Foard PANEL

Technical Bulletin

SIPs and the IECC-'09

INTRODUCTION

The 2009 IECC requires higher levels of insulation than previous energy codes. As with most ICC residential model codes, there are 2 main paths to compliance, 1) prescriptive and 2) performance. Most conventional (stick-frame-and-infill) homes use the prescriptive method. Because SIPs are not conventional in many respects, the performance method is more technically accurate. A method to ensure compliance with the IECC-'09 for SIP buildings via the performance path follows.

DETERMINE THE REQUIRED PRESCRIPTIVE R-VALUE

Using Table 402.1.1 of IECC-'09, select the required infill insulation R-value for the building component in question for the correct climate zone. SIPs are most commonly used as roofs, walls, and floor. The "Ceiling R-Value", "Wood Frame R-Value", and "Floor R-Value" are the columns that usually apply.

ACTUAL SIP PERFORMANCE, SUPPORTING DOCUMENTATION

The listed R-value for the prescriptive method is a "center-of-cavity number". It's named this way because that is what it is. Conventional construction assumes that there will be studs, rafters, jacks, headers, etc penetrating all the way through the cavity insulation. A batt of insulation labeled R-19 is just that, the batt itself is R-19. The 2x6 next to it is closer to R-6. Clearly, the performance of the whole wall somewhat less than the cavity alone. According to research done by the DOE at Oak Ridge National Labs, the "whole wall" R-value of this prescriptive "R-19" wall was actually measured to be R-14[1].

SIPs have very few wood elements penetrating all the way through the insulation. In the same DOE research program, using the same test, a nominal R-23 SIP returned results of R-22[2] and an R-15 SIP was measured to be R-14[3]. This is the fundamental reason that SIPs with R-values below IECC table requirements are still compliant.

There is another effect at work that isn't accounted for in IECC-'09, air infiltration. Another DOE test program that built several houses of the same design and location but built with different building systems illustrates this point well[4]. The SIP house had about 1/4 of the air leakage of a conventional house of the same design. Air leakage is widely accepted as a major contributor to energy loss. An argument can be made that, because of SIPs documented air infiltration resistance, the required R-value for a conventional-equivalent SIP should be lower still. We'll leave that discussion for another bulletin.

---

1 http://www.ornl.gov/sci/roofs+walls/AWT/HotboxTest/WoodFrame/2x6R_19/results.htm
2 http://www.ornl.gov/sci/roofs+walls/AWT/HotboxTest/SIPs/SIPA/test3.htm
3 http://www.ornl.gov/sci/roofs+walls/AWT/HotboxTest/SIPs/SIPA/test2.htm
4 https://sustainability-ornl.org/Documents/Best%20Practices%20Guide.pdf

DETERMINE REQUIRED SIP R-VALUE

Section 405 of IECC-'09 outlines the documentation when using the performance method. While a sub-section describes the requirements of any software used for energy modeling, it is assumed that sound mechanical engineering calculations that meet the same requirements are also acceptable.

The following assumptions are made in this engineering proof:

- The proposed (SIP) design is of a house with the same design, surface area, orientation, and construction methods & materials as the standard reference (conventional) design.
- The climate, location, shading, & other outdoor features of the SIP design and conventional design are identical.
- Interpolation and minor extrapolation of the DOE/ORNL Hot Box Surface-To-Surface R-value data is accurate within 2 digits of precision.
- The following is the base principal conductive heat transfer (gain/loss) equation:

$$q = \frac{k \cdot A \cdot \Delta T}{s}$$

Equation 1[5]

Where:
q = specific heat transfer (loss) rate in BTU/hr
k = coefficient of thermal conductivity in Btu/(hour deg F ft)
A = surface area in sq-ft
T = temperature difference between inside & outside in deg F
s = material thickness in ft.

For simplicity, this bulletin will use a more convenient form of Eq. 1 with units common in the HVAC industry.

$$Q_{ws} = \frac{A \cdot \Delta T}{R_{ws}}$$

Equation 2[6]

Where:
Q_{ws} = whole surface (ws) heat transfer rate in BTU/hr
R_{ws} = whole surface R-value, 1 R-value = 1 (hr sq-ft deg F)/BTU

Setting the heat loss of the proposed (SIP) design and the standard reference (Conv.) design equal to find the SIP requirement and simplifying results:

$$Q_{ws.Conv} = \frac{A \cdot \Delta T}{R_{ws.Conv}} = Q_{ws.SIP} = \frac{A \cdot \Delta T}{R_{ws.SIP}} \rightarrow R_{ws.Conv} = R_{ws.SIP}$$

Equation 3

Where:
$X_{ws.Conv}$ refers to the whole surface value of conventional construction
$X_{ws.SIP}$ refers to the whole surface value of SIP construction

5 QED, basic mechanical engineering, available in any heat transfer fundamentals text
6 QED, basic mechanical engineering, available in any building energy text

Using the DOE/ORNL Hot Box data we can establish the relative reduction in performance over a whole surface.

$$\frac{R_{ws.Conv}}{R_{nom.Conv}} = \frac{14}{19} = 0.73 \quad \text{and} \quad \frac{R_{ws.SIP}}{R_{nom.SIP}} = \frac{22}{23} = 0.96$$

Equations 4 & 5

Therefore, for a SIP wall, roof, or floor surface to equal it's conventional equivalent this relationship must be held:

$$R_{nom.Conv} \cdot \left(\frac{0.73}{0.96}\right) = R_{nom.SIP}$$

Equation 6

EXAMPLE

If a roof requires R-30 conventional insulation, the required nominal SIP R-value would be:

$$R_{nom.Conv} \cdot \left(\frac{0.73}{0.96}\right) = R_{nom.SIP} \rightarrow R30 \cdot \left(\frac{0.73}{0.96}\right) = R24$$

Equation 7

Using reasonable significant digit precision through the calculations, the following range of Foard Panel over all thicknesses meet or surpass the IECC-'09 for an R-30 roof:

- Polyiso SIPs: 4.50” or greater
- XPS SIP: 5.38” or greater
- EPS SIP: 6.50” or greater

CONTACT AND TECHNICAL SUPPORT

For any questions or consultations on particular applications, feel free to contact myself or any other project manager at Foard Panel. We'll be happy to help.

Paul Malko
O: 603-256-8800
F: 603-256-6902
E: paul@foardpanel.com