Green Building

Salient features of a Green Building are:

1. Site Planning - Minimal disturbance to the landscape
2. Building envelope design
3. Building system design (e.g., HVAC)
4. Integration of renewable energy sources to generate energy
5. Efficient use of water, water recycling and waste management
6. Selection of ecologically sustainable materials (with high recycled content, rapidly renewable resources with low emission potential)
7. Use of energy efficient and eco-friendly equipments
8. Indoor environmental quality (maintain indoor thermal & visual comfort and air quality)
9. Effective control and building management systems

"A green building is one which uses less water, optimizes energy efficiency, conserves natural resources, generates less waste and provides healthier spaces for occupants, as compared to a conventional building."

The Most Important Element: The Efficient Use of Energy

Buildings can incorporate many green features, but if they do not use energy efficiently, it is difficult to demonstrate that they are truly green.
Green Product

Green products are those products that are environmentally friendly and sustainable. They are made from natural or renewable materials and are produced by socially and environmentally responsible companies. They are also sustainably harvested, extracted, processed, and transported. They are produced locally, have low embodied energy, are efficient in their use of resources, non-polluting, and healthy for occupants.

Glass – A quick overview

- **Glass is an amorphous (non-crystalline) solid material**
- **The word ‘Glass’ is derived from the Latin term ‘Glesum’ which means transparent substance**
- **Glass is typically brittle and optically transparent**
- **The commonly used glass types are Flat glass and Container glass**

**Glass – Unmatched aesthetics**

- Unmatched aesthetics which allow architects and builders to explore unconventional building shapes.
- Zero-degeneration and easy maintenance which helps in maintaining a clean environment.

**Glass – No deterioration**

- No deterioration, corrosion, stains or fading throughout its lifespan.
- Can be recycled indefinitely as the structure of glass does not deteriorate through the process.

**Glass – Transparent**

- Transparent to visible light.
- A Sustainable material.

**Glass – Zero-degeneration and Easy Maintenance**

- Helps in maintaining a clean environment.

**Glass – No Deterioration**

- No deterioration, corrosion, stains or fading throughout its lifespan.
- Can be recycled indefinitely as the structure of glass does not deteriorate through the process.

**Glass – Transparent**

- Transparent to visible light.
- A Sustainable material.
Glass – A Green Building Product

How is Glass Green?

- Recyclable
- Use Renewable resources
- Locally or Regionally produced
- Energy Efficient
- Low Environmental Impact
- Durable
- Minimize Waste
- Positive Social Impact
- Affordable

There is no Black and White when it comes to Green

Glass- Industry Segments

<table>
<thead>
<tr>
<th>Flat glass</th>
<th>Container glass</th>
<th>Fibre glass</th>
</tr>
</thead>
<tbody>
<tr>
<td>is a type of glass, initially produced in plane form, commonly used for windows, glass doors, transparent walls and windshields and of two types: • Sheet Glass • Float Glass</td>
<td>is a type of glass used for the production of glass containers.</td>
<td>(glass wool) insulation for buildings, roofing and panels. Textile and plastic reinforcement fibers for composites in the construction, transportation and marine industries</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Container Glass</th>
<th>Flat Glass</th>
<th>Fiber Glass</th>
<th>Laboratory Ware</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>73</td>
<td>72</td>
<td>54</td>
<td>80</td>
</tr>
<tr>
<td>B₂O₃</td>
<td></td>
<td></td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>1.5</td>
<td>0.3</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>CaO</td>
<td>10</td>
<td>9</td>
<td>17.5</td>
<td>1</td>
</tr>
<tr>
<td>MgO</td>
<td>0.1</td>
<td>4</td>
<td>4.5</td>
<td>1</td>
</tr>
<tr>
<td>Na₂O</td>
<td>14</td>
<td>14</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>K₂O</td>
<td>0.6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Basic steps:
- raw materials selection.
- batch preparation (i.e. weighing and mixing raw materials).
- melting and refining.
- conditioning.
- forming.
- post-processing (i.e. annealing, tempering, polishing or coating).
- The technologies employed in each step depend on the glass product manufactured.

Glass Products
A single element added to glass can significantly change its properties.
• Natural gas is normally used as the fuel in glass furnaces.
• Some furnaces also use electrical boosters, usually based on molybdenum electrodes; since molten glass is an electrical conductor at high temperatures, the boosters, which supply ~ 10 – 30 % of the energy input to the furnace, help melt the glass. The melting of wool-type fiberglass is predominantly done with all electric furnaces.
• Glass melting is a large source of NOx emissions which must be reduced, while simultaneously reducing energy costs. Oxy-fuel firing (no N2 as in air-fuel mixtures) reduces the NOx emissions.

<table>
<thead>
<tr>
<th>Period</th>
<th>Tonnes Per Day</th>
<th>MJ/kg (net)</th>
<th>Campaign Length (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>270-450</td>
<td>10.5</td>
<td>5</td>
</tr>
<tr>
<td>1975</td>
<td>320-680</td>
<td>8.7</td>
<td>7</td>
</tr>
<tr>
<td>1985</td>
<td>320-820</td>
<td>7.6</td>
<td>10</td>
</tr>
<tr>
<td>1991</td>
<td>320-900</td>
<td>5.8</td>
<td>12</td>
</tr>
<tr>
<td>2013</td>
<td>upto 1000</td>
<td>5.2</td>
<td>18</td>
</tr>
</tbody>
</table>

Energy Consumption for different product Types

<table>
<thead>
<tr>
<th>Coating</th>
<th>Colour</th>
<th>VLT</th>
<th>SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non Coated</td>
<td>Clear</td>
<td>79</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>Green</td>
<td>65</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Blue</td>
<td>52</td>
<td>43</td>
</tr>
<tr>
<td>Hard Coated</td>
<td>Clear</td>
<td>58</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Green</td>
<td>47</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Blue</td>
<td>37</td>
<td>35</td>
</tr>
<tr>
<td>Soft Coated</td>
<td>Clear</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Green</td>
<td>35</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Blue</td>
<td>30</td>
<td>22</td>
</tr>
</tbody>
</table>

Energy Consumption for Various types of processing:
Tempering – 2.3 KW hr
Lamination – 19.7 KW hr
DGU – 2.5 KW hr
Glazing selection Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aesthetic</td>
<td>Enhances look of the building</td>
</tr>
<tr>
<td>Energy Efficiency</td>
<td>It is a combination of lighting &amp; cooling energy saving</td>
</tr>
<tr>
<td>Improved Day-lighting</td>
<td>Reduces artificial lighting requirement by using glazing</td>
</tr>
<tr>
<td>Glare Reduction</td>
<td>It can defeat the purpose of using glass</td>
</tr>
<tr>
<td>Acoustic</td>
<td>It can reduce sound transmission significantly</td>
</tr>
<tr>
<td>Strength</td>
<td>Gives strength that even can be used as flooring</td>
</tr>
</tbody>
</table>

Energy Efficiency

- Use high performance glass
- Use glass in appropriate orientation
- Smartly design building with shades, inclination etc. to reduce direct heat ingress
- Use IGU, if building design requires
- Use rated frames

Climate Response + Orientation & Design + Façade Design + Material used
Design factors impacting Glass Selection

**Climate Analysis:**
Climatic condition of the location is important to select type of glazing as different weather impacts differently.

**Optimum Orientation of Building:**
Before selecting any glazing material, study of building orientation is must, if rightly oriented, we may get energy efficiency without using high performance glass. (according to Indian context, South West orientation is responsible for maximum heat gain)

**Shadow Analysis:**
Shadow of the building as well as surrounding also impacts heat ingress (direct & defused), hence changes the glazing requirement.

**Daylight Analysis:**
Study of available lux level, window size and other passive design should be consider before defining the required VLT of a glass.

---

**Case Studies-Energy Impact**

<table>
<thead>
<tr>
<th>Glass</th>
<th>Energy Consumption in KWHr</th>
<th>Energy Impact</th>
<th>Initial Cost Impact</th>
<th>Payback in yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear</td>
<td>600000</td>
<td>534930</td>
<td>500160</td>
<td>0</td>
</tr>
<tr>
<td>Green</td>
<td>750000</td>
<td>520470</td>
<td>487650</td>
<td>14460</td>
</tr>
<tr>
<td>Blue</td>
<td>750000</td>
<td>520470</td>
<td>482410</td>
<td>14750</td>
</tr>
<tr>
<td>HPG</td>
<td>1050000</td>
<td>510668</td>
<td>464988</td>
<td>24262</td>
</tr>
</tbody>
</table>

Hotel in Kolkata

A star Hotel in Kolkata with the longer sides facing East—West direction and an example of linear relationship where the glass with lower SF was performing the best. However VLT did not have an impact as due to lower depths and direct light incident on the façade even a glass with 17% SF was sufficient for floor space lighting.
Case Studies – Learning center in Mumbai

Buffer on the E-W façade. Classrooms in N-S orientation, although critical, but using louvers to reduce heat gain, the best performing glass was a normal SC contrary to expectations.

Case Studies – Commercial Building in Chennai

A 5 storey office building in Chennai which was oriented properly E-W showed expected results in terms of improving performance as the SF decreased. However as the VLT increased beyond 30% there was risk of glare along the periphery. Even the higher embedded energy whilst during production was offset by better operational savings.
Case Study – Residential Building in Bangalore

<table>
<thead>
<tr>
<th>Glass</th>
<th>Cost</th>
<th>Prod &amp; Install</th>
<th>Operation</th>
<th>Total kWhr</th>
<th>Energy Impact</th>
<th>Initial Cost Impact</th>
<th>Payback in yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear</td>
<td>600000</td>
<td>34770</td>
<td>609685</td>
<td>644455</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Green</td>
<td>750000</td>
<td>32820</td>
<td>625431</td>
<td>658251</td>
<td>-13796</td>
<td>-94474</td>
<td>negative</td>
</tr>
<tr>
<td>Blue</td>
<td>750000</td>
<td>37770</td>
<td>637520</td>
<td>675290</td>
<td>-30835</td>
<td>-167008</td>
<td>negative</td>
</tr>
<tr>
<td>HPG</td>
<td>1050000</td>
<td>45680</td>
<td>604845</td>
<td>650525</td>
<td>-6070</td>
<td>29043</td>
<td>15.5</td>
</tr>
</tbody>
</table>

A favorite example of mine where the so-called high performance glasses were found to be wanting. The orientation was spot-on and the activity zones intelligently designed so as to reduce the HVAC loads. The moderate weather conditions in Bangalore only proved to be a blessing where the Clear Glass itself was sufficient in terms of meeting the functional requirements.

Do’s in Indian context

- Add overhead shading
- Add internal shading
- Have more windows on North and South facades
- Use glazing with Optimum VLT; low SHGC and U value
- Use dark tinted glass at visible height and clear at higher levels
- Use EA between 0.2 to 0.3
- Add light shelves to interiors
- Use high windows (ventilators in naturally ventilated buildings)
Don’t in Indian context

- Do not use glass with very low U value and moderate SHGC.
- Do not assume dark tinted glass brings solar control
- Do not use un-insulated frames
- Do not use Tempered glass as safety glass
- Do not use IGU as sound insulation glass

Learning

- Remember that same fenestration product behaves differently w.r.t. the specific design.
- It should not be assumed that products with Low U-value and SHGC are best and universal solution.
- Direct radiation falling on the windows should be minimized.
- For shaded windows, products with lower U values perform better.
- For un-shaded windows receiving high amount of solar radiation, products with low SHGC would perform better.
- Hence glazing should be selected after thorough considering the design.
Welcome to a world which enables you to do more

Thank you for your time