Façade Systems in Architecture: Into the Details

Arch 173: Building Construction 2

Generally the façade has evolved towards systems that are:

- Durable
- Lighter – so less mass, weight on foundations, carbon
- Higher R-values
- Made of multiple layers
- Using a rain screen/drainage plane
- External to the structural system to keep the structure at a constant temperature


1851 Crystal Palace

Thin Sheets of Air

Glazing has become stronger, more varied, and more selective in transmitting heat and light. Here's how.

Despite the premonitions of Post-Modernists, the all-glass building is anything but dead. Glazing now comes so clear that we can make walls disappear, so reflective that we can dematerialize entire buildings, in so many colors that we can give vitality and depth to the flattest façade. What has kept glass alive as a cladding material is not just its varied aesthetic, but its improved performance, for glazing materials, especially in the last ten years, have become much more weather, impact, and thermal resistant.

That's not to say that problems don't exist. For example, the Architectural and Engineering Performance Information Center (AEPIC) at the University of Maryland has noted an eightfold increase in insurance claims for glazing and window failures since 1977. No one yet knows what has caused so many claims, but a better understanding of glazing technology is part of the solution.

Making Up Glass

The technology used in the fabrication of glass has changed little since the development of float glass in the 1950s. Made by pouring and stretching molten glass over a bed of molten tin, float glass has come to dominate the glazing market, using much less energy than the now rarely produced plate glass and having a smoother surface than sheet glass. Little too has changed in the treatment of architectural glass over the last 20 years. Manufacturers still make annealed glass by cooling it gradually in continuous annealing ovens or lehrs, and heat-strengthened or tempered glass by reheating and rapidly cooling the material in horizontal or vertical furnaces.

Where change has begun to occur is in the variety of glass available. For example, smaller "mini-furnaces" promise to make the production of custom glass colors more economical. Some of the large glass com-

The historic photographs (right) document two earlier phases in the development of glass technology. The making of crown glass, which lasted from 1825 to around 1935, involved placing molten glass on the end of a punty, spinning the glass as it cooled, detaching the glass disc from the

Glass in Architecture and Decoration, by Raymond McGrath and A.G. Frost, Architectural Press, 1961.

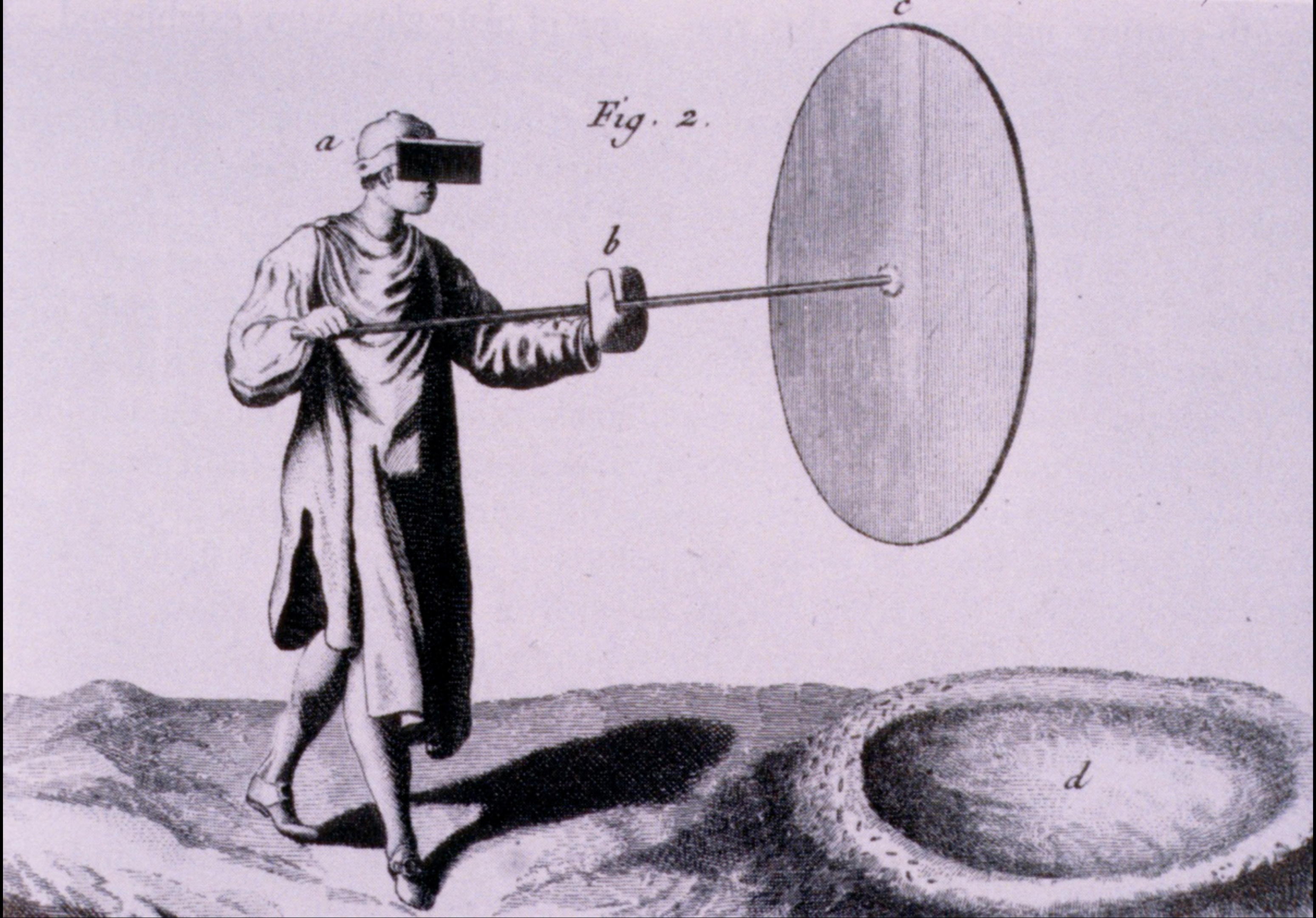
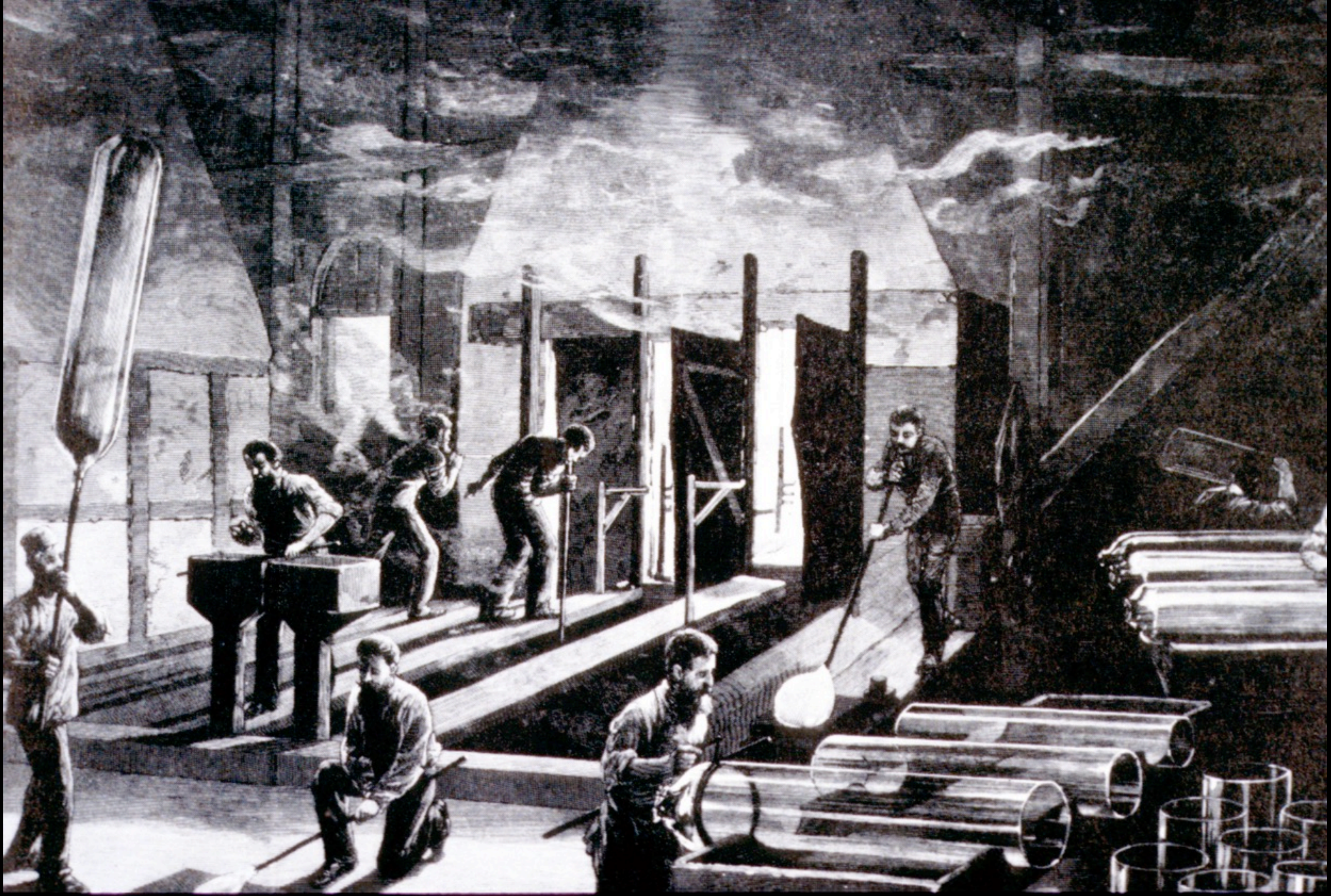
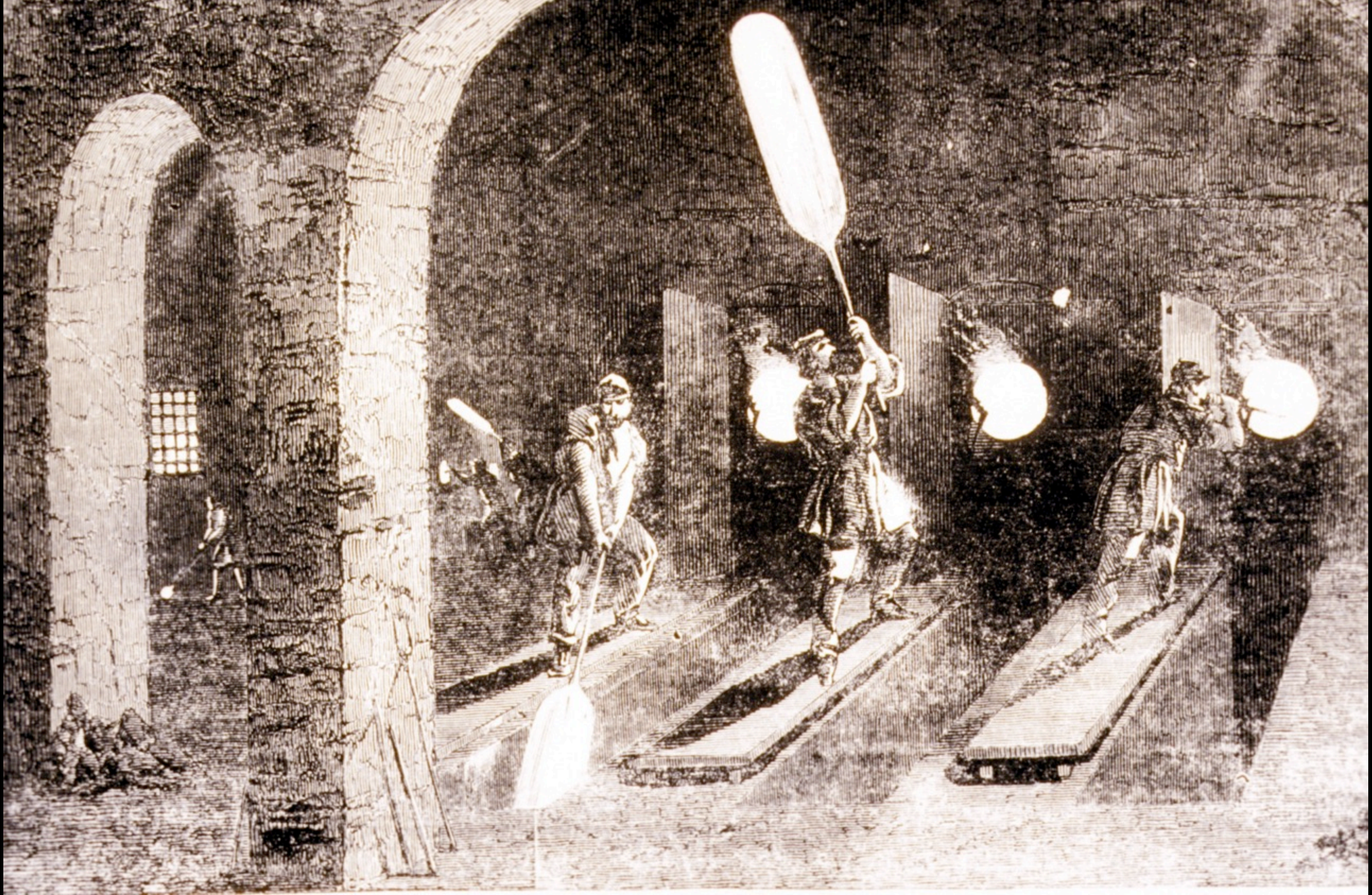
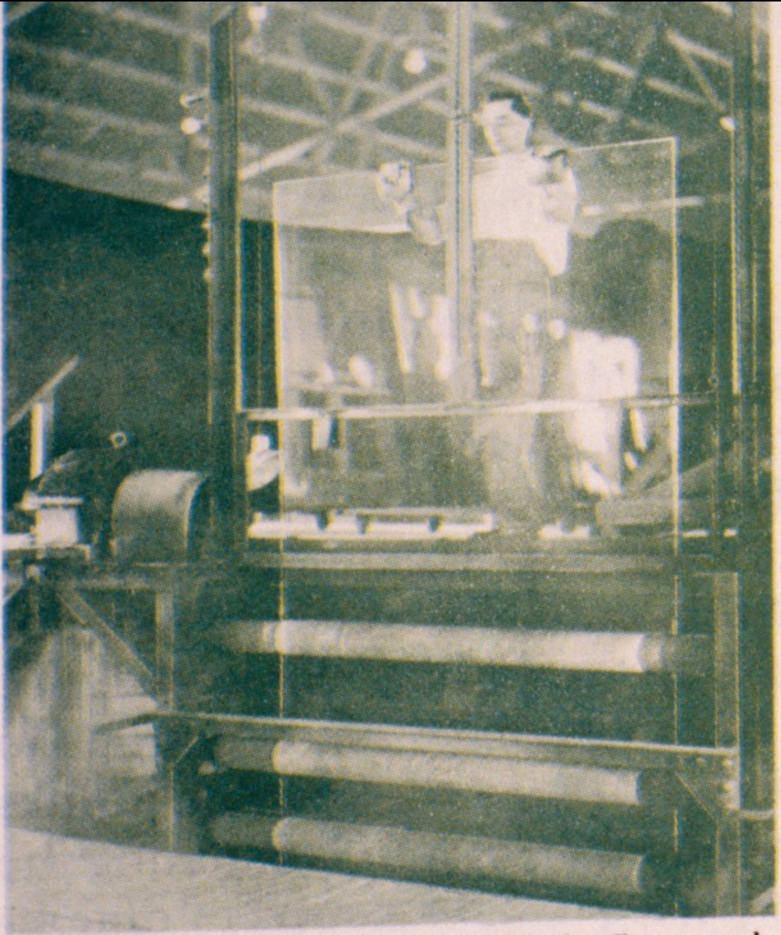


Fig. 2.
a
b
c
d

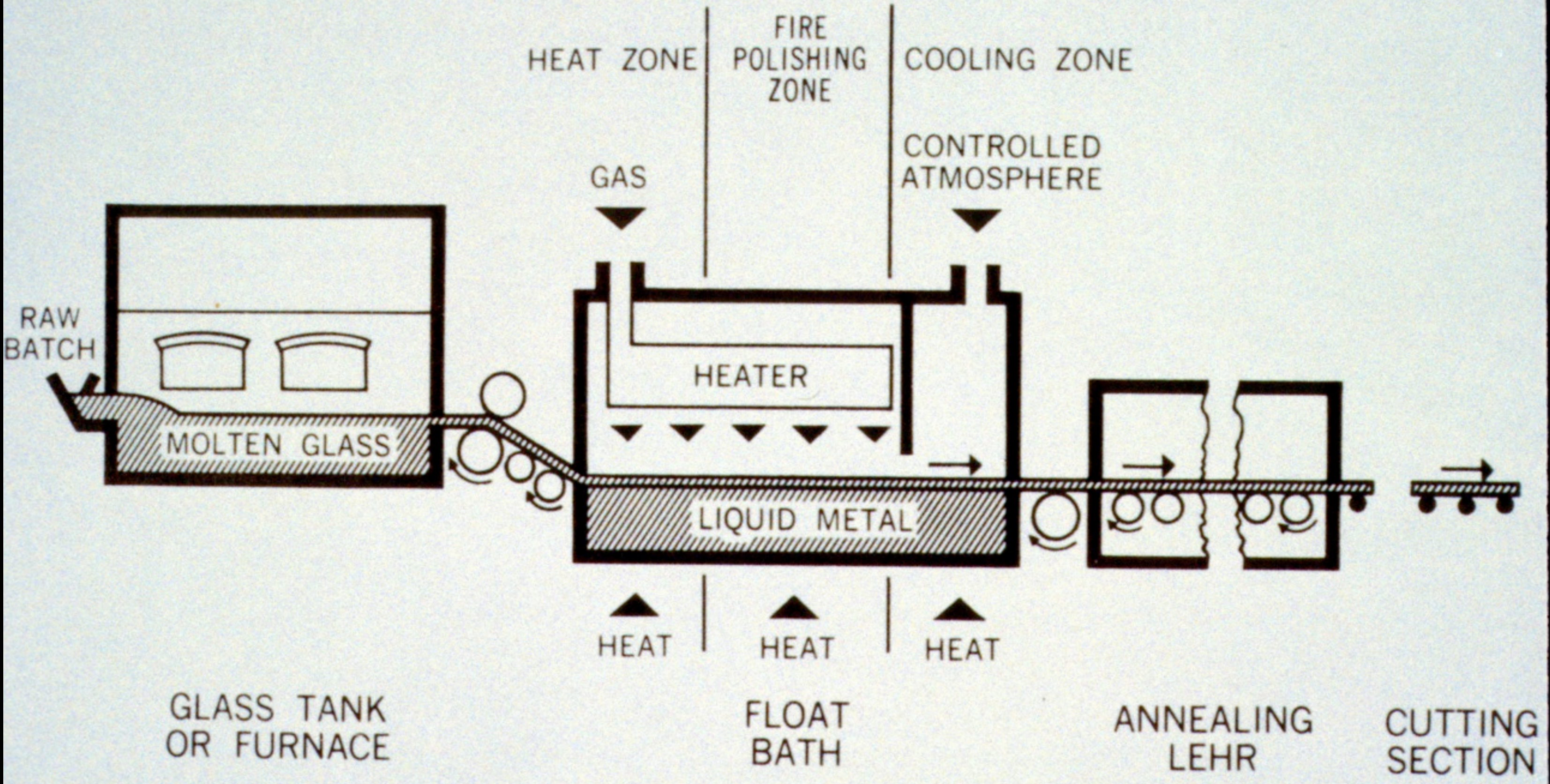


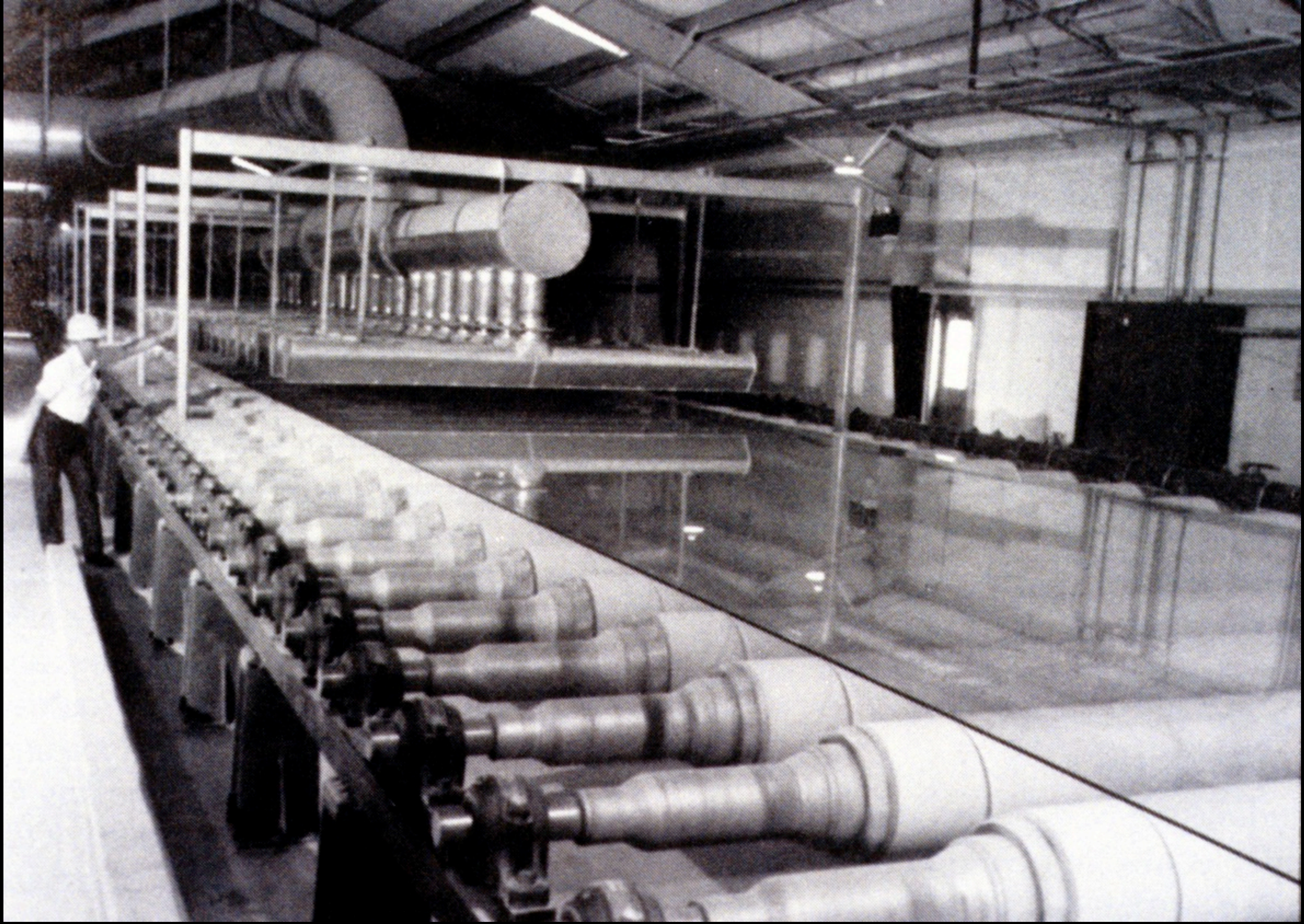


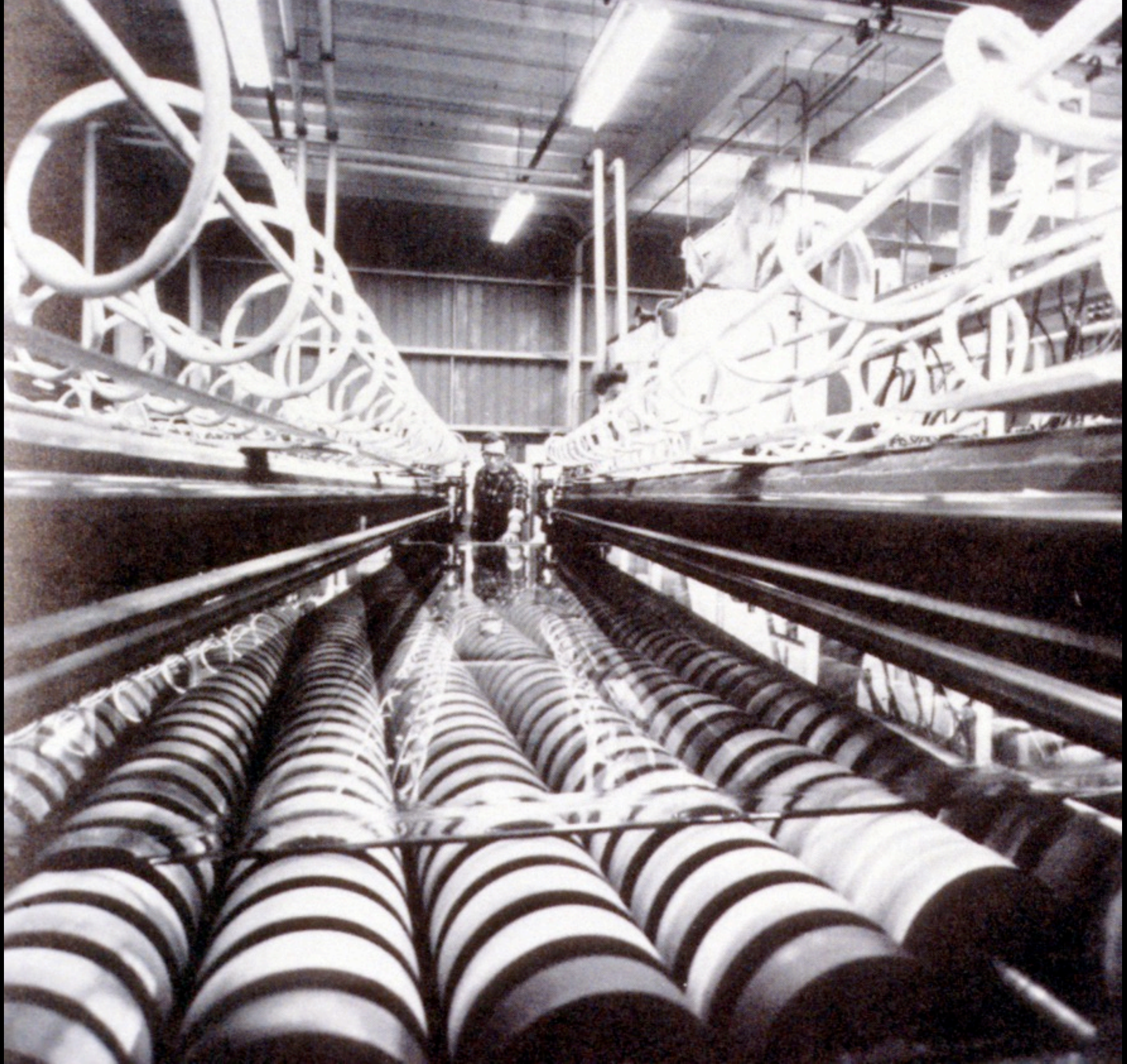


Glass in Architecture and Decoration, by Raymond McGrath and A.G. Frost, Architectural Press, 1961.

punty with shears, and cutting it. The flat drawing of sheet glass, a process first used in 1913, allows the fabrication of larger sheets, althoug it creates some surface irregularitie The float process has largely replace those earlier technologies for vision glass.


HEAT ZONE
FIRE POLISHING ZONE
COOLING ZONE
GAS
CONTROLLED ATMOSPHERE
RAW BATCH
HEATER
MOLTEN GLASS
LIQUID METAL
HEAT
HEAT
HEAT
GLASS TANK OR FURNACE
FLOAT BATH
ANNEALING LEHR
CUTTING SECTION

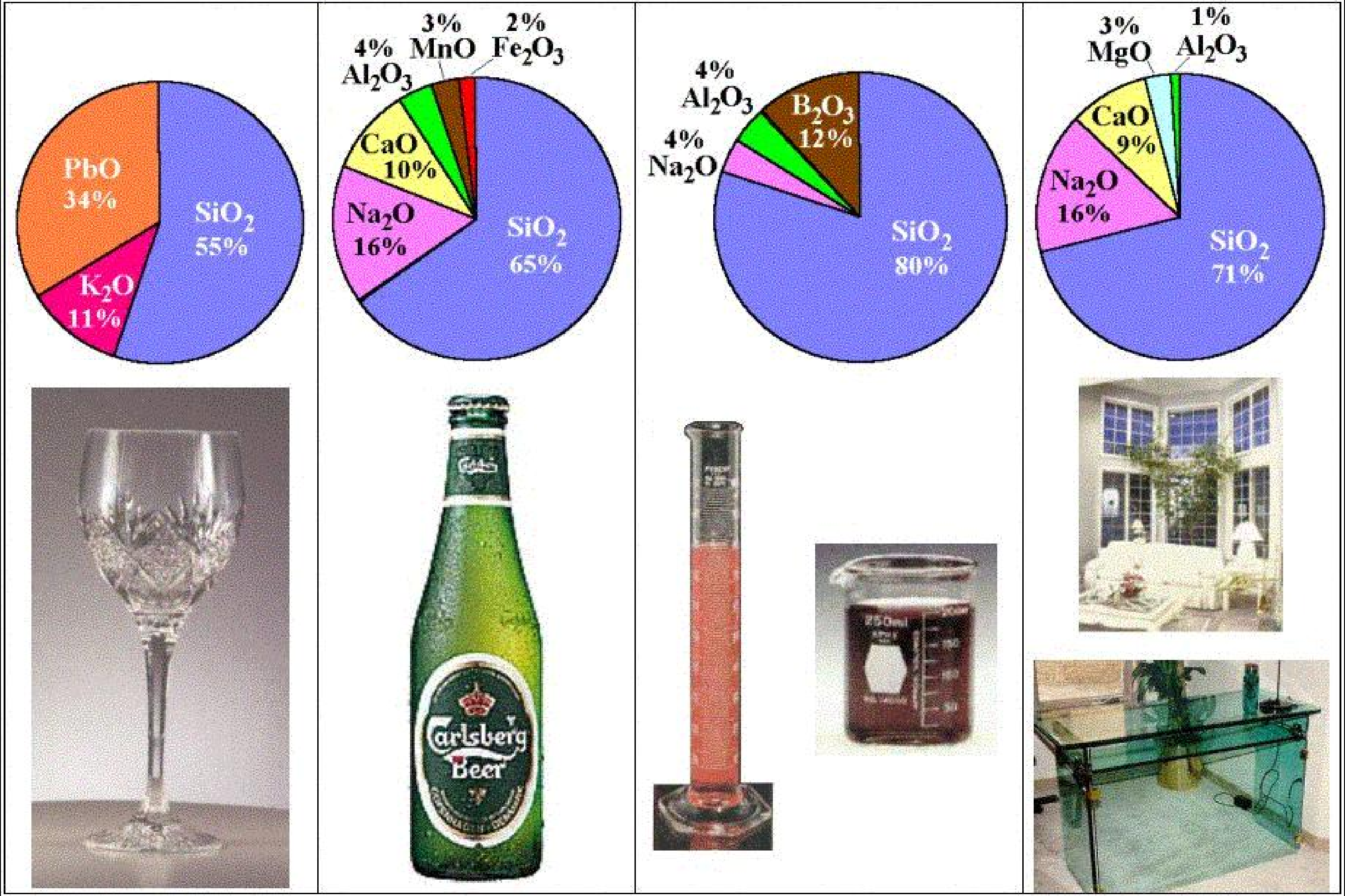


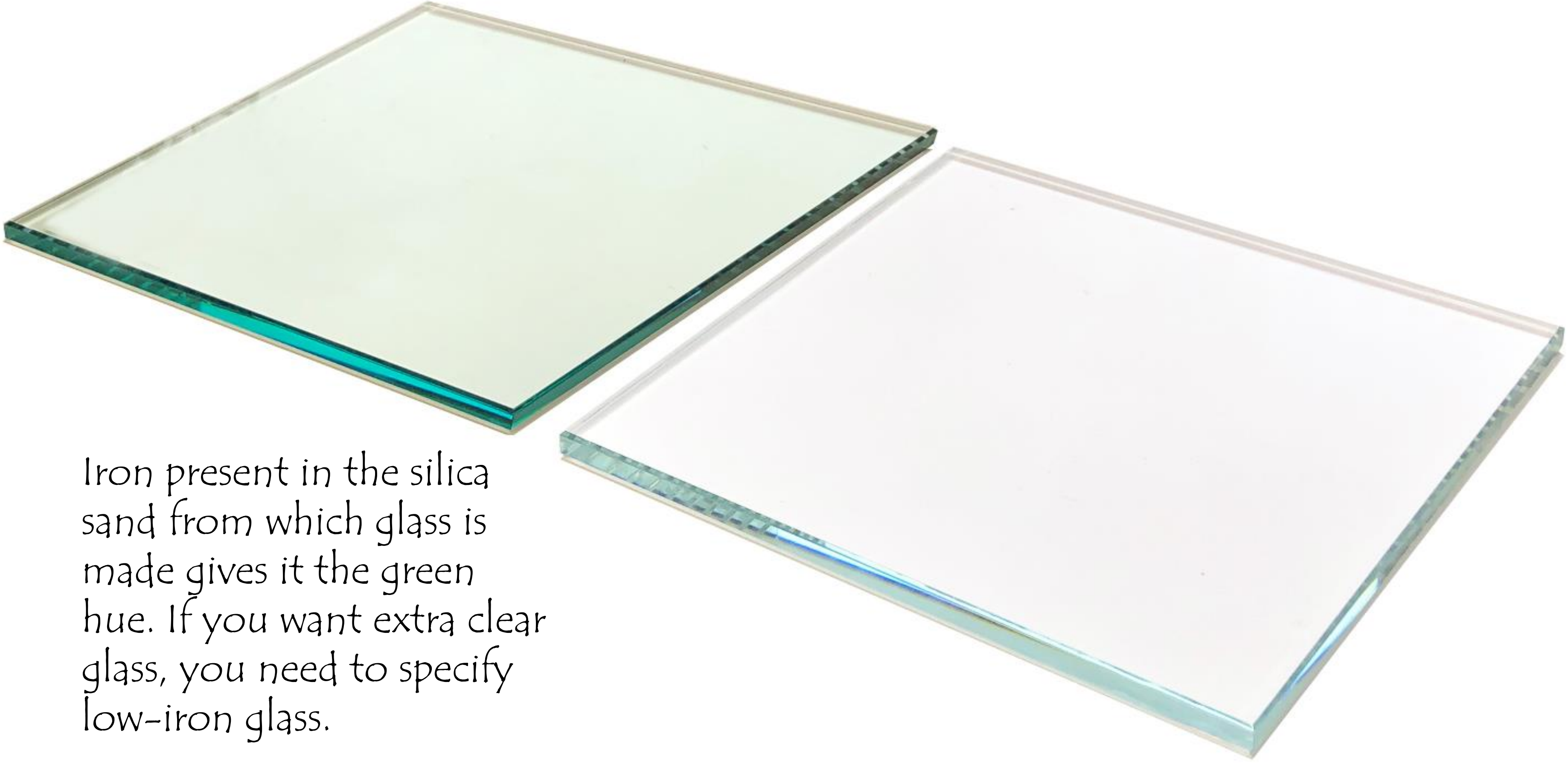


Controlled cooling of the glass is essential to managing the internal stresses in the material.

The Properties of Glass

Types of glass and their composition





Iron present in the silica sand from which glass is made gives it the green hue. If you want extra clear glass, you need to specify low-iron glass.

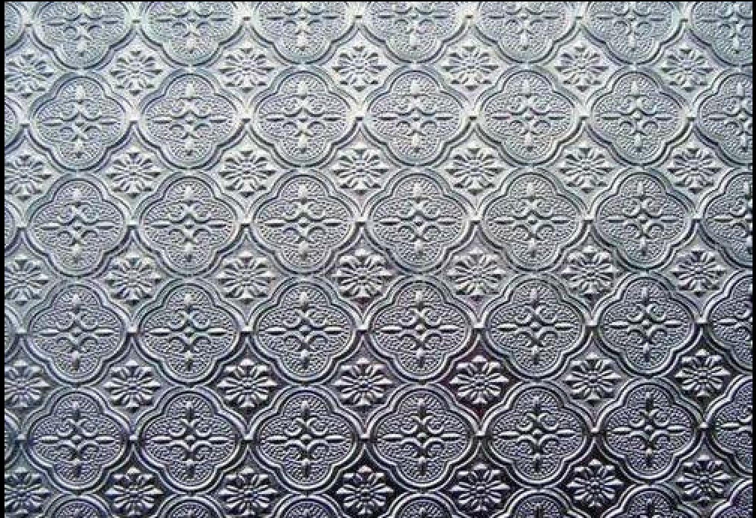
Glazing tint can become an issue in certain building types like observatories as the greenish hue impacts the view, particular in photographs

Image left shot with iPhone through the glass at the World Trade Tower, NYC

Right, colour fixed in Photoshop

Your eyes will fix the view for you but your camera isn't that smart.

Figured glass is embossed with a pattern to change its optical properties



Annealed Glass

Breaks easily, producing long, sharp splinters

Tempered Glass

Shatters completely under higher levels of impact energy, and few pieces remain in the frame

Laminated Glass

May crack under pressure, but tends to remain integral, adhering to the plastic vinyl interlayer

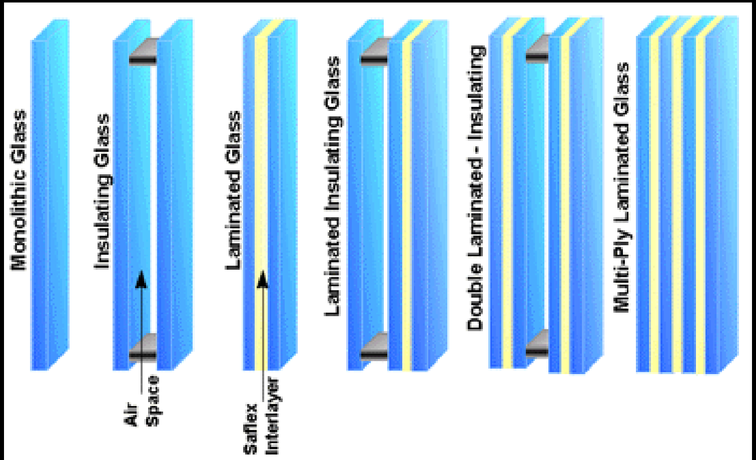

When you see actors going through breaking glass they are using a special kind of glass called "breakaway glass"

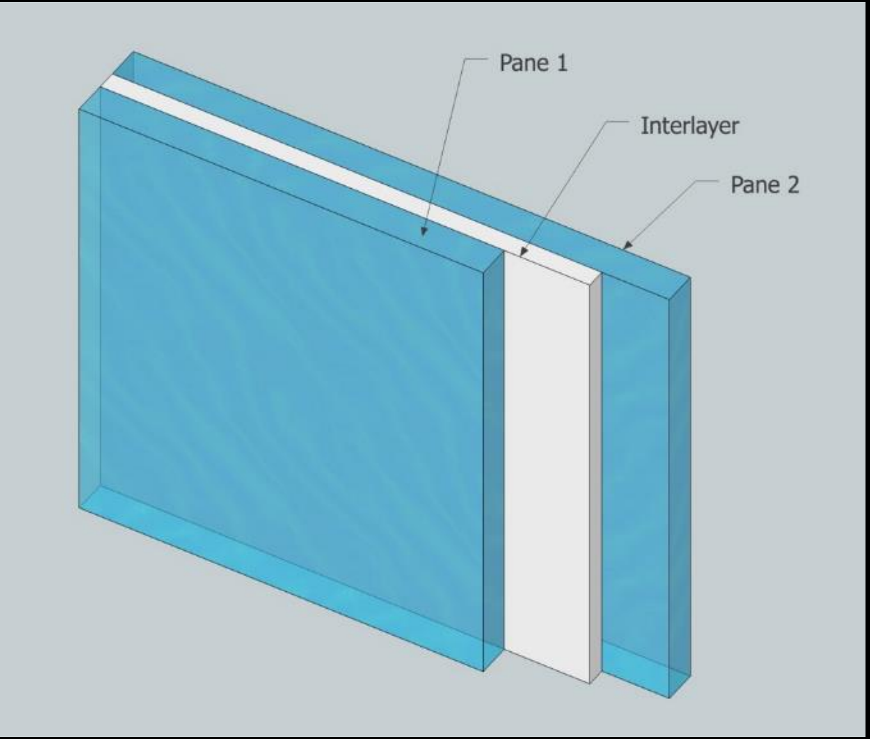
The kind of glass we specify depends on the position and use:

- Regular windows in houses use annealed glass
- Tempered glass is used in cars, bus shelters or entry areas where large shards would provide danger to the public
- Laminated glass is used in canopies, structurally glazed scenarios where extra strength is required (you can laminate any kind of glass)
- Heat strengthened glass is also an option
- Wired glass is used for fire resistance as well as formerly for break in resistance

The Canadian General Standards Board is set to remove wired glass from its national building standards at the end of February, saying it isn’t safe “because it’s not impact resistant.”
“It can shatter when hit and cause lacerations,” Jacqeline Jodoin, senior director of the federal organization, told The Canadian Press.

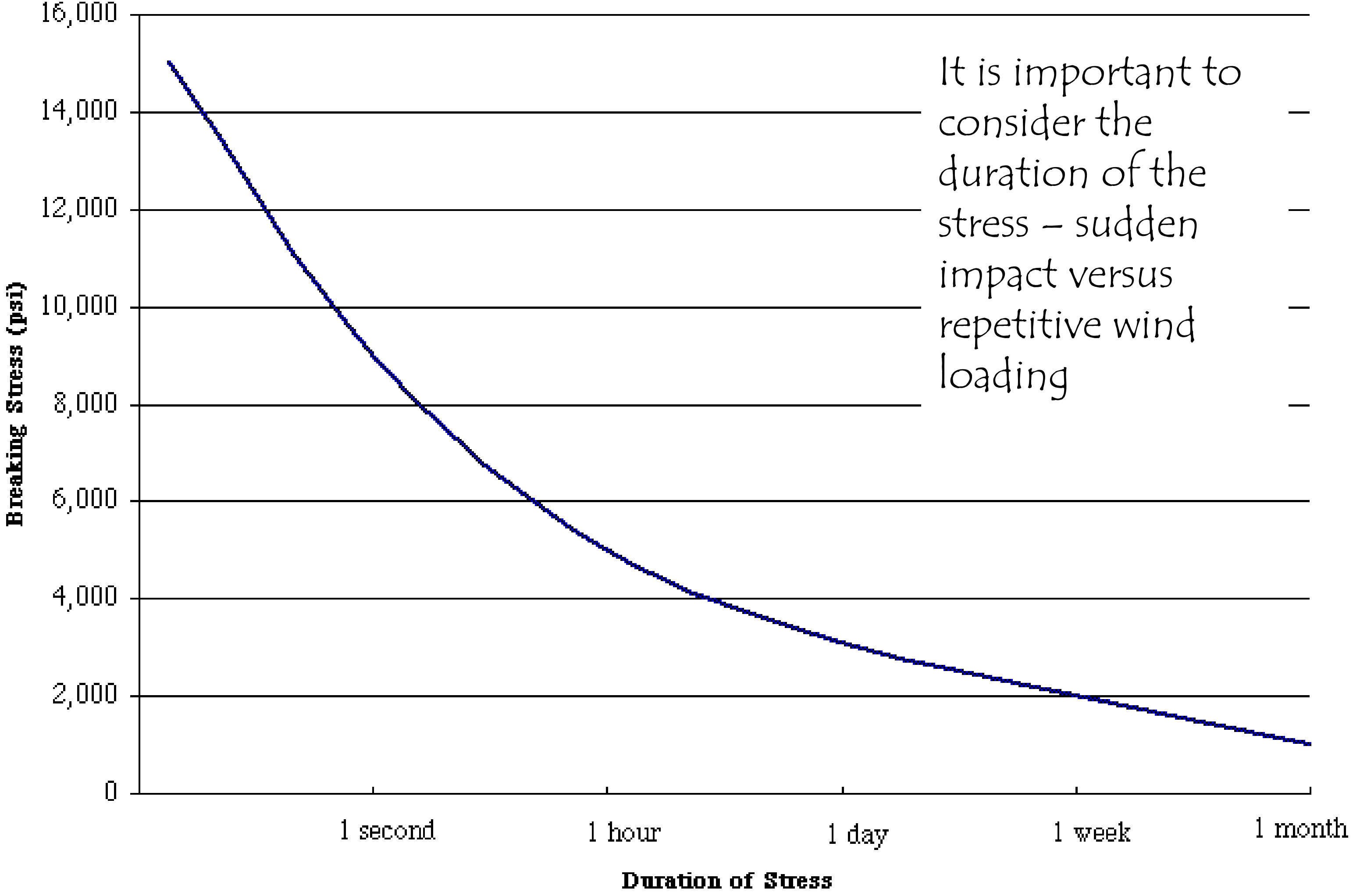
Laminated glass is the new standard for achieving break resistance.





Laminated glass uses a PVB layer between the panes to stop shattering

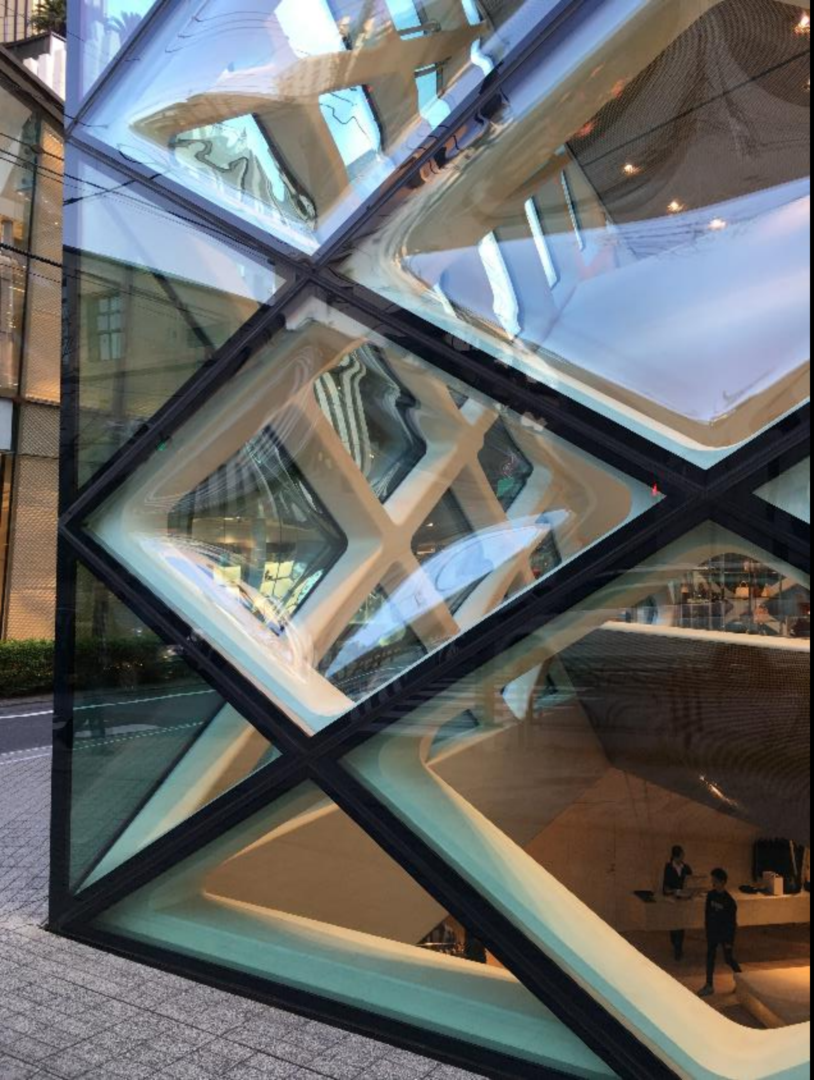
All sorts of tests are carried out on glass that is used for high risk areas including skylights and canopies.



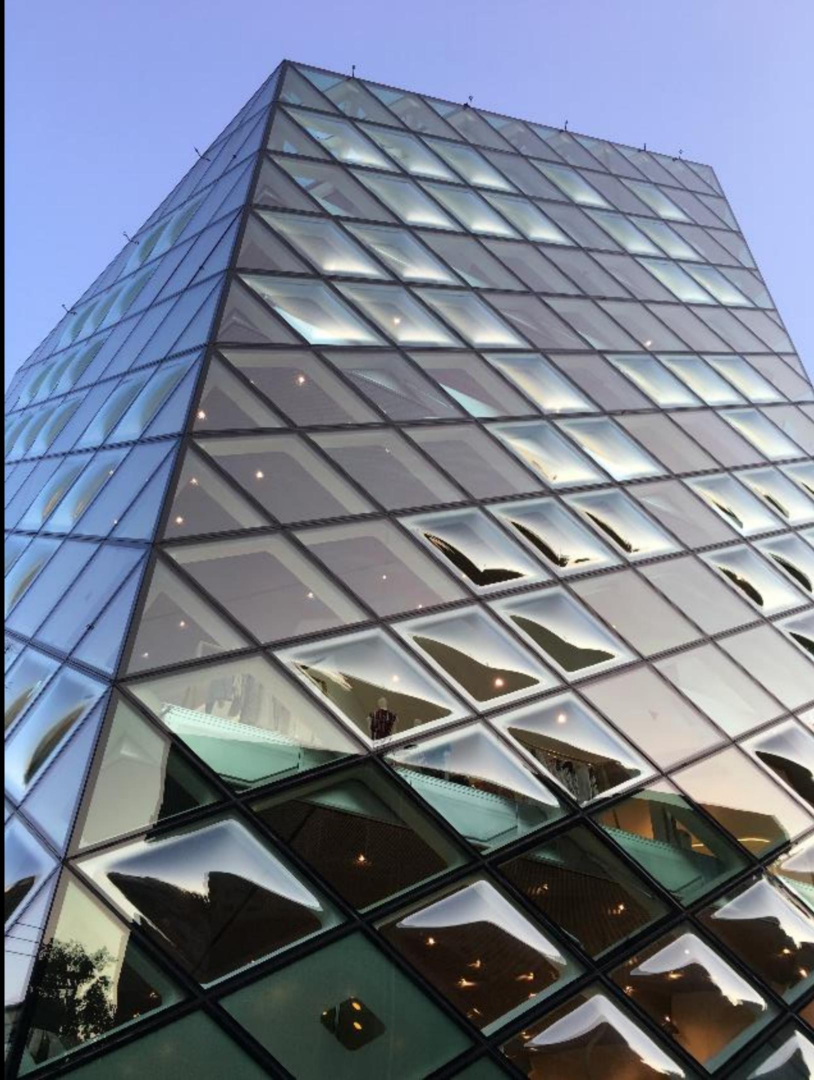
It is important to consider the duration of the stress – sudden impact versus repetitive wind loading


Glass can also be curved.
There are different bending
methods – cold vs hot

https://www.vitrum.ca/glass-products/curved-glass/



Prada Store,
Tokyo



Solar Transmission of Flat Glass

Type	Thickness, mm (in)	Solar Transmittance, %
Clear	2.5-6 (0.1-0.25)	78-87
Heavy-duty clear	8-22 (0.3-0.87)	67-74
Tinted	6-12 (0.25-0.5)	47-68
Heavy-duty tinted	10-12 (0.39-0.5)	24-33
Reflective	6-12 (0.25-0.5)	3.0-29
Insulating	15-18 (0.59-0.7)*	#
Solar (super clear)	6-30 (0.25-1.18)	90-93
Architectural laminated	6-30 (0.25-1.18)	#
Spandrel	6 (0.25)	&
Figured	3-4 (0.12-0.15)	78-80
Wired	6 (0.25)	78-80
Heat-resisting	3-12 (0.12-0.5)	80-92

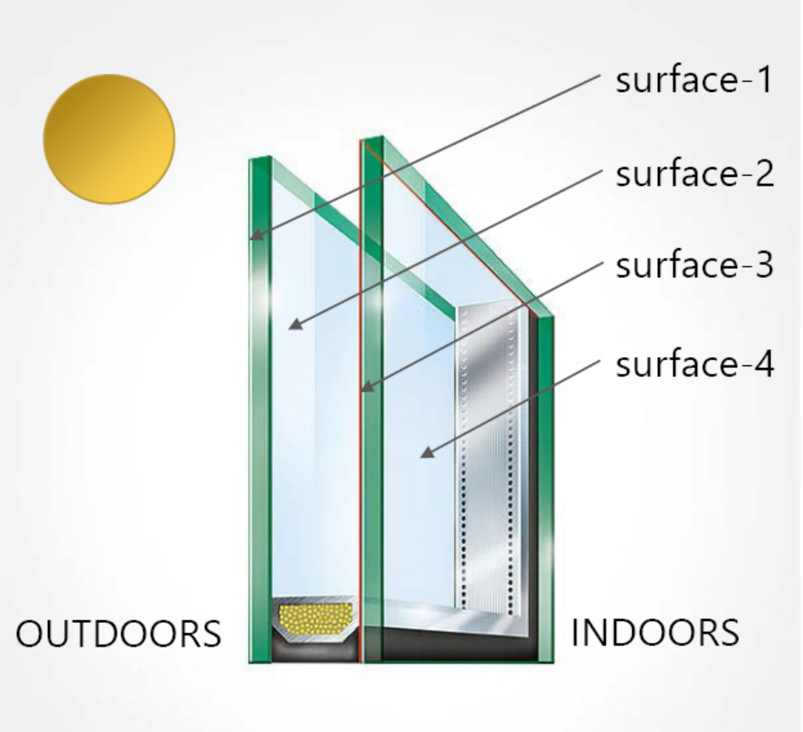
*Thickness is listed total thickness, made up of lights 3 to 6mm thick separated by a 12mm air space

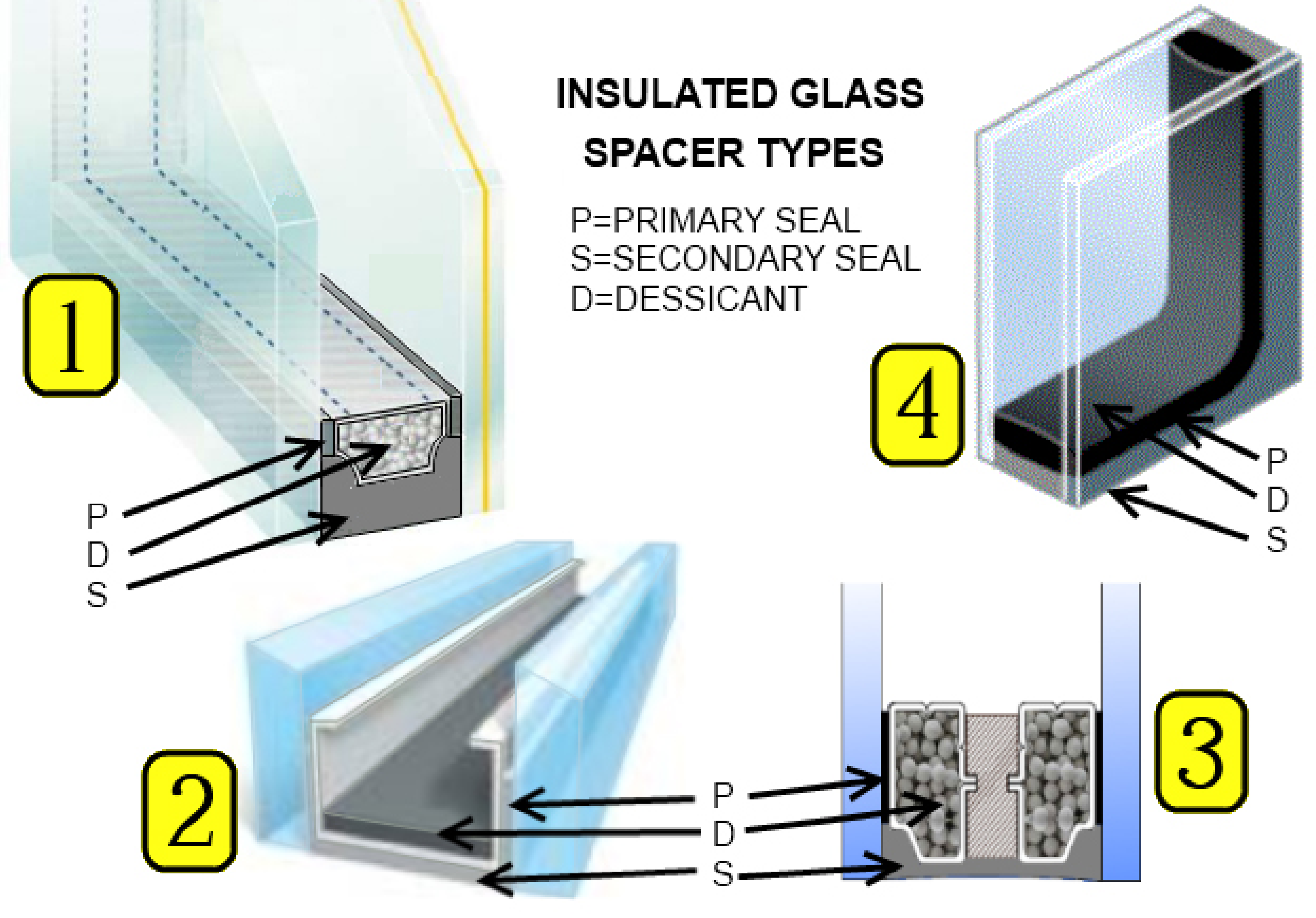
Transmittance of insulating and laminated glass varies widely depending on whether or not one or more surfaces is treated with a reflective film

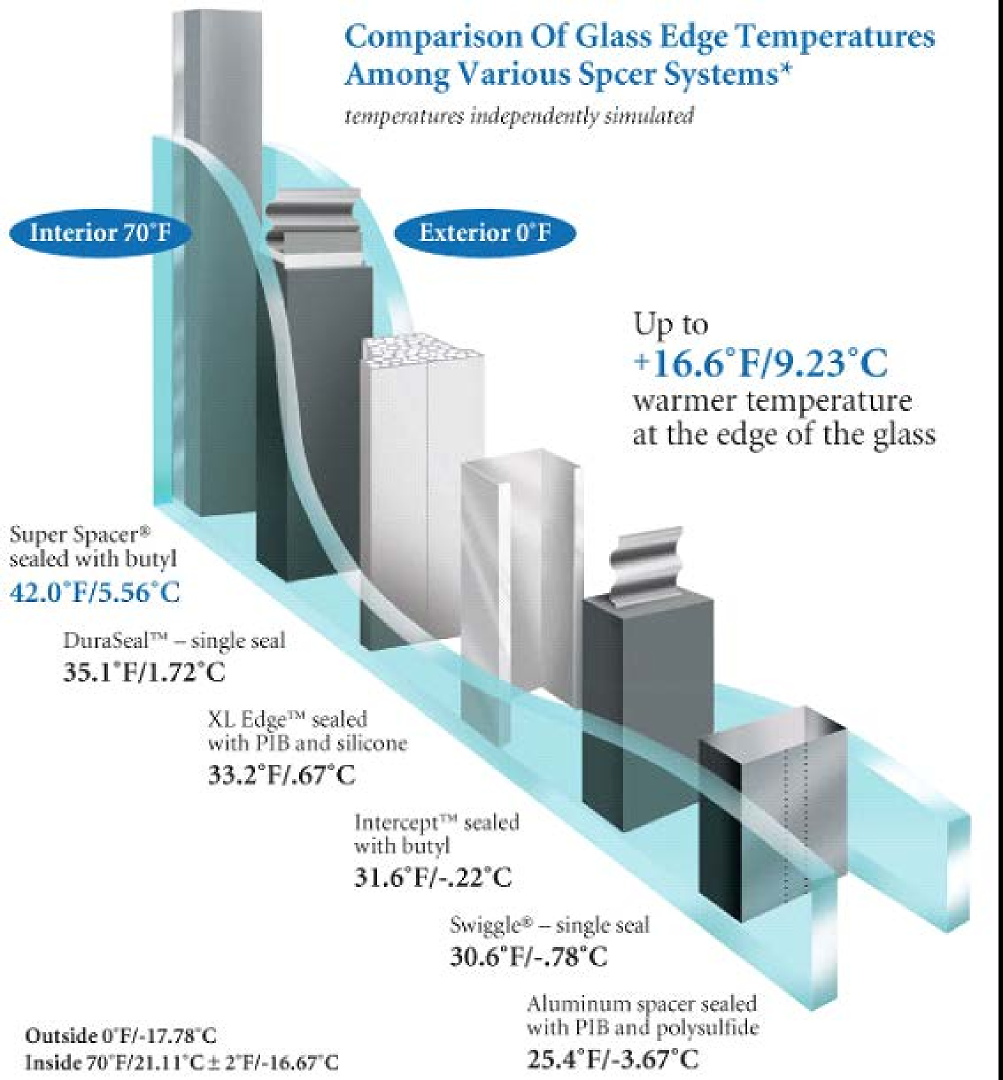
& Spandrel glass is assumed to be back painted and insulated so no solar transmittance

IGU – INSULATING GLASS UNITS

- **Air-tightness**
- **Solar heat gains**
- **U-value (the lower the better)**
  - Reduce convective H.T.
    Air vs Ar vs Vacuum
  - Reduce radiative H.T
    Soft vs hard low-e coatings
  - Reduce conductive H.T.
    Thermal breakers
  - Multi-layer IGU
- **Color Rendering Index (CRI)**



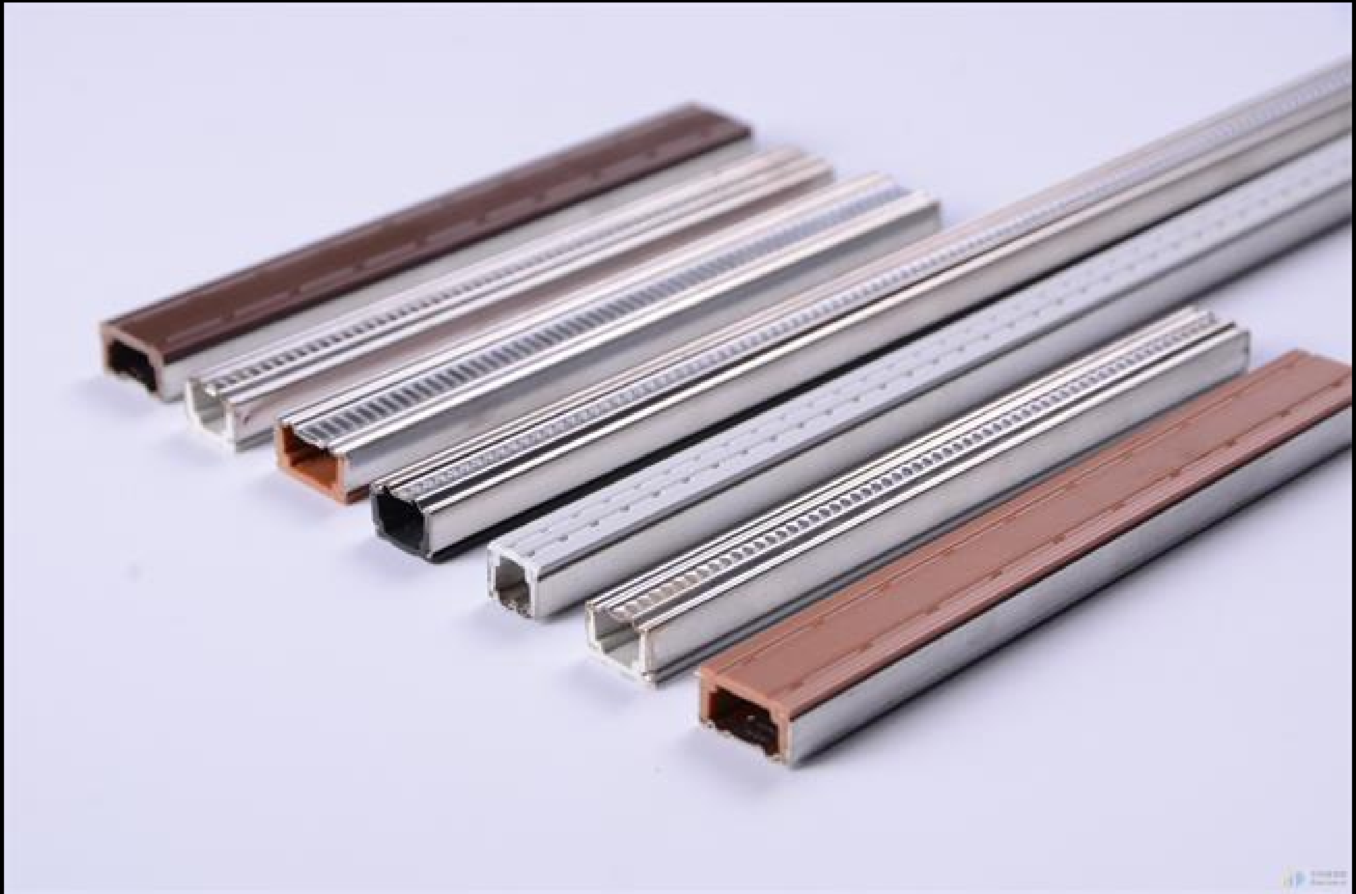

INSULATED GLASS
SPACER TYPES
P=PRIMARY SEAL
S=SECONDARY SEAL
D=DESSICANT
1
P
D
S
2
P
D
S
3
4
P
D
S

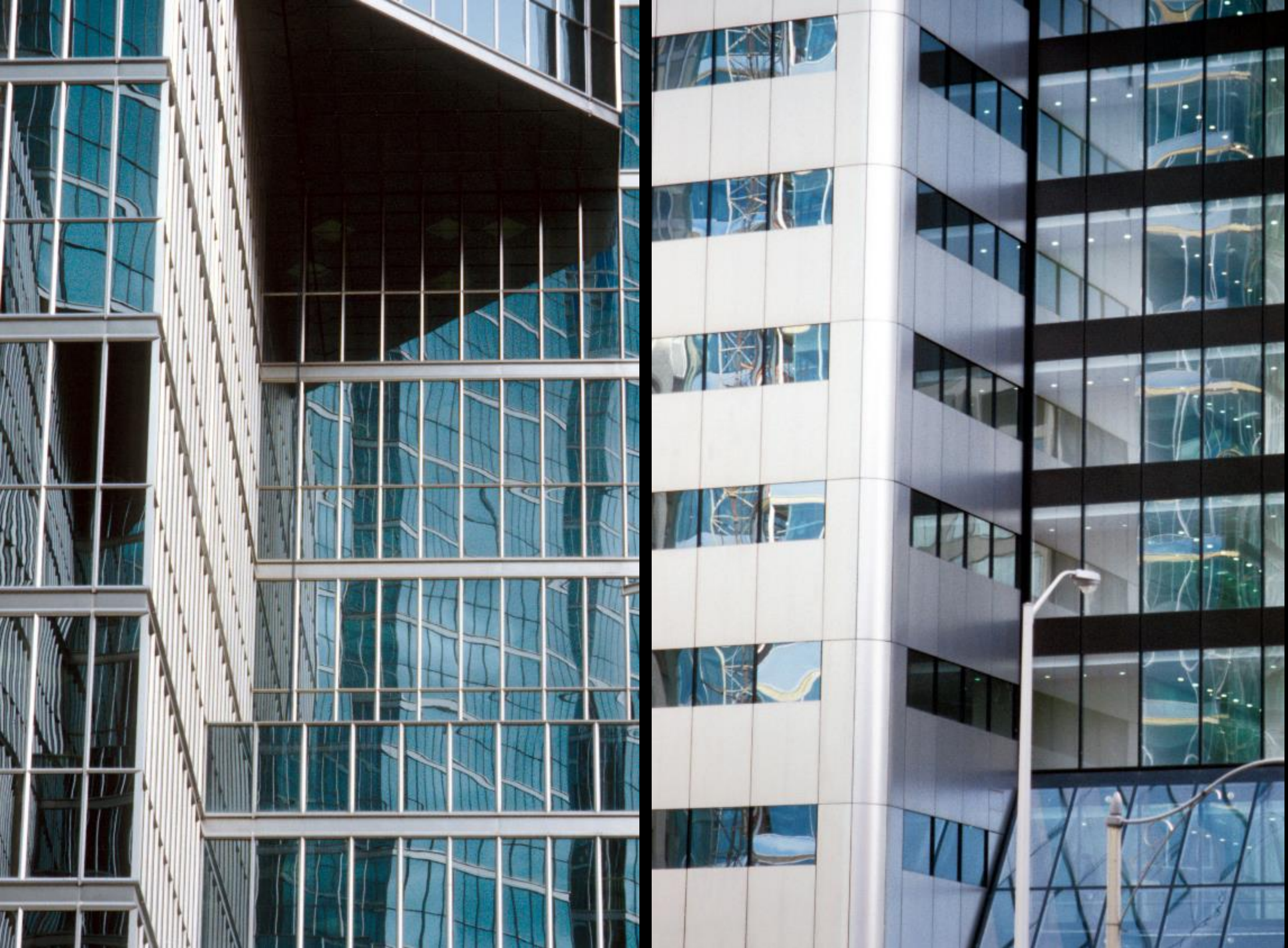


The spacer material that joins the layers of the IGU makes a HUGE difference as to the efficiency of the unit.

When invented aluminum spacers were normal but they result in lower temperatures at the edge of the glass.

Structural sealant type spacers are the best at this point.





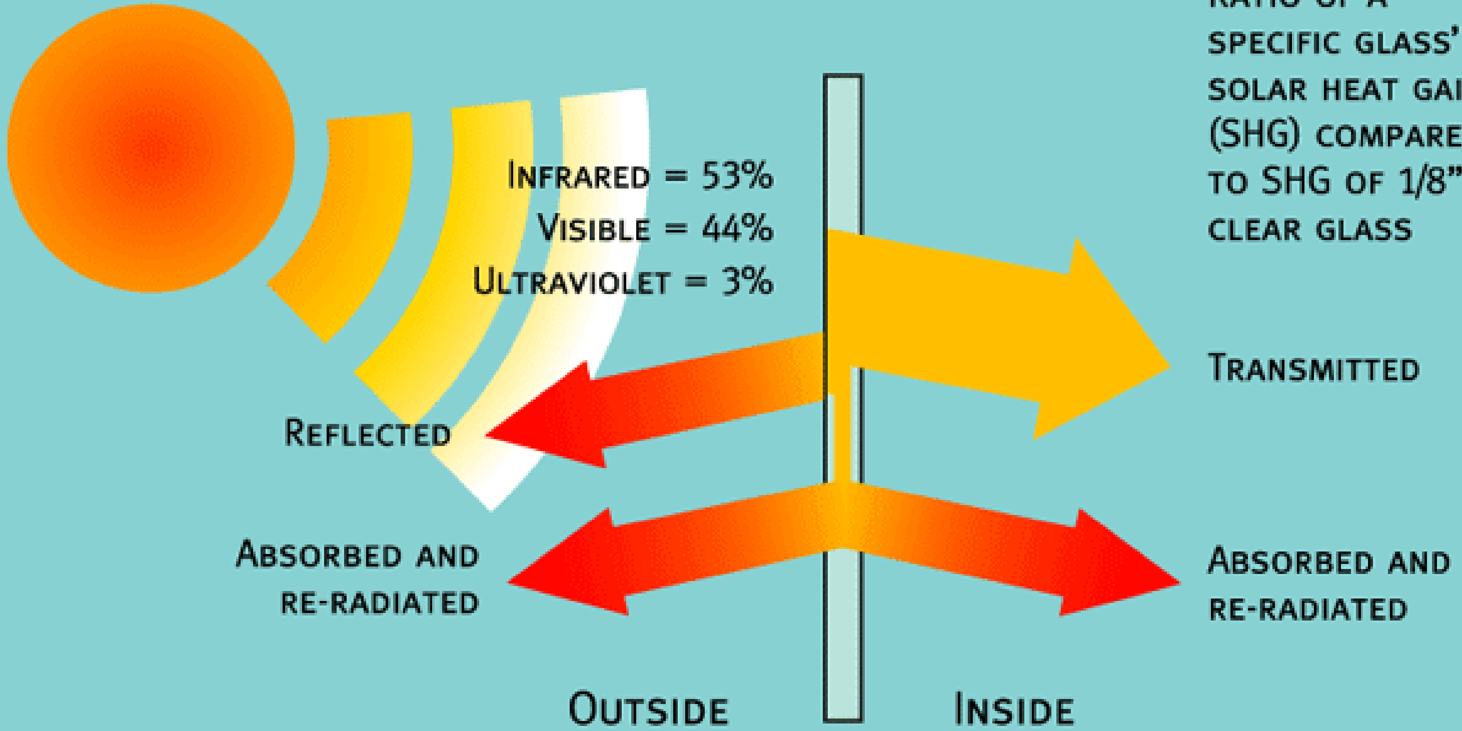
The proportion of glazing to frame directly impacts energy efficiency and cost. The more perimeter to the glass the more energy loss due to the edge conductivity.

It is also more expensive to make smaller units.

Solar energy Review

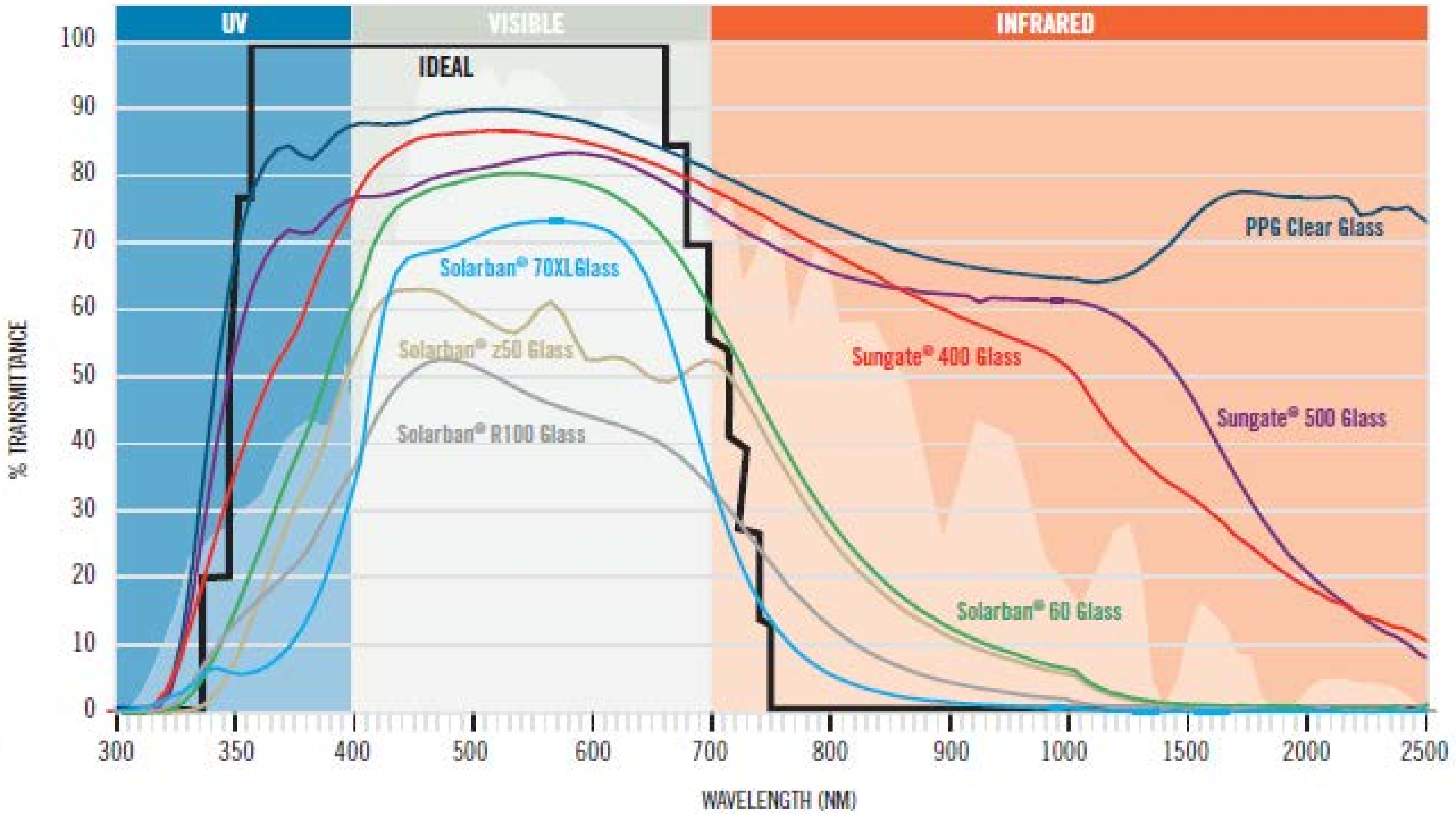
Solar energy spectrum → R+A+T=100% → Solar heat gain → Shading coefficient

Ratio of a specific glass' solar heat gain (SHG) compared to SHG of 1/8" clear glass



	Ordinary Glass	ComfortPlus	EnergyTech Low-E	LoE³-366®
	3mm Clear Glass	6.38mm ComfortPlus Clear	Insulated Glass Unit 6mm EnergyTech 12mm Argon 6mm Clear	Insulated Glass Unit 6mm LoE³-366® 12mm Argon 6mm Clear
Visible light transmittance	89%	82%	73%	62%
Reflectance exterior	8%	10%	16%	11%
Solar Heat Gain Coefficient (SHGC)	0.85	.68	0.61	0.27
U-Value	5.9	3.6	1.6	1.32
UV transmission (Tuv)	68%	0.007%	35%	0.03%

Spectral Curve



As this chart illustrates, when compared to conventional clear glass, ***Solarban*** *solar control, low-e glasses significantly limit the amount of solar radiation that enters a building from the infrared (heat energy) portion of the solar spectrum. Light transmittance from the visible portion of the solar spectrum remains comparatively high.*

TABLE 3-4 Typical Glazing Characteristics (center of glass)

Type of Glazing	U-Value (R-Value)	Visible Light Transmittance	UV Light Transmittance*	Solar-Heat-Gain Coefficient	Recommended Applications
Single glazing, clear	1.0 (1.0)	90%	71% (85%)	.86	None
Double glazing, clear	.50 (2.0)	81%	56% (59%)	.76	None
Double glazing, low-E, high-solar gain	.35 (2.9)	75%	47% (51%)	.71	Cold climates; passive solar
Double glazing, high-solar gain, low-E, argon**	.29 (3.4)	75%	47% (51%)	.71	Cold climates; passive solar
Double glazing, moderate-solar gain, low-E, argon	.27 (3.7)	78%	23% (40%)	.58	Cold or mixed climates
Double glazing, spectrally selective low-E, argon***	.25 (4.0)	71%	16% (33%)	.39	Hot or mixed climates; west-facing glass
Double glazing (1 inch) with clear Heat film	.21 to .26 (3.8 to 4.8)	20 to 81% (varies with coating type)	<1% (28% to 53%)	.14–.57	Match coating to climate and design needs.

*Number in ( ) is "damage-weighted transmittance (T-dw)," which includes the portion of visible light that contributes to fading. Lower numbers indicate less fading.

**High-solar-gain glass uses "hard-coat" or pyrolitic coatings.

***Spectrally selective glass is also called "low-solar-heat-gain low-E."

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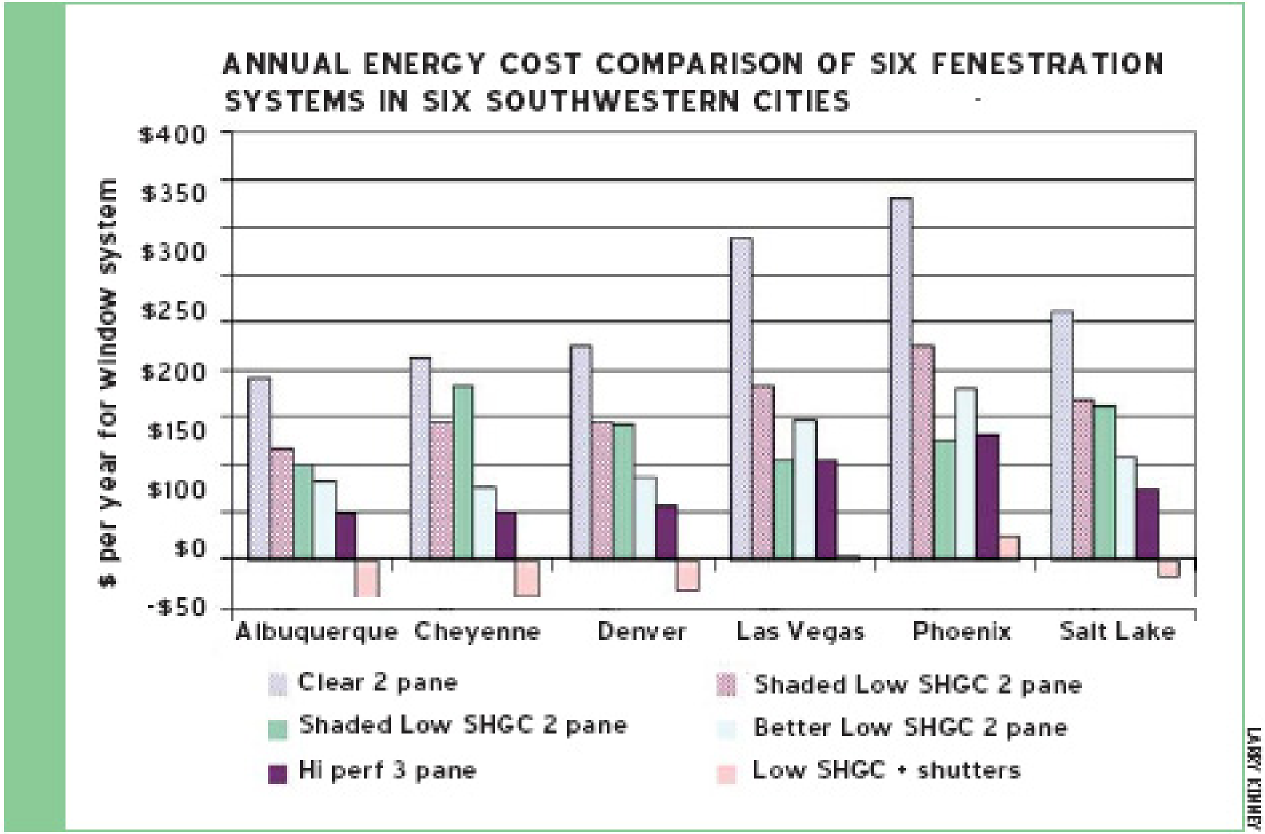
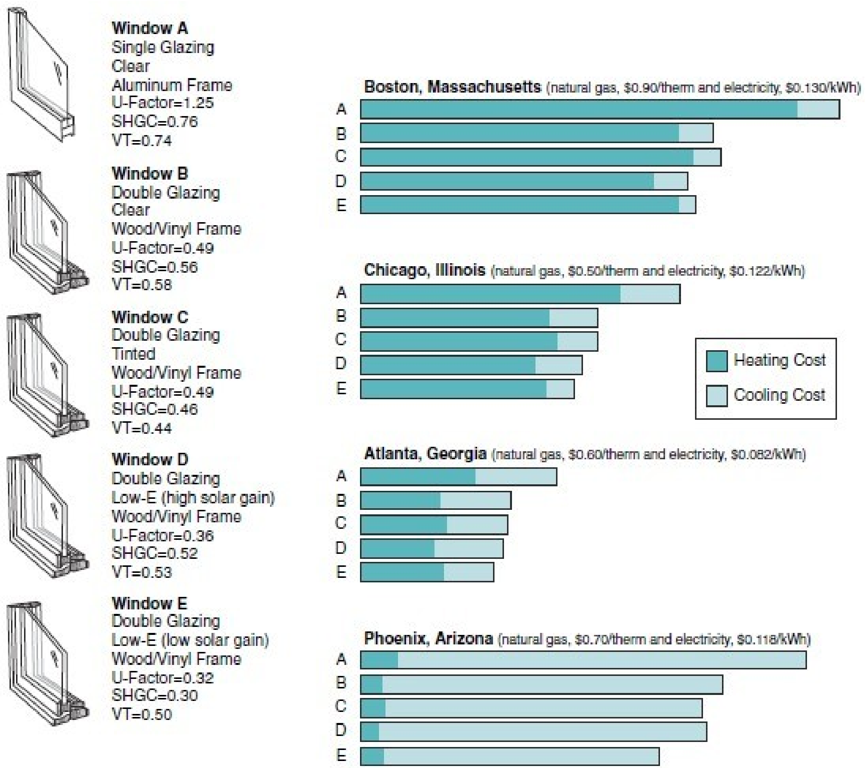


Figure 1. The annual energy cost associated with the windows is cut roughly in half by going from ordinary aluminum frame double pane windows to spectrally selective low solar gain low-e glass.

FIGURE 3-10 Annual Energy Performance of Glazing Types by Climate.



NOTE: Annual energy-performance figures were generated using RESFEN software for a typical 2,000 square feet house with 300 square feet of window area, equally distributed on all four sides, with typical shading. Costs for heating with a gas furnace and cooling by air conditioning are based on typical energy costs for each location. U-factor, SHGC, and VT are for the total window, including frame.

SOURCE: Reprinted with permission from *Residential Windows, 2nd Edition* © 2000, John Carmody, Stephen Selkowitz, Dariush Arasteh, and Lisa Heschong. Published by W. W. Norton & Co.

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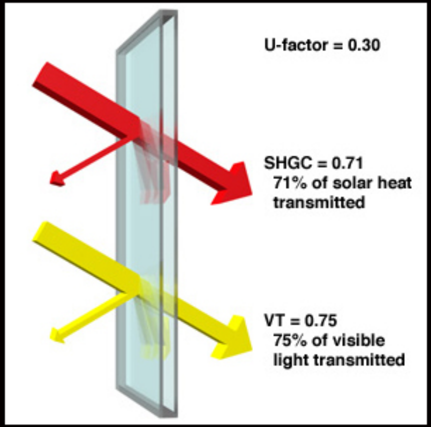
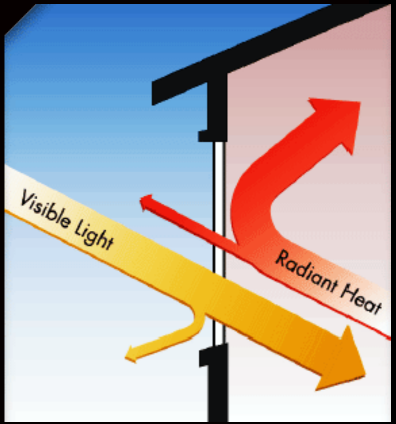
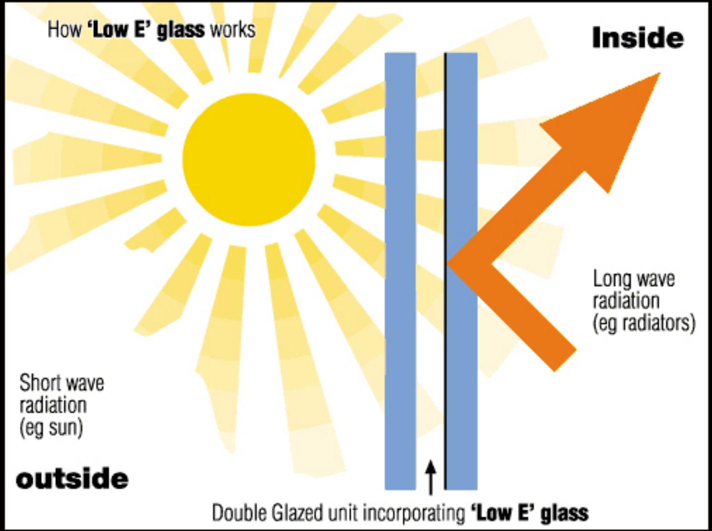
Low E glass coatings work by reflecting or absorbing IR light (heat energy). The thickness of the Low E coating and the position in the window (#2 or #3 surface) dictate how the window will perform.



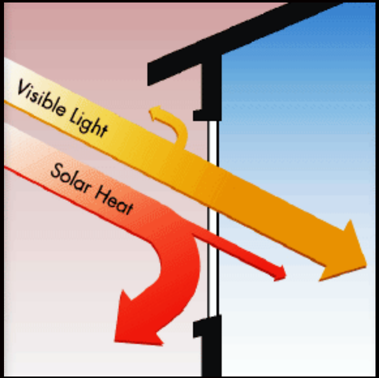
When installed on the #3 surface of an insulated glass unit (IG), the Low E coating will reflect IR heat from inside the room to help reduce the energy loss during the cold months, thereby reducing heating costs.

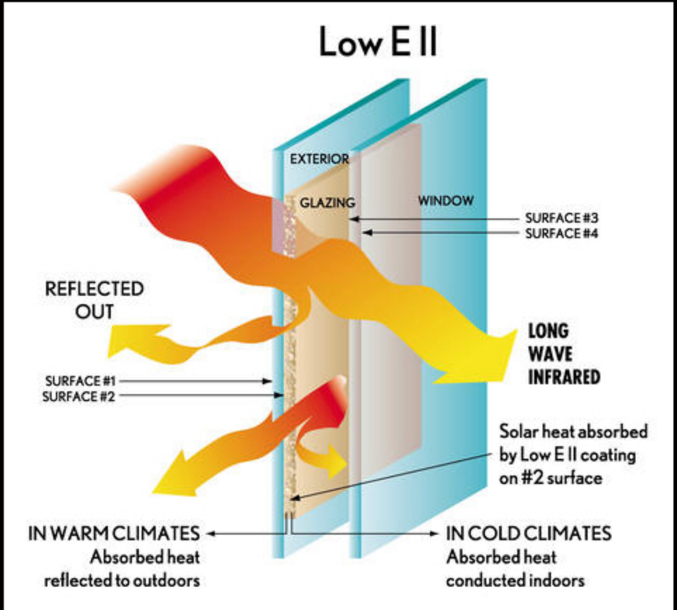




HIGHER SHGC

When installed on the #2 surface of an IG unit, the Low E coating will reflect or absorb IR heat from the outside, thereby reducing solar gain and cooling costs during the warm months.





LOWER SHGC

6.3 The Canadian Energy Rating (ER) System

Although CSA-A440 protects the consumer and is the minimum performance standard referenced in most building codes, the bottom line for the energy-conscious consumer is a window's Energy Rating, or ER number, based on the CSA-A440.2 *Energy Performance of Windows and Other Fenestration Systems* standard, which applies to all windows and sliding glass doors, and the CSA-A453.0 which applies to all swinging or entry door systems.

A window's ER rating is a measure of its *overall* performance, based on three factors: 1) solar heat gains; 2) heat loss through frames, spacers and glass; and 3) air leakage heat loss. A number is established in watts per square metre, which is either positive or negative, depending on heat gain or loss during the heating season. The range is wide. **Fig. 31** lists the typical ER ratings for windows most commonly available.

Window Ratings	Max. Air Leakage Rate $(m^3/h)m^{-1}$
A1	2.79
A2	1.65
A3	0.55
Fixed	0.25
Window Ratings	**Water Leakage Test Pressure Differential (Pa)**
B1	150
B2	200
B3	300
B4	400
B5	500
B6	600
B7	700
Window Ratings	**Wind Load Resistance Test Pressure (kPa)**
C1	1.5
C2	2.0
C3	3.0
C4	4.0
c5	5.0

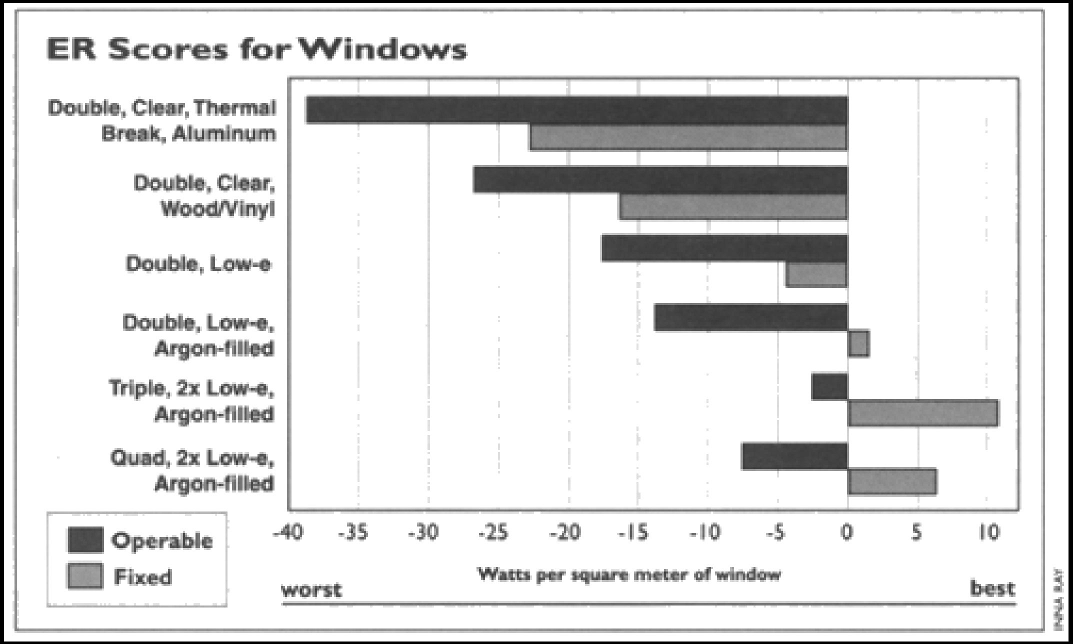


Fig. 31 - Typical Energy Ratings (ER)

Window Category	Type of Spacer	Type of Glazing	Fixed Window	Operable Window
Common	Aluminum	Double	-15	-25
Moderate-cost, high-performance	Insulated	Double, low-E, argon gas	0	-8
Best high-performance commercially available	Insulated	Triple, low-E coating, krypton gas	+8	+1


8

	Material's Used	Resource Depletion	Mfg Emissions	Embodied Energy	Energy Used During Life	Ozone Depletion	Emissions During Life	Disposal
Fiberglass	Glass fiber, resin, polystyrene insulation	**low**	**low**	**med**	**low**	**low**	**med**	**med**
Alum Clad Wood	Wood and aluminum	**med**	**med**	**med**	**med**	**low**	**low**	**med**
Vinyl	Polyvinyl chloride	**high**	**high**	**med**	**med**	**low**	**low**	**med**

WINDOW SELECTION CONSIDERATIONS

WINDOW TYPES	ADVANTAGES: 100% vent opening	Diverts inflowing air upward	Deflect drafts	Rain protection while partly open	Screen/storm sash easy to install	Easy to wash	DISADVANTAGES: Only 50% of area openable	No protection from rain when open	Hard to operate when over an obstruction	Hazard if vent low and close to walkways	Hard to wash	Interferes with furniture, drapes, blinds, etc.	Screens-storm windows difficult to provide	Sash has to be rem for washing
Horizontal sliding					◆	◆	◆	◆	◆				◆	
Double hung					◆		◆	◆	◆		◆			◆
Double hung (reversed)					◆	◆	◆	◆	◆					
Casement (out)	◆		◆		◆			◆		◆	◆			◆
Casement (in)	◆		◆		◆	◆		◆				◆		
Pivoted (vertical)	◆		◆			◆		◆		◆		◆	◆	
Pivoted (horizontal)	◆	◆	◆	◆		◆			◆	◆		◆	◆	
Top hinged (out)	◆			◆	◆				◆	◆				◆
Bottom hinged (in)	◆	◆	◆	◆		◆						◆		
Fixed sash											◆			◆
Jalousie	◆	◆		◆							◆			

Source: National Bureau of Standards

COMPARE WINDOW FRAME MATERIALS

modernize

	WOOD	VINYL	FIBERGLASS	ALUMINUM
Will not crack		✓	✓	✓
Will not peel		✓	✓	✓
Will not bend or warp		✓	✓	✓
Paintable	✓		✓	✓
Wood window-like profile	✓	✓	✓	
Available with wood clad interior	✓		✓	
High energy-efficency coefficient		✓	✓	
Will not stick due to expansion & contraction	✓	✓	✓	

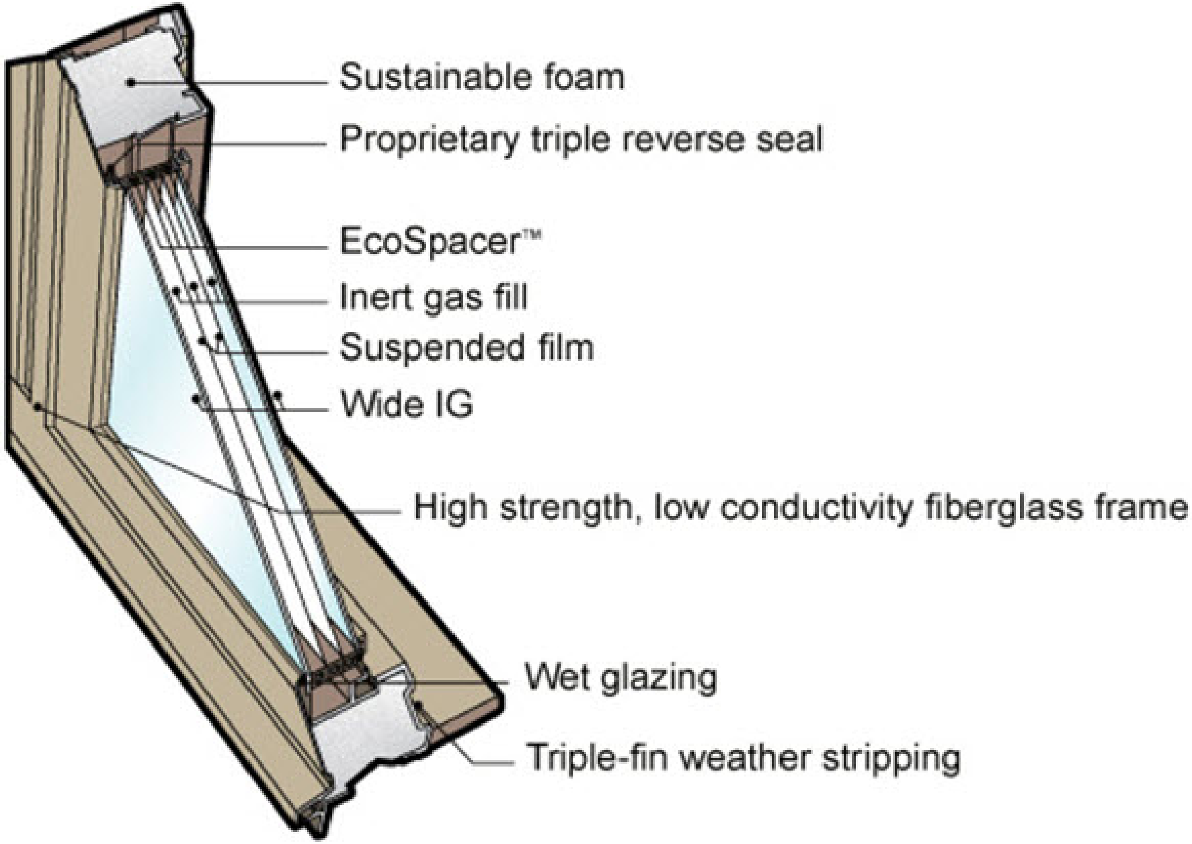
www.modernize.com

Window Types

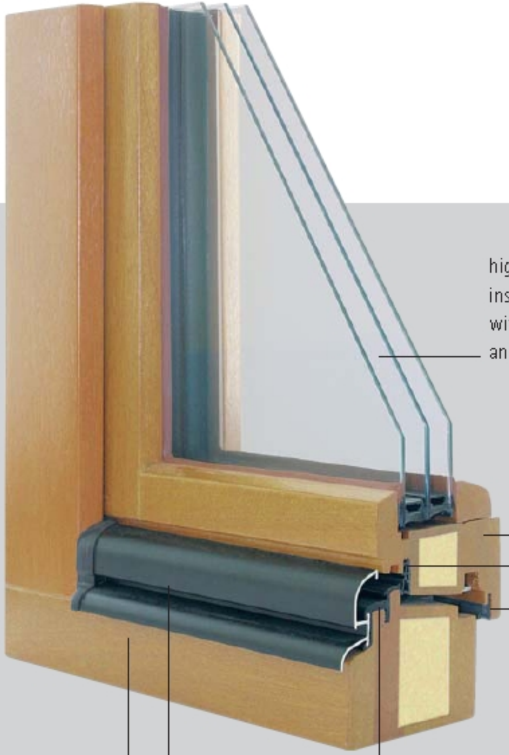
Energy-efficient windows come in traditional styles.

Type	Aesthetics			Performance					Cost[5]
	Sightlines	Finish Options	Customization Options	Energy / Thermal Performance[2]	Strength[3]	Durability & Rot Resistant	Maintenance	Color Durability[4]	
Vinyl[1] Extruded PVC frames	★	★	★	★★★	★	★★★	★★★	★★★	$
Fiberglass[1] Frames made of a composite material of glass fibers and resin	★	★★	★	★★★	★★	★★★	★★★	★★★	$
Aluminum Extruded alumimum frame	★★	★★★	★★★	★★★ thermally broken ★ non-thermally broken	★★	★★★	★★★	★★	$$
Wood-Clad Aluminum Aluminum windows with a wood trim piece attached to the exterior	★★	★★★	★★★	★★★ thermally broken ★ non-thermally broken	★★ varies by wood species	★	★ Requires refinishing (reseal/repaint) in future years	★★	$$-$$$
Wood Solid wood frames or split-finish	★★	★★	★★★	★★★	★★ varies by wood species	★	★ Requires refinishing (reseal/repaint) in future years	★★	$$-$$$
Fiberglass-Clad Wood Wood windows with a fiberglass exterior cap	★★	★★	★★	★★★	★★ varies by wood species	★★★	★★★	★★★	$$
Alum-Clad Wood Wood windows with an aluminum extrusion cap on the exterior	★★	★★★	★★★	★★★	★★ varies by wood species	★★★	★★★	★★	$$$
Steel Steel frames made of hot or cold-rolled steel and bronze	★★★	★★★	★★★	★★★ thermally broken ★ non-thermally broken	★★★	★★★	★★★	★★	$$$$

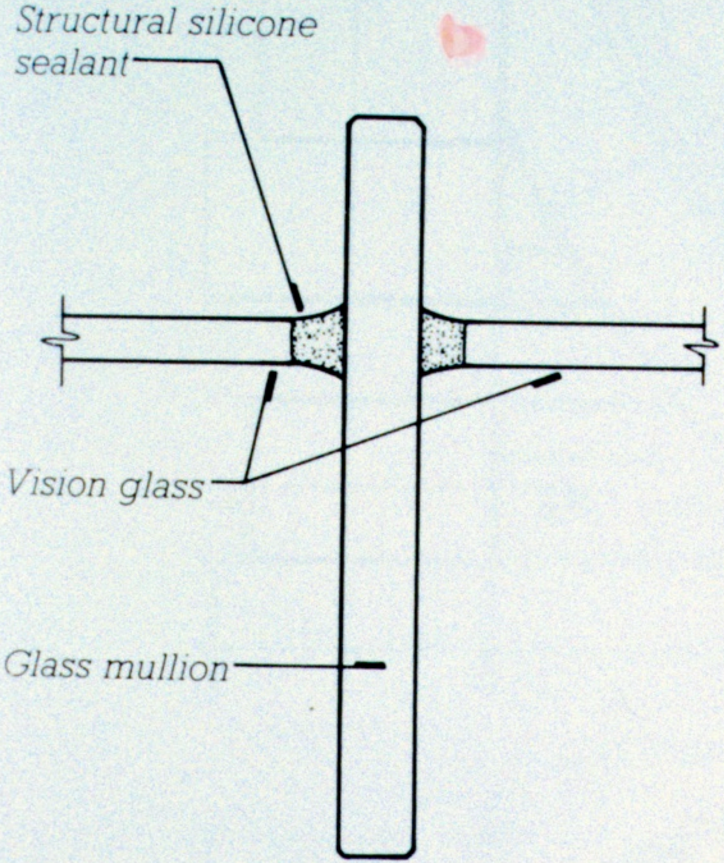
1



* Triple weather stripping offered in casement and awning frame styles. Double weather stripping is included in all other frame styles.


high-quality triple insulation glazing with inert gas filling and warm edge spacers
solid wood casement frame with thermal insulation core, profile strength 105 mm
two circumferential seals in the casement frame
thermal separation for an improved thermal protection
solid wood blind frame with thermal insulation core, profile strength 105 mm
large volume rain bar (in different colours)

Structural Glass



Structural glazing references the use of glass to provide its own support without the use of an aluminum framing system

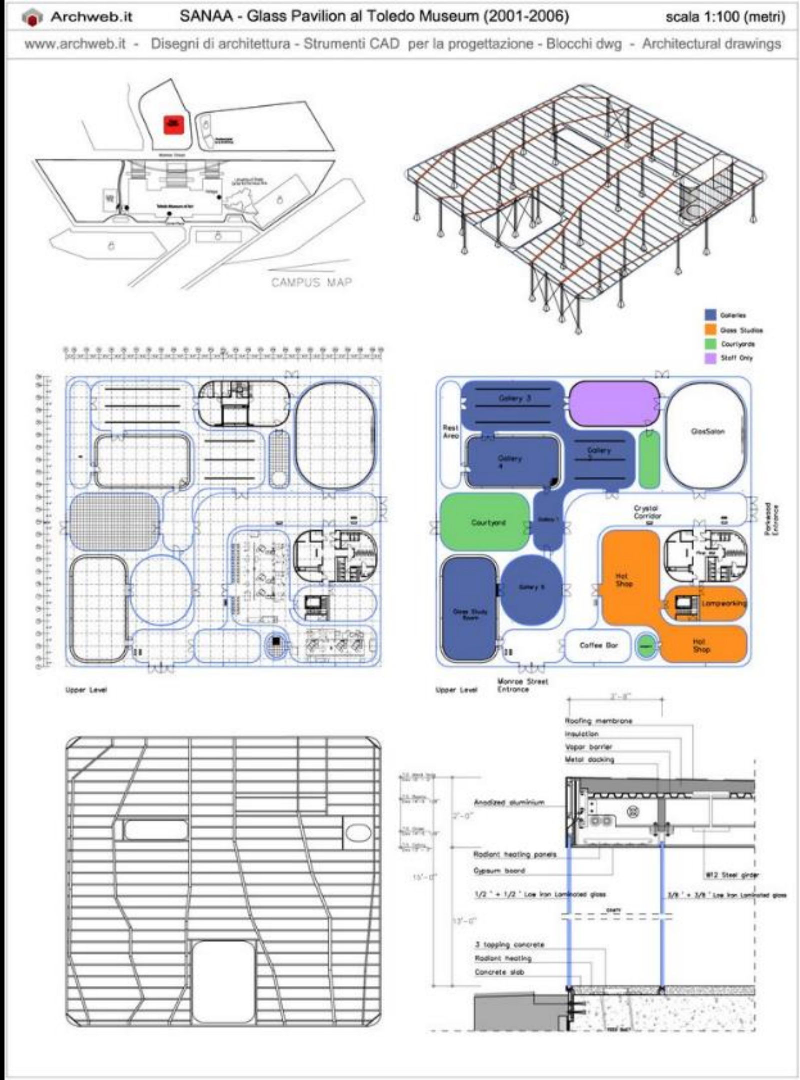
FIGURE 14.28
A typical detail of a glass mullion in suspended glazing assembly.

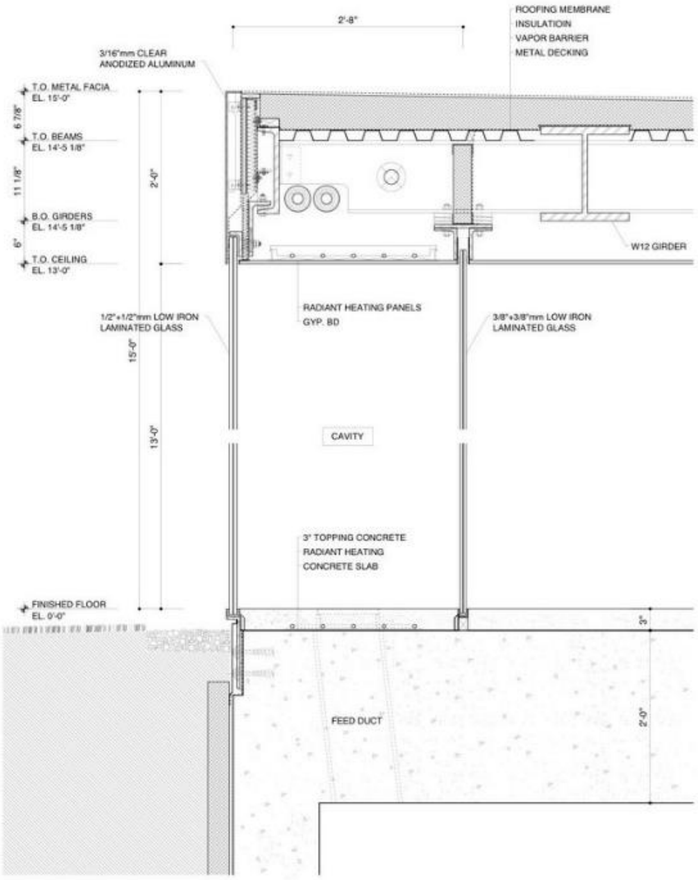
The glass used for this was originally monolithic (meaning a single glass layer but quite thick – in the range of 25mm in thickness).

Wind bracing elements placed at right angles from the vision units provided lateral stability in lieu of an aluminum frame.

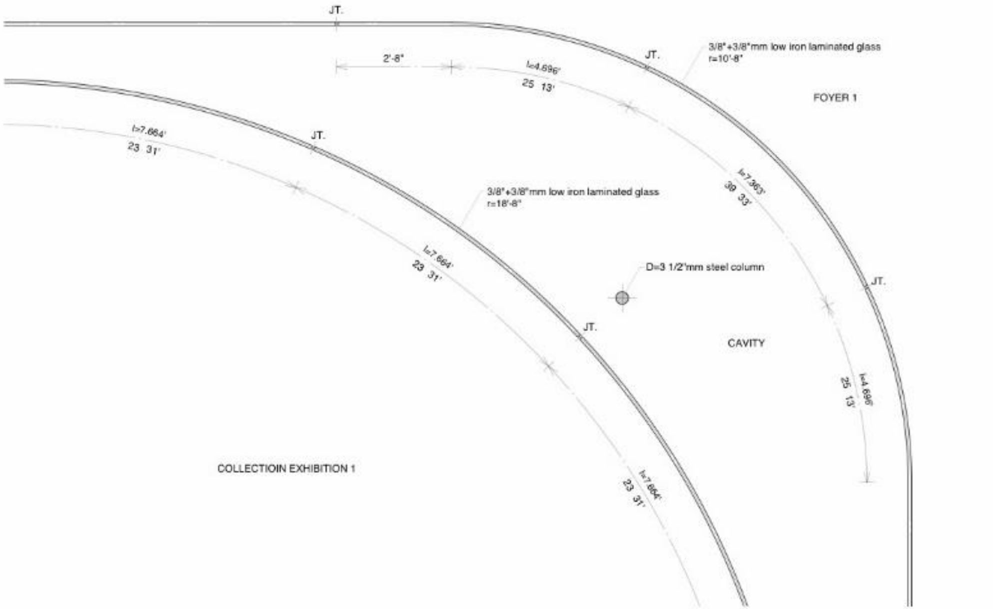

Ceramics Museum,
Toledo, Ohio
Sanaa


Join
Now!
My
Museum


Archweb.it
SANAA - Glass Pavilion al Toledo Museum (2001-2006)
scala 1:100 (metri)
www.archweb.it - Disegni di architettura - Strumenti CAD per la progettazione - Blocchi dwg - Architectural drawings
CAMPUS MAP
Galleries
Glass Studios
Courtyards
Staff Only
Upper Level
Upper Level
Monroe Street Entrance
Crystal Corridor
Courtyard
GlasSalon
Hot Shop
Lampworking
Coffee Bar
Roofing membrane
Insulation
Vapor barrier
Metal decking
Anodized aluminium
Radiant heating panels
Gypsum board
3 topping concrete
Radiant heating
Concrete slab



TOLEDO MUSEUM OF ART GLASS PAVII



TOLEDO MUSEUM OF ART GLASS PAVILION DETAILED PLAN S=1/50

Entry lobby,
Richard Rogers
Tokyo, Japan

Structural glazing is now used to create entirely self supporting structures.

For the most part laminated glass has replaced the use of monolithic panes as they are stronger and more break resistant.

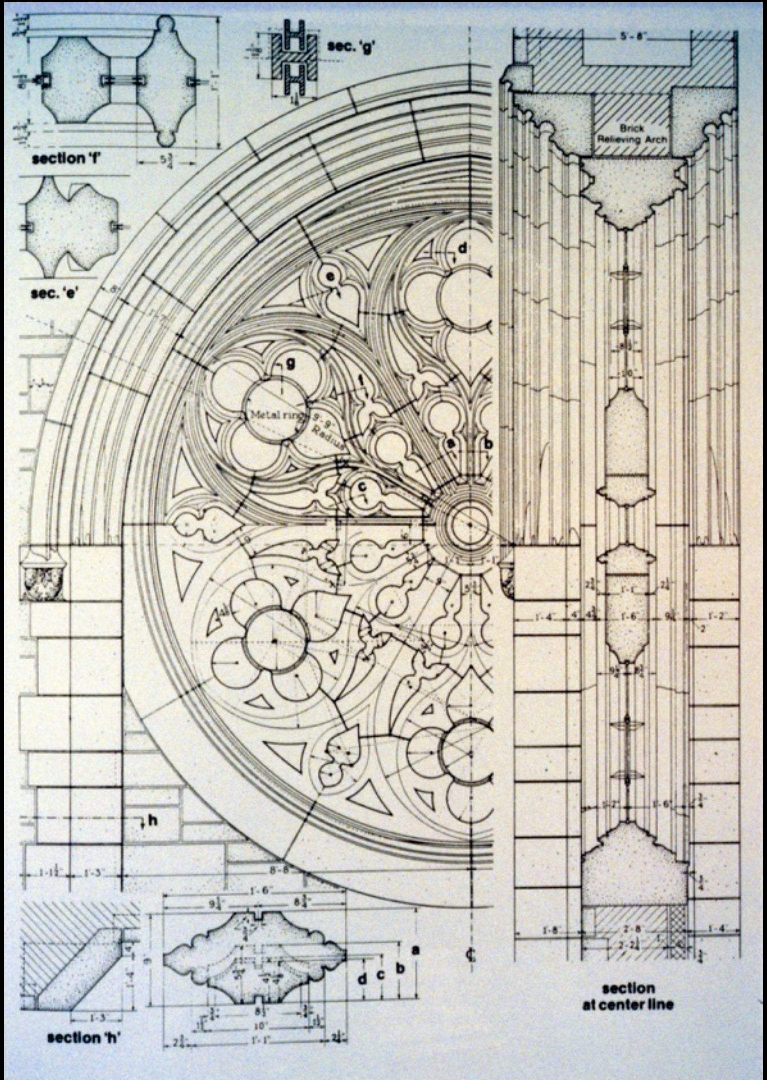
Although the
triangular structural
frame is made from
steel, the glass support
system is all glass

Apple Store, Boston

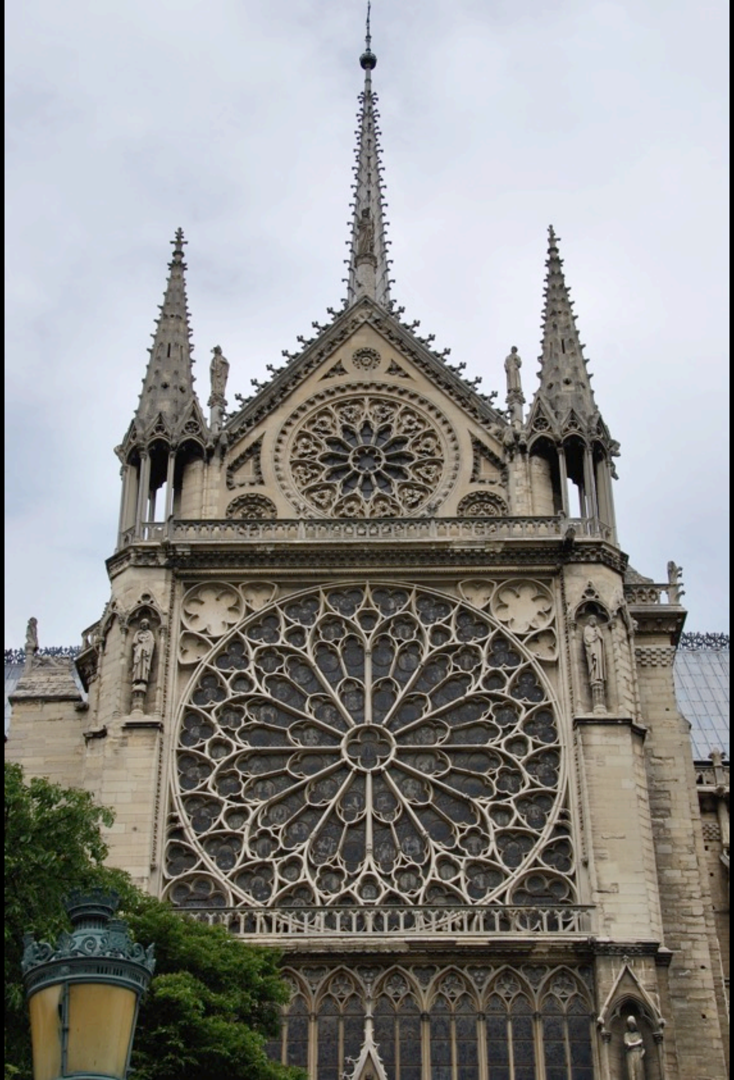
Apple Store, Pudong, Shanghai

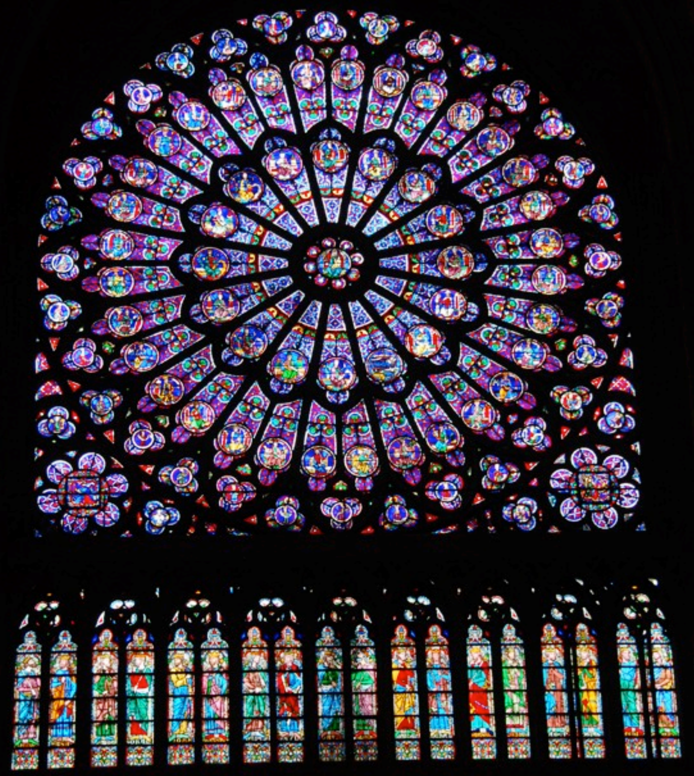
Subway canopy, Tokyo

Coloured Glass Applications



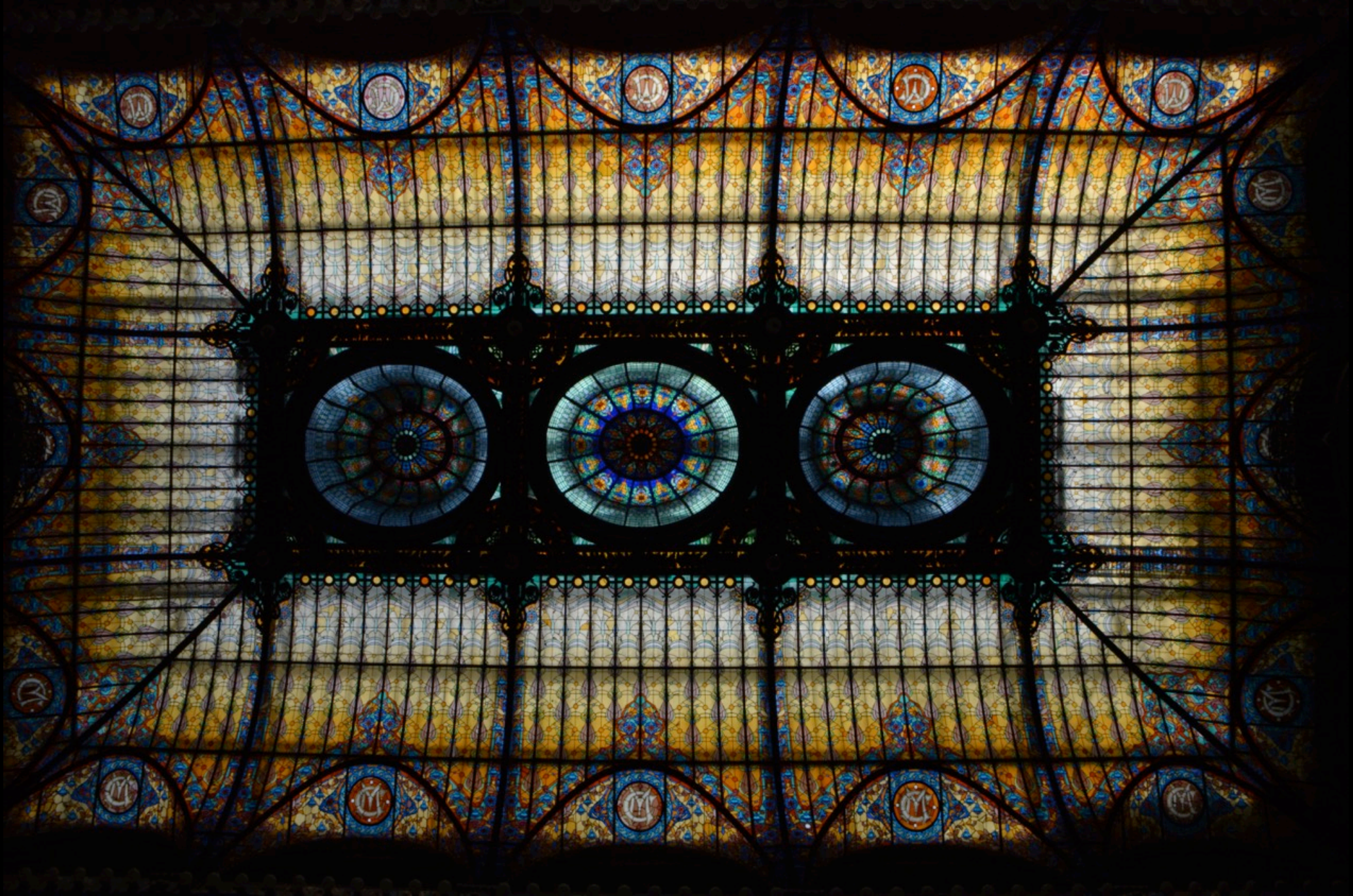
section 'f'
sec. 'g'
sec. 'e'
Brick Relieving Arch
Metal ring
9'-9" Radius
section 'h'
section at center line



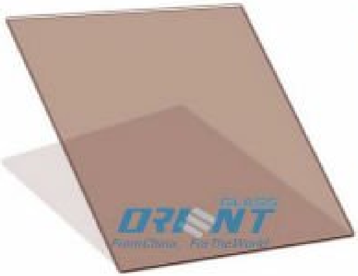


Church, Berlin

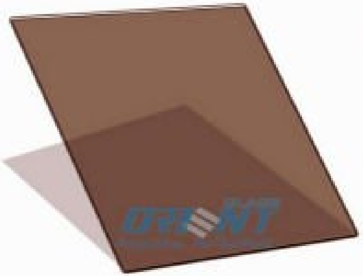
Hotel Ceiling, Mexico City

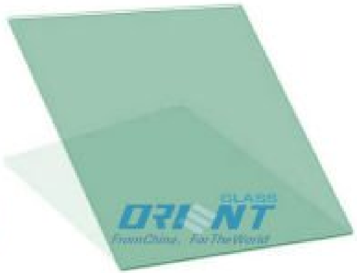


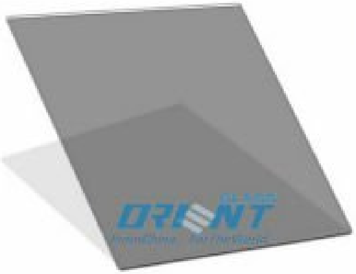
Robie House, Frank Lloyd Wright, Chicago

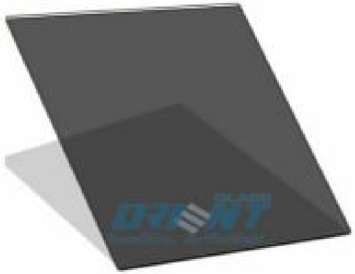

Euro Bronze


Golden Bronze

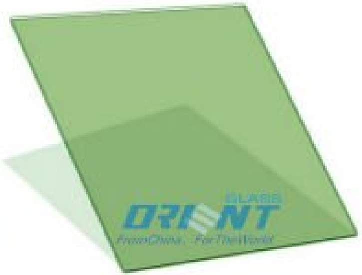

Dark Bronze

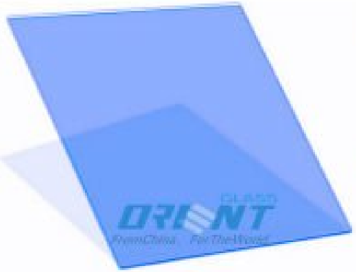

F - Green


Euro Grey


Dark Grey

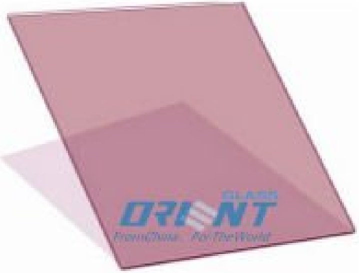

Blue Grey


Dark Green

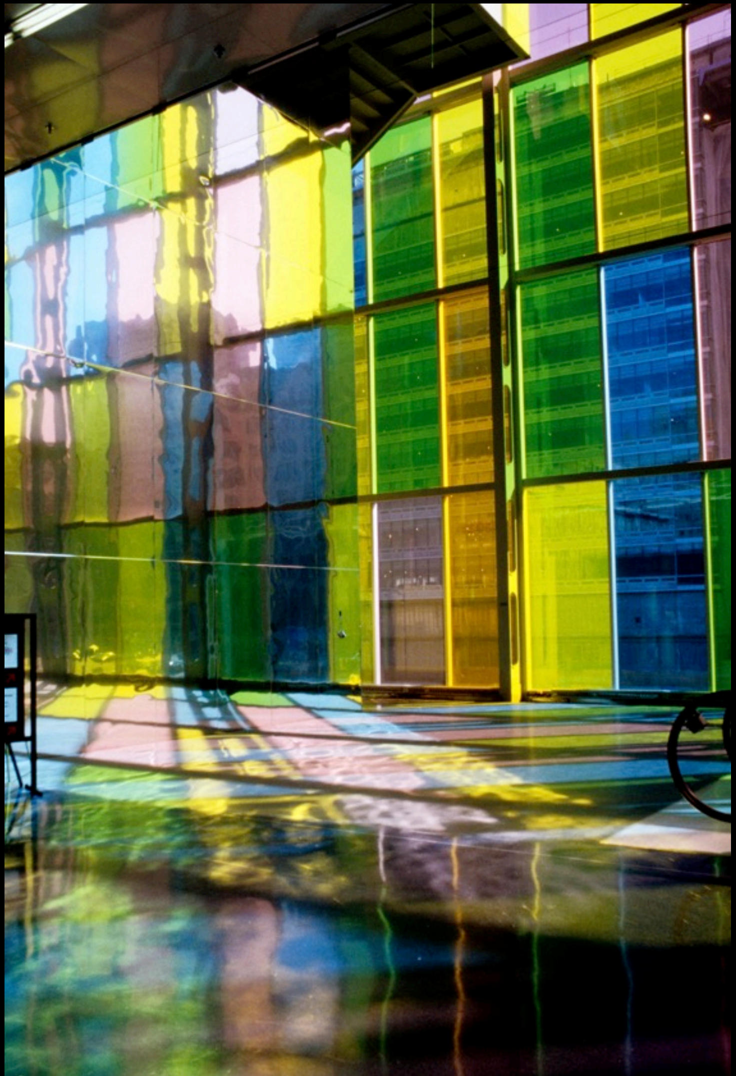

Dark Blue


Ford Blue


Ocean Blue

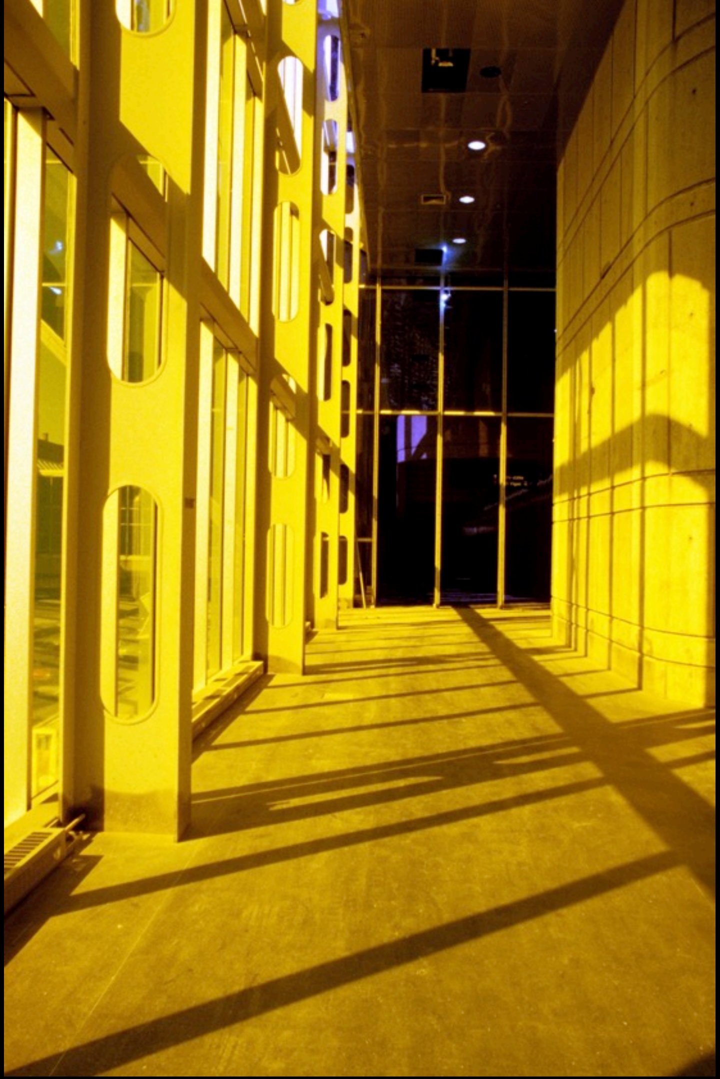

Pink

Palais des Congres, Montreal

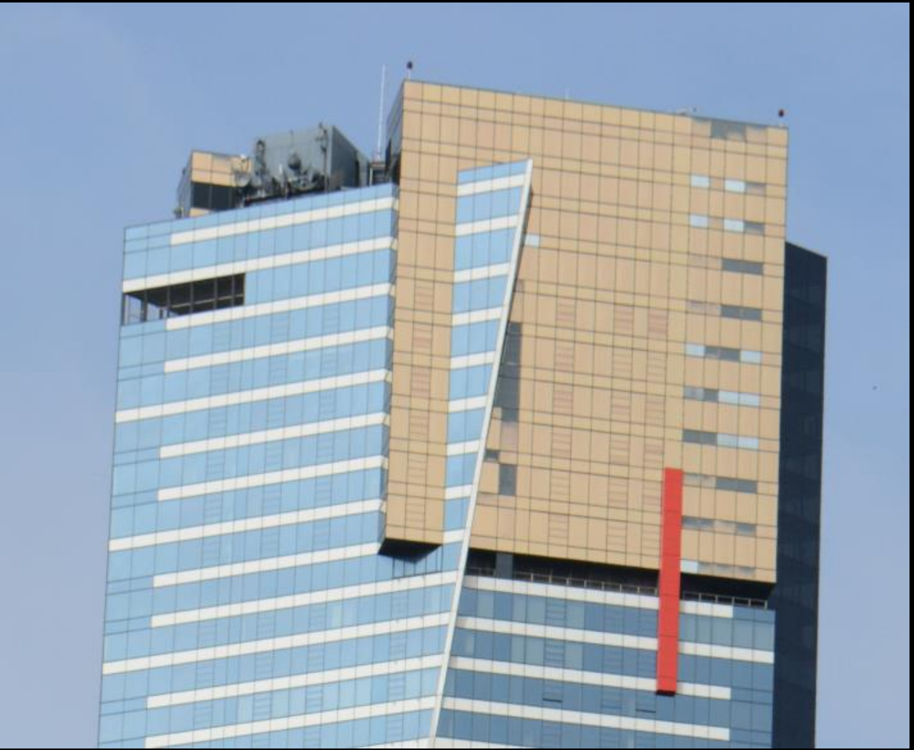




Rez-de-chaussée





Eureka Tower, Melbourne

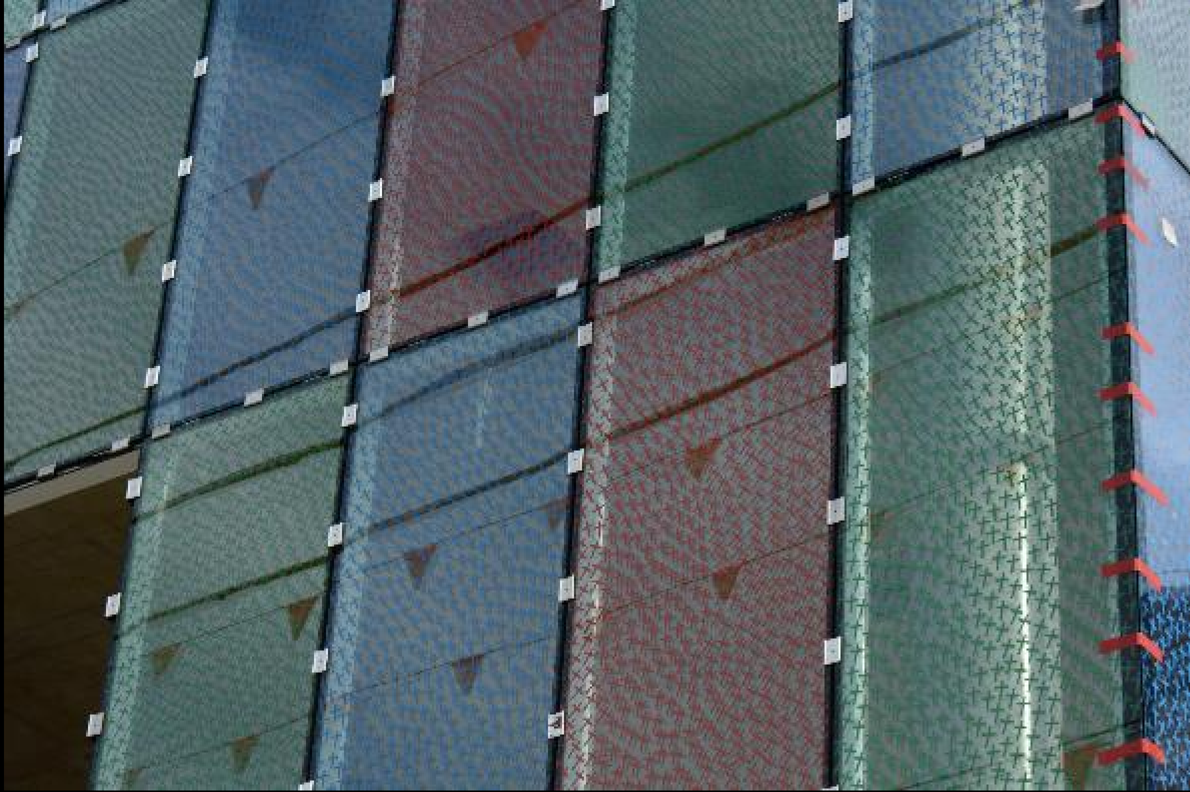
Even a very dark tint can destroy the view

Ceramic Fritted Glass

Ceramic Fritted Glass:

- Silk screening onto glass improves solar control performance
- Can be combined with clear or tinted substrates
- Reduces glare
- Can be any pattern (cost dependent)

Chicago O'Hare International Airport

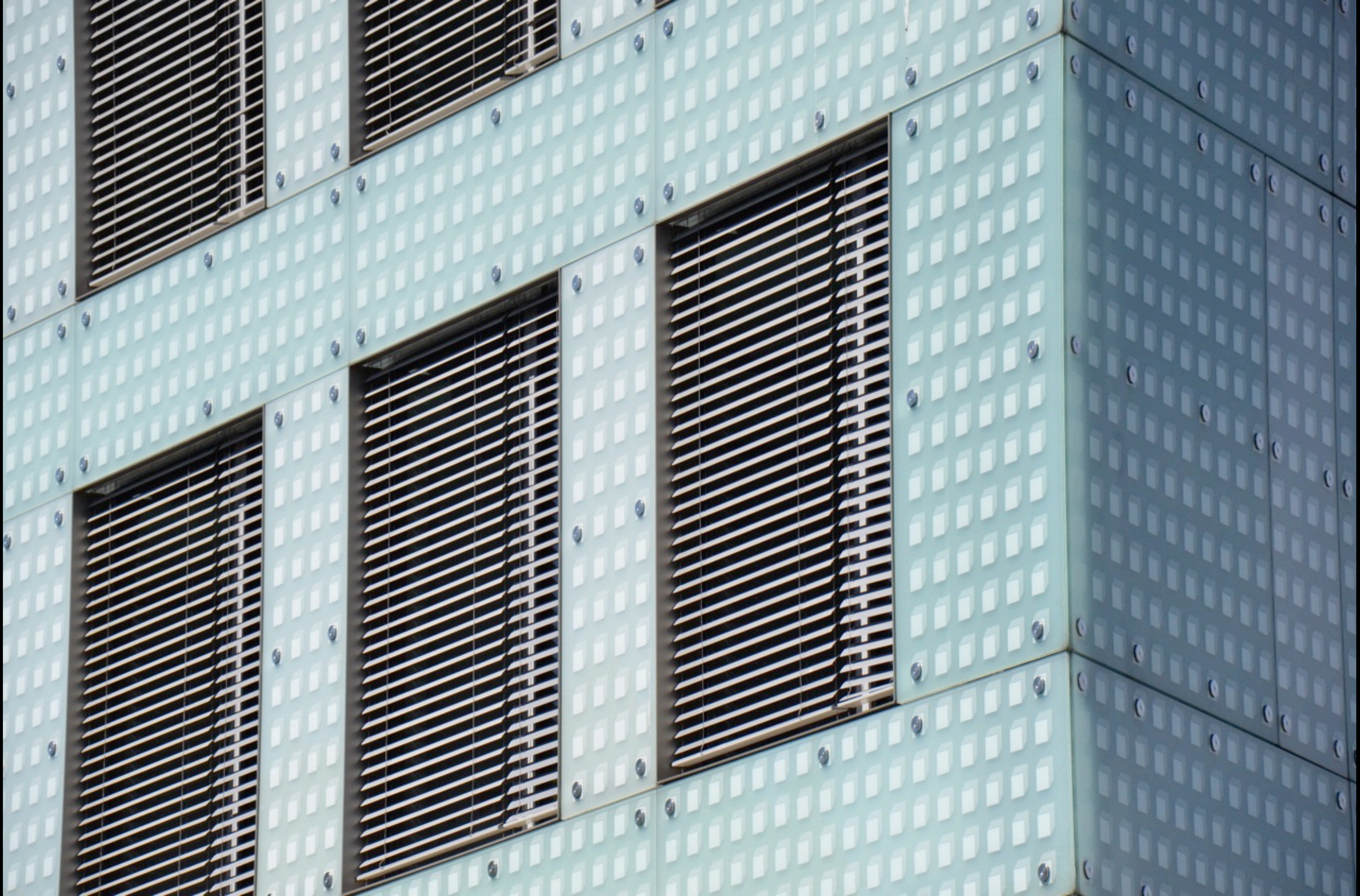



One New Change Shopping Centre
London, England
Ateliers Jean Nouvel

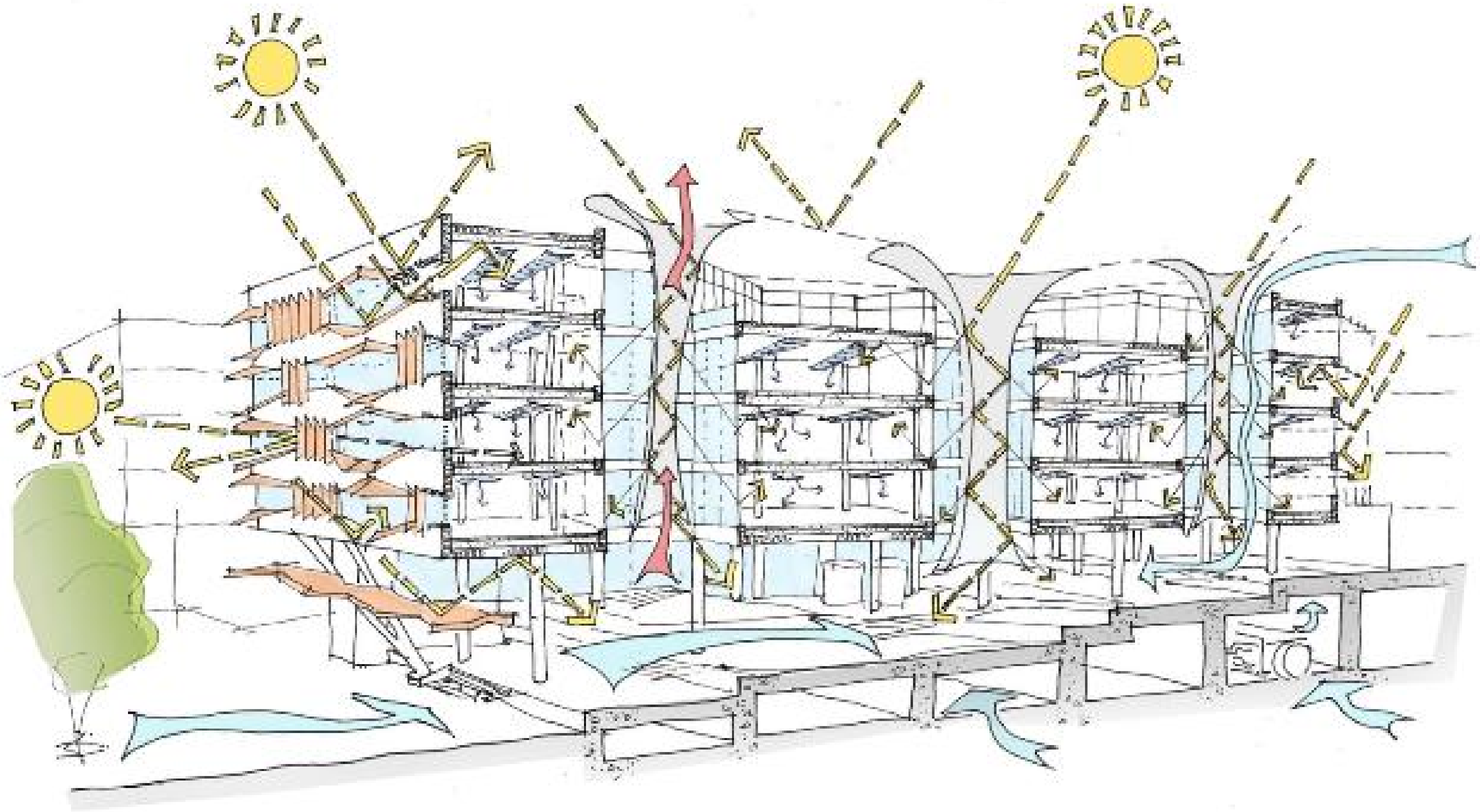

London Bridge 521
beauty
next

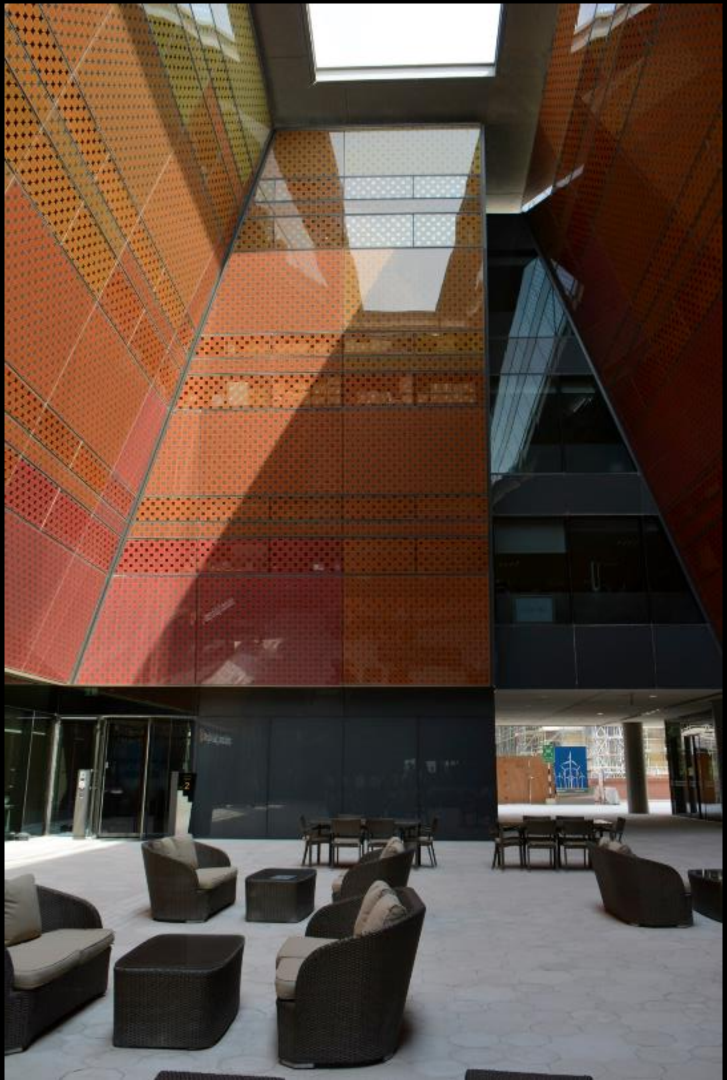

K&L GATES

Office Building
Brisbane, Australia



Siemens HQ
Masdar City, Abu Dhabi, UAE
Sheppard Robson Architects
2013



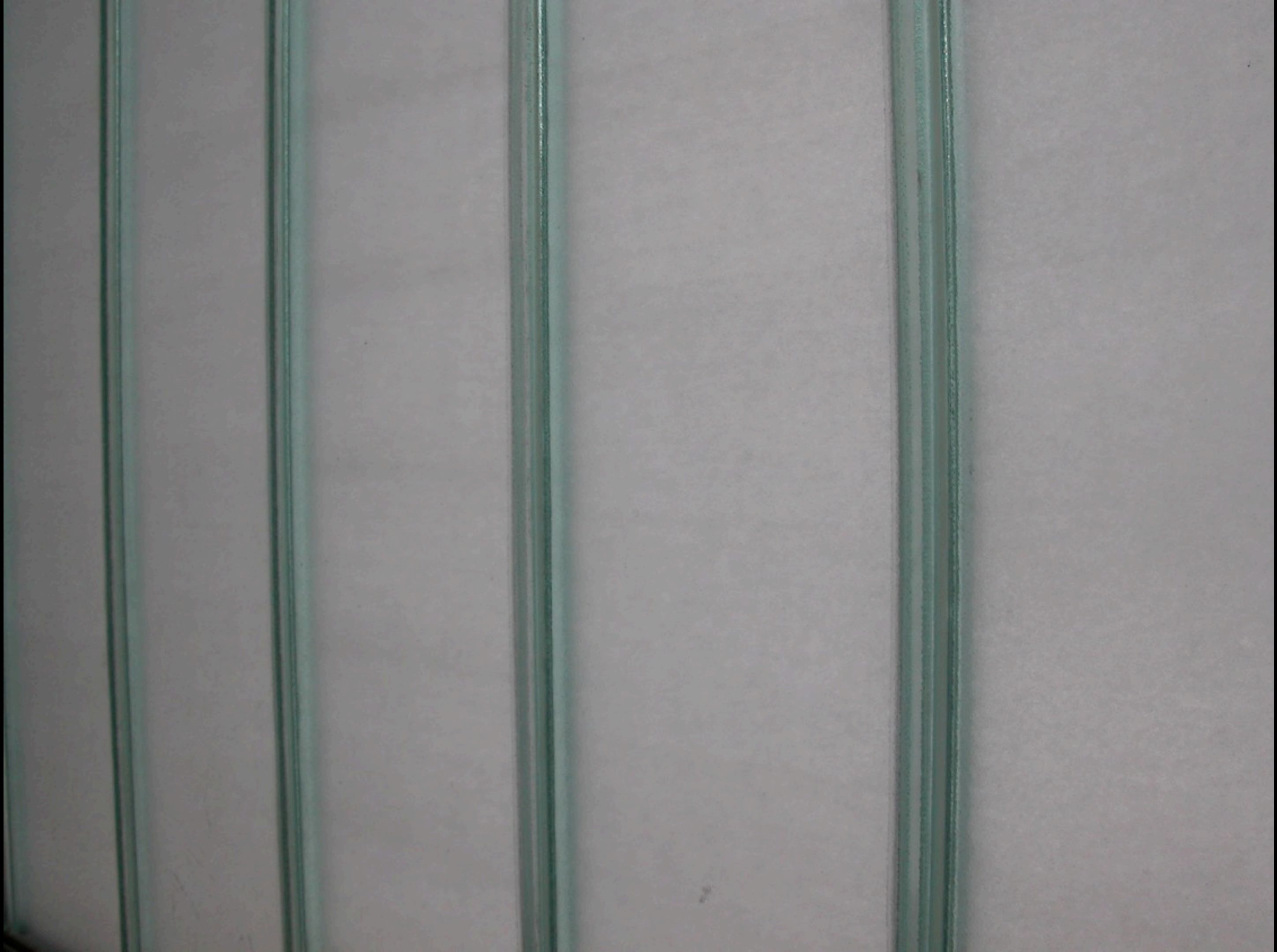


The Branley Museum
Paris, France
Ateliers Jean Nouvel


Billetterie

Channel Glass


University of Minnesota School of Architecture
Steven Holl Architects

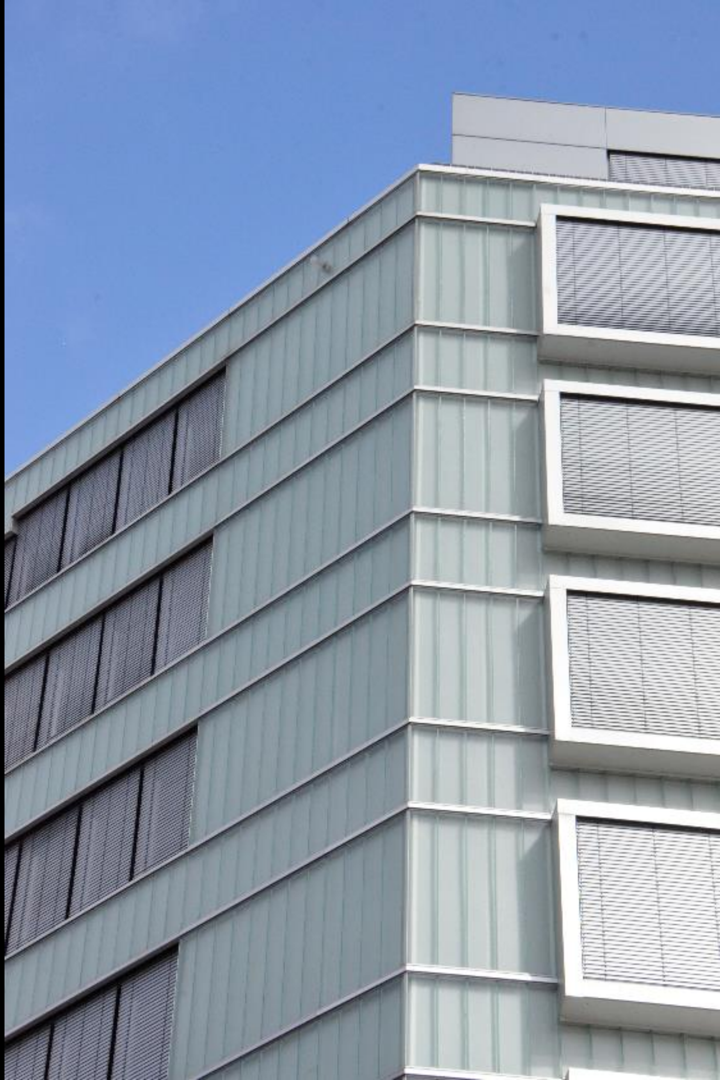


What is it like to have
no access to a real view?

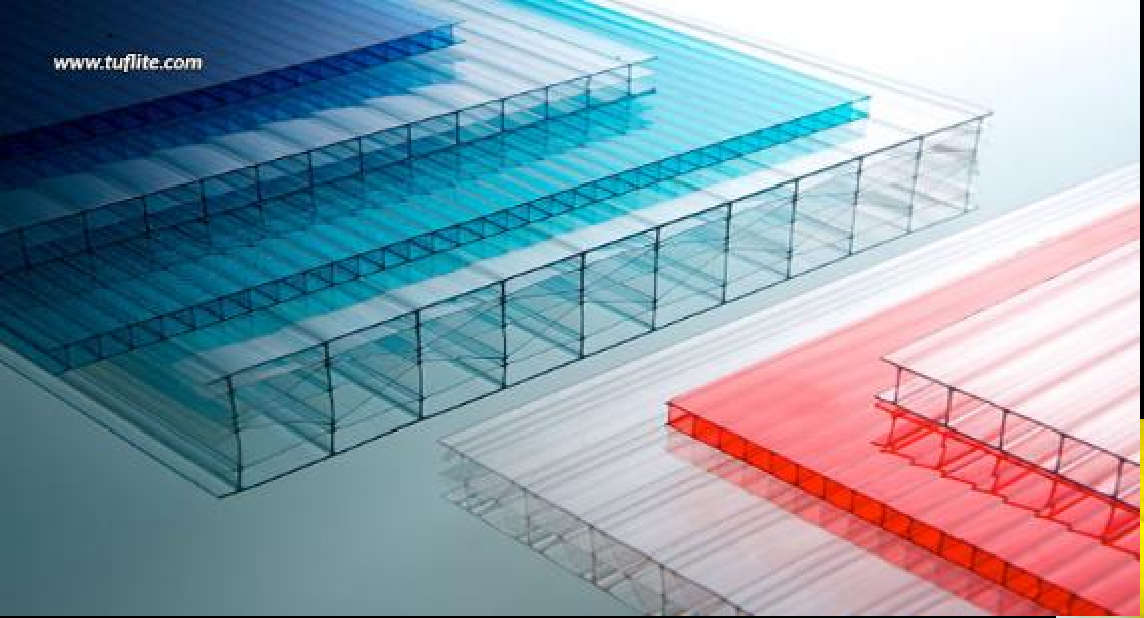

Boston Art Gallery
Diller Scofidio Renfro

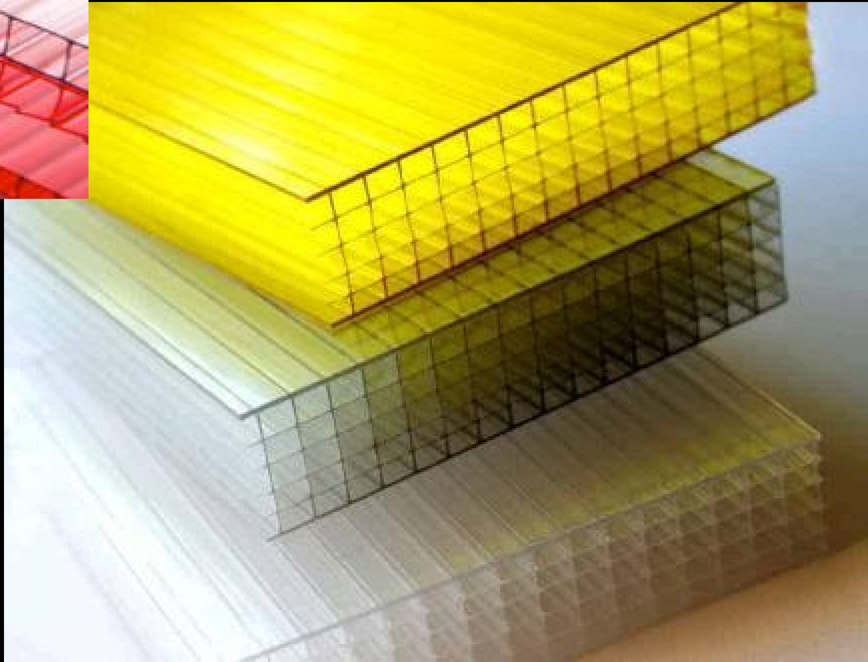

Nelson Atkins Art Gallery
Kansas City, Missouri
Steven Holl Architects

Channel glass used for the opaque wall sections on an office building in Berlin



Parking Garage
Quebec City





Polycarbonate Panels

https://danpal.com/polycarbonate-panels/

Trinity Laban Dance Centre
London, England
Herzog & deMeuron

ETFE

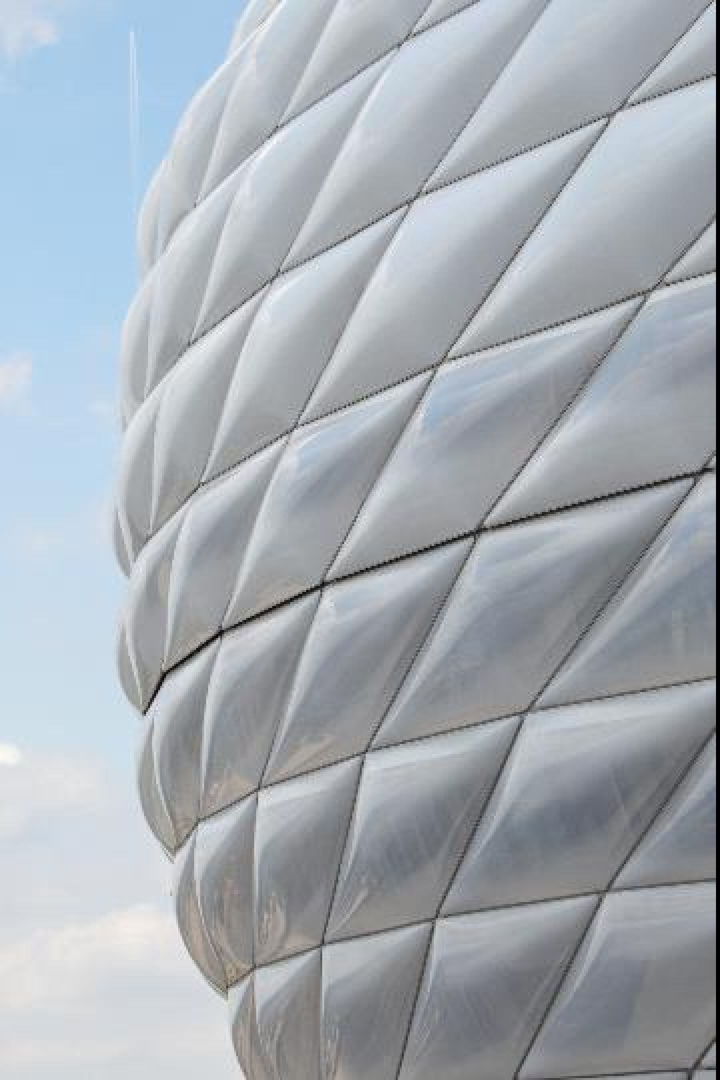
Ethylene tetrafluoroethylene (ETFE) is a fluorine-based plastic. It was designed to have high corrosion resistance and strength over a wide temperature range. ... ETFE has a relatively high melting temperature and excellent chemical, electrical and high-energy radiation resistance properties.

The Water Cube
2008 Beijing Olympics

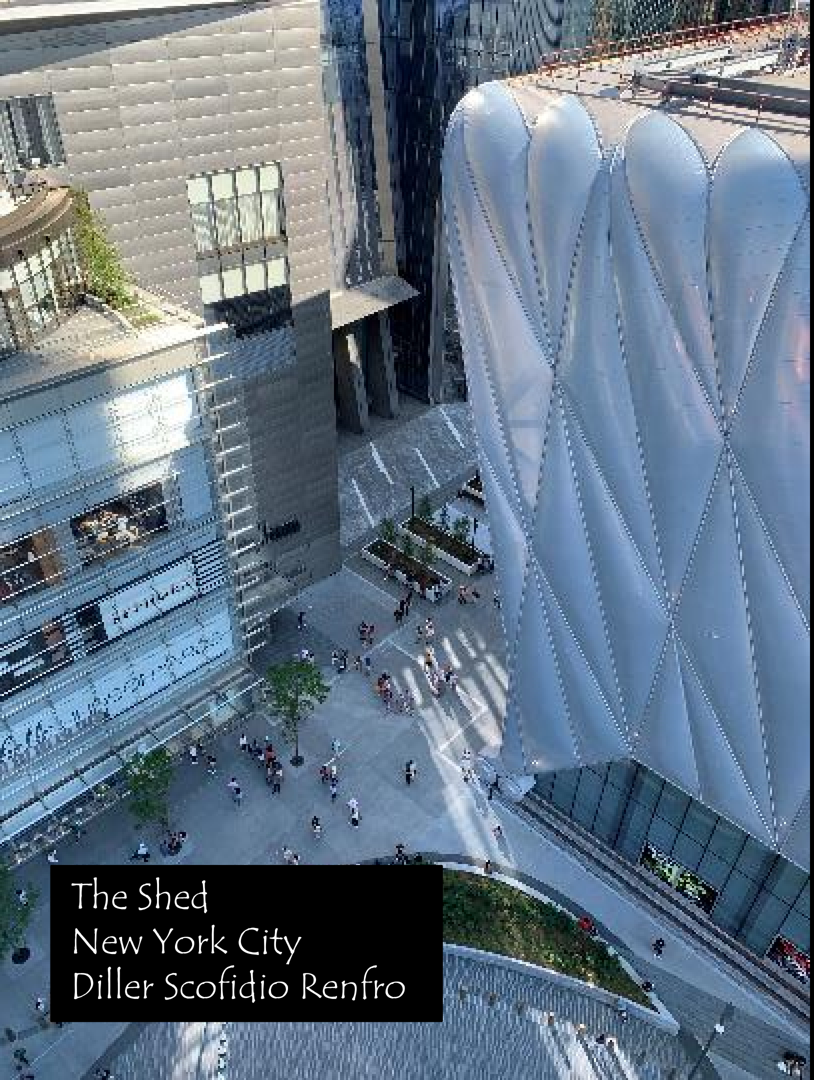
Eden Project
St. Austell,England
Nicholas Grimshaw

Japan National Pavilion
Shanghai Expo 2010

Parkview Green
Beijing, China



Allianz Arena
Munich, Germany

The Shed
New York City
Diller Scofidio Renfro

Tensile Glass Support Systems

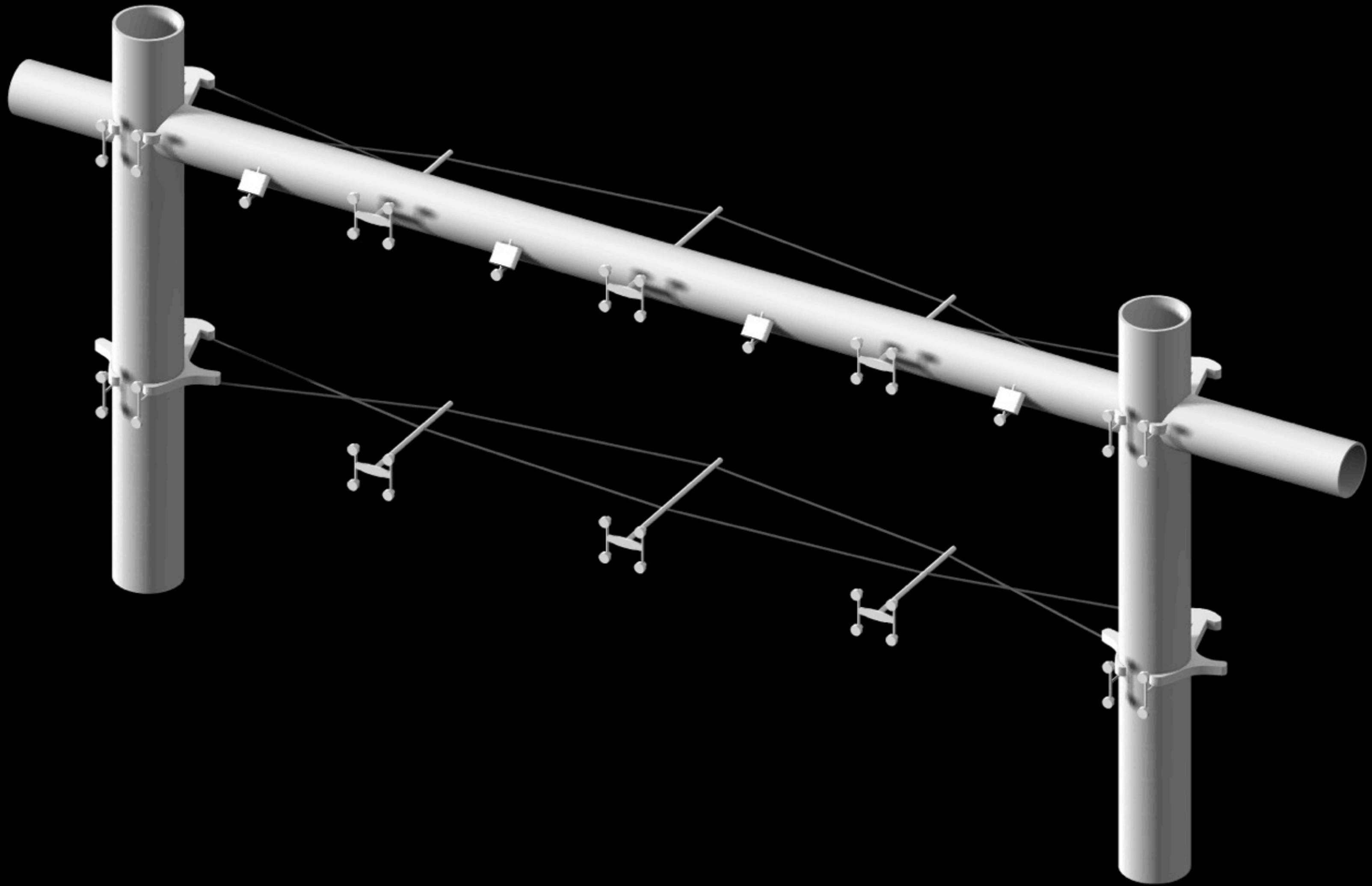
This is a very brief overview – I cover this in great detail in Arch 570 offered in 3B

SPIDER

- This is a frameless system of making large glazed façades
- Glass panels attached to stainless steel cables usually by spider or butterfly connectors
- Spider type connections require the pre-drilling of the corners of the glass panels
- Butterfly connectors go between the glass panels so no drilling
- Early installations used only monolithic glass but now these can use insulated glass units

BUTTERFLY

The Serres, Paris
Peter Rice



Newseum, Washington, DC
Ennead Architects


INTERACTIVE NEWSROOM Level 2


Luxury Coach Inc

Tower Bridge House, London
Richard Rogers


M MOSER


Bridge House

Rose Museum of Space,
New York City
Ennead Architects

CABLE NET SYSTEM

Kempinski Hotel, Munich Airport
Helmut Jahn

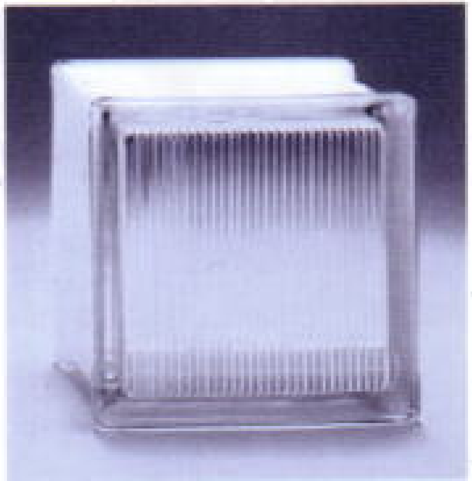
Glass Block


Maison de Verre, Paris

All of the schools built in the 1950s and 1960s


Lattice Pattern

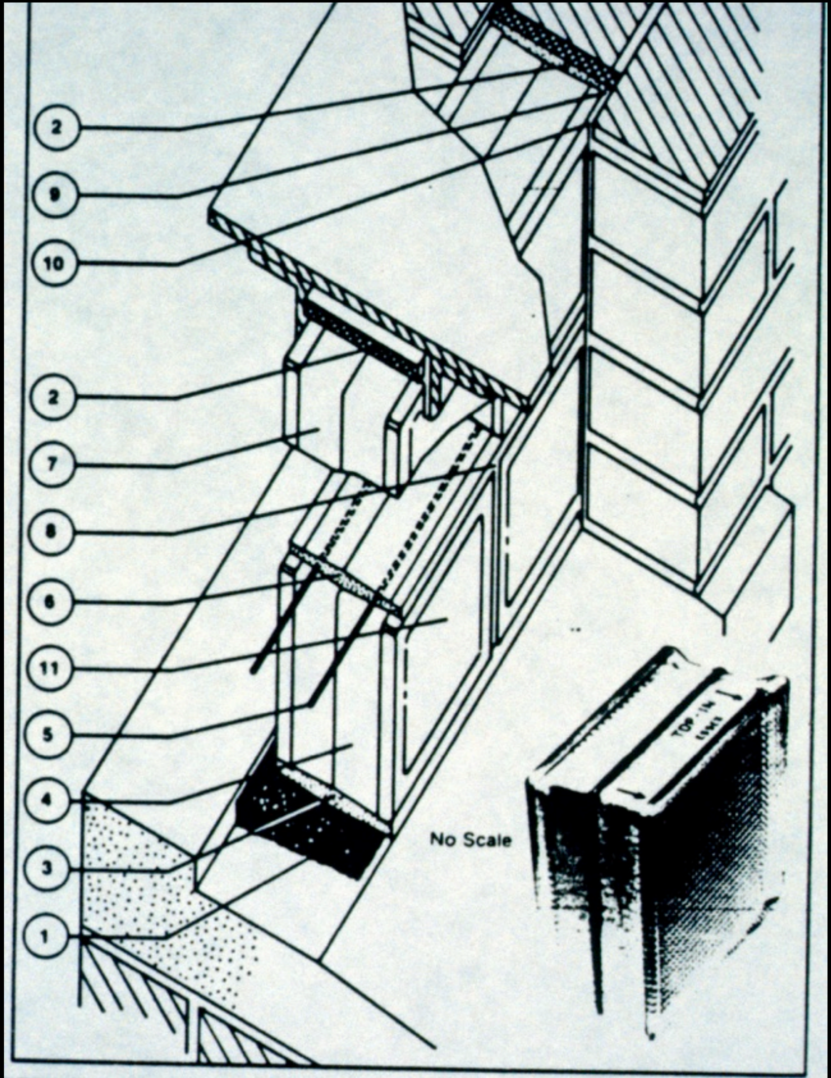

Mist Pattern

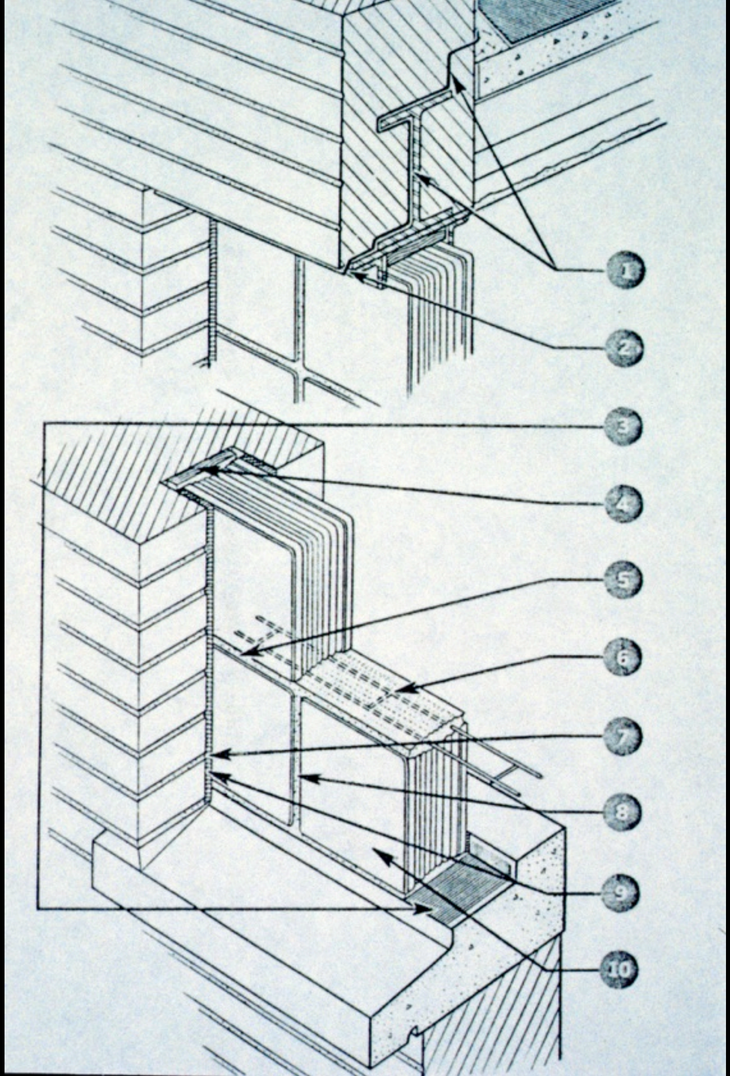

Ribbed Pattern

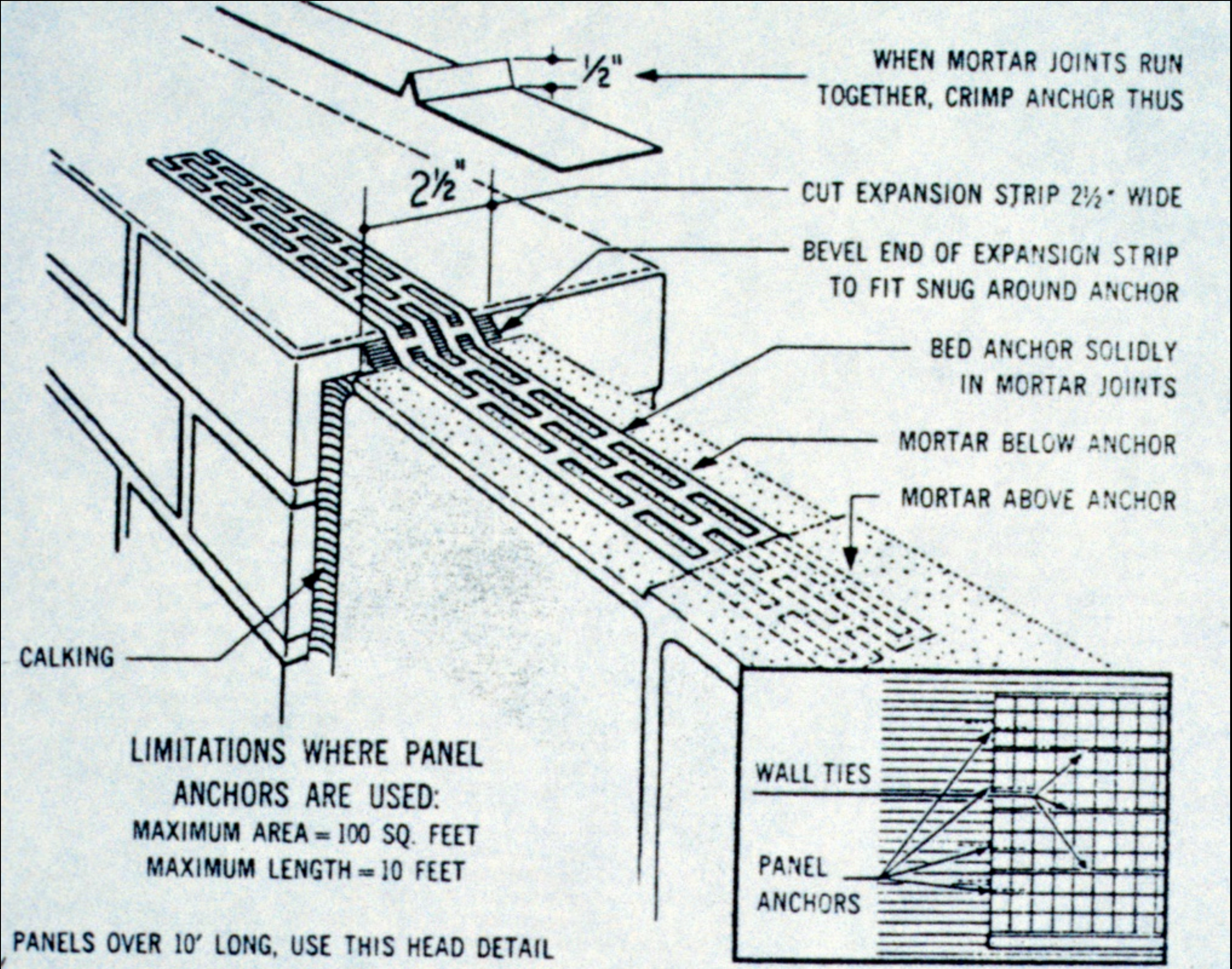

Corona Pattern


Double Star Pattern

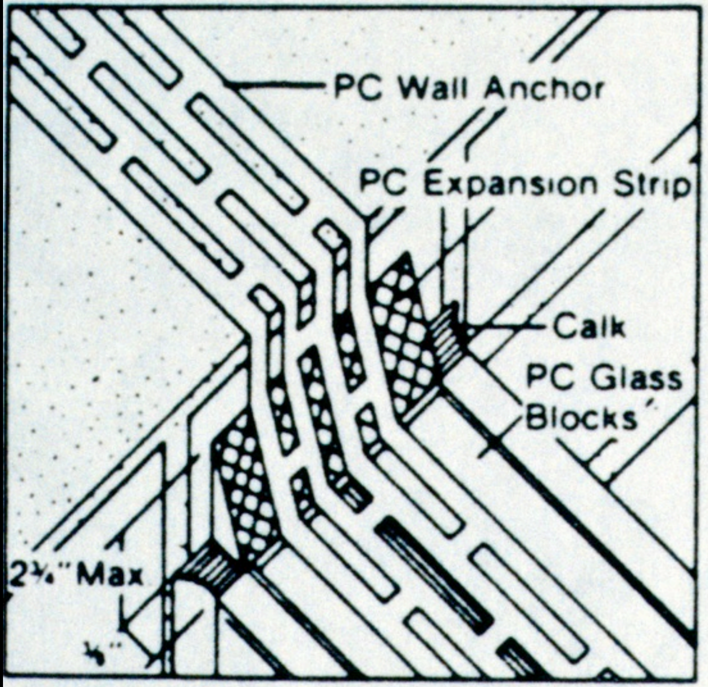

Well Shape Pattern


2
9
10
2
7
8
6
11
5
4
3
1
No Scale

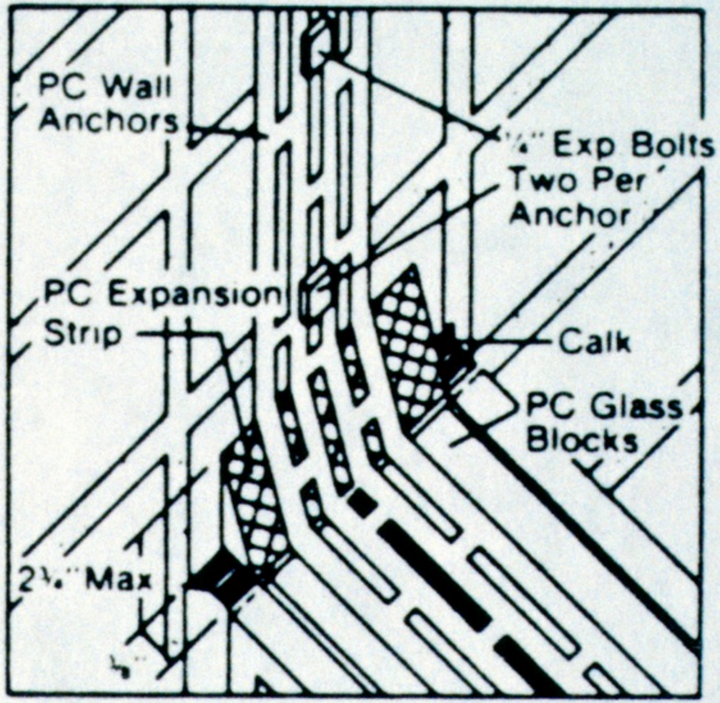

1
2
3
4
5
6
7
8
9
10


WHEN MORTAR JOINTS RUN TOGETHER, CRIMP ANCHOR THUS
½"
2½"
CUT EXPANSION STRIP 2½" WIDE
BEVEL END OF EXPANSION STRIP TO FIT SNUG AROUND ANCHOR
BED ANCHOR SOLIDLY IN MORTAR JOINTS
MORTAR BELOW ANCHOR
MORTAR ABOVE ANCHOR
CALKING
LIMITATIONS WHERE PANEL ANCHORS ARE USED:
MAXIMUM AREA = 100 SQ. FEET
MAXIMUM LENGTH = 10 FEET
WALL TIES
PANEL ANCHORS
PANELS OVER 10' LONG, USE THIS HEAD DETAIL

Panel Anchors

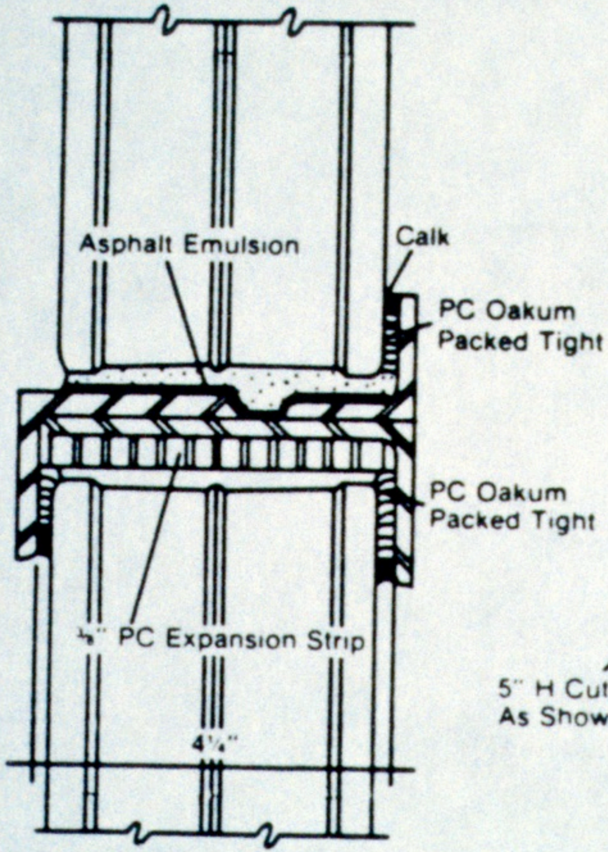


NEW CONSTRUCTION

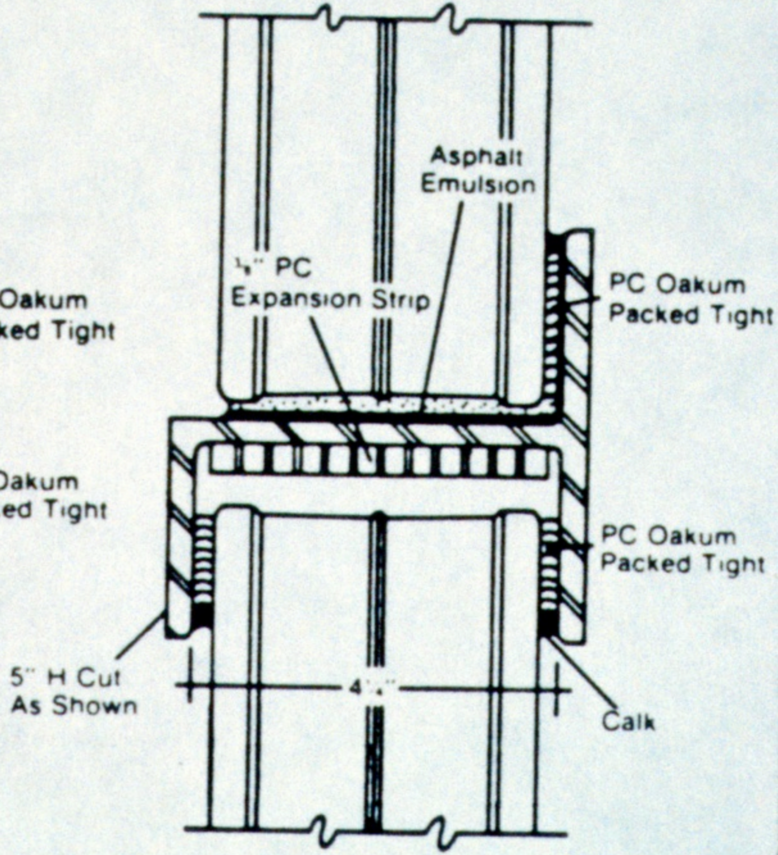


EXISTING CONSTRUCTION

Shelves



SECTION "E"



SECTION "E-1"

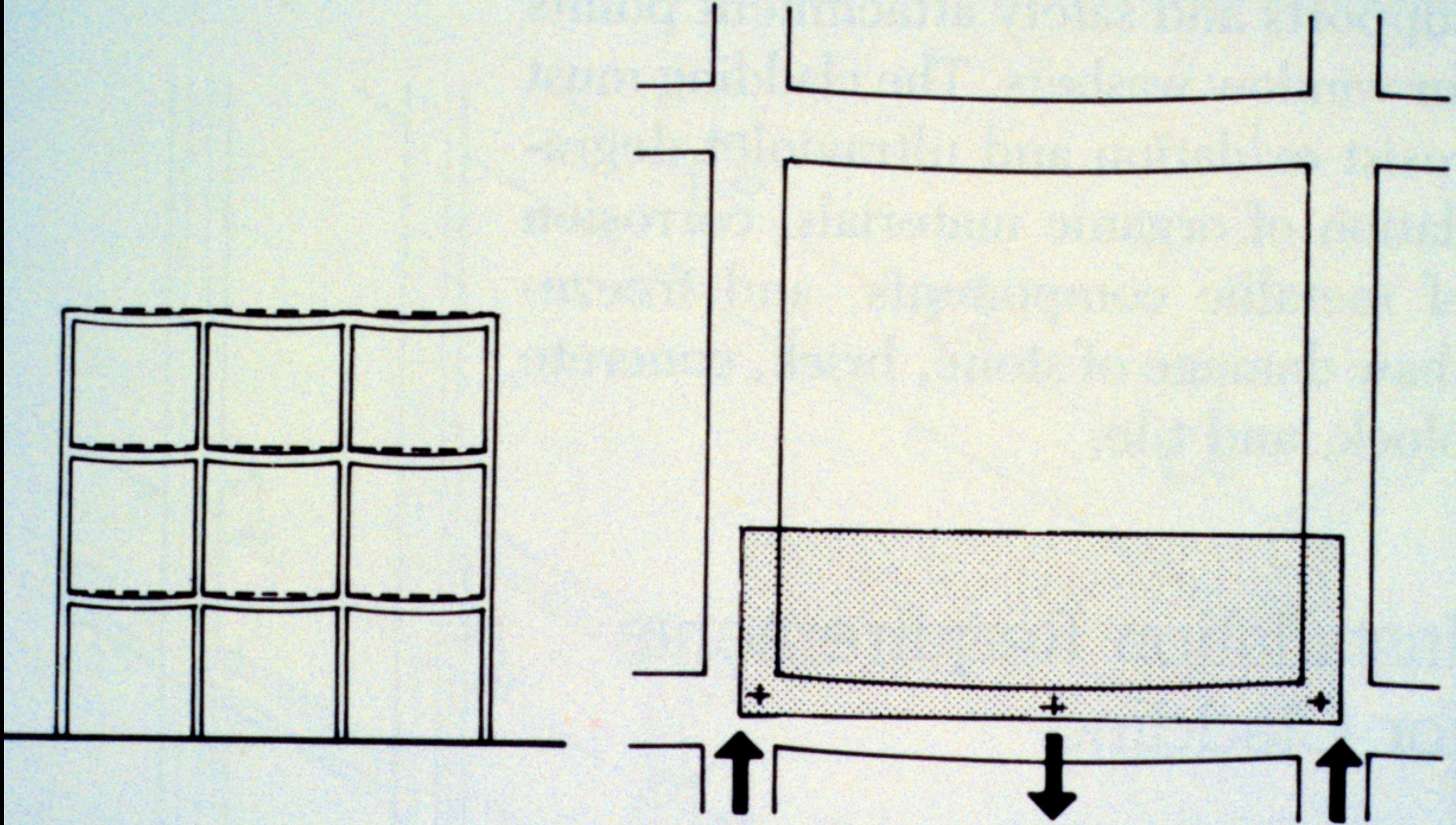


THE YMCA OF
METROPOLITAN TORO
15

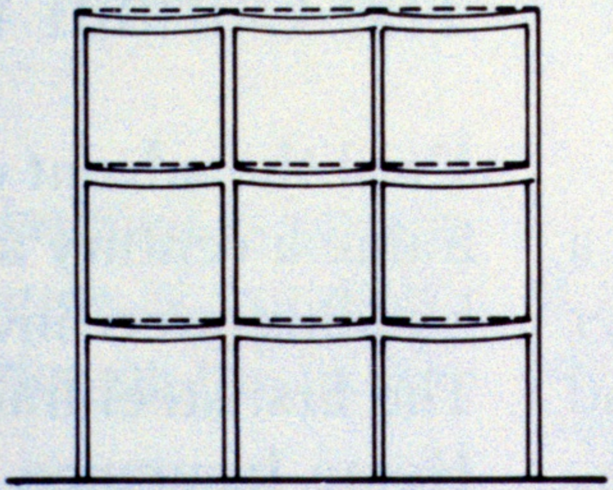
HE YMCA OF
POLITAN TORO
15

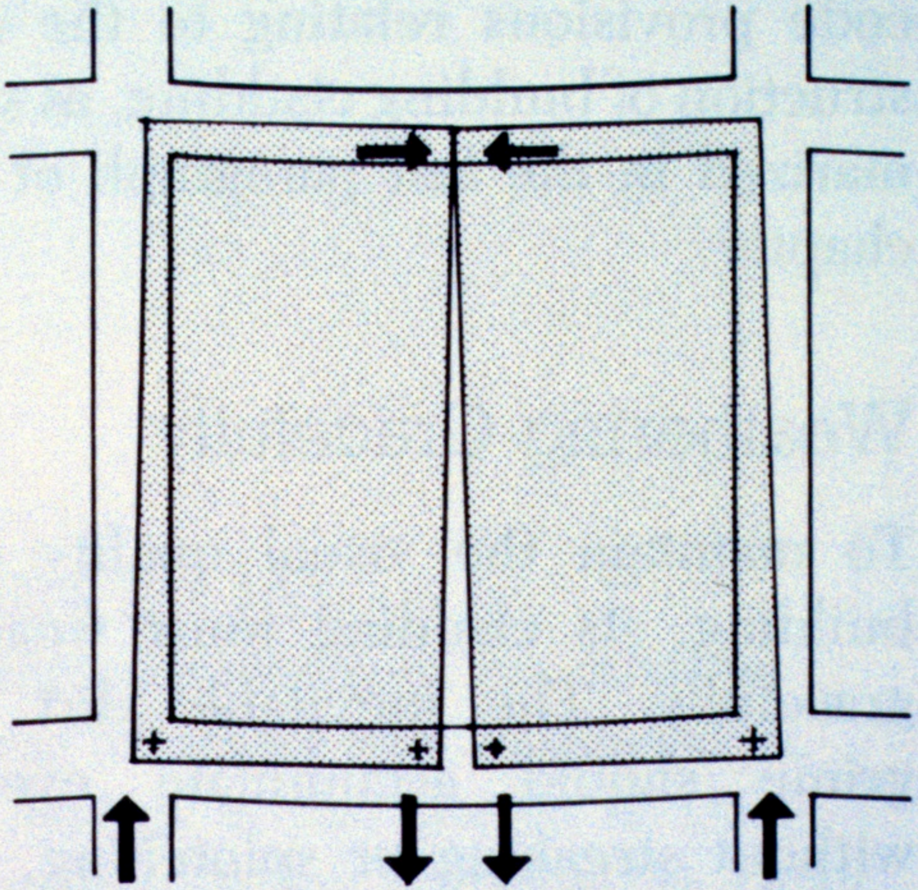
For interior applications the weight of the glass block must be considered

DEFORMATION IN BUILDINGS

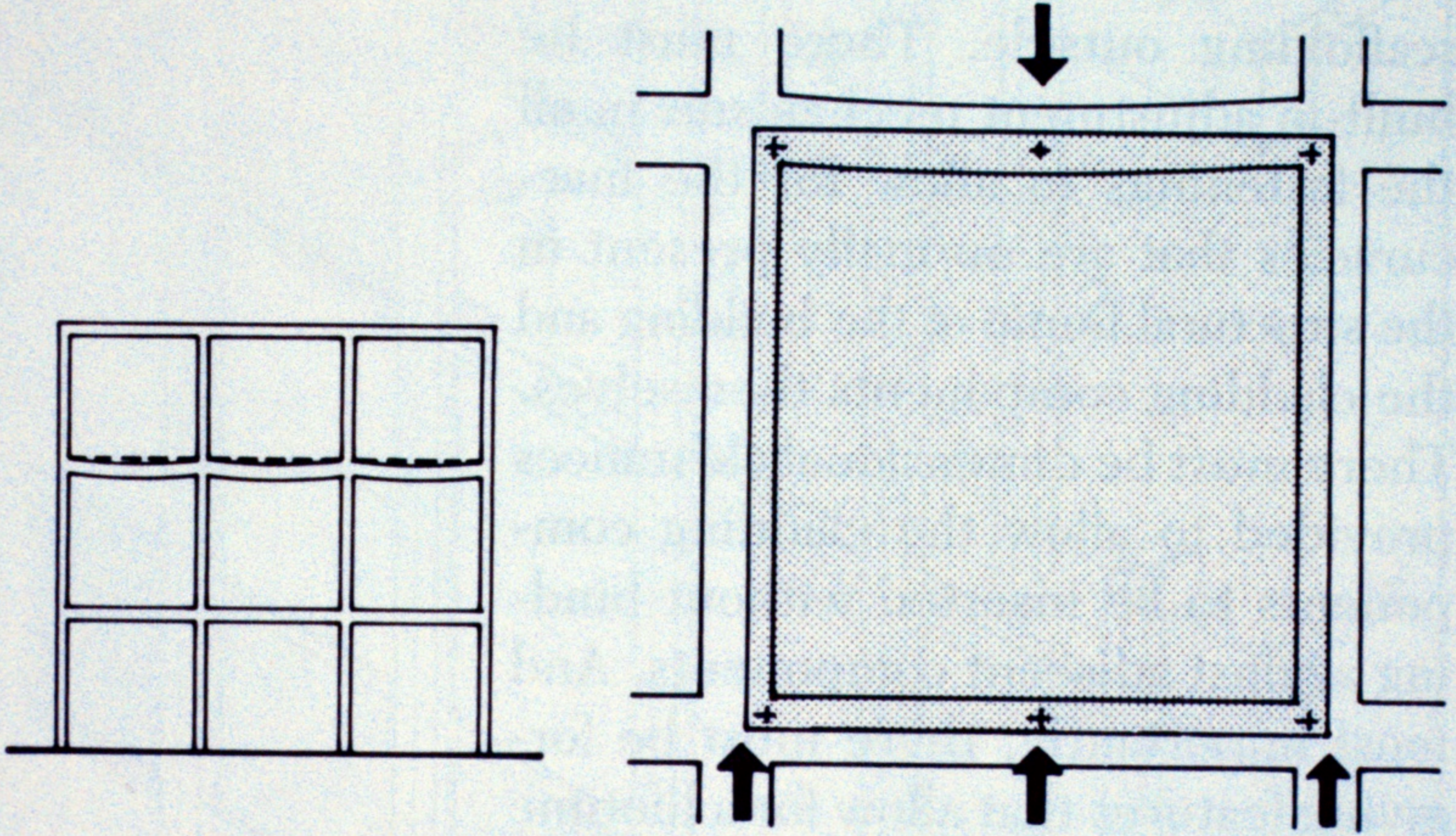


SPANDREL BEAM DEFLECTION

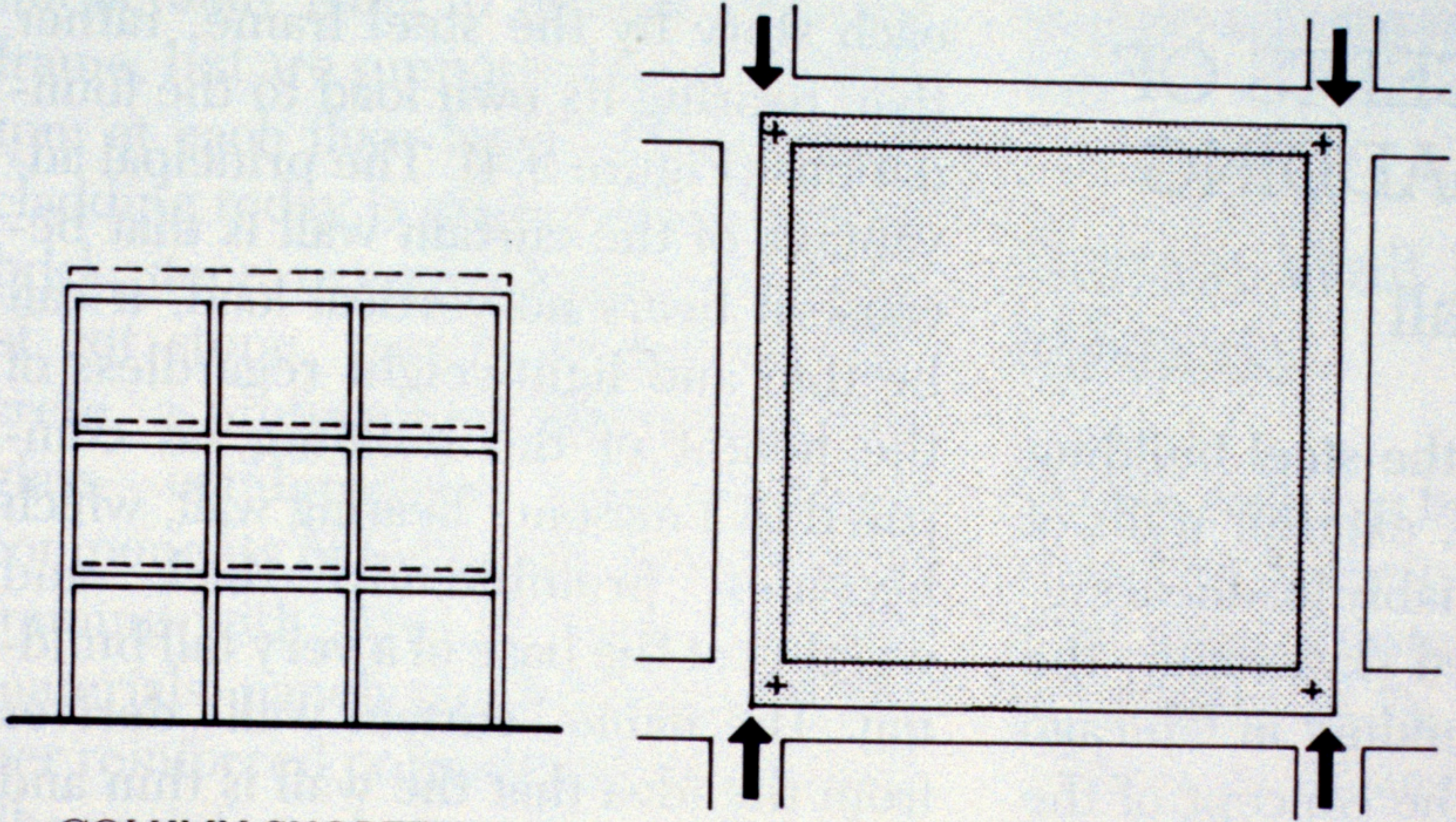




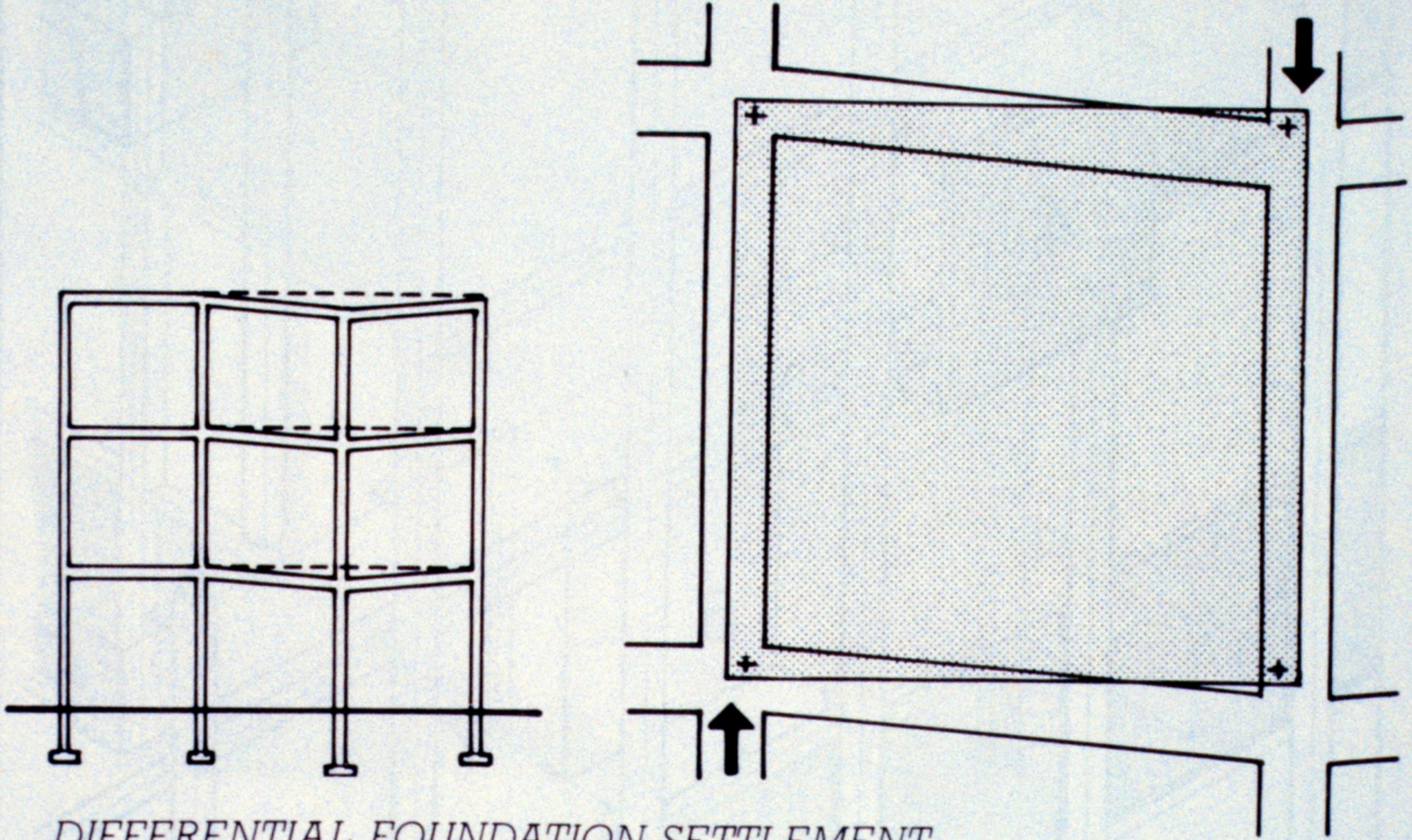
SPANDREL BEAM DEFLECTION



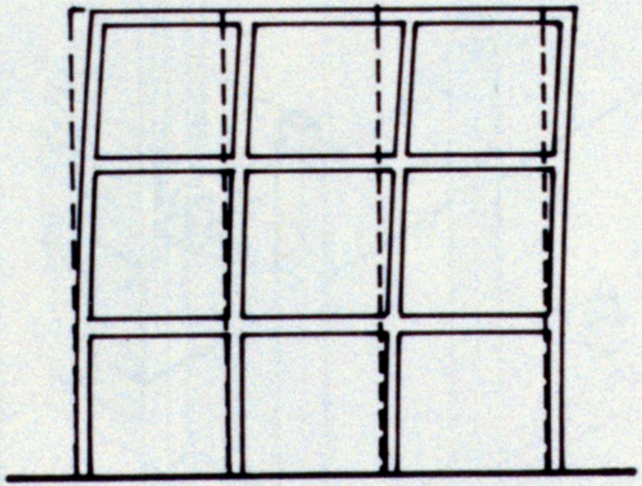
DIFFERENTIAL SPANDREL BEAM DEFLECTION

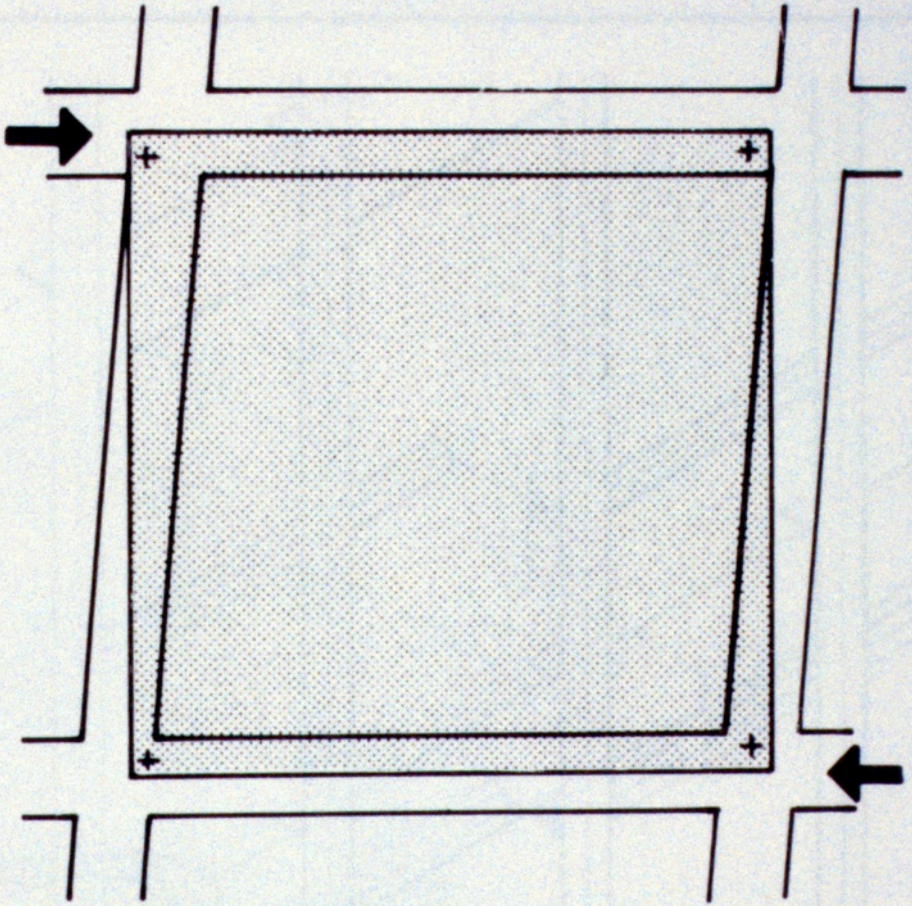


COLUMN SHORTENING



DIFFERENTIAL FOUNDATION SETTLEMENT





WIND AND EARTHQUAKE DEFORMATIONS

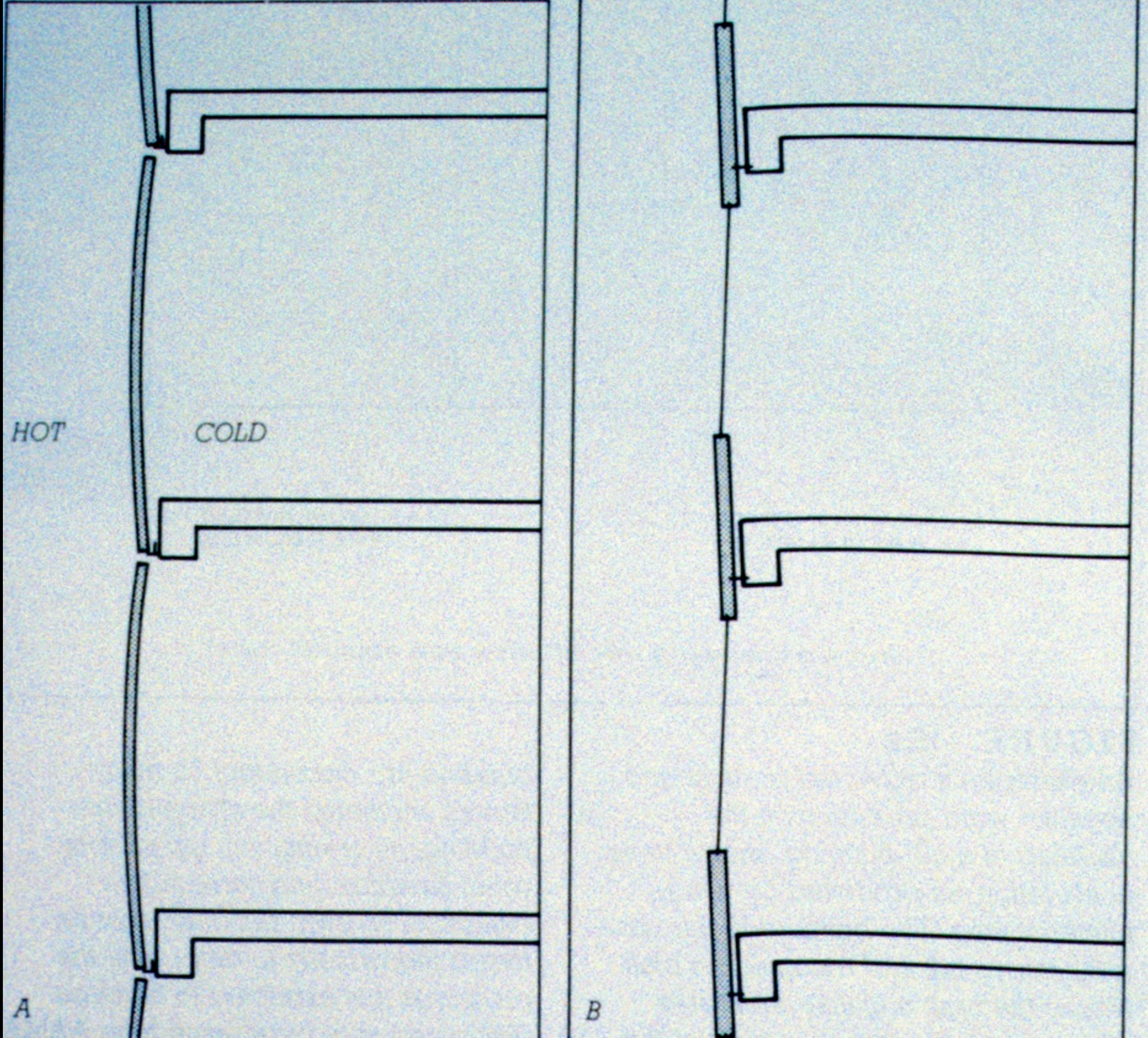
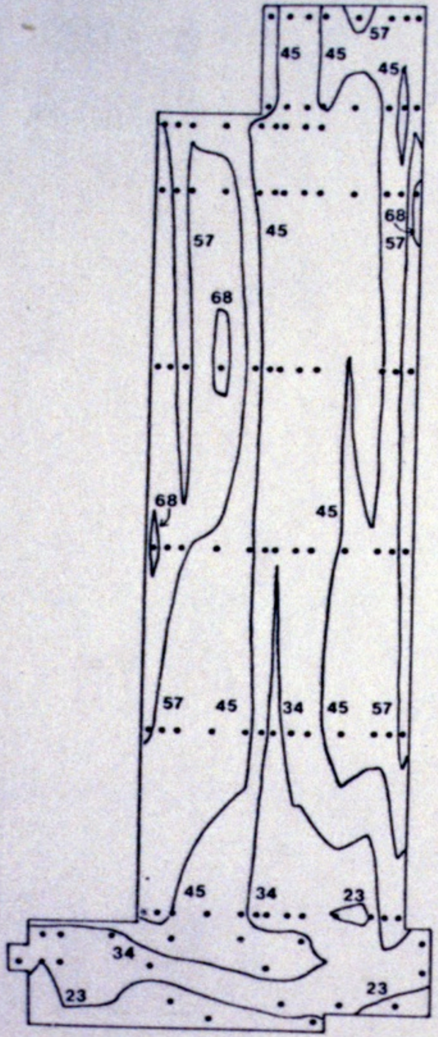
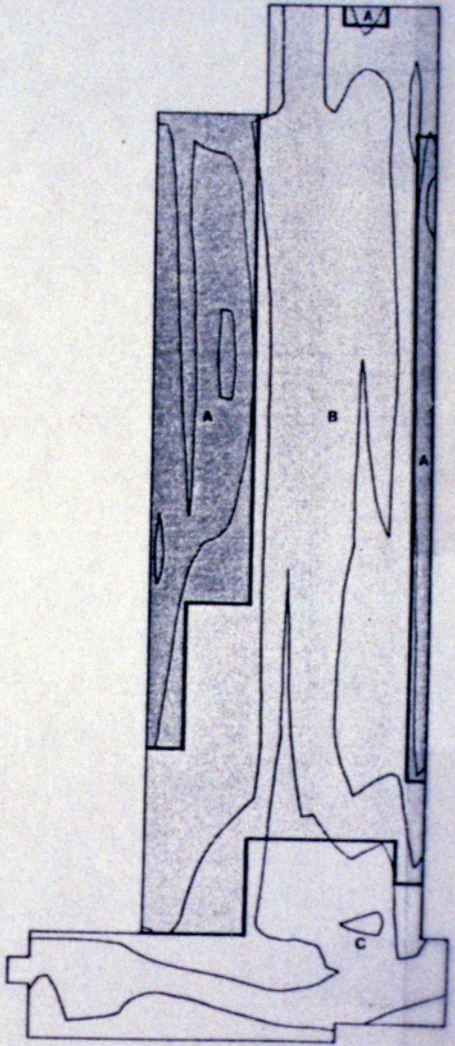
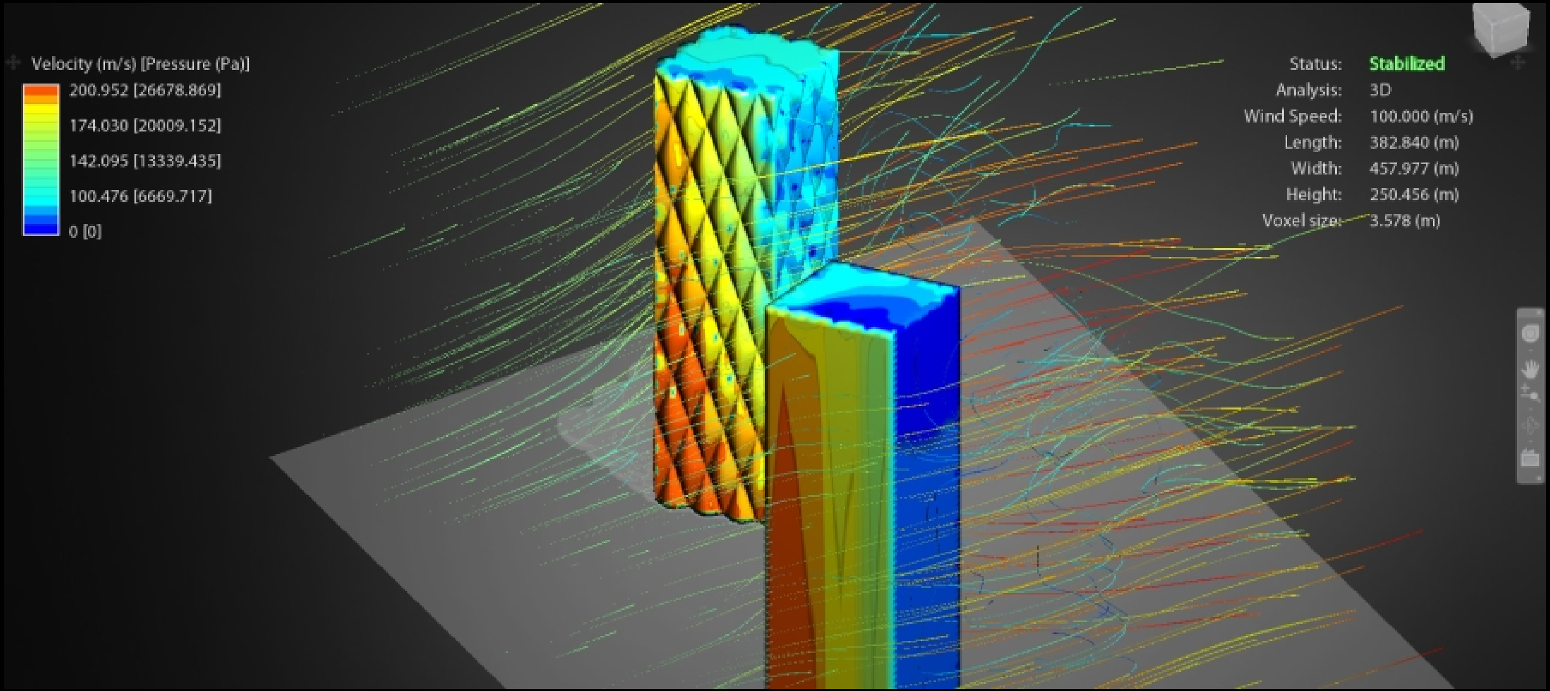


FIGURE 15.5
Distortions of curtain wall panels, illustrated in cross section: **A.** *Bowing due to greater thermal expansion of the outside skin of the panels under hot summertime conditions.* **B.** *Twisting of spandrel beams due to the weight of the curtain wall.*



These drawings of the north elevation of an actual high-rise building show the basis for the designer's choice of curtain-wall design loads. The irregular lines on the left-hand drawing are wind-pressure contours determined from wind-tunnel testing based upon the maximum wind velocity recurring during a 100-year period. The consultant, after studying the wind-pressure diagram, designated three different design wind pressures. These are illustrated by the three gray tones in the right-hand drawing: area A = 73 psf, area B = 56 psf, and area C = 42 psf.

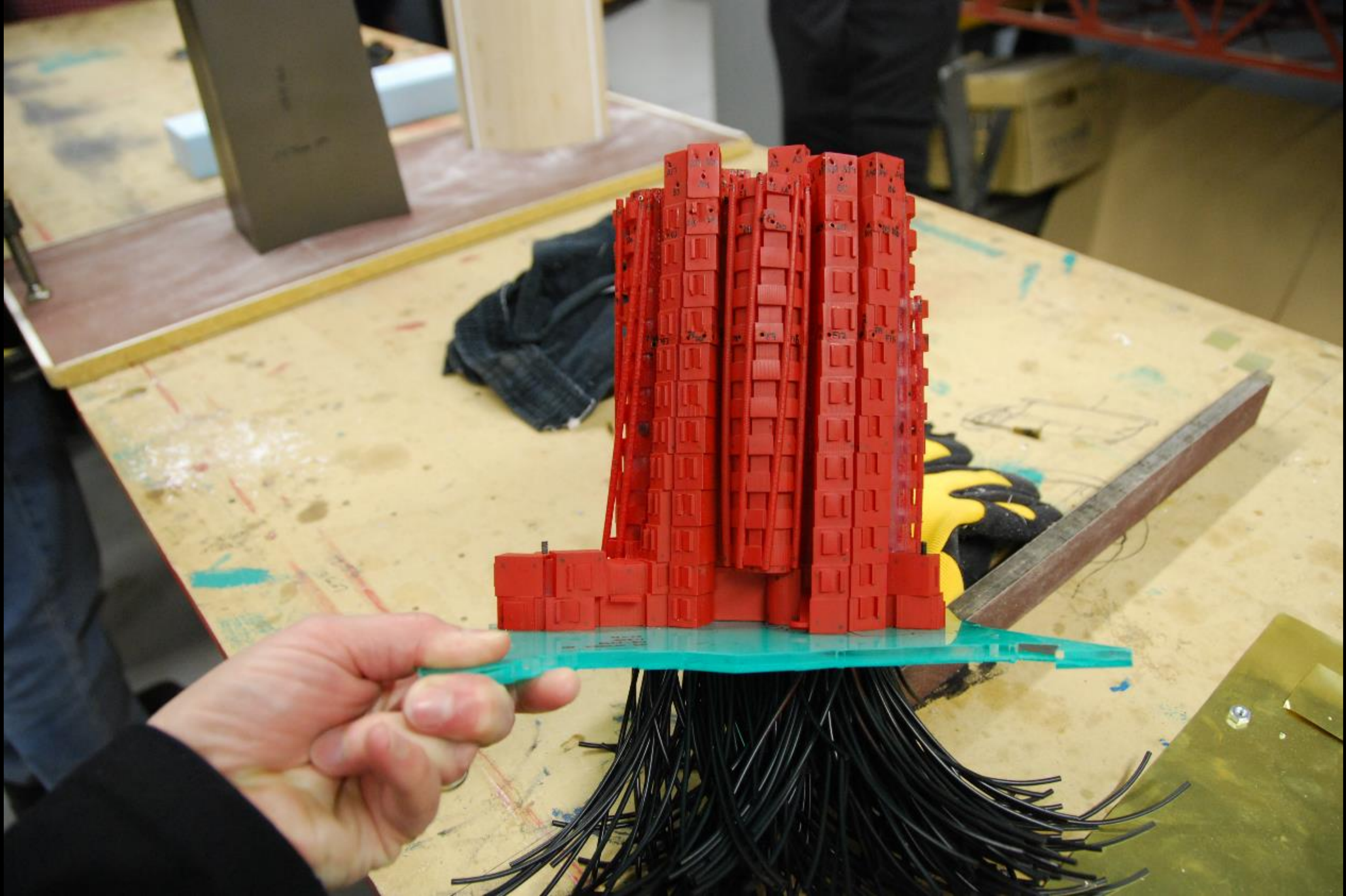




Velocity (m/s) [Pressure (Pa)]
200.952 [26678.869]
174.030 [20009.152]
142.095 [13339.435]
100.476 [6669.717]
0 [0]
Status: Stabilized
Analysis: 3D
Wind Speed: 100.000 (m/s)
Length: 382.840 (m)
Width: 457.977 (m)
Height: 250.456 (m)
Voxel size: 3.578 (m)


NOTICE
KEEP AREA
CLEAR BEYOND
THIS POINT


Rowan Williams
Davies & Irwin Inc.
Consulting Engineers

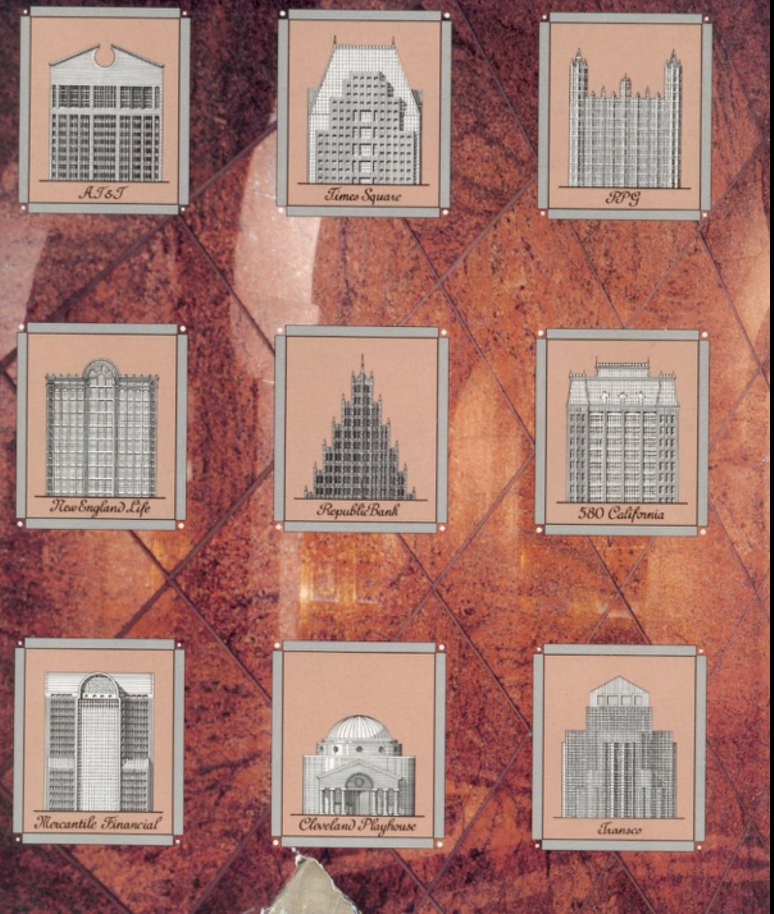



CURTAIN WALL

Progressive Architecture

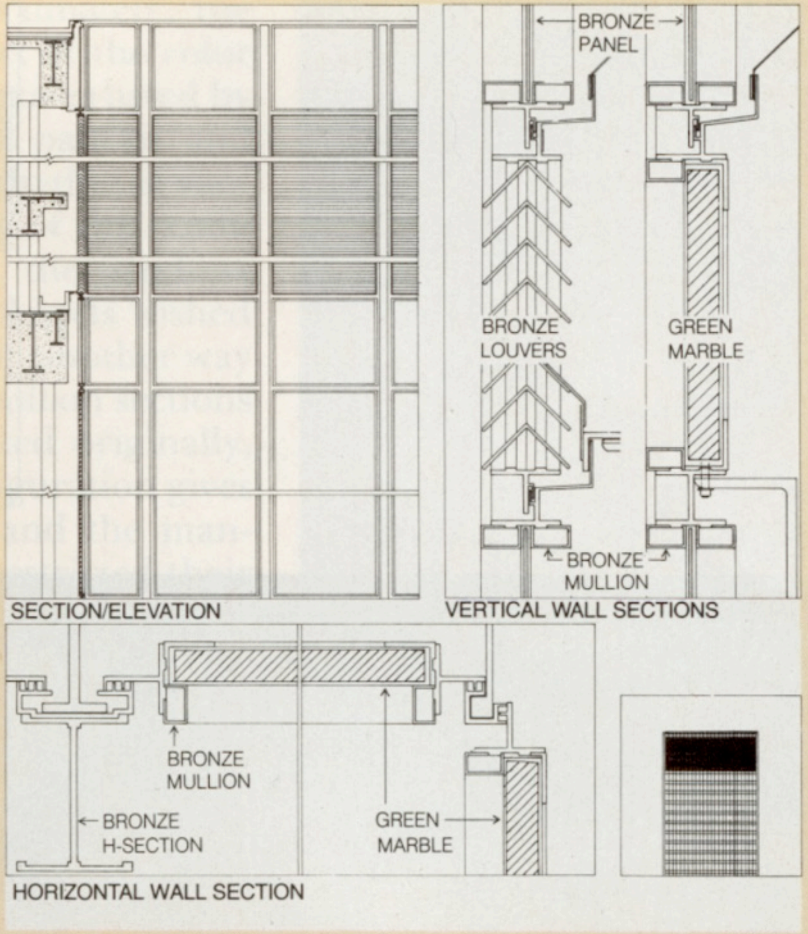
February 1984

Special issue: Johnson and Burgee

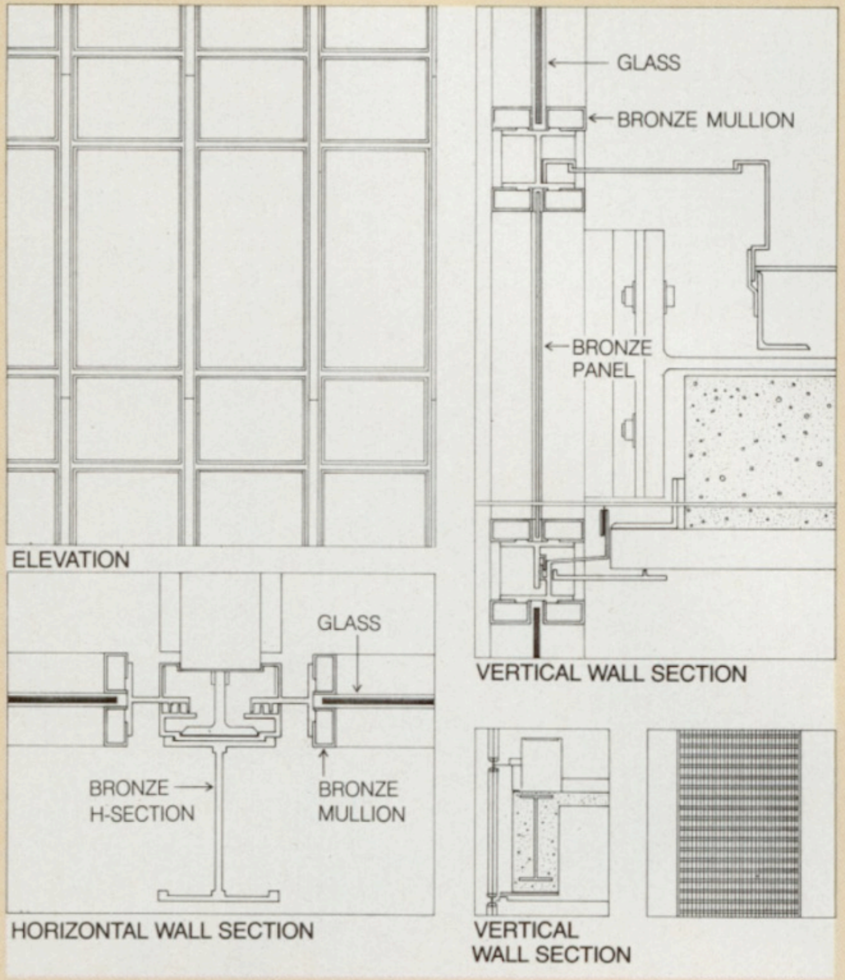



MetLife

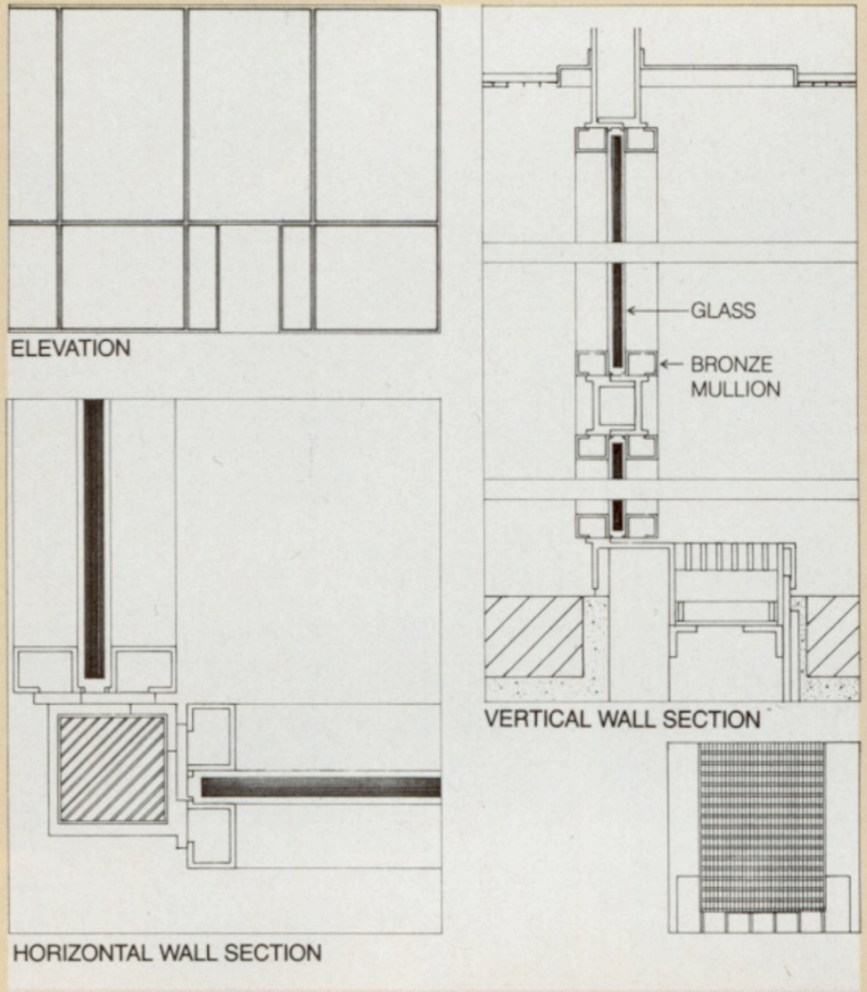
SEAGRAM BUILDING



1 CROWN CONDITION



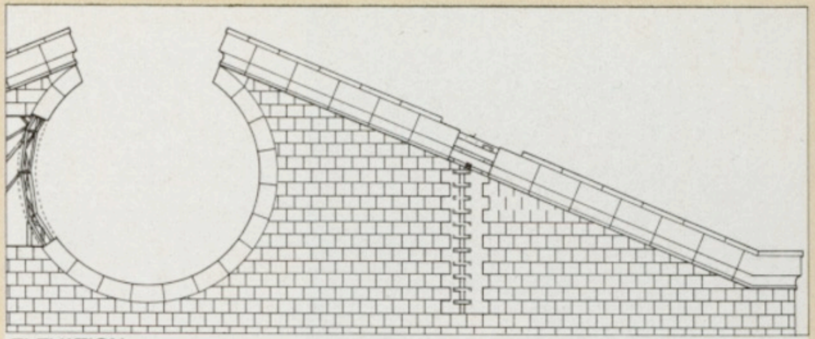
2 TYPICAL CONDITION



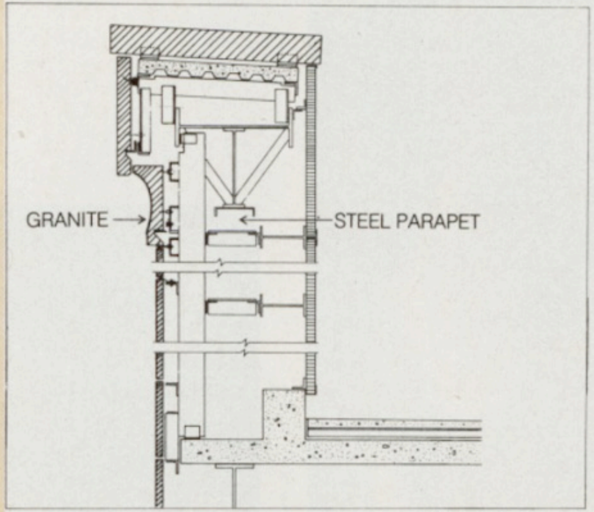
3 BASE CONDITION

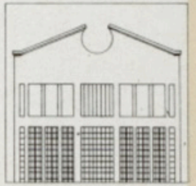

Sheraton

AT&T HEADQUARTERS



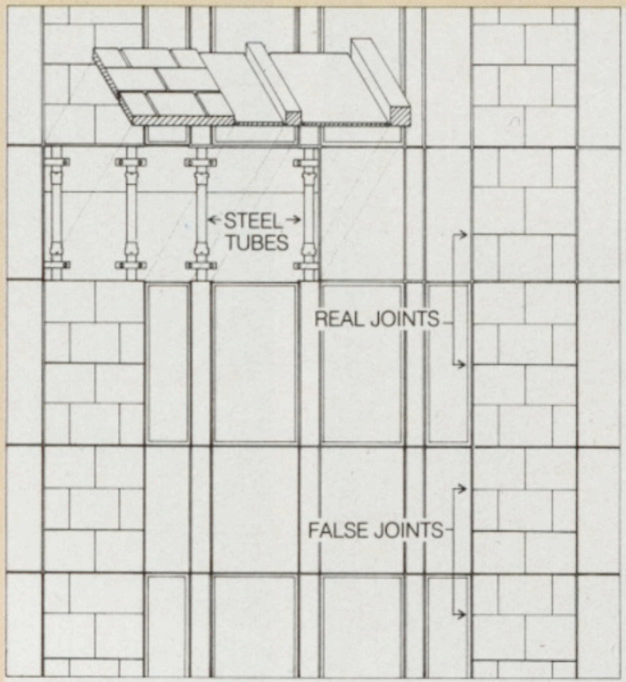
ELEVATION



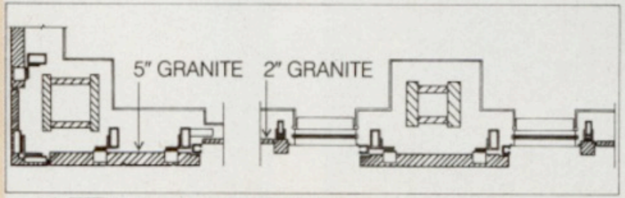


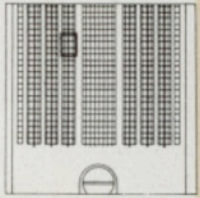
VERTICAL WALL SECTION

4 CROWN CONDITION



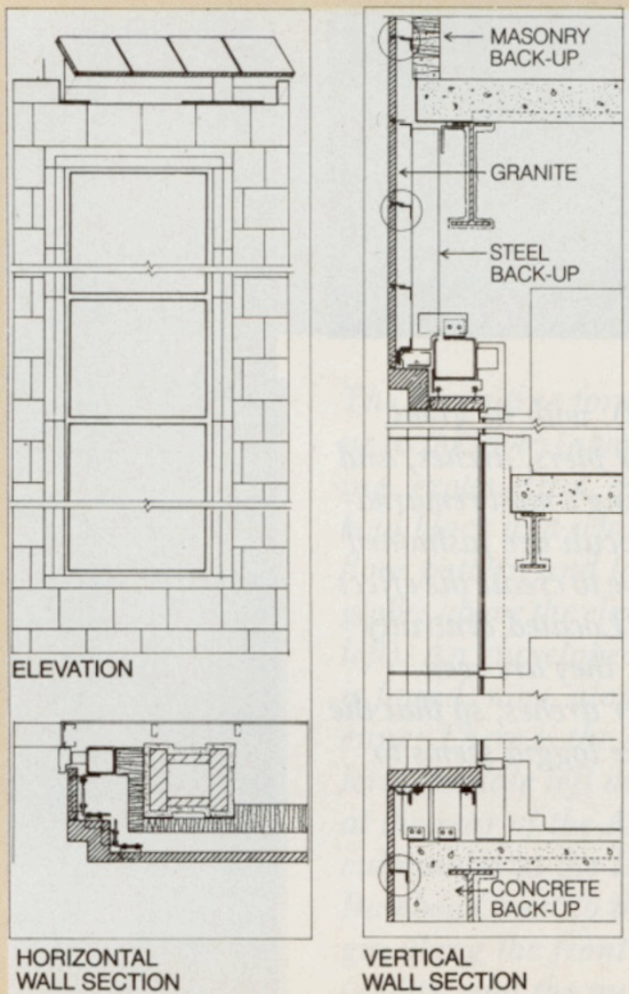
ELEVATION

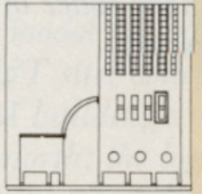




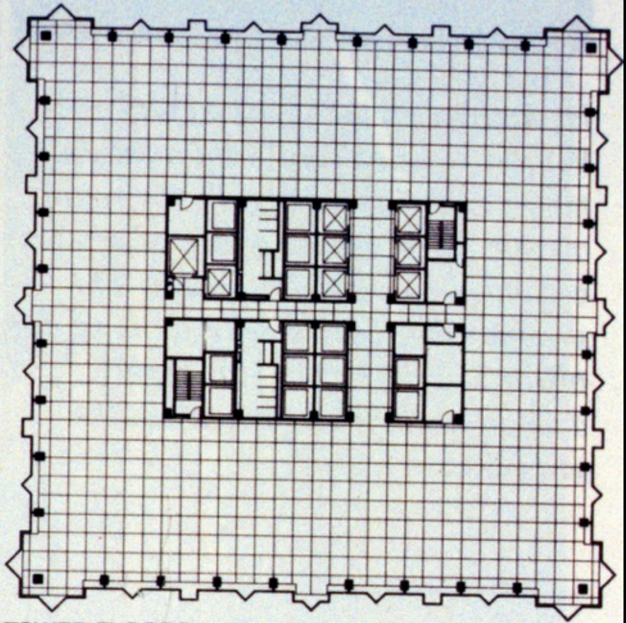
HORIZONTAL WALL SECTION

5 TYPICAL CONDITION

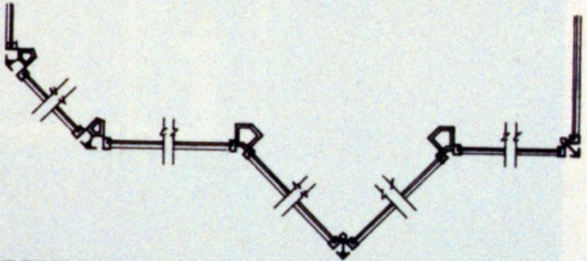




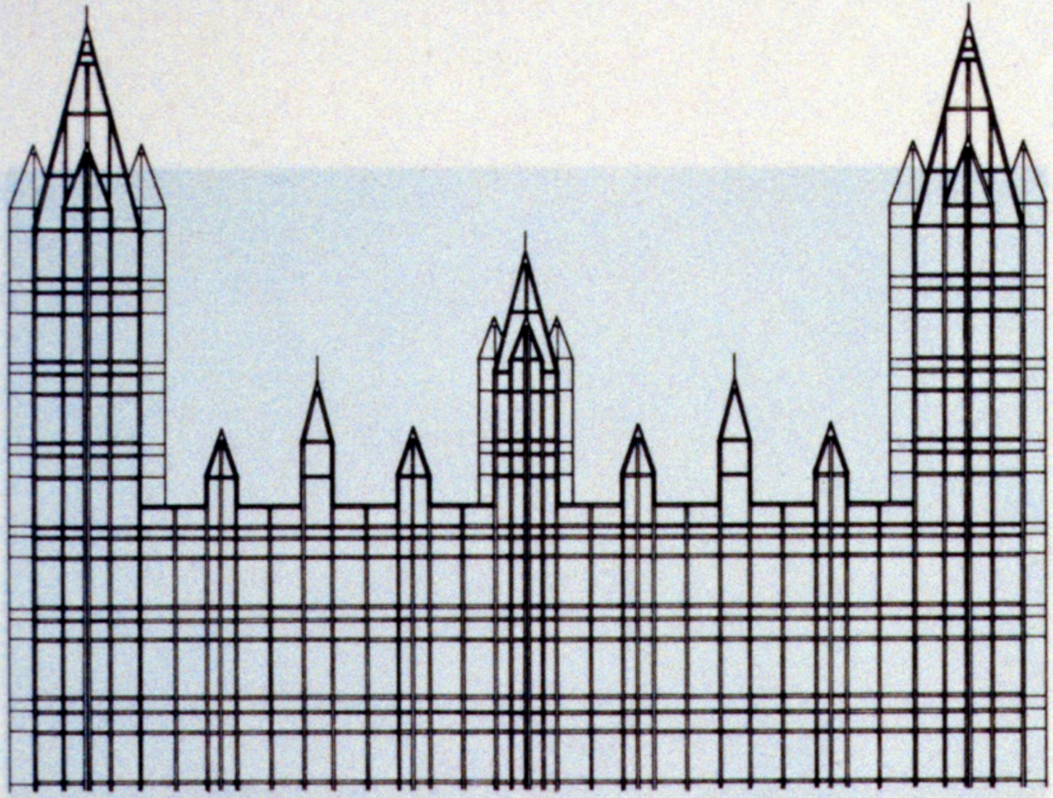
6 BASE CONDITION



TOWER FLOORS 2-12 N → 20'/6m



PORTION OF CURTAIN WALL PLAN AT TOWER BASE

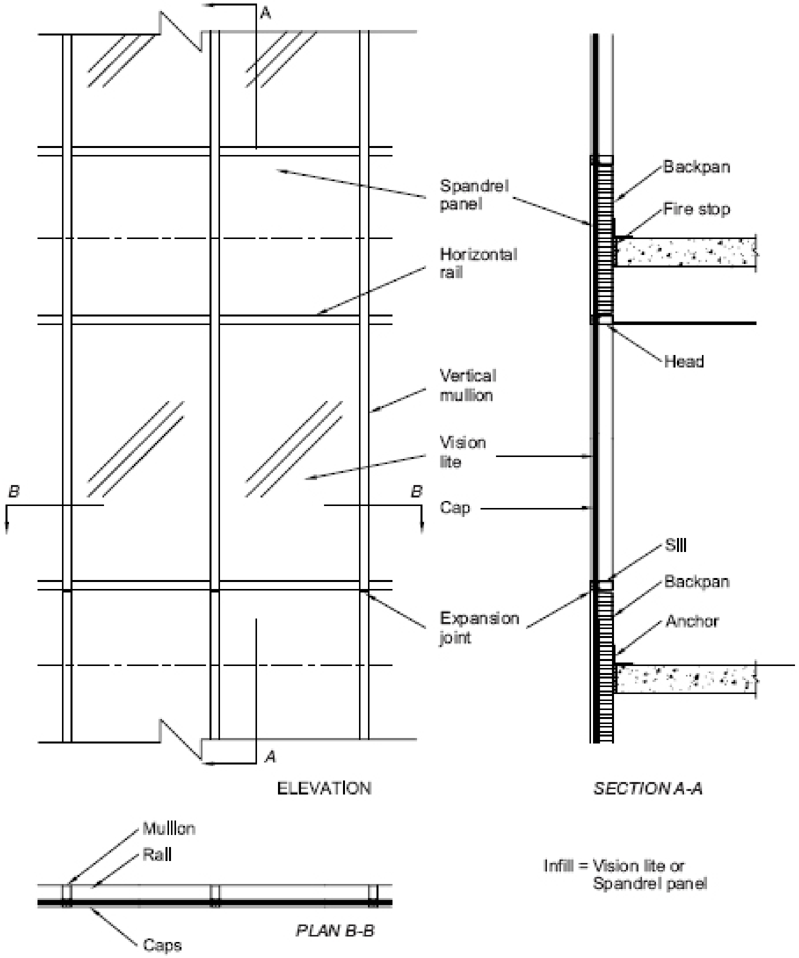


ELEVATION, TOWER SPIRES

A typical tower floor (below) has 184 vertical mullions: 64 outside 90 degrees, 56 inside 135 degrees, 32 inside 90 degrees, and 32 180 degrees (the typical detail for conventional curtain walls). The pleats are resolved into spires at the top (left) and arches at the bottom (detail plan, bottom).


2
2
3

CURTAIN WALL "SYSTEMS"


A
B
Spandrel panel
Horizontal rail
Vertical mullion
Vision lite
Cap
Expansion joint
Backpan
Fire stop
Head
Sill
Backpan
Anchor
ELEVATION
SECTION A-A
Mullion
Rail
Caps
PLAN B-B
Infill = Vision lite or Spandrel panel

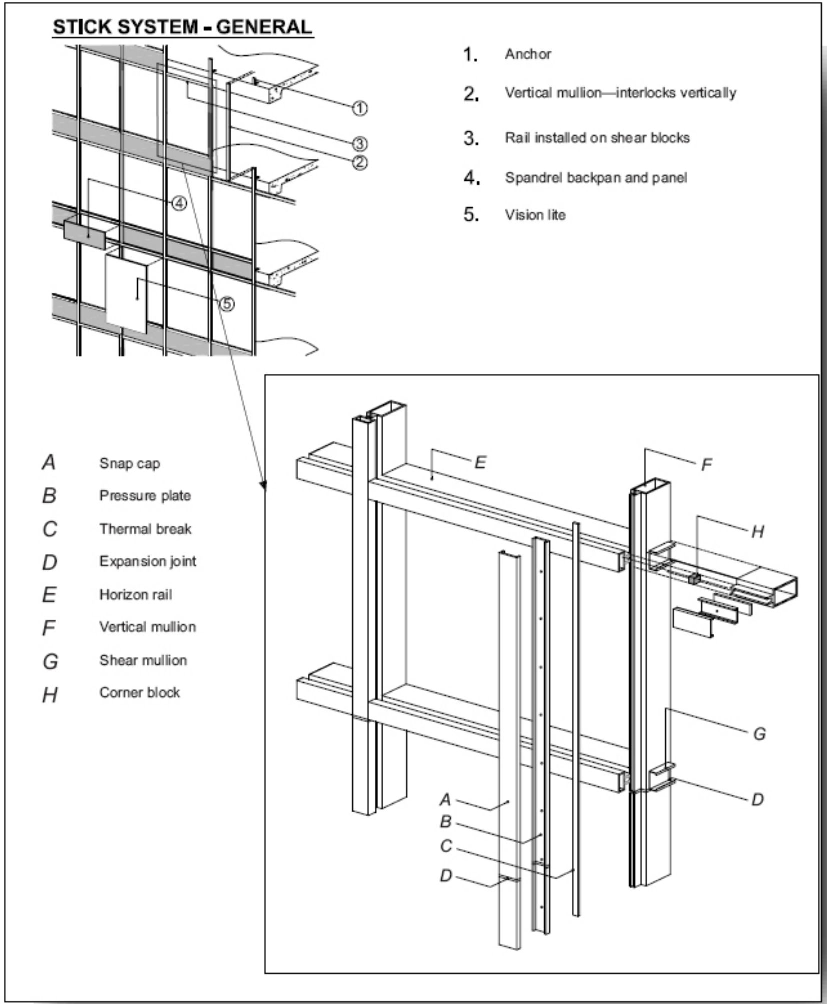


Figure 2.2: Stick system - general

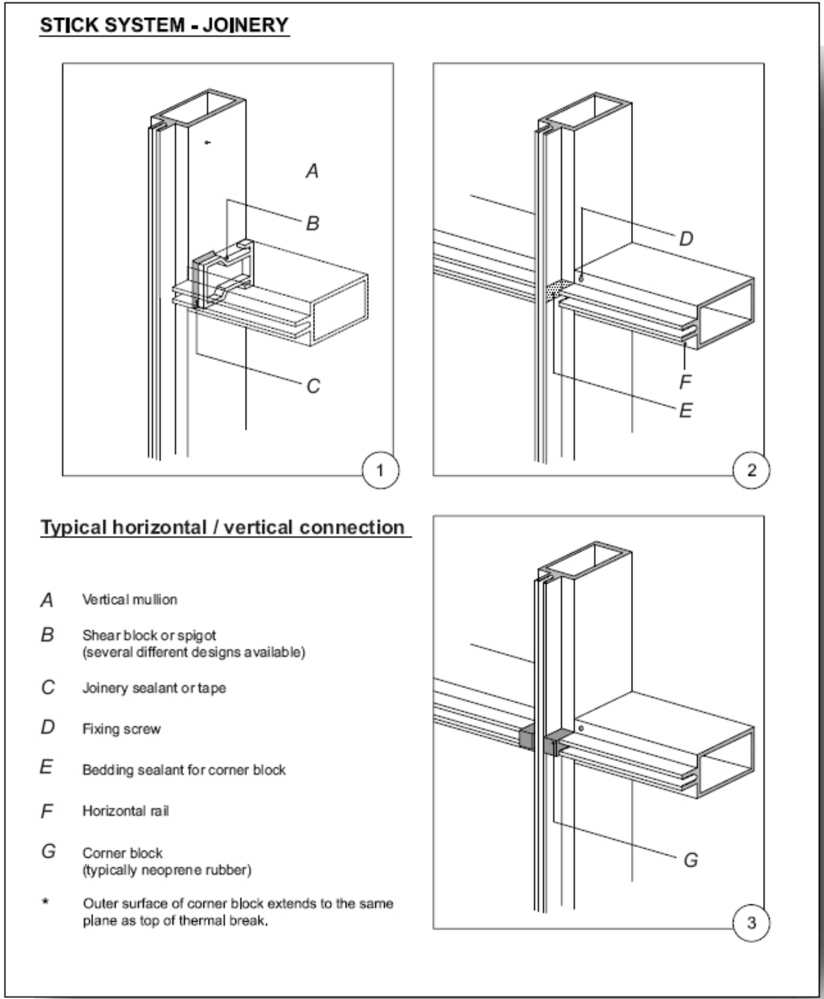
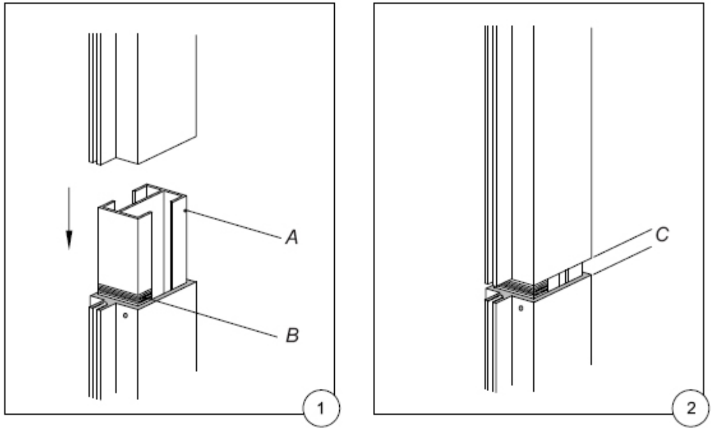


Figure 2.3: Stick system — joinery — typical horizontal/vertical connection

STICK SYSTEM - JOINERY



Typical expansion joint assembly

A Mullion sleeve or spigot

B Bond breaker

C Expansion / tolerance joint

D Sealant applied to completed assembly

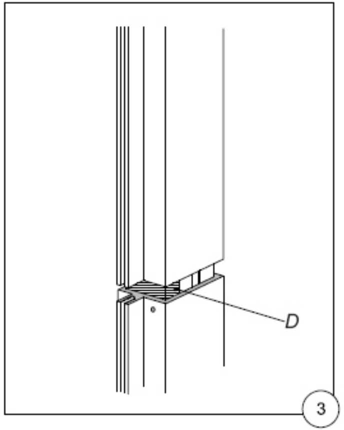
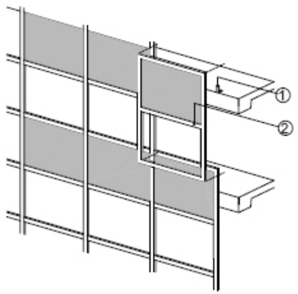
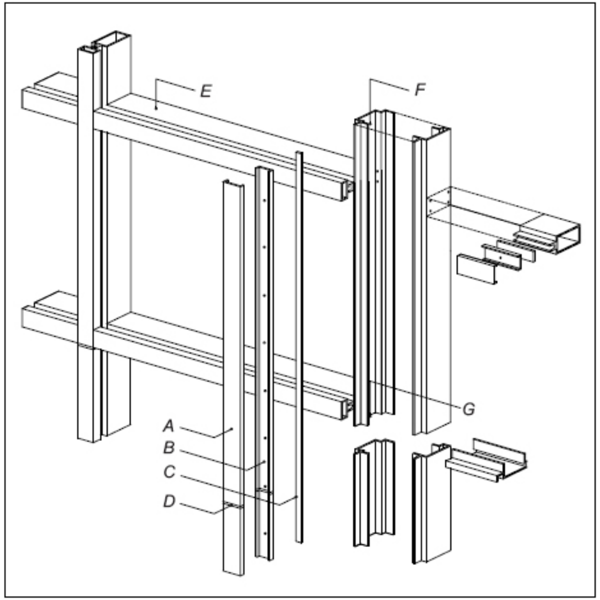


Figure 2.4: *Stick system — joinery — typical expansion joint assembly*

UNITIZED SYSTEM - GENERAL



1. Anchor
2. Prefabricated, pre-glazed frame



A Snap cap

B Pressure plate
(May be in two pieces)

C Thermal break

D Expansion joint

E Horizontal rail

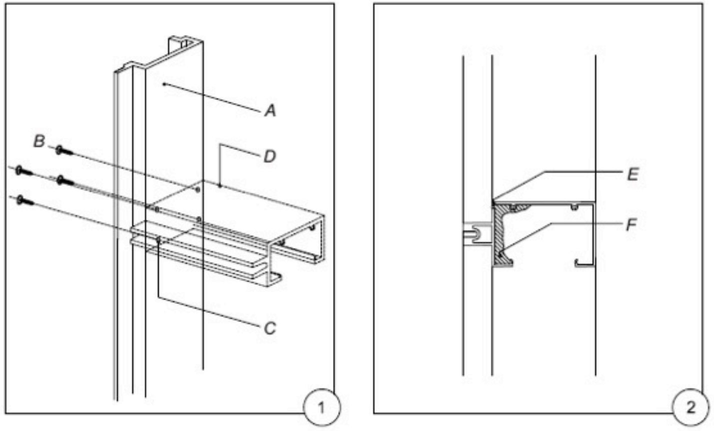
F Split mullion

G Mullion sleeve*

* Connection at expansion or stack joint varies widely with different designers

Figure 2.5: *Unitized system — general*

UNITIZED SYSTEM JOINERY



A Split mullion

B Rail fixing

C Predrilled holes

D Horizontal rail, often open section, incorporating screw lots

E Sealant continuity hole

F Sealant applied inside horizontal*

* Closed section horizontals may use butyl tape seals

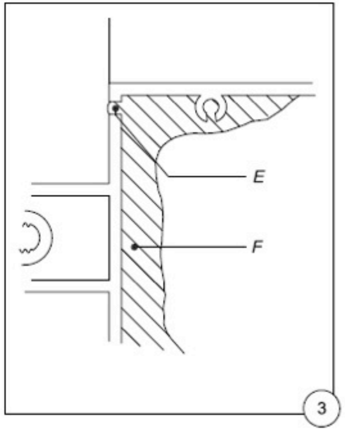
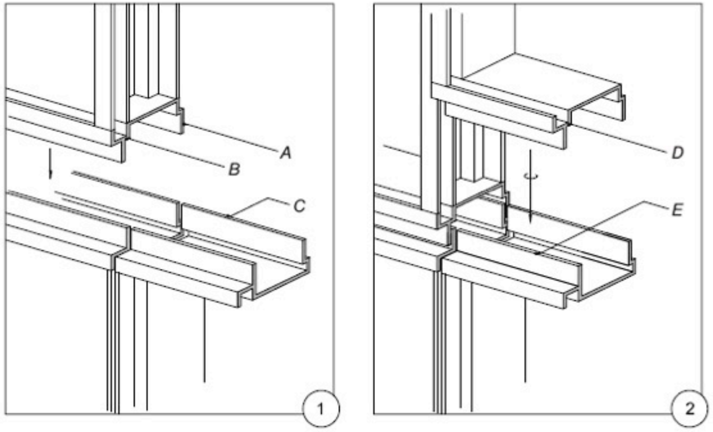


Figure 2.6: Unitized system — joinery — typical expansion joint assembly

UNITIZED SYSTEM - GENERAL



Four-way stack joint concept

A Frame lowered into position onto installed frames

B Mullion interlock

C Interlocking rail

D Mullion interlock is engaged—frame is rotated and lowered into position

E Airseal gasket

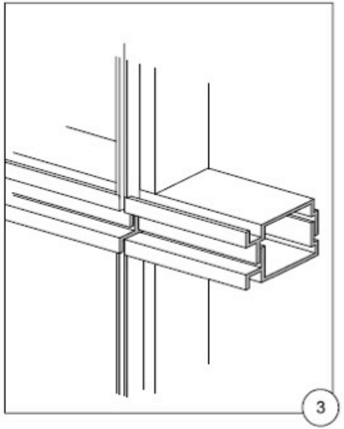


Figure 2.7: Unitized system — general — four-way stack joint concept

MULLION AND PANEL - GENERAL

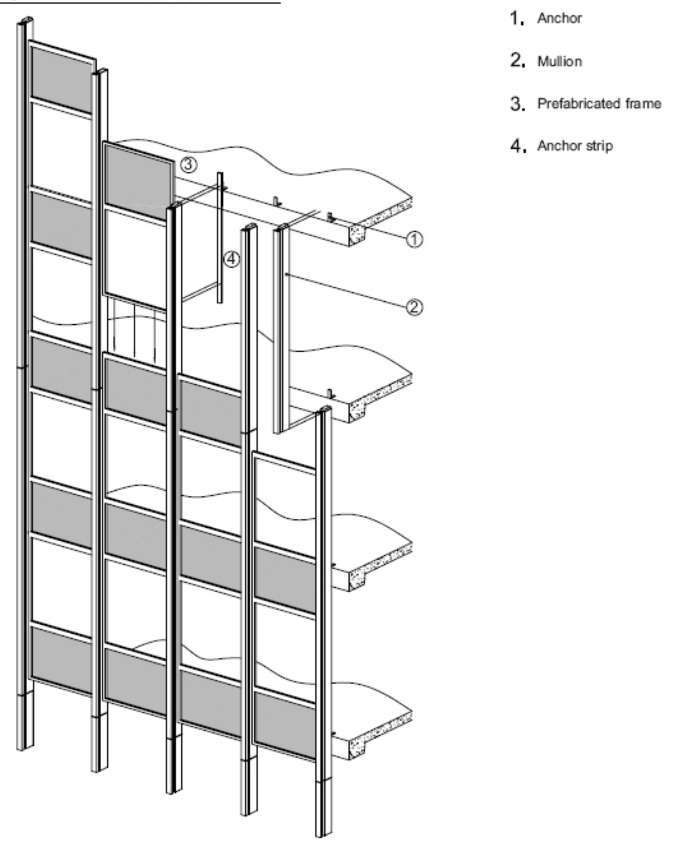


Figure 2.8: Mullion and panel — general

WINDOW WALL - GENERAL

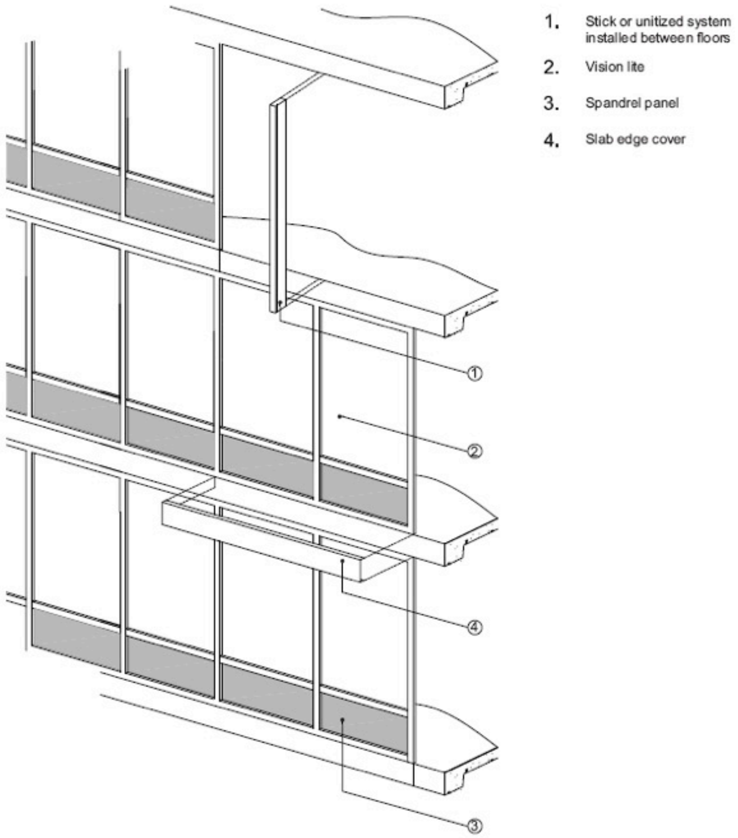


Figure 2.10: Window wall — general

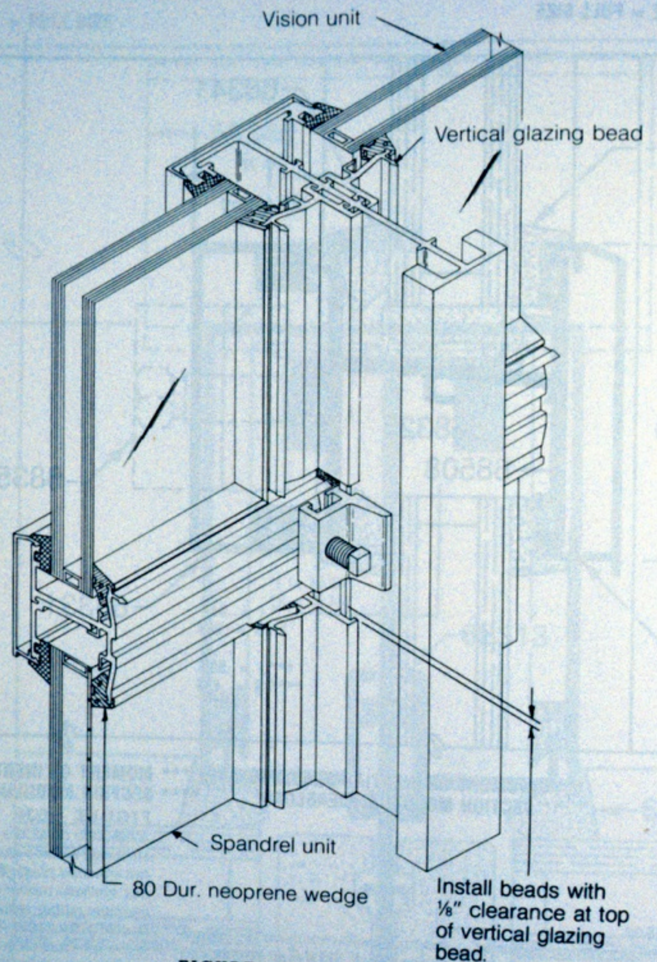


FIGURE 15.35
A three-dimensional view of the assembly of the horizontal and vertical mullions. (Courtesy of Amarlite Architectural Products)

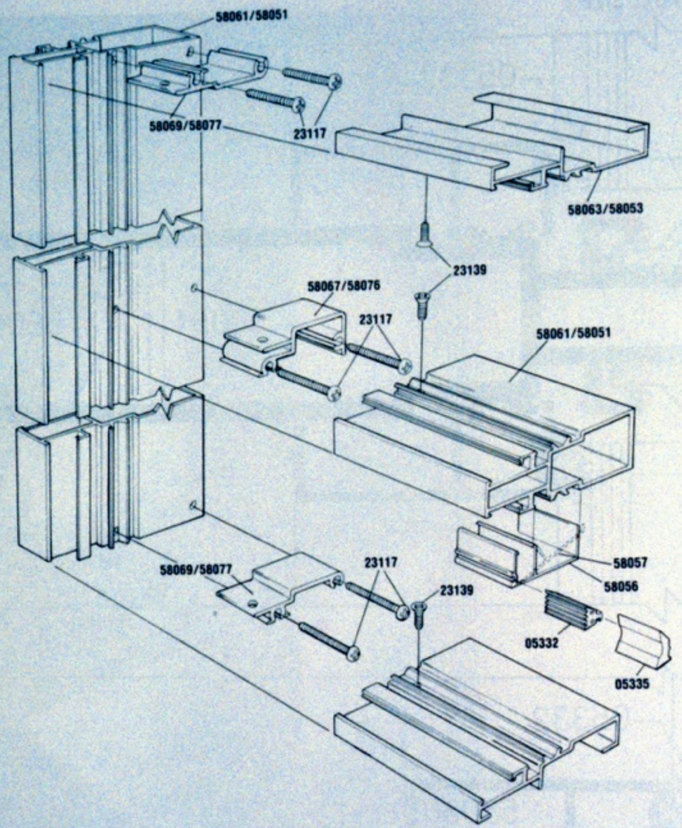


FIGURE 15.40
An exploded assembly diagram of the aluminum components for the lockstrip gasket curtain wall. Short clips with screw ports are screwed to the vertical mullion to allow attachment of the horizontal mullions with flat-head screws (23139). (Courtesy of Amarlite Architectural Products)

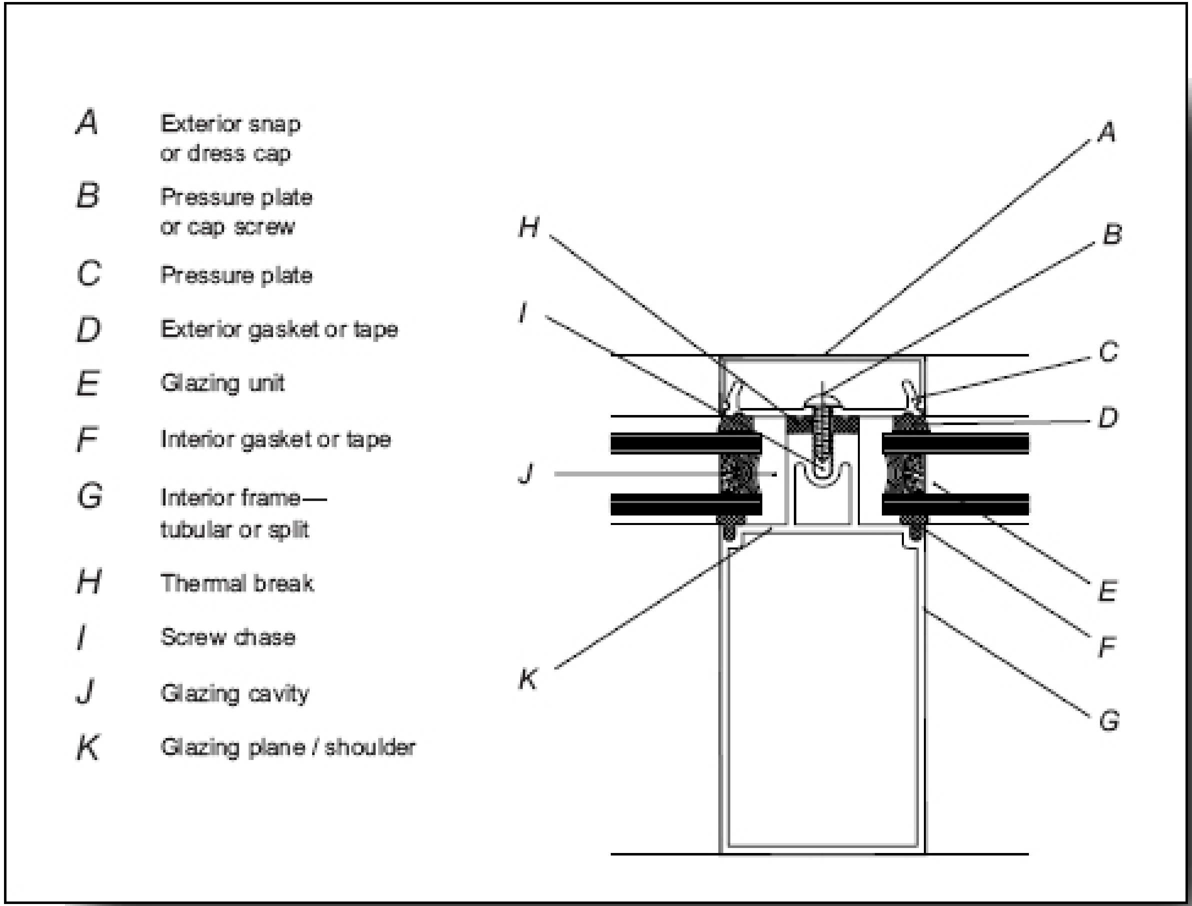


Figure 2.12: Glazing method — exterior batten

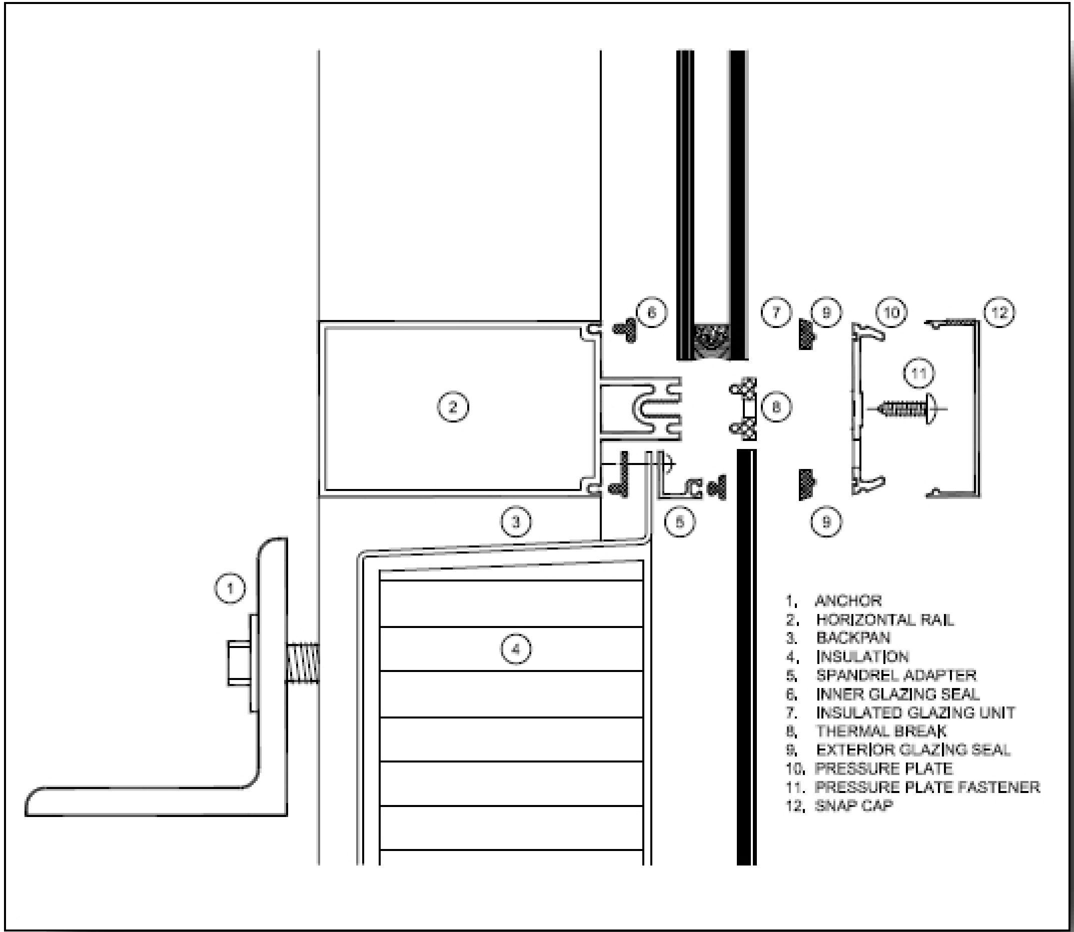
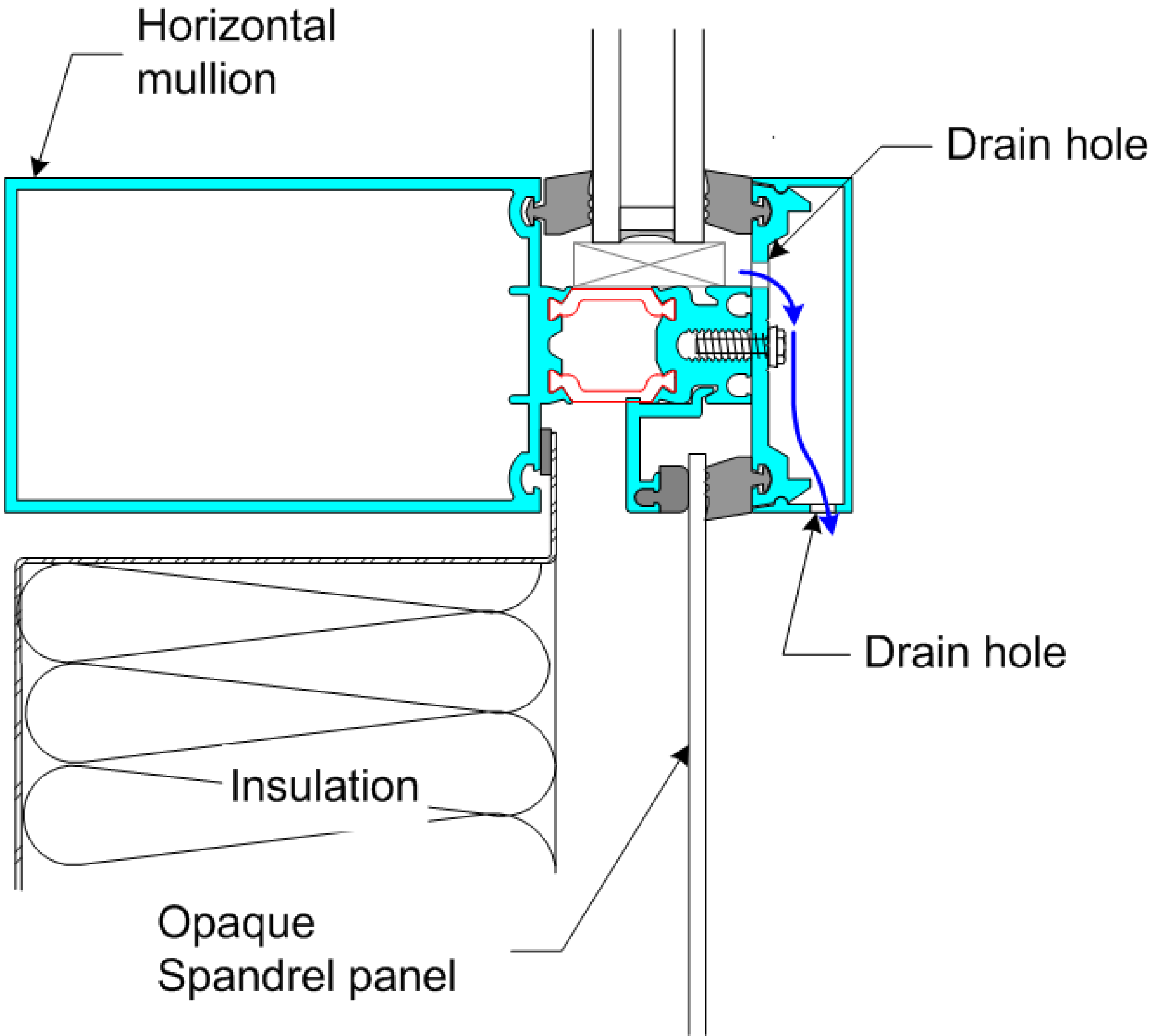


Figure 3.1: *Components and materials*


Horizontal mullion
Drain hole
Drain hole
Insulation
Opaque Spandrel panel

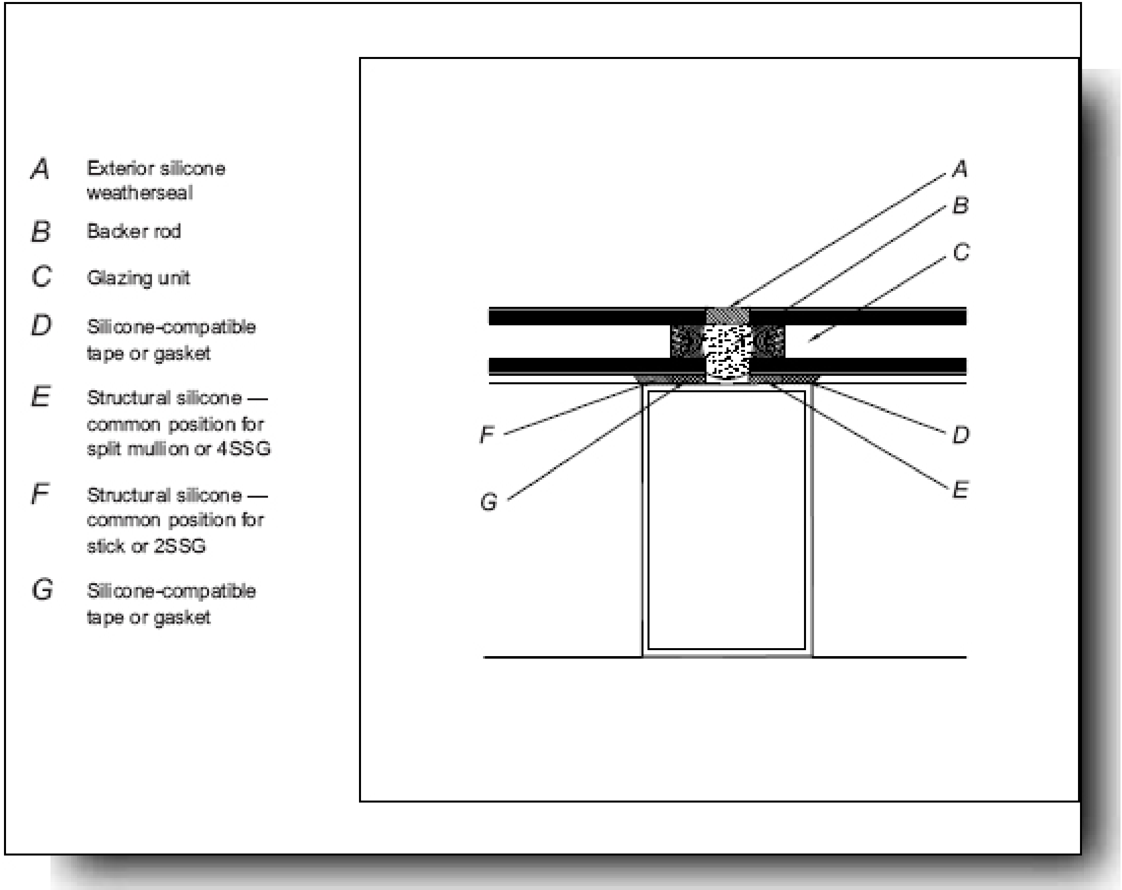


Figure 2.14: Glazing method — structural silicone (SSG)

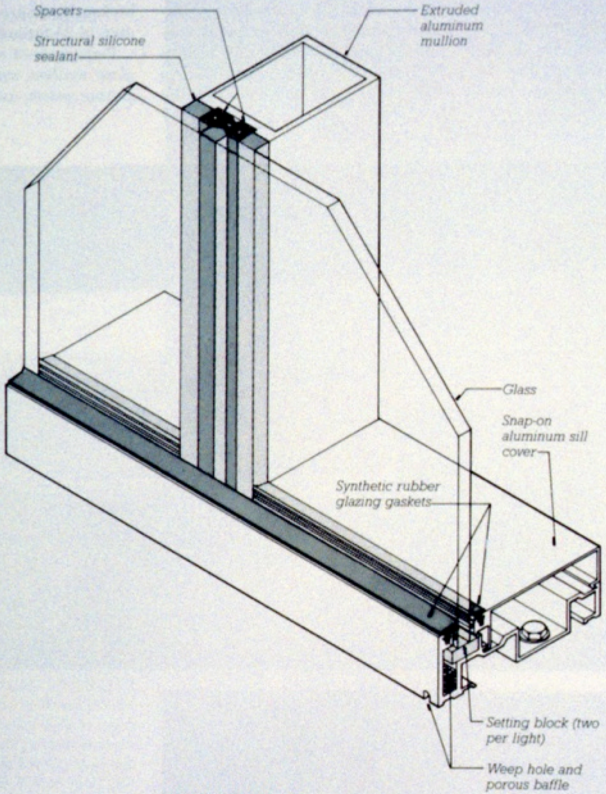


FIGURE 14.23
Horizontal strip windows that need to appear mullionless only from the exterior can be created by adhering the glass to interior mullions with structural silicone sealant. The sill and head are conventionally glazed, using snap-on aluminum covers to hold the interior glazing gaskets. Either single glazing, as shown, or double glazing can be used with this type of system (Copied by permission from PPG EFG System 401 details, courtesy of PPG Industries)

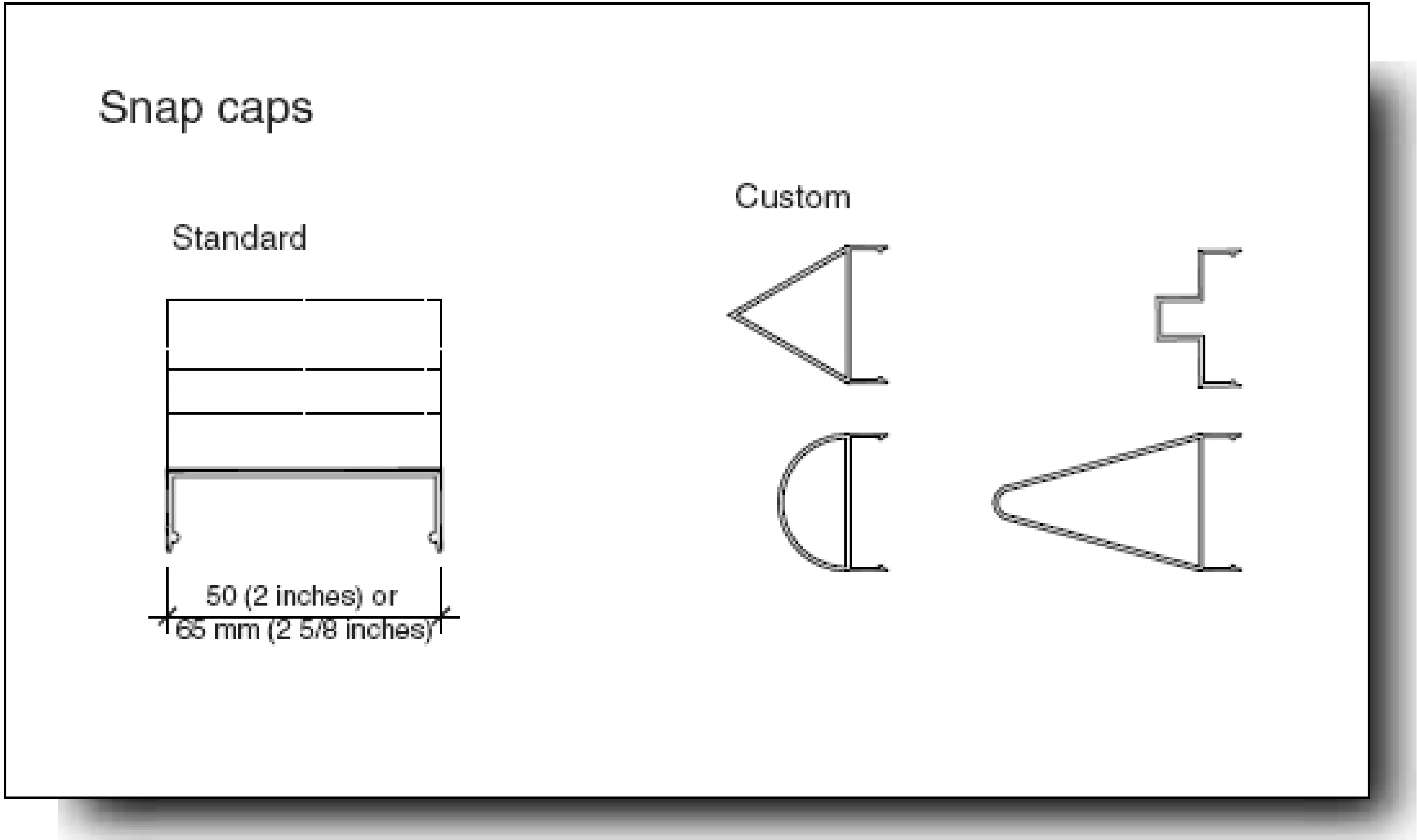


Figure 3.12: Snap caps

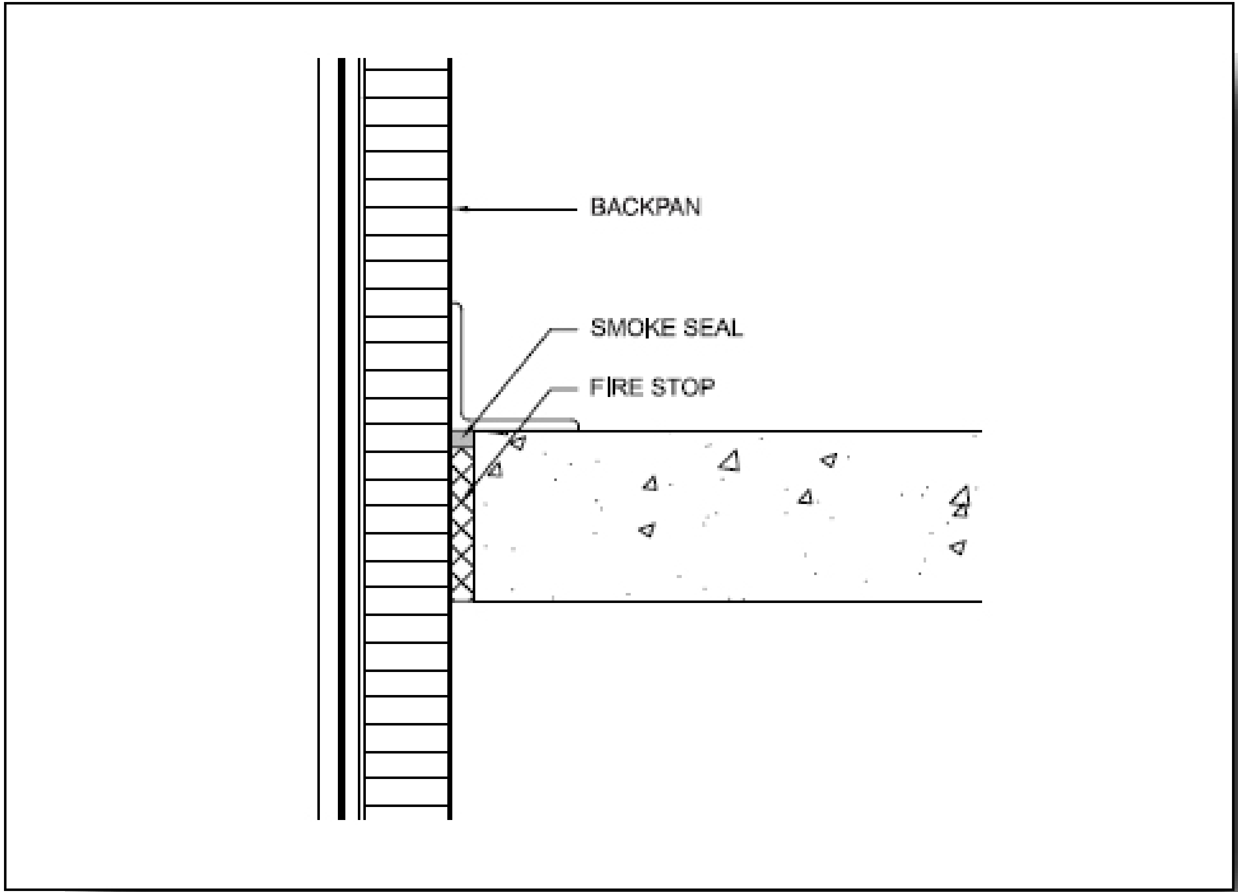
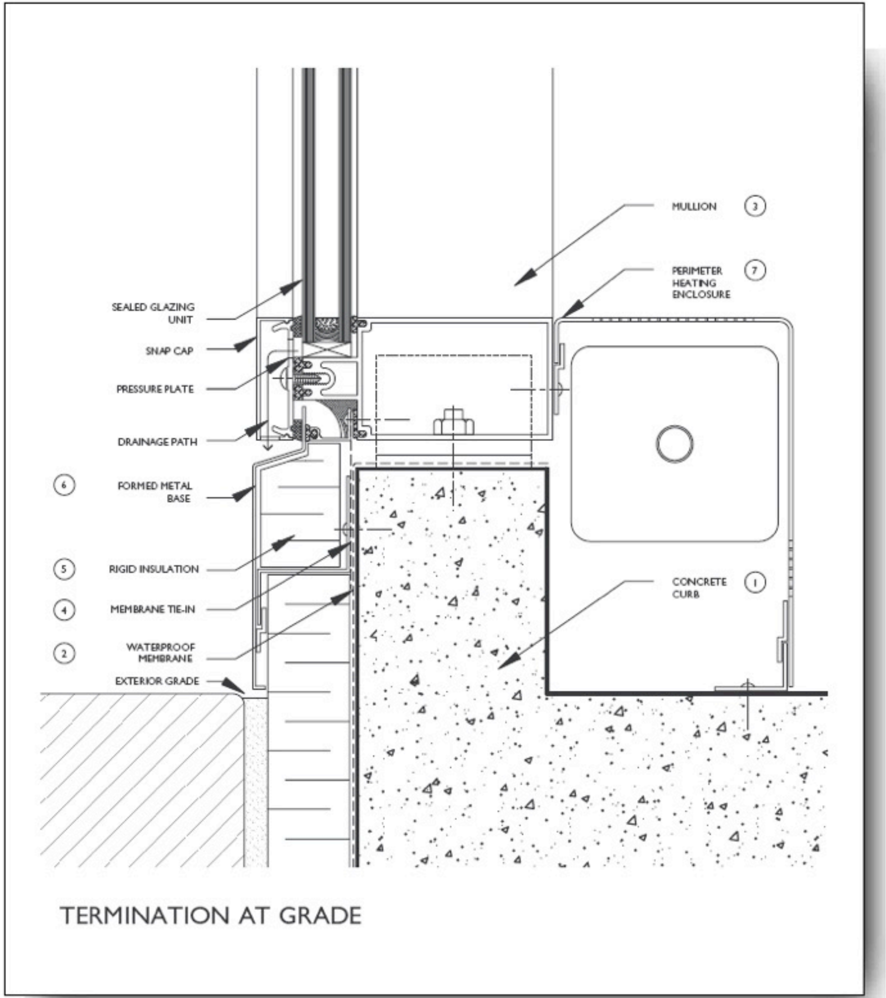
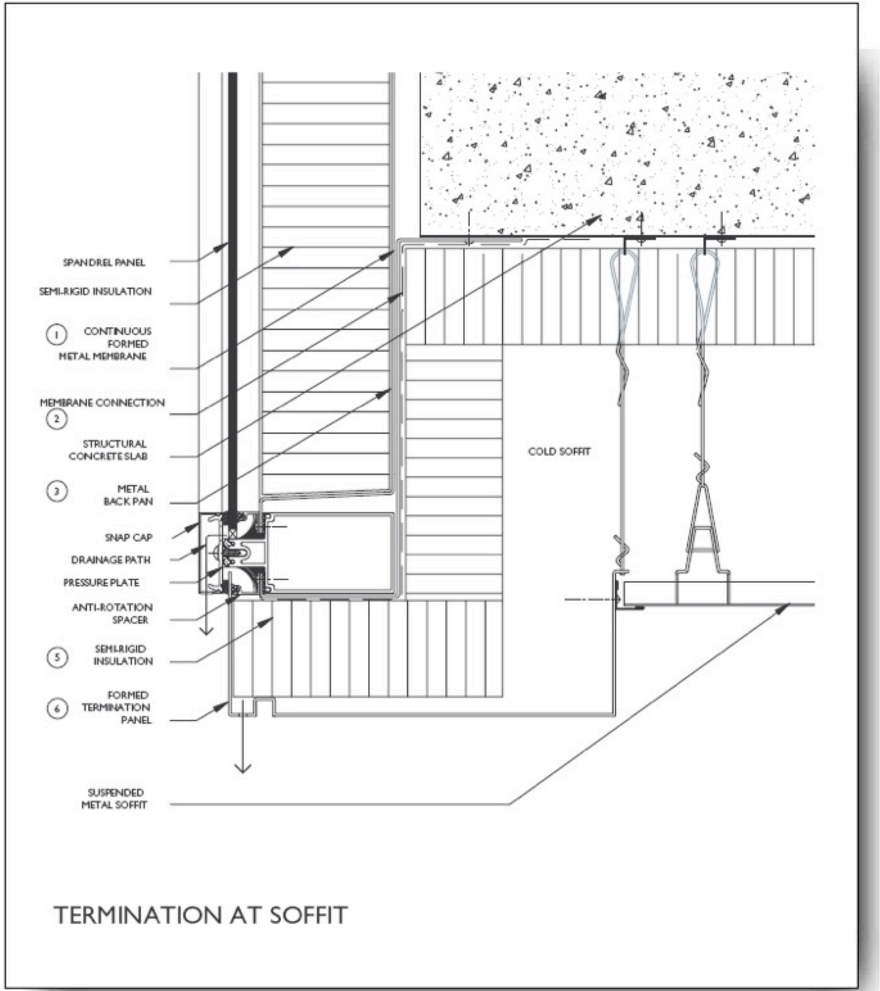


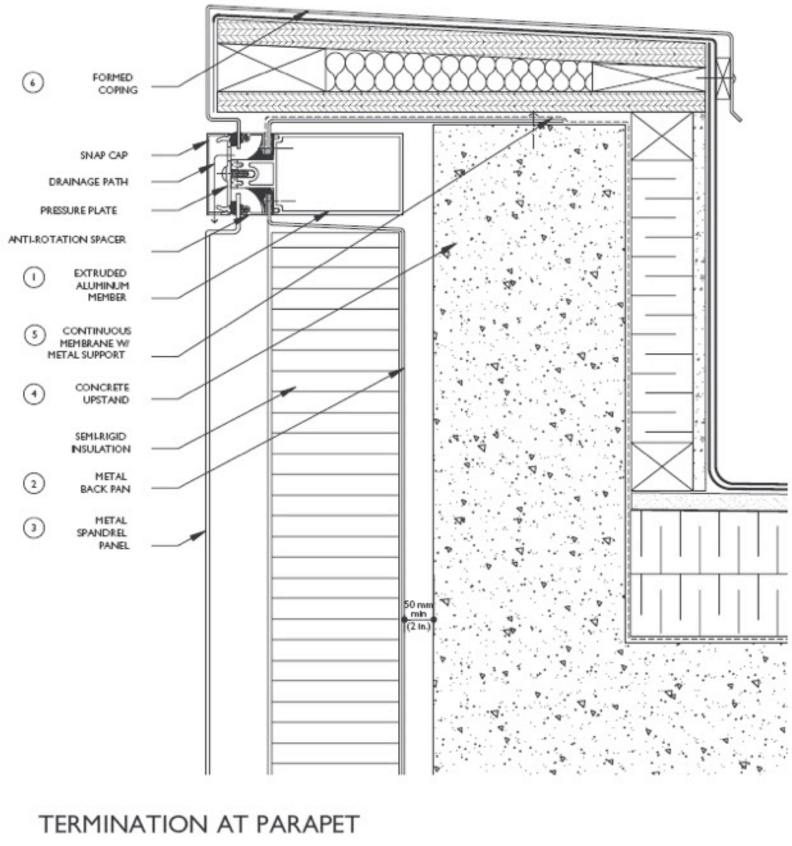
Figure 4.12: Firestopping and smoke sealing



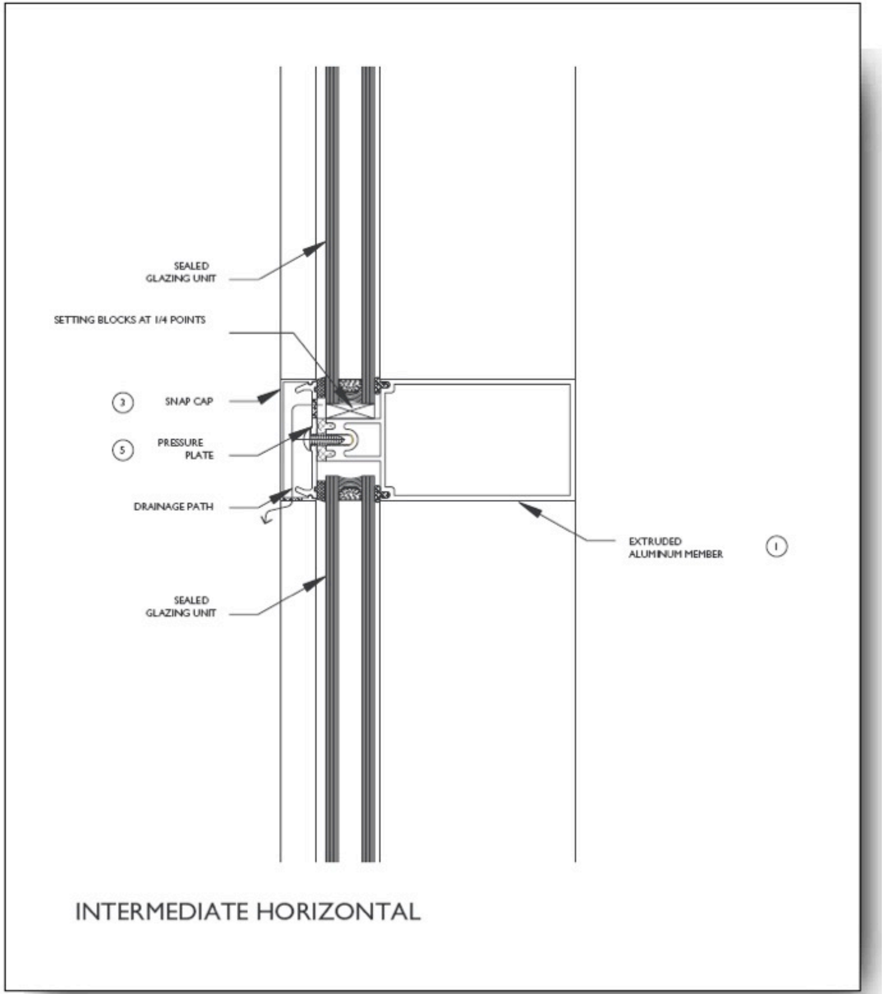
Detail 1: Termination at grade



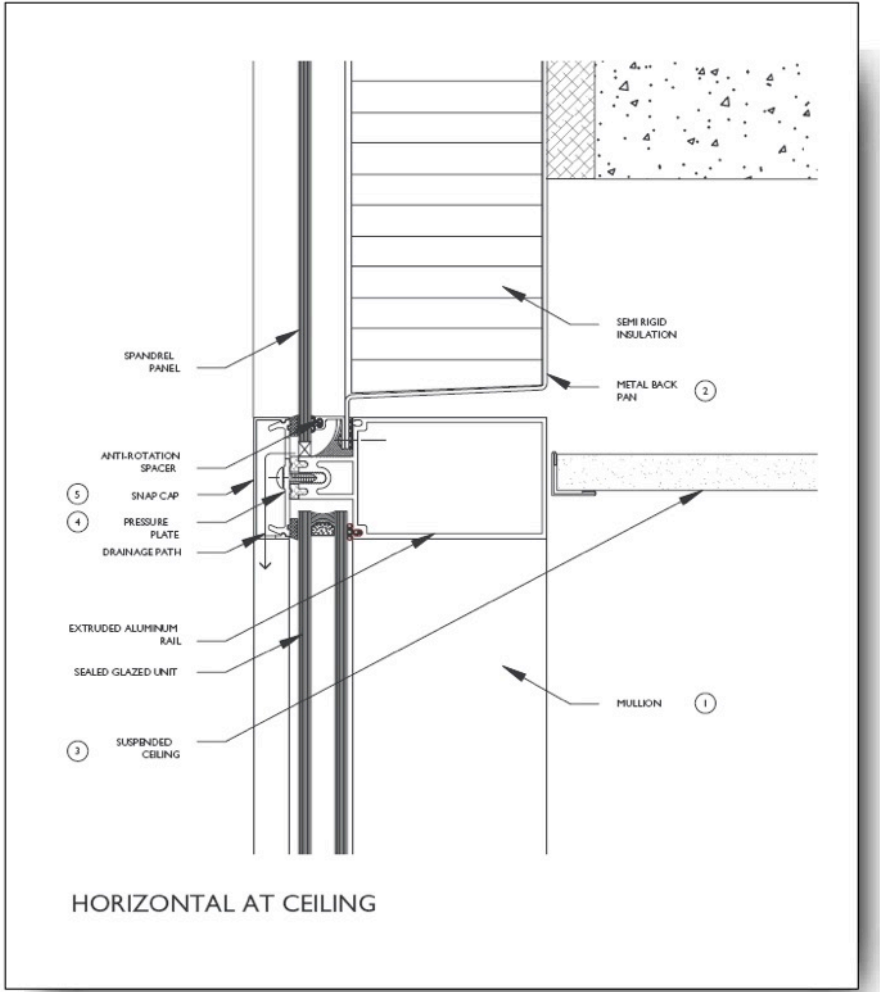
Detail 2: Termination at soffit



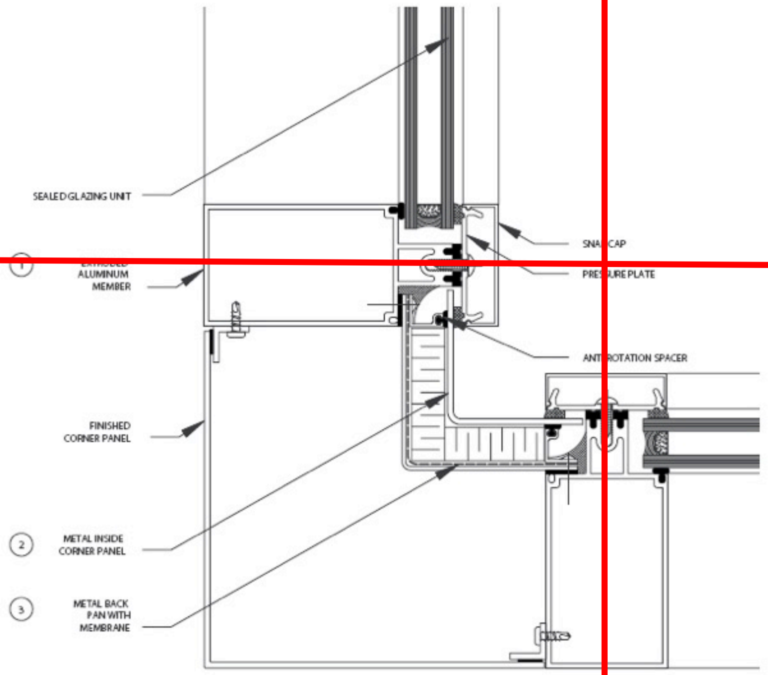
Detail 3: *Termination at parapet*



***Detail 4:** Intermediate horizontal*

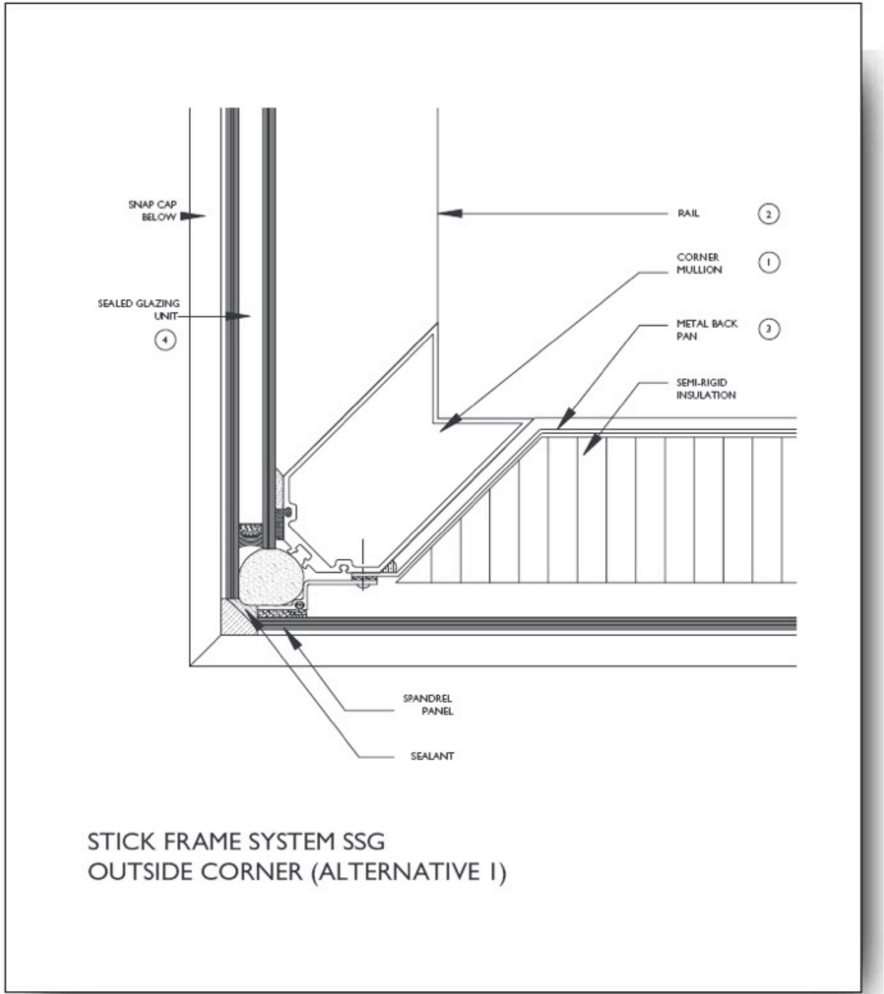


***Detail 6:** Horizontal at ceiling*

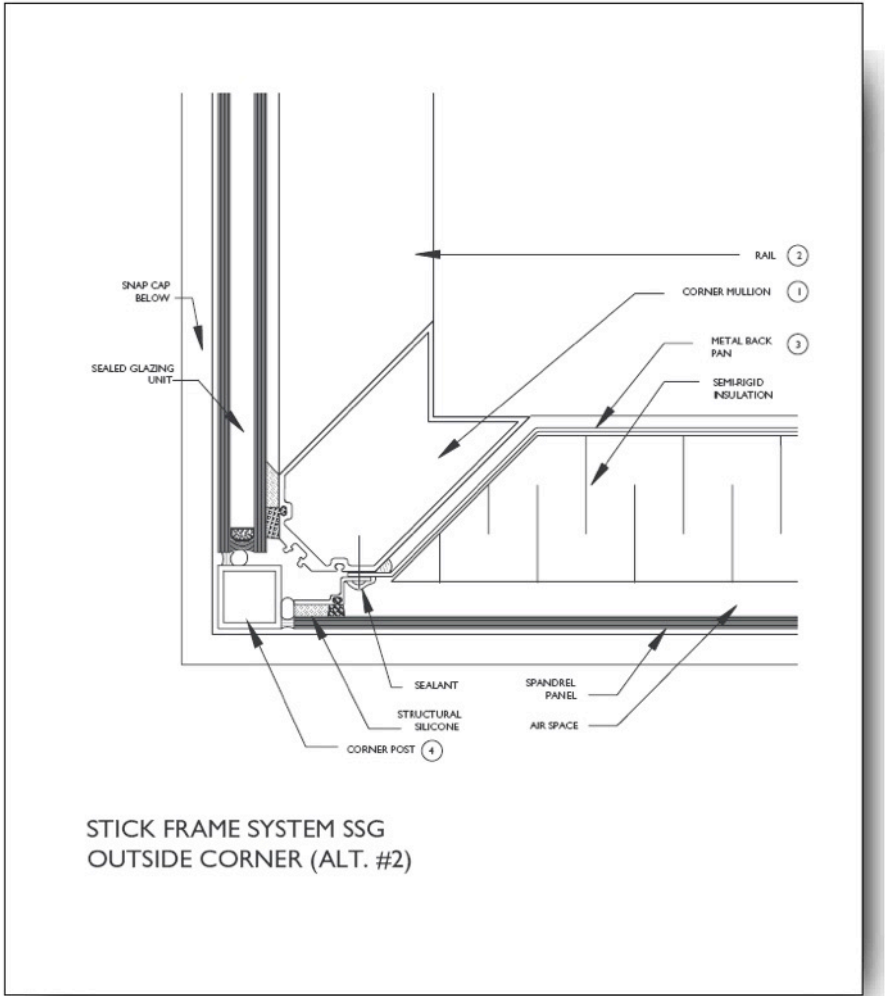


INSIDE VERTICAL CORNER

***Detail 8:** Inside vertical corner*

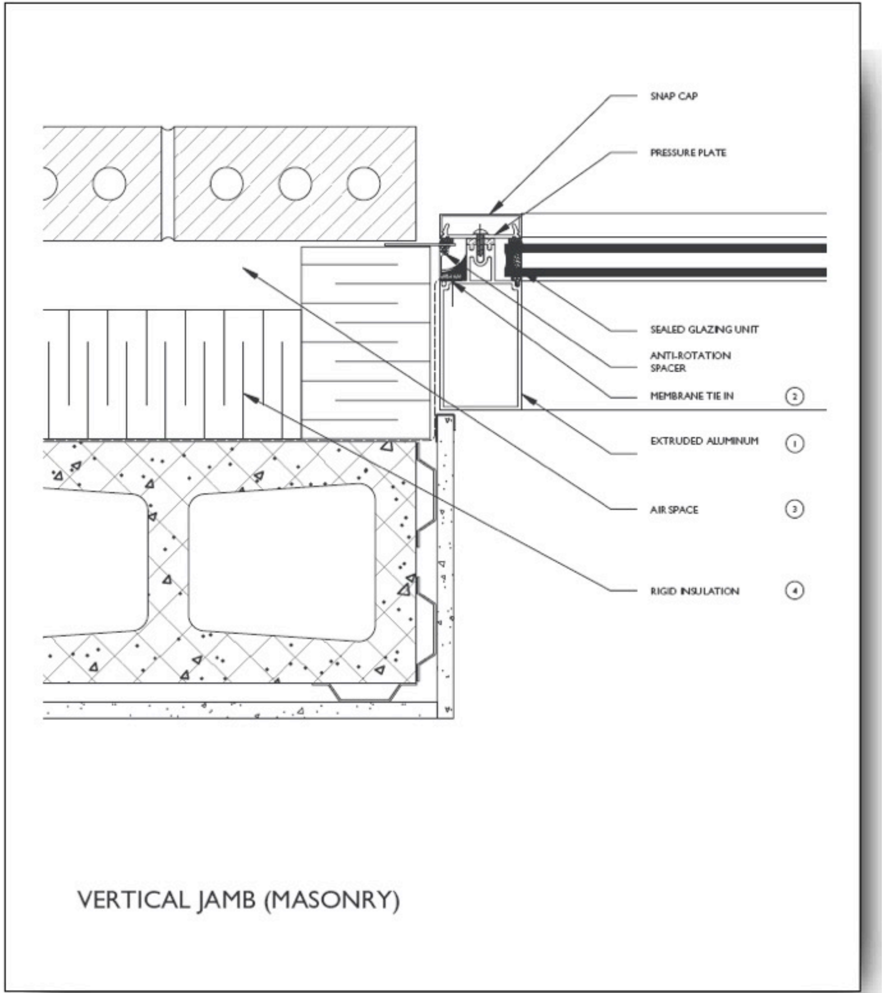


Detail 15: *Stick frame system SSG outside corner (alternative 1)*

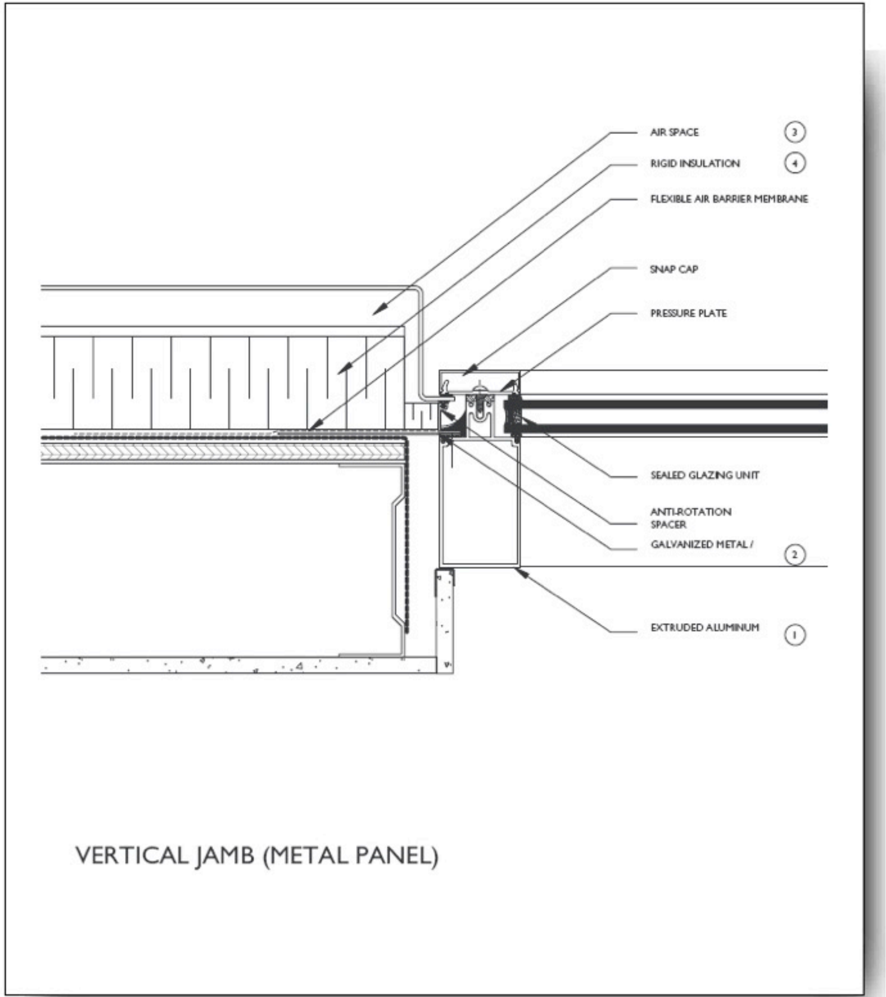


Detail 16: *Stick frame system SSG outside corner (alternative 2)*

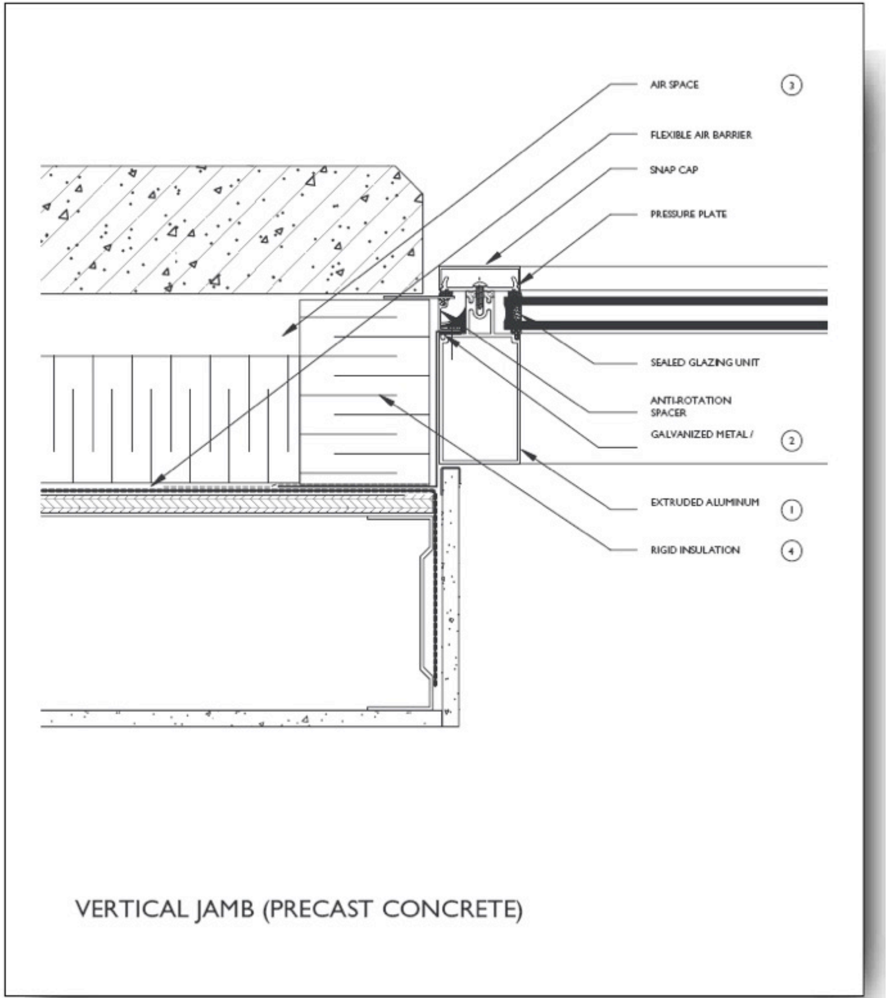

363-4777



Detail 9: *Vertical jamb (masonry)*



Detail 10: *Vertical jamb (metal panel)*



***Detail 11:** Vertical jamb (precast concrete)*

Curtain Wall Attachment Systems

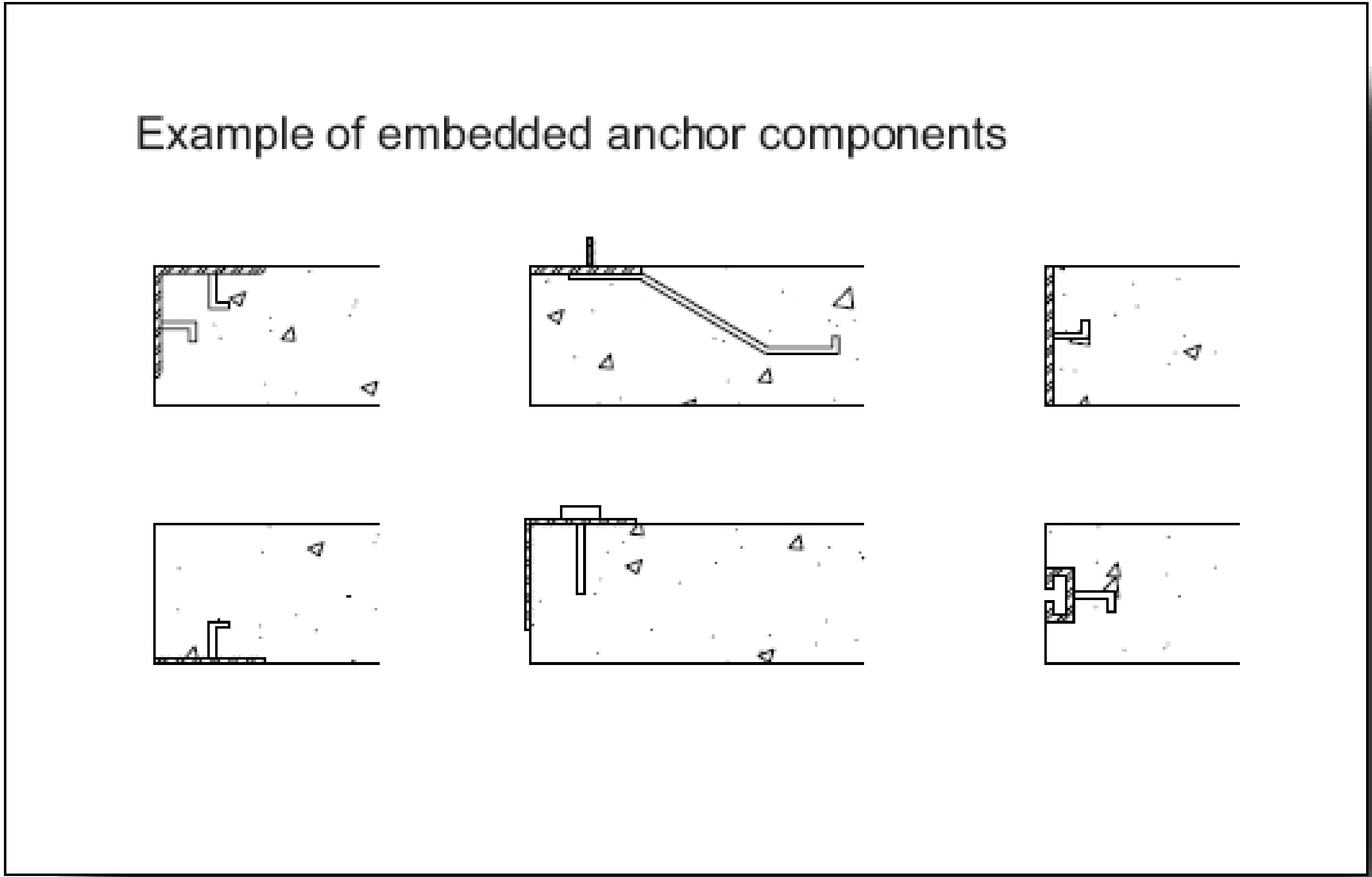


Figure 3.2: Examples of embedded anchor components

Curtain wall is attached to the slab edge and ONLY onto the vertical curtain wall frames to prevent glass breakage

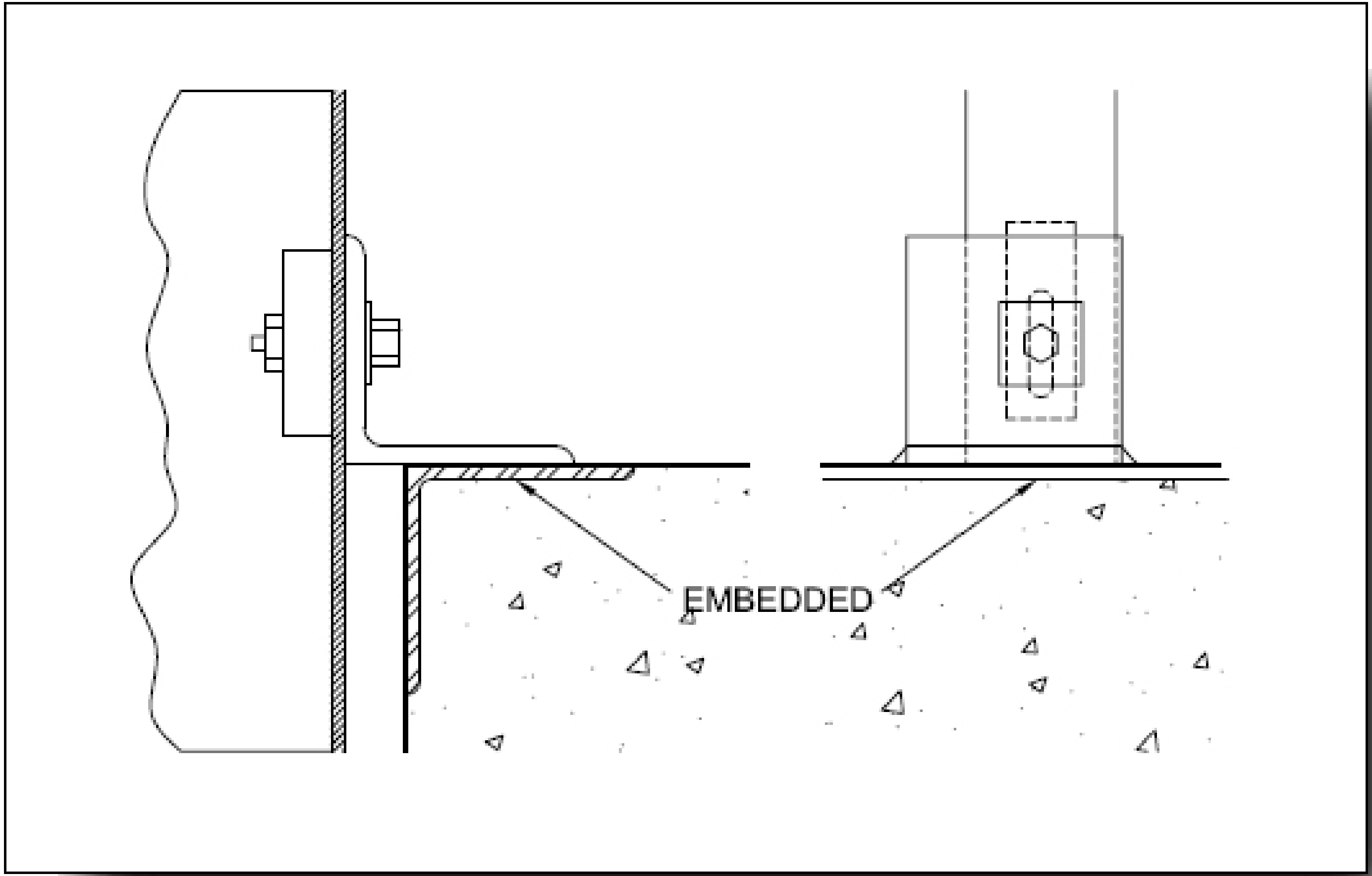


Figure 3.3: Common anchor in many stick-erected curtain wall systems

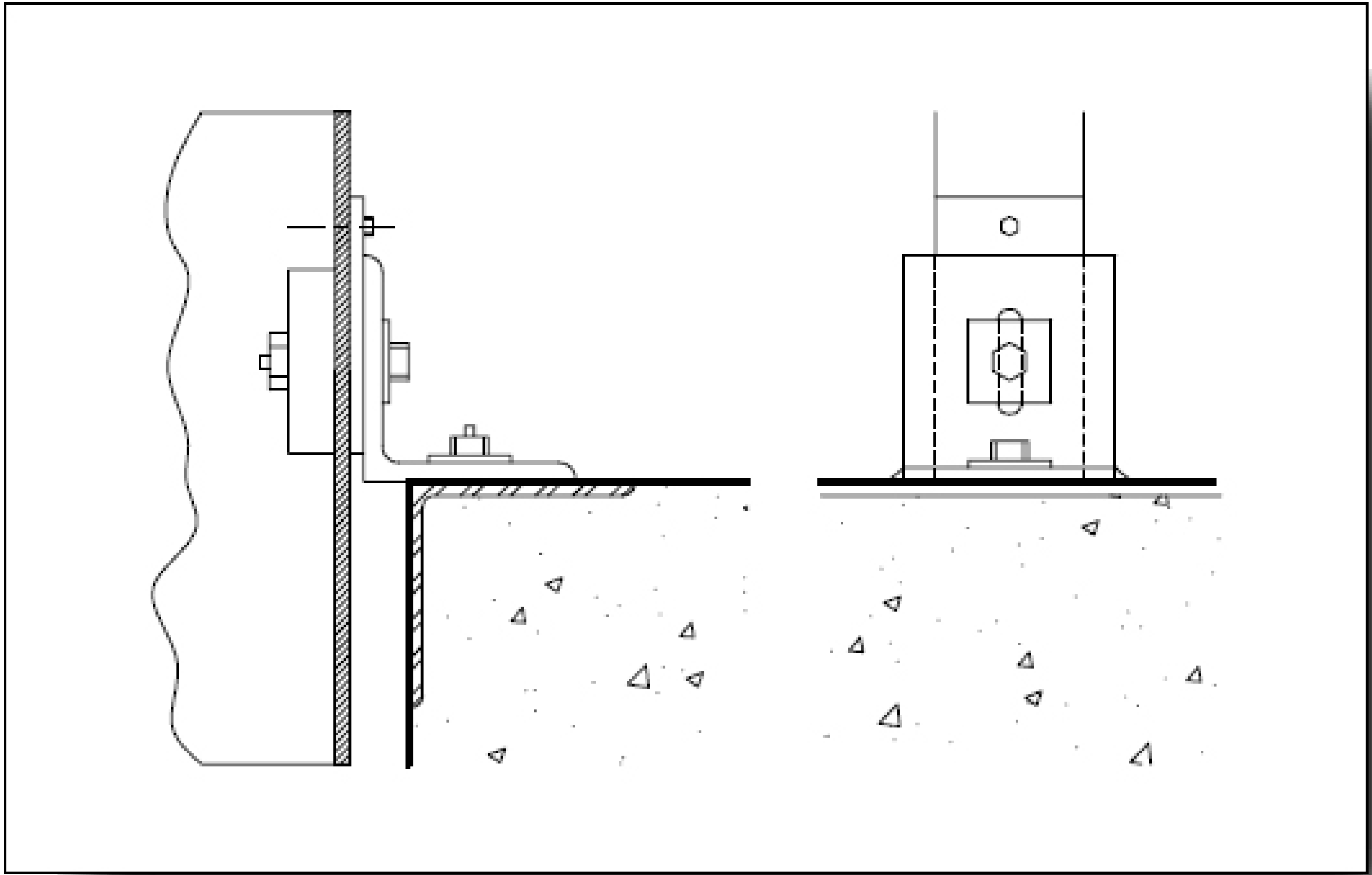


Figure 3.4: More sophisticated anchor

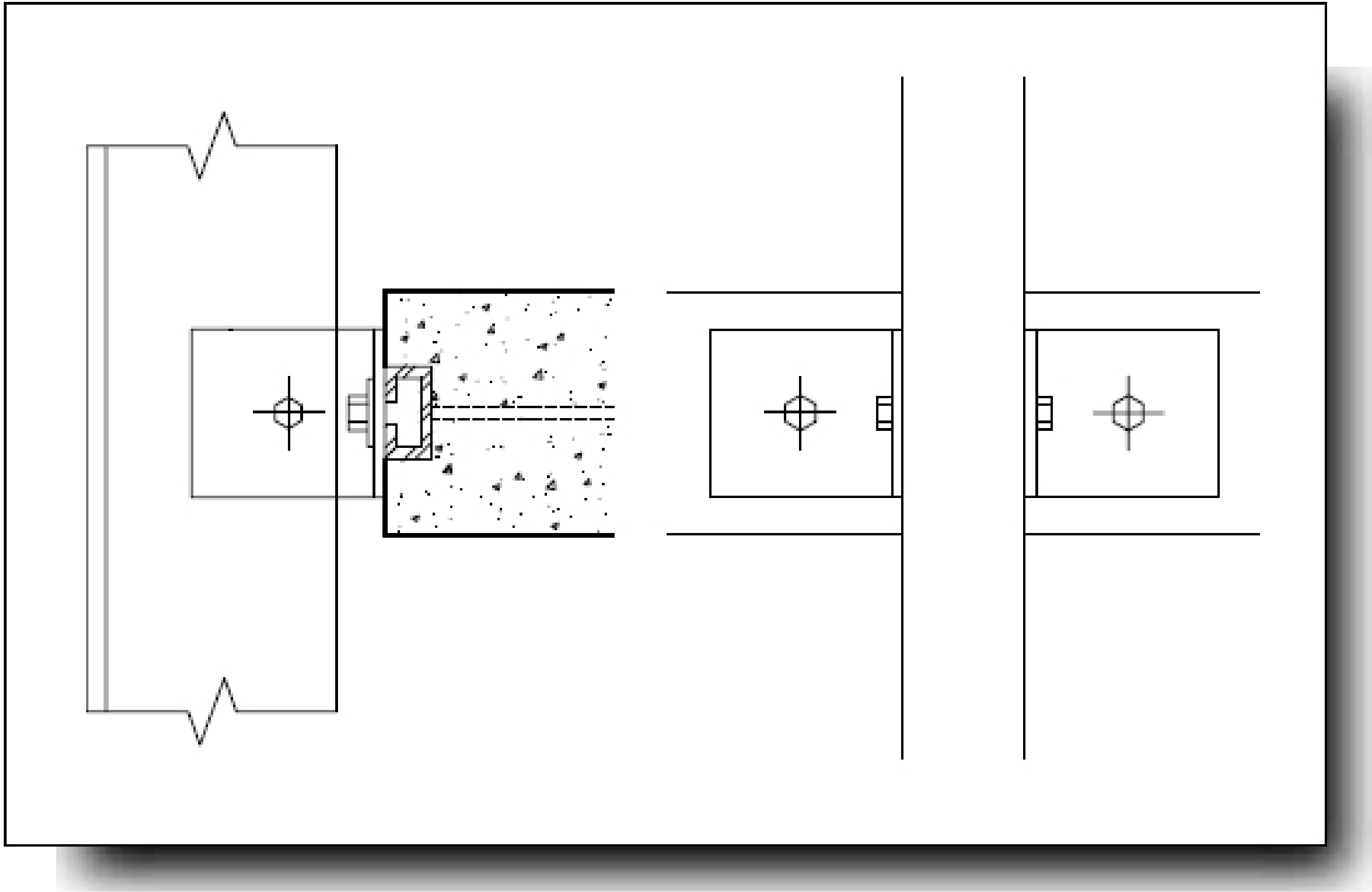
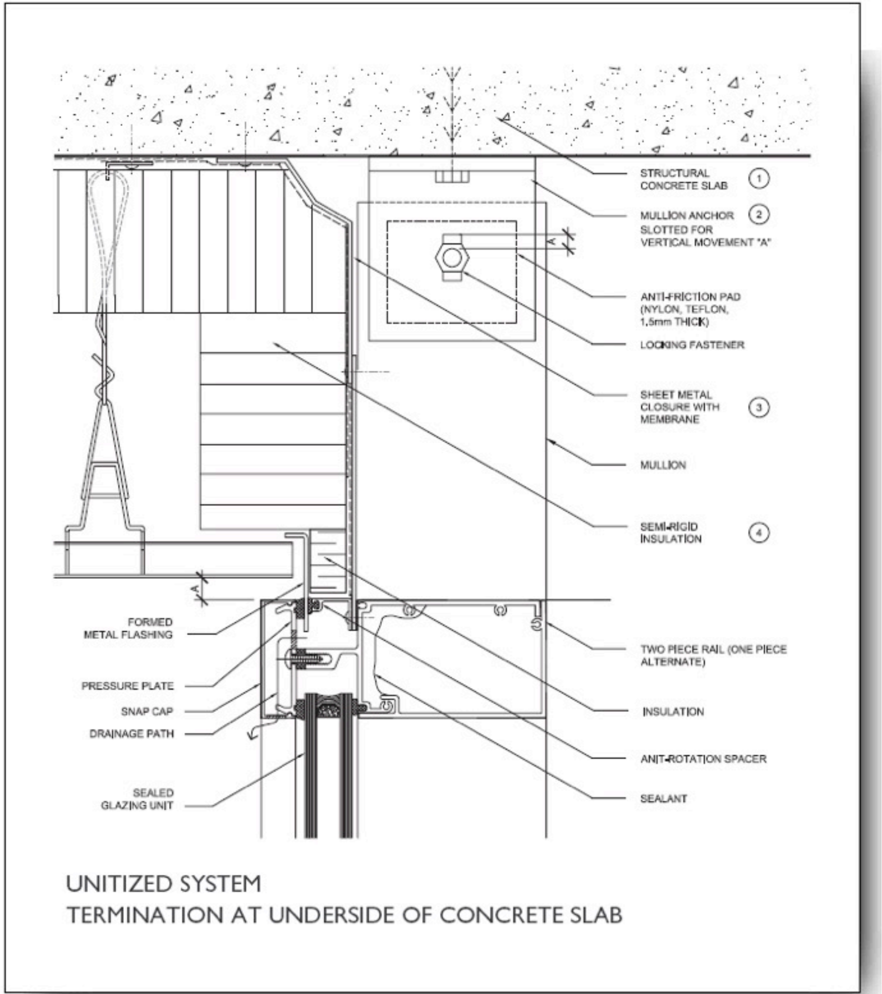


Figure 3.5: Slab edge anchor



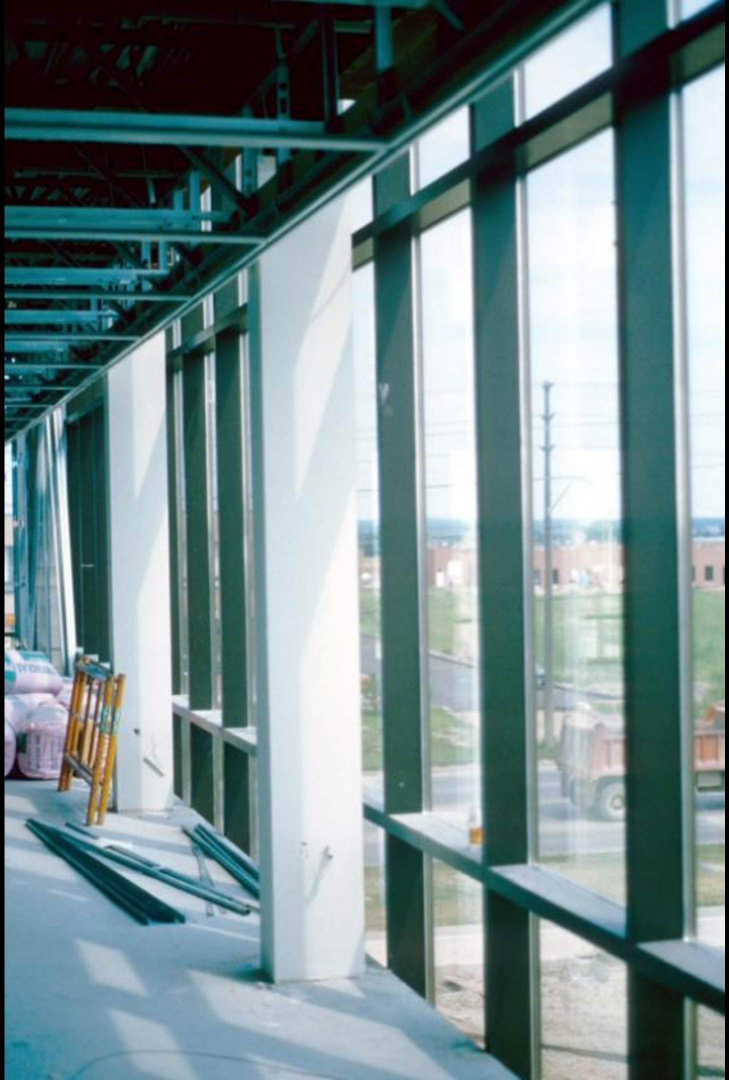
Detail 18: *Unitized system termination at underside of concrete slab*

Curtain wall project will
have integrated
concepts and usually
structure for allowing
cleaning operations


60



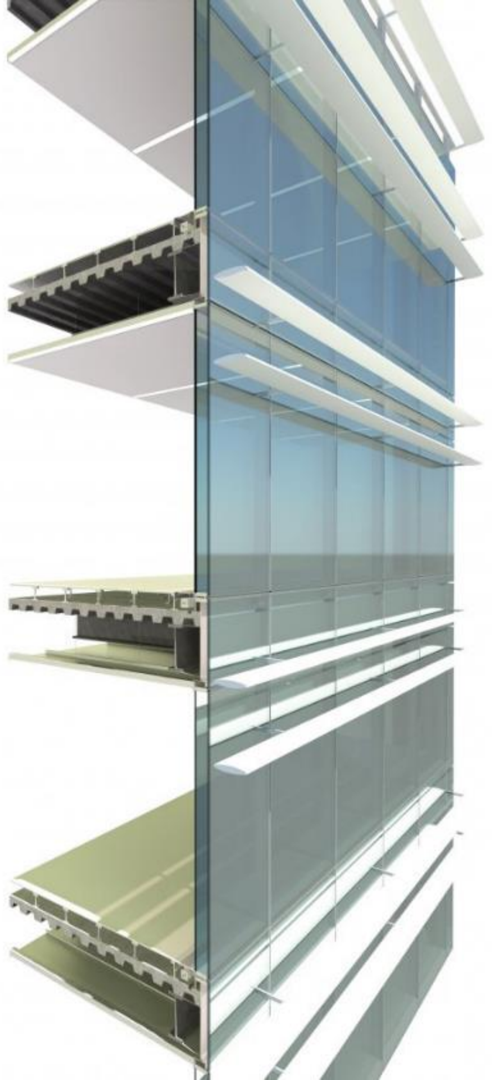

PETROLIA RD





Bankia
REÀLIA

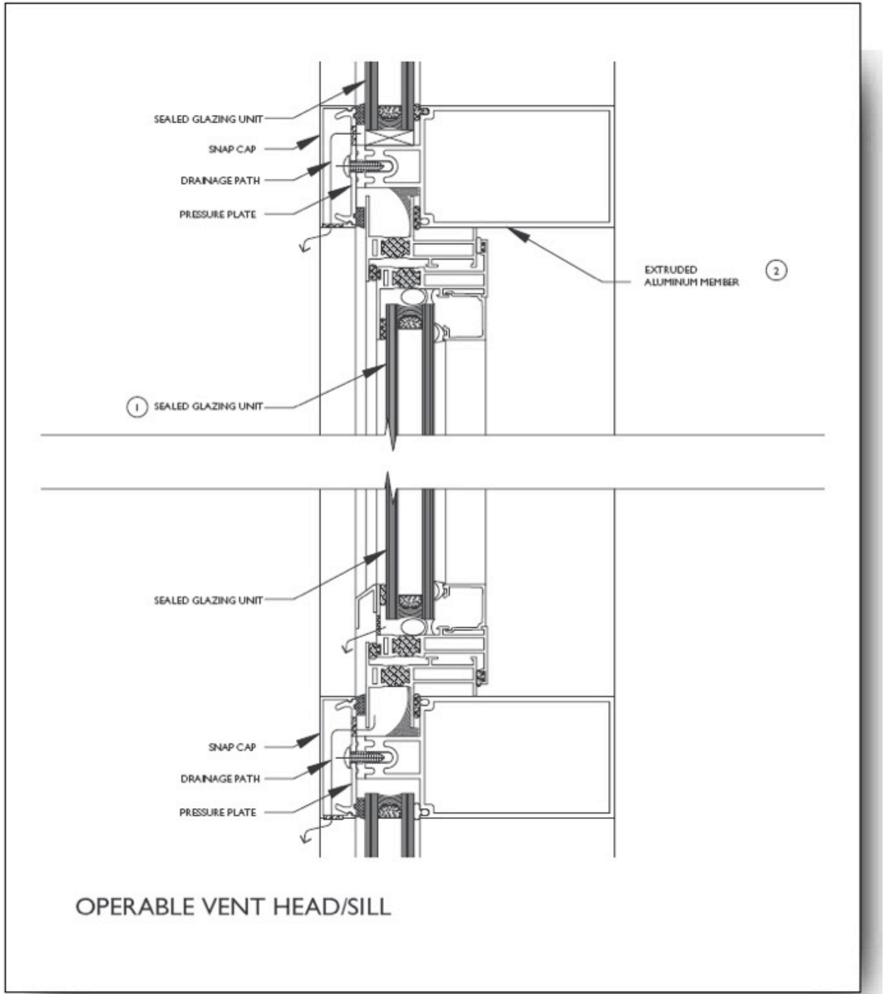

REALIA



The height of the glass divisions will be coordinated with

- the placement of the slab
- Need for vision glass
- Dropped ceilings
- Raised floors


Tall installations need extra wind bracing AND heat distributed for the upper range



***Detail 12:** Operable vent head/sill*

Curtain wall can incorporate operable windows


Nachströmung NRA
3a
Nymphenburger Straße