The Trend of High-Performance Construction Glass Usage - Silicone Crystal Clear Bonding Technology (TSSA & TSSL & HM2400)

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ZAK World Of Façade, Hong Kong Conference
Architectural Trends

• Maximize Façade Vision Effect through larger Glass Panel used, Linear or Point Fix Glazing Design & Structural Silicone Bonding >50 Years (SSG)
Shaping the façades of world cities with **silicone** technologies
Unmet need and Critical Customer Requirement

Clear silicone solutions for structural bonding, secondary sealing and weathersealing in the spirit of engineered transparency

Aesthetics/transparency combined with structural performance requirements and durability to assure 50 years life on construction façades

ICE Kraków, Photo: G Ziemianski

Photo Scagliola/Brakkee/ NeutelingsRiedijk Architects (The MAS City History Museum of Antwerp (Belgium))

Consumer Solutions
Unmet need and Critical Customer Requirement

‘Soft’ transfer of the load into the glass pane → avoiding stress peaks

no visibility from the exterior → aesthetics, sleek façade
Point Bonded Gas-Filled Insulating Glass

Gas-filled double and triple IGU

→ No drilling, no gaskets
→ No gas loss
→ No breaching of IG cavity

Designing office UltraCAD

Bilfinger & Berger, Germany

Consumer Solutions
Transparent Structural Silicone ADHESIVE (TSSA)

- Silicone film adhesive - 1mm thick film
- Simple application – 50mm-100mm, die-cut buttons
- Multiple layers, if required
- High transparency, crystal clear
- Strong adhesion performance
- High performance silicone durability
- Removable by cutting
- High design strength
  - 1.3 MPa Dynamic design strength
  - 0.6 MPa static design strength

12 button per case (1 is free for QA check use), 20 cards in 1 carton box

Coolers & Temperature recorder Included in carton box.

TSSA Case – Dow Europe S&T Office Building in Belgium
TSSA - Cure Behavior

- **One-part** material
- **Heat-activated addition-cure**
- **No cure by-products** (and no odor) are evolved during the reaction.
- Film adhesive is cured at temperatures of 120-130°C for a period of ~30 minutes while applying a pressure (0.15-1.3 MPa/ 22-128 psi).
- Optimum cure conditions are achieved in an autoclave.
Determine where to apply the buttons and marked with proper tool
TSSA – Application

Surface cleaning on both glass and stainless steel buttons
Position buttons & pre-apply pressure
TSSA – Application

Ideally pre-define pressure for perfect surface wetting
Cure in autoclave with the use of vacuum bag to reduce air bubbles
TSSA – Application

QA load test on each bonded buttons

Exhibits a cohesive failure on tempered and heat strengthened glass.

Consumer Solutions
TSSA - Long term durability:

- High durability under high temperature and humidity,
- Also under outdoor exposure and accelerated ageing
TSSA - Creep and failure under permanent load (tension):

- Point fixation 20mm under permanent tension load of 20kg and 40kg (1.25MPa and 0.62MPa)

- No creep could be measured
TSSA - Creep and failure under permanent load (shear):

- 20mm point fixation under permanent shear load with 0.6 to 3.4MPa

- Measuring time to failure:
  - 2.6 MPa: 5 – 6 hours
  - 2.0 MPa: 4 – 24 hours
  - 1.7 MPa: 34-126 days
  - < 1.7 MPa: no failure
TSSA - Time to failure under permanent load:

- For permanent loads below 1.1 MPa service life will be more than 30 years.

Function:

\[ \sigma_{\text{creep}} = A t_{\text{fail}}^B \]

where \( y = 2.1611x^{-0.964} \) and \( R^2 = 0.9269 \).
TSSA - SAFETY INSIDE...Installation of point fixed units

- TSSA turns white, when reaching max. stress level (12.5 vs 22.6 MPa)
- Reversible – turns crystal clear again, when stress released
- Indicates immediately if stress exceeded

→ Establish Installation Guideline considering
  → All relevant installation parameters
  → No permanent torque during installation
TSSA – Finite Element Modelling

- FEA analysis for a point fixation under eccentric shear load, stress in TSSA interlayer based on hyperelastic material law.
- “Crescent Moon” shaped whitening and cohesive failure pattern observed during full mock up test.
- Model simulated to both whitening and failure
  Load at whitening: 12.504 MPa
  Load at failure: 22.649 MPa
TSSA - Full Scale Mock Up Test

• Tested Glass Size: 1.8m x 3.6mx 15mm monolithic glass
• Glass had 6 x 50mm TSSA support in this PMU test
• Mock-up was tested at 0.5 kPa increments to failure (3.7 kPa)
  - Material experienced whitening at 2.0kPa load
  - Material experienced failure at middle button under 3.7kPa
TSSA – Project Reference

Airborne America skydiving tunnels, San Diego, CA, USA
Airborne America skydiving tunnels, San Diego, CA, USA
TSSA – Project Reference

JR-Tsudanuma Station South Gate Skylight For Lift, Japan
TSSA – Project Reference

Suginami Special Welfare Koonji Office, Japan
TSSA – Project Reference

PressGlass Factory Varazhdin, Croatia
Transparent Structural Silicone Laminates (TSSL)

- Silicone film adhesive - 1mm thick film
- Supplied in a cooled container on a roll in different lengths (1-20m), width:180mm
- Multiple layers, if required
- High transparency, crystal clear
- Strong adhesion performance
- High performance silicone durability
- Removable by cutting
- High design strength
  - 1.0 MPa Dynamic design strength
  - 0.6 MPa static design strength

For Glass Stair Connection
For Glass Railing Bonding

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TSSL - Crystal Clear FUN

Vidre Slide, Cricursa and EOC
Transparent Structural Sealant 2400

- For interior and exterior applications
- High transparency, crystal clear
- Linear bonding
- Strength
  - Primerless adhesion
  - High initial tack
  - 0.14 MPa dynamic design strength
  - 8,000 Pa static design strength
  - 50% movement capability
2400 - Optically Clear

Transparency data after aging. Human eye’s visible range are between 380-780nm

UA340 exposure 10,000hrs test shown no yellowing.
2400 - Cure Behavior and Initial Tack

- Hotmelt, 130°C
- 1p, moisture-activated condensation cure
- Neutral cure, methanol as by-product
- VOC < 15 g/L

\[
2\text{Si(OR)} + \text{H}_2\text{O} \xrightarrow{\text{catalyst}} \text{SiOSi} + 2\text{ROH}
\]

- Pulling speed: 6mm/min
- glass-glass H-pieces
  (12 x 3 x 50 mm3)
2400 - Green Strength Build Up

Time = 0
Dispensed onto
883-gram granite slab
(8.66 N)

Time = 10 s
Polycarbonate coupon
5.6 \times 25.4 = 142 \text{ mm}^2
adhered to granite slab

Time = 20 s
Assembly lifted off
8.66 N \div 142 \text{ mm}^2 =
0.06 \text{ MPa (8.7 psi)}

One-part structural sealant green strength is 300Pa

HM2400 green strength up to 10,000Pa
Dynamic Load Resistance

<table>
<thead>
<tr>
<th>Tension</th>
<th>Max tension (MPa)</th>
<th>Elongation at break (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4W RT</td>
<td>1.02</td>
<td>400</td>
</tr>
</tbody>
</table>

1.0MPa Safety Factor of 6 → 0.16MPa

Dynamic design strength = 0.14MPa
Static Load Resistance

• Lap shear 15*30*2mm
• 4 weeks cure
• Climatic chamber at 60°C and 85% relative humidity under permanent stress and Max stress applied on the material:
  • 33,000Pa: more than 110 days, no movement
33,000 Pa with a Safety Factor of 4

Static design strength = 8000Pa
## 2400 - Durability

<table>
<thead>
<tr>
<th>Sample</th>
<th>Maximum tensile (MPA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4W/RT (reference)</td>
<td>1.02</td>
</tr>
<tr>
<td>UV exposure</td>
<td></td>
</tr>
<tr>
<td>4W/RT + UV 10000hr</td>
<td>0.99</td>
</tr>
<tr>
<td>Hot water immersion</td>
<td></td>
</tr>
<tr>
<td>4WRT 6W/H20 45°C</td>
<td>1.15</td>
</tr>
<tr>
<td>4WRT 3W/H20 55°C</td>
<td>1.13</td>
</tr>
</tbody>
</table>

Hurricane testing (ASTM E1886)
- Passed 9000 cycles at ±3.8kPa
2400- Crystal Clear Structural Glass Connections
HM2400 has better WVTR than conventional structural sealant (15~30% improvement)
Crystal Clear Bonding Technology

**TSSA**
- Point fixing, EXTERIOR Application
- Glass-Metal
- Bundled Services: Blueprint, Testing, Calculation, Start-up, QB, warranty
- Strength: $\delta_{DYN}=1.3$ MPa, $\tau_{Stat}=0.6$ MPa

**TSSL**
- Point or other geometries, INTERIOR & EXTERIOR Application
- Glass-Glass or Glass-Steel
- Bundled Services: Start-up, QB, Warranty
- Strength: $\delta_{DYN}=1.0$MPa, $\tau_{Stat}=0.6$MPa

**2400**
- Structural and assembly adhesive, INTERIOR & EXTERIOR
- Various substrates
- Bundled Services: Blueprint, Calculation, Start-up, QB, warranty
- Strength: $\delta_{DYN}=0.14$MPa, $\tau_{Stat}=8000$Pa
Dow Corning Became 100% Dow Chemical Subsidiary in 2016 and merged into Dow Chemical in Feb 2018

Dow Corning® Products Rebrand to DOWSIL™

DOWSIL™ 2400
DOWSIL™ TSSA
DOWSIL™ TSSL
DOWSIL™ 795
DOWSIL™ 983
DOWSIL™ 791

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Consumer Solutions
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