Introduction

Glazed barriers occur in many forms, including balustrades, building facades and partitions. A barrier generally has one of two key functions – separate one group of people from another, or protect people from a fall.

The glass in a glazed barrier may take the form of an infill panel within a structural frame, or it may be the primary structural material, as in a freestanding cantilevered glass balustrade. Either way the glass must be able to resist some applied loads.

This Technical Note summarises the design requirements for glass in barriers. Where detailed recommendations are given in other published documents, reference is made to those documents.

Technical Note 100 describes methods of testing glass balustrades.

Basic Performance Requirements

For glazed barriers there are four important criteria to be satisfied:

- the barrier/glass should have sufficient strength to resist the design loads with an appropriate factor of safety,
- the displacement of the barrier, under load, should be within acceptable limits for human comfort,
- the barrier/glass should have reasonable resistance to accidental impact,
- the post-failure behaviour of the glass in a barrier should be safe and, if necessary, failed glass should retain some residual strength where needed to preserve life.

Building Regulations

Building Regulations in England, Scotland, Wales and Northern Ireland incorporate the need for barriers in and around buildings where it is necessary to protect against falls. Any barrier may incorporate a glass element.

Guidance on satisfying the Building Regulations is given in the relevant versions of Approved Document K for England or Wales, Section 4 of the Technical Handbooks (for both Domestic and Non-domestic buildings) in Scotland and Technical Booklet H in Northern Ireland. The guidance in these documents is similar but there are detail differences.

The guidance typically addresses the following issues:

- Locations where barriers are required;
- Required height of barriers;
- Loads to be resisted; and
- Requirements in relation to the safety of children.

BS 6180

Guidance on the design of barriers is given in BS 6180, and this Standard is referred to in Approved Documents K for both England and Wales, and in Technical Booklet H for Northern Ireland. The Technical Handbooks for Scotland do not refer to BS 6180 in the section on barriers.

The guidance in BS 6180 also applies where there is no change in level, which is particularly relevant to internal glazed partitions. Where there is no change in level, the barrier will be subject to design loads, and permanent barriers would normally be expected to withstand these loads so as to limit damage to the barrier. However, the consequences of failure may be somewhat reduced as it is less likely to affect the safety of building users.
It should be recognised that where crowd loads can occur, failure of a barrier may affect public safety even where there is no change in level, as uncontrolled movement of crowds may cause a crush.

BS 6180 gives guidance on acceptable deflections of barriers and the design of infill to barriers. Some specific guidance is given in relation to the use of glass, but this should be regarded as setting minimum requirements; CWCT guidance as stated in this Technical Note is more onerous than BS 6180 in some respects.

**Location of Barriers**

For England and Wales, Approved Document K requires protection at any change of level of at least 600mm in dwellings, or 380mm (or the height of two risers on stairs) in buildings other than dwellings. In a non-dwelling it is reasonable to assume that building users may be less familiar with the building, and that there are more likely to be crowds, hence the more stringent requirement.

In Scotland, protection is required to protect a change of level of 600mm, and protection is also required where any change in level occurs at a change of direction on an access or circulation route. These rules apply equally to domestic and non-domestic buildings.

In Northern Ireland, Technical Booklet H does not specify where barriers are required, other than where it is necessary to reduce the risk of people ‘being injured by a fall from height’.

**Required Barrier Height**

Table 1 of BS 6180 specifies minimum barrier heights for various circumstances as follows:

<table>
<thead>
<tr>
<th>Use</th>
<th>Position</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-family dwelling</td>
<td>Barriers in front of a window</td>
<td>800 mm</td>
</tr>
<tr>
<td></td>
<td>Stairs, landings, ramps, edges of internal floors</td>
<td>900 mm</td>
</tr>
<tr>
<td></td>
<td>External balconies including Juliette balconies, edges of roofs</td>
<td>1100 mm</td>
</tr>
<tr>
<td>All other uses</td>
<td>Barrier in front of a window</td>
<td>800 mm</td>
</tr>
<tr>
<td></td>
<td>Stairs</td>
<td>900 mm</td>
</tr>
<tr>
<td></td>
<td>Balconies and stands, etc. having fixed seating within 530 mm of the barrier</td>
<td>800 mm</td>
</tr>
<tr>
<td></td>
<td>Balconies and stands, etc. having fixed seating within 530 mm of the barrier, providing the sum of the barrier width and the barrier height is greater than 975 mm</td>
<td>750 mm</td>
</tr>
<tr>
<td></td>
<td>Other positions including Juliette balconies</td>
<td>1100 mm</td>
</tr>
</tbody>
</table>

**Table 1 Minimum barrier heights**

This Table is used as the basis for the specific guidance given in the various Approved Documents, Technical Handbooks and Technical Booklet.

**Barriers on Upstands**

Where the barrier is supported on top of an upstand or low parapet wall which people might be able to step onto, BS 6180 requires that the barrier height is measured from the top of the upstand.

If the barrier design is such that it would prevent a person from standing on the parapet wall then this requirement could reasonably be disregarded. For example, if a glass infill is designed such that it extends down below the inside face of the parapet, or if the infill comes down so close to the inboard edge of the parapet coping that it would prevent a person (including a child) from being able to gain a foothold, then the parapet/upstand might not be considered to be a step.

BS 6180 gives no guidance on how high such a parapet wall can be before it ceases to be considered a step. Building Control Alliance Guidance Note 25 gives specific guidance, for balcony edges, which is primarily aimed at protecting young children where there is a barrier mounted on top of an upstand or parapet.
• Where there is a parapet up to 300 mm high, there should be a minimum height of 800 mm from the top of the parapet to the top of the barrier, but the 1100 mm minimum overall barrier height must be maintained (e.g. if the parapet is 200 mm high, then the barrier needs to be at least 900 mm high from the top of the parapet);
• Where there is a parapet more than 300 mm high, and up to 600 mm high, then there should be a minimum barrier height of 700 mm above the top of the parapet, whilst maintaining the minimum overall height of 1100 mm (e.g. if the parapet is 350 mm high then there needs to be a minimum 750 mm from the top of the parapet, but if the parapet is 500 mm high then the barrier only needs to be 700 mm from the top of the parapet, giving a total barrier height of 1200 mm);
• For a parapet above 600 mm in height the only requirement is that the top of the barrier is at least 1100 mm above the adjacent floor level (e.g. if the parapet is 800 mm high, then the barrier only needs to extend 300 mm upwards from the top of the parapet).

Young children are considered unlikely to be able to climb onto parapets greater than 600mm high. In all cases the actual barrier element needs to be non-climbable.

Comfort

Comfort plays an important role in the specification and design of barriers. Whilst architects like the concept of the transparent building, many people are wary of heights and will noticeably stay away from the floor edge in a building with a full-height glazed façade (including internal facades around lightwells).

For the edges of balconies and walkways where there is a substantial drop, having a partial-height barrier that is more than the recommended minimum height will help to allay fear in those who are wary of heights, and will also help to reduce the risk of items being accidentally dropped or knocked over the top of the barrier.

Likewise, setting the barrier inboard of the edge of a drop can also help to alleviate fear, but care must then be taken that persons are not able to climb over the barrier and walk along the outside edge.

Finally, the deflection of barriers under static loads can be a significant issue. Many barriers move relatively easily when first pressed against, although once the initial slack has been taken up the barrier will tend to become much stiffer. Full-height glazing in barriers may deflect relatively easily if leaned against, and this can also cause sensations of discomfort in many people.

Requirements for the Safety of Children

To protect children there are limits on the maximum size of opening in the barrier, and measures must also be taken to make the barrier difficult to climb.

BS 6180 requires that if children under the age of 5 are able to access a building, then the size of opening in any barrier should be limited to prevent a 100 mm diameter sphere passing through the barrier, making due allowance for deflection under load (although no formal means of assessing deflection under load is identified). For practical reasons an exception is given to the 100 mm rule for the triangular opening formed between the tread and riser on a stairway.

In the Approved Documents K, and Technical Booklet H these restrictions apply where children under 5 may be present but there is no specific guidance on when children should be assumed to be present. Section 4 of the Technical Handbook states that children should be expected to be present in all areas except where their presence is expressly prohibited, such as restricted industrial areas.

Static Loads on Barriers

Static loads are usually specified in three forms:
• A uniformly distributed line load, which typically includes a horizontal load at a specified height above floor level,
• An area-based uniformly distributed horizontal load (pressure), which may be limited in extent for full-height barriers (i.e. it is only applied up to the minimum barrier height);
- A horizontal point load, which may be taken to occur anywhere on the barrier.

These loads are considered as individual load cases and are not additive.

<table>
<thead>
<tr>
<th>Type of occupancy for part of the building or structure</th>
<th>Examples of specific use</th>
<th>Horizontal uniformly distributed line load (kN/m)</th>
<th>Uniformly distributed load applied to the infill (kN/m²)</th>
<th>A point load applied to part of the infill (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic and residential activities</td>
<td>(i) All areas within or serving exclusively one single family dwelling including stairs, landings, etc. but excluding external balconies and edges of roofs</td>
<td>0.36</td>
<td>0.5</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>(ii) Other residential, i.e. houses of multiple occupancy and balconies, including Juliette balconies and edges of roofs in single family dwellings</td>
<td>0.74</td>
<td>1.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Offices and work areas not included elsewhere, including storage areas</td>
<td>(iii) Light access stairs and gangways not more than 600 mm wide</td>
<td>0.22</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(iv) Light pedestrian traffic routes in industrial and storage buildings except designated escape routes</td>
<td>0.36</td>
<td>0.5</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>(v) Areas not susceptible to overcrowding in office and institutional buildings, also industrial and storage buildings except as given above</td>
<td>0.74</td>
<td>1.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Areas where people might congregate</td>
<td>(vi) Areas having fixed seating within 530 mm of the barrier, balustrade or parapet</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Areas with tables or fixed seating</td>
<td>(vii) Restaurants and bars</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Areas without obstacles for moving people and not susceptible to overcrowding</td>
<td>(viii) Stairs, landings, corridors, ramps</td>
<td>0.74</td>
<td>1.0</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>(ix) External balconies including Juliette balconies and edges of roofs. Footways and pavements within building curtilage adjacent to basement/sunken areas</td>
<td>0.74</td>
<td>1.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Areas susceptible to overcrowding</td>
<td>(x) Footways or pavements less than 3 m wide adjacent to sunken areas</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>(xi) Theatres, cinemas, discotheques, bars, auditoria, shopping malls, assembly areas, studio. Footways or pavements greater than 3 m wide adjacent to sunken areas</td>
<td>3.0</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>(xii) Grandstands and stadia</td>
<td>See requirements of the appropriate certifying authority</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retail areas</td>
<td>(xiii) All retail areas including public areas of banks/building societies or betting shops</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Vehicular</td>
<td>(xiv) Pedestrian areas in car parks, including stairs, landings, ramps, edges or internal floors, footways, edges of roofs</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Table 2 Minimum horizontal imposed loads for parapets, barriers and balustrades
Table 2 of BS 6180 presents minimum horizontal design loads for various kinds of building. These loads are the same as those given in the UK National Annex to BS EN 1991-1-1, which in turn are the same as those given in the previous loading code, BS 6399-1. The UK National Annex to BS EN 1991-1-1 does not give area or point loads but these are given in PD 6688-1-1. These loads, which are given in Table 2, apply to all countries of the UK.

Some barriers will also be exposed to wind load. BS 6180 states that wind load should be considered as a separate load case and not combined with the imposed load. CWCT ‘Guidance on the actions on non-loadbearing building envelopes’ recommends this approach for normal residential and office applications. For areas where people may congregate, it recommends that serviceability should be assessed on the basis of separate load cases but safety should be checked on the basis of a combined load of half the wind load plus the full imposed load or half the imposed load plus the full wind load whichever gives the greater load effect.

Height of application of load

According to clause 6.3.1 of BS 6180 the line load is to be applied at ‘design height as presented in Table 1’, or ‘at design level (1100 mm) for barriers higher than the design height’. This guidance is contradictory to Figure 1 of BS 6180 which suggests that ‘in design’ the load is always applied at the ‘1100 mm ‘design level’. From a design perspective, assuming the load to apply at the height of 1100 mm will usually result in a conservative design for shorter barriers. Where the barrier is less than 1100 mm high, CWCT recommends that the load to be applied at the top of the barrier may be calculated as the load that gives the same moment at the base of the barrier as the line load from Table 2 applied 1100 mm above floor level.

The uniformly distributed load (pressure) is only applied to the area below the design height, so that if a full-height barrier is used it is only necessary to apply this load from the floor up to a maximum of 1100 mm above floor level.

The point load should be applied ‘at the most onerous point anywhere on the barrier structure’. This requires the designer to consider the likely worst case locations, in terms of both stress and deflection, for each of the components and materials used in the barrier construction.

PD 6688-1-1 specifies vertical static loads to be applied to parapets, which comprises either a concentrated load of 1 kN or a line load of 0.6 kN/m. The designer is to take whichever load ‘gives the worst design condition in combination with the recommended horizontal loading of Table NA.8’. Importantly table NA.8 only gives the pressure and concentrated design loads, and so the vertical load is not intended to be combined with the design horizontal line load. It would not be unreasonable to require this design requirement to be applied to part-height barriers, which are effectively a form of parapet.

Area of Application of Load

For simple calculations, a point or line load can be assumed to act on a true point or line. For physical testing and analytical techniques such as finite element analysis it is necessary to apply the load to an area of the surface.

The area chosen will affect the results but it should represent the way the load is likely to be applied in practice. BS 6399-1 (now withdrawn) recommended an application area of 50x50 mm for point loads, but gave no guidance for line loads.

In the absence of other guidance CWCT recommends that a point load should be applied over an area 100x100 mm, and a line load should be applied to an area with a width of 100mm.

Performance under Load

Excessive movement of a barrier under load can cause concern to building occupants who may worry that a flexible barrier does not have sufficient strength. This is an issue of perception: a large movement does not necessarily mean that a barrier is likely to fail, just as rigidity under small loads does not guarantee strength if the load is increased.
Barriers must therefore be designed to ensure deflections are limited (serviceability) and that they have adequate strength (safety). The loads given in Table 2 are characteristic values, Q_k or q_k. For the serviceability limit state, the characteristic load can be used without modification to assess deflection. To ensure safety, factors must be applied to the characteristic loads for strength assessment.

These requirements are confirmed in section 6.2 of BS 6180.

**Deflection Limits**

Although deflection (or more correctly displacement) is primarily a matter of comfort, it can also be a problem if it causes openings to increase in size, allowing people and especially children to slip through or become trapped.

BS 6180 gives an absolute limit on displacement at any point on a barrier of 25 mm, unless the design code for the material requires a lower limit. This is a limit on displacement which will result from deflection of the barrier relative to its fixings combined with rotation of the barrier at the fixing point, as illustrated in Figure 1.

![Figure 1 Displacement of Glass Barriers](image)

Displacement limits are subjective and particularly in the case of freestanding glass barriers may be the governing design criterion. BS 6180 gives recommendations and the designer is ultimately responsible for determining acceptable displacement limits.

Although there is no limit for displacement at part-load, many free-standing glass barriers appear to be more flexible at low loads, when people first lean against the barrier. CWCT therefore recommends that an additional limit of 10 mm under half the design line load for a domestic barrier should be adopted. Under this load any movement due to ‘slack’ in the fixings is likely to occur.

**Duration of application of load**

The strength of glass depends on the duration of the load. Performance of laminated glass will also depend on the duration of the load as creep of the interlayer will reduce composite action and increase deflection. I Struct E (2014) recommends a load duration of 30 seconds for domestic construction and 5 minutes in other cases. These values have also been adopted in a draft European standard for laminated glass interlayer materials.

**Redundancy and Laminated Glass**

For a freestanding glass balustrade, failure of the glass can result in total loss of the barrier even where a laminated glass is used. BS 6180 recommends that a handrail is used with freestanding glass balustrades that are protecting a change in level. The handrail is required to be able to support the design line load in the event of failure of a glass pane. This requires the adjacent glass panes to be able to withstand the additional load from the handrail. It would be reasonable to limit this requirement to the safety condition. Consideration should be given to the support to the handrail at the end of a run of balustrading. The following options are available to the designer:
Design of glazed barriers

- provide an end post,
- return the handrail to the adjacent façade and fix the handrail to it,
- design the end pane of glass to be much narrower than the adjacent pane such that if it fails the handrail can act as a cantilever from the adjacent pane but if the adjacent pane fails, the end pane is still sufficiently wide to be able to support the handrail.

Where laminated glass is used for a freestanding balustrade, BS 6180 permits the barrier to be designed without a handrail. In this case CWCT recommends that the laminated glass should have sufficient strength to resist the full design load with one ply of the laminate broken; the deflection can exceed the limits in BS 6180 but deflection should not be sufficient to allow a person to fall through an opening in the barrier. The barrier should also remain in place with some residual strength if both plies of the laminate are broken. These requirements can be satisfied with the use of a structural interlayer; the use of heat strengthened glass in the laminated pane will also give greater residual strength than toughened glass.

Where a handrail is not used, and also for outdoor balustrades, CWCT recommends that the top edge of the glass is protected by a capping. This can prevent both panes breaking simultaneously under impact and will also protect the top of a laminated glass pane from standing water.

**Assessment of structural performance of glass barriers**

For metal components of barriers the appropriate sections of the Eurocode should be used. Eurocode 3 (BS EN 1993) covers the design of steel structures, and Eurocode 9 (BS EN 1999) deals with aluminium structures.

For glass there is no structural design code available. GGF(2014) gives guidance on glass type, thickness and size of pane that will satisfy the loading requirements for different types of barrier. Alternatively I Struct E(2014) gives design recommendations including limiting values for glass strength and appropriate safety factors. The I Struct E(2014) adopts a partial factor approach but the overall factor of safety is less than recommended by BS 6180. BS 6180 refers to a minimum partial safety factor of 4 for glass. Provided the guidance on glass selection and residual strength given in this Technical Note is followed, CWCT recommends that the design guidance from the I Struct E can be adopted. The guidance provided by I Struct E includes:

- a method of calculating the design strength of glass taking account of load duration, appropriate partial factors and the strength components of heat treated glass (ie basic strength and thermally induced stress),
- a method of calculating effective thickness of laminated glass,
- a worked example for a glass barrier consisting of laminated glass continuously supported at floor level and with a handrail.

It will normally be possible to demonstrate the structural performance of a glass barrier using the methods described above. In some situations it may be necessary to carry out tests to confirm that the performance is satisfactory.

Testing balustrades to establish the design strength is unlikely to be satisfactory on its own as a large number of tests would be required to allow for the variability of glass strength. For a complex support arrangement there may be a requirement for some test evidence to back up a calculation model. If a calculation model is developed, an instrumented test may be used to determine the stresses developed in the glass and hence to confirm the validity of the model. The detailed requirements for such testing are outside the scope of this Technical Note.

Load testing is more likely to be used to check displacement. This may either be a laboratory test to assess a design or a site test to check the quality of installation. Displacement of a glass balustrade is likely to be a combination of flexural deflection of the glass pane and rotation of the glass pane at its support as described above and illustrated in Figure 1. The general flexural deflection of monolithic glass can be calculated but where laminated glass is used testing to confirm performance may be required. Rotation at the fixings may also be more difficult to assess without testing. Satisfactory results in a deflection test give no assurance of adequate strength.
Testing may also be required to demonstrate the residual strength of a glass balustrade after the glass has failed. This is particularly applicable to a freestanding glass barrier where there is no handrail.

For the fixings which secure the barrier to the building structure, BS 6180 recommends an additional factor of safety of 1.5, to ensure that the fixings do not fail before any element of the barrier fails (if the fixings fail then this would allow the entire barrier to collapse).

**Impact Performance**

In addition to static loads considered above, barriers may be subject to impact. The performance of glass under impacts simulating human impact is currently assessed by testing in accordance with BS EN 12600. The assessment results in a classification in the form $\alpha(\beta)\Phi$ where:

- $\alpha$ is the highest impact energy class at which the product either does not break or breaks safely (i.e. in a way that is unlikely to cause severe cutting or piercing injuries),
- $\beta$ is the mode of breakage,
- $\Phi$ is the highest impact energy class at which the product either does not break or when it breaks it still has sufficient integrity to retain the impactor and hence provide containment.

The test is carried out with three levels of impact energy so that $\alpha$ and $\Phi$ may take the value 1, 2 , 3 or 0. Class 1 is the highest level of performance and the impact energy decreases from 1 to 3. 0 indicates the glass failed to give satisfactory performance at any level of impact energy.

Glass where $\alpha$ has been classified as 1, 2 or 3 is called a safety glass. Safety glass must be used in areas where the glass may be subject to accidental impact, in order to reduce the risk of severe cutting and piercing injuries.

Glass where $\Phi$ has been classified as 1, 2 or 3 is able to provide containment at the given impact energy class and is applicable to barriers protecting a change in level.

BS 6180 provides guidance on impact performance of glass for use in barriers. To prevent injury from contact with broken glass, all glass in barriers that is within 800 mm of floor level is required to be a safety glass unless it is otherwise protected from impact. A safety glass with $\alpha$ of 3 is generally sufficient.

Where barriers protect persons from a fall, the glass is also required to provide containment. The impact energy to be resisted depends on the distance a person can travel perpendicular to the glass before hitting it, known as the free path. Where the free path is less than 1.5 m the glass is required to provide containment under a class 3 impact and where the free path is greater than 1.5 m the glass is required to provide containment under a class 1 impact.

In BS 6180 the requirement for containment given above applies to ‘barriers with glass infills or freestanding balustrades’ and does not apply to glass in full height barriers. Full height glass walls potentially present a greater risk as there is less likely to be a handrail which would bridge the gap across a broken pane of glass. CWCT therefore recommends that the requirement for containment should also apply to full height glass barriers.

BS 6180 permits the use of single glazing with monolithic toughened glass in barriers if it is sufficiently thick to resist the specified impact without breaking. CWCT considers that this does not give a sufficient level of safety. Toughened glass provides no significant residual strength after fracture and may fracture for reasons other than impact leaving an unguarded opening. Glass should preferably be laminated with an interlayer of at least 0.76mm pvb or equivalent so that it provides some residual strength after failure. A glazing unit with two panes of toughened glass might be considered acceptable subject to a risk assessment.

Use of a glazing type that provides containment under the standard BS EN 12600 test does not ensure that the glass will provide containment when used in the barrier. In the standard test, the
glass is supported on four edges whereas glass in a barrier may be point supported, two edge supported or even supported on one edge acting as a cantilever. Under some methods of fixing the glass may be displaced from the support structure by the impact. It may be necessary to carry out impact tests to assess behaviour in some cases. Further guidance on testing is given in Technical Note 100.

The requirements above relate to accidental impacts from people. In some cases barriers may be subject to greater impacts for example from loaded trolleys, people on skateboards or mobility scooters and these should be considered on a case by case basis.

Glass Type

Glass for use in barriers must be selected so that it can meet the specified performance requirements. A particular issue is the need for the area around the barrier to remain in use if the glass has been damaged by an impact. It would not necessarily be considered appropriate if part of a building had to be closed for any length of time due to failed glass in a barrier.

Glass is a brittle material and gives no warning of failure, such as excessive deflection or noise. The designer must remember that any pane of glass may fracture in service, for any number of reasons. Glass should therefore be selected on the basis that:

- It will, carry the design loads without fracturing and within acceptable deflection limits;
- It may fail for any number of reasons;
- Its post failure behaviour is acceptable and does not create an unacceptable hazard. Hazards include the possibility of glass falling from height, and the risk that the barrier no longer provides effective protection against falls.

A risk assessment is required to determine the suitability of a particular glass selection, however, to meet the CWCT recommendations, the selected glazing will normally be as follows:

- **Insulating glazing unit which extends below barrier level in a glazed wall**
  One layer should be a laminated safety glass capable of providing containment. If the laminated glass is to the outside of the barrier (i.e. on the drop side) then the inner pane of glass will need to be toughened;

- **Single glazing in a balustrade or below barrier level in a glazed wall**
  A laminated safety glass capable of providing containment.

With certain systems of fixing, a laminated glass composed of two plies of toughened glass may be too flexible to provide containment if both plies break. In case of doubt, a post breakage test should be carried out, which should include loading after failure.

Where the glass is not fully framed, and particularly with localised edge clamping, it may be necessary to test the proposed glass and method of fixing to ensure that containment can be achieved.

Freestanding glass barriers are often fixed to the edge of a floor slab or balcony deck with bolted fixings. Monolithic toughened glass fixed in this way is highly likely to fall immediately if it fails, even where there is no horizontal force applied to the glass. The fragments may clump together and fall en-masse and may be blown or projected some distance from the balustrade.

Edge cover to framed glazing

BS 6180 requires an edge cover of at least 15 mm unless a lower value is justified by test or calculation. It is not clear what the origin of the 15 mm requirement was, and 15 mm edge cover is difficult to achieve with a typical 50 mm wide stick curtain wall framing system, which typically provides about 12 mm edge cover. Despite this requirement, 50 mm wide curtain wall frames are frequently used in situations where the glass is required to provide a barrier function.

Sometimes it is argued that the edge cover can be increased by including the cover provided by the gasket but this is rather dubious and cover should be limited to the cover provided by the metal part of
the frame. Toggle-fixed glazing units provide even less edge cover, and have little in the way of external glass retention.

Edge cover is required to resist load on the glass when the glass is unbroken, and numerous tests for wind load on standard curtain wall systems indicate that 12 mm edge cover is adequate to resist wind loads up to 3600Pa on storey height panes of glass. Barrier loadings will normally be much less than this.

Edge cover may need to be increased to retain glazing after fracture. This will apply particularly in the case of single glazing with laminated glass where the additional flexibility of the glass after fracture may allow it to slide past the gaskets. Where a glazing unit is used it is unlikely that both panes will break hence the unit is unlikely to be displaced from the frame.

References

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Building regulations (Wales) Approved Document K protection from falling collision and impact www.gov.wales/topics/planning/buildingregs/?lang=en


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Building Control Alliance, Guidance Note 25 Guarding to balconies, September 2016

CWCT, Guidance on the actions on non-loadbearing building envelopes, 2017

BS 6180 Code of practice for Barriers in and about buildings

BS EN 1991-1-1 Eurocode1: Actions on structures – General actions

NA to BS EN 1991-1-1 UK National Annex to Eurocode1: Actions on structures – General actions

PD 6688-1-1 Recommendations for the design of structures to BS EN 1991-1-1