BUILDING AMERICA TOP INNOVATIONS HALL OF FAME PROFILE

INNOVATIONS CATEGORY:

1. Advanced Technologies and Practices
1.1 Building Science Solutions: Thermal Enclosure

High-R Walls

Building America research partner Steven Winter Associates worked with Rural Development Incorporated to design affordable duplexes in western Massachusetts that used double 2x4 walls spaced 5 inches apart to hold 12 inches of blown cellulose for R-43.

Research on common high-R wall assemblies has shown that the measured R-value is almost always lower than the rated whole-wall R-value and that the potential for condensation occurs 15% – 95% of the time with several common high-R wall types. Thus, Building America research is proving critical to achieving high efficiency and durability goals.

BUILDING AMERICA TOP INNOVATIONS

Recognizing Top Innovations in Building Science – The U.S. Department of Energy's Building America program was started in 1995 to provide research and development to the residential new construction and remodeling industry. As a national center for world-class research, Building America funds integrated research in market-ready technology solutions through collaborative partnerships between building and remodeling industry leaders, nationally recognized building scientists, and the national laboratories. Building America Top Innovation Awards recognize those projects that have had a profound or transforming impact on the new and retrofit housing industries on the road to high-performance homes.

High-performance homes require walls that cost-effectively control both thermal and moisture flow. Building America research results have provided proven high-R wall options for builders across the country.

Building America's research teams have conducted modeling analysis as well as field studies of several different wall assemblies to identify effective "whole-wall" R-values that take into account thermal bridging of framing members. Researchers have also investigated critical moisture potential and durability issues since high-R walls have much less drying potential.

Between 2008 and 2012, CARB conducted several evaluations of wall types (see for example Aldrich et al. 2010). In one study, CARB performed THERM and WUFI analysis on three typical cold climate wall assemblies modeled at ASHRAE 160 interior conditions (SWA 2012). The three wall types were 1) a code-minimum wood-sided house with OSB, closed-cell spray foam, and fiberglass batt; 2) a brick wall with XPS rigid foam, OSB, and fiberglass batt; and 3) a high-R wall with OSB and R-40 to R-60 blown cellulose. The study found that drying to the interior is severely limited in high R-value walls constructed with the OSB on the exterior of all the insulation and recommended that these walls employ a vented cladding to increase the wall's capacity to dry to the exterior, thus reducing the risk for moisture-related damage.

High R-value walls constructed with the OSB sandwiched between a permeable insulation on the interior and an impermeable insulation on the exterior should maximize the ratio of impermeable to permeable insulation to keep the OSB as warm as possible, reducing the potential for condensation and promoting drying to the interior. A minimum of 50% of the total cavity wall R-value should be provided by the impermeable insulation in Climate Zones 4 through 6, and 60% is recommended in Climate Zone 7 (SWA 2012). Nearly every wall in this study failed the ASHRAE 160 30-day criteria, with interior relative humidity levels reaching 90% in all cases despite air conditioning. Based on these findings, the researchers recommended that the ASHRAE 160 criteria for interior conditions in moist climates be further studied.

Building Science Corporation evaluated 12 high-R-value wall cases with variations for a total of 20 wall assemblies (Straube and Smegal 2009). Results are summarized in the table. According to their analysis, many of the wall assemblies perform significantly below their rated R values. The researchers identified seven wall assemblies that actually performed at whole-wall R values of 30 or higher (see table).

Measured Whole Wall R-Value for Tested Wall Assemblies *(Straube & Smegal 2009)*

Wall Assembly	Rated R	Measured R-Value	Hrs of Potential Condensation
Less than R-20 Walls			
2x4, 16" oc, R-13 fiberglass batt, OSB	13	10.0	--
2x4 adv frame, 24" oc, R-13 fiberglass batt, OSB	13	11.1	4,503
2x6 16" oc, R-19 fiberglass batt, OSB	19	13.7	--
SIP 3.5" EPS	13	14.1	--
2x6 adv frame, 24" oc, R-19 fiberglass batt, OSB	19	15.2	4,379
ICF 8" ICF, 4" EPS	14.8	16.4	--
2x6 adv frame, 24" oc, 5.5" R-21, 0.5 spray foam, OSB	24	16.5	0
ICF 14" cement w/ rockwool	17.4	17.4	--
2x6 adv frame, 24" oc, 2" spray foam, 3.5" cellulose	23	17.5	934
R-20 Walls			
2x6 adv frame, 24" oc, 5" R-29 spray foam, OSB	29	19.1	0
2x6 adv frame, 24" oc, R-19 fiberglass batt, 1" R-5 XPS rigid	24	20.2	3,813
ICF 15", 5" EPS	20.6	20.6	--
2x6 adv frame, 24" oc, 2x3 R-19 +R-8 fiberglass batt	27	21.5	4,594
Greater than R-30			
Double-stud walls with 9.5" R-34 cellulose	34	30.1	4,576
2x6 24" oc adv frame, EIFS w/ 4" EPS rigid foam	31.4	30.1	1,532
Double-stud 2" spray foam, 7.5" cellulose	36.2	32.4	2,284
2x6 24" oc adv frame, R-19 fiberglass batt, 4" R-20 XPS	39	34.5	1,189
SIPS with 11.25" EPS	36	36.2	--
Truss wall 12" R-43 cellulose	43	36.5	4,622
Offset frame walls with exterior spray foam	40.6	37.1	0
-- = unkown			

Key Lessons Learned

These results indicate that assemblies constructed with OSB on the exterior should employ a vented cladding to assist in drying of that layer regardless of the type of insulation in the cavity.

Building Science Corporation concluded that whole-wall R value was always less than the rated R value. At the time of the study, assemblies with high-density spray foam (on its own or in combination with other insulation types) performed the best in terms of condensation potential and other issues (Straube and Smegal 2009).

REFERENCES

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