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TECHNICAL BRIEFING - THERMAL STRESS & THERMAL FRACTURE IN GLASS

Issued 22/12/2008 v2

The recent introduction of energy efficiency regulations has led to a new awareness of the benefits of solar control glass, insulated frames and shading devices for residential and commercial windows. The use of solar control glass in preference to clear glass can, in some applications, require careful consideration to avoid the possibility of a thermal fracture. The risk of thermal fracture in any type of building can be minimised and is a consequence of the development of critical thermal stress in the glass. Minimising the risk requires an understanding of the characteristics of these products and the various factors that can cause thermal fracture to occur.

Thermal stress development

Thermal stress develops from a differential expansion within annealed glass caused by heating or cooling of areas of the panel. In a window, the edge of the glass is shielded from sunlight by the frame; thus the covered edge will be cooler than the central area which is exposed to the sun. The expansion of the central area will cause the glass to stretch and yet be resisted by the cooler, covered edges, which will, as a consequence, develop tensile stress. If this stretching of the edges becomes sufficiently large, then the resulting tensile stress will be sufficient to break the glass. This break is termed a thermal fracture.

Factors which influence the development of thermal stress

- Solar absorption and heat traps

The amount of heat which is absorbed by the glass has a direct effect on the temperature of the glass, so is an important factor in the development of thermal stress. A high performing solar control glass will absorb considerably more heat than clear glass so the solar control glass will be at greater risk of thermal fracture than clear glass. In addition to this, blinds reflect heat back into the glass as well as allow the air between the glass and the blind to warm up. This causes the glass to become even hotter than by exposure to the sun passing through the glass alone. The same effect is caused by the presence of drop down ceilings and by heat absorbing or reflecting labels or decorations on the glass, etc. Spandrel glazing is an extreme example of a heat trap condition.

- Shadows

The presence of a shadow produces a cool area larger than that from a frame alone. This enables the glass edge to stay even cooler. The consequence is a greater temperature difference between the exposed and shaded areas of the glass and therefore higher thermal stress and likelihood of a thermal fracture occurring.
Shadows are commonly cast across glass by vertical mullions, balcony overhangs, eaves and columns, etc. The resulting shadows may be static or mobile. A static shadow is more critical because it produces a cooler area of glass than a mobile shadow.

- Edge strength

When the tensile stress in the glass edge exceeds a critical point, a crack will form. The magnitude of this critical point depends on the strength of the glass edge. A clean-cut edge is the strongest as the cutting produces the least amount of damage. A polished edge is the next strongest. The actual edge strength depends on the quality of the glass edge so if there is damage to the edge, this will reduce its strength and increase the likelihood of failure due to thermal fracture. The probability of breakage becomes significant. The strength of a damaged edge is highly variable so it is not possible to determine the risk of thermal fracture. For this reason the process of assessment for the risk of thermal fracture assumes clean cut edges.
The edges of glass are easily damaged by incorrect handling so it is important that glass is handled carefully during glazing. Do not glaze glass that has damaged edges. If it is likely that the cutting of glass may result in some damage to the edge, then consideration should be given to having the edges polished to remove the damage.

- Artificial heating and cooling

The presence of heating or cooling vents that blow directly onto the glass can cool or heat the glass excessively. This can cause significant thermal stress in the glass.

- Frame type and colour

The frame in which the glass is captured affects the temperature of the edge of the glass. An insulating material such as timber or vinyl will keep the glass edge cool while a conductive material such as aluminium is influenced by the frame colour. A dark colour is more absorptive than white so will enable the frame to absorb more heat. This means that the edge of the glass inside the frame will be warmer than if the frame was white in colour.

The cooler the edge of the glass, the greater the difference in temperature between the warm area of the glass and the edge of the glass, so the greater the thermal stress. Therefore, a light coloured insulating frame will have a greater contribution to the development of thermal stress than a dark non-insulating frame.

- Glass type

The type of glass will also have an influence on the risk of thermal fracture. This is influenced by the

capacity of the glass to absorb and release heat, and the characteristic edge strength of the glass.
Solar control glass absorbs radiant heat from the sun, so the body of the glass will be warmer than a clear glass under the same solar exposure. The presence of a low emissivity coating on glass will restrict the loss of heat from that surface, resulting in the glass being warmer.
The edge strength of glass such as wired glass is significantly less than that of ordinary glass due to weakening caused by the cutting process. Therefore thermal cracks will form in the wired glass at a lower level of thermal stress than for ordinary glass. Textured glass is subject to similar edge weakening due to cutting.
The internal stress levels of heat-strengthened and toughened glass are high enough to ensure that they are not subject to thermal stress under normal solar and architectural conditions.

- Geographic Location

Solar exposure will vary with latitude as solar intensity increases as the location approaches the equator. It is therefore important that this is considered when an assessment of thermal risk is undertaken.

Types of thermal fracture

There are two types of thermal fracture and they relate to the magnitude of stress required to cause the fracture:

- Low energy

This is by far the most common type of thermal fracture encountered. It is caused by damage to the edge of the glass. This weakens the edge so that only a small amount of thermal stress is required to cause a fracture. The likelihood of this type of fracture cannot be determined using a thermal assessment process.

- High energy

This is very rare and requires a very high level of thermal stress. The likelihood of this type of thermal fracture occurring can be determined by using a thermal assessment process.

Preventative actions

- Low energy

The vast majority of thermal fractures are of the low energy type so the likelihood cannot be determined using a thermal assessment process.

The following can be undertaken to minimise the chances of fracture.

1. Where annealed laminated glass is used, consideration should be given to having the edges polished.
2. Inspect the glass when delivered and check for any edge damage. Reject any damaged glass.
3. Inspect the glass before glazing into the frame. Do not glaze glass with damaged edges.

- High energy

High-energy thermal fractures are very rare but their likelihood can be determined by undertaking a thermal assessment. If the thermal assessment determines that the glass is at risk, then heat-strengthen or toughen the glass as this will increase the thermal resistance and effectively eliminates the potential for thermal fracture in buildings.

Conclusion

The potential for high-energy thermal fracture should be addressed at the design stage with the completion of a thermal assessment. Decisions can then be taken as to how to alleviate any risk factors.
Examining the glass before it is glazed and not glazing those panels that have damaged edges can substantially reduce low energy thermal fractures.

Thermal risk assessment

A thermal risk assessment is recommended for all solar control glass and double-glazing. Viridian carries out thermal assessments for its customers, free of charge. Viridian will, as the manufacturer, provide a warranty against thermal high energy fracture provided that a thermal assessment has been carried out, and all glazing and installation recommendations have been followed.

Further information

Please visit viridianglass.com or freecall 1800 810 403