Thermally Appropriate Building Material Technologies

D E V S Kiran Kumar

The GRIHA Summit
12-13 March 2015
TERI, New Delhi

Energy Efficiency in Buildings

Conventional Building

Low Energy Building
Thermal Performance of Building Materials

- Indigenous materials
- Thermally appropriate materials

Sue Roaf et al, 2001, Ecohouse-A design guide
Thermal Performance of Building Materials

Phase Change Materials

Image Courtesy: Insulla

Randall McMullan 1983, Environmental Science in Building
Phase Change Materials

Thermal Performance of Building Materials

- Mineral Characteristics
- Heat capacity and thermal conductivity

- Density/porosity
- Thickness

- Surface texture
- Reflectivity

Thermal Performance of Building Materials

Roof Coatings - Cenospheres

Roof Coatings - Mica particles

Glazing - Nano Louvers

Bhavani Balakrishna, 2011, Ceramic Insulation Paints: The need for Insulating construction materials, Guenther Walze et al, 2005, Combination of microstructures and optically functional coatings for solar control glazing

The Issue and Solution

Major source of heat gain by the roof is absorbed solar radiation

Reflect incident solar radiation using high albedo surface

Heat gain through roof elevates ceiling surface temperature and causes radiant heat load inside the building

Store absorbed radiant heat for longer time by using heavier materials

When hot ambient air touches these surfaces, the inside air might become hotter than outside

Make indoor surface temperatures near to air temperatures, reduce heat load
Hypothesis

- Maintaining the surface temperature equal to or lower than the air temperature by reflecting back the solar radiation and further using minimal heat insulation performs better than a highly insulated surface.

- Light and highly resistive materials (low heat capacity) have a minor impact in un-conditioned buildings located in hot dry climates when surfaces are either reflective or shaded.

Experimental Setup

Roof 1_ Cement Tile
Roof 2_ XPS
Roof 3_ POP False Ceiling
Experimental Setup

Performance Indices

**Theoretical**
- U-Value
- Admittance

**Experimental**
- Time lag
- Decrement Factor

**Comfort**
- Building Index
- Discomfort Degree Hour
Air Temperature

Surface Temperature
Performance Indices

Average Heat Flux (Day & Night)

- Model 1 (Cement Tile)
- Model 2 (XPS)
- Model 3 (POP False ceiling)

Performance Indices

U-Value & Admittance

- Model 1 (Cement Tile)
- Model 2 (XPS)
- Model 3 (POP False ceiling)

Timelag & Decrement Factor

- Model 1 (Cement Tile)
- Model 2 (XPS)
- Model 3 (POP False ceiling)

Building Index & Discomfort Degree Hour

- Model 1 (Cement Tile)
- Model 2 (XPS)
- Model 3 (POP False ceiling)
Physical Structure

<table>
<thead>
<tr>
<th>Material</th>
<th>Conductivity</th>
<th>Specific heat</th>
<th>Density</th>
<th>Volumetric Heat Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cool mortar - Model 1</td>
<td>0.451</td>
<td>0.87</td>
<td>1850</td>
<td>1925</td>
</tr>
<tr>
<td>Extruded Polystyrene - Model 2</td>
<td>0.028</td>
<td>1.25</td>
<td>34</td>
<td>1290</td>
</tr>
<tr>
<td>POP false ceiling board- Model 3</td>
<td>0.499</td>
<td>0.2</td>
<td>1080</td>
<td>764</td>
</tr>
</tbody>
</table>

Conclusions

• Innovative indigenous materials like cement tile performs better in 24-hour occupied residential buildings in hot and dry climates due to its high volumetric heat capacity.

• Indicators like Discomfort Degree Hour & heat flux clearly show better thermal performance of the cement tile

• There is a need for a more specific and climate wise thermal performance indices for the codes like Energy Conservation Building Code (ECBC) of India
Thank You

d.kumar@teri.res.in