Technical Update No 10

Use of glass overhead

This Technical update is based on and replaces Technical Update 4 first published in December 2000. The intent of the guidance is unchanged but the text has been amended to avoid misunderstanding, particularly in respect of the use of laminated glass.

The CWCT 'Standard for slope glazing systems' published in January 1999 covers all aspects of overhead sloping glazing systems. The purpose of this update is two fold:

- To give further guidance on the safe use of glass in overhead slope glazing systems
- To extend the scope of the CWCT Standard to include the performance of glass in slope glazing systems that are between vertical and 15° of vertical.

Slope glazing is defined as glazing that makes an angle of 15º or more with the vertical. This definition has been used for a long time and relates to the loading experienced by the glass, notably snow loading. Glass that is vertical may stay in place after failure provided that:

- The failure is due to thermal stress, or an edge defect, or is induced internally by a nickel sulfide inclusion.
- There is no impact or significant lateral loading (eg. from wind) to dislodge the glass fragments
- The glass is retained in a four-sided rebate. (Glass held by bolted fixings is likely to fall upon breakage. Glass unsupported on one edge is likely to incur more localised falling of fragments.)

Note that although glass that is sloping with an angle of between 0º and 15º from the vertical is not termed slope glazing, toughened glass used in this situation is likely to fall on fracture due to the action of its own weight even if there is no impact. Where there is a risk of overhead glazing failing and falling onto occupied areas, a risk assessment should be carried out.

Clause 2.4 of the CWCT Standard for slope glazing systems covers glazing selection. The first paragraph of this clause states, 'The selection of glazing systems shall be based on a sensible assessment of the consequences of glazing failure, coupled with an assessment of the risk of glazing failure'. The selection of materials permitted by the remainder of the clause will be subject to this risk assessment which may preclude the use of some options or require the adoption of additional safety measures.

The risk assessment should be undertaken in collaboration with the building owner to help ensure that the owner's requirements and concerns are duly identified and addressed. When selecting glass many factors may have to be considered including solar gain, thermal fracture, acoustics, bomb blast and so on.

Clause 1.5.5.4 states that toughened glass shatters into small, relatively harmless, fragments. A vertical pane may remain in its frame but sloping panes are more likely to fall out when they break. The greatest risk with toughened glass is that the fragments may clump together and fall *en masse.*

Glass fragments have been seen to remain together in clumps up to 250 mm diameter. These have a natural tendency to fall edgeways and only break up on impact with a sufficiently hard surface. Such clumps may weigh up to two kilograms each and when falling from heights above five metres can have considerable energy. Toughened glass fragments are less harmful than large shards of glass but still have sharp edges.

For thicker glasses the individual fragments will include fragments with length equal to the glass thickness, although numerous smaller fragments and splinters will also occur. The thicker glasses with the larger fragments are more likely to fall as clumps. Even if full separation occurs the fragments will be larger and a greater mass of fragments will fall.

Single glazing

Clause 2.4.2 allows the use of heat soaked toughened glass for glazing up to five metres above the lowest floor level. Heat soaking toughened glass greatly reduces, but does not eliminate, the risk of failure by the presence of a critical nickel sulfide inclusion. The distinction between glass used below five metres and that used above five metres is to do with the kinetic energy of the falling glass and because low level glazing is frequently associated with smaller thinner panes of glass (conservatories and walkways). Where thicker or larger panes are used serious consideration should be given to the use of alternative glasses, such as laminated glass, or provision of a wire mesh under the toughened glass, see below.

For glass used between five and thirteen metres above lowest floor level, Clause 2.4.2 allows heat soaked toughened glass to be used in thicknesses up to 6 mm and pane sizes up to 3m2. This requirement limits the total mass of glass that can fall to 45 kilograms. However, it should be noted that the glass might fall as clumps of unseparated fragments weighing up to 2 kilograms. The right hand column of Clause 2.4.2 states that ‘consideration should be given to positioning a wire mesh below the glazing, such that falling clumps of broken glass are broken into clusters no larger than 25 mm square’. A wire mesh should be provided unless the risk assessment shows that it is not necessary.

Meshes may be provided in the form of screens, sunshading and so on and may not detract from the appearance of the glazing. When used at height, a wire mesh may not be readily apparent to the casual viewer.

A mesh will catch or fragment the glass in case of failure. However, toughened glass should be heat soaked to reduce the risk of failure due to the presence of critical nickel sulfide inclusions. This reduces the risk of fragments falling, albeit through the mesh. A reduced risk of failure also reduces the need for repair, which frequently entails working at height.

Clause 2.4.2 allows the use of laminated glass in all situations. The strength in use and post-failure behaviour of laminated glass both depend on the glasses used to form the laminate and the type of interlayer. Post-failure behaviour is mainly determined by the types of glass used to form the laminate. Clause 1.5.5.5 describes laminated glass.

In light of concerns in recent years over the use of monolithic toughened glass in sloping situations, laminated alternatives are now generally used. Laminated annealed glass is commonplace in sloping overhead applications and experience shows that it tends to remain in place following breakage if it is:

- used within normal design parameters;
- not subjected to high loads;
- not subjected to sufficient heat to soften unduly the interlayer of the laminate following breakage;
- appropriately framed.

Laminated heat-strengthened glass manufactured to BS EN 1863 breaks in a similar pattern to annealed glass. Such glass is stronger than annealed glass and will resist somewhat higher temperatures prior to cracking. Following breakage, such glass will perform similarly to annealed laminated glass.

Some architectural designs may necessitate use of toughened glass to accommodate high thermal stresses or to facilitate use of bolted fixings. When such applications are proposed, it is prudent to consider the failure mode of any overhead sloping laminated panes containing toughened glass sheets. Consideration should be given to the behaviour if only one sheet of the laminate breaks and if more than one sheet breaks.

In a laminate comprising only toughened glass, once the glass sheets have broken, the post-breakage behaviour is dominated by the tensile strength and tear resistance of the interlayer. If used in a sloping situation, there is a risk that a laminated pane comprising two sheets of toughened glass may slump and fall in a single piece from the rebate once both sheets have broken. Bolted laminated panes comprising only toughened glass may also be at risk of falling if the interlayer tears around the bolt holes once the glass has broken; solutions to this have included use of special interlayer materials or use of a laminate comprising a toughened glass sheet and a non-toughened glass sheet.

Following breakage, laminated combinations of toughened glass with heat strengthened or annealed glass may provide improved strength and tear resistance compared with a laminate comprising only of toughened glass. This is due to the non-toughened glass breaking into larger pieces that are then held together more effectively by the interlayer. For the same reason, even greater post-breakage strength will be achieved by using laminated combinations of annealed and/or heat strengthened glass only. Appropriate thicknesses of glass need to be selected when combining glass types of differing strength.

If proposing to use sloping laminated glass in a situation outside normal design parameters, the post-breakage behaviour should be investigated at a realistic service temperature and stability demonstrated for a period of time acceptable to all interested parties. It should be noted that the properties of interlayer plastics vary according to a number of factors including time, temperature and composition.

A design risk assessment for the glazing should also be undertaken. This should consider whether there is a real risk of broken glass falling, bearing in mind that if laminated glass were to fall from its frame or fixings it could fall as a single piece thus presenting a greater threat than falling toughened glass.

In the rare event that acceptable post-breakage behaviour cannot be demonstrated by any of the available glazing options, secondary systems of support, such as wires or mesh beneath the glazing, may need to be devised and demonstrated to support safely broken glass if it should become displaced. However, such provisions are extremely rare in practice due to the exceptionally low risks normally envisaged and encountered."

Multiple glazings

The above considerations that apply to single glazing also apply to the lower pane of multiple glazing units. This is the principle of Clause 2.4.3 of the CWCT Standard for slope glazing systems. Where the lower pane of a multiple glazing unit may fall on fracture the post failure behavior of the next lowest layer must also be considered. Every project should be considered on its own merits and specific requirements. Decisions on the selection of glass should be based on a full risk assessment.

If safety is the primary concern, the CWCT's advice is to use a laminated glass as the lowest glazing layer.

With existing overhead glass installations, the question of whether or not a mesh or other measures should now be introduced may arise. The answer depends upon the conclusions of an appropriate risk assessment. If the building's usage or performance to date does not give any reasonable cause for concern, then no action may be required.