-lamination process, so it would be more expensive—probably comparable to isocyanurate. Furthermore, it would be identical to EPS in terms of fire safety.

Phenolic foam would be superior to both EPS and isocyanurate in terms of fire safety. It also has the highest R-value of any insulation material—about R-8 per inch—although, like isocyanurate, the R-value may drop somewhat as the Freon is replaced by air. But phenolic-foam insulation tends to be brittle. Stressed-skin panels could conceivably shear, especially in an earthquake. Phenolic foam, also, is more permeable to moisture than the other foams (isocyanurate is the lowest of the three), which could cause problems.

The ideal insulation for stressed-skin panels may lie just around the corner. As we speak, chemical companies are probably hard at work developing improved insulation materials.

Until that time, we are likely to see rapidly expanding use of both EPS and isocyanurate as stressed-skin technology takes off. ■

*The PFS Corp. of Madison, Wisc., carried out ASTM fire testing for Winter Panel Corp., which makes isocyanurate panels. Information on the results of these tests can be obtained by writing to Winter Panel Corp., RR 1, Box 161, Brattleboro, VT 05301.

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