Envelope Optimization

Approach to Sustainability

NBC Chapter 11: section 8

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Team

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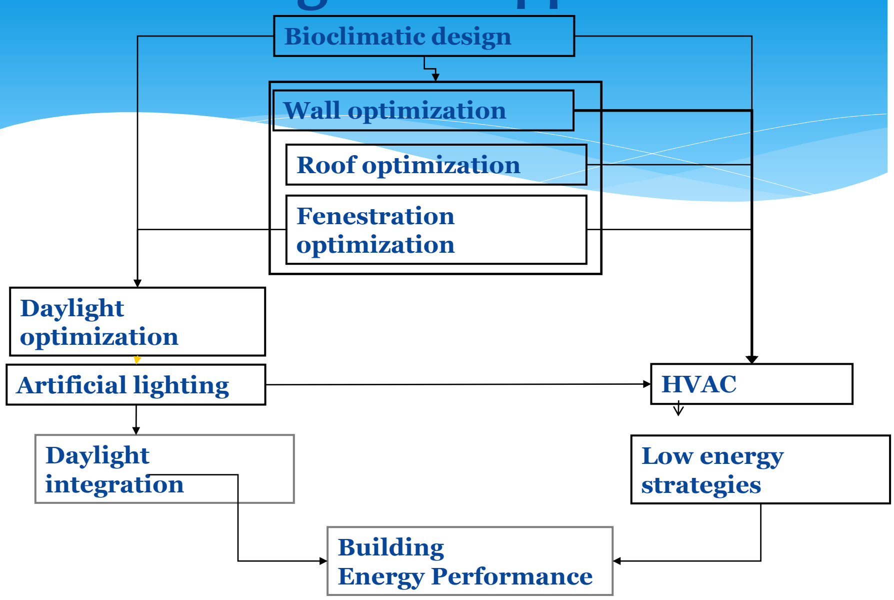
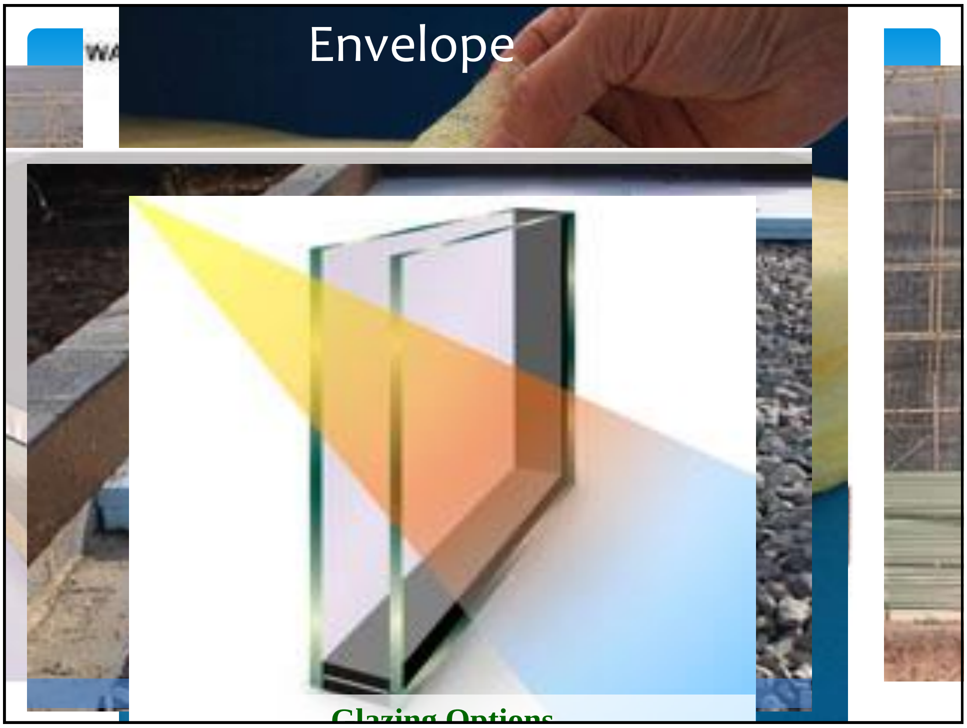
Optimize energy performance

- **Apply bio climatic architectural principles and use onsite sources and sinks**
- **Use of efficient envelope materials**
- Relax design criteria to reduce demand
- Use efficient lighting ,equipment, space conditioning, water heating systems and effective controls.
- Use renewable forms of energy to meet a part of consumption.

.....Integrated design process

Integrated Approach





Building Envelope

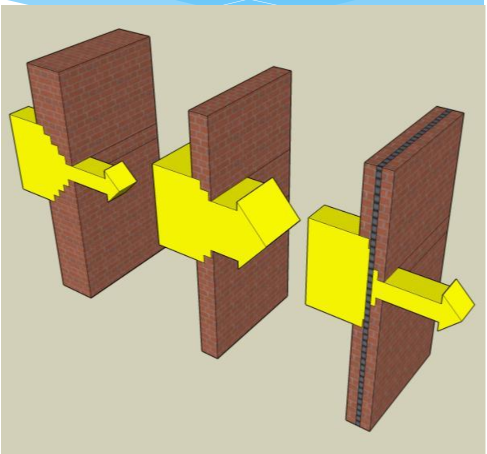
- Walls / Opaque surfaces
- Roof
- Windows / Fenestration / Aperture

Walls
Thermal performance of wall

- Insulation
- High thermal mass
- Air Cavity
- High SRI coating

Walls

- Wall with insulation
  - Rigid or semi rigid blocks and boards,
  - Boards with impact or weather resistant surfaces suitable as exterior grade material,
  - Loose fill,
  - Foam and dry spray, and
  - Blankets, felts or sheets.
- Wall with high thermal mass
- Wall with Air Cavity

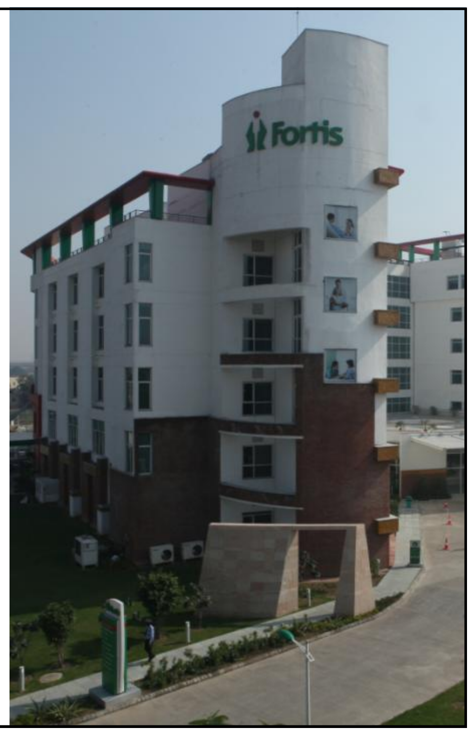


Walls

Wall with Air Cavity

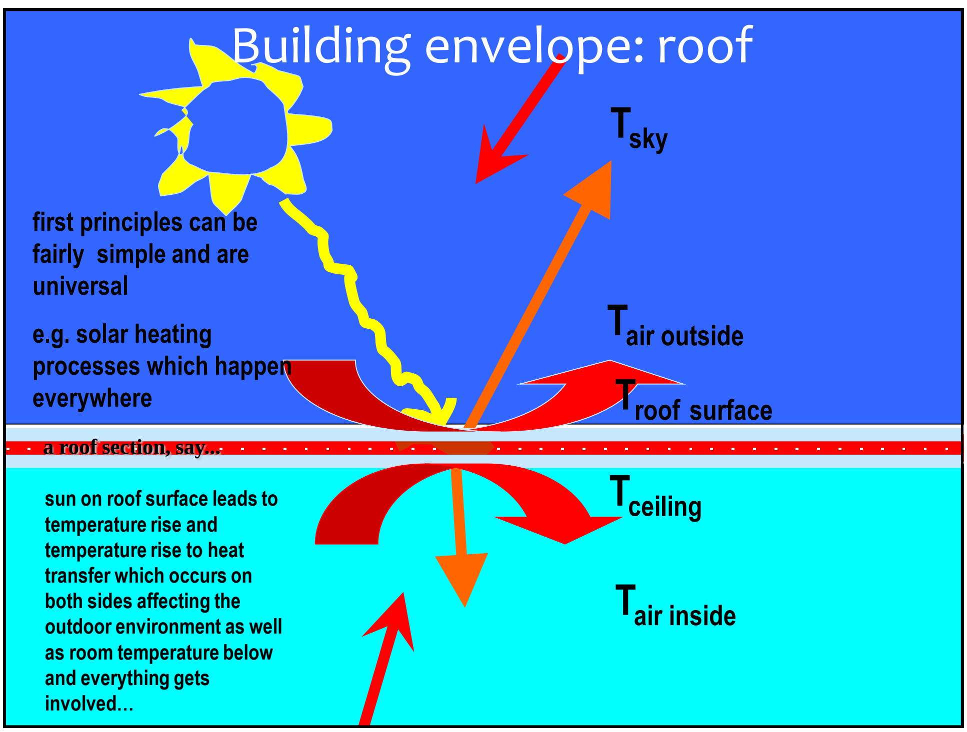
Walls

- Wall with high SRI coating
  - Reflection of incident heat



Roof

- Roof with overdeck insulation
- Cool Roofs
- Green Roof



Roofs

- Roof insulation through:
  - Use of preformed insulation materials
    - 1) Expanded polystyrene sheet.
    - 2) Extruded polystyrene sheet.
    - 3) Polyurethane/polyisocyanurate sheet.
    - 4) Perlite board.
  - In-situ application using spray applied polyurethane
  - Conventional roof insulation practices
  - Other traditional practices of roof insulation

Impact of insulation

Table 2 Typical Thermal Performance of Flat Roof Constructions

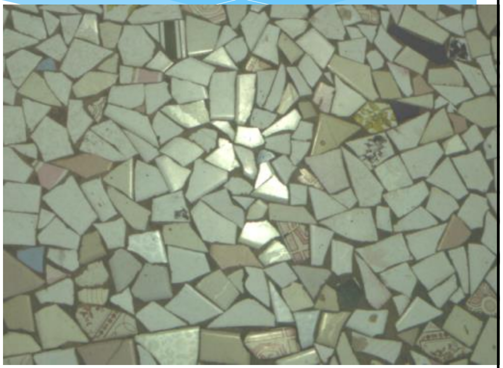
Sl No.	Specification of Roof	U Values
(1)	(2)	(3)
		$W/(m^2.K)$
i)	100 mm RCC	3.59
ii)	100 mm RCC + 100 mm lime concrete	2.78
iii)	100 mm RCC + 50 mm foam concrete + waterproofing	1.08
iv)	50 mm RCC + 25 mm expanded polystyrene	1.08
v)	50 mm expanded polystyrene + 50 mm RCC + waterproofing	0.62
vi)	25 mm expanded polystyrene + 50 mm RCC	1.09

Building envelope optimization for Air conditioned and Non Air conditioned spaces

		Roof	Wall	Glazing_View Window			AC Spaces
	Alternative	U-Value	U-Value	U-Value	SHGC	VLT	Reduction in TR Load
		W/m2K	W/m2K	W/m2K			(%)
1	Base Case	2.49	3.17	6.17	0.815	0.88	
2	ECBC Roof Case_Over deck	0.36	3.17	6.17	0.815	0.88	1.76
3	ECBC Roof Case_Under deck	0.37	3.17	6.17	0.815	0.88	-0.18
4	Glazing optimised Case	2.49	3.17	1.59	0.28	0.4	4.20
5	Cumilative 1(Over Deck)	0.36	3.17	1.59	0.28	0.4	9.67
6	Cumilative2 (Under Deck)	0.37	3.17	1.59	0.28	0.4	7.93

Building envelope: roof

- Roof receives significant solar radiation
- Roof insulation particularly important for hot climates
  - inverted earthen pots
  - insulating material e.g vermiculite insulation
  - reflective surfaces e.g broken china mosaic , reflective paints for inclined roofs



Roof

- Cool Roofs (minimum solar reflectance of 0.7and thermal emittance of 0.75)
  - Roof coatings
  - Broken china mosaic terracing
  - Cool colours
  - Traditional methods (lime wash)

Roof

Green Roof (evapo transpiration and thermal mass)

Wall Requirements

Table 4.3.2 Opaque Wall Assembly U-factor and Insulation R-value Requirements

	Maximum U-factor of the overall assembly (W/m²-°C)	Minimum R-value of insulation alone (m²-°C/W)	Maximum U-factor of the overall assembly (W/m²-°C)	Minimum R-value of insulation alone (m²-°C/W)
Composite	U-0.440	R-2.10	U-0.440	R-2.10
Hot and Dry	U-0.440	R-2.10	U-0.440	R-2.10
Warm and Humid	U-0.440	R-2.10	U-0.440	R-2.10
Moderate	U-0.431	R-1.80	U-0.397	R-2.00
Cold	U-0.369	R-2.20	U-0.352	R-2.35

Roof Requirement

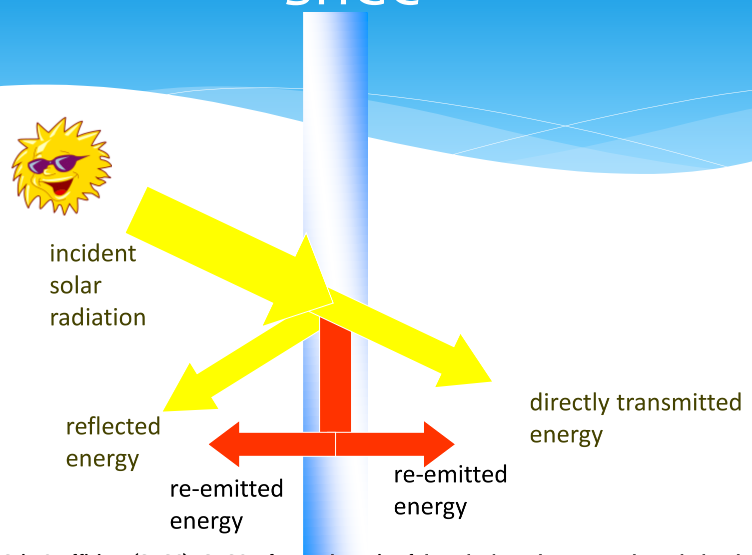
Table 4.3.1 Roof assembly U-factor and Insulation R-value Requirements

	Maximum U-factor of the overall assembly (W/m2-°C)	Minimum R-value of insulation alone (m2-°C/W)	Maximum U-factor of the overall assembly (W/m2-°C)	Minimum R-value of insulation alone (m2-°C/W)
Composite	U-0.261	R-3.5	U-0.409	R-2.1
Hot and Dry	U-0.261	R-3.5	U-0.409	R-2.1
Warm and Humid	U-0.261	R-3.5	U-0.409	R-2.1
Moderate	U-0.409	R-2.1	U-0.409	R-2.1
Cold	U-0.261	R-3.5	U-0.409	R-2.1

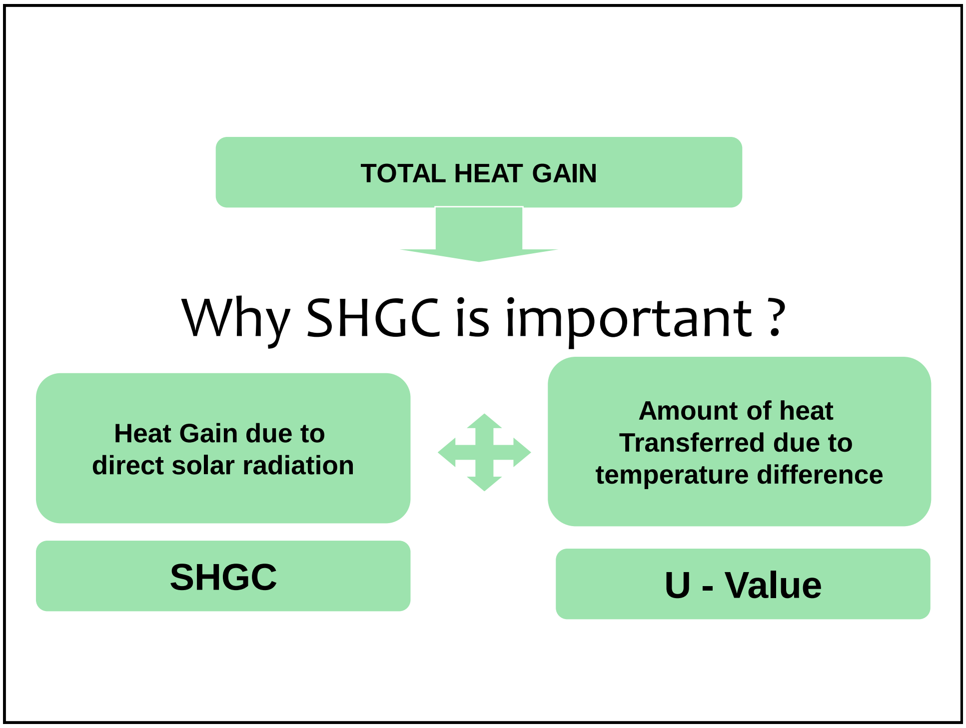
Fenestration and shading devices

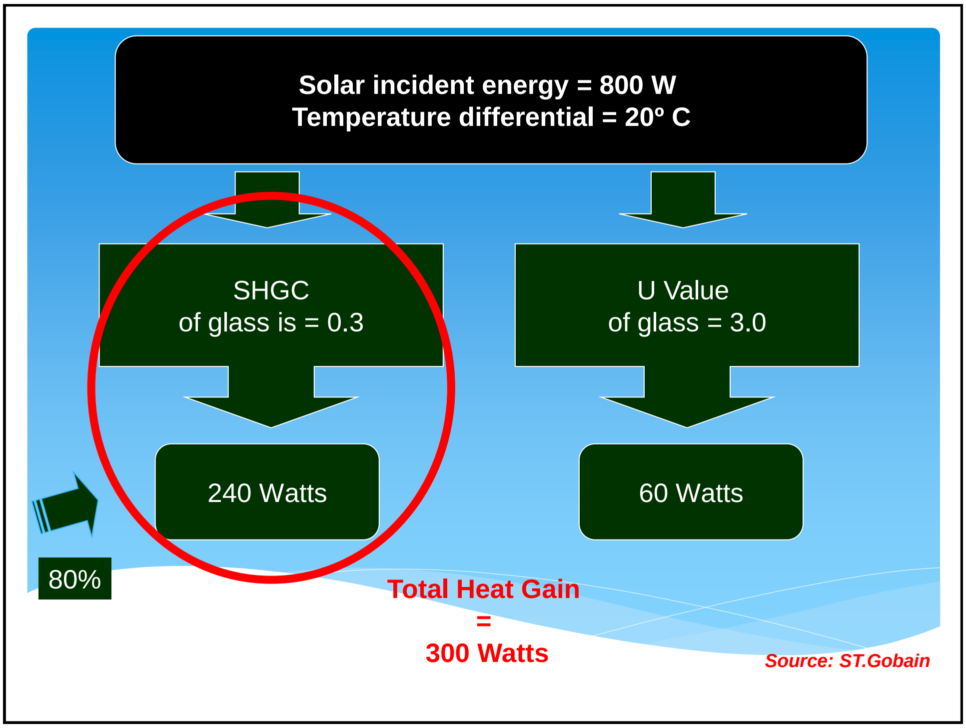
- Windows are most vulnerable to heat gains and losses.
- Heat gain through glazed surfaces determined by the direct gain component (defined by shading coefficient) and U- value
- Window size and location should be determined by:
  - Orientation
  - Daylight requirement
  - Glazing type
  - external shading
  - wind direction
  - Thermal comfort

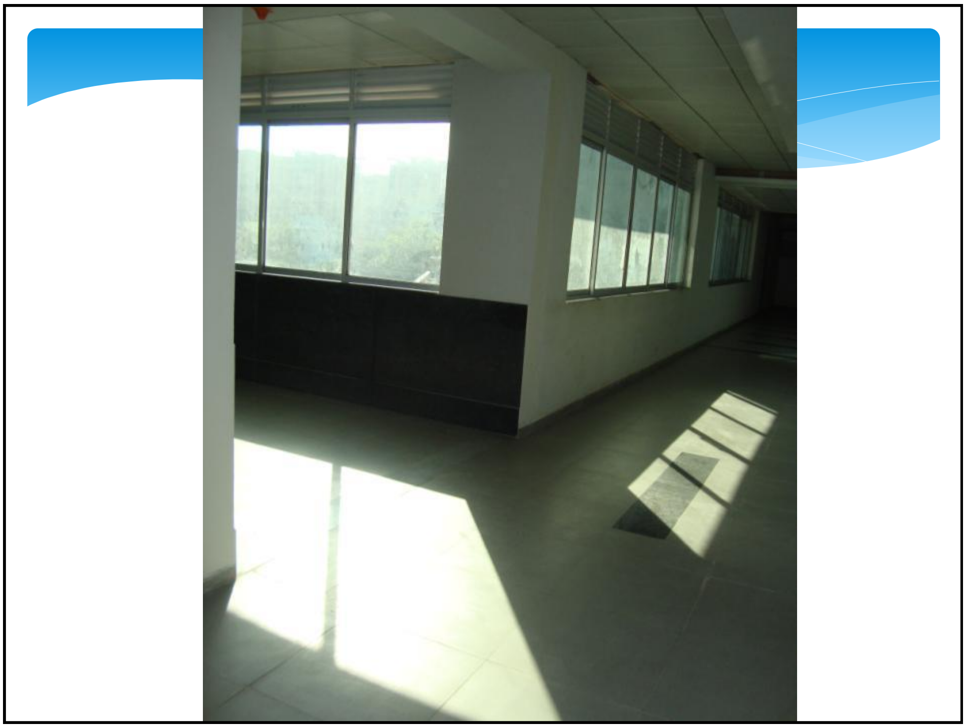
SHGC



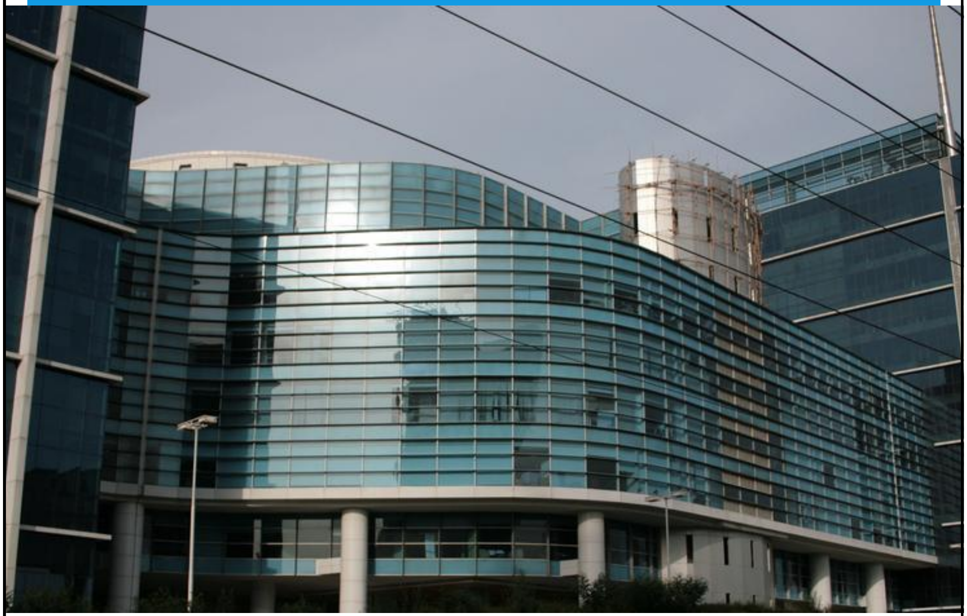
Solar Heat Gain Coefficient (SHGC) : SHGC refers to the ratio of the solar heat that passes through the glazing to the total incident solar radiation. The lower the SHGC, the lesser the direct incident heat gains from the glazing surfaces.


TOTAL HEAT GAIN
Why SHGC is important ?
Heat Gain due to direct solar radiation
Amount of heat Transferred due to temperature difference
SHGC
U - Value


Solar incident energy = 800 W
Temperature differential = 20º C
SHGC of glass is = 0.3
U Value of glass = 3.0
240 Watts
60 Watts
80%
Total Heat Gain = 300 Watts
Source: ST.Gobain




SAMSUNG




FUJITSU

27/wwshop/images/ManMarinCap.jpg

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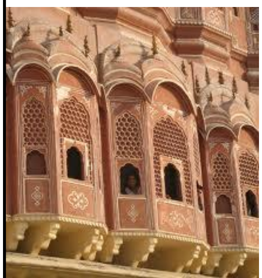
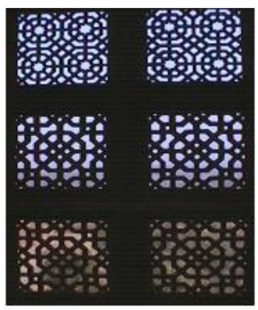




Fenestrations (AC and non AC spaces)

- Window sizes and heights
- Separate apertures for view and daylight
- WWR
- Glass Specifications
- Frames
- Shading Devices

Fenestrations

- Window sizes and heights
  - Height of window head
  - Sill height (height from floor to the bottom of the window)
- Use of separate apertures for view and daylight
- Window wall ratio (WWR)

Fenestrations

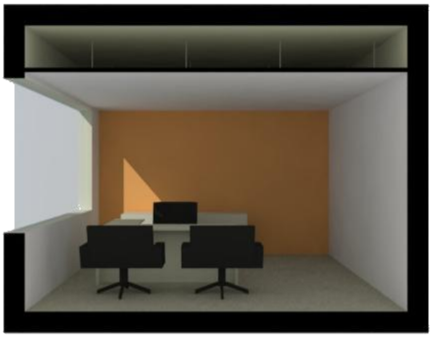
* Glass Specifications
  * Visible transmittance (affecting daylight),
  * Visible reflectance (affecting heat and light reflection),
  * Thermal transmittance or U value (affecting conduction heat gains),
  * Solar heat gain (affecting direct solar gain),
  * Spectrum selectivity (affecting daylight and heat gain),
  * Glazing material, and
  * Glazing colour (affecting the thermal and visual properties of glazing systems).

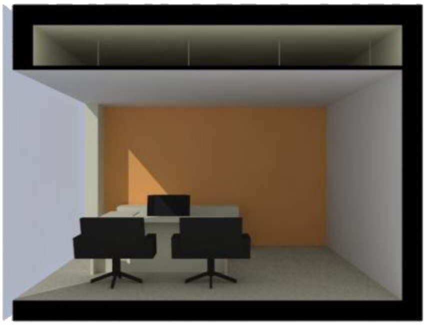
Fenestrations

* Shading Devices
  * External shading and screens/jalis,
  * Internal shading, and
  * Use of solar control glass.

Window Wall Ratio

- Window-Wall-Ratio (WWR) : The Window Wall Ratio refers to the ratio of the total fenestration area to the gross wall area.
- ECBC in a prescriptive approach recommends a maximum WWR of 60%.





The portion of the glazing which lets in light is same in both cases. This is why WWR is important. The rest of the glass does not contribute to daylight, only permits more heat inside.

Optimize glazing design

- Recommended to maintain a maximum of 40% WWR
  - ECBC allows up to 60% in prescriptive approach and
  - 40% in whole building approach
- Use a combination of
  - external shading and
  - high performance glass

  for
  - proper solar control
  - Day lighting and
  - glare control

Glazing Requirements
(for sun control and day lighting)

Vertical Fenestration U-factor and SHGC Requirements (U-factor in W/m²-°C)

		WWR = 40%	40% <WWR<=60%
Climate	Maximum U-factor	Maximum SHGC	Maximum SHGC
Composite	3.30	0.25	0.20
Hot and Dry	3.30	0.25	0.20
Warm and humid	3.30	0.25	0.20
Moderate	6.90	0.40	0.30
Cold	3.30	0.51	0.51

Mandatory controls for daylit areas

Minimum VLT Requirements

Window Wall Ratio	Minimum VLT
0-0.3	0.27
0.31-0.4	0.20
0.41-0.5	0.16
0.51-0.6	0.13
0.61-0.7	0.11

U-value thresholds specified in the ECBC

GLASS

Climate	Maximum U-factor (W/sq.m.-°C)
Composite	3.3
Hot and Dry	3.3
Warm and Humid	3.3
Moderate	6.9
Cold	3.3

WALLS

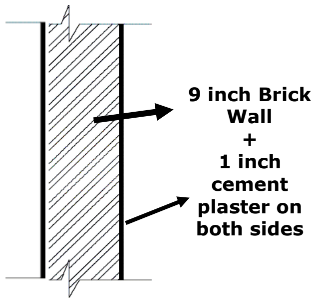
Climate	Maximum U-factor (W/sq.m.-°C)
Composite	0.44
Hot and Dry	0.44
Warm and Humid	0.44
Moderate	0.44
Cold	0.369

Building Envelope impact on Energy Performance

Energy Efficient Envelope-Wall

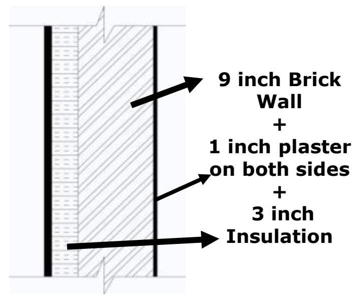
WALL

Conventional case



U Value- 0.32 btu/f2/hr/degF

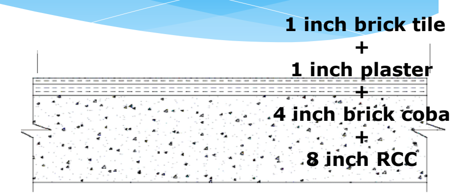
Energy Efficient Case



U Value- 0.07 btu/f2/hr/degF

Energy Efficient Envelope-Roof

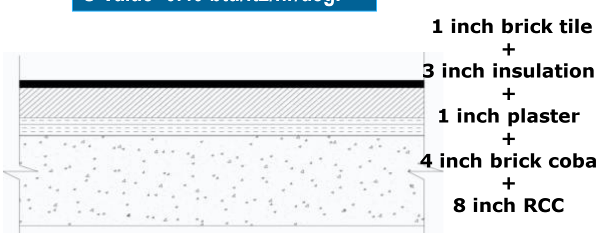
Conventional case



U Value- 0.40 btu/ft2/hr/degF

Roof

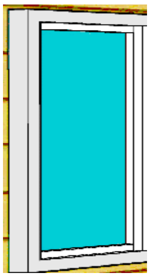
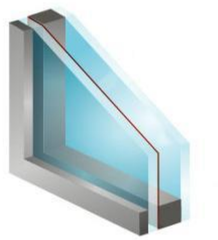
Energy Efficient Case



U Value- 0.07 btu/ft2/hr/degF

Energy Efficient Envelope-Glass

GLASS

Conventional case	Energy Efficient Case
	
U Value- 1.087 btu/ft2/hr/degF SHGC – 0.815	U Value- 0.58 btu/ft2/hr/degF SHGC – 0.25 for WWR <40%

Impact of Efficient Envelope

Impact on Cooling load (TR)

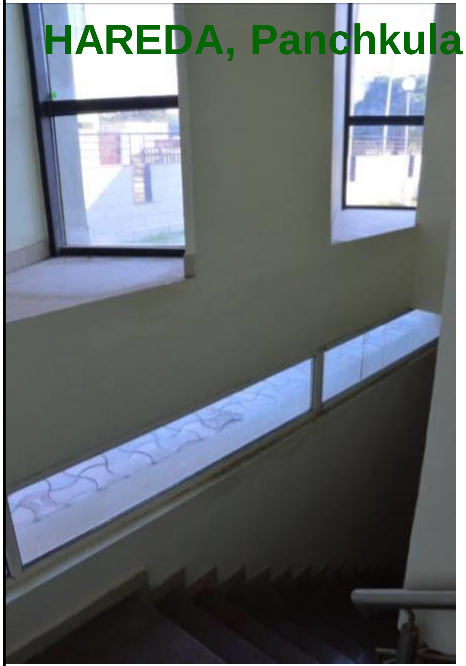
Base Case	233	
Efficient Envelope	163	30 %

Impact on EPI (kWh/m2/yr)

Base Case	202	
Efficient Envelope	168	17 %

Examples of optimized design

HAREDA, Panchkula




HAREDA, Panchkula


HAREDA, Panchkula

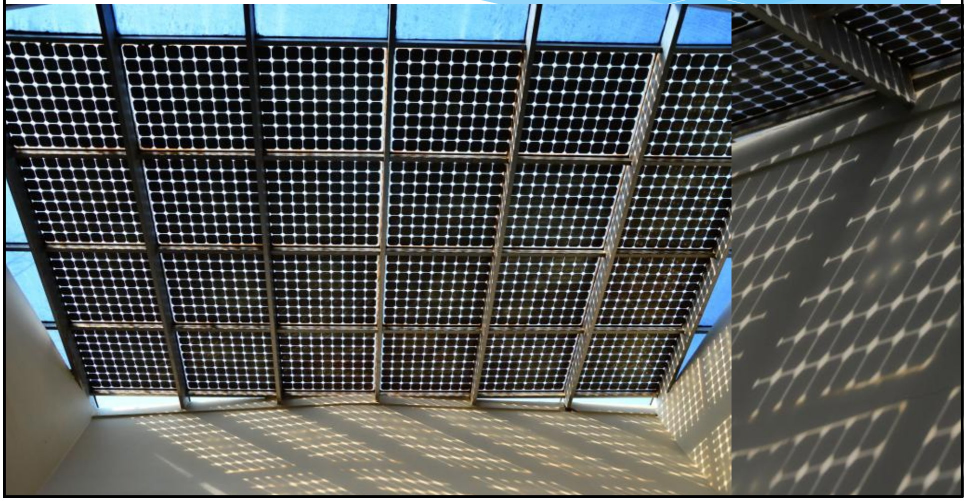
CESE building, IIT Kanpur

Suzlon OneEarth, Pune


INFOSYS, Hyderabad


INFOSYS, Hyderabad
EDUCATION
&
RESEARCH

Integrated Renewable Energy Technologies



Scope of ECBC

* Building Envelope
* Interior and Exterior Lighting
* Mechanical Systems
* Service Water Heating
* Electrical Power and Motors

Compliance Approaches

- Mandatory provisions to be complied
- Prescriptive method
- Whole Building Performance Method
  - (use of simulation tool)
- Trade-off option
  - (applicable to Envelope only)

Comments