White paper: Advanced engineering can unlock higher allowable stresses for structural glazing designs

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Dow's understanding of sealant behavior and advanced engineering analysis validate increases in allowable stress or sealant structural bonding strength

Introduction

Dow Building Science has a long history of innovation and exceptional success with the worldwide application of structural silicone glazing (SSG) for building façades. In 2021, the company marked the 50-year anniversary of the first four-sided SSG application, located in Detroit, Michigan, USA, which is still reliable today (Figure 1). From two-part silicones commercialized in the early 1980s to high-performance silicone sealants that are used in protective glazing applications to resist seismic, blast and hurricane impacts, Dow continues to drive innovation and thought leadership in structural glazing applications for façades.

***Figure 1**: Four-sided SSG application in Detroit, Michigan, USA.*

Current

Today, challenges remain relative to structural design. Increased climatic loads and larger lites of glass are counter to desires to increase vision areas and reduce frame widths when properly dimensioning structural silicone bites.

Dow Building Science has invested significantly in research to improve our understanding of the behavior of structural silicone sealants in service of a curtainwall assembly. The research utilized advanced engineering methods to expand and deepen the understanding of sealant behavior. Finite element analysis software was used to look beyond conventional assumptions of sealant strength and modulus based on quasi-static stress-strain behavior. Physical validation of the modeling was completed to compare the theoretical to real-world examples.

What we learned

The shape of the joint can influence how the sealant behaves. Current design assumption is that the sealant acts fully in tension when under negative wind loads. The basis for design strength is the tensile adhesion joint to determine the stress-strain relationship of a structural sealant. Figure 2 shows a tension-adhesion joint model. It illustrates the distribution of stresses in a tensile adhesion joint pulled to 20 psi (140 kPa) and 30 psi (210 kPa), indicating that the sealant is acting in tension.

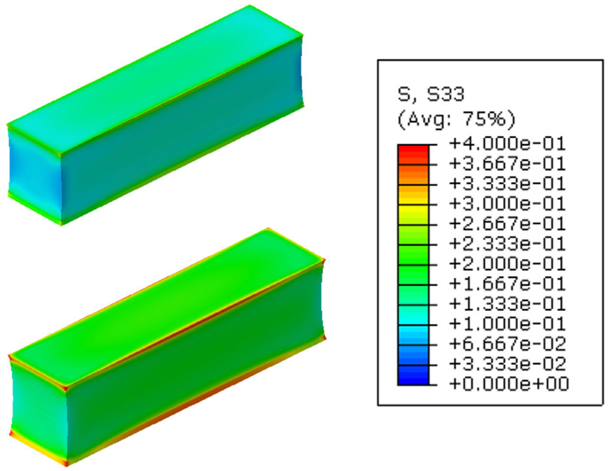

***Figure 2**: Tensile adhesion joint model.*

Analysis of finite element models shows that a structural sealant in an actual SSG unit can include a combination of shear, tension and compression because of the shape of the glazing joint and how the glass will bend. Figure 3 shows a structural sealant joint under negative wind load. The dimension of the joint is 3/8″ (9.525 mm) in bite and 1/4″ (6.35 mm) in glueline thickness. The distribution of stresses for the joint is mostly in tension as indicated by the color scale between green and red. Blue would indicate compression as noted by a negative sign for the stress.

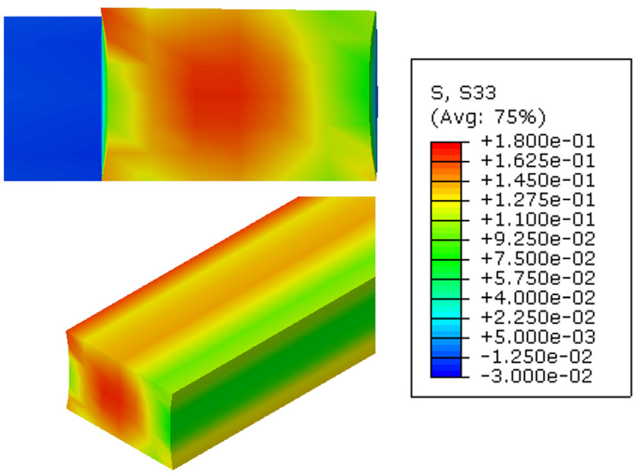

***Figure 3**: Structural joint 3/8″ by 1/4″ (9.525 mm by 6.35 mm) under negative wind load.*

As the joint aspect ratio becomes large, so does the apparent modulus of the sealant. Figure 4 illustrates a structural joint under negative wind load. The dimension of the joint is 1-9/16″ (39.6875 mm) in structural bite and 1/4″ (6.35 mm) in glueline thickness. The distribution of the stress in the joint shows a mixture of compressive and tensile forces occurring due to the stiffness of the connection.

As joint dimensions increase, increases in design strength are not considered detrimental and may help optimize the joint performance through improved distribution of stresses.

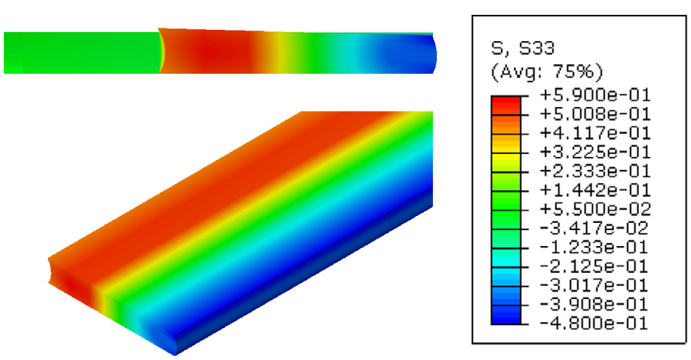

***Figure 4**: Structural joint 1-9/16″ by 1/4″ (39.6875 mm by 6.35 mm) under negative wind load.*

Advanced Engineering: Smart. Strong. Science.

Because of the research using advanced analysis engineering, Dow Building Science can validate increases in allowable sealant stresses up to 30 psi (210 kPa) for properly designed structural glazing projects with DOWSIL™ Brand Silicone Structural Sealants.

Selected additional requirements are needed when designing with the higher allowable stresses. These include the following:

- Minimum bite of 1/2″ (12.7 mm)
- Typical aspect ratio of 2:1 minimum instead of 1:1 (exceptions can be made for large gluelines above 6.35 mm)
- Use of high-performance one-part and two-part DOWSIL™ Brand Silicone Structural Sealants
- Projects originating from shop fabrication and field repair
- Evidence of engineering

State of the art: Higher allowable stresses

Dow Building Science has leveraged its in-depth experience, advanced engineering capabilities and innovations toolbox to expand an understanding of the behavior of structural sealants in real-world applications. Through finite element analysis and engineering studies, façade designers can use higher allowable stresses while continuing to use conventional, demonstrated-effective design approaches without the need for special sealants.

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Planned publications:

Bomb blast Silicone Bonding at Challenging Glass Conference in 2022

Seismic performance of silicone bonding at Façade Tectonics 2022

Learn more

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