SER Jersey Technical Bulletin Number 6

Certification of the Structural Design of Glazing Systems

1. Introduction

This Technical Bulletin is a guide to the Certification of glazing installations for domestic and commercial buildings. It is not intended as a design guide, and designers of glazing installations should not rely on it as such.

Generally glazing systems will be designed by a specialist contractor and on larger projects, the glazing may well form a separate design stage, in which case it must be designed and detailed before a Design Certificate is signed for that stage.

It is unlikely that a detailed check will be necessary for most domestic and many commercial buildings where the installation comes within the provision of BS 6262:2005[1] (see below). Many of these installations will be carried out by installers who may be registered under one of the fenestration self-assessment schemes by FENSA and CERTASS, although these schemes only apply to replacement domestic windows.

2. Glazing Systems

Glazing systems normally form part of the envelope of a building but are also often used internally as part of volume dividers. They can vary in structural importance from simple windows fitted in openings provided in the building envelope to curtain walling that may also provide support to other parts of the structure, and may include composite cladding systems referred to as unitised glazing. Many glazing systems include doors and may also act as pedestrian barriers.

Glazing systems are normally procured after a Building Permit has been obtained and are designed and provided by specialist contractors. The providers must be properly instructed with respect to the loadings to which the building will be subjected and the British or European Standards that apply and this information should be included in the relevant drawings accompanying the design certificate.

There is no general British Standard covering the design of façades, though there are many codes covering the materials used, and two that cover glazing systems. These systems vary from simple windows to curtain walls and purpose designed façade systems. Façades normally need only be designed for self-weight and wind loads, though roofs, canopies and

rooflights will also need to take account of superimposed loads such as normal and drifting snow, and all need consideration for maintenance access.

Glazing, in the sense of windows, for most projects is covered by the provisions of BS 6262:2005[1] "Glazing for buildings", which satisfactorily defines the requirements for glazing for most situations, including calculation of wind loads. Guidance is given below on when it is appropriate to rely on compliance with this code.

Where more extensive areas of glazing are involved this often includes what is termed Patent Glazing; though, strictly speaking, this term refers to systems where the glazing does not rely on the external seals for water-tightness. These systems use glazing support members (transoms and mullions) with drainage incorporated in the details. They are often referred to as 'stick' systems and 'curtain walling'.

For Patent Glazing the framing, which is generally formed from aluminium extrusions, is used to support the glass and resist the applied loads over long spans. The glazing can be set vertically or sloping, where it may form part of a roof surface. BS 5516:2004[2] "Patent glazing and sloping glazing for buildings" covers the design and installation of vertical and sloping Patent Glazing. Manufacturers provide design information and many offer a design service for the specialist contractor.

Both the above codes include instruction on calculating the wind and superimposed loadings that the glazing is required to resist. Note that the framing system and structural framing sections, be they of timber, metal, glass reinforced plastic and/or plastic, can be common to both types of glazing. Where glazing is formed from a number of large panes the framing system will require to be purpose designed.

Point Fixed glazing (sometimes also referred to as Curtain Walling), is where the glass is supported not at the edges but by bolt fixings through the glass, with weather seals provided to prevent moisture ingress.

In Point Fixed glazing the support system is generally formed from steel components, often a combination of hollow sections and rods in forms sometimes having the appearance of an exposed lattice or bowstring girders. There is no British Standard which describes such glazing, though various components are covered by materials codes.

Glass used in all these systems can be single or multiple glazing, using float (annealed), heat strengthened or toughened glass, or a combination of these, including laminated panes and panes having special surface finishes. Plastic sheet glazing is also used.

BS 6262[1] and BS 5516[2] give guidance on calculating wind loads and establishing pane thicknesses in glass and plastics. The wind load calculations are based on BS 6399-2: 1997[6] "Loading for buildings – Code of Practice for Wind Loads" with guidance which is specific to glazing installations. Both codes are restricted in their cover and the graphs used do not extend to the larger pane sizes now available.

There is no British Standard covering calculation of glass thickness for the larger panes sizes, though European Standard (DRAFT) prEN 13474[3] Parts 1 and 2 exist and give methods for calculating glass stresses for different glass types and pane thicknesses. This draft code has not yet been published in all its intended parts and, so far, only covers edge supported panes

and uniformly distributed loads. It is normal in the UK to abide by the recommendations given by the glass manufacturer but it is currently unlikely that justifying calculations will be provided.

The publication "Structural use of glass in buildings"[4] is a useful reference book that gives guidance on design with glass. The paper 'Recent developments in design methods for glass structures'[8] also gives guidance on this subject and the Certifier may find Tables 4 and 5 give useful data for rule of thumb checking where full design information is not made available.
The Certifier should be aware that most glazing systems are relatively rigid in the plane of the system and are built to much closer tolerances than the supporting structure. It is probable that the structural design of the glazing and the main structure are carried out by different parties and there is a risk that the loads and relative tolerances and movements may not be properly accounted for. Glazing systems are subject to greater temperature variation than the supporting structure and this should also be allowed for. Be particularly aware that building frames, especially in timber or reinforced or pre-stressed concrete can move appreciably after construction.

Insulation requirements, the need for special types of glass required in certain situations and security requirements are not matters which are covered by the Design Certificate, but it is prudent to recognise where these requirements may apply and ensure that any resulting physical needs are transmitted as part of the specification.

3. British Standards

BS 6262:2005[1] Parts 1 to 7 cover the design and construction of vertical glazing for buildings. They cover calculation of wind loads and treatment of impact loads and include where glass fins are used structurally as part of the glazing. Although Part 4 gives guidance on 'human impact' at critical locations on glazed screens it does not cover situations where glazing is used as a barrier, such as over a change in level, to restrain persons, or security requirements. For barrier loadings refer to BS 6399-1:1996[5] and BS 6180:2011[9].

It should be noted that BS 6262 Part 5 (Code of practice for frame design considerations) is not yet available and that it is unclear when it will be published.

BS 5516[2] Parts1 and 2 cover vertical and sloping Patent Glazing systems. They cover calculation of wind loads and the glass sizing and give advice on the support system. As in BS 6262 they do not cover where the glazing is used as a barrier or security implications.

Both BS 6262 and BS 5516 include methods of determining the wind pressure based on BS 6399-2[6]. BS 5516 also covers imposed loading, referring to BS 6399-3[7]. These requirements are interpreted specifically for window design, and tend to use the 'worst case' option to cover all elements.

Where the glazing system falls outside the provisions of these two codes the design will need to comply with material codes and good practice, though it is probable that the guidance given the codes will be relevant. Wind loads will be calculated to BS 6399-2[6].
Safety requirements for the glazing system are covered by BS 8213[10].

There are currently no Eurocodes relating to the design of windows or glazing systems and the existing British Standards on Glazing make no reference to Eurocodes. For consistency Certifiers/Designers may however elect to use the loadings given in BS EN 1991-1 (including the National Annexe) in place of BS6399 when Eurocodes are being used in the design of the Primary Structural elements.

4. The Role of the Certifier

The role of the certifier is essentially to ensure that there is sufficient design information to ensure that the glazing systems, and their connections to the primary structure, have been designed for the appropriate loadings by competent persons in accordance with the relevant standards and Codes of Practice and that "interface issues" between building elements, such as deflections, tolerances and differential movement have been suitably addressed.

Clearly glazing, such as is covered by BS 6262, is generally used in situations carrying a low risk and the Certifier needs do no more than ensure that the supplier is briefed regarding the appropriate Standard provided with sufficient information to establish the wind loads. The wind design provisions in both British Standards are limited to heights above ground not exceeding 15 m and above this wind loads will need to comply with BS6399-2:1997 or BS EN 1991-1-4. It is expected that glazing to a house, including patio doors, will generally come within the provisions of BS 6262, and need no further action by the Certifier other than ensuring that the Standard is specified.

Section 5 (below) sets out a Risk Assessment methodology by which certifiers may make a reasoned and informed assessment of the risks associated with each of their projects and provides guidance on the actions which should be taken when assessing projects which involve higher risk categories.

BS 5516 considers pane sizes up to 20 m^2, depending on method of support. However, systems complying with this Standard will involve some level of structural design that will require scrutiny by the Certifier. The design must include for the supporting structure, how this is attached to the primary structure, provision for tolerances and relative movement between the two and all relevant load situations.

Further, it is possible that some aspects of such glazing have special requirements, such as acting as a barrier, and provisions for compliance with these should always be subject to scrutiny.

The certifying engineer may not be sufficiently experienced in glazing systems design to undertake a check personally. It is also possible that justifying calculations by a supplier are inadequately checked, if at all. While compliance with BS 6262 and BS 5516 will be relatively straightforward to check, the Certifier will need to consider if this delivers the necessary level of reassurance appropriate to the risk. For more complex systems, and those not covered by those Standards it may be necessary to request that an independent check is carried out.

5. Certifying

Before issuing a Structural Design Certificate for a building the certifier should consider the building type and the size and location of glazing panels and carry out further investigations, design and/or specification, as necessary in accordance with a suitable Risk Assessment of the particular circumstances and requirements of the particular project/glazing element.
Items affecting the Risk categorisation include:

1. The inclination of the element (vertical/horizontal/inclined)
2. Size of the glazing element (frame)
3. Size of a single pane
4. Height of glazing above ground level
5. Does the glazing form a barrier?
6. Ownership/public access to land immediately outside building

Low Risk	Medium Risk	High Risk
Glazing Panels are Vertical.	All inclined or horizontal Glazing Panels.	Building/glazing which falls outside range of BS6262:2005 or 5516:2004.
AND	**OR**	**OR**
Window does not constitute a barrier.	All glazing (internal or external) which constitutes a barrier.	All point fixed glazing systems.
AND	**OR**	**OR**
Window panes are rectangular and supported on 4 sides.	All glazing whose highest point exceeds 6m AGL.	Any unitised systems, innovative glazing systems or design approaches.
AND	**OR**	
Top of highest window < 6m AGL.	All glazing panels which exceed $8m^2$ in area.	
AND	**OR**	
Individual glazing panels < $8m^2$ in area.	All glazing panels with the effective area of individual panes > $4m^2$.	
AND	**OR**	
Individual panes of glass with effective areas < $4m^2$.	Land for 0.5 x building height beyond face of building is normally accessible to the general public.	
AND	**OR**	
Mullions are not required to sustain/transmit externally applied vertical loads (e.g. bay windows or openings where lintels require intermediate support).	Mullions required to transmit externally applied vertical loads (e.g. bay windows or openings where lintels require intermediate support). .	

AND	AND	
Building falls into RC-1 category in accordance with SER TB-2.	Glazing and Building falls within range of BS6262:2005 or 5516:2004.	
AND		
Land for 0.5 x building height beyond face of building not normally accessible to the general public.		

Certifiers also need to clearly understand that consideration of glazing is not related simply to the glass panels but also includes the supporting framework AND fixings back to the primary structure. It will also be necessary to check that the design of the primary structure includes allowance for the appropriate resulting loads and that deflections, tolerances and provision for differential movement between each of the components, are compatible.

Actions required by certifiers for "low risk" situations

Where glazing falls into the "low risk" category as described above it will be considered sufficient for the certifier to ensure that the glazing elements, (panes, frames and fixings) are specified to comply with BS6262:2005 and/or BS5616:2004 in the drawings submitted with the design certificate. No further design substantiation will normally be required and certificates can be signed off on the basis of relevant standards having been specified on the plans specification listed on the design certificate.

Actions required for "medium risk" situations

Where glazing falls into the medium risk category as described above it is anticipated that the glazing will normally be designed by the manufacturer/supplier (however this does not preclude the certifier carrying out the design themselves - or checking the designs of others - prior signing the warrant if they so desire (and have sufficient knowledge and experience).

Where the glazing is being designed by the manufacturer/supplier it is obviously beneficial if the Certifier has the opportunity to contribute to the design brief/specification given to the supplier, particularly in respect of the specification of the loads which are appropriate for the site location and conditions (design wind speed, location, altitude and site factors etc). If that is not the case particular care is required when checking or reviewing the design.

The derivation of wind loading in accordance with BS6262 is relatively simple and uses a conservative approach to avoid the complexities involved in BS6399 and Eurocode 1[11]. Where BS 6399, or Eurocode 1, is being used to derive the relevant wind loading a simple reference to, for example, "loading to BS 6399-2" in the design specification is unlikely to be sufficient as the site parameters etc require to be identified such that a remote supplier has the relevant information to enable him to prepare an appropriate design. Similarly the use of appropriate local Cpe values and a suitable value for "a" (largest diagonal dimension of the loaded area envelope) to BS6399 part 2 should be specified, or used in the derivation of the loads specified. In such cases it may therefore be advantageous to quote the design wind pressure to be sustained by the glazing, based on a worst case scenario, directly in the specification.

Prior to issuing a design certificate for the project the certifier should:

- obtain copies of the supplier's/manufacturer's design calculations and details (including fixings back to the primary structure)
- satisfy themselves that these have been carried out by a suitably competent person most designers working for glazing firms do not hold formal qualifications (such as CEng, IEng or TechEng) and may not be used to working with BS6399 part 2. Certifiers may therefore need to make their own judgement as to the designer's level of competence against the requirements of each individual project.
- ensure that the design has been carried out to the relevant standards and loadings (dead, wind, imposed, maintenance, impact etc)
- confirm that the calculations have been checked (or carry out checks as required)
- satisfy themselves that the design and details are compatible with that of the supporting elements of the building (including appropriate deflections, tolerances and provision for differential movement)
- record that these options have been certified using options 2 or 3 (SER Jersey Guidance Note 2) in Schedule 3 of the Design Certificate

N.B. suitable accredited test results, which are appropriate to the panel size, aspect ratio and loading of the elements under consideration, may be accepted in the place of design calculations.

Actions required for High Risk Situations

Where glazing falls into the "high risk" category it is unlikely that most certifiers will have sufficient experience of the design of glazing to be able to determine if the design of the glazing elements meets the requirements of the building bye-laws.

In such circumstances the advice of an acknowledged expert should be sought, either to carry out, or confirm, the design.

In these circumstances the certifier should:

- satisfy themselves of the relevant expertise of the "expert"
- satisfy themselves that the design has been checked by a suitably experienced individual
- obtain copies of the supplier's/manufacturer's design calculations and details (including fixings back to the primary structure)
- ensure that the design has been carried out to the relevant standards and loadings (dead, wind, imposed, maintenance, impact etc)
- confirm that the calculations have been checked (or carry out checks as required)
- satisfy themselves that the design is compatible with that of the supporting elements of the building
- record that these elements have been certified using Option 4 (SER Jersey GN2) in Schedule 3 of the certificate

Alternatively suitable accredited test results, which are appropriate to the panel size, aspect ratio and loading of the elements under consideration, may be accepted in the place of design calculations.

6. Bibliography

Eurocode equivalents are given where known. National Annexes are referred to as NA.

1. BS 6262:2005 “Glazing for buildings”.

   Part 1: General methodology for the selection of glazing

   Part 2: Code of practice for energy, light and sound

   Part 3: Code of practice for fire, security and wind loading

   Part 4: Code of practice for safety related to human impact

   Part 5: Code of practice for frame design considerations (not yet published)

   Part 6: Code of practice for special applications

   Part 7: Code of practice or the provision of information

2. BS 5516:2004 “Patent glazing and sloping glazing for buildings”

   Part 1: Code of practice for design and installation of sloping and vertical patent glazing

   Part 2: Code of practice for sloping glazing

3. DRAFT prEN 13474 “Glass in buildings – Design of glass panes”

   Part 1: General basis of design

   Part 2: Design of uniformly distributed loads

4. “Structural use of glass in buildings” published by the Institution of Structural Engineers; 1999.

5. BS 6399-1:1996: “Loading for buildings – Code of practice for dead and imposed loads”
   (Superseded by: BS EN 1991-1-1:2002: and NA –“Actions on structures. General Actions. Densities, self-weight, imposed loads for buildings” but still in use.)

6. BS 6399-2:1997: Loading for buildings – Code of practice for wind loads
   (superseded by: “BS EN 1991-1-4:2005: and NA - Actions on structures. General Actions. Wind actions” but still in use.)

7. BS 6399-3:1988: Loading for buildings – Code of practice for imposed roof loads
   (Superseded by: “BS EN 1991-1-3:2003: and NA - Actions on structures. General Actions. Snow Loads” but still in use.)

8. Overend, M: ‘Recent developments in design methods for glass structures’ Structural Engineer, 88 (14) 20th July 2010, p18-26.

9. BS 6180:2011 “Barriers in and about buildings. Code of practice”

10. BS 8213: “Windows doors and rooflights”.

    Part 1:2004: Design for Safety in use and during cleaning of windows, including door-height windows and roof windows. Code of Practice.

    Part 2: 2007: Code of practice for the survey and installation of windows and external doorsets.

11. BSEN 1991-1-4:2005 Eurocode 1: Actions on structures- Part 1-4: General actions – Wind actions (including the UK National Annexe).

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