THERMAL STRESS BREAKAGE

VIRACON TECH TALK

Glass breakage can occur for several reasons; one of which is thermal stress. This document provides information about how to identify and minimize thermal stress glass breakage.

THERMAL STRESS BREAKAGE

BACKGROUND

At one time, the use of annealed (AN) glass was common in architectural applications. As building design advanced, glass sizes became larger, tinted glass options expanded and high-performance glass coatings were developed. These advances led to an increased use of heat-treated glass and a decrease in the use of AN glass. One reason for the increased use of heat-treated glass is its ability to resist thermal stress, thus reducing thermal stress breakage.

Thermal Stress Analysis

When the majority of fabricated glass units contained AN glass it was also common for glass fabricators to offer thermal stress analysis. This analysis helped designers and glazing subcontractors understand whether the AN glass they specified was sufficient to resist anticipated thermal loads. If the AN glass was likely to encounter high thermal stress, heat-treated glass was recommended.

Today, the majority of glass in architectural applications is heat treated. Heat treating increases glass strength, allowing it to resist thermally induced stress (AGGA 2011). Undamaged heat-treated glass will withstand thermal stresses due to solar heating, seasonal temperatures, shading conditions or window coverings. Thermal stress analysis is not necessary when heat-treated glass is specified.

Note, thermal stress analysis is not the same as what is commonly referred to as glass strength analysis. Glass stress analysis typically refers to calculations performed according to ASTM E1300, Standard Practice for Determining Load Resistance of Glass in Buildings. This standard is for vertical and sloped glazing in buildings where loads consist of wind load, snow load and self-weight. Glass strength analysis should be performed regardless of the heat treatment.

THERMAL BREAKAGE OF AN GLASS

Viracon recommends heat-treated glass. If project circumstances require annealed glass, understand that the risk of thermal stress breakage is increased and that breakage is not covered by warranty.

Non-Uniform Temperature Gradients

Generally, thermal loads on glass occur as a result of the glass being exposed to sunlight and interior heating. If the glass is heated uniformly, the entire panel expands. If the glass is heated non-uniformly, temperature gradients occur within the glass, creating tensile stresses. Thermal breakage occurs when the tensile stresses exceed the glass edge strength.

In conventionally glazed windows, temperature gradients normally occur between the glass edges and the glass center. At least 1/2” (13mm) of the glass edges are generally captured so they are insulated from the sun’s rays. When the glass is sunlit, the glass edge temperature increases more slowly than the glass center. This increases thermal stress because the framing inhibits the temperature from increasing at the glass edge. As a result of the temperature difference between the glass edge and center, higher tensile stresses occur, increasing the risk of glass breakage.

Non-uniform temperature gradients can also occur when exterior building elements, such as overhangs, project in a way that shades only a portion of the glass surface. In this circumstance, heat-treated glass is required.

To reduce non-uniform temperature from interior conditions, any interior window treatments should be hung in a location that permits natural air movement between the window treatment and the glass (Figure 1). This can be accomplished by leaving 1-1/2" (38mm) clearance at the bottom, 1-1/2" (38mm) clearance on either one side or the top and 2" (50mm) clearance between the glass surface and the shading device. In addition, interior heating and cooling elements should on the room side of the interior window treatments (GANA 2008).

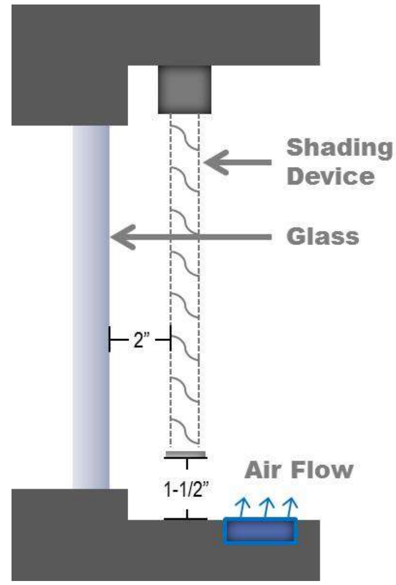

FIGURE 1: INTERIOR CLEARANCES

A clean-cut glass edge will resist a tensile stress of ~2,400 psi. Due to the coefficient of thermal expansion of soda lime glass, a 1°F (0.56°C) temperature differential across the glass area produces ~50 psi tensile stress. A glass edge temperature of 70°F (21°C) and a center pane temperature of 120°F (48°C) will have a 50°F (27°C) differential. This results in 2,500 psi tensile stress at the glass edge, which is sufficient to cause breakage in annealed glass.

Storage Conditions

AN glass products are susceptible to thermal stress breakage not only after installation but also while being stored. Glass products need to be stored in locations where partial and full exposure to sunlight does not occur.

Exterior scaffolding can create large shade patterns on the glass and elevate thermal stresses. Before a building is heated, it is subjected to large daily temperature fluctuations. Since the framing can cool down dramatically overnight, the glass edges remain cooler for longer periods. These high stresses can cause significant breakage.

PREVENT DAMAGE

If glass is damaged prior to, or during, installation its ability to resist thermal stresses is dramatically decreased and may result in breakage. This is true whether the glass is AN or heat-treated. Welding, painting and concrete work should be performed prior to glass installation. Any of these activities performed after glass installation increase the potential for glass surface damage and thermal stress breakage. Materials used to protect installed glass from adjacent work by other trades may also elevate thermal stress and cause breakage.

MAINTAIN SPANDREL CLEARANCE

In spandrel applications, a clearance of at least 1” should be maintained between the glass and the insulation (Figure 2). This will decrease the risk of thermal stress breakage that can occur in AN or heat-treated glass due to highly elevated temperatures that can occur in spandrel cavities.

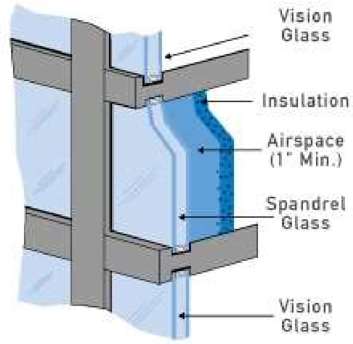

FIGURE 2: SPANDREL CLEARANCE

REFERENCES

AGGA. 2011. AGGA Technical Fact Sheet: Thermal Stress Glass Breakage. Glass & Glazing Association of Australia.

GANA. 2008. GANA Glazing Manual 50th Anniversary Edition. Glass Association of North America.

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