Selection of Glass and its effect on Heat Load Estimation

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By
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In Association with

SNC

ASHRAE India Chapter
About Presenter

- Samdarsh Nayyar is the founder of Green Horizon Consulting, LLP. He is also one of the Directors in Sunil Nayyar Consultants Pvt. Ltd. A very strong background of Building Engineering Systems and Systems efficiency, he has been involved in MEP designing of a number of projects for DLF, Commonwealth Games Delhi 2010, Lemon Tree Hotels to name a few.

- **Qualifications:**
  - B Eng (Mechanical)
  - US Green Building Council - certified LEED Accredited Professional (AP) BD+C
  - GRIHA Trainer & Evaluator (India’ National Green Building Rating System under the Ministry of New and Renewable Energy, Govt. of India)
  - MNRE BEE-certified Energy Auditor and Energy Manager
  - MBA (Strategic Management) from Management Development Institute (MDI), Gurgaon

- **Key Industry Positions:**
  - ASHRAE India Young Engineers Chapter Chair 2013-24
  - ISHRAE Delhi Programs Chapter Chair 2013-14

- **Memberships:**
  - Member of American Society of Refrigeration and Air-conditioning Engineers (ASHRAE)
  - Member of Indian Society of Refrigeration and Air-conditioning Engineers (ISHRAE)
  - Member of FSAI (Fire and Security Association of India)
  - Member of ISLE (Indian Society of Lighting Engineers)
Why do we use glazing in buildings?

• Aesthetics
• Daylight
• Views
• Heating/Cooling the building

Disadvantages:
• Increase in building heating or cooling loads
Modes of Heat Transfer

- **Conduction** - The transfer of energy between objects that are in physical contact.
- **Convection** - The transfer of energy between an object and its environment, due to fluid motion.
- **Radiation** - The transfer of energy to or from a body by means of the emission or absorption of electromagnetic radiation.

**Questions:**
- What is the formula of conduction heat transfer?
- Which Radiation??
- Does radiation require a medium?
Sources of Heat Gain

**Internal Heat Gains (IHG)**

- PEOPLE (sensible and latent heat gain)
- LIGHTS (sensible heat gain only)
- EQUIPMENT
  - Receptacles or electrical plug loads (sensible heat gain only)
  - Processes such as cooking (sensible and latent heat gain)
- Duct Loss

**External Heat Gains (EHG)**

- Walls
- Roofs
- **Windows**
- Exposed Floors
- Basement Walls
- Basement Floors
- Infiltration
- Ventilation – Fresh Air
Heat Transfer Through Windows

1. **Conduction** is the direct transfer of heat through the window to the outdoors.

2. **Radiation** is the movement of heat as infrared energy throughout the glass.

3. **Air Leakage** is the passage of heated air through cracks and around weather stripping.

4. **Convection** occurs when air gives up its heat to the cooler glass and sinks toward the floor. This movement sucks new, warmer air through the glass that is in turn cooled, creating a draft.

Heat Transfer through Glass is through Conduction and Radiation.
# Definitions of Various Glass Factors

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Factor</th>
<th>Definition</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Visible Transmittance</td>
<td>percentage of visible light striking the glazing that will pass through.</td>
<td>Green Building Consultant</td>
</tr>
<tr>
<td>2</td>
<td>Visible Reflectance</td>
<td>to what degree the glazing appears like a mirror, from both inside and out. percentage of light striking the glazing that is reflected back</td>
<td>Architect</td>
</tr>
<tr>
<td>3</td>
<td>Solar Heat Gain Coefficient (SHGC) or Shading Coefficient (SC)</td>
<td>ratio of total transmitted solar heat to incident solar energy, typically ranging from 0.9 to 0.1, where lower values indicate lower solar gain. SC= 1.15 x SHGC. <strong>SOLAR RADIATION GAIN</strong></td>
<td>HVAC Consultant. Green Building Consultant</td>
</tr>
<tr>
<td>4</td>
<td>U-Value</td>
<td>measure of heat transfer through the glazing due to a temperature difference between the indoors and outdoors. <strong>CONDUCTION GAIN</strong></td>
<td>HVAC Consultant. Green Building Consultant</td>
</tr>
<tr>
<td>5</td>
<td>Ultraviolet Transmittance</td>
<td>percentage of ultraviolet radiation (a small portion of the sun’s energy) striking the glazing that passes through</td>
<td>Client, Architect</td>
</tr>
<tr>
<td>6</td>
<td>Spectral Selectivity</td>
<td>ability of a glazing material to respond differently to different wavelengths of solar energy – in other words, to admit visible light while rejecting unwanted invisible infrared heat.</td>
<td>HVAC Consultant. Green Building Consultant</td>
</tr>
<tr>
<td>7</td>
<td>Glazing Color</td>
<td>affects the appearance of view</td>
<td>Architect, Client</td>
</tr>
<tr>
<td>8</td>
<td>Sound Transmission</td>
<td>Outdoor-to-indoor transmission class (OITC) is the property used to express sound attenuation characteristics</td>
<td>Client</td>
</tr>
</tbody>
</table>
An ideal spectrally selective glazing admits only the part of the sun’s energy that is useful for daylighting.
1. What should be the ideal Building orientation in India?
2. Which building orientation should have more glazing and which should have lesser glazing?
3. What type of glazing to be expected at different façade orientation – daylighting, reduce heat ingress etc.
### Solar Heat Gain in Btu/hr

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Solar Heat Gain in Btu/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>14</td>
</tr>
<tr>
<td>S</td>
<td>12</td>
</tr>
<tr>
<td>W</td>
<td>164</td>
</tr>
<tr>
<td>E</td>
<td>12</td>
</tr>
<tr>
<td>NE</td>
<td>12</td>
</tr>
<tr>
<td>NW</td>
<td>123</td>
</tr>
<tr>
<td>SE</td>
<td>12</td>
</tr>
<tr>
<td>SW</td>
<td>100</td>
</tr>
</tbody>
</table>
Climatic Zones

- Delhi- Composite
- Mumbai- Warm & Humid
BENCHMARK - As per ECBC 2007

### Table 4.3.3-1 Vertical Fenestration U-factor and SHGC Requirements (U-factor in W/m²·°C)

<table>
<thead>
<tr>
<th>Climate</th>
<th>Maximum U-factor</th>
<th>Maximum SHGC</th>
<th>Maximum SHGC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite</td>
<td>3.30</td>
<td>0.25</td>
<td>0.20</td>
</tr>
<tr>
<td>Hot and Dry</td>
<td>3.30</td>
<td>0.25</td>
<td>0.20</td>
</tr>
<tr>
<td>Warm and Humid</td>
<td>3.30</td>
<td>0.25</td>
<td>0.20</td>
</tr>
<tr>
<td>Moderate</td>
<td>6.00</td>
<td>0.40</td>
<td>0.30</td>
</tr>
<tr>
<td>Cold</td>
<td>3.30</td>
<td>0.51</td>
<td>0.51</td>
</tr>
</tbody>
</table>

See Appendix 11.2.1 for typical complying vertical fenestration constructions.

### Table 4.3.3.1 Minimum VLT Requirements

<table>
<thead>
<tr>
<th>Window Wall Ratio</th>
<th>Minimum VLT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 0.3</td>
<td>0.27</td>
</tr>
<tr>
<td>0.31-0.4</td>
<td>0.20</td>
</tr>
<tr>
<td>0.41-0.5</td>
<td>0.16</td>
</tr>
<tr>
<td>0.51-0.6</td>
<td>0.13</td>
</tr>
<tr>
<td>0.61-0.7</td>
<td>0.11</td>
</tr>
</tbody>
</table>
As per IGBC Green Homes - Baseline Values

**Baseline Criteria for Energy Performance of the Building**

### A. Envelope Measures:

(* For Climatic Zones of India, please refer Exhibit – C)

#### Fenestration - SHGC value

<table>
<thead>
<tr>
<th>Climate Zone *</th>
<th>Maximum SHGC Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WWR &lt; 20%</td>
</tr>
<tr>
<td>Composite</td>
<td>0.5</td>
</tr>
<tr>
<td>Hot and Dry</td>
<td>0.5</td>
</tr>
<tr>
<td>Warm and Humid</td>
<td>0.5</td>
</tr>
<tr>
<td>Moderate</td>
<td>0.6</td>
</tr>
<tr>
<td>Cold</td>
<td>0.8</td>
</tr>
</tbody>
</table>

**Glazing U-value**

(Applicable only if Window to Wall Ratio (WWR) > 30%)

<table>
<thead>
<tr>
<th>Climate Zone *</th>
<th>Maximum U-Value (W/m²K) (WWR &gt; 30%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite</td>
<td>5.7</td>
</tr>
<tr>
<td>Hot and Dry</td>
<td>5.7</td>
</tr>
<tr>
<td>Warm and Humid</td>
<td>5.7</td>
</tr>
<tr>
<td>Moderate</td>
<td>5.7</td>
</tr>
<tr>
<td>Cold</td>
<td>5.7</td>
</tr>
</tbody>
</table>

### Wall Assembly - U Value

<table>
<thead>
<tr>
<th>Climate Zone *</th>
<th>Maximum ‘U’-Value of the Overall Wall Assembly (W/m²K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite</td>
<td>2.5</td>
</tr>
<tr>
<td>Hot and Dry</td>
<td>2.5</td>
</tr>
<tr>
<td>Warm and Humid</td>
<td>2.5</td>
</tr>
<tr>
<td>Moderate</td>
<td>2.5</td>
</tr>
<tr>
<td>Cold</td>
<td>1.1</td>
</tr>
</tbody>
</table>

### Roof Assembly - U Value

<table>
<thead>
<tr>
<th>Climate Zone *</th>
<th>Maximum ‘U’-Value of the Overall Roof Assembly (W/m²K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite</td>
<td>1.2</td>
</tr>
<tr>
<td>Hot and Dry</td>
<td>1.2</td>
</tr>
<tr>
<td>Warm and Humid</td>
<td>1.2</td>
</tr>
<tr>
<td>Moderate</td>
<td>1.8</td>
</tr>
<tr>
<td>Cold</td>
<td>1.2</td>
</tr>
</tbody>
</table>
### As per IGBC Green Homes - Prescriptive Values

#### Annexure - II

**Prescriptive Criteria for Building Envelope Measures**
(EE Credit 1 - Enhanced Energy Performance)

**A. Envelope Measures:**

(*For Climatic Zones of India, please refer Exhibit – C*)

**Fenestration - SHGC value**

<table>
<thead>
<tr>
<th>Climate Zone*</th>
<th>Maximum SHGC Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WWR &lt; 40%</td>
</tr>
<tr>
<td>Composite</td>
<td>0.38</td>
</tr>
<tr>
<td>Hot and Dry</td>
<td>0.38</td>
</tr>
<tr>
<td>Warm and Humid</td>
<td>0.38</td>
</tr>
<tr>
<td>Moderate</td>
<td>0.50</td>
</tr>
<tr>
<td>Cold</td>
<td>0.8</td>
</tr>
</tbody>
</table>

**Wall Assembly - U Value**

<table>
<thead>
<tr>
<th>Climate Zone*</th>
<th>Maximum ‘U’-Value of the Overall Wall Assembly (W/m²K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite</td>
<td>1.8</td>
</tr>
<tr>
<td>Hot and Dry</td>
<td>1.8</td>
</tr>
<tr>
<td>Warm and Humid</td>
<td>1.8</td>
</tr>
<tr>
<td>Moderate</td>
<td>1.8</td>
</tr>
<tr>
<td>Cold</td>
<td>0.8</td>
</tr>
</tbody>
</table>

**Roof Assembly - U Value**

<table>
<thead>
<tr>
<th>Climate Zone*</th>
<th>Maximum ‘U’-Value of the Overall Roof Assembly (W/m²K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite</td>
<td>0.5</td>
</tr>
<tr>
<td>Hot and Dry</td>
<td>0.5</td>
</tr>
<tr>
<td>Warm and Humid</td>
<td>0.5</td>
</tr>
<tr>
<td>Moderate</td>
<td>0.75</td>
</tr>
<tr>
<td>Cold</td>
<td>0.5</td>
</tr>
</tbody>
</table>
Glass Catalogue

### Monolithic Glass Performance Data

<table>
<thead>
<tr>
<th>Glass Type</th>
<th>Nominal Thickness</th>
<th>Visible Light</th>
<th>Solar Energy</th>
<th>U-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in.</td>
<td>mm.</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Pilkington Solar-E™ Clear</td>
<td>1/4</td>
<td>6</td>
<td>60</td>
<td>8</td>
</tr>
<tr>
<td>Pilkington Solar-E™ Grey</td>
<td>1/4</td>
<td>6</td>
<td>30</td>
<td>8</td>
</tr>
<tr>
<td>Pilkington Solar-E™ Blue-Green</td>
<td>1/4</td>
<td>6</td>
<td>51</td>
<td>7</td>
</tr>
<tr>
<td><strong>Pilkington Solar-E™ EverGreen</strong></td>
<td>1/4</td>
<td>6</td>
<td>45</td>
<td>6</td>
</tr>
<tr>
<td>Pilkington Solar-E™ Arctic Blue</td>
<td>1/4</td>
<td>6</td>
<td>36</td>
<td>6</td>
</tr>
</tbody>
</table>

### Insulating Glass Performance Data

An insulating unit consists of two layers of equal glass thickness. A unit containing a 1/4 in. lite 1/2 in. airspace and 1 in. overall thickness.

<table>
<thead>
<tr>
<th>Glass Type</th>
<th>Nominal Thickness</th>
<th>Visible Light</th>
<th>Solar Energy</th>
<th>U-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in.</td>
<td>mm.</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Pilkington Solar-E™ Outer Lite (2 lite Surface) and Pilkington Optiflot™ Clear Inner Lite</td>
<td>1/4</td>
<td>6</td>
<td>53</td>
<td>11</td>
</tr>
<tr>
<td>Pilkington Solar-E™ Grey</td>
<td>1/4</td>
<td>6</td>
<td>27</td>
<td>11</td>
</tr>
<tr>
<td>Pilkington Solar-E™ Blue-Green</td>
<td>1/4</td>
<td>6</td>
<td>46</td>
<td>8</td>
</tr>
<tr>
<td>Pilkington Solar-E™ EverGreen</td>
<td>1/4</td>
<td>6</td>
<td>40</td>
<td>8</td>
</tr>
<tr>
<td>Pilkington Solar-E™ Arctic Blue</td>
<td>1/4</td>
<td>6</td>
<td>32</td>
<td>7</td>
</tr>
</tbody>
</table>

*U.S. U-Factor (Btu/h·ft²·F) is based on NFRC/ASTM standards.
**European U-Factor (W/m²·K) is based on EN 410/973 (CEN) standard.

All performance values are center-of-glass values calculated by the LBNL Window 5.2 program. See Pilkington Architectural Product Guide for explanation of references 1-10.
## Glazing Configurations

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Glazing Type</th>
<th>Configuration</th>
<th>U-Value (Btu/hr/s.ft-F)</th>
<th>SHGC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SGU</td>
<td>6mm clear/tinted glass</td>
<td>1</td>
<td>0.56</td>
</tr>
<tr>
<td>2</td>
<td>SGU (High performance)</td>
<td>6mm clear/tinted high performance /low-E /Solar reflective</td>
<td>0.58</td>
<td>0.34</td>
</tr>
<tr>
<td>3</td>
<td>DGU</td>
<td>6mm clear/tinted glass + 12mm air gap + 6mm clear/tinted glass</td>
<td>0.9</td>
<td>0.56</td>
</tr>
<tr>
<td>4</td>
<td>Insulated DGU (High Performance)</td>
<td>6mm clear/tinted high performance /low-E /Solar reflective glass (external) + 12mm air gap + 6mm clear/tinted glass (internal)</td>
<td>0.264-0.31</td>
<td>0.19-0.25</td>
</tr>
</tbody>
</table>
Exercises - Heat Load Calculation

Type of Building: Office
Location: Gurgaon
Climate: Composite
Area=81,872 sq.ft.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Type of Glazing</th>
<th>Summer TR</th>
<th>% Savings (against Base Case of SGU)</th>
<th>Sq.ft/TR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SGU</td>
<td>312</td>
<td>--</td>
<td>262</td>
</tr>
<tr>
<td>2</td>
<td>SGU (High performance)</td>
<td>285</td>
<td>8.65%</td>
<td>287.27</td>
</tr>
<tr>
<td>3</td>
<td>DGU</td>
<td>308</td>
<td>1.28%</td>
<td>265.82</td>
</tr>
<tr>
<td>4</td>
<td>Insulated DGU (High Performance)</td>
<td>271</td>
<td>13.14%</td>
<td>302.11</td>
</tr>
</tbody>
</table>
Exercises

1. Define Applications of the following. Which is ideal for Delhi climate?
   a. High SHGC, High U-value
   b. Low SHGC, Low U-value
   c. High SHGC, Low U-value
   d. Low SHGC, High U-value

2. If a client wants you to prescribe the ideal glazing and orientation for the building, what would that be? The project is in New Delhi. WWR=42%

   1. What is night purging?
THANK YOU