GLASS AND GLAZING

NATIONAL BUILDING CODE 2016

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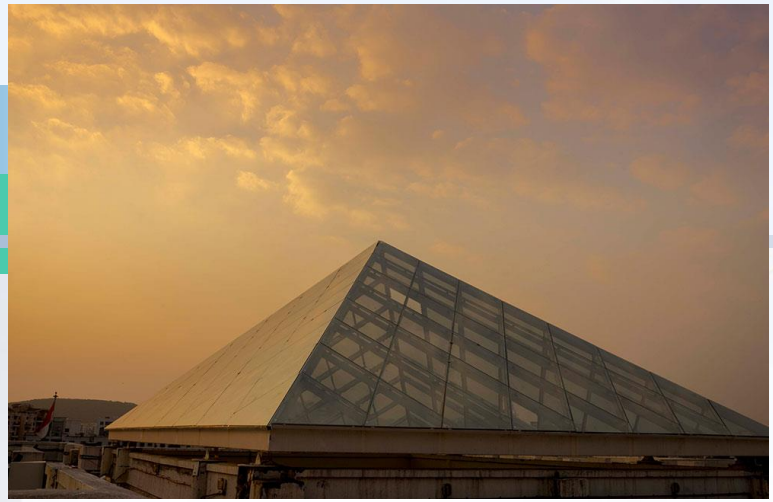
WHAT ARE GLASS FACADES?

- The outer skin of the building made of glass is known as a glass facade.
- It is a non-structural element capable of sustaining its own weight. In very rare cases glass acts as a structurally load bearing member.
- Glasses are supported with Aluminum members called as Mullions and Transoms. In some cases where the loading becomes higher, steel is also used as a supporting member.

ITC KOHINOOR, HYDERABAD

RAJIV GANDHI INTERNATIONAL AIRPORT, HYDERABAD



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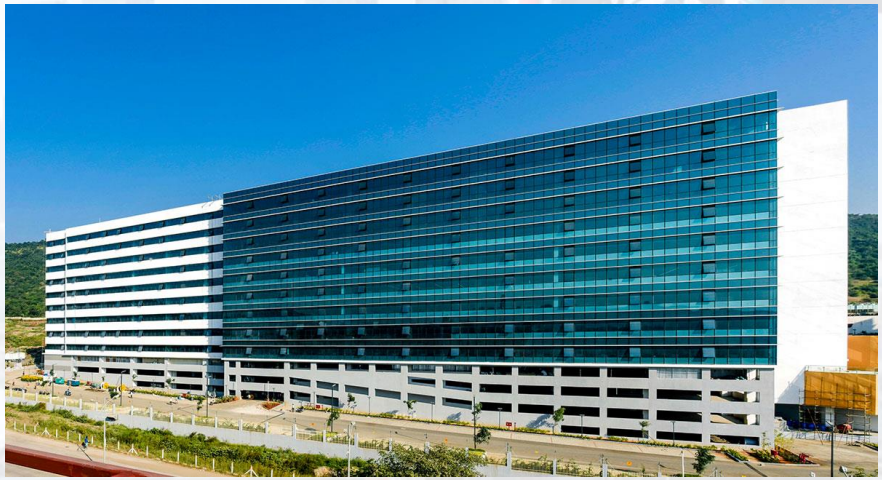

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ADVANTAGES OF GLASS FACADES

- Only envelope material which can give contact to the outside world for the occupants of the building.
- Gives a pleasing architecture.
- Can accommodate thermal expansion and contraction and also the building movements.
- Can accommodate water diversion, smoke seal, safety and security of the building.
- Does not required painting and hence the maintenance in lower.

DISADVANTAGES OF GLASS FACADES

- Glass absorbs heat. This means that it can act has a greenhouse and hence not suitable for countries with hot climate.
- Most glasses are not earthquake resistance and not suitable for countries that witness frequent earthquakes. A very expensive kind of treatment given to glass can make then earthquake resistant but such type of glass is not very affordable.
- Use of glass in a building may result in higher costs in making the building safe and secure because glass results in lot of transparency.
- Glass, being an expensive material as compared to the other materials used in the construction industry, eventually augments the total cost of the building.

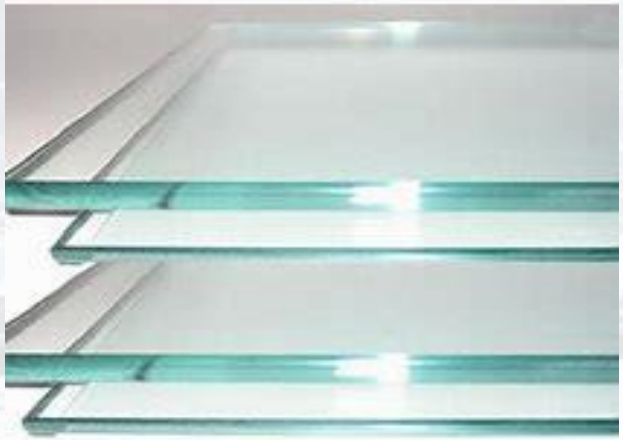
TYPES OF ARCHITECTURAL GLASS

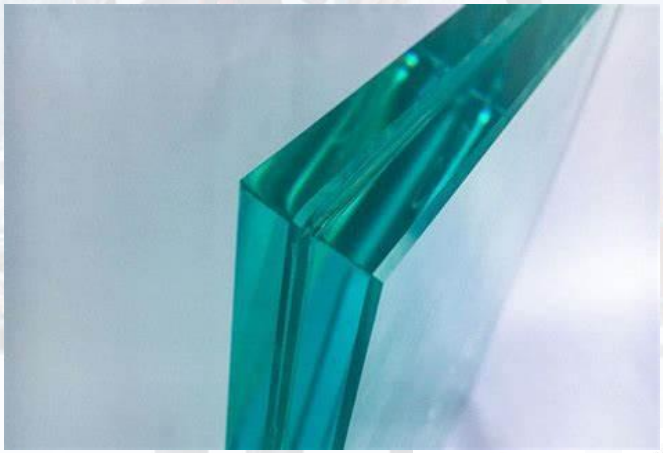
- Base glass
  - Clear glass
  - Tinted glass
- Double glass unit
- Heat strengthened glass
- Safety glass
  - Toughened safety glass
  - Laminated safety glass
- Energy efficient glass
  - Online coated glass (or) Chemical Vapour Deposition (CVD)
  - Offline coated glass (Magnetron Sputtering)

CLASSIFICATION OF SAFETY GLASS

- Toughened Safety Glass : Processed by controlled thermal and chemical treatments to increase its strength. It is 4 times more stronger than annealed glass.
- Laminated Safety Glass : Polyvinyl Butyl is used to hold two slices of glass together.

Other types like Heat Strengthened Glass, Coated Glass can be part of Laminated Safety Glass.





APPLICATIONS OF SAFETY GLASS

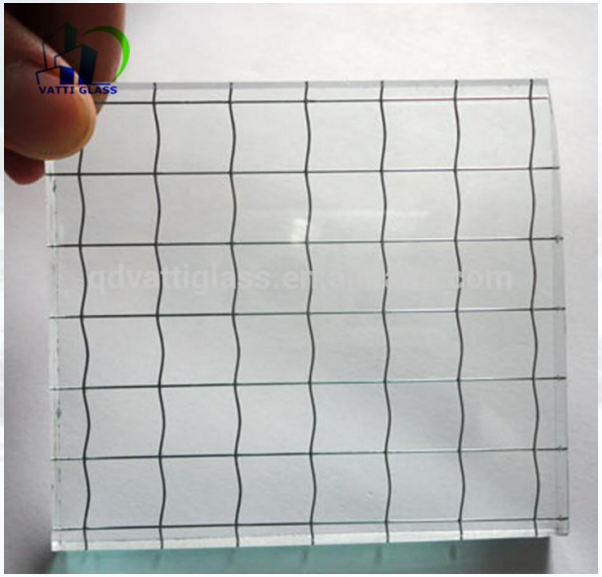
- Overhead glazing (Skylights) which are either horizontal or inclined.
- Sloping glass – used when there is a change in floor level and thereby poses a danger of glass falling.
- Balustrades, floors and stairs – directly accessed by human and thereby direct transmission of loads to the glass.

Critical locations of vulnerable human impact according to NBC 2016

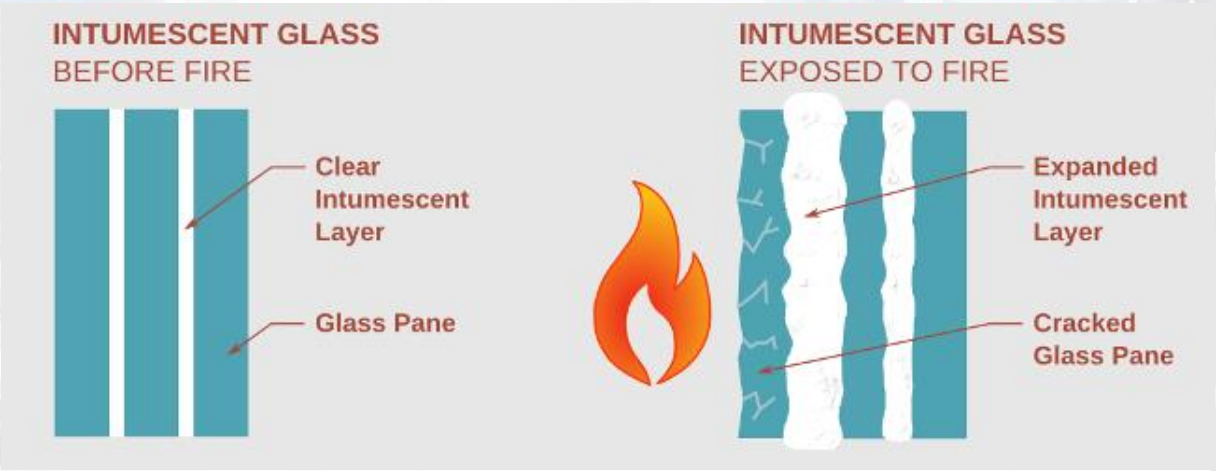
- In and around doors, low windows
- Door side panels
- Panels mistaken for doorway or opening
- Panels at low levels in walls and partitions
- Bathrooms
- Buildings associated with specific activities like gymnasia, enclosed swimming pool
- Schools and child care facilities
- Nursing homes and care facilities for the aged and infirmed

TYPES OF FIRE RESISTANCE GLASS

- Wired glass : Not recommended for doors except as vision glass and there are size restrictions for windows
- Annealed fire resistance glass (AFG) : Not to be used in areas which require safety against human impact
- Tempered fire resistance glass (TFG) : Dual property of withstanding both fire and human impact



- Intumescent laminated fire resistance glass (LFG) : Fire side of glass will break but it has a gel between glasses to resist the fire from passing to the last glass layer for a stipulated period of time, say 30 minutes, 60 minutes, 90 minutes, 120 minutes
- Double glazed fire resistant glass (DFG) : Both sides are resistant to human impact



FIRE RESISTANCE – TYPE OF PRODUCTS

- Stability (E) : Resist fire and smoke without loss of structural stability.

- Integrity (EW) : Resist fire, smoke and thermal heat transfer that happens through glass.

- Insulation (EI) : Resistance to temperature rise on non-fire side of glass.

MEMBER

KEY FACTORS ON FIRE RESISTANCE

- Entire glass assembly needs to be tested for fire resistance.
- Fire test certificate obtained for one application say, single door, double door or partition wall, should not be used for any other applications.
- None of the linear dimensions of glass shall exceed that of glass that has been tested.
- Same hardware that is used for testing shall be used for execution. In case of replacement standard guidelines need to be followed.
- The dimensions of profile need to be same as tested.
- Factors like edge cover, type of gaskets and type of fixtures play a vital role in fire performance must be used and installed as per test reports/available standards.

BASIS FOR GLAZING SELECTION

- Thickness of glazing is calculated subjected to wind load based on IS 875 Part 3 where factors like
  - Type of building
  - Location of building
  - Height of building
  - Local wind impacts are considered

- For criteria on safety against human impact
  - Critical location of glass
  - Type of glass used

- For criteria on optical, solar and thermal performance

➢ Visual Light Transmission : Percentage of light transmission that happens through the glass from outside environment to inside environment or from source to inside the building.

➢ Solar Factor : Percentage of direct heat transfer that happens from outside environment to inside environment.

➢ U Value : Heat transfer that happens through a building part such as wall or window due to difference in climatic conditions or temperature differences between outside and inside environment.

Outside temperature – Inside temperature = Δt

Normal clear glass has Visual Light Transmission of 89%, Solar Factor of 83-85% and U Value of 5.7

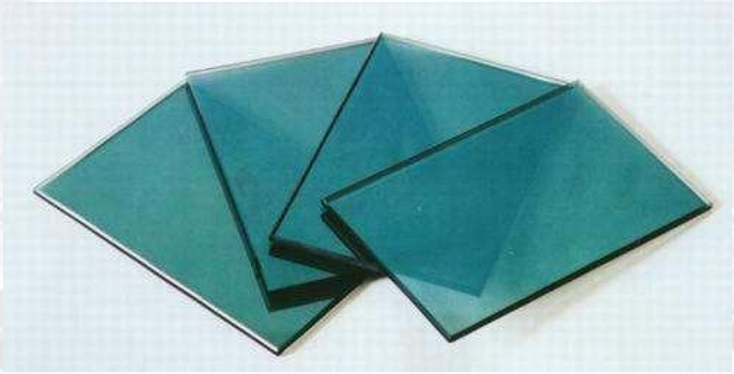
FACTORS INFLUENCING SOLAR HEAT GAIN

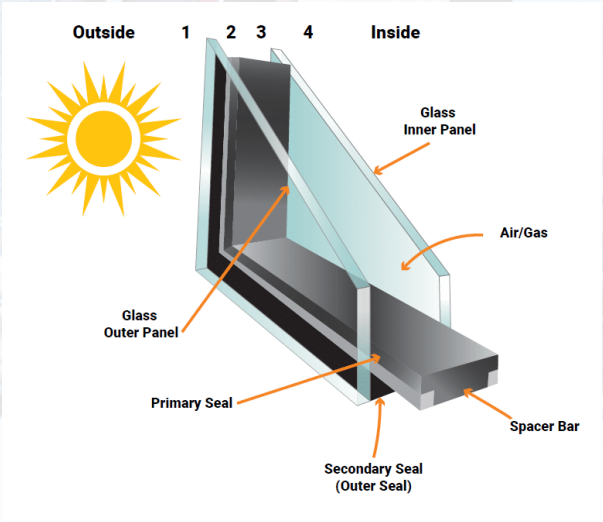
- Building orientation
- Glazed area : Window to wall ratio
  They can be between 0% - 40% or 40% - 60%
- Shading devices – External & Internal
- Properties of the glazing

HOW TO REDUCE SOLAR HEAT GAIN THROUGH GLAZING

- Reflective Coated Glass : Use of low emissivity coatings on glass

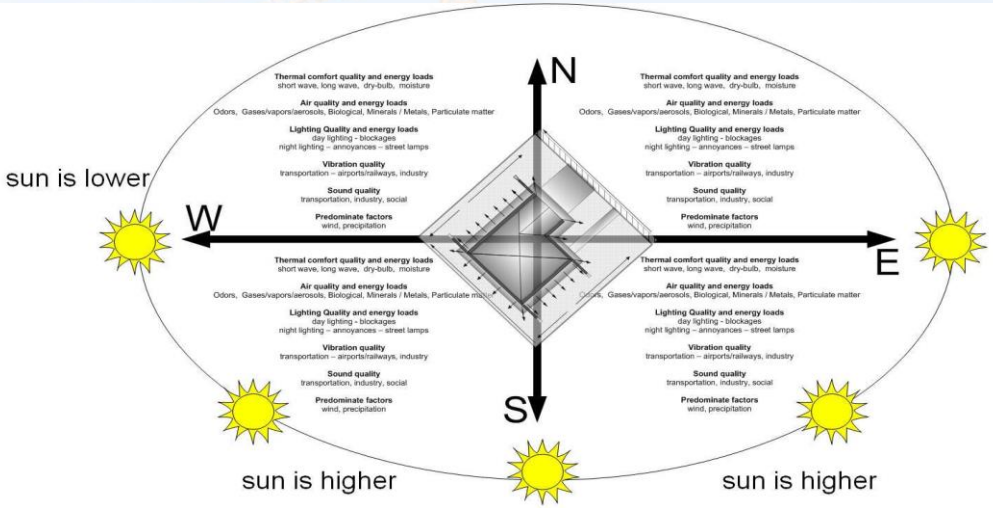
- Insulated Glass Units :
  - ➢ Increasing width of air space by providing double glazing (outer glass is coated and inner glass is clear with 12mm air space between them)
  - ➢ Use of inert gas in Insulated Glass Unit (IGU)

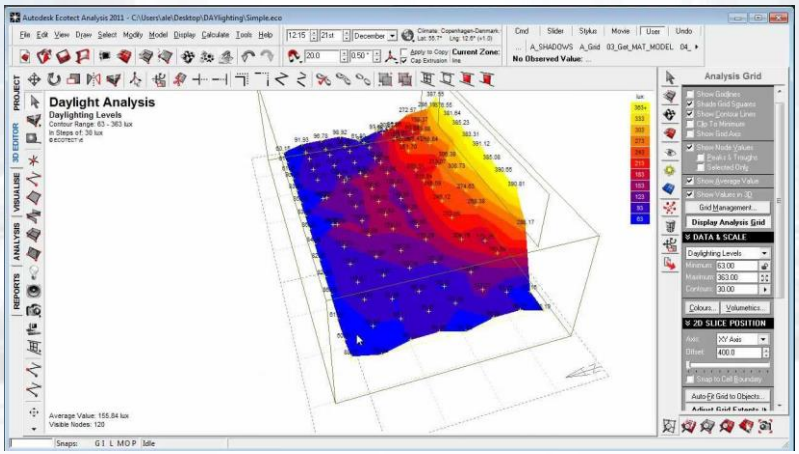


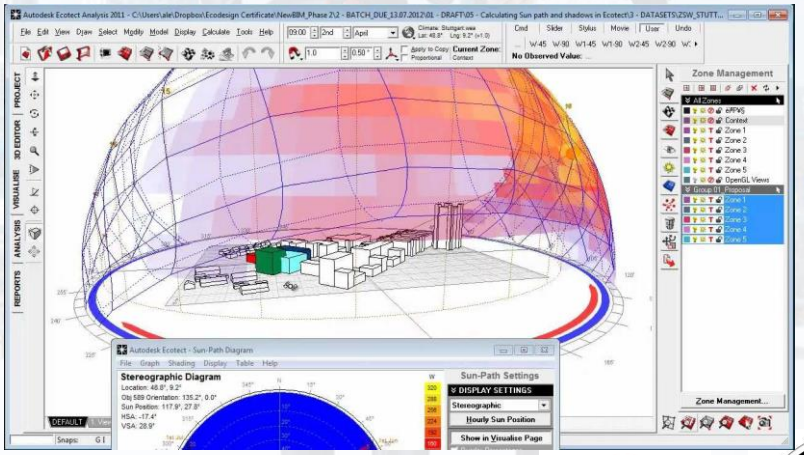


ANALYSIS FOR SELECTION OF GLAZING

- Building orientation analysis
- Sun path analysis
- Site shadow analysis
- Solar exposure analysis
- Daylight analysis
- Acoustic analysis







ENERGY CONSERVATION USING THE RIGHT GLASS AND GLAZING

- On controlling the thermal heat transfer through the glazing provided by using the right Solar Heat Gain Constant and U Value, we can reduce the cooling loads in buildings

- On utilizing the daylight by controlling the transmittance of light through glass and adopting proper window to wall ratio, we can reduce the need and usage of artificial lighting

REDUCING GLARE THROUGH GLAZING

Glare results from excessive contrast of illumination, or from an excess of illumination in the field of view. Ways to reduce glare :

- Reduce Visual Light Transmission of the glazing to 60%
- Use of shading devices
- Re-orienting the glazing to avoid direct solar radiation
- Increasing illumination by means of more windows
- Reducing contrast between window and its surroundings
- Provision for allowing more daylight by daylight panes/light shelves

FENESTRATION DAYLIGHT REQUIREMENTS AS PER ECBC

The Energy Conservation Building Code (ECBC), was launched by Ministry of Power, Government of India in May 2007, as a first step towards promoting energy efficiency in the building sector.

Building Category	Percentage of above grade floor area meeting the UDI requirement		
	ECBC	ECBC +	Super ECBC
Business, Educational	40%	50%	60%
No Star Hotel Star Hotel Healthcare	30%	40%	50%
Resort	45%	55%	65%
Shopping Complex	10%	15%	20%
Assembly*	Exempted		

UDI : useful daylight illuminance – 90% of daylight time has to be within the range of 100 to 2000lux level.

Vertical fenestration assembly U-factor and SHGC requirement for ECBC buildings

	Composite	Hot and dry	Warm and humid	Temperate	Cold
Maximum U factor (W/m2k)	3	3	3	3	3
Maximum SHGC Non-North	0.27	0.27	0.27	0.27	0.62
Maximum SHGC North for latitude ≥ 15°N	0.5	0.5	0.5	0.5	0.62
Maximum SHGC North for latitude < 15° N	0.27	0.27	0.27	0.27	0.62

TEST REQUIREMENTS FOR GLAZING

- Energy performance parameters to be tested on coated glass/IGU

Visible Light Transmittance	*Light Reflectance (Internal and External)*
Solar Direct Transmittance	*Solar Direct Reflectance (Internal and External)*
Solar Direct Reflectance (Internal and External)	*UV Transmittance*
SHGC	*U value*
Shading coefficient	*Relative Heat Gain coefficient*

- Tests for durability
  - Condensation resistance : For coated glass
  - Acid resistance/salt spray analysis
  - Abrasion resistance

SAFETY RELATED TO HUMAN IMPACT

According to NBC 2016, a safety glass is one that

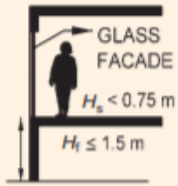
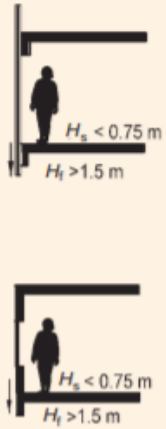
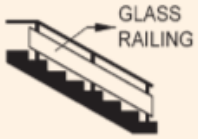
- Does not break under most likely forms of human impact
- Even on breaking, the likelihood of cutting and piercing will be minimized

Further the NBC 2016 does not deal with safety and security of people or goods in relation to risks of

- Vandalism, riots, burglary or break in protection
- Fire arm protection
- Protection from explosion such as a terrorist attack
- Natural disasters
- Plastic glazing material, safety and security glazing, etc.

Table 30 Type of Glass Suggested for Use at Different Critical Locations/Cases in Buildings

(Clause 7.3)

CASE 1 Vertical Walls with Residual Protection or $H_s \geq 0.75$ (not Likely to be Subjected to Human Impact) (1)	CASE 2 Vertical Walls $H_s < 0.75$m and $H_f \leq 1.5$m (Human Impact but no Risk of Fall) (2)	CASE 3 Vertical Walls $H_s < 0.75$m and $H_f > 1.5$m (Human Impact and Risk of Fall) (3)	CASE 4 Horizontal or Sloped Glazing Glass (Risk of Fall) (4)	CASE 5 Glass Acting as a Balustrade/ Railing (Human Impact and Risk of Fall) (5)
				
Type of glass: Any glass[1]	Safety glass	Safety glass[2]	Laminated safety glass	Laminated safety glass
Examples: Residual protection is the safeguard provided to avoid the impact of human being on glass. It is provided on the side of the glass where there are chances of human impact. It can be achieved by providing protection in the form of a sill structure or transom, chair rail or grill work inside	a) Doors b) Side panels c) Curtain walls d) Glazed area e) Doors in bathroom 1) Fully framed 2) Partially framed 3) Frameless f) Façade g) Windows h) Internal partitions and doors j) External facade and doors on ground floor, above floor with terrace outside.	a) Curtain walls b) Façade c) Spandrels d) High activity area e) High risk area f) To avoid risk	a) Roof (Skylights) b) Ceilings c) Bus shelters d) Floors e) Stairs f) Sloped facade	a) Balustrades b) Balcony c) Railings

[1] Safety glass is not mandatory.
[2] Laminated float glass is preferred.

TEST REQUIREMENTS FOR SAFETY GLASS AS PER NBC 2016

Table 31 Test Requirement
(Clause 7.6.1)

Sl No.	Requirements	Laminated Safety Glass	Toughened Safety Glass	Test Requirement as per
(1)	(2)	(3)	(4)	(5)
i)	Impact/ Resistance to shock	YES	YES	Accepted Standard [6-8(5)]
ii)	Fragmentation test	—	YES	
iii)	Warp test	—	YES	
iv)	Boil test	YES	—	
v)	Fracture and Adhesion test	YES	—	
vi)	Light stability test	YES	—	
vii)	UV light test	YES (for glass used in the exterior portions and subject to natural light)	—	
viii)	Shot bag impact test	YES	YES	*see* Annex E

NOTES

1 Bake test (high temperature) and humidity test may also be carried out as an option to determine the characteristics of laminated safety glass.

2 Surface compression test, four point bending test and waviness may also be carried out to determine such characteristics.

PERFORMANCE CRITERIA FOR GLAZING SYSTEM

- Design Parameters :
- Loading – Wind load, Dead load, Live load, Seismic load, load combinations
- Deflection and allowable stresses for glass and frame
- Movements – Horizontal movements due to earthquakes, vertical movements due to wind speed, thermal expansion and contraction, deflection
- Impact resistance
- Resistance to fire
- Acoustics and sound insulation
- Energy performance
- Structural stability and safety
- Visual comfort
- Air infiltration
- Water penetration

CONCLUSION

Glass and glazing systems play a vital role in buildings. Their use in buildings has increased manifolds in the recent times. Glass facades not only provide an aesthetically appealing view to a building and psychologically and physiologically increasing the well being of the occupants but also conserving energy used by the building.

The inclusion of 'Glass and Glazing' in the Part 6 Structural Design Section 8 of the National Building Code 2016 is indeed useful in the selection of type of glazing required considering key factors like building location, orientation and height, type of application of the glass, the properties of the glass etc.

India is a fast growing nation and over 100+ airports use glass facades for their terminals. As a civil engineer, the knowledge on glass and glazing and its design is vital. There is a lot of scope for façade engineers in the current scenario.

REFERENCES

- National Building Code 2016
- NPTEL Videos
- Study Materials from CMTI
- CMTI Connect - YouTube Videos