PLASTICS Takes Improvement to the Wall

NEW NAHB RESEARCH CENTER WALL STUDY ABOUT THERMAL RESISTANCE—R-VALUE NOT THE WHOLE STORY

By Craig Drumheller, NAHB Research Center

> “Plastics building products can reduce heat transfer up to 29 percent over baseline wall.”

In an effort to more accurately quantify the thermal performance of a variety of wall system alternatives under ‘real-world’ conditions, the National Association of Homebuilders (NAHB) Research Center, through the labs of Architectural Testing Inc., conducted a series of residential wall panel tests during 2005 and 2006. The purpose was to compare the most common ‘baseline wall’ (*i.e.* fiberglass batt insulation between 2x4 wooden studs finished with interior drywall) against several walls containing plastic building products (including plastic foam insulating materials).

R-value represents resistance to heat flow, where higher numbers indicate increased resistance to heat flow. (In other words, the higher the R-value, the greater the insulating power.) Although R-value has been traditionally used in building codes for decades to quantify minimum insulation requirements for standard wall construction, it does not provide a complete measurement of the overall wall system’s energy efficiency. Effects such as thermal bridging of framing members, air and wind infiltration resistance, and stack

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Prior to the National Association of Home Builders (NAHB) insulation study, wall samples were stored in a warehouse for a year. This helped account for any R-value changes with the spray polyurethane foam (SPF) samples—any degradation of the material would occur within the first couple of months.

effect of the building shell under normal, real-world operating conditions are not considered in the R-value. This study is unique in its evaluation of overall wall system performance. It was designed to accurately characterize the energy consequences of wall construction and insulation material choices.

To more accurately simulate various climates and real world conditions, each wall system was tested under two conditions:

- in a 'static state' condition with no additional atmospheric wind pressures at one temperature alternative;' and
- with a 24-km/h (15-mph) 'wind loading' at three different outdoor temperatures.

Testing showed under no wind conditions, all the wall systems performed similarly (within the statistical accuracy of the testing apparatus). Of course, all walls under wind conditions performed less well than with no wind. Nonetheless, once real-world wind loading was applied, the wall systems with plastic and plastic foam insulation products performed between 14 and 29 percent better than the baseline wall, with relative performance increasing as the outside temperature rose. This indicates air infiltration plays an important role in the thermal performance of a wall system in real-world conditions.

Table 1
Panel Study Parameters

Interior finish	Insulation*	Sheathing	Weather barrier
12.7-mm (0.5-in.) gypsum	R-13 KFB (88.9 mm [3.5 in.])	11-mm (0.4-in.) OSB	None
0.5-in. gypsum	R-13 KFB (3.5 in.)	0.4-in. OSB	House wrap
0.5-in. gypsum	R-13 spray foam (~54.4 mm [2.14 in.])	0.4-in. OSB	None
0.5-in. gypsum and OSB	Net R-15 SIP (92 mm [3.625 in.])	0.4-in. OSB	None
0.5-in. gypsum	R-13 KFB (3.5 in.)	0.5-in. rigid foam board ~R-3.5	Tape

* NAHB C-518 tested material R-value determination, not the manufacturer's specifications
OSB = oriented strand board • KFB = kraft-faced fiberglass batt • SIP = structural insulated panel

This study addressed the net effect of temperature and wind pressure differences across a variety of residential walls, comparing them to the most common 'stick and batt' wall construction. The testing shows how a home wall assembly would be expected to perform thermally while actually in use.

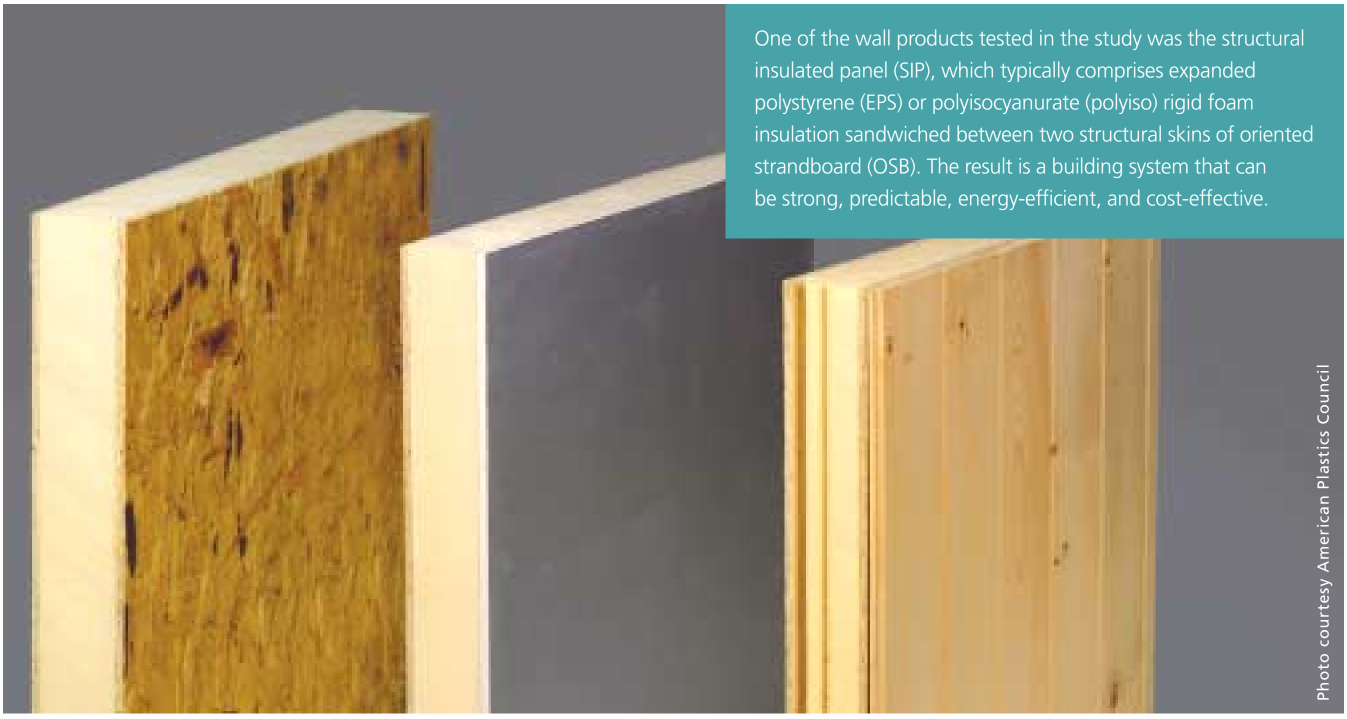
The protocol was designed so the performance tests would be equitable for all the wall assemblies; additionally, the testing process was designed in such a manner to be repeatable. No two walls are made of exactly uniform materials due to factors such as wood warping, oriented strandboard (OSB) thickness variations, and nail placement.

As such, special effort was made to first evaluate a typical wall assembly against expected performance using calculations based on measured material R-values. That specific assembly's performance became its starting point ('benchmark') for each test, right down to replicating volumes of air infiltration and placements of connecting hardware. Conditions were representative of both typical and extreme real-world conditions in various climates.

Five wall types were assembled for whole-wall thermal testing. Plastic building products such as building wrap, spray-in-place plastic foam insulation, rigid plastic foam insulation, and structural insulated panels (SIPs) of plastic foam were

Photo courtesy NAHB Research Center

Water jacket tubing runs in and out of a wall panel specimen. In the study, each wall system with plastic building products performed better than its expected benchmark—this suggests traditional R-values are not an accurate indicator of how well a wall resists energy loss and gain.



One of the wall products tested in the study was the structural insulated panel (SIP), which typically comprises expanded polystyrene (EPS) or polyisocyanurate (polyiso) rigid foam insulation sandwiched between two structural skins of oriented strandboard (OSB). The result is a building system that can be strong, predictable, energy-efficient, and cost-effective.

Photo courtesy American Plastics Council compared to the baseline wall's benchmark construction (Table 1). Note: the R-value of spray polyurethane foam (SPF) may degrade after installation. Generally, most degradation occurs within the first couple of months after application. To account for this possible change, the SPF panels tested by NAHB were warehoused nearly a year prior to the study.

According to the NAHB Research Center, the tested baseline wall represented the most common wall construction used in home building today: a 2.4 m (8 ft) high, 101.6-mm (4-in.) overall thickness, wood stud framed wall with studs spaced 406.4 mm (16 in.) on-center (oc), sheathed with OSB, R-13 kraft-faced fiberglass batt (KFB) insulation, and 12.7-mm (0.5-in.) drywall covering the inside. Furthermore, best installation practices and the manufacturers' specifications were used. Individual insulation products were thermally characterized through alternate testing to validate the overall wall and material performance designations.

Since each plastic-insulated wall performed better than its benchmark, the NAHB Research Center concluded that the supposed performance values based on traditional R-value measurements and calculations are not a complete indicator of how well a wall system will resist the loss or gain of energy.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Summary

This laboratory testing clearly demonstrated the benefits of using plastic and plastic foam insulation construction materials by showing significantly improved thermal performance of residential wall systems under real-world, wind-loaded conditions at various temperatures, compared to the baseline wall construction, as specified below.

No wind and moderate temperature (static state)
When there is no wind at 21 C (70 F) inside and –4 C (25 F) outside, all wall systems performed similar to their expected calculated benchmark. Compared to a typical batt insulation baseline, wall systems with plastic building products had a heat flow reduction of only three percent (not statistically significant).

Wind and extremely cold temperature (real world)
Under a 24-km/h (15-mph) wind, at 70 F inside and a temperature of –26 C (–15 F) outside, plastic- and foam plastic-insulated wall panel systems reduced heat flow on average 18 percent better than the baseline.

Wind and moderate temperature (real world)
Under a 15-mph wind, at 70 F inside and a temperature of 25 F outside, the performance results changed significantly. The wall systems with plastic building products overall reduced heat flow on average 20 percent better than the baseline.

Wind and extremely hot temperature (real world)
Under a 15-mph wind, at 70 F inside and a temperature of 46 C (115 F) outside, wall systems with plastic building products reduced heat flow an average of 25 percent better than the baseline. One panel sample performed 29 percent better in this category.


Photo courtesy NAHB Research Center

The NAHB study suggests approximately 85 percent more batt material than plastic insulation would be needed for a 88.9-mm (3.5-in.) cavity to achieve similar results.

Conclusion

An important finding is all the walls containing plastic or plastic foam insulation performed similarly to the baseline wall with respect to reducing heat flow in the 'no-wind' conditions. Interestingly, though, when real-world wind conditions were applied, the research found all wall systems with plastic building products performed similarly better than the baseline. It also found that as the temperature changed, all wall systems with plastic building products performed similarly better as a group to the baseline wall at each new temperature level.

An important implication of this research indicates it would require a typical 'standard' (*i.e.* stick and batt) wall to be constructed as an R-15 wall to perform thermally equivalent in real-world windy conditions with an R-13 wall using plastic building products listed above. As mentioned earlier, the higher the R-value, the greater the insulating power. (Design professionals should ask an insulation seller for a fact sheet on R-values.) Nonetheless, without considering air infiltration issues, this means approximately 85 percent more batt material would need to be inserted in the same 88.9-mm (3.5-in.) cavity to achieve similar performance results to plastic building products in this study, according to the NAHB Research Center.

About the Author

Craig Drumheller is a senior engineer with the National Association of Home Builders (NAHB) Research Center.