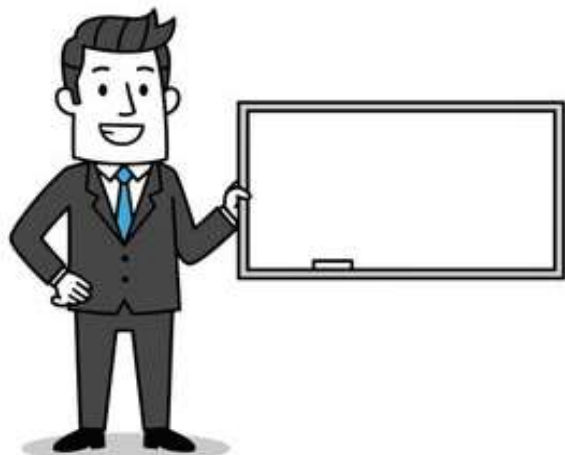




INDIAN STANDARDS FOR PATTERN AND SOLAR GLASS



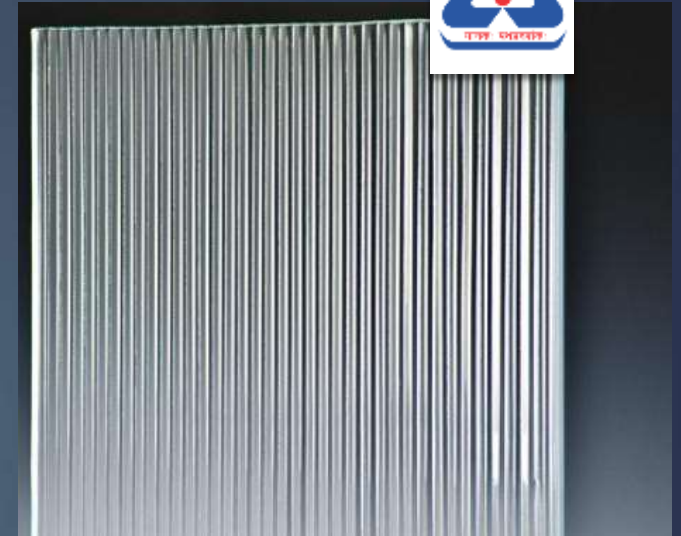
MOHIT GARG

SCIENTIST-C/DEPUTY DIRECTOR

BUREAU OF INDIAN STANDARDS

PATTERNED GLASS

- ❑ Patterned glass is a type of **decorative glass** which is characterized by textures or patterns embossed onto one or both sides of a glass pane.
- ❑ This makes it **translucent** and able to diffuse light.
- ❑ Also known as **textured glass** or **figured glass**.
- ❑ Its features make it ideal for enhancing the **aesthetic appeal** and **privacy** of a home/office.



APPLICATIONS:

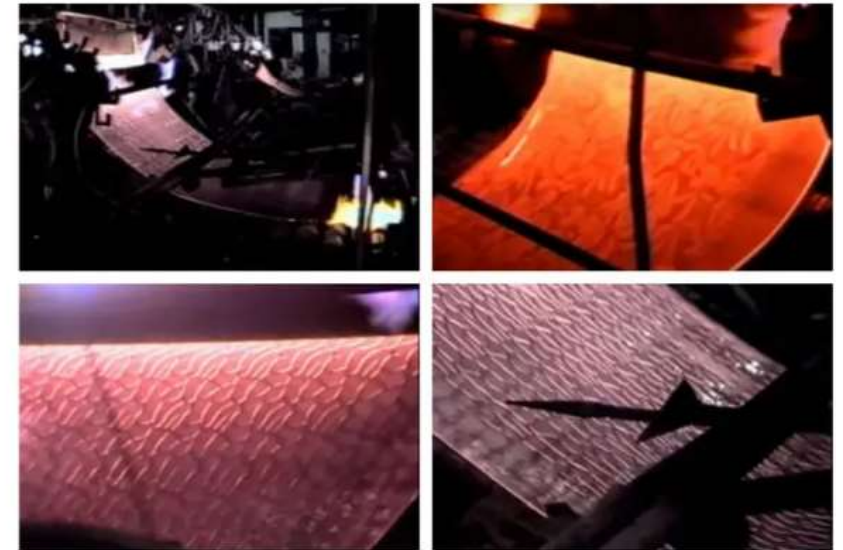
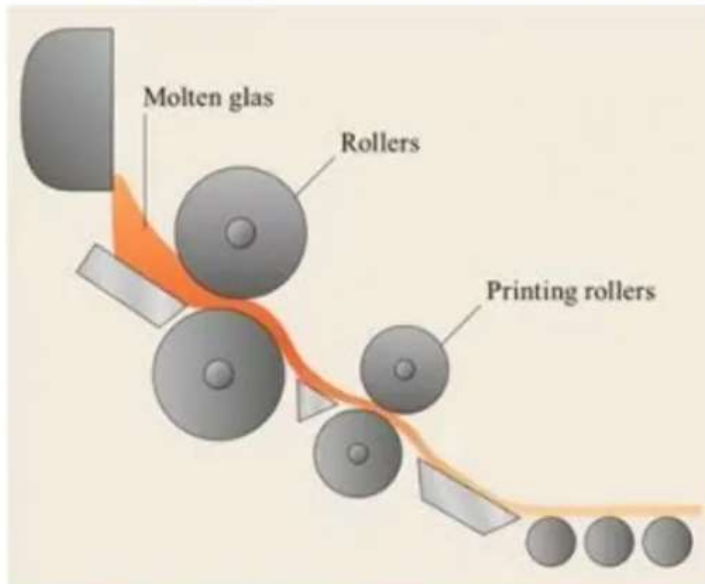
- ✓ Doors and Windows
- ✓ Bathroom and Shower Enclosures
- ✓ Office Partitions
- ✓ Furniture and Cabinets
- ✓ Interior Decorative Glazing

WHY PATTERNED GLASS?

- ✓ Enhances privacy without blocking natural light
- ✓ Improves architectural aesthetics
- ✓ Offers versatile decorative applications



Patterned Glass – Manufacturing



Pattern glass is made by feeding molten glass between rollers which bear a negative impression of the desired pattern, which transfers this pattern onto one or both sides of the glass. After rolling, the glass is allowed to cool before being cut into the intended shape.



Patterned Glass - Specification

IS 5437: 2024 specifies the requirements for patterned glass:

Dimensional Requirements:

- ✓ Nominal Thickness
- ✓ Tolerance on Final Cut Sizes
- ✓ Squareness

Visual Faults Requirements:

- ✓ Spot Faults
- ✓ Elongated Spot Faults
- ✓ Linear/Extended Faults

Specific Requirements:

- ✓ Warpage
- ✓ Pattern Faults

5.1.1 Nominal Thickness

- Average of four measurements at the thickest and closest point to the centre of each side.
- Micrometer or calipers, which is graduated to 0.01 mm.
- Tolerances as specified in Table 1.

NOTES:

1 There may be other nominal thicknesses also as agreed to between the manufacturer and the purchaser, however in such cases the tolerance for just below nominal thickness shall be considered. Example, for nominal thickness of 7 mm, a tolerance of ± 0.5 shall be considered.

2 Thickness shall be measured at the crest of the design.

Sl No.	Nominal Thickness (mm)	Tolerance (mm)
(1)	(2)	(3)
i)	< 2	± 0.1
ii)	2	± 0.2
iii)	2.5	± 0.2
iv)	2.8	± 0.2
v)	3	± 0.2
vi)	3.2	± 0.2
vii)	3.5	± 0.2
viii)	4	± 0.3
ix)	5	± 0.5
x)	6	± 0.5
xi)	8	± 0.8
xii)	10	± 1.0
xiii)	12	± 1.5
xiv)	14	± 1.5
xv)	15	± 1.5
xvi)	19	± 2.0





Table 2 Tolerances on Nominal Dimensions (Length and Width)

(Clause 5.1.2.1)

SI No.	Nominal Thickness, t	Tolerance, v		
		$(H, B) \leq 1\ 500$	$1\ 500 < (H, B) \leq 3\ 000$	$(H, B) > 3\ 000$
(1)	(2)	(3)	(4)	(5)
i)	$t \leq 6$	± 2	± 3	± 4
ii)	$6 < t \leq 10$	± 3	± 4	± 5
iii)	$10 < t \leq 19$	± 4	± 5	± 6

NOTE — All dimensions are in mm.

Table 3 Maximum Limit on the Difference Between the Diagonals

(Clause 5.1.2.2)

SI No.	Nominal Thickness, t	Maximum Limit on the Difference Between Diagonals		
		$(H, B) \leq 1\ 500$	$1\ 500 < (H, B) \leq 3\ 000$	$(H, B) > 3\ 000$
(1)	(2)	(3)	(4)	(5)
i)	$t \leq 6$	3	4	5
ii)	$6 < t \leq 10$	4	5	6
iii)	$10 < t \leq 19$	5	6	8

5.1.2.1 Tolerances on final cut sizes

- The deviations from nominal dimensions width (W) and length (H) shall be within the limits as specified in the Table 2.
- Shall be measured with a steel scale (tape) which is graduated to 1 mm.
- The measurement shall be made on adjacent two sides.

5.1.2.2 Squareness

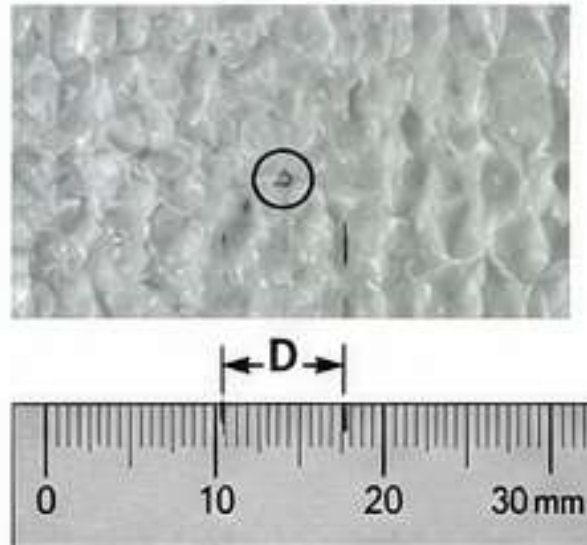
- The difference between the diagonals of the glass pane shall not be more than the values specified in the Table 3.

ANNEX A

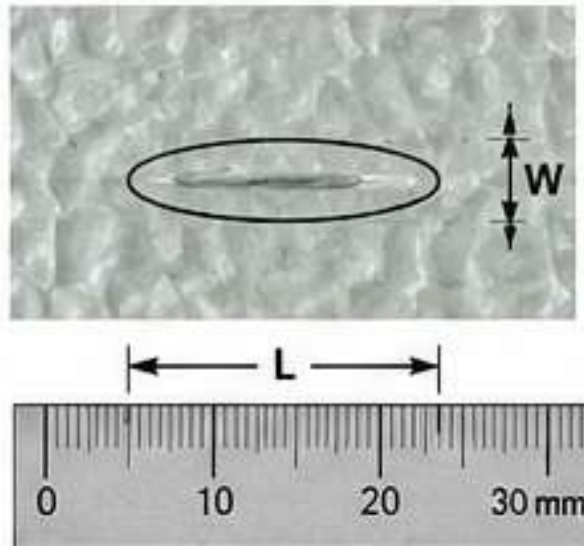


- The glass pane to be examined shall be illuminated in conditions approximating to diffuse daylight and shall be observed in front of a matt grey screen.
- The glass pane to be examined shall be placed vertically, 3 m in front of the screen and parallel to it. The point of observation shall be at a distance of 1.5 m from the glass, keeping the direction of observation normal to the glass surface.
 - a) For spot faults, measure the maximum diameter (D).
 - b) For elongated/linear faults, measure the maximum length (L) and maximum width (W) at right angles to the length.
 - c) Use a transparent scale placed on the glass surface.

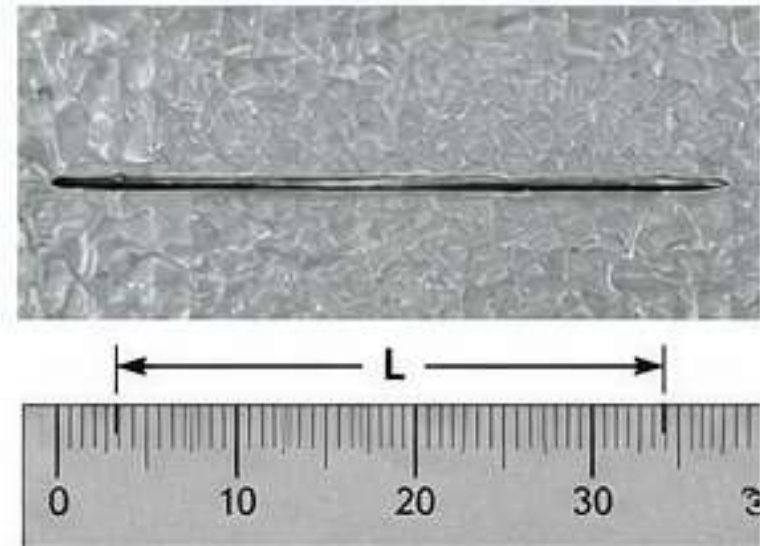
SPOT FAULT



ELONGATED SPOT FAULT



LINEAR / EXTENDED FAULT



5.2.1 Spot Faults



- It is a nucleus, which is generally accompanied by halo of distorted glass. The dimension of the spot fault comprising of nucleus with a halo is obtained by multiplying the dimension of the nucleus by factor of approximately 3. Spot faults can be solid inclusions, bubbles, rubs, crush etc.
- Spot faults are categorized based on their size and determined as per Annex A.
- The maximum permissible number of the different size of spot faults are specified in Table 4.

Table 4 Allowable Number of Spot Faults

(Clause 5.2.1)

Sl No.	Dimension of Spot Fault, mm	Allowable Number per m ² , <i>max</i>
(1)	(2)	(3)
i)	≤ 0.5	Any
ii)	> 0.5 and ≤ 1.5	6
iii)	> 1.5 and ≤ 3.0	2
iv)	> 3.0	0





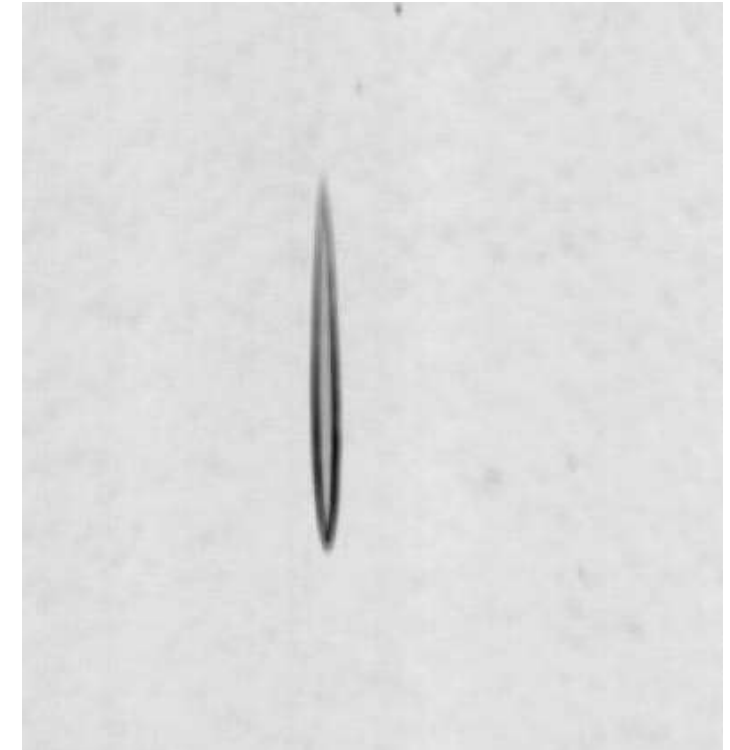
5.2.2 Elongated Spot Faults

- A distorted *spot fault* whose larger dimension is more than twice the smaller dimension.
- Elongated Spot faults are categorized based on their size and determined as per Annex A.
- The maximum permissible number of the different size of elongated spot faults are specified in Table 5.

Table 5 Allowable Number of Elongated Spot Faults

(Clause 5.2.2)

Sl No.	Width of Fault, mm	Length of Fault, mm	No. of Elongated Spot Faults, <i>Max</i>
(1)	(2)	(3)	(4)
i)	≤ 1	≤ 10	4
ii)	≤ 1	> 10 and ≤ 15	2
iii)	≤ 1	> 15	0
iv)	> 1 and ≤ 2	≤ 10	2
v)	> 1 and ≤ 2	> 10	0
vi)	> 2	—	0



5.2.3 Linear/Extended Fault

- Faults which can be on or in the glass, in the form of deposits, marks or scratches which occupy an extended length or area.
- Determined as per Annex A.
- Maximum permissible number specified in Table 6.

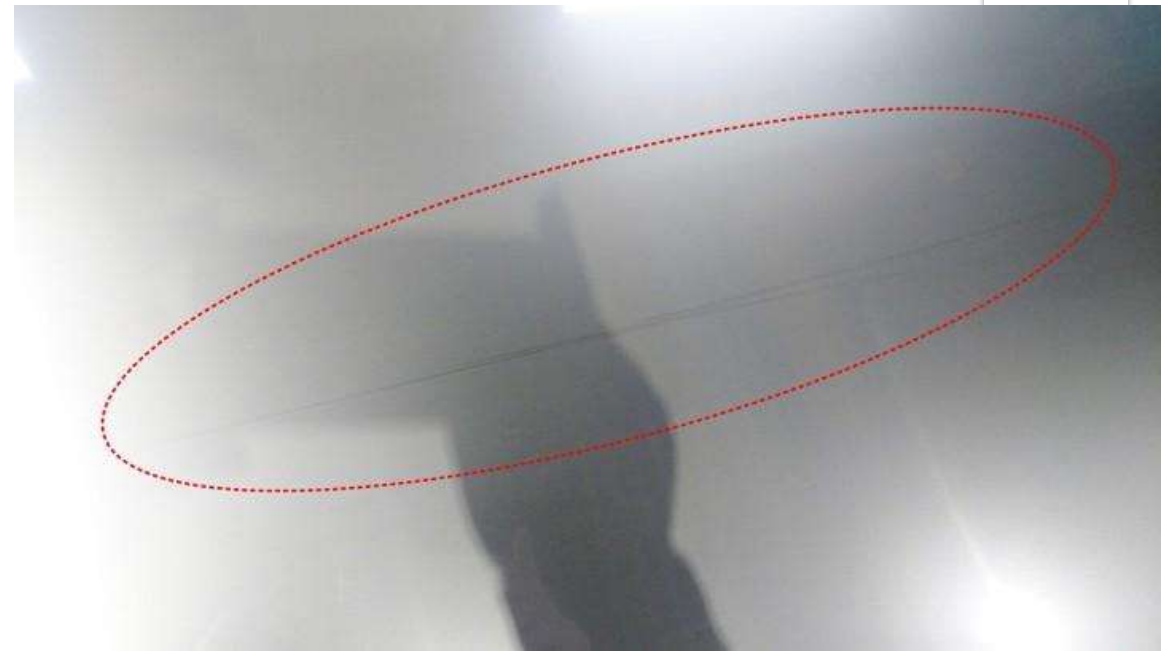


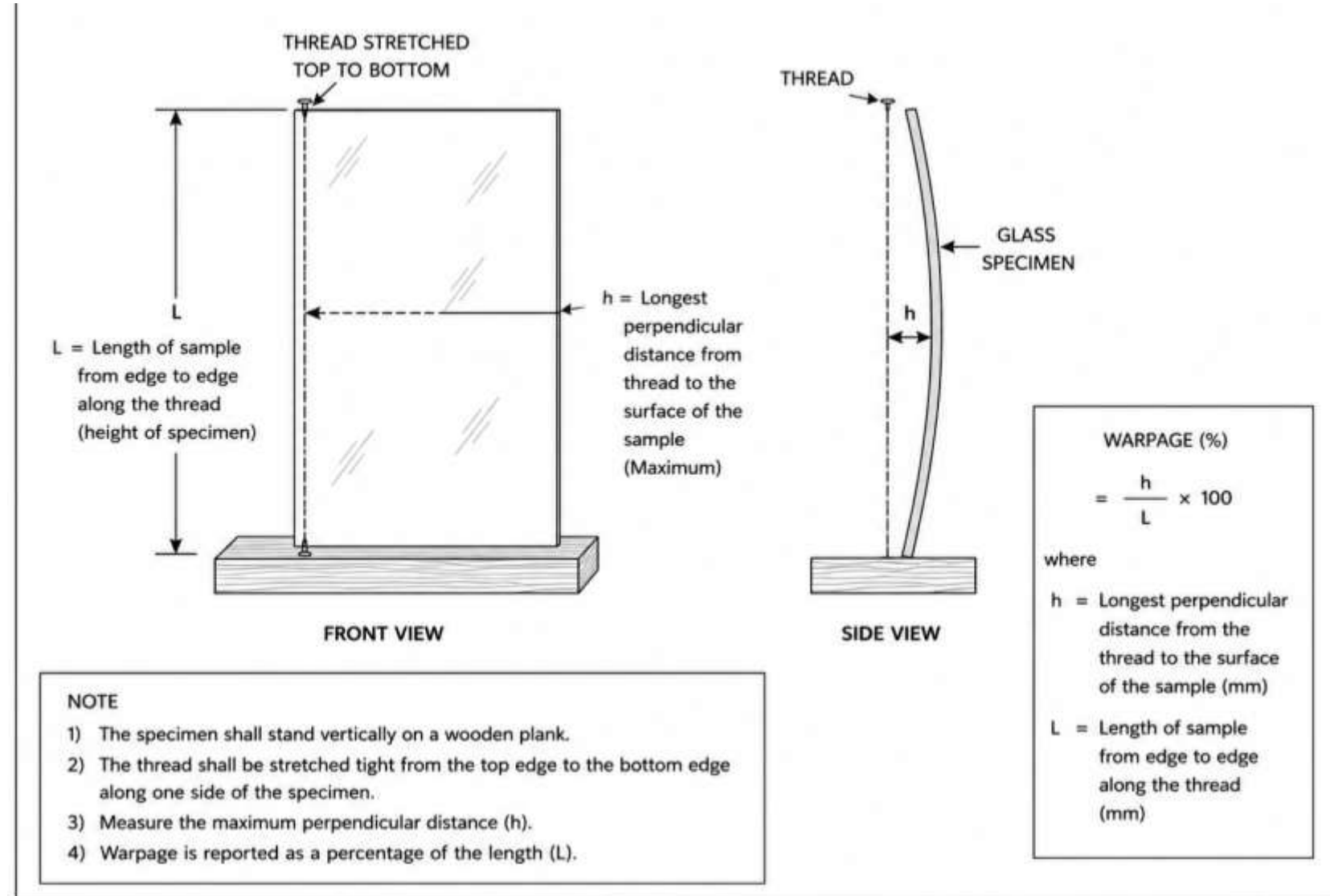
Table 6 Allowable Number of Linear/Extended Faults

(Clause 5.2.3)

Sl No.	Width of Fault, mm	Length of Fault, mm	No. of Elongated Spot Faults, <i>Max</i>
(1)	(2)	(3)	(4)
i)	≤ 1	≤ 5	4
ii)	≤ 1	> 5 and ≤ 10	2
iii)	≤ 1	> 10 and ≤ 15	1
iv)	≤ 1	> 15	0
v)	> 1	—	0

5.2.4 Warpage

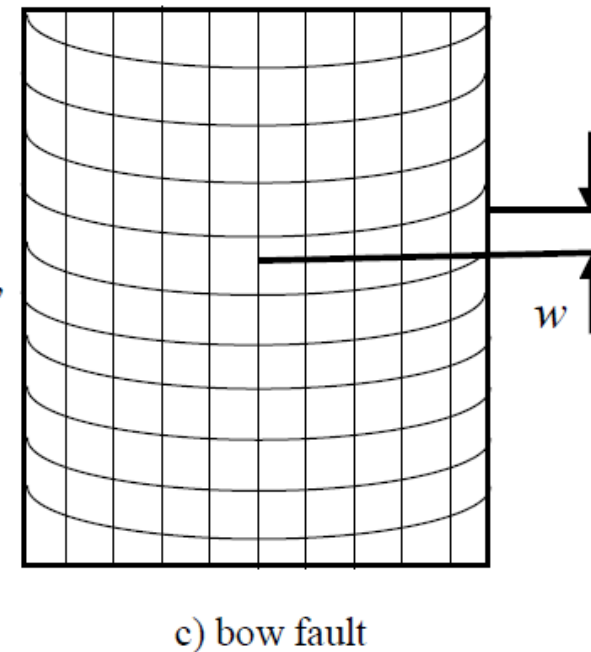
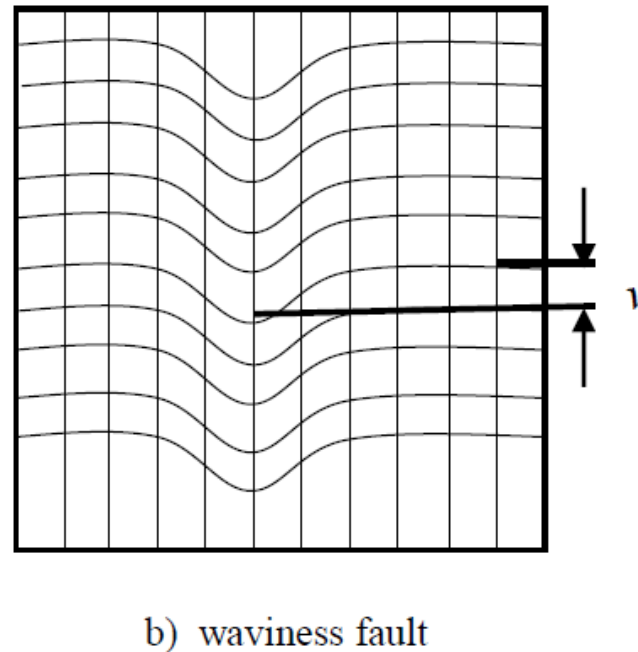
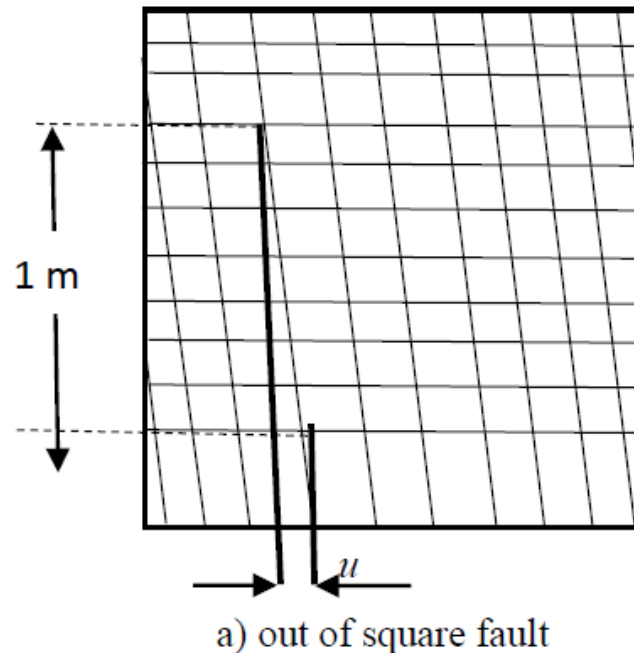
- Warpage shall be measured with the specimen standing vertically on a wooden plank.
- Stretch a thread edge to edge of the sample. Measure the longest perpendicular distance from the thread to the surface of the sample facing the thread and express it as percentage of the length of sample from edge to edge along the thread.
- Warpage shall not be more than 1 percent.





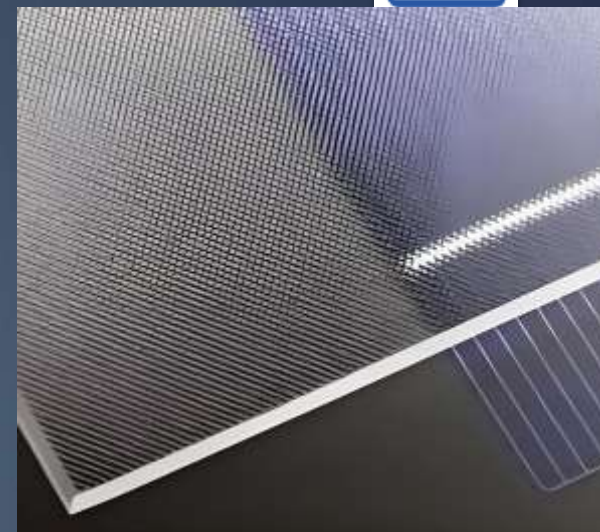
6.1 Pattern Faults

- Pattern faults may be of the following three types; (a) out of square, (b) waviness and (c) bow.
- All of these faults may occur simultaneously.
- To measure these faults, a reference, for example, line or straight edge, is placed on the glass as shown in the fig. The deviations, u , v or w of the pattern in relation to this reference are measured.
- Pattern faults shall not be more than 12 mm/m.



EXTRA CLEAR PATTERNED GLASS

- ❑ A type of **patterned glass** which is characterized by **low iron content** and **high light transmittance**.
- ❑ This category was introduced specifically for use in **solar applications**.
- ❑ Low iron content minimizes the **absorption of solar radiation** and **reduces the natural green tint** of glass, resulting in **higher optical clarity and solar transmittance**. Consequently, more sunlight reaches the photovoltaic cells, improving the power output and energy yield of the solar module.
- ❑ **Micro-textured patterns** such as Mist (Mistlite), Nashiji (pear-skin), random micro-texture, and micro-prismatic patterns. These surface textures typically have a pattern depth ranging from **20 μm to 200 μm** .
- ❑ The micro-patterned surface **reduces reflection losses** and **enhances light scattering**, allowing more sunlight to enter the photovoltaic cells.





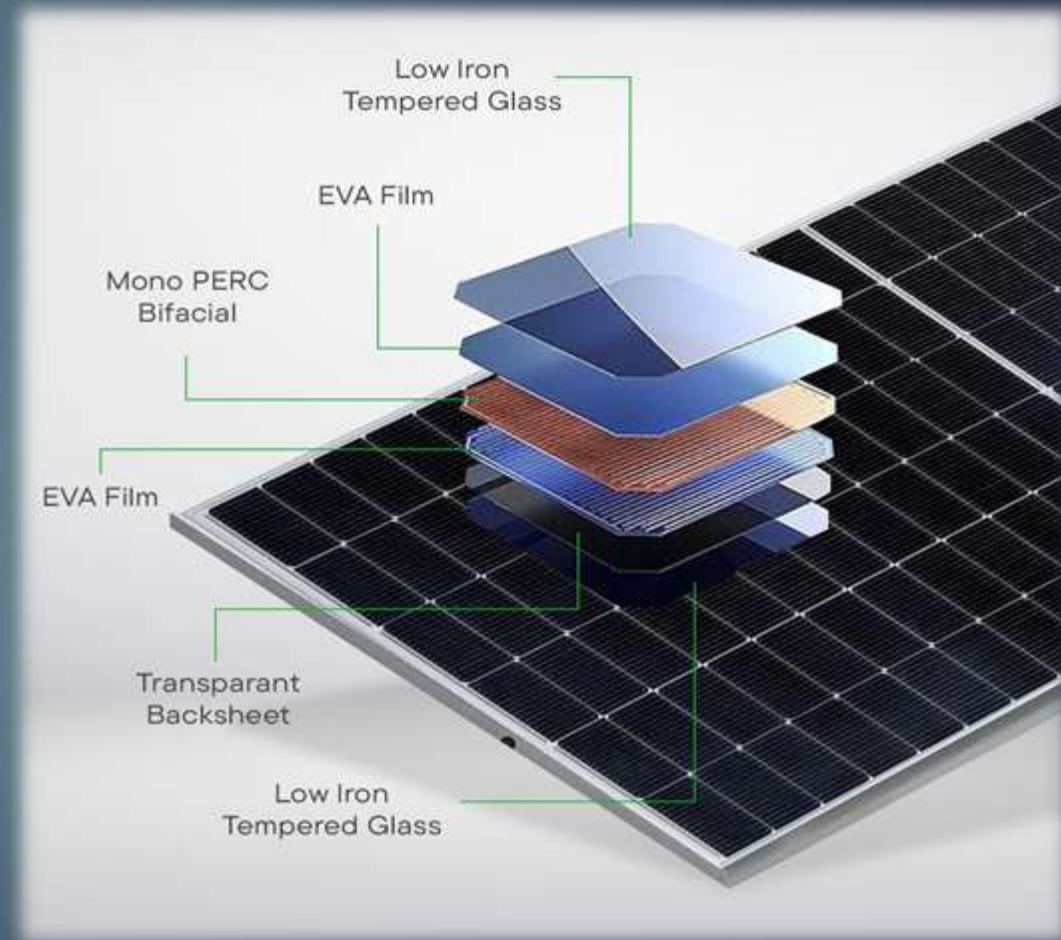
Extra Clear Patterned Glass - Specification

Additional Requirements:

- ✓ **Iron Content** – The iron content when determined and calculated as Fe_2O_3 shall not exceed **120 ppm**.
- ✓ **Antimony Content** – The antimony content shall not exceed **3000 ppm**.
- ✓ **Hydrolytic Resistance** – When tested and graded in accordance to IS 2303 (Part 1/Sec 2), the grade of glass shall be equal to or better than **HGA 2**.
- ✓ **Light Transmission** – The light transmission values shall not be less than **91.5 percent** in 380 nm to 1100 nm wavelength range.
- ✓ **Solar Direct Transmittance** – The solar direct transmittance values shall not be less than **90.5 percent** in 380 nm to 2500 nm wavelength range.

SAFETY GLASS FOR SOLAR APPLICATIONS

- ❑ Solar glass is a high-performance, low-iron glass specifically engineered to maximize solar light transmission while providing mechanical strength, environmental protection, and long-term durability for photovoltaic and solar thermal energy systems.
- ❑ Specifications are given in IS 2553 (Part 3): 2026.
- ❑ Two types of Solar Safety Glasses:
 - Toughened Glass
 - Heat Strengthened Glass (shall be used only in glass to glass laminates)





Solar Safety Glass - Specification

IS 2553 (Part 3): 2026 specifies the requirements for safety glass for solar applications:

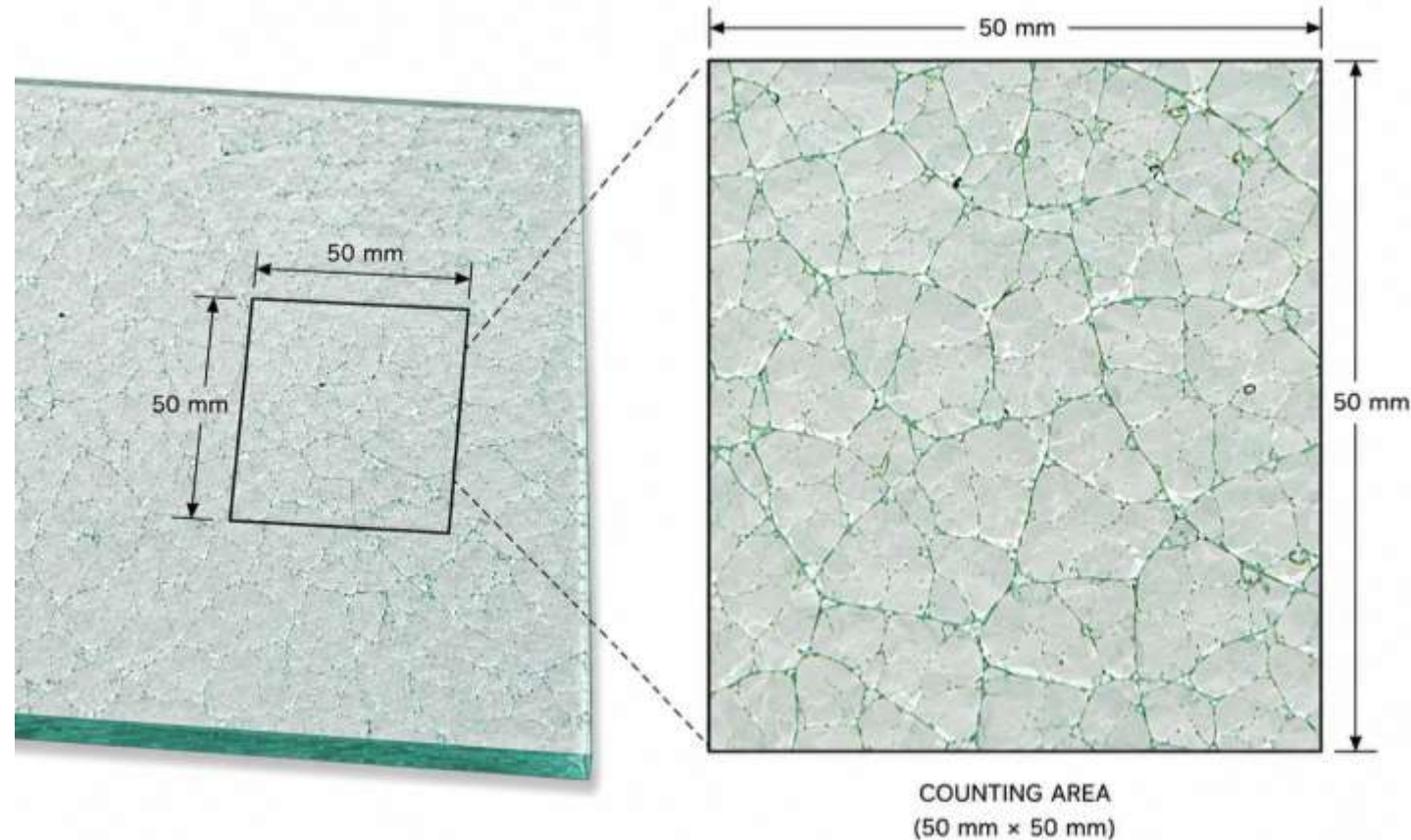
- 1) Raw Material
- 2) *Dimensional Requirements*
- 3) Fragmentation
- 4) Compressive Stress Measurement
- 5) Mechanical Strength
- 6) *Flatness*
- 7) Resistance to Shock (Ball Drop Test)
- 8) *Fabrication in Glass*
- 9) *Light Transmission*
- 10) *Solar Direct Transmission*

5.1 Raw Material

- For photovoltaic modules, the raw glass shall conform to '**extra clear patterned glass**' type specified in IS 5437.
- For solar flat plate collector, the raw glass shall conform either to **IS 14900** or '**extra clear patterned glass**' type specified in IS 5437.

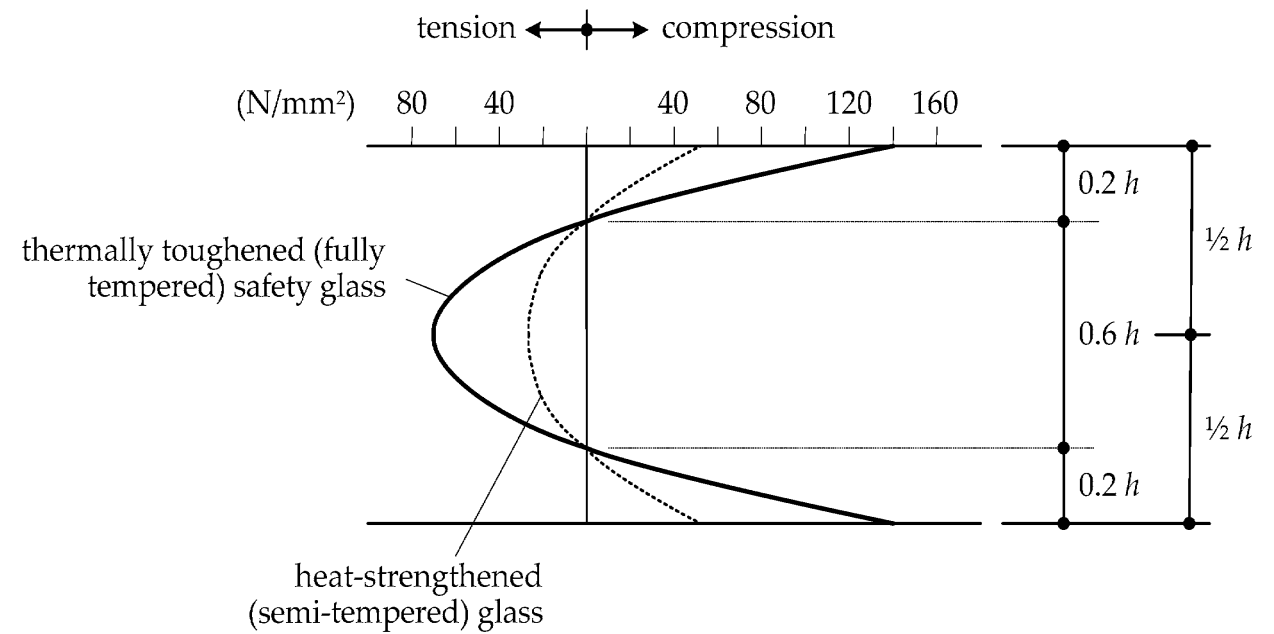
5.3 Fragmentation

- On event of breakage the minimum particle count in 50 mm x 50 mm square shall not be less than:
 - a) 15, if glass thickness < 4 mm
 - b) 40, if glass thickness ≥ 4 mm



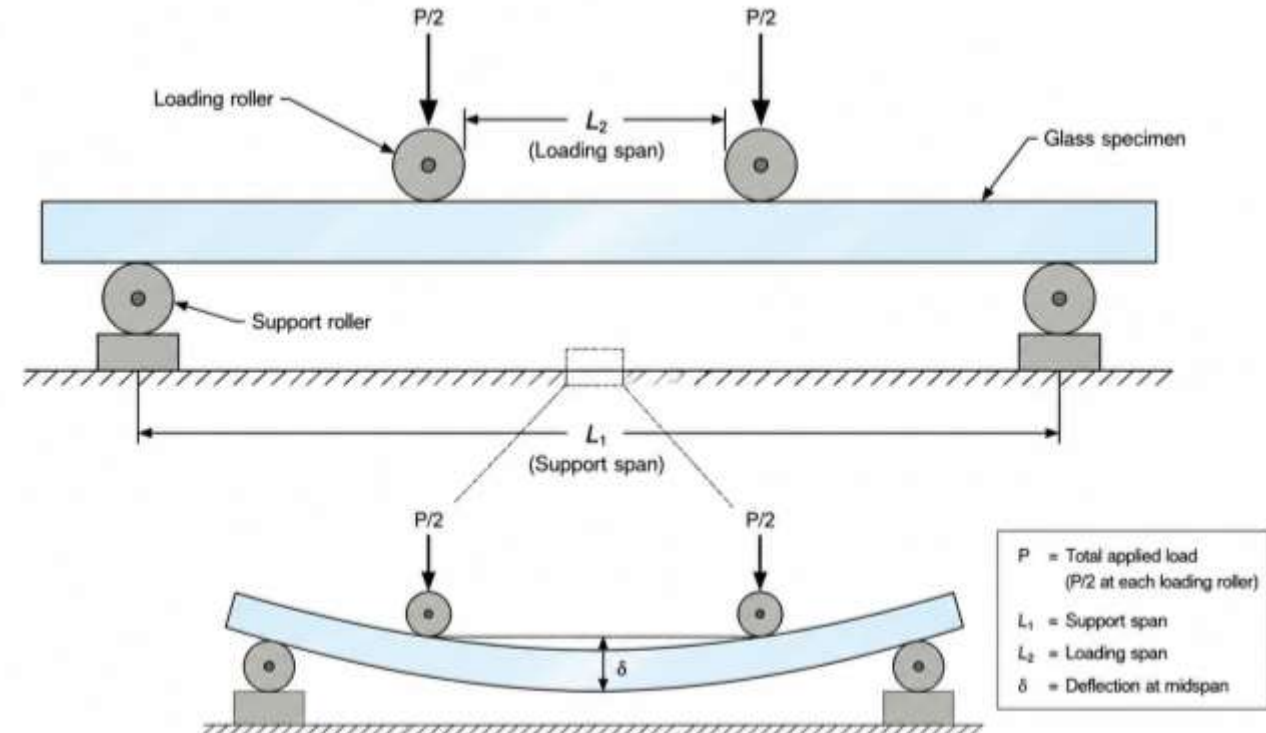
5.4 Compressive Stress Measurement

- Tested as prescribed in **6.5** of IS 17004.
- The toughened glass shall have a minimum surface compression of **69 MPa** (10 000 psi).
- The heat strengthened glass shall have a minimum surface compression of **31 MPa** (4500 psi).



5.5 Mechanical Strength (Four point bending)

- Tested as prescribed in **6.3** of IS 17004.
- The minimum mechanical strength shall be:
 - a) Float Toughened Glass: **120 MPa**.
 - b) Patterned Toughened Glas: **90 MPa**.
 - c) Heat Strengthened Glass: **70 MPa**.



5.7 Resistance to Shock (Ball Drop Test)

- Tested as per the procedure prescribed in **6.2.1** of IS 17004.
- *For Toughened Glass:* Dropping a steel ball of mass (227 ± 5) g from height of **100 cm**.
- *For Heat Strengthened Glass:* Dropping a steel ball of same mass from a height of **80 cm**.





THANK YOU

ANY QUESTIONS ?

YOU CAN FIND US AT:

chd10@bis.gov.in

