

Glass - A Vital Building Material for Smart Cities



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Outline

- Architectural Glass
- Classification of Architectural glass
- Glass as a Building Material
- Architectural Glass Research and Testing at CGCRI



CSIR-Central Glass & Ceramic Research Institute, Kolkata

Established in 1950



- **Characterization of Raw Materials**
- **Help Ceramic & Glass Industries Grow**

- **Generation of HR and Trained Manpower in Relevant Disciplines**



CSIR-Central Glass & Ceramic Research Institute, Kolkata



VISION

Enduring innovation in science & technology of materials to attain the status of an ultimate centre of excellence in Glass and Ceramics technology

MISSION

To provide scientific industrial research and development in the area of glass, ceramics and related materials that maximizes the economic, environmental and societal benefit for the people of India



GLASS

**FIBER OPTICS &
PHOTONICS**

**SPECIALITY GLASS
TECHNOLOGY**

**FUNCTIONAL MATERIALS
& DEVICES**

**NON-OXIDE
CERAMICS &
COMPOSITES**

**FUEL CELL &
BATTERY**

**REFRACTORY &
TRADITIONAL
CETAMICS**

**BIOCERAMICS &
COATING**

**MATERIALS
CHARACTERIZATION &
INSTRUMENTATION**

**ADVANCED MATERIALS &
MATERIALS
CHARACTERIZATION**

**WATER
TECHNOLOGY**

**CERAMIC
MEMBRANE**

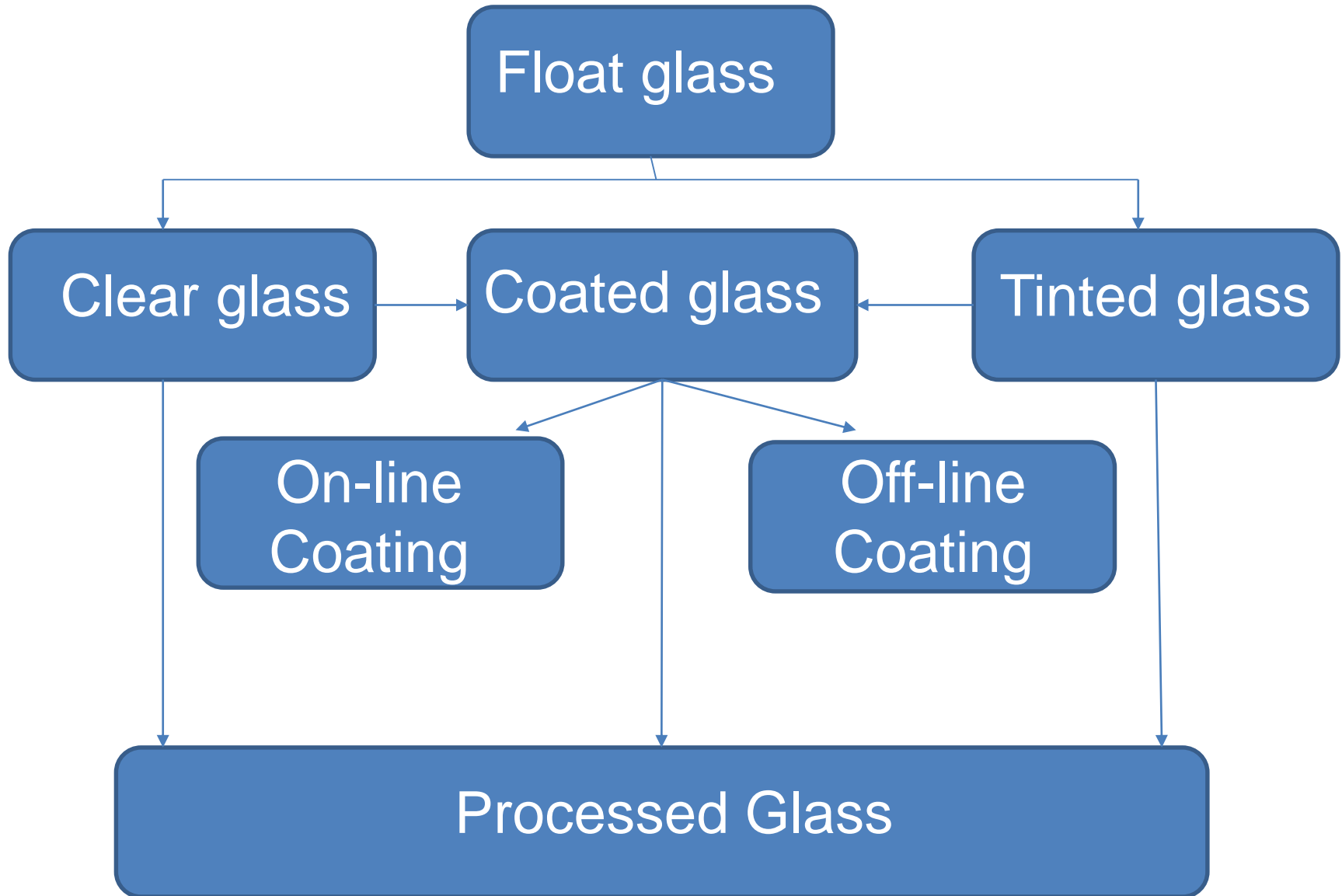
Architectural Glass

- ✓ Glass enables the architect to transform concepts into spectacular reality
- ✓ Provides number of value additions
 - Day light management
 - Cuts down Heat
 - Safety and Security
 - Acoustic comfort
 - fire resistance
- ✓ Reduces construction area – More usable space
- ✓ Extensive Colour and texture



Burj Khalifa, Dubai

Classification of Architectural Glass



Processing of Glass

- ✓ Value addition on annealed Glass for better performance
 - Energy
 - Safety
 - Acoustics
 - Fire resistance
 - Aesthetics, etc

Types of Processing

- ✓ Heat strengthening and Heat toughening /Tempering
- ✓ Lamination
- ✓ Insulated glazing units
- ✓ Ceramic frit
- ✓ Patterned, etc

Processing of Glass

✓ **Heat treated Glass**

A permanent surface compressive stress has been induced by a controlled heating and cooling process in order to give it increased resistance to mechanical and thermal stress and prescribed fragmentation characteristics

✓ **Laminated Glass**

Assembly consisting one sheet of glass with one or more glass sheets joined together one or more inter layers, wherein inter layers serve to retain the glass fragments, limits the size of opening, offers residual resistance and risk of cutting or piercing injuries

✓ **Insulated glazing units (IGU)**

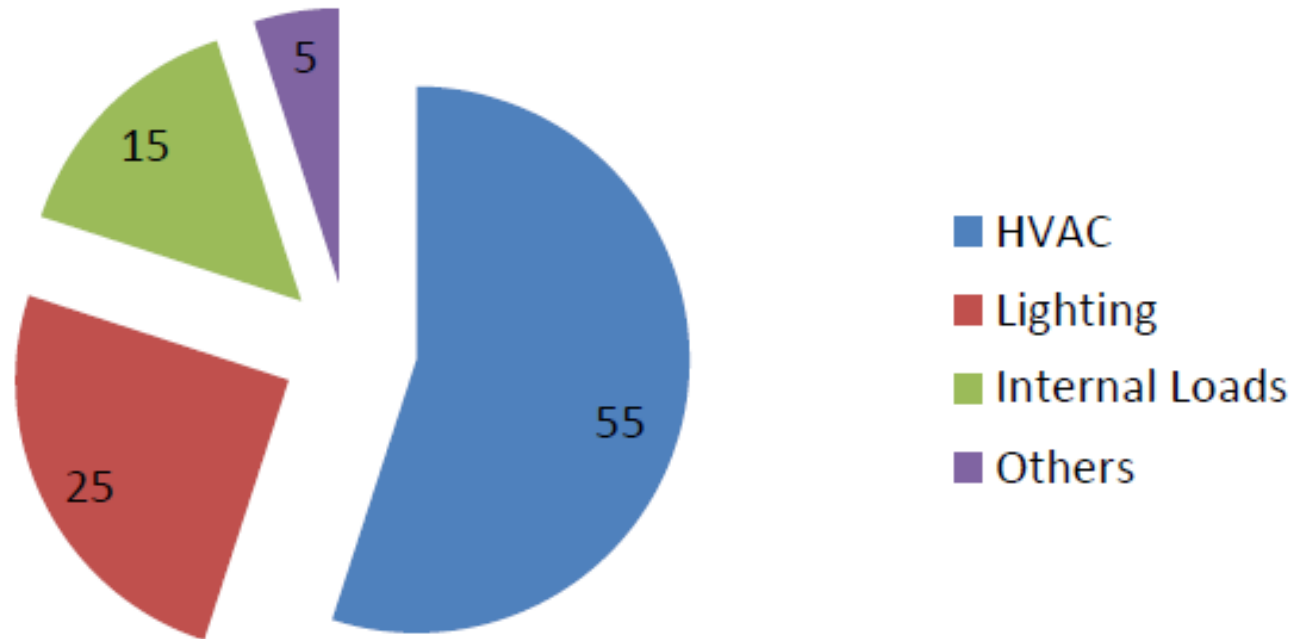
Assembly consisting of at least two panes of glass, separated by one or more spacers, hermetically sealed along the periphery, mechanically stable and durable

Glass as a Building material

- Energy Performance**
- Structural Performance**

Glass as Building material – Energy prospective

Electricity Usage in Commercial Buildings

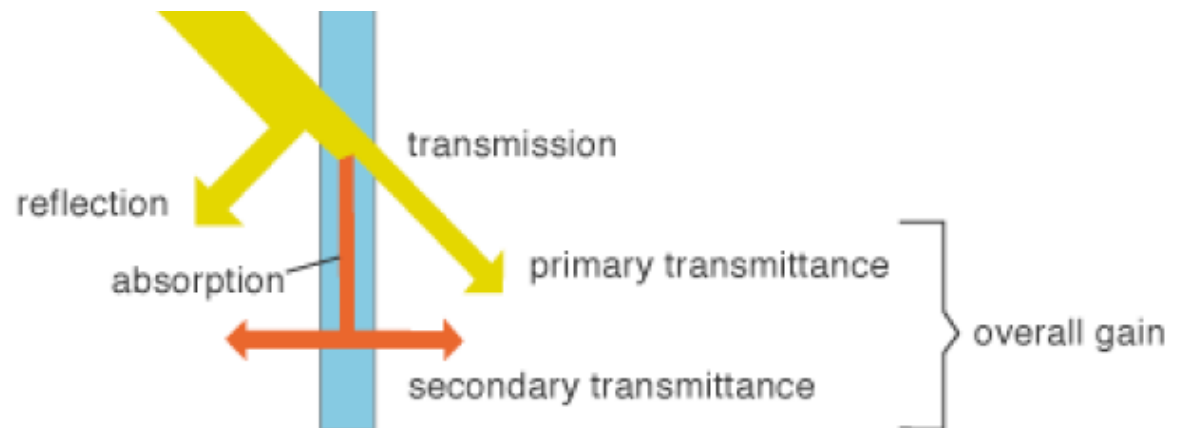


- There is a need for energy conservation in Buildings in India
- 20 – 30% of Energy Savings possible with Energy Efficient Buildings

Glass as Building material – Energy Parameter

SHGC (Solar Heat Gain Coefficient)/SF (Solar Factor)

- The fraction of external solar radiation that is admitted through a window or skylight, both directly transmitted, and absorbed and subsequently released inward.
- SHGC is expressed as a number between 0 and 1
- The lower the SHGC, the more a product is blocking solar heat gain
- SHGC may be expressed in terms of the glass alone or may refer to the entire window assembly.

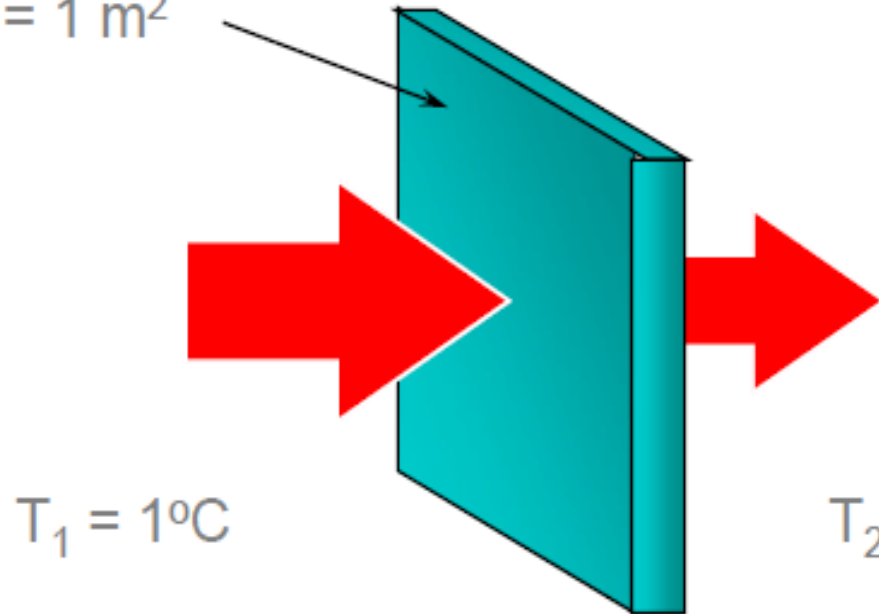


Glass as Building material – Energy Parameter

U Value

- A value that describes the ability of a material to transmit heat. The number of Watts that flow through one square metre of material.
- It is the reciprocal of the R-value (i.e. $U\text{-value} = 1/R\text{-value}$).
- The lower the number, the lower is the heat transferred through the material.

Area = 1 m²



Glass as Building material – Energy Parameter

Relative Heat Gain (RHG)

- RHG (Relative Heat Gain)- An attribute which describes the total performance of the glazing with regard to heat transfer due to temperature differential (U-Value), as well as solar gain (shading coefficient).
- The relative heat gain predicts how much total energy will be gained through each square metre of glazing for a specific set of conditions.
- $RHG = \text{Direct Heat Gain} + \text{Indirect Heat Gain}$

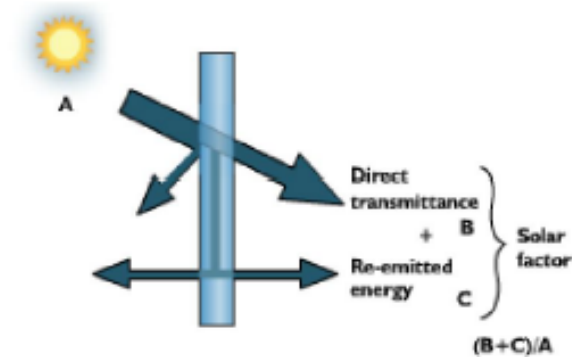
$$RHG = SC \times SI + \Delta T \times U$$

- Lower the number, better is the product.

Glass as Building material – Energy Performance

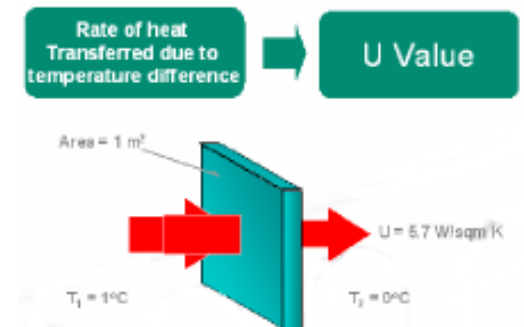
✓ Lower Total Heat gain through building envelope, by

- Low Solar Factor
- Low U value



✓ Every 3500 Watts of Heat Load requires 1 Ton of refrigeration.

- Clear Glass RHG:450-600 W/Sqm
- Every 5 to 7 Sqm of clear glass requires 1 TR
- Coated Glass RHG:100 -250 W/Sqm
- Every 12-30 Sqm requires 1 TR



Glass as Building material

– Visible Light Transmittance

- The percentage of visible light that passes through a window or other glazing unit is called the Visible Light Transmittance
- A higher VLT means there is more daylight in a space which, if designed properly, can offset electric lighting and its associated cooling loads.
- Visible transmittance is influenced by the glazing type, the number of panes, and any glass coatings

Barely Glazed Room



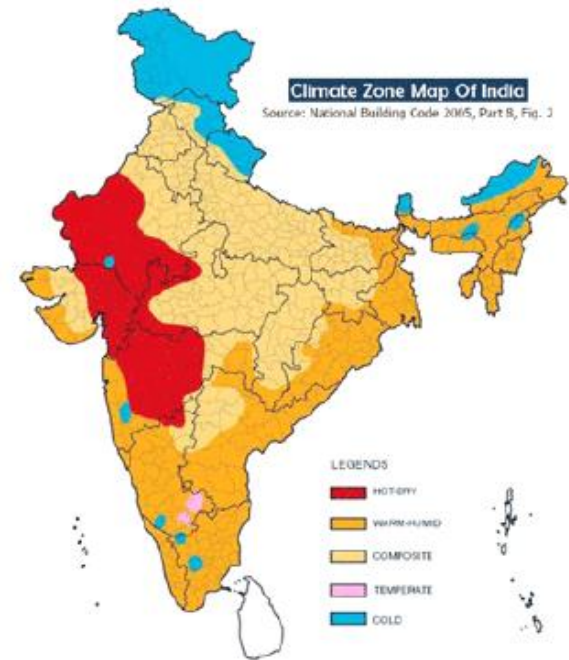
Largely Glazed Room



ECBC – Indian Code

Light Transmission (Prescriptive)

WWR	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



SHGC / U value (Prescriptive)

		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

Glass as Building material

– Safety and structural Performance

Heat Strengthened Glass

Characteristics

- ❖ Increased mechanical strength – twice than the annealed glass
- ❖ Mechanical strength: 40 N/mm^2 (as per EN 1863-1)
- ❖ Compressive Stress: $24 - 52 \text{ Mpa}$ (as per ASTM C 1048)
- ❖ Thermal shock resistance upto 130°C
- ❖ Breakage pattern: Relatively larger particles with no jagged / sharp edges



Glass as Building material

– Safety and structural Performance

Toughened / Tempered Glass: Characteristics

- ❖ Increased mechanical strength – five times than annealed glass
- ❖ Mechanical strength: (as per IS 16231 – 4)
 - ❖ Float Toughened glass – 120 MPa
 - ❖ Enamelled Toughened glass – 75 Mpa
- ❖ Compressive Stress: 69 MPa (as per ASTM C 1048)
- ❖ Thermal shock resistance upto 250 °c
- ❖ Breakage pattern: Round small and harmless fragments



Glass as Building material

– Safety and structural Performance

Laminated Glass: Characteristics

- ❖ Safety Glass – On breakage the pieces do not fall off due to adhesive nature of interlayer (ex: PVB, EVA, etc)
- ❖ The properties of the Laminated glass varies based on the interlayers used.
- ❖ Used for Security purposes, better acoustic insulation, UV resistance, bullet / ballistic resistance, fire resistance, etc
- ❖ High impact resistance when compared with Heat treated glass.
- ❖ Toughened / Heat Strengthened Glass can be used as part of Laminated glass for better / high performance

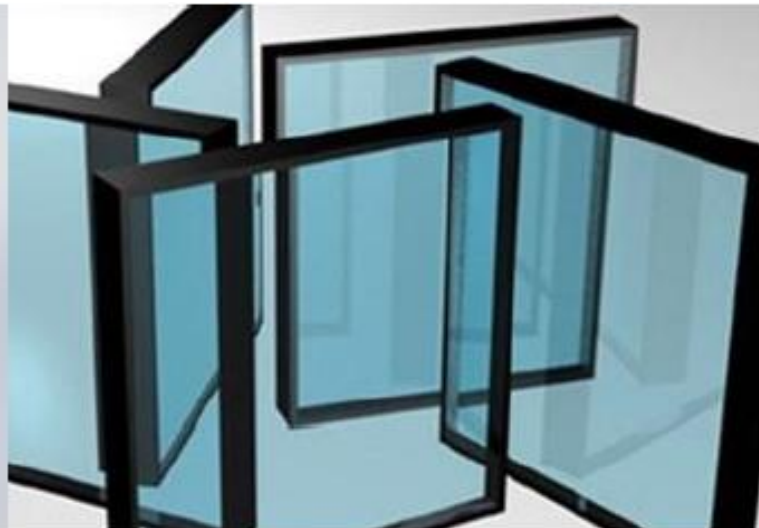
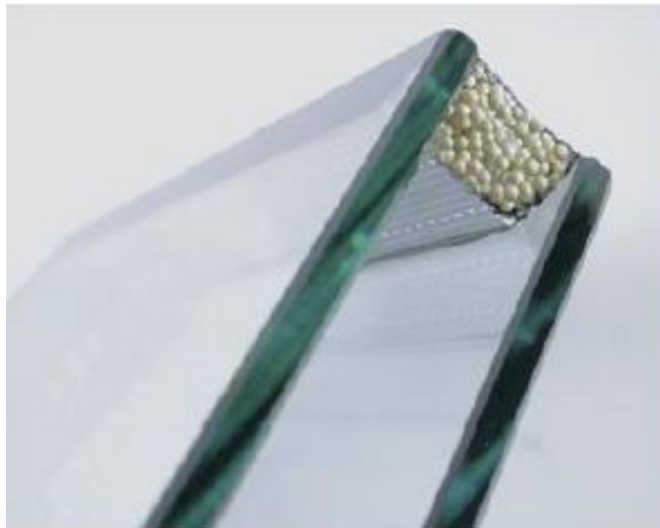


Glass as Building material

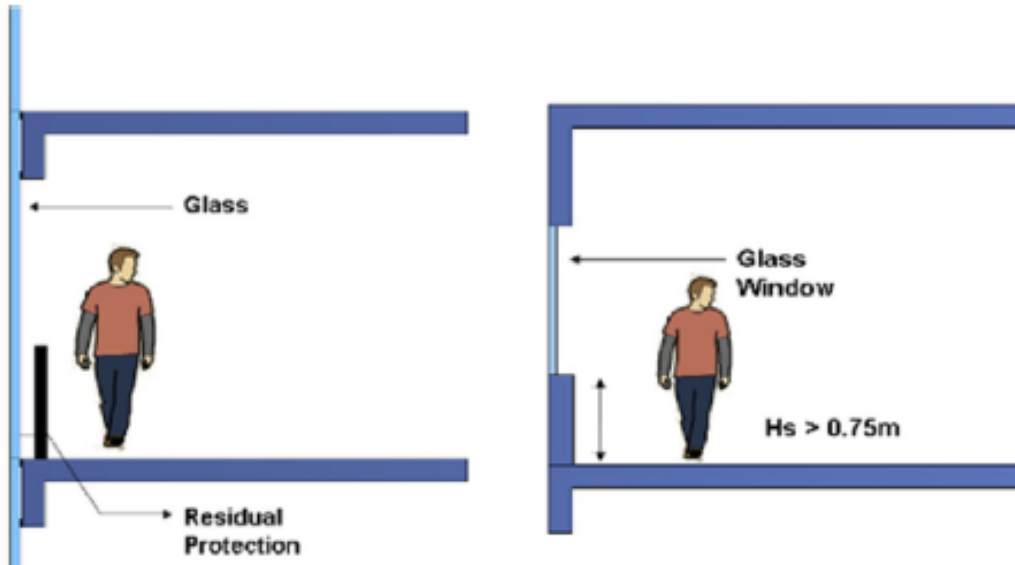
– Safety and structural Performance

Insulated Glazing Unit: Characteristics

- ❖ Different combination of glasses can be used for high performance
 - ❖ Energy efficiency
 - ❖ Sound Insulation
 - ❖ Reduces condensation

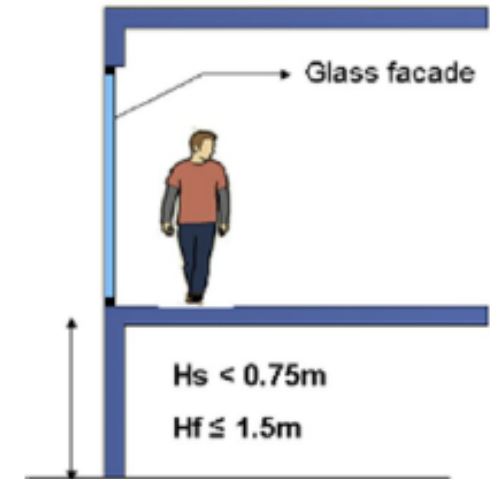


BIS IS 16231 – 4 :Impact to human safety



$H_s > 0.75\text{m}$ - Any Glass

H_s - sill height with reference to floor height
 H_f - height of fall of human or glass

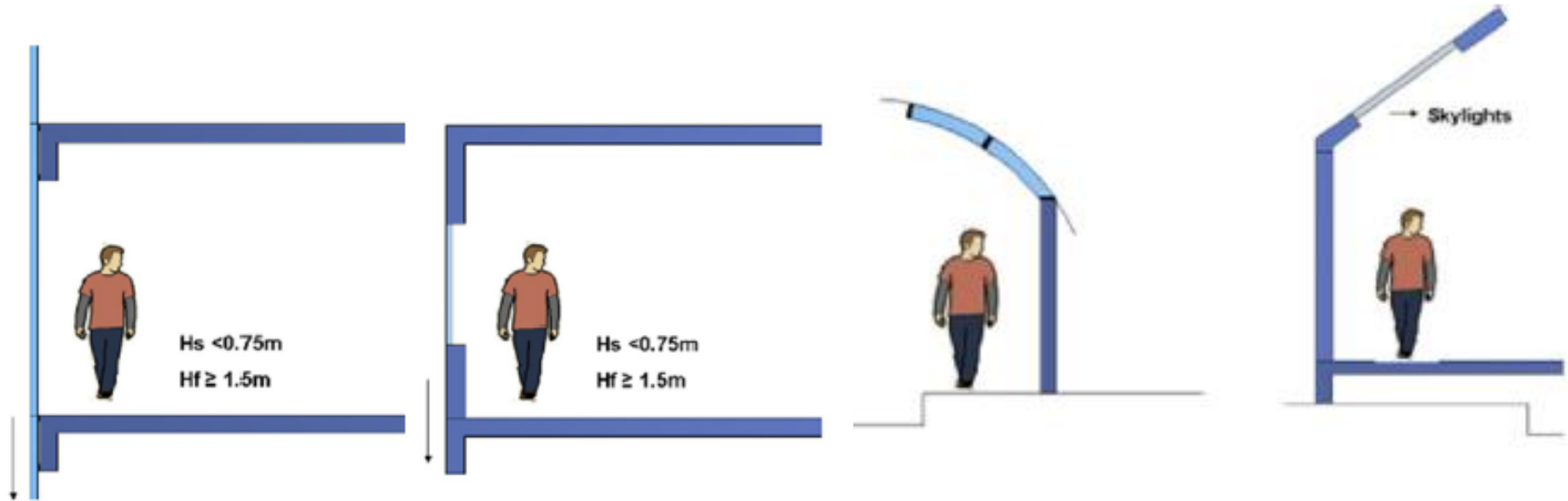


$H_s < 0.75\text{m}$

$H_f < 1.5\text{m}$

Safety Glass

BIS IS 16231 – 4 :Impact to human safety



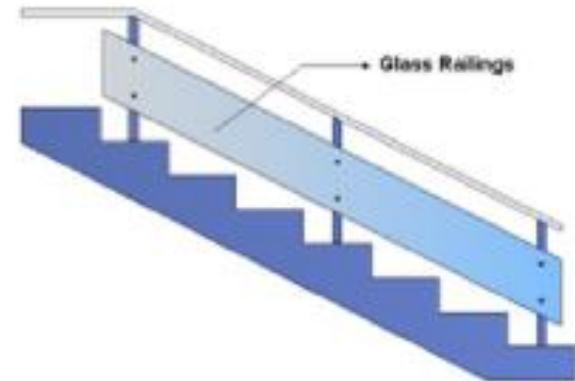
$H_s \leq 0.75\text{m}$

$H_f > 1.5\text{m}$

Safety Glass

H_s - sill height with reference to floor height

H_f - height of fall of human or glass



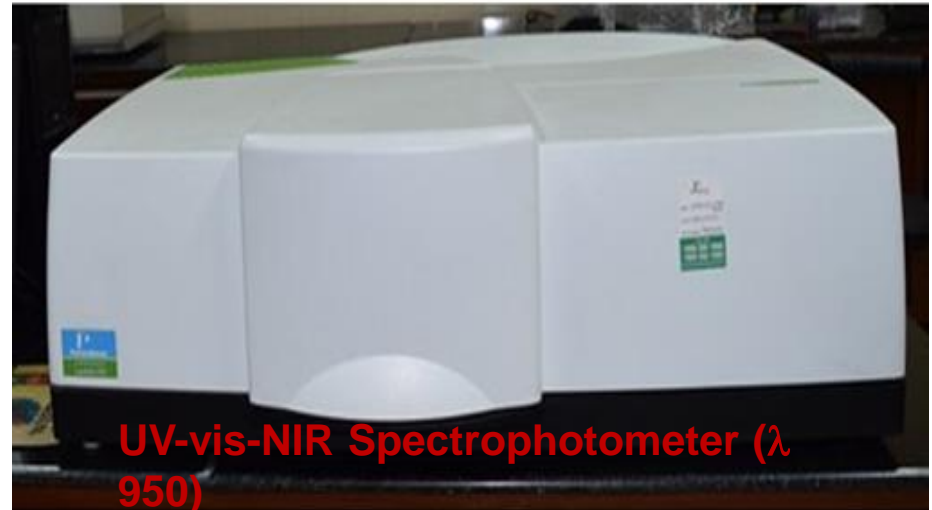
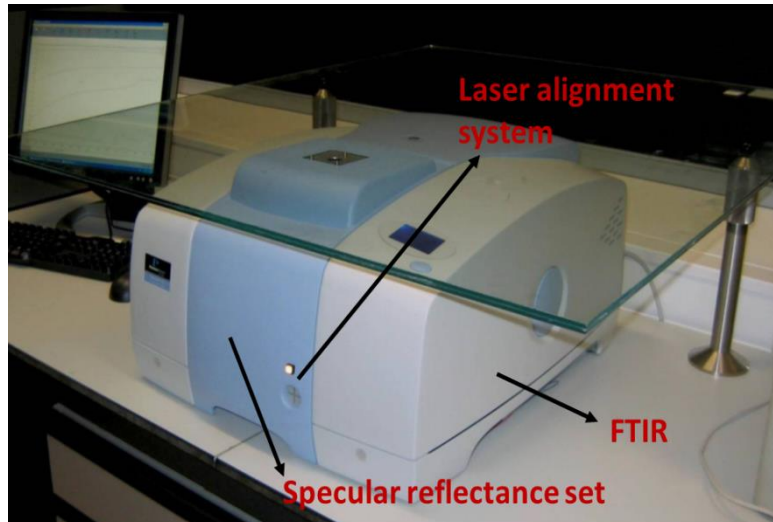
Laminated Safety Glass

Architectural Glass Research and Testing (AGRT) Facility at CSIR-CGCRI

An ISO 9001: 2015 Certified Laboratory

Architectural Glass Research and Testing (AGRT) Facility

A joint initiative of CSIR-CGCRI and Glazing Society of India (GSI) for testing of energy and structural performance of architectural glass, glazing system



Energy performance testing of glazing system using FTIR spectrometer and UV-Vis-NIR spectrophotometer Make : Perkin Elmer

Energy Performance Testing:

- Solar Direct Transmittance,
- Solar Direct Reflectance (External)
- Light Direct Reflectance (Internal)
- UV Transmittance
- Shading Co-efficient (SC)
- Emissivity & U Value
- Solar Factor (SHGC)
- Light Direct Reflectance (External)
- Light Direct Transmittance,
- Solar Direct Reflectance (Internal)

Architectural Glass Research and Testing (AGRT) Facility

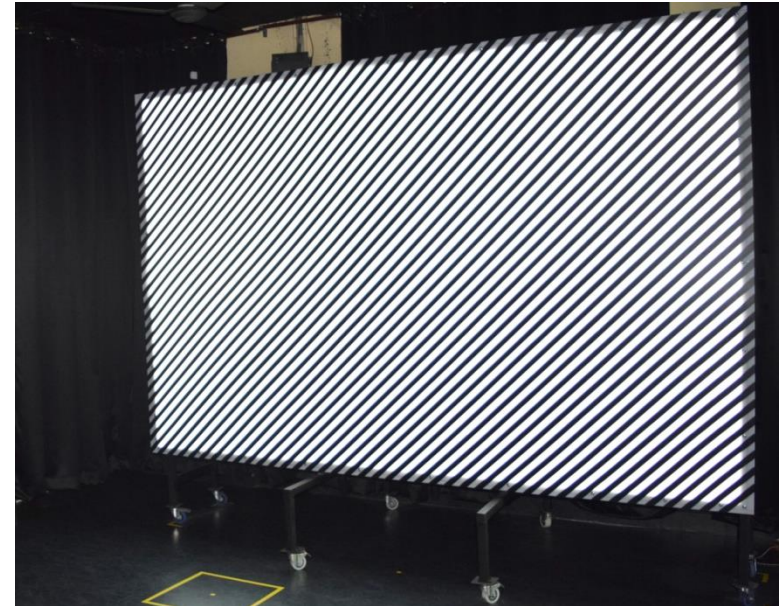
Float glass testing as per standard IS 14900: 2018



DETERMINATION OF
SPOT FAULTS



DETERMINATION
OF REAMS,
STRINGS, LINES
AND LINEAR
FAULTS



DETERMINATION OF
OPTICAL FAULTS
Zebra Board of 2500 mm x
2000 mm

UV test to identify the tin side of float glass
Determination of visual light transmittance
Bloom Test

Services towards Testings of Glass/Glass products

➤ Optical properties:

- Refractive Index and Abbe number
- Dispersion curve
- Visible Light transmission (VLT)
- Reflectance
- Absorption
- Yellow Index etc

➤ Thermal Properties:

- Coefficient of thermal expansion (CTE)
- sagging temperature
- DSC/DTA
- Thermal shock resistance

➤ Mechanical Properties

- Micro Hardness
- Residual stress/
toughened glass test

➤ Total chemical analysis

➤ Optical Homogeneity

➤ Identification of types of glasses

**Laboratory scale trial meltings of Industrial glasses;
specific problem solving tests**

An aerial photograph of a suspension bridge spanning a deep, lush green forest. The bridge has a white metal frame and numerous cables supporting its deck. A large group of people is walking across the bridge, their shadows cast onto the deck. The forest below is dense and green, with some rocky outcrops visible. The text "THANK YOU" is overlaid in large, blue, 3D-style capital letters in the lower half of the image.

THANK YOU