

AR12 – 52 BUILDING CONSTRUCTION MATERIALS & STRUCTURAL SYSTEM- IV

MODULE 1(10HRS)

GLASS

Glass is an **amorphous solid** which is often transparent & has widespread uses.

It is hard, is **easily moulded** into shapes

Glass has been a fascinating material to humankind since it was first made in about 500 BC.

It is one of the **most versatile and oldest materials** in the building industry.

USE OF GLASS IN ARCHITECTURE

FACADES

BUILDING FENESTRATIONS

Windows , Doors (Sliding , Fixed)

CLADDINGS

Structural glazing.

CONSTRUCTION

CANOPIS / ROOF/ SKY LIGHT

PARTITION WALLS

STAIRCASE

BEAMS & FLOORINGS

Glass products

TYPES OF GLASS

- Wired glass,
- fiber glass,
- laminated glass,
- glass building blocks,
- Heat strengthened glass- toughened glass, laminated glass

SPECIAL PURPOSE GLASSES

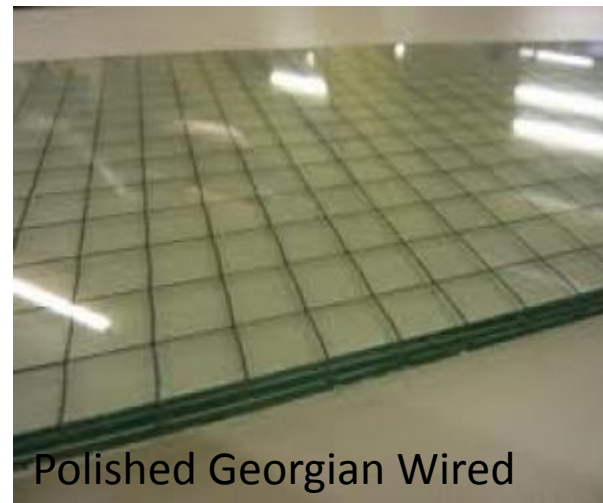
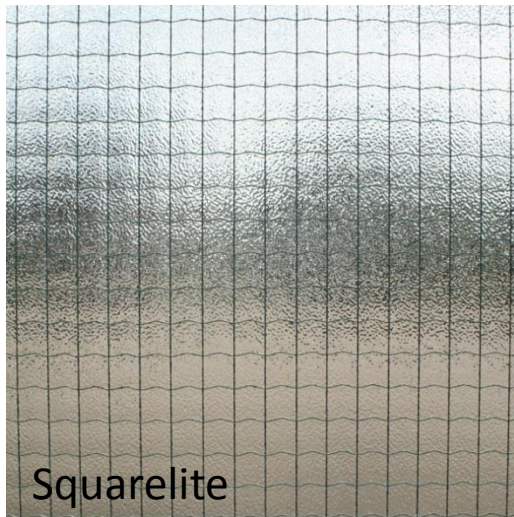
- Low emissivity glass,
- Solar control glasses and
- Variable transmission glass,
- Fire resistant glass,
- Self cleaning glass their properties and uses in buildings

GLAZING:

- Single, double and triple glazing
- Glazed curtain walls & sky lights.
- Sketches : Structural glazing

Wired glass

- Wired glass has 13mm square electrically welded steel wire mesh sandwiched in its centre during the manufacturing process.
- It is commonly used in fire rated windows and doors to the maximum sizes and FRR times as tested by the manufacturers. It is a Grade B safety glass.
- Squarlite is a stippolite pattern providing privacy and Polished Georgian Wired is clear class.
- Standard and stocked in 6mm Squarlite, 6mm Polished Georgian Wired.



WIRED GLASS

- Wired glass is used as a safety glass as it prevents glass from falling during fire emergencies.
- Glass is reinforced with wire mesh to make it more fire-resistant and durable as compared to float glass.
- Wired glass, which is also known as Georgian wired glass, was invented by Frank Shuman.
- Steel wire mesh is placed in the glass during the manufacturing process.
- The wire mesh acts as a reinforcement. If the glass breaks due to impact, the pieces of glass are held by wire reinforcement in position.
- Wired glass has high resistance to fire as it does not break when exposed to fire.
- Due to such property, it is also called fire-rated glass or fireproof glass.
- Thus in areas which are prone to fire, people prefer to install wire glass windows rather than float glass windows.
- The wire mesh is available in square grids as well as diamond grids.
-



Size & Thickness:

- Wired glass is available in thickness ranging from 6 mm to 19 mm.
- The standard size of glass sheets is 1370 mm x 1370 mm.
- The maximum size of wired glass sheet available is 1981 mm x 2540 mm.

ADVANTAGES OF WIRED GLASS:

- Due to wire mesh present in the glass, wired glass blocks fire and some to enter the building for some time.
- This provides people sufficient time to escape from the building and thus it helps in preventing life damage in case of fire emergencies.
- Wired glass can break through impact, but the fragments of glass stick to the wire mesh and hence help in preventing a burglary or a theft.

WIRED GLASS



DISADVANTAGES OF WIRED GLASS:

- Placing of wire into the glass makes it actually weakens the glass from the strength standpoint and makes it more susceptible to breaking.
- Upon breakage, the **sharp wires** in the glass are exposed, which may cause serious injuries to persons in the vicinity of the glass. Hence it is not recommended to install wire glass windows in areas where kids are frequently visiting such as schools, institutions, vicinity of gardens, etc.
- If a **clear view** is desired, wired glass cannot be used as wires in the glass obstruct and distort the view.
- Wired glass does not have high durability in areas which are exposed to more rain and humidity, as the wire in the glass will rust eventually.

WIRED GLASS - application

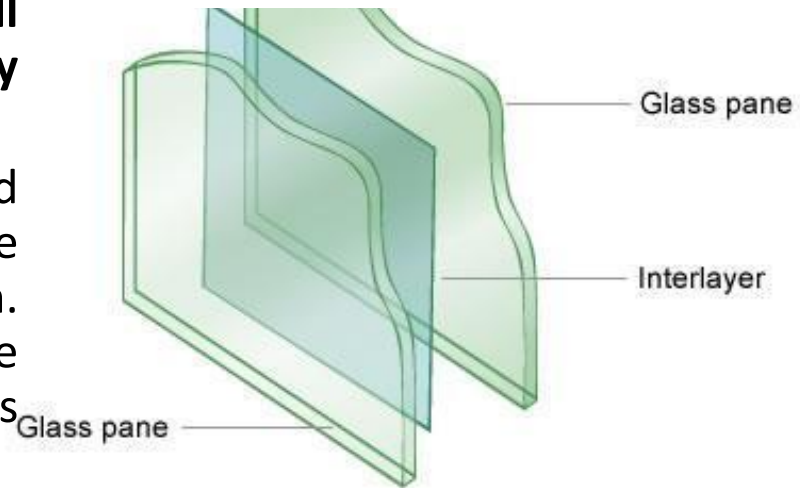
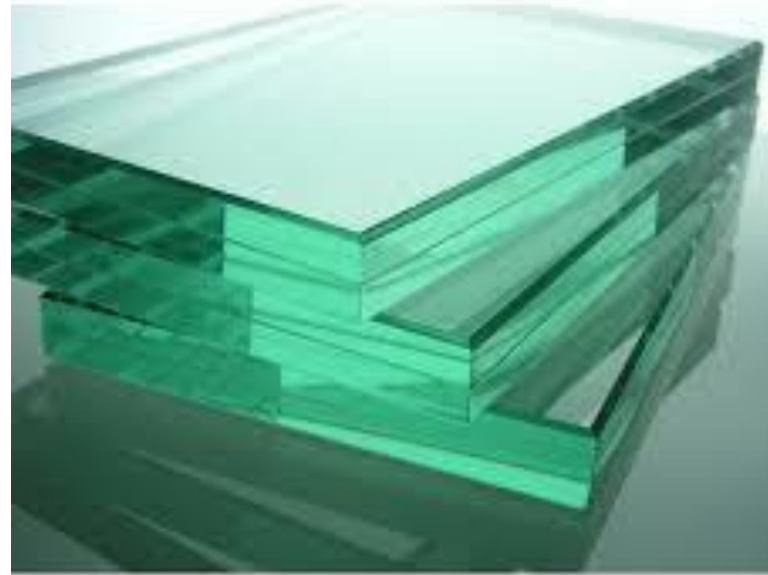
- It is widely used in places where nominal fire resistance properties are required.
 - Wired glass is generally installed in windows of fire escape routes of the structure, to gain time for evacuating people in case of fire emergencies.
 - Windows in stairwells and in hallways are prime examples of emergency exits where fire rated wire glass is a smart addition.
 - It is used in roofs, skylights, fire resisting doors and windows.
- **Applications:**
 - - Overhead glazings
 - - Interior partitions
 - - Bathing areas
 - - Glazed doors and side panels
 - - Stairs, landings and balustrades

LAMINATED GLASS

- It is a combination of layers of normal glass.
- Laminated glass is a type of safety glass that holds together when shattered.
- The interlayer keeps the layers of glass bonded even when broken.
- Weight more, has more thickness, UV proof and sound proof.

PVB membrane has good tenacity performance and when the laminated glass breaks due to violent force, the **PVB will absorb a large amount of impact energy and disperse it rapidly.**

Therefore, it's **hard to break** the laminated glass and the shape of the glass may be maintained even if being broken. Furthermore, personnel inside and outside the buildings will not be hurt by the glass fragment.



LAMINATED GLASS



- In the event of breaking, it is held in place by an interlayer, typically of polyvinyl butyral (PVB) or ethylene-vinyl acetate (EVA), between its two or more layers of glass.
- The interlayer keeps the layers of glass bonded even when broken, and its high strength prevents the glass from breaking up into large sharp pieces.
- This produces a characteristic spider web cracking pattern when the impact is not enough to completely pierce the glass.
- In the case of the EVA, the thermoset EVA, offers a complete bonding (cross-linking) with the material whether it is glass, polycarbonate, PET, or other types of products.

LAMINATED GLASS

Properties of Laminated Glass:

Properties	Annealed	Tempered	Laminated
Alteration	Possible	Not possible	Possible
Risk of Injury	High	Low	Low
Impact Resistance	Low	High	Low
Optical Distortion	Low	High	Low
Environment Control	No	No	Yes, protects from UV rays
Acoustic Insulation	No	No	Yes
Heat Insulation	No	Yes with reflective coating	Yes with reflective coating

- Sizes upto 3000 X 5000 mm.
- A full range of clear, tinted and reflective glass combinations and thickness.
- Clear PVB of 0.38mm, 0.76mm and multiples of 0.38 mm thickness.
- Colored PVB on special bulk orders.
- Diverse glass combinations available in single and double glazing.

LAMINATED GLASS

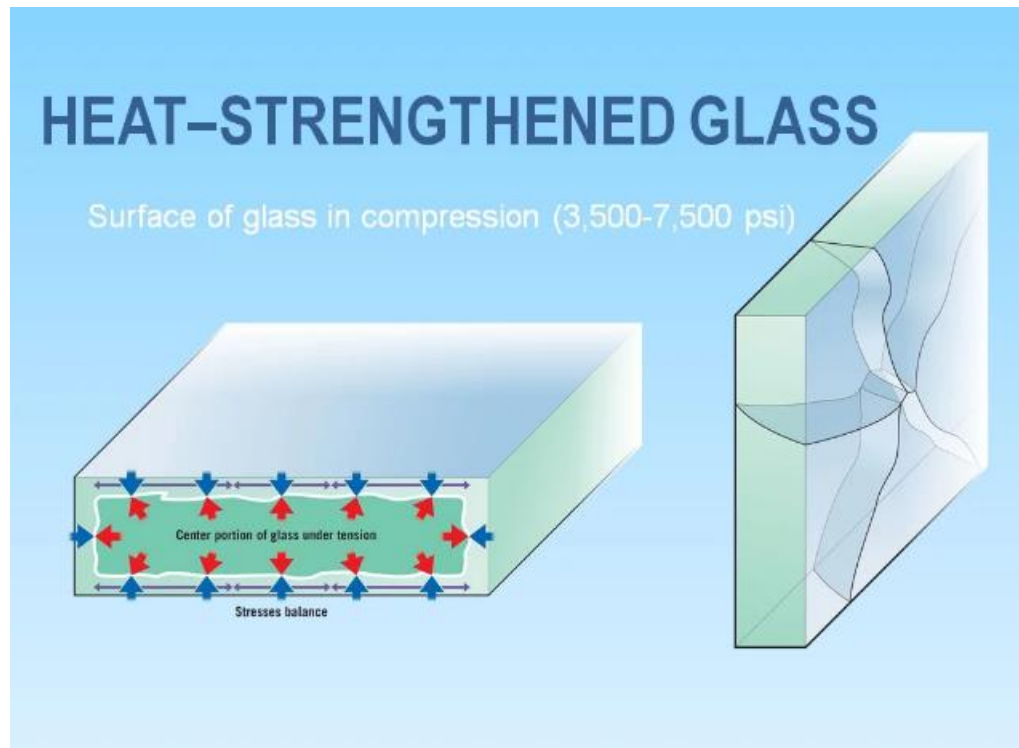
LAMINATED	3210 X 2550	7.5 & 11.5mm
	6000 X 3210	6.4, 6.8, 8.8, 10.8 & 12.8mm
WHITE LAMINATED	3210 X 2550	6.4 & 10.8mm
SOFTCOAT LAMINATED	6000 X 3210	6.4, 8.8 & 10.8mm
LAMINATED SILENCE	6000 X 3210	6.8, 8.8, 10.8 & 12.8mm
LAMINATED HARDCOAT	6000 X 3210	8.8 & 10.8mm
LAMINATED MIRROR ONE WAY	3005 X 1900	6.8mm

glass building blocks

Heat strengthened glass- toughened glass

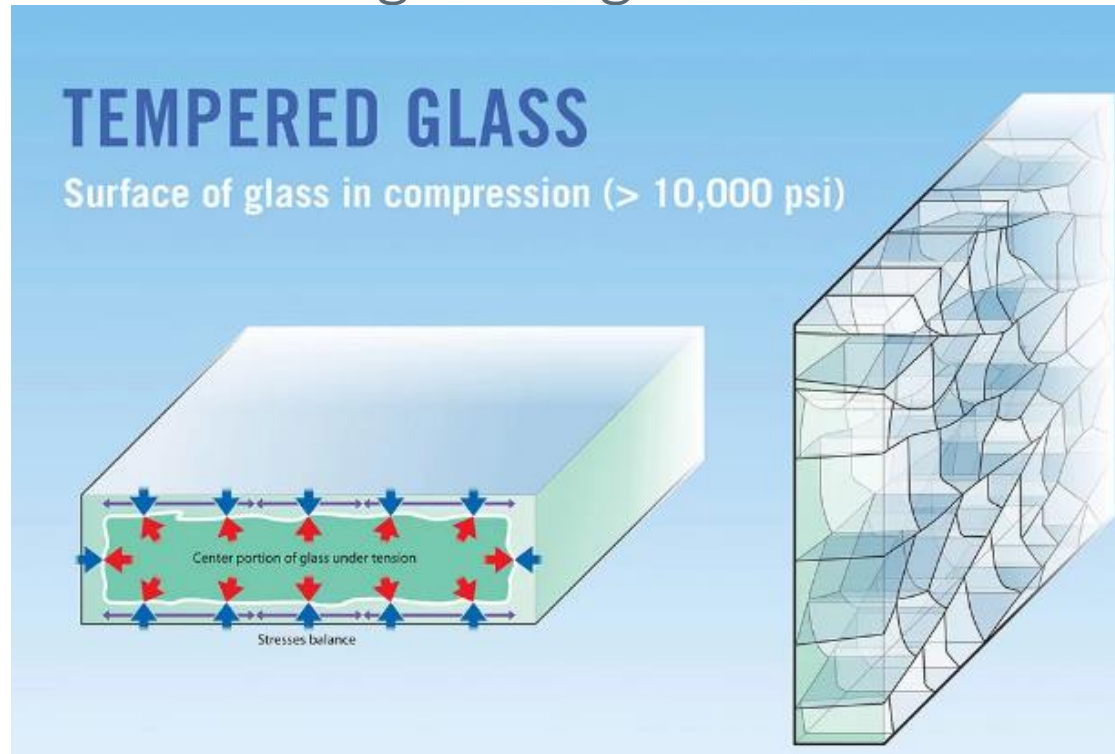
- Heat strengthened glass is treated to be more resistant to breakage than simple annealed glass.
- It undergoes a similar process to toughened glass but the resultant surface compression is not high enough to result in the production of small pieces when the glass is broken.
- It is normally used in applications that are subject to thermal stress or require increased strength.
- Heat strengthened glass cannot be cut after it has been strengthened.

Heat strengthened glass



- Heat-strengthened glass is typically specified when additional strength is needed to resist wind pressure, thermal stress or both, and the additional strength or safety break pattern of fully tempered glass is not required.
- Another advantage of heat-strengthened glass is that when broken, the glass fragments are more similar in size and shape to annealed glass fragments and thus tend to stay in the opening longer than fully tempered glass particles.
- Although heat-strengthened glass is NOT a safety glazing by building code, this breakage pattern prevents the glass from falling and injuring someone

Tempered Glass - Toughened glass



- Safety glazing, when broken, fractures into relatively small pieces, thereby greatly reducing the likelihood of serious cutting or piercing injuries in comparison to ordinary annealed glass.
- For some applications, such as glass in doors, tub and shower enclosures and fixed glass in close proximity to a walking surface, fully-tempered safety glass is required by building codes and ordinances.
- Fully-tempered safety glass is often used for other applications where its strength and/or safety characteristic are desirable, such as table tops, counter tops, showcase enclosures, refrigeration and food service equipment, furniture and similar applications.
- Fully-tempered glass also is used in applications when significant additional strength is needed to resist wind pressure, thermal stress or both.

Tempered Glass - Toughened glass



- Toughened Glass (Tempered Glass) Toughened glass is treated to be far stronger and more resistant to breakage than simple annealed glass, and to break in a more predictable way when it does break, thus providing a major safety advantage when compared to annealed glass in almost all of its applications.
- Toughened glass is made from annealed glass treated with a thermal tempering process.
- Toughened glass has increased mechanical resistance to breakage, and when it does break, causes it to produce regular, small fragments.
- Toughened glass also has an increased resistance to breakage as a result of stresses caused by different temperatures within a pane.
- Toughened glass has extremely broad application in products both for buildings and for automobiles and transport, as well as other areas.
- Car side and rear windows, glass portions of building façades, glass sliding doors and partitions in houses and offices, glass furniture such as table tops, and many other products typically use toughened glass.
- Products made from toughened glass often also incorporate other technologies, especially in the building and automotive and transport sectors. Toughened glass cannot be cut after it has been toughened.

Tempered Glass - Toughened glass

COATED GLASS

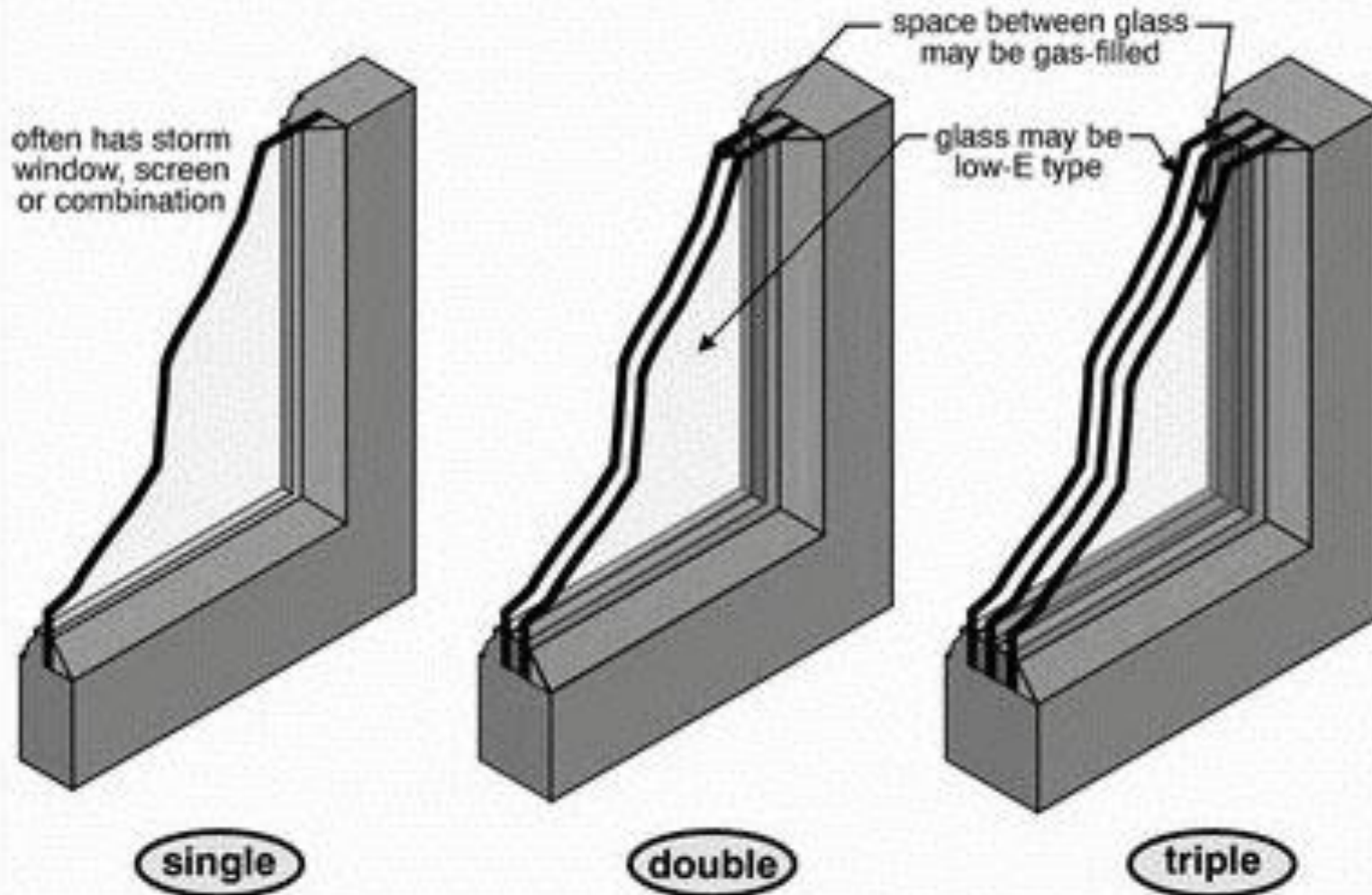
HARD COAT TOUGHENED	6000 X 3210	4 & 6mm
SOFT COAT TOUGHENED	6000 X 3210	4mm
K SOFT COAT TOUGHENED	6000 X 3210	4mm
'K' OPTI-WHITE (LOW IRON) TOUGHENED	6000 X 3210	4 & 6mm
LOW E 1.0 TOUGHENED	6000 X 3210	4 & 6mm
P.F.N 1.2 TOUGHENED	6000 X 3210	4mm
PLANIBEL A TOUGHENED	3210 X 2550	4mm
CLIMAGUARD A TUFF	6000 X 3210	4mm
GUARDIAN CLARITY (ANTI REFLECTIVE GLASS)	6000 X 3210	6 – 10mm

GLAZING:

- Single, double and triple glazing
- Glazed curtain walls & sky lights.
- Sketches : Structural glazing

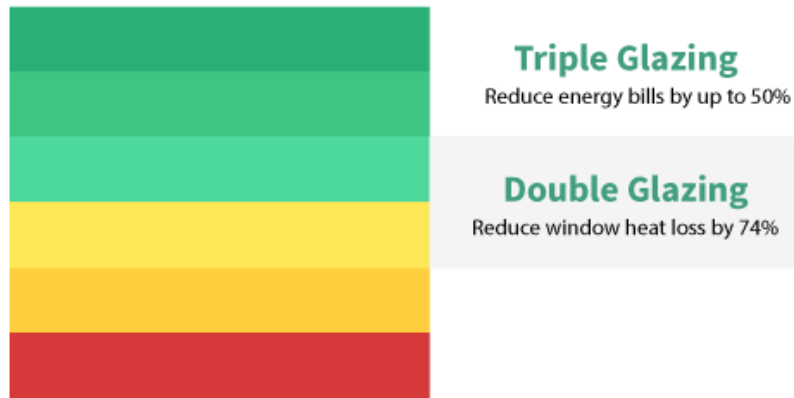
GLAZING

Glazing types



- **Single glazed** windows basically just keep the rain and wind out.
- **Double glazing** is the installation of two sheets of glass, with spacer bars fixed around the edge to keep the panes apart. Between the two glass sheets is a layer of insulated air; this air space is often filled with an inert gas such as argon.
- Double and triple glazing provides MUCH higher levels of insulation than single glazing, as heat is trapped within the panes. The gap between panes is often filled with air, but sometimes inert gasses (e.g. nitrogen or argon) are used to boost the insulative properties.
- These insulative layers of air found in double and triple glazing slow down convection and conduction between the warmer indoor pane and the cooler outdoor pane. As a result, heat energy escapes your home more slowly, keeping your house warmer for longer.

Double and Triple Glazing



Double or triple glazing must be viewed as an investment that will reap rewards in the future by reducing the money you spend on your energy bills

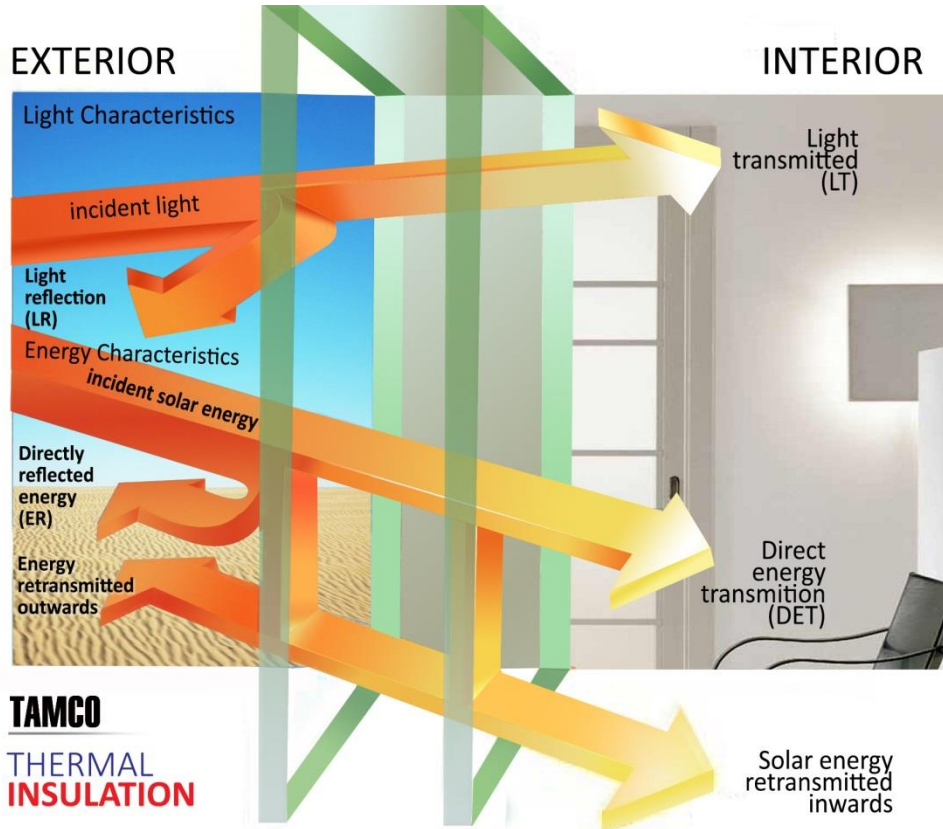
- U-VALUES
- Thermal transmittance can be expressed as the U-value. Simply put, the higher the U-value, the more heat a window loses. Generally, the U-values are;
- Single glazing: 5
- Double glazing: 3
- Triple glazing: 0.8 – 1.6

Double Glazing

- Bonding of two panes with the use of aluminum spacer at the edges and sealing the joint.
- Air is trapped in the cavity. The desiccants filled in the aluminum spacer absorbs the moisture thus making it dry air.
- This is very important to avoid condensation inside the double glazed unit.
- The cavity can also be filled with inert gas like argon or krypton to get better insulation. The cavity can vary from 6mm to 20mm.



Triple Glazing



- Double & Triple Glazing maximizes **heat reflection technology** on exterior panes, allowing natural light to enter while still ensuring the highest degree of heat insulation.
- With Double & Triple Glazing its possible to:
- Lower the overall uValue
- Ensure that light still enters
- Reflect much of the heat from outside

Double and triple glazing

Additional benefits of double or triple glazing over single glazing systems:

- MUCH better insulation.
- MUCH better acoustic absorption.
- Added security through multiple panes which are also more difficult to break through.

Drawbacks of multiple glazing

- Higher cost.
- Interstitial condensation can occur if window seals fail, giving rise to the window fogging up and sometimes becoming dirty from the inside.
- More expensive to replace if broken.



CURTAIN WALL

- A non-load bearing external wall supported from the frame.
- Serve primarily as an enclosure.
- Supported by the structural system, such walls need to be strong enough to carry only their own weight and wind pressure on the e
- Nonbearing walls may be supported on the structural frame of a building, on supplementary framing (girts or studs, for example) in turn supported on the structural frame of a building, or on the floors.
- For the curtain wall framing box or solid members of steel or aluminum alloy are normally employed.
- To meet requirements, curtain walls may vary in construction from a simple siding to a multilayer-sandwich wall.
- They may be job-assembled or be delivered to the job completely prefabricated.



FUNCTIONAL REQUIREMENTS OF CURTAIN WALLS

1. Provide the necessary resistance to penetration by the elements.
2. Have sufficient strength to carry own self weight and provide resistance to both positive and negative wind pressures.
3. Provide required degree of fire resistance glazed areas are classified in the Building Regulations as unprotected area, therefore any required fire resistance must be obtained from the infill or undersill panels and any backing wall or beam.
4. Be easy to assemble, fix and maintain.
5. Provide the required degree of sound and thermal insulation.
6. Provide for thermal and structural movements.
7. The exterior surface of a curtain wall should be made of a durable material, capable of lasting as long as the building. Maintenance should be a minimum; initial cost of the wall is not so important as the life-cycle cost (initial cost plus maintenance and repair costs).

COMPONENTS OF CURTAIN WALL

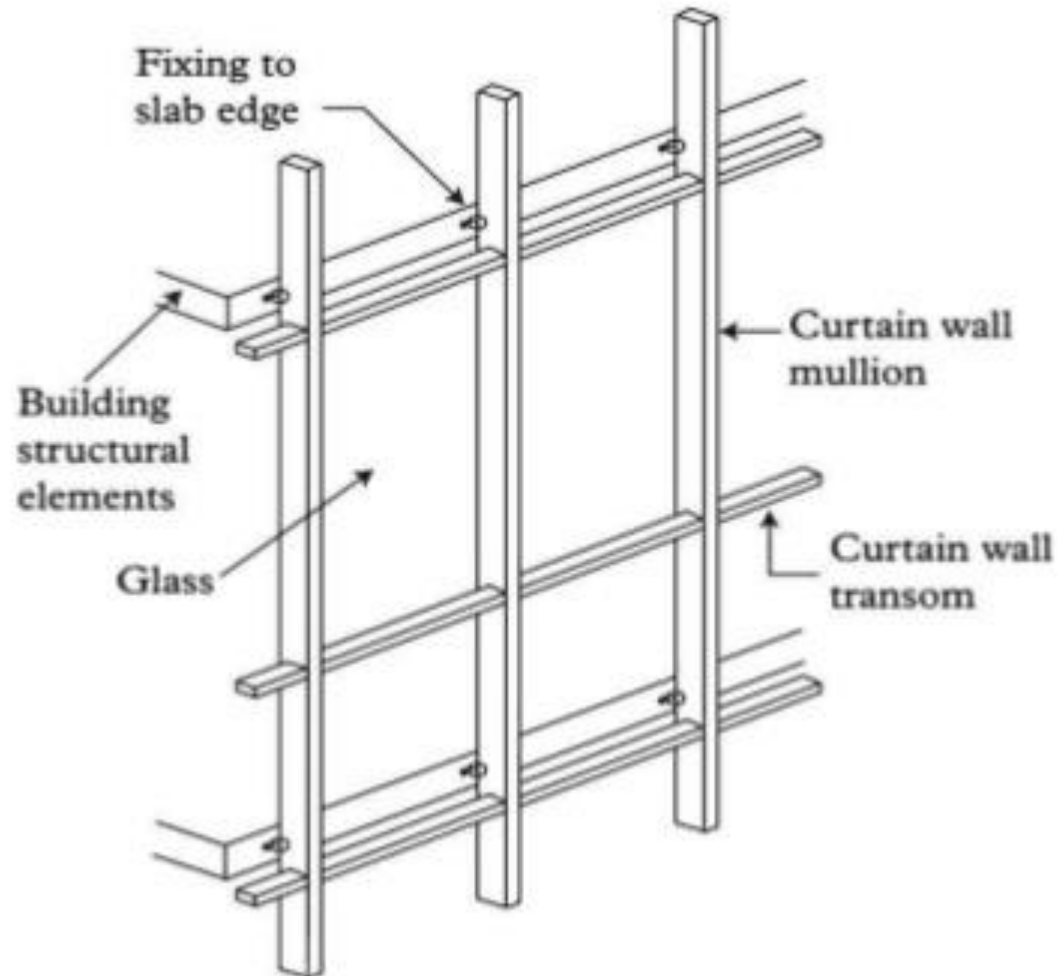


Fig 3:Components

TYPES OF INSTALLATION SYSTEMS

Stick-built curtain wall system

- ▶ Installed piece by piece at site
- ▶ Thermal expansion and contraction of mullions are accommodated by expansion joints
- ▶ System components are shop fabricated and shipped

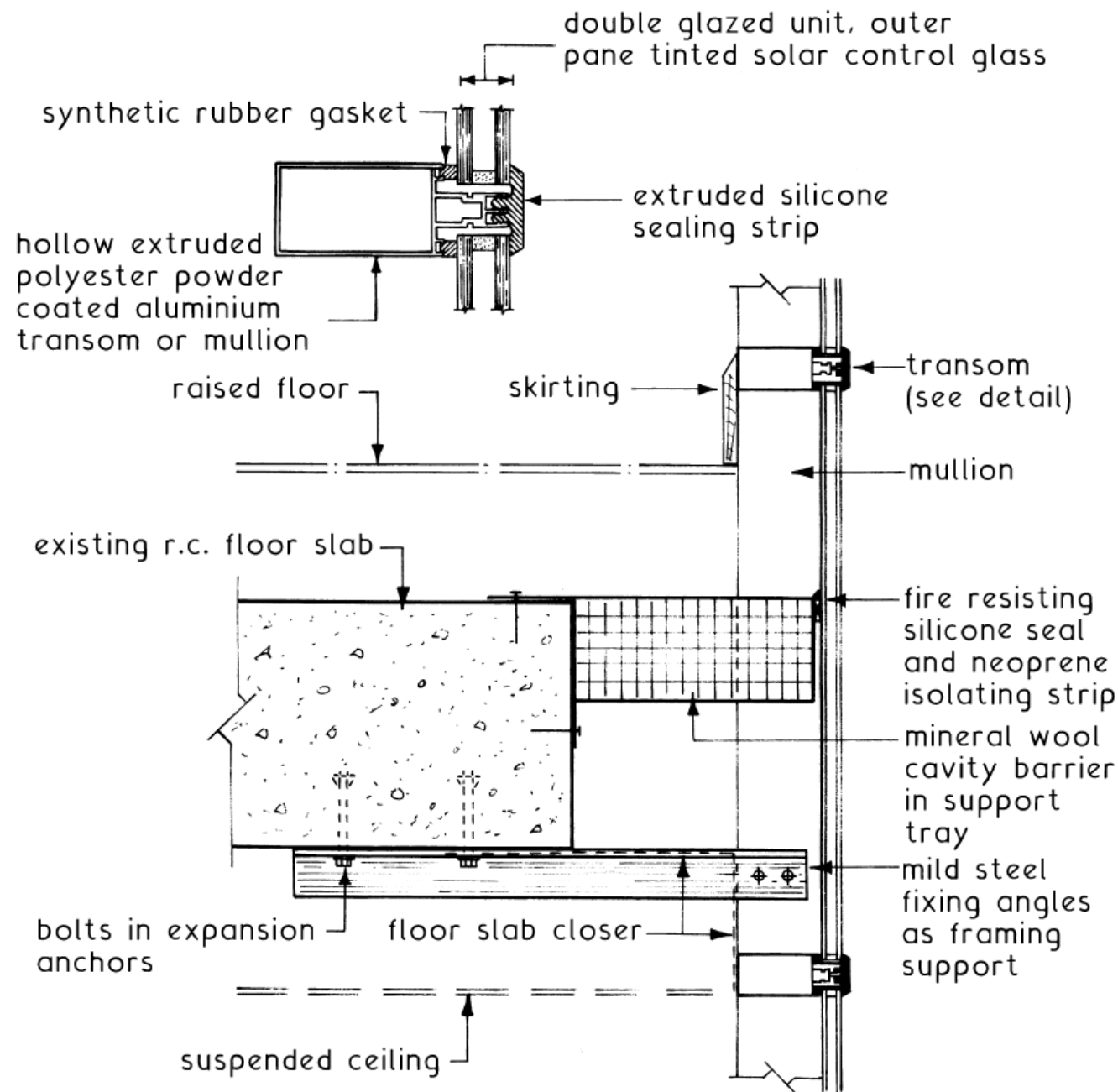
Unitized curtain wall system

- ▶ Units are shop fabricated and pre-assembled
- ▶ Units are designed so that the horizontal and vertical members in adjacent units interlock to form common mullions and rails

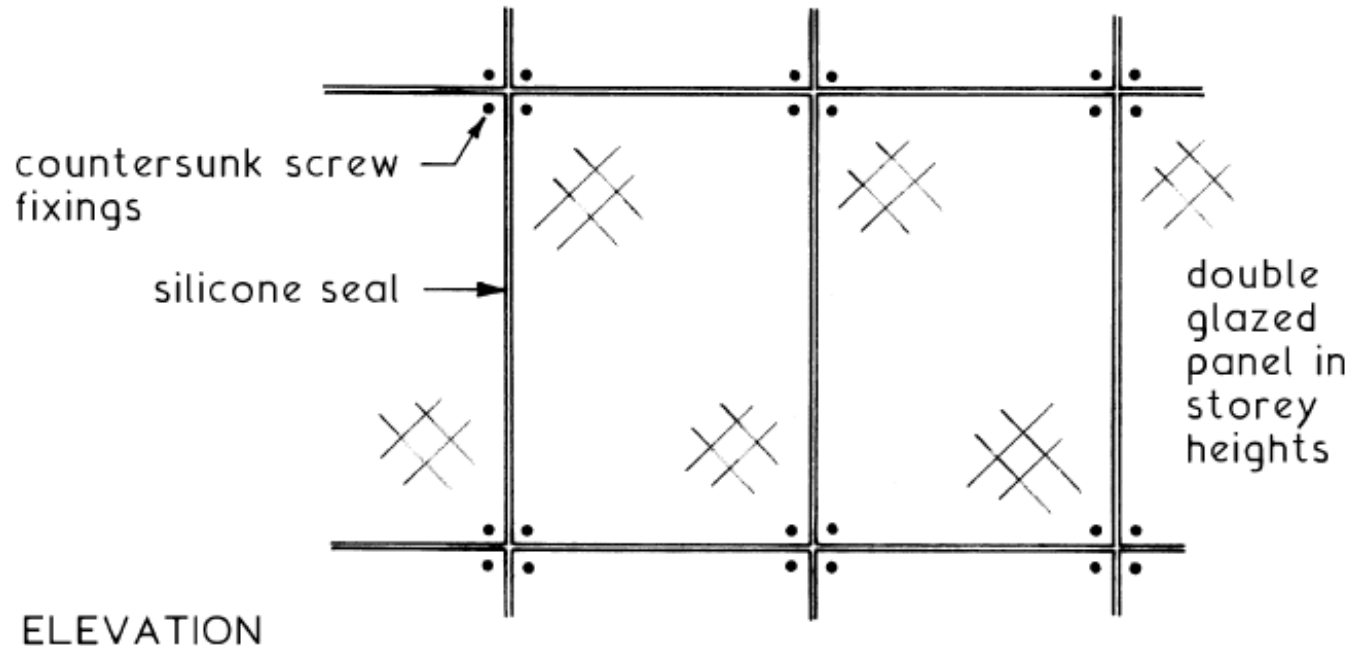
GLAZED CURTAIN WALLS

- Structural glazing systems, in their simplest form, are types of curtain wall systems consisting of glass that is bonded or anchored back to a structure without the use of continuously gasketed aluminum pressure plates or caps.
- The glass can be comprised of monolithic, laminated, dual-glazed or even triple-glazed insulating glass units (IGUs).
- The back-up structure may use horizontal and/or vertical aluminum mullions or be a glass mullion, steel blade, cable or stainless steel rod.
- The interior and exterior may use extruded silicone/EPDM (Ethylene Propylene Diene Monomer Rubber) gaskets, or a wet sealed silicone depending on the system.
- This system creates a completely clean, flush exterior appearance while the interior members have many different options depending on design and budget.

Framing detail

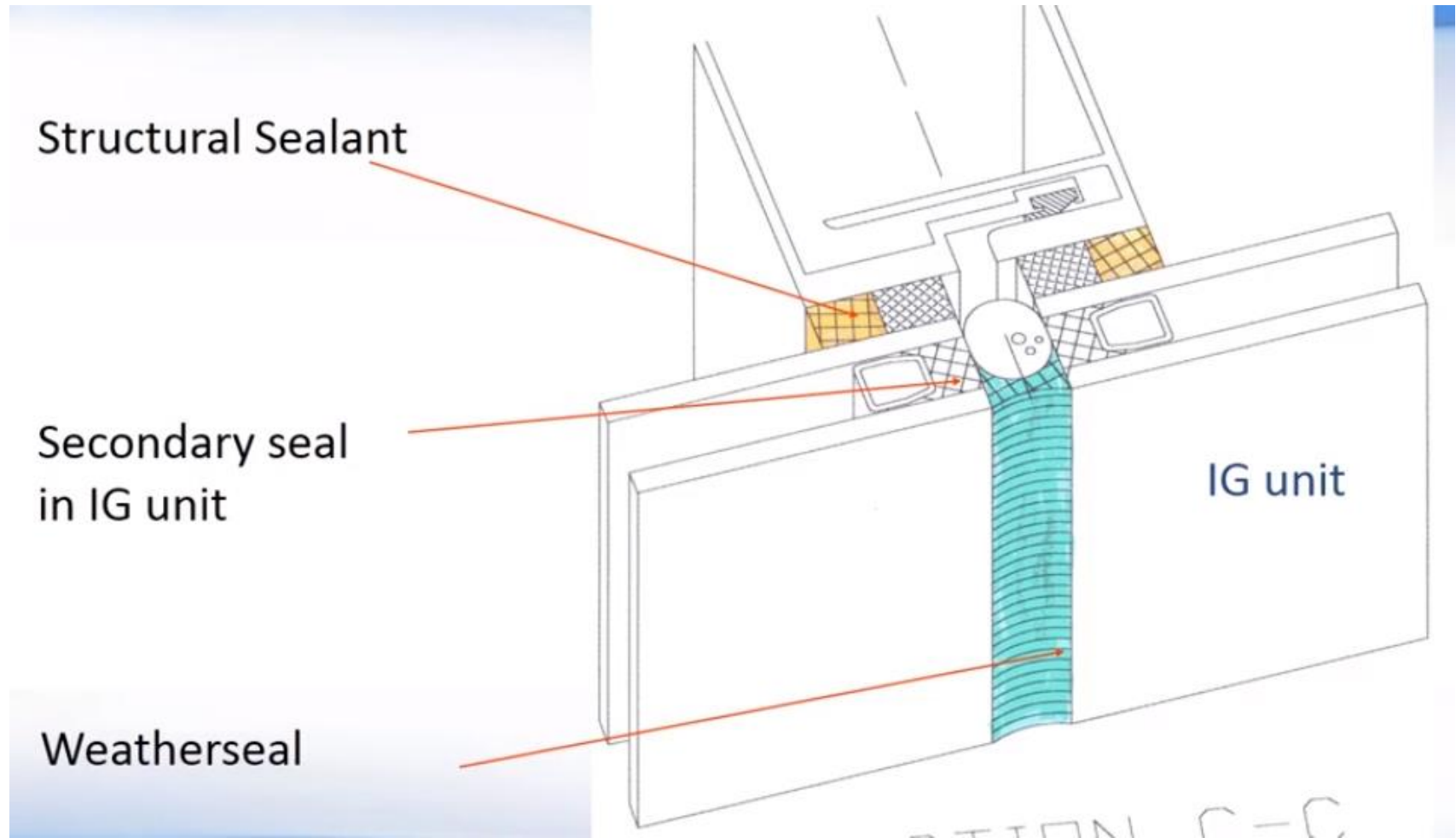


STRUCTURAL GLAZING



- Structural glazing is otherwise known as frameless glazing.
- It is a system of toughened glass cladding without the visual impact of surface fixings and supporting components.
- Unlike curtain walling, the self-weight of the glass and wind loads are carried by the glass itself and transferred to a subsidiary lightweight support structure behind the glazing.

Structural Silicone Glazing



Structural Glazing



- It refers to a method of retaining the glass in a window storefront or curtain wall.
- Instead of the edges of the glazing being captured in a pocket of the framing and secured in place with gaskets.
- The structurally glazed is retained on one or more sides by an adhesive/sealant, normally silicone.

Structural Glazing - Advantages

- There are less visual interruptions due to the lack of metal on the exterior (and potentially the interior), creating a seamless, continuous glass look.
- Traditional captured curtain wall systems have pressure plates and caps that can conduct large amounts of heat in or out of the façade depending on the season.
- Since there is little to no exposed exterior metal, there is also less thermal bridging with structural glazing, saving on energy consumption costs.

Structural Glazing

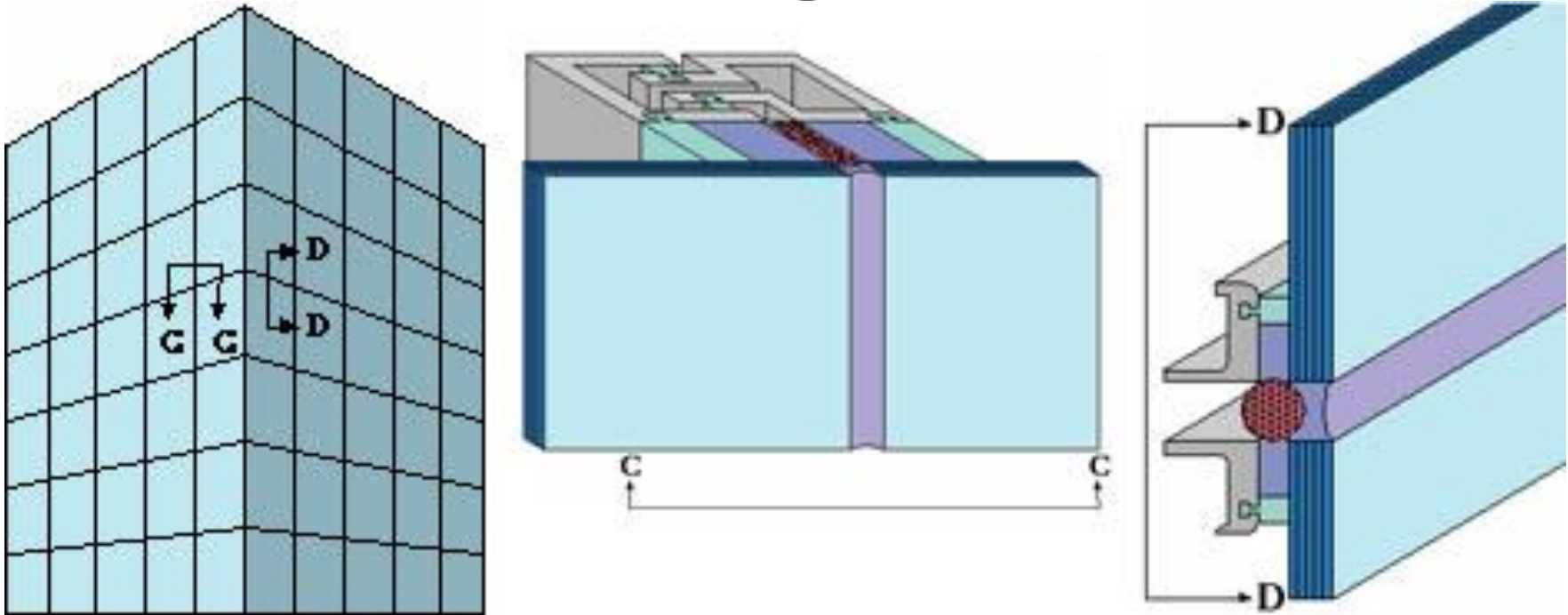
A typical structural glazing junction consists of

- Structural bonding providing a static effective connection
- Insulating glass edge seal adapted on wind and dead loads and with density function
- Weather seal

The structural silicones provide a high sheer and Young's modulus for compensation or transferring

- Dynamic loads (wind suction, wind pressure, traffic loads)
- Static loads (dead and snow loads)
- Differences in the thermal dilatations of involved materials such as glass and aluminium

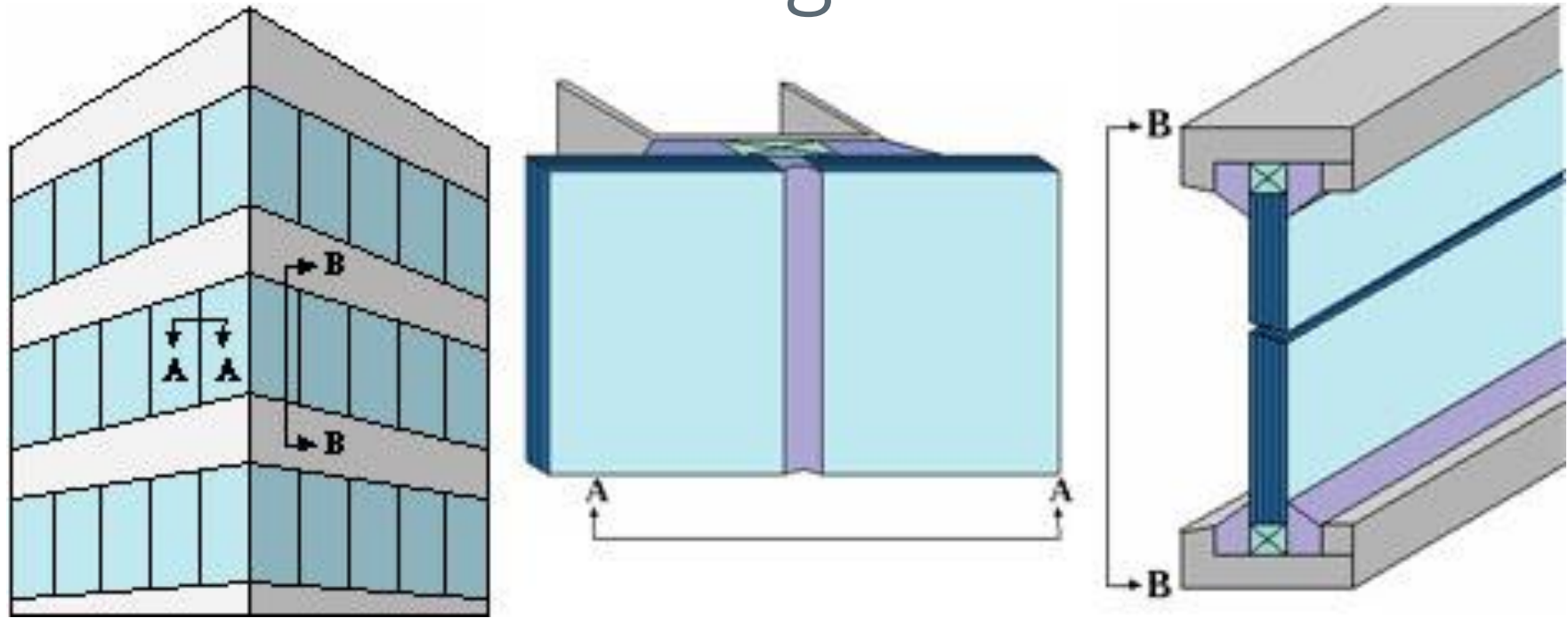
Structural Glazing



4-sided structural glazing

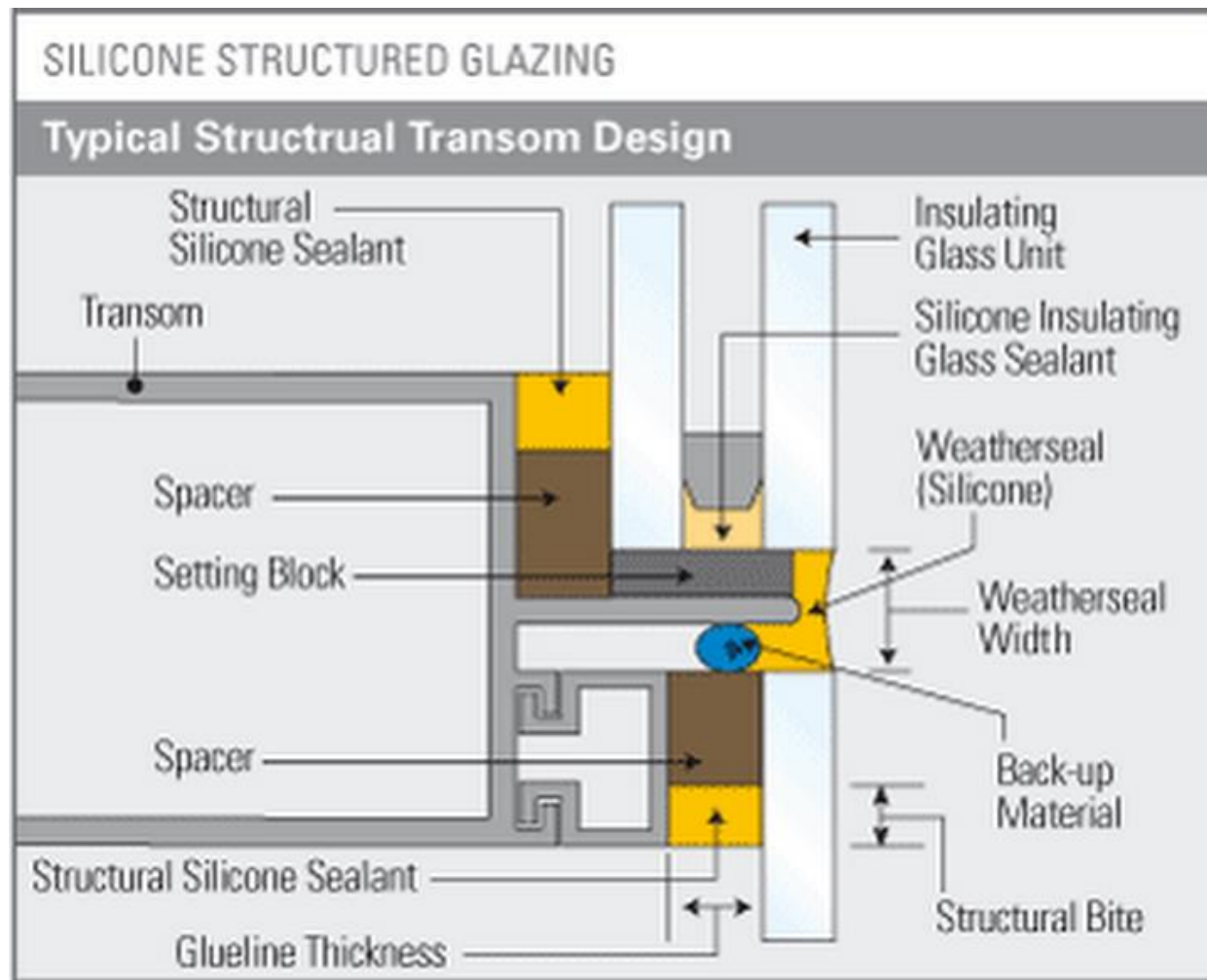
The most widespread and economic system of structural glazing. Glass is supported from 4 sides by structural silicone. These systems are usually prefabricated and then installed at the construction site.

Structural Glazing



2-sided structural glazing

In these systems silicone is used only on 2 sides of the glass panel. Two other sides of the glass are supported by a mechanical frame or another non-structural method. These systems are prefabricated or assembled at construction site.

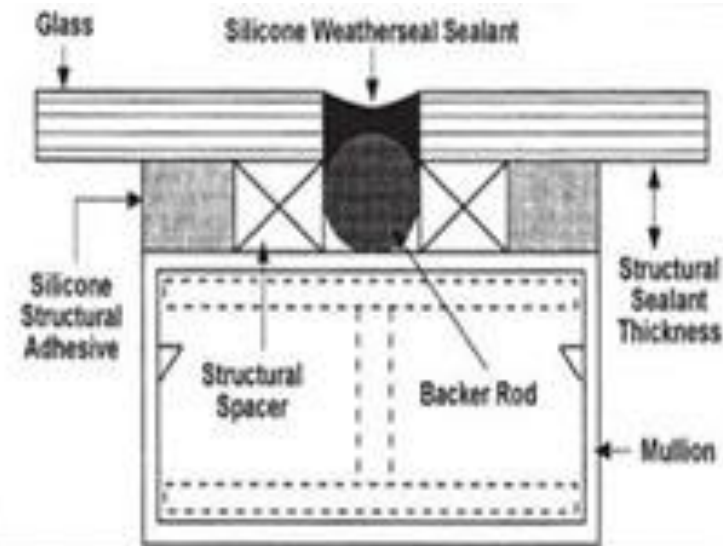


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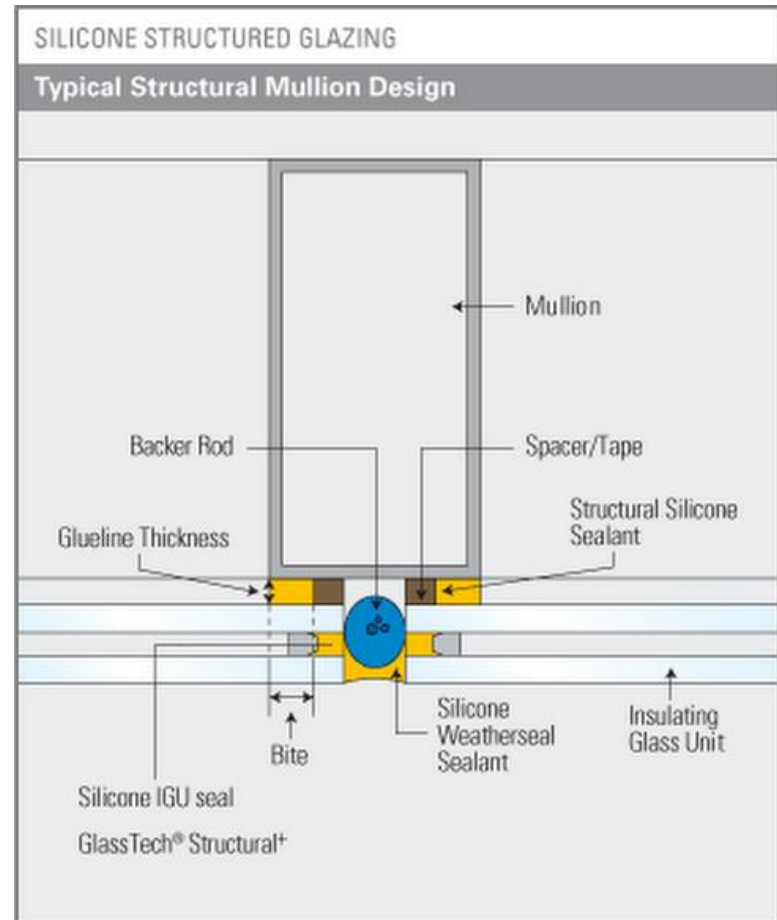
Structural Glazing

- Structural sealant glazing involves attaching glass, metal, or other panel materials to a building's window or curtain wall metal framing system in place of using gaskets and other mechanical attachments.
- Only structural quality silicone sealants are used since they must be able to withstand ultraviolet radiation, weathering effects, wind load and other stresses, and transfer these affects to the metal framing system.



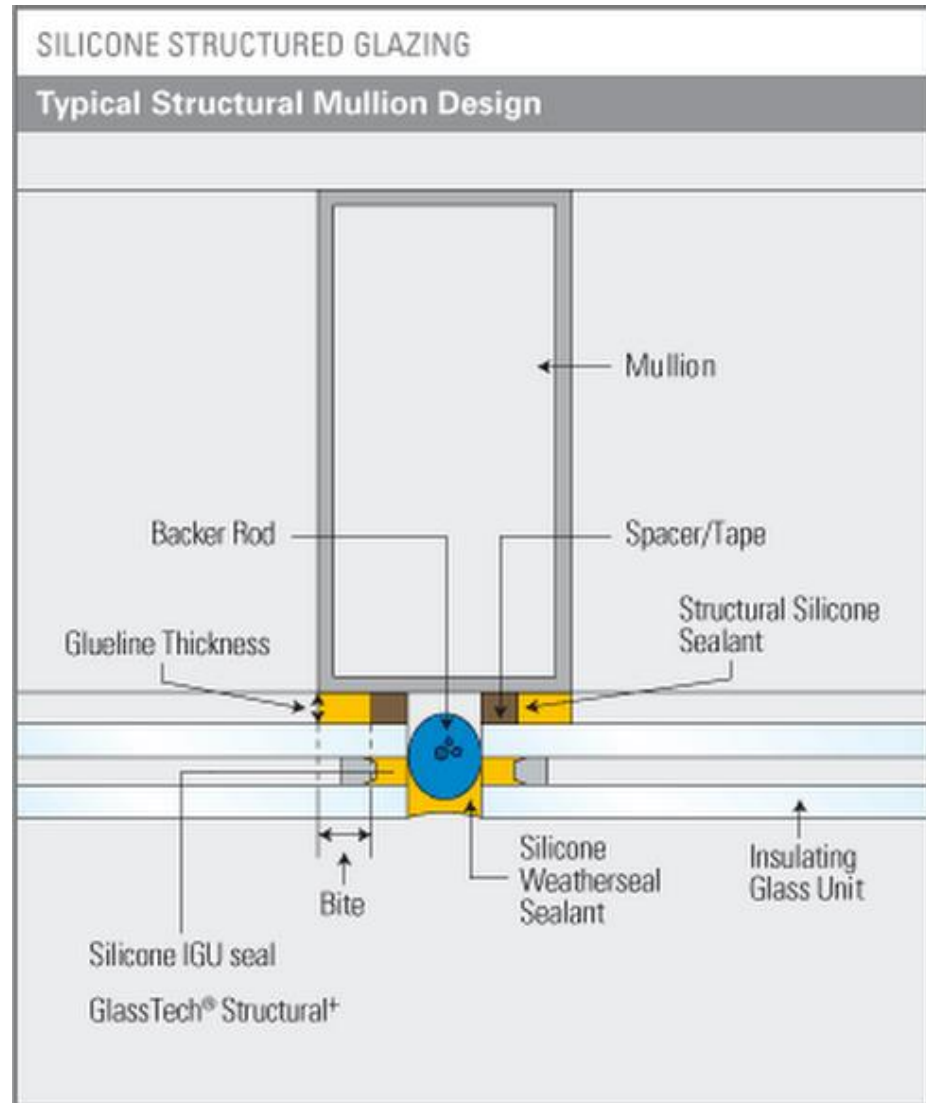
Structural Glazing

- For effective structural sealant glazing joint design, the following structural joint parameters must be considered:
- “Bite”—defined as the effective structural contact dimension of a structural sealant required on both the panel and frame faces to accommodate the required transfer of loads.
- “Thickness”—defined as the minimum structural sealant dimension between structurally bonded substrates (the panel and frame) to facilitate the installation of a sealant and to reduce stress on the structural sealant joint that results from differential thermal movement.



Structural Glazing

- Silicone Structural Glazing (SSG) is a method of attaching a glass panel to a metal frame using a structural silicone adhesive sealant.
- The sealant contact dimension (bite) and thickness are designed to provide a method of structural support to glass, an airtight and weather-tight seal and a flexible connection that absorbs differential movements between dissimilar materials from wind, thermal or seismic loading.
- The joints are not intended to absorb live load movements due to floor loadings.
- This method of glass attachment provides a smooth exterior glass facade on a building either as a 2 sided, 3 sided or 4 sided system.



Structural Glazing

Other glazing systems

In these systems silicon joint sealants play an important role in the protection of joints exposed to atmospheric effects, as well against moisture penetration and for insulation of glass panels.

Frameless glazing systems

These systems are frequently referred to as "spider systems" or bolted systems. They are not systems of structural glazing in spite of having similar looks. In some designs spider fixtures are only fastening the interior panels of the glass unit. In such designs the joint sealant has a structural function.

Point supported glass systems



Point supported glass systems

- They are the most transparent structurally glazed systems available on the market today.
- They can be custom engineered to fit any opening. From the exterior, they have silicone sealants between the joints like other structurally glazed systems, but have far less obstructed views looking from the inside out and vice versa due to the elimination of vertical and/or horizontal aluminum mullions.
- When using [glass fins](#) as a vertical back-up structure, the whole façade can appear to be virtually transparent.
- Glass is held in at specific points using [stainless steel fittings](#) to transfer deadload and wind loads back to the structure. Most glass types are available for point supported glazing, including: insulating glass units, low-e coated glass, laminated glass, monolithic, etc.
- These glasses can be paired with a host of back-up structures to create vertical walls, roofs and skylights, canopies, elevator enclosures, or windscreens.

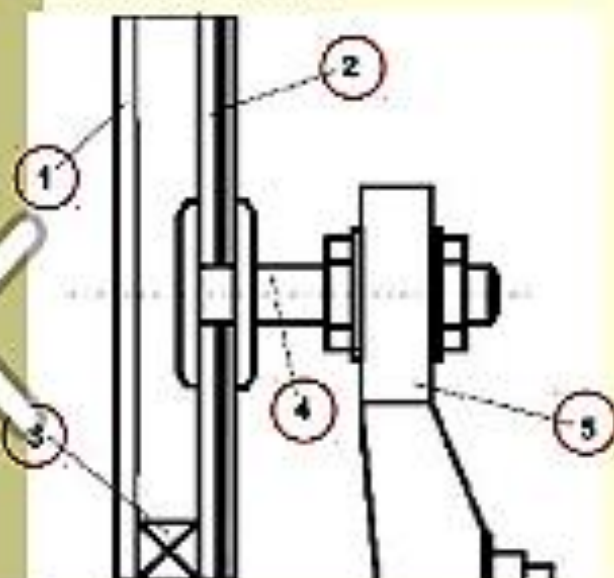
Point supported glass systems

- Vertical cable tension walls (sometimes also known as [cable nets](#)) are the thinnest point supported glass system structures that can make the tallest unsupported spans, but require the largest amount of load on the boundary structure and are usually the most expensive.
- There are also stainless steel tension structure systems that are deeper, but put less loads on the boundary structure; however, these systems have similar costs to that of vertical cable walls.
- There can even be hybrid combinations of horizontal steel and cables/tension rods as well. Glass fin walls and glass on steel systems (steel tubes, plate beams, or pipes) are usually the least expensive option and put far less loading on the boundary structure.
- They do, however, require greater depth of the vertical members to resist loads.

Assembled pointwise



Figure 24: Pointwise glass assembly scheme



1. hardened glass
2. hardened and resined glass
3. constructional silicone
4. bolt
5. X-bit

- Glass panels are assembled with steel elements. Inner plates are fixed mechanically. Pins are introduced into the glass. External plate is glued to the structure with constructional silicon.
- Such a facade is externally uniform. Seal of the connection of glass and bolts is realised with silicon sealants which additionally increases stiffness of structure.

Structural glass

In this technology a silicon glue is the only binder bonding a glass panel to the structure of the building.



1. dilatational tape
2. structural silicon

Figure 25: Double-sided system scheme

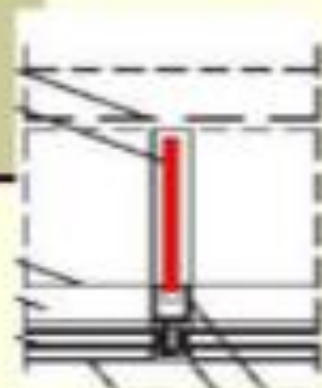
Double-sided system. Two sides of the glass set are glued to the aluminium frame while the remaining two are fixed mechanically.



1. structural silicon
2. PE filling cord
3. silicon sealant

Figure 26: Four-sided system scheme

Four-sided system. All four sides of the panel are glued to the aluminium frame.



Glass-rib system. Facade glass panels are stuck to the glass ribs mechanically assembled to the structure of the building.

Glued bolt system. Panels are fixed to the aluminium frame by means of a glued bolt.

Figure 27: Glass-rib system scheme

<http://www.frontdesk.co.in/forum/>