Energy Conservation & Building Envelope

Objectives

• Determine the Building Envelope of a House
• Calculate Heat Loss of a Building

Introduction

• "Let me first define what green should be focused on if I was in charge: 80% energy, 20% everything else, such as water and materials."

Why is the building envelope so important?

- Homes consume 21% of total US energy production.
- All buildings in the US consume 40% of the total US energy.

Energy Information Administration / Annual Energy Review 2007

Why is the building envelope so important?

- The more insulation and tighter a building envelope, the less energy needed for a building
- "Build Tight then Ventilate Right"
- Controls
  - Heat Transfer
  - Moisture movement
  - Airflow & pressure

What is the building envelope?

- the separation between the interior and the exterior environments of a building.
What is the building envelope?

Types of Energy Efficient Homes

• 1976 - Lo-Cal House – Wayne Schick at University of Illinois @ Urbana-Champaign

Types of Energy Efficient Homes

• 1977 – Saskatchewan Conservation House - Eyre, Besant, Dumont & Orr from Saskatchewan, Canada
Types of Energy Efficient Homes

• 1979 – Leger House – Gene Leger from Pepperell, MA.

• 2006 – Westford House – Betsy Pettit, couple miles from the Leger House

Heat & Moisture Sinks
Heat & Moisture Sinks

- Ventilated areas

- Holes in walls

- Doors & windows
Correcting Sinks

- Design for ventilation
- Insulate & Caulk!

Heat Transfer

- Conduction
- Convection
- Radiation

Heat Transfer Conduction

- Heat & Moisture move thru the walls & windows from the outside to the inside of the house
- More insulation + tighter seal = better heat & moisture control in the house
R Values

<table>
<thead>
<tr>
<th>Climate zone</th>
<th>Ceiling R-Value</th>
<th>Wood Frame Wall R-Value</th>
<th>Floor R-Value</th>
<th>Basement Wall R-Value</th>
<th>Slab R-Value &amp; Depth</th>
<th>Crawl Space R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>13</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>13</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>13</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td>5/13</td>
</tr>
<tr>
<td>4 except Marine</td>
<td>38</td>
<td>13</td>
<td>19</td>
<td>10/13</td>
<td>10, 2ft</td>
<td>10/13</td>
</tr>
<tr>
<td>5 &amp; Marine 4</td>
<td>38</td>
<td>19 or 13+5</td>
<td>30</td>
<td>10/13</td>
<td>10, 2ft</td>
<td>10/13</td>
</tr>
<tr>
<td>6</td>
<td>49</td>
<td>19 or 13+5</td>
<td>30</td>
<td>10/13</td>
<td>10, 4ft</td>
<td>10/13</td>
</tr>
<tr>
<td>7 &amp; 8</td>
<td>49</td>
<td>21</td>
<td>30</td>
<td>10/13</td>
<td>10, 4ft</td>
<td>10/13</td>
</tr>
</tbody>
</table>

Table from Energy Star Qualified Homes Codes & Standards

How to Calculate Heat Loss

- \[ Q = \frac{A \cdot \Delta T}{R} \]
- \( Q \) = Heat Loss, BTU/hr
- \( A \) = Area, \( ft^2 \)
- \( \Delta T \) = Temperature difference, \( ^\circ F \)
- \( R \) = R value, hr*ft\(^2\)*F/BTU

How to Calculate Heat Loss

- Calculate the heat loss thru a 4' by 8' Structurally Insulated Panel that is 4.5" thick and made out of expanded polystyrene. The indoor temperature is 73\(^\circ\) F and the outdoor temperature is 5\(^\circ\) F.

SIP R-Values (Calculated R-Values)

<table>
<thead>
<tr>
<th>SIP Panel Thickness</th>
<th>4 1/2&quot;</th>
<th>5 1/2&quot;</th>
<th>6 1/2&quot;</th>
<th>8 1/2&quot;</th>
<th>10 1/2&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyurethane SIP</td>
<td>31.4</td>
<td>28.0</td>
<td>25.6</td>
<td>19.9</td>
<td>13.2</td>
</tr>
<tr>
<td>Polyurethane SIP</td>
<td>38.0</td>
<td>35.4</td>
<td>32.9</td>
<td>27.5</td>
<td>21.2</td>
</tr>
<tr>
<td>Polyurethane SIP</td>
<td>45.9</td>
<td>43.2</td>
<td>40.8</td>
<td>36.4</td>
<td>30.1</td>
</tr>
</tbody>
</table>

Consult the panel manufacturer for exact R values. R values can vary between SIP manufacturers.
• Panelized Building System:
  - Insulating foam core
  - Structural skin
  - Structural Adhesive

Insulation Types

<table>
<thead>
<tr>
<th>Insulation Type</th>
<th>R Value (per inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiberglass, mineral wool – batt or blanket</td>
<td>3-4</td>
</tr>
<tr>
<td>Cellulose, wool – fill in type</td>
<td>2-4</td>
</tr>
<tr>
<td>Expanded polystyrene (EPS)</td>
<td>4</td>
</tr>
<tr>
<td>Extruded polystyrene (XPS)</td>
<td>5</td>
</tr>
<tr>
<td>Polysiocyanurate &amp; Polyurethane</td>
<td>6-7</td>
</tr>
</tbody>
</table>

Calculating R values in Walls

• 3 methods used to measure the R value for your home.
  1. Clear Wall R Values: the R values of a wall with just the studs. This doesn't include framing, windows, doors and exterior corners.
  2. Center of Cavity R values: the estimate of cavity space area between the studs.
  3. Whole Wall R Values: the estimation of R values for both the clear wall system and the center of cavity system. It takes into account additional materials such as windows, door and exterior corners. Whole wall systems are generally the most reliable method for determining R values for insulation of walls.
R Value of framing members

• The R-Value of wood is specified as 1.25/in
• A 2X6 wall studs R-Value is measured as, 5.5" X 1.25. The R-Value = 6.875
• A 2X4 wall studs R-Value is measured as, 3.5" X 1.25. The R-Value = 4.375

Example 2

• Compare the heat loss between a 16" o.c. framed wall and a 24" o.c. framed wall with the same profile. The wall is 40 ft long and 10 ft in height. The change in temperature is 65°F.

Example 3

• Calculate the heat loss thru the same wall w/ 24" oc studs. The outdoor temperature is 72°F and the indoor temperature is 72°F. The wall has the following:
  – 4 double pane windows (2' by 4')
  – 5 outlets that is 2' by 4' that has no insulation around it. The R value of the outlet is 0.5 hr*ft²*oF/BTU
  – 1 metal polystyrene door that is 3' by 7'
• What would the size of the furnace need to be if the furnace had an AFUE of 85%?
Retrofitting

- Most popular home improvement
- Best buyback
- Improve resale value

Retrofitting


<table>
<thead>
<tr>
<th>Item</th>
<th>Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windows or storm windows</td>
<td>$1500</td>
</tr>
<tr>
<td>Doors or storm doors</td>
<td>$1500</td>
</tr>
<tr>
<td>Roof</td>
<td>$1500</td>
</tr>
<tr>
<td>Insulation</td>
<td>$1500</td>
</tr>
</tbody>
</table>

For More Information

- [http://www.buildingscienceconsulting.com/resources/homeowner.htm](http://www.buildingscienceconsulting.com/resources/homeowner.htm)