STRUCTURAL GLAZING – DESIGN CONSIDERATIONS

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COURSE DESCRIPTION

- **Description:** Structural Design Considerations: Structural Design within a curtain wall focuses on innovative design requirements with a foundation starting from basic construction. Design, validation, and material selection are introduced giving Architects more options in the future.

LEARNING OBJECTIVES

- A basic review of industry definitions and facade, Insulated Glass and Weatherseal components.
- Present several examples of the application of innovative materials to meet the design and efficiency requirements specified within the Architectural community.
- Learn about typical project processes in the design, testing, validation and production of a curtain wall.

STRUCTURAL SEALANT GLAZING

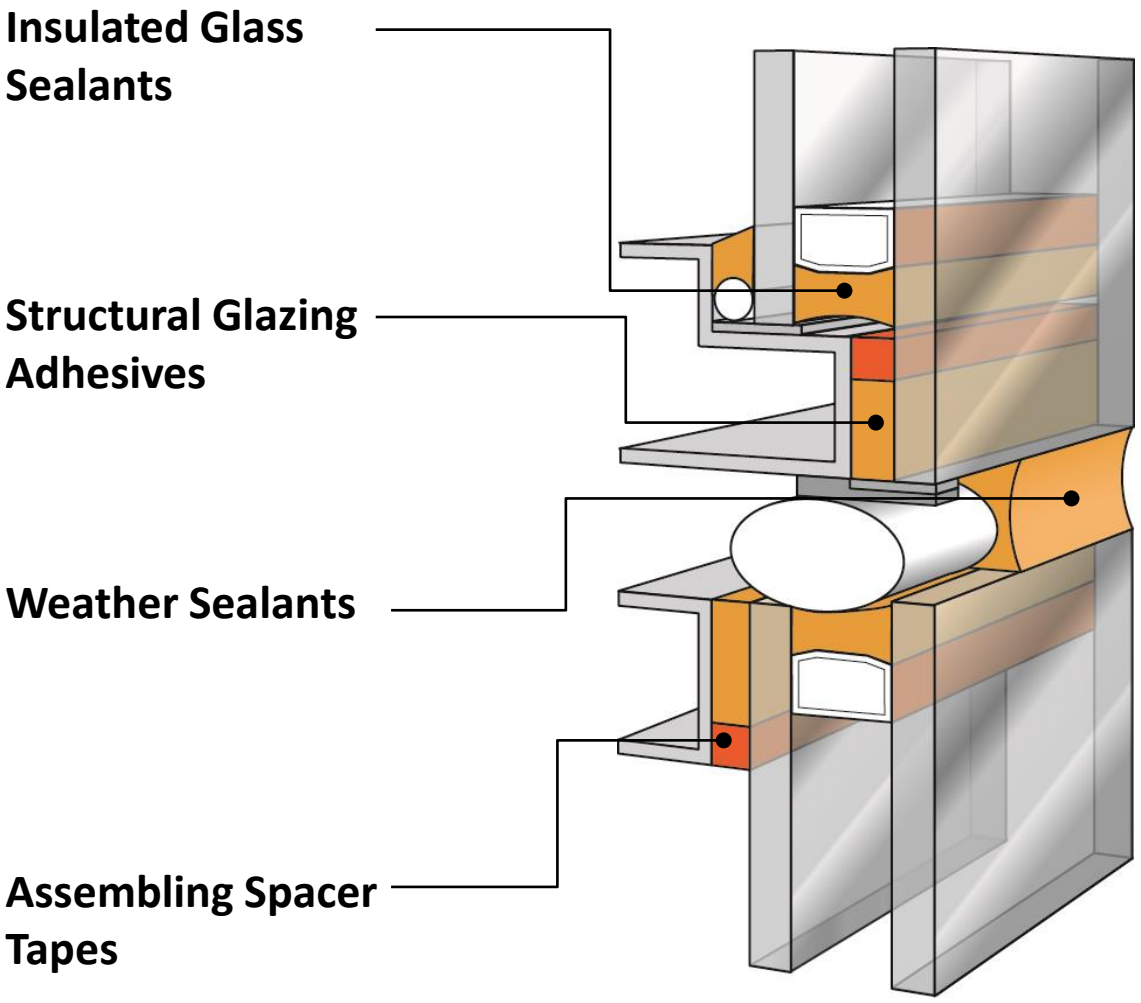
STRUCTURAL SEALANT GLAZING
LEADING FACADE TECHNOLOGY

- **Visible in all metropolitan cities**
- **Suitable to all architectural trends**

- **Elastic Glass Bonding in Facades**
- **Simple and economical systems**
- **Energy efficient facade technology**
- **Factory preassembled units**
- **Fast on-site installation**

STRUCTURAL SEALANT GLAZING
STATE OF THE ART

STRUCTURAL SEALANT GLAZING
COMPATIBLE SYSTEM APPROACH



System approach

- Approved systems
- Compatible products
- Worldwide available

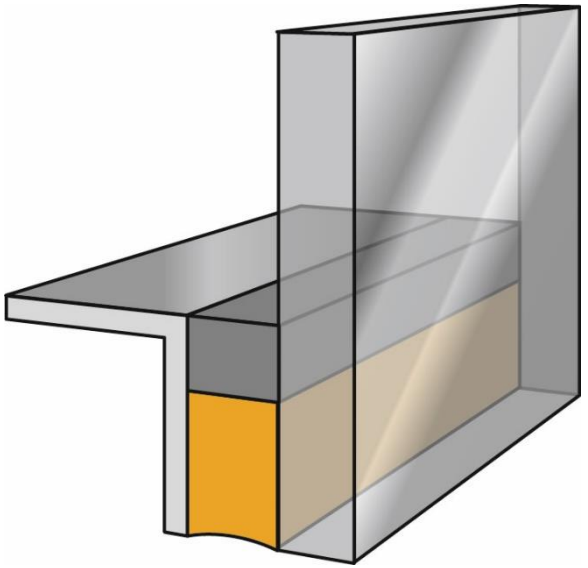
STRUCTURAL SEALANT GLAZING
SILICONES FOR STRUCTURAL BONDING

Structural Glazing with 1-component Silicones

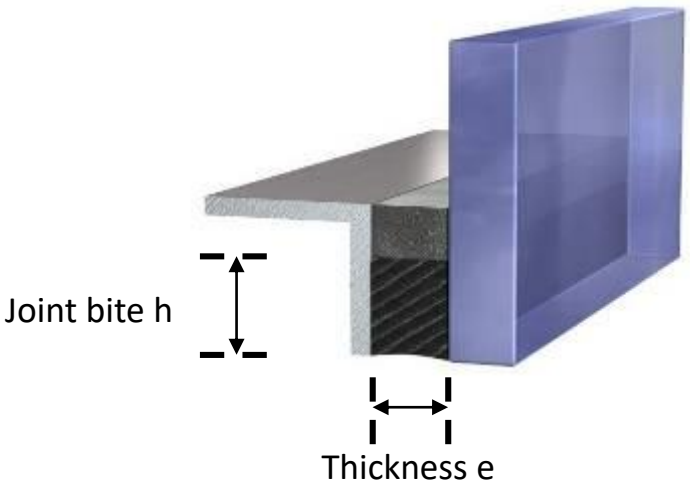
- Start of Structural Sealant Glazing
- On-site / repair applications
- ASTM / ETAG approval

Structural Glazing with 2-component Silicones

- Machine applied
- Factory Glass Bonding
- On-site solution with 2-part cartridges
- ASTM / ETAG approval

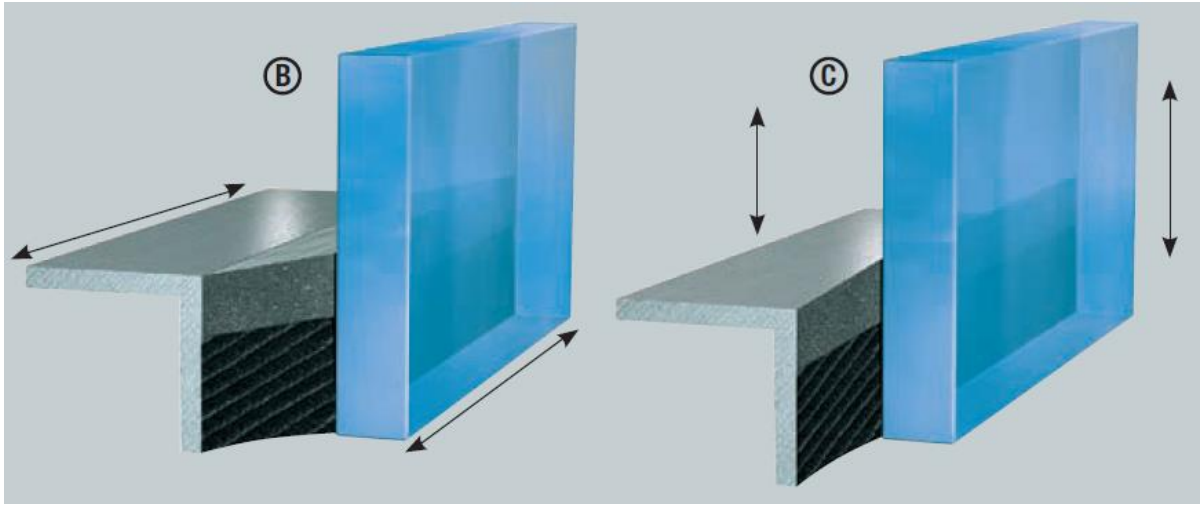


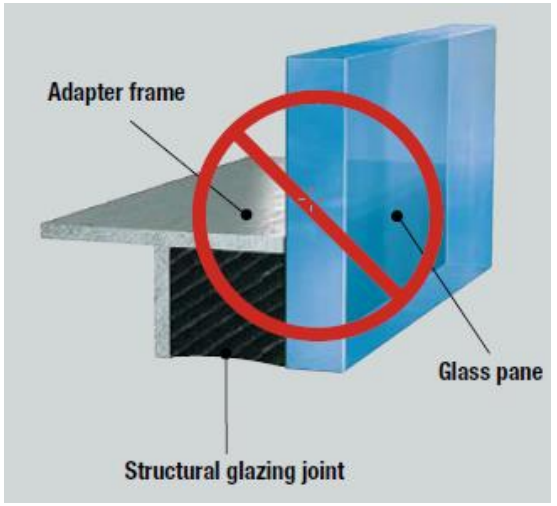
STRUCTURAL SEALANT GLAZING
DESIGN RULES



- Minimum joint dimension 6 x 6 mm
- Optimum ratio of joint bite to thickness: 1:1 to 3:1 (4:1)

STRUCTURAL SEALANT GLAZING
DESIGN RULES





- Minimum joint dimension 6mm x 6mm
- Optimum ratio of joint bite to thickness: 1:1 to 3:1 (4:1)
- Joint to be designed according to expected loads and movements
- Prevent adhesion on three surfaces

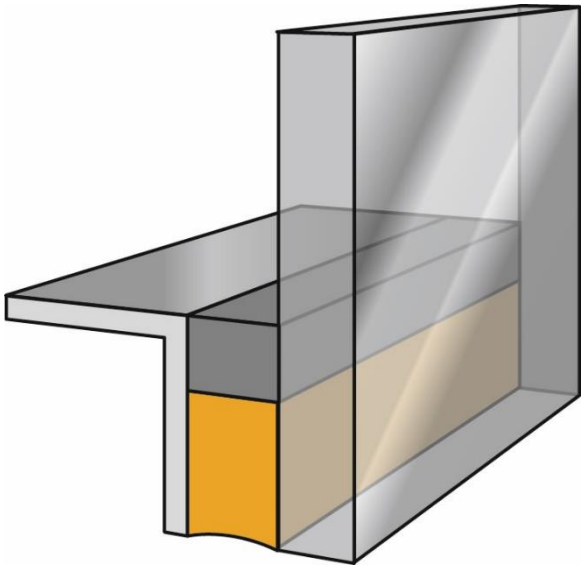
STRUCTURAL SEALANT GLAZING
SILICONES FOR STRUCTURAL BONDING

Structural Glazing with 1-component Silicones

- Start of Structural Sealant Glazing
- On-site / repair applications
- ASTM / ETAG approval

Structural Glazing with 2-component Silicones

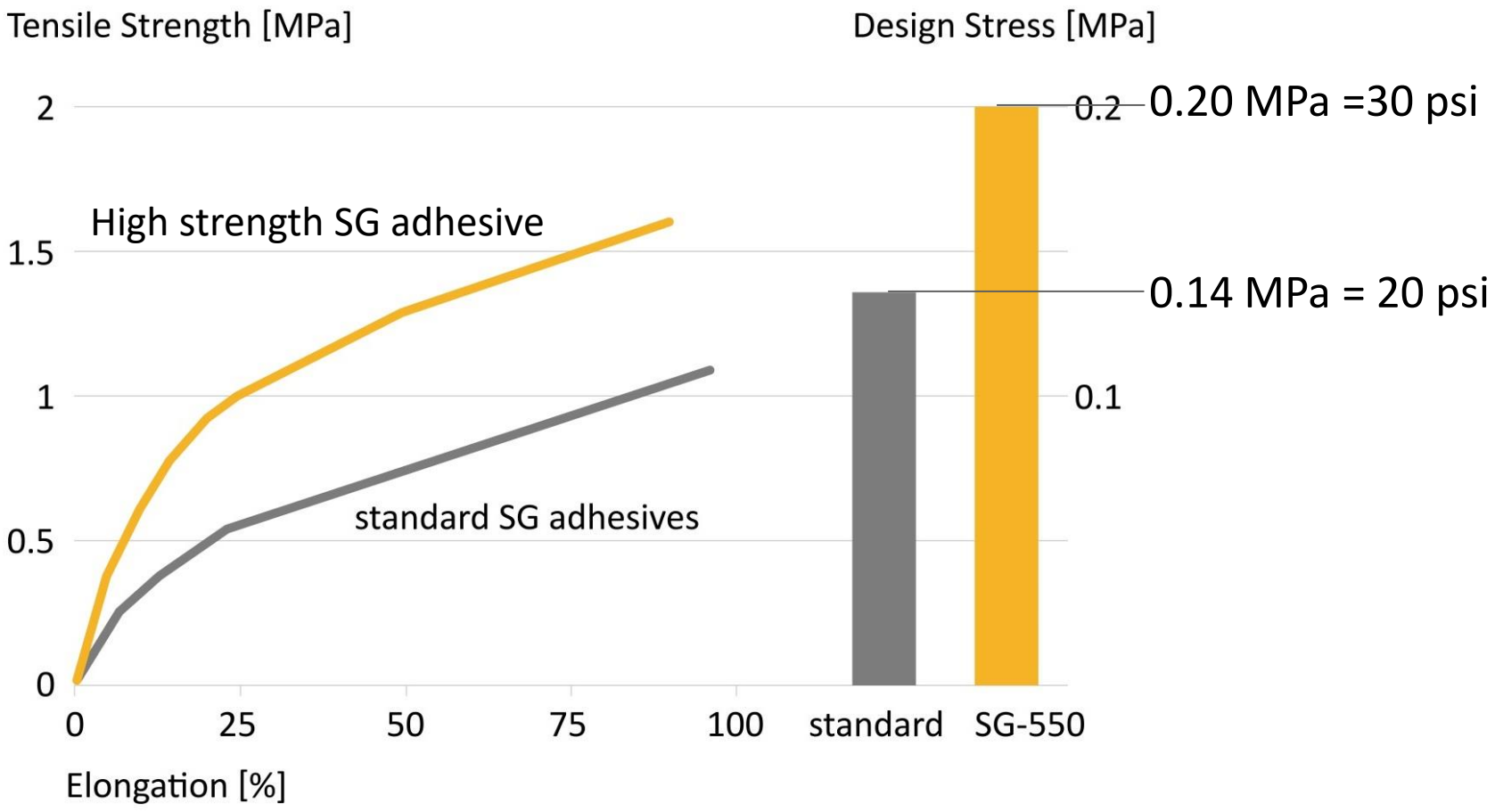
- 2-part system, machine applied
- Factory Glass Bonding
- On-site solution with 2-part cartridges
- ASTM / ETAG approval



High Strength Structural Glazing Silicones

- 2-part system, Factory glass bonding
- 30% higher design strength
- ASTM / ETAG approval

STRUCTURAL SEALANT GLAZING
HIGH-STRENGTH SG-ADHESIVE



STRUCTURAL SEALANT GLAZING

HIGH STRENGTH– BENEFITS

Please fill in the parameters			Comments or remarks
Maximum expected wind load	[kN/m^2]	3.25	
Glass width	[mm]	2200	
Glass height	[mm]	2500	
Total thickness of outer pane	[mm]	14	
Total thickness of inner pane	[mm]	0	
Which sealant is used?		High Strength SG	
Temperature during production	[deg C]	20	
Maximum temperature of the glass	[deg C]	80	
Maximum temperature of the profile	[deg C]	55	Aluminum
Glass is deadload supported?		True / False	
System is 4 sided Structural Glazing?		True	
Glass panes are vertical?		True	

Results of the Calculation				
Bite of the SG joint in case of windloads	[mm]		17.88	
Bite of the SG joint in case of unsupported panes	[mm]		0.00	
Bite of the silicone	[mm]	Σ	**17.90**	
Thickness of the silicone	[mm]		**6.00**	Calculated value 3.90 mm

			Comments or remarks
3.25			
2200			
2500			
14			
0			
Standard SG			
20			
80			
55			Aluminum
True / False			
True			
True			
25.54			
0.00			
25.60			
8.60			Calculated value 3.90 mm

STRUCTURAL SEALANT GLAZING
TORRE PUIG, BARCELONA

- Architect: Rafael Moneo
- Facade: Permasteelisa Spain

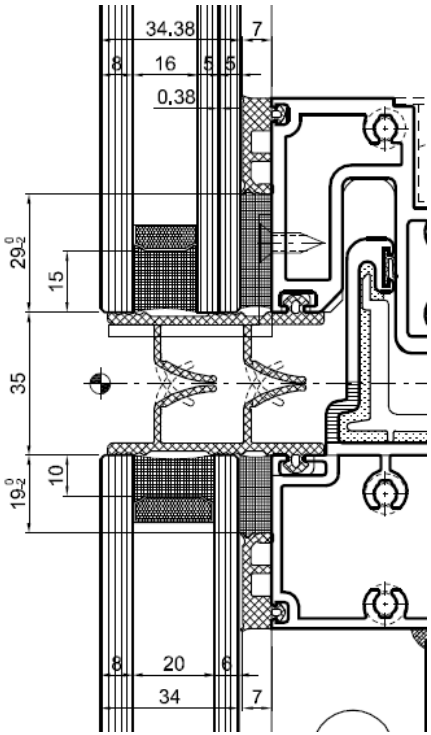
- Height: 109 m, 22 floors
- 20.000 m^2 of double skin facade

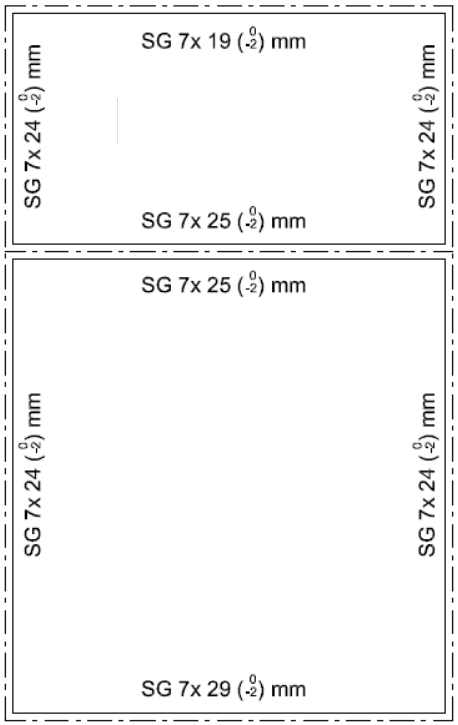
- Construction Phase:
  July 2012 –August 2013

- High Strength SG Silicone:
  glass-metal bonding
- High Strength IG Sealant:
  insulating glass

STRUCTURAL SEALANT GLAZING
TORRE PUIG, BARCELONA

- High wind loads (2.0 => 3.1 kPa)
- Big elements (2.7m x 2.7m)
- Joint shape limited by the aluminum system (predefined by architect)





STRUCTURAL SEALANT GLAZING
ADVANTAGES OF A HIGH STRENGTH SILICONE

Increasing the capacity

- Carrying higher loads and bigger glass units while using standard joint shapes and curtain walling systems

Saving material and increase transparency

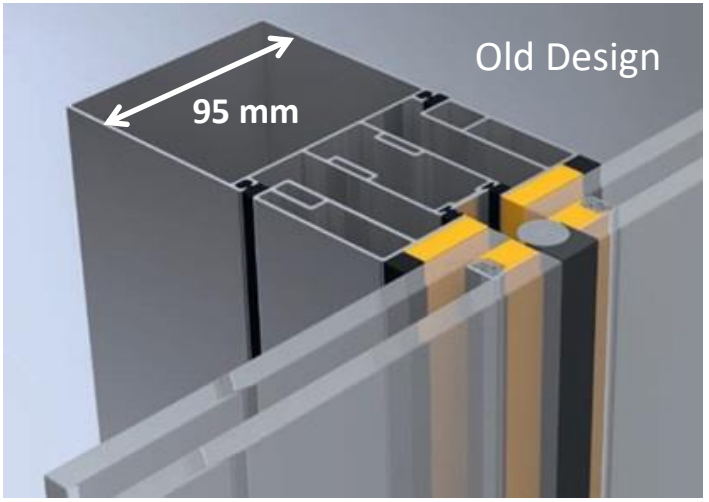
- Reduction of joint dimensions and supporting structure,
- 30% reduction in frame width
  => 10% aluminum mass

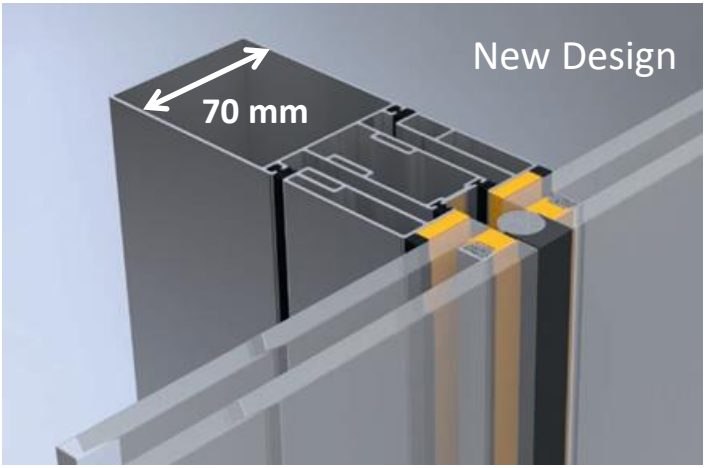
High safety level

- No compromise on safety

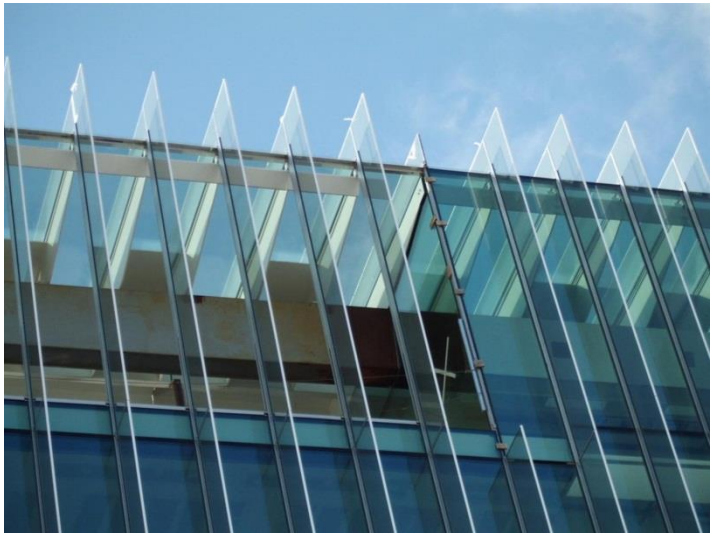
Replacing / Reducing mechanical devices

- Expanding feasibility and acceptance of bonded structures



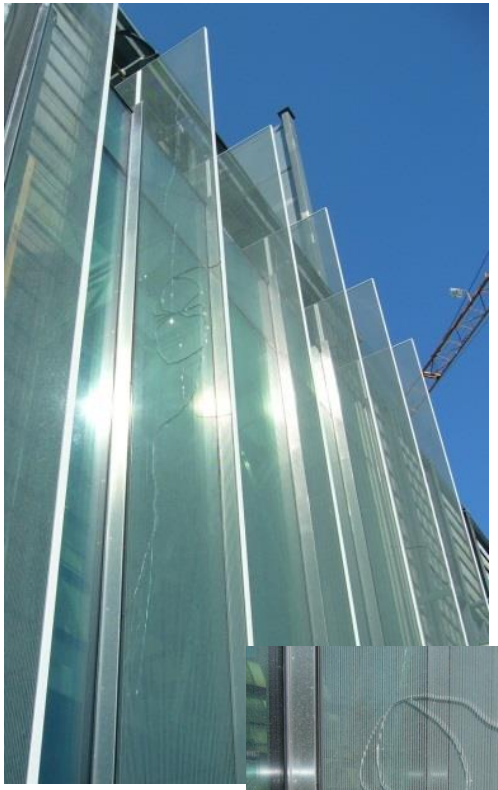


STRUCTURAL SEALANT GLAZING
NOVARTIS, NJ USA



- Facade area: app. 7.000 m²
- Fin spacing: app. 0.93m
- Glass fin for stiffening the mullions
- Longest Glass Fin = 9m

STRUCTURAL SEALANT GLAZING
NOVARTIS, NJ USA



Performance mock-up

STRUCTURAL SEALANT GLAZING
NOVARTIS, NJ USA

- Switzerland: Corporate Technical Service & Global Key Account Management
- Germany: Engineering and Mock-up
- China: Application of adhesive joints
- USA: Installation

INSULATING GLAZING

INSULATING GLAZING
COMPONENTS IN IG DUAL SEAL SYSTEM

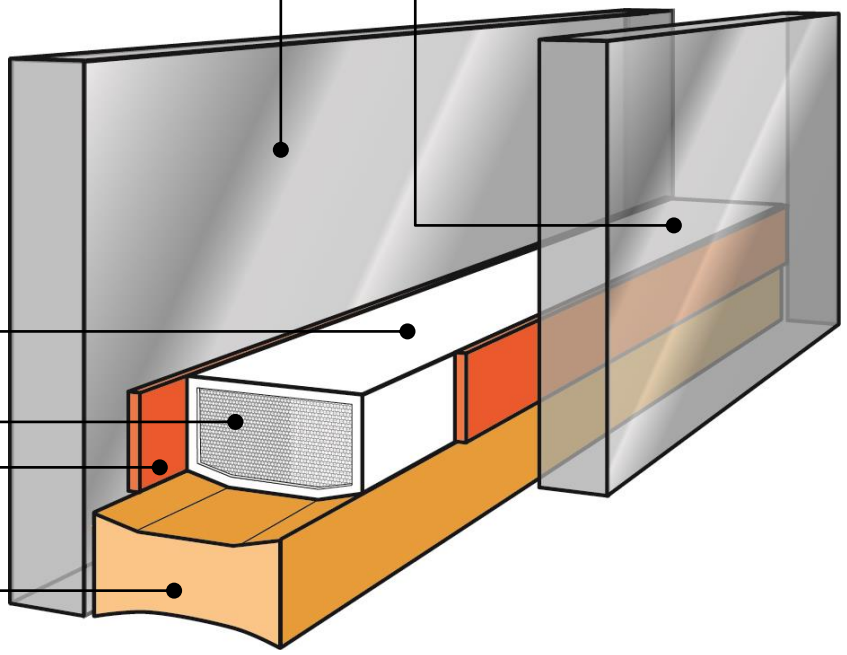
Glass panes
- Coatings
- Edge deleted bonding surfaces

Spacer
- Keeps glasses at distance
- Gas barrier

Desiccant

Primary seal
- Polyisobutylen (PIB)
- Prevents vapor penetration and argon losses

Secondary seal
- Keeps glasses together
- Protects primary seal
- Prevents vapor penetration



INSULATING GLAZING IG
UV RESISTANT SECONDARY SEAL

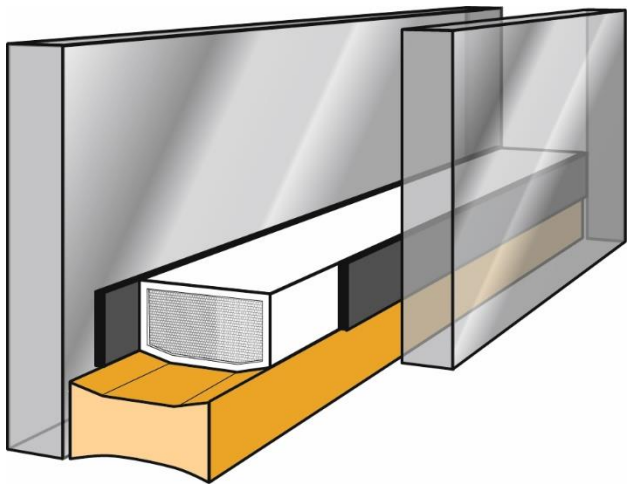
Standard Silicone

- 1-part silicone
- Manual or machine application

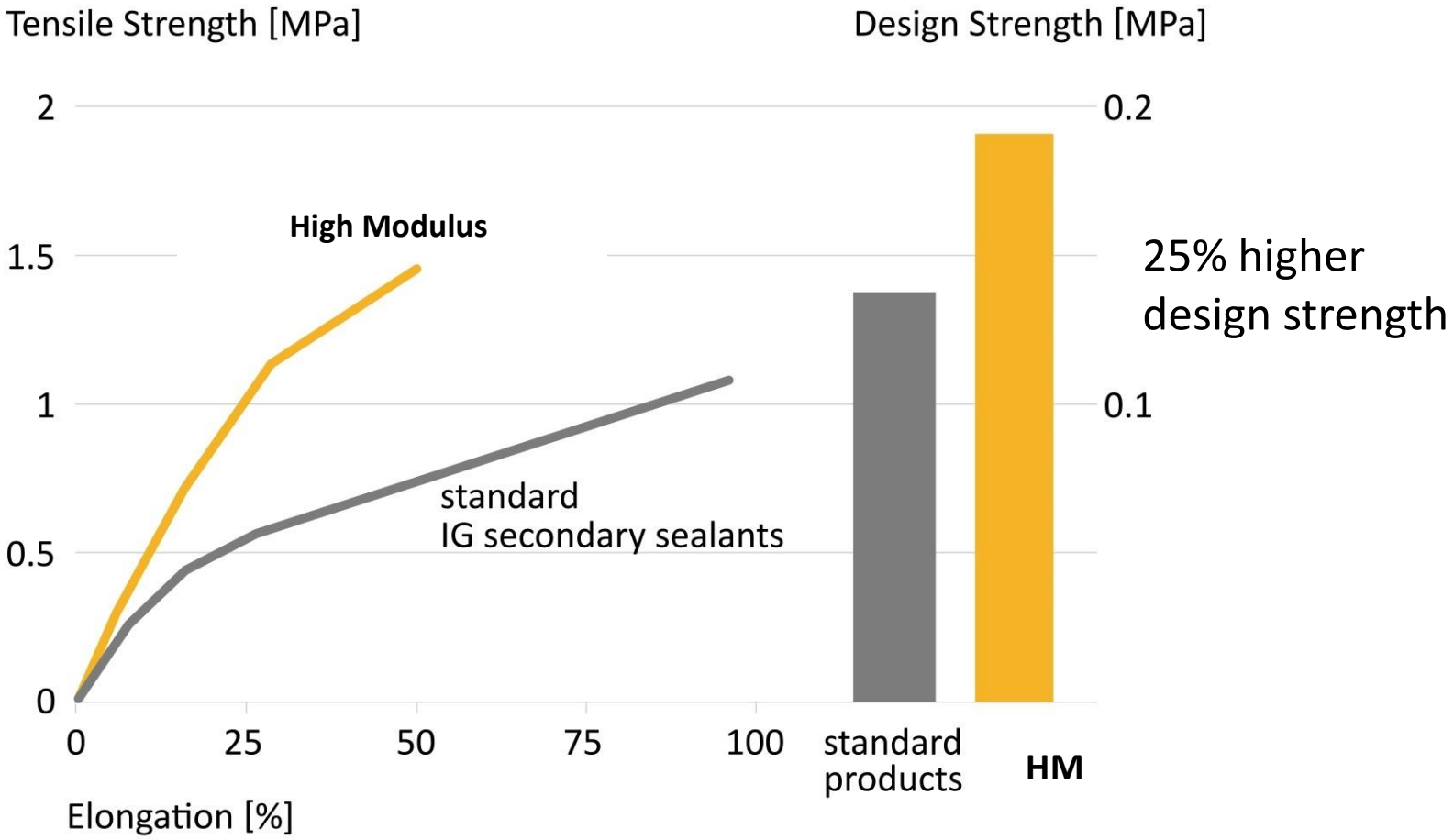
- 2-part silicone
- Machine application, automatic IG-Lines

High-modulus Silicone

- 2-part silicone
- Machine application/automatic IG-Lines
- 25% higher mechanical strengths



INSULATING GLAZING
HIGH-MODULUS SILICONES

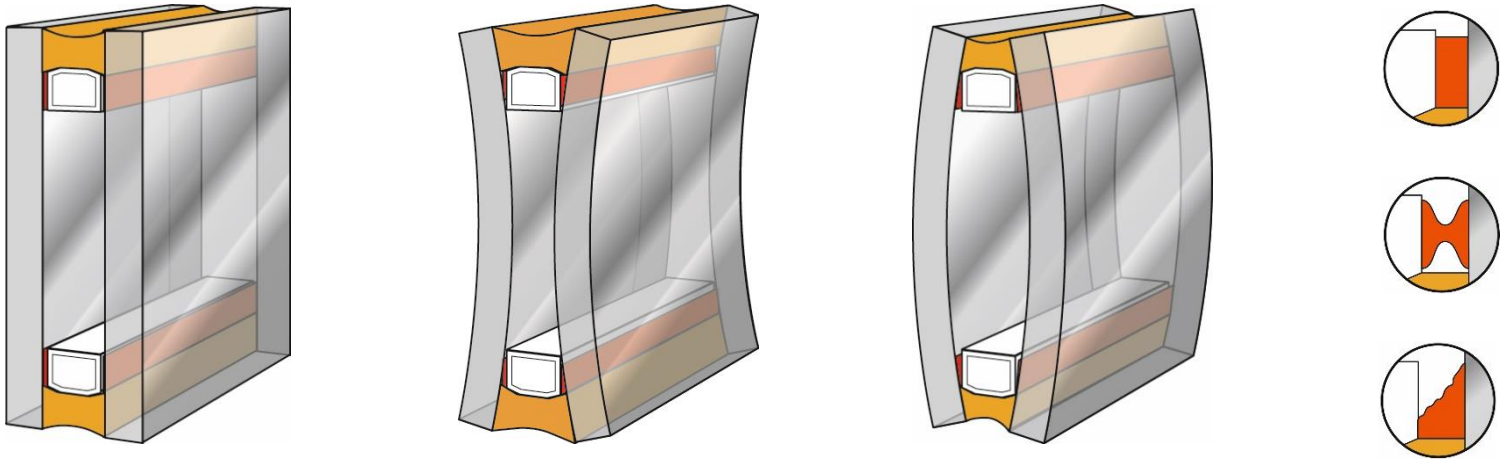


INSULATING GLAZING
GAS-FILLED UNITS WITH SILICONE

High Strength Silicones

Ultra-high modulus (HM) silicone sealant as secondary edge seal to prevent gas leaking through primary seal. Three times lower argon penetration than standard silicones

→ Stress reduction at primary seal
→ Low gas loss rates (0.3 - 0.6 %/year, compl. EN 1279-3)



INSULATING GLAZING

HIGH MODULUS – BENEFITS

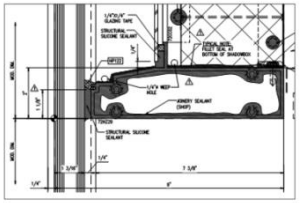
Please fill in the parameters			Comments or remarks
Maximum expected wind load	[kN/m²]	2.00	
Glass width	[mm]	2200	
Glass height	[mm]	2500	
Total thickness of outer pane 1	[mm]	8	
Total thickness of outer pane 2	[mm]	0	
Total thickness of inner pane 1	[mm]	6	
Total thickness of inner pane 2	[mm]	0	
β		1.00	
Space between inner and outer pane	[mm]	16	
Which sealant is used?	Sikasil®	High Modulus	
Outer panes are deadload supported?		True	
Glass panes are vertical?		True	
Climatic load Δp_0	[kN/m²]	18	
Thickness of IG unit secondary seal			
Silicone seal height of the IG unit in case of EOTA ETAG 002 (windloads)	[mm]	**11.58**	
Silicone seal height of the IG unit in case of climatic loads	[mm]	**0.31**	
Silicone seal height of the IG unit in case of unsupported outer pane	[mm]	**glass must be supported**	
Minimum Thickness **"C"** of the IG unit secondary seal	[mm]	Σ **11.89**	Reduction > 25%

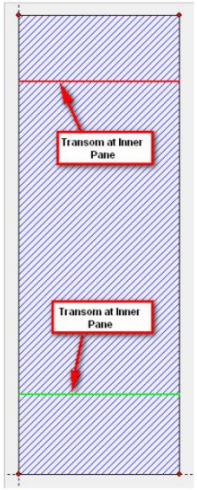
	Comments or remarks
2.00	
2200	
2500	
8	
0	
6	
0	
1.00	
16	
Standard IG	
True	
True	
18	
15.72	
0.41	
glass must be supported	
Σ **16.14**	

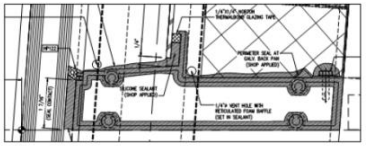
INSULATING GLAZING
HUDSON YARDS, NEW YORK

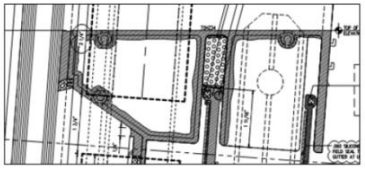
- Kohn Pederson Fox Associates / SOM Skidmore, Owings & Merrill
- Height: 273 m (895 feet)
- 160 000 sqm SSG Facade

INSULATING GLAZING
HUDSON YARDS, NEW YORK









CONDITIONS

- Standard unit: 1500 mm x 4100 mm
- Bigger unit: 2650 mm x 4500 mm
- Glass configuration: 10 / 12 / 8 [mm]
- 4-sided structurally bonded
- Inner lite additionally bonded to one or two intermediate transoms

WIND LOADING

- Up to -5.8 kPa (-121 psf)

ISOCHORIC PRESSURE

- p_0 = 16.6 kPa ($\Delta T_{cavity} \leq 50K$; $\Delta p_{atm} \leq 2.0$ kPa; $\Delta H_{altitude} \leq -200$ m)

INSULATING GLAZING
HUDSON YARDS, NEW YORK

Method of calculation	Type WT01 SSG bonded transom 2817mm from bottom edge 1460mm x 4069mm 10 / 12 / 8 wind load: -5.794kPa p_0 = 16.6kPa	Type WT02 SSG bonded transoms 711mm and 3518mm from bottom edge 2292mm x 4112mm 10 / 12 / 8 wind load: -4.692kPa p_0 = 16.6kPa
Standard method, only 4-sided, standard sealant	32mm	39mm
Feldmeier, only 4-sided, standard sealant	21mm	26mm
Feldmeier, only 4-sided, High Modulus	16mm	19mm
FEA calculation incl. intermediate transoms, High Modulus	**12mm**	**9mm** applied: 12mm

Feldmeier, F.: Insulating Units Exposed to Wind and Weather – Load Sharing and Internal Loads, GPD Glass Processing Days, Tampere, pp. 633-636, 2003.

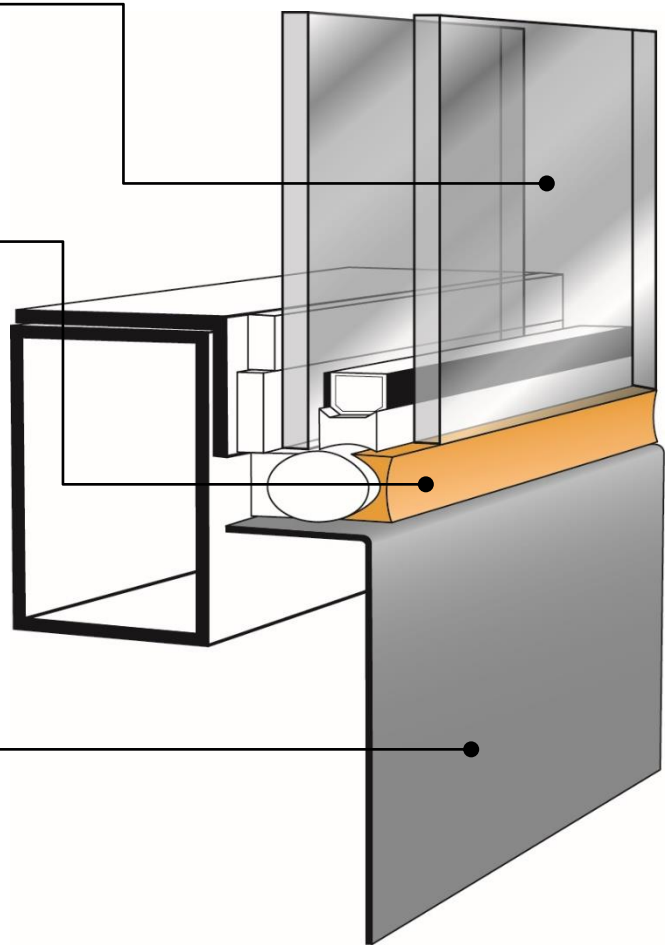
WEATHER SEALING

WEATHER SEALING
DETAILS

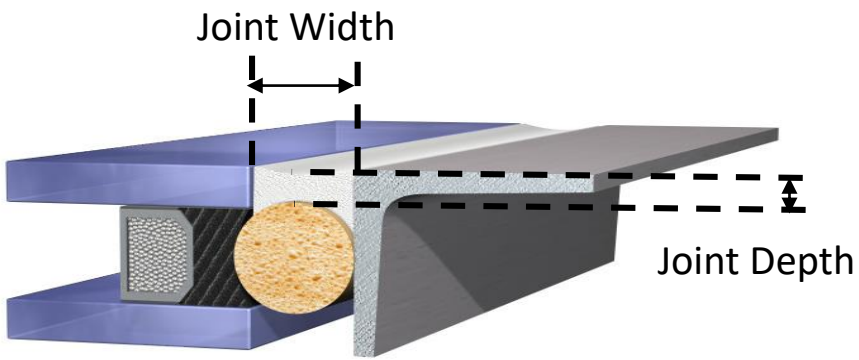
Glass unit
- Single, double or triple glazed

Weather sealant
- Appearance
- Weather proofing
- Movement accommodation

Opaque panel
- Composite
- Metal
- Natural stone
- HPL



WEATHER SEALING
DESIGN RULES



- Prevent adhesion on three surfaces
- Optimum ratio of joint width to joint depth is between 2:1 (for smaller joints) and 4:1 (for bigger joints)
- Minimum joint depth: 6 mm (proper section of sealant / adhesion area)
- Maximum joint depth: 15 mm (complete curing of 1-part silicone)
- Joint width to be designed according to expected movement and movement capability of sealant
- Application temperature: +5 to +40°C

➔ Compatibility with the edge sealing system must be ensured!

WEATHER SEALING
CALCULATION JOINT WIDTH

SEALING JOINT, NORMAL MOVEMENT

$$\text{Joint width} = \frac{\text{Expected elongation or compression [mm]}}{\text{Movement capability of the sealant [\%]}}$$

$$\text{Joint width} = \frac{\textbf{5 mm} \text{ (tension)}}{\textbf{0.25} \text{ (}\pm\text{25 \% Movement capability)}} = \textbf{20 mm}$$

WEATHER SEALING
CALCULATION JOINT WIDTH

$$\text{Joint width} = \frac{\text{expected shear movement [mm]}}{\sqrt{2c + c^2}}$$

c = Movement capability sealant [%]

$$\text{Joint width} = \frac{\mathbf{15mm}}{\sqrt{2*\mathbf{0.25} + \mathbf{0.25}^2}} = \mathbf{20mm}$$

c = 0.25 (±25% Movement capability sealant)

STRUCTURAL SEALANT GLAZING - TECHNICAL SERVICE

TECHNICAL SERVICE
TYPICAL PROJECT PROCEDURE

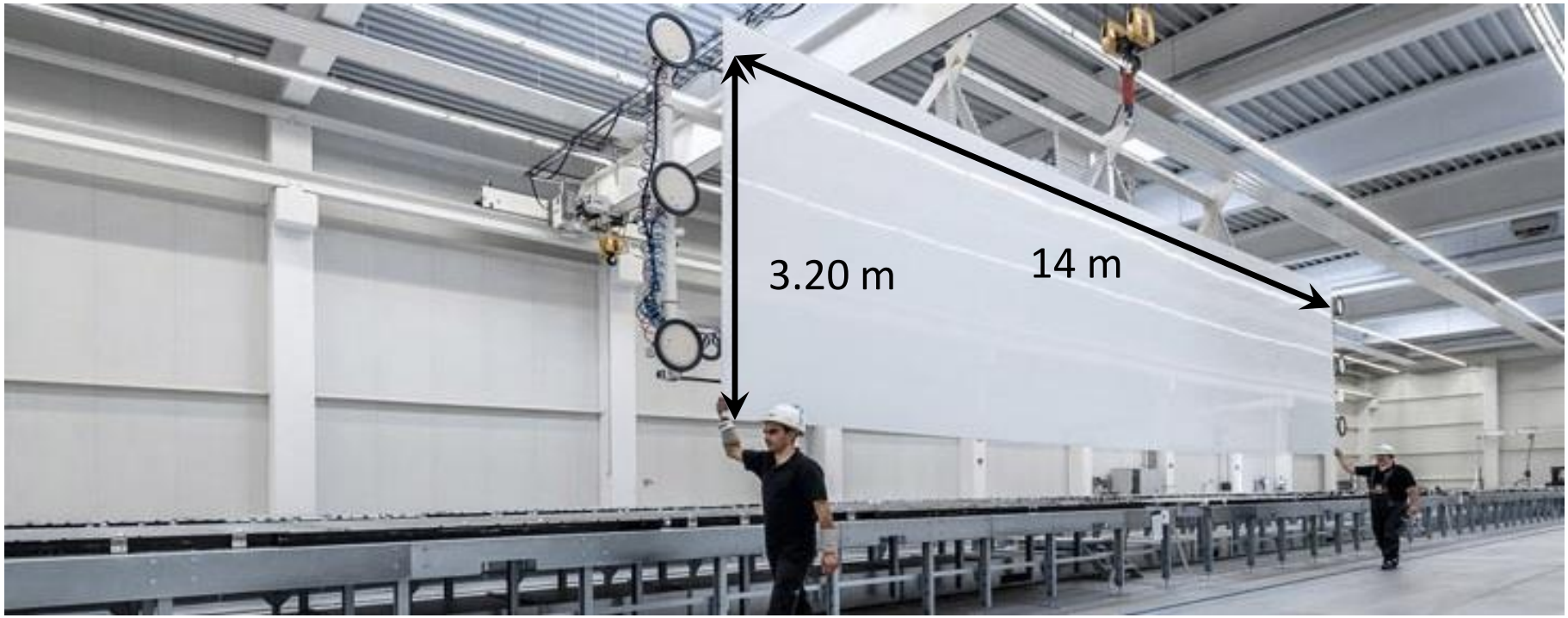
1. Design Phase	2. Test Phase	3. Application Phase	4. Warranties
Project request; Drawing submission	Sample; Submission & description	Training on product application and QC	QC Documentation
Design review; joint calculation; product recommend.	Sample testing; lab report; recommendation cleaning/pre-treatment	Application; Quality control	Warranties

Responsibility of:

Customer

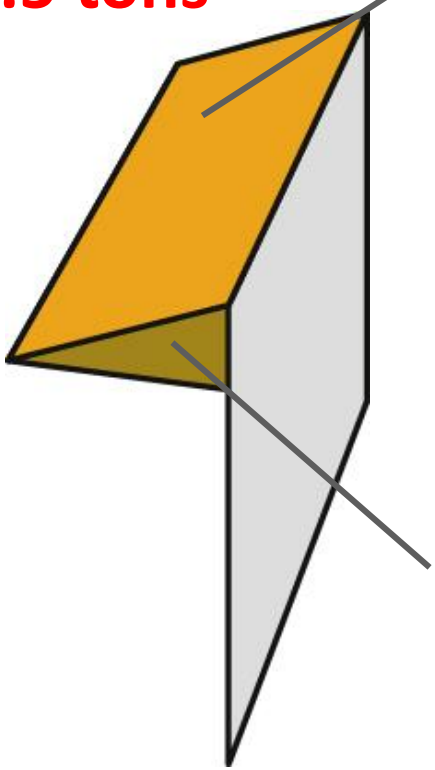
Supplier

WHAT'S NEW IN GLASS BONDING ??



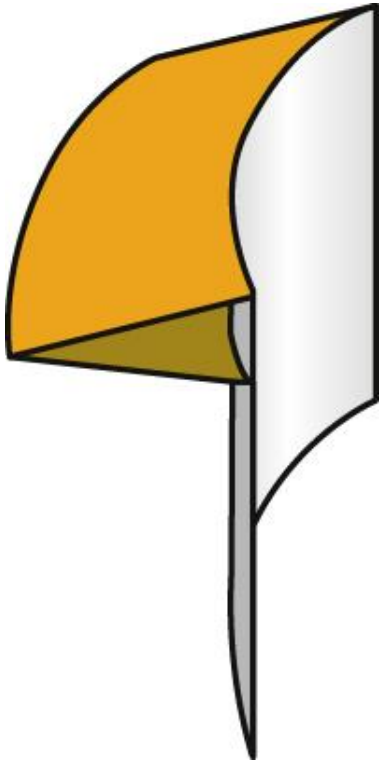
USE AS SUN SHADES
SLOPED & OVERHEAD APPLICATION

Σ 5.5 tons

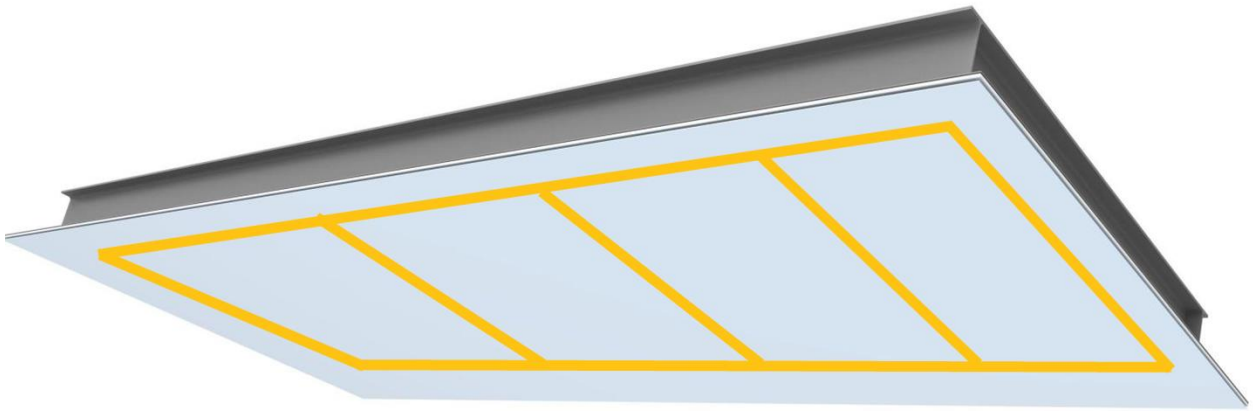


Lying on subcontruction

Hanging overhead
at subcontruction



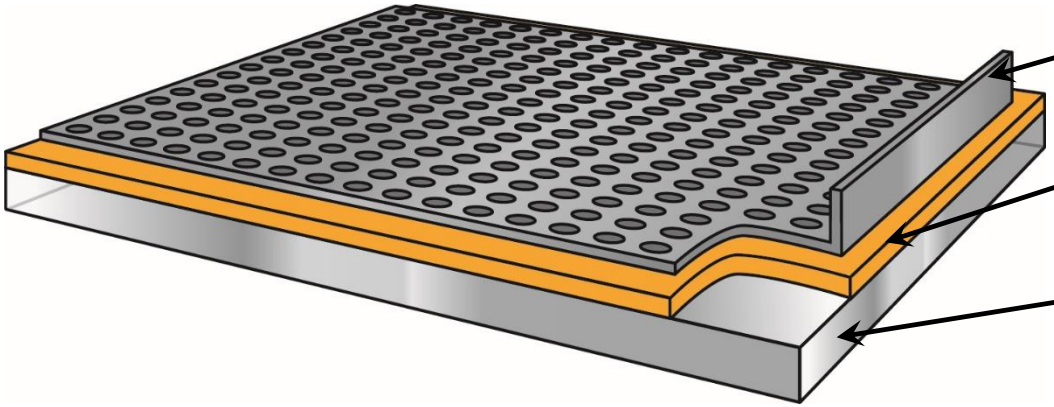
LINEAR BONDED FRAME FIXATION



- Number of additional bond lines with Standard SG adhesive:
  ➔ 22 lines (every 70 cm = 2.3 feet)
- Number of additional bond lines with high-strength SG adhesive:
  ➔ 14 lines (every 100 cm = 3.2 feet)

- Automated production (65’000 m^2) ???

ALTERNATIVE
LAMINAR SILICONE BONDING



LAMINAR SILICONE BONDING
DEVELOPMENT

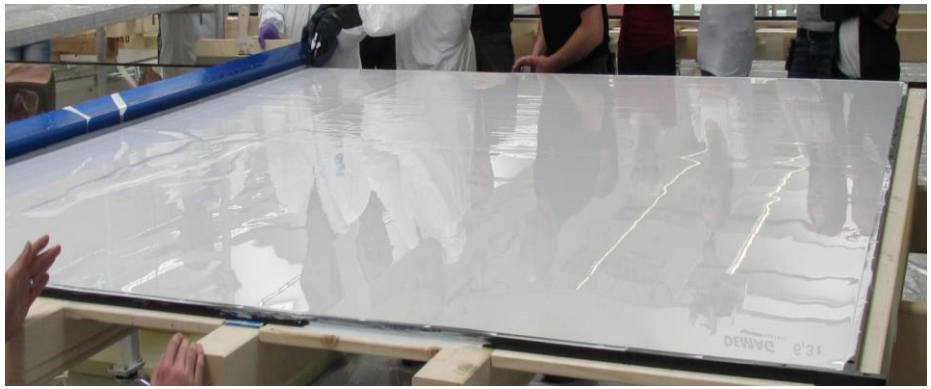
APPLICATION REQUIREMENTS

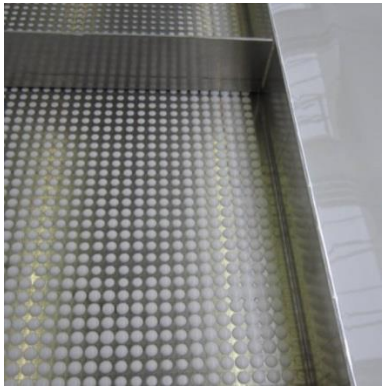
- Laminar and bubble-free
- Fluid and self-levelling
- Uniformly adjustable to a specific thickness
- High output and fast vulcanization

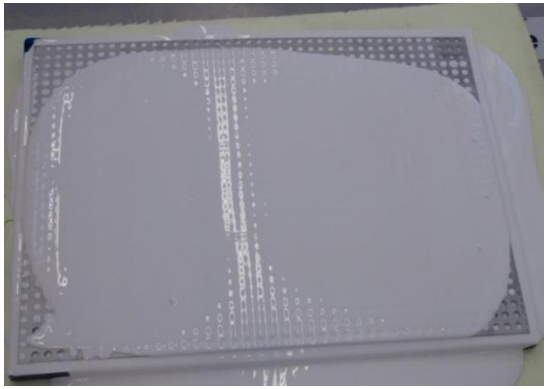
QUALITY ASSURANCE

- Control of proper contact / wetting
- Release of air bubbles and reaction by-products

  → uniform curing







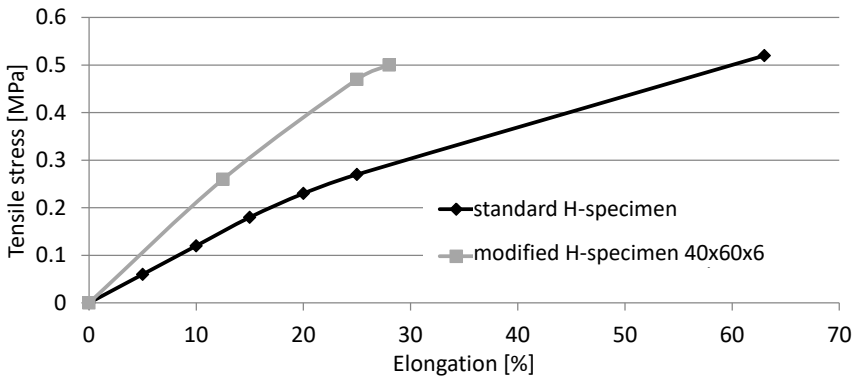
LAMINAR SILICONE BONDING
SAFETY

MECHANICAL PROPERTIES

- Laminar application instead of four sided linear SSG
- Modulus and failure mode for a laminar joint
- Long-term performance according to ETAG 002 and ASTM C 1184

POST-BREAKAGE BEHAVIOR

- 64h after glass breakage at dead load and after application of additional dynamic loading
- After cutting the intermediate silicone joints between the aluminum trays



LAMINAR SILICONE BONDING
PRODUCTION

MANUAL MOCK-UP PRODUCTION

- Simulation of production layout

PROCESS EVOLUTION

LAMINAR SILICONE BONDING
PRODUCTION

SEMI-AUTOMATED LINE PRODUCTION

- Fully automated silicone application

Photos: René Müller Photographie/sedak

PROCESS EVOLUTION

LAMINAR SILICONE BONDING
ACHIEVEMENTS

SAVINGS IN WEIGHT, ENERGY AND RESOURCES

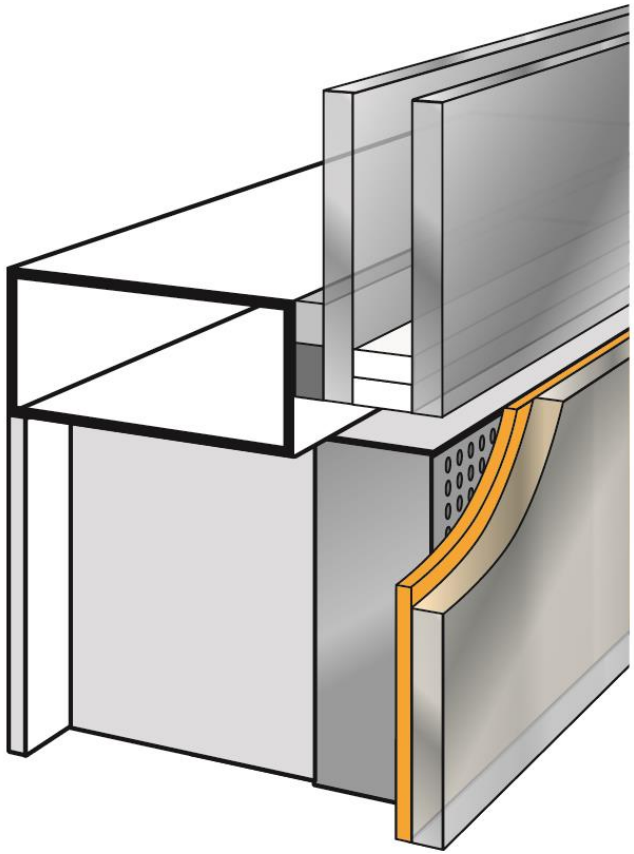
- One single glass pane (10 mm, 1860 kg) replaces heavy laminated glass units (2x 12 mm, 2760 kg) ➔ 30 % weight reduction
- No interlayer, no lamination process
- Tempering and ceramic screen print not mandatory
- No glass fittings, no bore holes
- Weathering and temperature resistant silicone adhesive
- Application concept for serial line production realized
- Flexible application for varying dimensions or shapes
- Experience in engineering

- Mega reference project under construction

LAMINAR SILICONE BONDING
OPPORTUNITIES: INTERIOR WALL PANELS

LAMINAR SILICONE BONDING
PROSPECTS: SPANDREL PANEL / SHADOW BOX

- Valuable cover of the metal box
- Temperature and weathering resistant bonding
- Process integration



LAMINAR SILICONE BONDING
OPPORTUNITIES: SPANDREL PANELS

LEARNING OBJECTIVES

- A basic review of industry definitions and facade, Insulated Glass and Weatherseal components.

- Present several examples of the application of innovative materials to meet the design and efficiency requirements specified within the Architectural community.

- Learn about typical project processes in the design, testing, validation and production of a curtain wall.

GLASS BONDING IS OUR PASSION

THANK YOU! THIS CONCLUDES THE AIA CONTINUING EDUCATION SYSTEMS COURSE