Euridice Feluy, Belgium
Crystal clear bonding
Point fixed structural glazing with Dow Corning ™TSSA

Imagine... Design Freedom Structural Glazing & High Performance Building

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Design freedom enables architects to realize their vision. Highest possible buildings, filigree construction, slim designs, specific shapes, high transparency, maximum light transmission, large glass areas, colour – all these elements can be limited by increasingly stringent technical requirements. Global warming and climatic changes drive efforts to reduce CO_2 emissions and promote consideration of energy efficiency, sustainability, life cycle analysis and embodied energy.

Durability is assumed to be a given along the whole life cycle of a building whereas extremes in temperature, wind, earthquakes, safety precautions and others challenge the ability of architects to exercise creativity.

Structural glazing is a proven and established technology which has been available for more than 45 years. Structural silicones help address these technical challenges, enable high performance buildings and provide... Design Freedom.

Ultimate Design Elements - Transparency, Shape & Colour

If architects were to define "design freedom", ultimate transparency, almost invisible sub construction, ultimate shape and colour flexibility would likely be mentioned.

Capital Gate in Abu Dhabi is just one example where pure design is combined with high technical functionality.

With a facade constructed from 23,000 square meters of glass and steel, the iconic Capital Gate is the world's most inclined high rise building. It has 35 storeys, is 160m tall and is the centerpiece of the business and residential Capital Centre development.

The tower leans 18 degrees westward which is 14 degrees more than the Leaning Tower of Pisa. With floor plates that are staggered from the 10th floor up, the building leans and twists like a corkscrew as it reaches skywards, creating an image which looks different from every direction.

Apart from Building Design, technical requirements and complexity is becoming more and more important. The Infrax Building (Picture 2) impressively combines both leading to a structural bonding design without mechanical retention. The construction of

NFRAX, Tournhout, Belgium
Design & Peformance.
Coloured double-skin facade
Structurally glazed with Dow Corning ™993 - No mechanical retention

Princess Elisabeth Station
Extreme Performance Dow Corning ™3362 structural sealant for insulating glass at -50°C

an office, warehouse and storage facility with important features of sustainability and low energy consumption was commissioned by the West-Flanders Energy Company. Covering 4800 m^2, the building is configured on three levels and incorporates a double skin facade to provide high thermal insulation of the building shell and provide better acoustic insulation between the busy ring road and the offices.

The extensive use of glass provides maximum transparency and allows ample daylight to reach the building occupants whilst the windows are set well back in the intelligent façade to shield them from direct sun radiation.

Extraction and storage of energy from the soil through the use of a borehole energy storage field, combined with a high performance water pump powered by photovoltaic solar cells integrated in the facade is just one of the many sustainable characteristics of this remarkable structure. This provides low temperature heating during the winter months.

This sustainable and energy efficient design required fixation of the thermally efficient insulating glass units in the ceiling and serigraphic glass panels on the external skin of the building facade.

In order to permit such design versatility, it was necessary to take into consideration the weight limitations of the curtain wall and roofing structure when selecting the method of fixation, whilst ensuring that the final aesthetic appearance of the building remained within the architects' original vision.

Capital Gate, Abu Dhabi
Design & Performance
Glass & Structural Silicones

Structural bonding technology enabled the glass to be attached without the use of mechanical retention, thereby reducing the overall weight and improving the appearance of the ceiling and facade. It is noteworthy and quite exceptional for a glazed ceiling to be attached purely through the use of a structural silicone without any other form of fixation.

This structural bond transfers the wind load to the supporting structure, withstanding tension, compression and differential thermal movement. It also provides outstanding longevity and low maintenance offering significant cost efficiency throughout the life cycle of a building.

Colour is a key design element which influences building aesthetics and its character. Specific colour requirements with regard to structural silicone components can be addressed.

Whereas black is the preferred colour, there is an increasing trend towards grey shades or even white. This colour choice supports design flexibility.

Brighter, Lighter & Sustainable

Increased glazed areas and reduced frame size are general trends which offer additional benefits:
From the outside one can enjoy pure glass aesthetic.

Pure glass aesthetics à Less thermal bridging (metallic façade penetration) à Improved energy efficiency

More glass à Higher transparency à More light, quality of life à Increased solar heat gain

Structural glazing enables sleek, flush façade designs and can contribute to energy efficiency. The increased solar heat gain can be advantageous in colder periods of the year (mainly spring and autumn), but it is clear that the advantages of solar heat gain of buildings in northern Europe compared to buildings in southern Europe may be completely different. Intelligent glass solutions incorporated into the insulating glass can address area specific requirements.

Sustainability is important with energy efficiency, durability and façade maintenance being key contributors. However, embedded energy levels of used building components

Burj Khalifa, Abu Dhabi
Extreme Performance
Windloads up to 7kPa and hot desert climate
Dow Corning ™993 Structural Silicone for long-term durability

are quite different and provide an opportunity for thought. A reduction in different material components used in a façade, can positively impact the equation of embedded energy. Whereas structural silicones represent less than ~0.5-1 percent of the total façade cost, other components like glass and metal contribute much more to the embedded energy level.

One way to improve overall sustainability could be to adjust the aspects of the metal sub construction. This requires specific system development and is typically determined long before the final decision for a structural glazing or mechanical design is taken.

Durability – Structural Silicones under extreme conditions

Durability of building components feels like a small detail and is often assumed to be a given. As the world's climate changes due to high carbon dioxide emissions, the conditions regarding wind and hurricane loads, temperature extremes etc. will become more stringent. Therefore, durability has an important, fundamental contribution to a sustainable, low maintenance and long lasting building.

There are two extremes impressively demonstrating durability of long-term proven structural glazing technology: The Princess Elisabeth Research Station and the Burj Khalifa Tower.

With the most extreme meteorological conditions known to man, air temperatures of -50°C to -5°C, and maximum wind speeds of 250 km/h, durability enters a new dimension. The Princess Elisabeth is the first ever 'zero emission' research station constructed in the Antarctic running entirely on renewable energy. The International Polar Foundation (IPF) and its technical partners have taken a pioneering step forward in the domain of sustainable development and in doing so, proved that if it is possible to construct such a building in the Antarctic, it is possible to do this anywhere in the world.

Durability and long-lasting performance was paramount. The window system is a double skin of insulating glass units with a 400mm space in between. The insulating glass units are composed of a triple insulating and laminated glass system that use Heat Mirror™ technology and high performance structural silicones.

By nature, the structural silicones selected are characterized by their high tensile and tear strength, long-term flexibility, resistance to harsh weather, temperature extremes and UV light. They became a perfect fit for helping the station reduce its ecological footprint through energy savings in Antarctica's fragile environment.

The other extreme is demonstrated by the world's tallest building, the Burj Khalifa. Here, the challenge was to specify products that can withstand the rigors of high temperature, UV light, seismic activity and inclement weather conditions. In addition, large areas of the curtain wall, which in total is equivalent in size to 17 soccer fields, are positioned at extreme height, which in turn, brings a new set of technical challenges. This iconic project has overcome the greatest of challenges and technical difficulties, not least of which are the wind forces dominating the structural design of the tower.

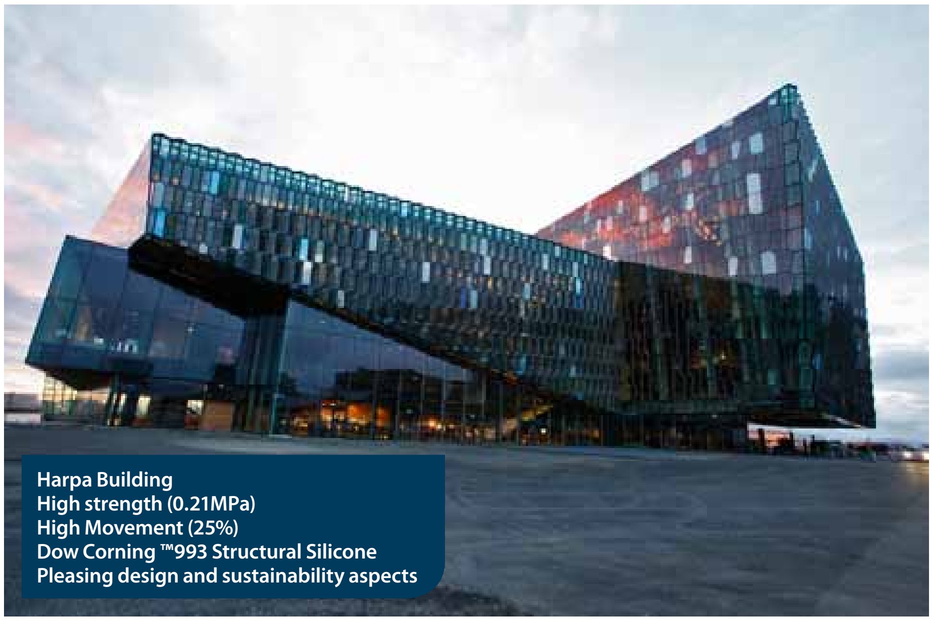
Whereas in Europe typical norms and standards state maximum wind loads of 2.6 to 3.0 kPa (Eurocode, DIN 1055, etc.), the Burj Khalifa was designed to withstand up to 7 kPa to cover weather extremes which might occur only once in 25 years. A total of 103,000 square meters of glass was used in the cladding panels. These advanced panels maximize resistance against heat transmission from the sun and save energy through the use of sophisticated engineering techniques which include high performance reflective glazing.

Air tightness of buildings is of increasing importance, as air infiltration negatively impacts the thermal efficiency of buildings. Therefore an air-tight façade skin is desirable throughout the life time of a building. Durability is important to ensure a sustainable and long lasting design. Extreme weather conditions around the world have a direct impact on technical capability and long-term functionality of enabling structural silicones and therefore the overall façade. Here again, silicones are the material of choice withstanding harshest weather conditions.

Energy Efficiency – Gas-filled Insulating Glass

Today, gas-filled insulating glass (IG) is state of the art. In structural glazing construction, the edge of an IG unit is typically exposed to temperature, sun and UV radiation.

Conventional organic secondary sealants are not long term UV stable and therefore not suitable in a UV and high temperature exposed environment. Structural silicone is tailor-made to resist these elements and is able to pass the EN 1279 for gas filled insulating glass. The gas loss rates are below the required limits and indicate long term durability. Calculated for a period of 25 years, there is still gas content above 80% in the insulating glass unit. Prime Tower in Zuerich is one of the most recent examples of triple IG in a modern structural glazing design providing low ug values.



Harpa Building
High strength (0.21MPa)
High Movement (25%)
Dow Corning ™993 Structural Silicone
Pleasing design and sustainability aspects

Flame Towers, Baku, Azerbaijan.
High Strength (0.21 MPa)
High Movement (25%)
Windloads up to 7.5 kPa, large glass units
Dow Corning ™993 Structural Silicone.
Supplied by Engineering & Facade Consultant Office Professor Sobek

Ultimate Structural Performance - High Strength versus Thermal Movement

From a design aspect, larger glass units are beneficial. Following this trend, structural silicones must accommodate this increase and withstand a range of dynamic loads including moderate to extreme weather conditions. Technically, there are two things to take into consideration:

Bigger glass units: Higher loads to be accommodated by the structural silicone
Bigger glass units: Increased thermal elongation between glass and frame to be accommodated by the structural sealant.

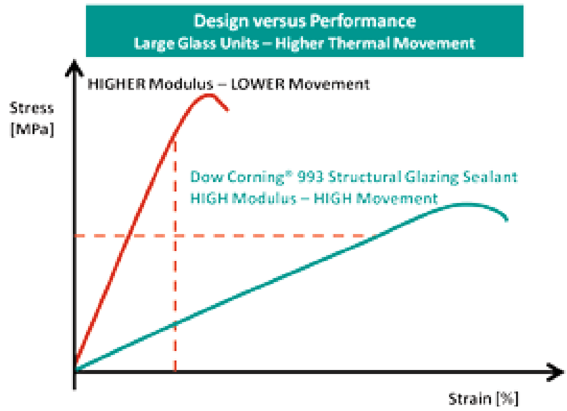
The first point could be addressed by a new technology development providing higher structural strength. However, if a structural silicone becomes stiffer, the movement capability is typically reduced.

Worst case examples are high strength bonding technologies like acrylates, which transfer extreme loads, but cannot accommodate significant movement, which would result in the failure of the façade element, i.e. glass breakage. There is a trade off between movement capability and structural capability. High strength sealants also show a significant increase in stress levels at the adhesion interface. This in combination with thermal movement needs consideration, as it can negatively impact adhesion durability.

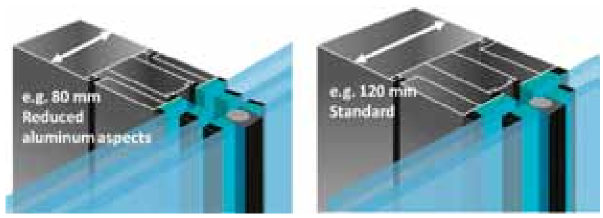
The Flame Towers, Baku as well as the Harpa Concert Hall in Iceland are interesting examples, where large unit sizes (1.5m x 3.5m) and high thermal movement are combined with extreme wind loads.

In the case of Baku Flame Towers, planned by the engineering and façade consulting office Prof. Sobek, wind loads up to 7.5 kPa have been considered, whereas the thermal movement under high temperature has been accommodated by the structural silicone (~25% movement capability for largest possible units

-one of the highest possible in the market). Structural joints have been calculated according to a specific finite element analysis with a significantly increased design value whilst using well established proven structural silicone technology (0.21 MPa, according to ETA) combined with its high movement capability. Of course, these examples may be extremes, but it impressively underlines what this proven technology is able to perform. Technical design flexibility enabled by high strength and high movement leads to design freedom for the architect.



Design versus Performance



Imagine... Filigree façade designs reducing aluminum aspects

New Generation of Crystal Clear Bonding

Crystal clear bonding has now become a reality with the latest development for structural bonding applications. In opposite to standard structural glazing (linear bonded), where movement capability plays an important role, in point fixed structural glazing applications it is less critical. Here, high strength is key. Combined with a crystal clear appearance, this opens new design opportunities for point fixed applications regarding aesthetics, structural designs and energy efficiency.

Dow Corning ® TSSA (Transparent Structural Silicone Adhesive) is a new generation crystal clear structural silicone specifically designed for point fixed facades. Used to bond the bolt fixing to the glass, it is capable of a design load which is 10 times higher than traditional structural glazing sealants.

This new technology enables sleek flush facades without interruption or breaching of any coloured inter layers. Compared to a conventional structural glazing silicone, the applicable loads are impressive: 15 tons for a "standard" SG - bolt fixing (e.g. 120mm) – instead of 1.5 tons. The bolt size can be significantly reduced for an almost invisible structural bond between glass and metal.

The first project in Belgium, Euridice has a façade design with double glazed gas filled insulating glass. A nice example combining high technical functionality with a different design.

Point fixed structural glazing is only one of many more applications where crystal clear bonding provides nice design benefits. There is room for thoughts – just imagine... Design Freedom.

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