Guidelines for
USE OF PVC-U WINDOWS AND FRAMES IN COMMERCIAL / LIGHT INDUSTRIAL APPLICATIONS

(REFERENCE 351/1 FEBRUARY 1995)
COMMITTEE

These Guidelines have been prepared by a Working Party of the British Plastics Federation Windows Group.

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FOREWORD

These Guidelines are concerned with the design, materials, construction and performance requirements of light duty curtain walling incorporating PVC-U windows in commercial and light industrial applications.

These Guidelines have been prepared for both specifiers and manufacturers. They apply to large areas of fenestration which are outside the scope of BS 6375 : Part 1 : 1989 'Performance of Windows - Classification for weathertightness'.

The current de-facto British Standard for curtain walling is produced by the Centre for Window and Cladding Technology (CWCT) and gives most of the requirements for the product. The January 1993 edition of the CWCT 'Standard and Guide to Good Practice for Curtain Walling' (CWCT Standard) is applicable to systems based on the insertion of PVC-U windows and applies to most products covered by these Guidelines. These notes are in addition to the CWCT Standard for the specific case of PVC-U frames and do not in any way conflict with them.

Compliance with these Guidelines does not of itself confer immunity from any legal obligations.

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**Appendices**

- Appendix 1 - Simplified Wind Pressure Map of the UK
- Appendix 2 - Sample Trapezoidal Load Calculation

**Standards Referred To**
1.0 Scope

These Guidelines are confined to PVC-U fenestration systems in any of the following forms:

(a) Separate vertical and/or horizontal members fixed to the building structure, which support intermediate members inserted between them on site.

(b) Separate vertical and/or horizontal members fixed to the building structure which support framed infill.

(c) Factory assembled units.

These Guidelines do not include PVC-U fenestration forming sloping or overhead glazing, where snow loads, additional drainage and different safety requirements need to be considered. Fenestration in sloping or overhead applications is covered by BS 5516 which deals with patent glazing.

These Guidelines cover PVC-U fenestration and curtain wall systems where the members are continuous from ground level to no more than 12m above ground level or, if the members are fixed between floor spans, where the length of any of the vertical members does not exceed 5m. Further details of recommended heights and fixing distances are given later in these Guidelines (See section 3.4).

2.0 Definitions

For the purposes of these Guidelines the definitions given in BS 6100 generally apply plus the following specific definitions:

Curtain Walling
Curtain walling is a form of vertical building enclosure which supports no load other than its own weight and the environmental forces which act upon it.

Design Wind Pressure
The wind pressure that can be expected on a surface of a building having taken into account the topography, ground roughness, building height above ground and the shape of the building by applying pressure coefficients to the dynamic pressure of the wind (see CP3, Chapter V, Part 2).

Fixing
Any item that is used to secure separate members of the system to each other, or to secure the system to the building structure.

Ribbon Walling
A form of curtain walling comprising of a length of PVC-U panels that does not exceed 3m in height but may be of any length. Ribbon walling is broken into smaller panels of up to 3m in length by the inclusion of thermal expansion joints. To avoid repetition the term 'curtain walling' has been used in this document when the Guidelines apply to ribbon walling.

Water Leakage
The penetration of water onto the internal face of the curtain wall or into parts of the curtain wall that would be adversely affected by the presence of water. The term 'gross water leakage' means that the infiltration of water is such that it will cause damage to the fabric of the building.

3.0 Design and Construction

3.1 General

The curtain walling system should be designed to meet the weathertightness and other performance requirements in Section 6 of these Guidelines.

These Guidelines apply to the basic form of curtain walling where the resistance to weather penetration is achieved by sealing the outer joints, using sealants or gaskets.

Some systems have provision for drainage of water which may enter the system. A typical example is the drainage of hollow sections such as at the bottom of mullions.

3.2 Structural Tolerances and Deflections.

Curtain walling should be designed, manufactured and then erected in such a manner as to be functional, visually acceptable, and allow sufficient clearances to accommodate the manufacturing tolerances and thermal movement.

The specifier should state the amounts to be accommodated by the framing and fixings in respect of:

(a) the structural construction tolerances.

(b) any structural differential deflection movements between floors, or other movements, including liveload deflections and settlement of the building structure.

The manufacturer should agree all tolerances to be catered for in the design with the specifier.

3.3 Manufacturing and Erection Tolerances

The manufacturer should state, if requested, the manufacturing work sizes and erection tolerances.

3.4 Recommended Maximum Heights

The recommended maximum overall height of individual component members is dependent on whether the span is inter-floor or intra-floor.
Inter-floor spans are where the curtain wall is fixed to the outside of the building face and extends along the face of the building. This type of construction is defined by BS 8200 as a 'sheath wall'. In such cases intermediate fixings to the building are generally available but the maximum recommended vertical length of product is 12m from ground level.

The curtain wall and glazing should be constructed and installed with sufficient clearances and, where necessary, expansion joints incorporated to allow for thermal expansion and contraction without buckling, distortion of joints, or damage to sealants or other components.

Changes in the dimensions and shape of a component resulting from changes in air or surface temperature should not adversely affect the performance of the curtain walling specified elsewhere in the Guidelines.

For design purposes external air temperatures of -20°C to +35°C and internal air temperatures of 0°C to +30°C should be used. Surface temperatures may vary from these (see section 3.5.1).

3.5.1 Thermal Movement of the Curtain Wall

Thermal movement will depend on the difference between the two extreme temperatures of the curtain wall members.

This temperature differential is dependent on variables, including the following:

i. The location i.e. whether in shade, partial sunlight, or full sunlight.

ii. Colour and texture of the exposed surface.

iii. The shape and dimensions of the members, namely the percentage of surface area of a member on the outside of the glazing line to that on the inside and the cross section area of the connection between the outside and inside surfaces.

iv. The internal temperature of the building.

For expansion and contraction an allowance of +/-1mm per metre length should prove satisfactory.

The thermal movement of the curtain wall should be considered in conjunction with thermal movement of the building structure.

In considering the thermal movement at curtain wall joints, allowance must be made for the movement of the jointing materials.

3.5.2 Condensation Control

For condensation control an external air temperature of -5°C and an internal air temperature of +21°C should be assumed unless others are specified and agreed.

The specifier should state the thermal performance required of the curtain wall infills.

Curtain walling systems are not normally claimed to
have any specific performance in respect of condensation.

Condensation should not form on the building interior surface of any framing members prior to the formation of condensation on the interior surface of any double glazing unit contained in the vision areas of the curtain wall.

In the event of condensation occurring it should not cause any damage to the structure or system.

3.6 Resistance to Corrosion

The possibility of electrochemical corrosion occurring from the proximity or abutment of dissimilar metals should be assessed at the design stage. Metals which are well separated in their electrochemical series and present the possibility of galvanic corrosion should be separated from each other by the use of insulating materials such as PVC tape or other plastics or neoprene pads or spacers, or low permeability paint finishes (e.g. bitumen or pitch).

The highly alkaline nature of concrete means that the possibility of corrosion of certain non-ferrous metal components (e.g. aluminium or zinc) abutting concrete should be considered.

Note 1: Crevices at metal to metal joints should be avoided as such locations are prone to the development of corrosion.

Note 2: Galvanic corrosion will only occur with the presence of moisture, particularly if this contains pollutants. Extra care should be taken in marine atmospheres.

Note 3: To minimise corrosion arising from electrolytic reaction, metals which are in contact with each other should only be used in combinations which have ratings 0 or 1 for atmospheric environments given in PD 6484 or are otherwise protected to prevent electrolytic reaction.

3.7 Fire Resistance

PVC-U curtain walling systems normally have no significant fire resistance and are classed as an unprotected areas.

It is the specifier's responsibility to ensure that the specification is so compiled that when it is strictly adhered to the resultant curtain wall will comply fully with all appropriate regulations, concerning the spread of fire and/or smoke and fumes within a building, not only from floor to floor but also from one floor area to another on the same floor.

3.8 Security

Glazing, infill panels and other components should be designed to inhibit unauthorised removal.

In areas where high security is a requirement, the curtain walling system should be regarded as the last and not the first line of defence.

3.9 Fixings

Fixings are of two basic types:

(a) those that are firmly attached to the building structure and the curtain walling and are intended to resist loads applied in any direction.

(b) those designed to permit movement in the plane of the curtain walling, for example, thermal movement.

Fixing points in concrete structures should be positioned clear of reinforcing bars. The penetration and positioning of the fixings should be in accordance with the bolt manufacturers recommendations. When fixing to steel members the beams to which the fixings are applied should have adequate torsional strength, in addition to vertical and lateral stability.

All fixings and ties should be adjustable in all planes to accommodate:

(a) agreed building tolerances, including tolerances in fixing position.

(b) manufacturing tolerances of the curtain wall.

(c) erection tolerances.

(d) building movements (settlement e.g. floors, shrinkage, thermal, etc.) agreed and advised by the specifier.

(e) framing thermal movement.

Suitable clearances must be allowed to accommodate the above items and provision should be made for final securing of the fixing after adjustment.

In all such cases the degree of movement to be accommodated must be given by the specifier and agreed by the curtain walling manufacturer.

Note 1: With concrete construction it is reasonable to consider a deviation of +/− 10mm on the floor to floor dimensions and +/− 10mm between bays.

Note 2: Reinforced concrete structures are subject to shrinkage and creep movements, which can continue for several years after a building has been completed. Specific data should be obtained from the specifier.

3.9.1 Anchorage of Curtain Walling

Fixing points in the building structure should be located on the top of the floor slab positioned clear of reinforcing bars and with the reinforcement between the anchor and the outside face of the structure. The penetration of the fixing should be greater than the concrete cover to the reinforcement.
Fixing points on the face or underside of floor slabs may present difficult locations in which to work and sometimes requires the use of scaffolding and/or ladders. The use of such fixing points should be limited.

3.9.2 Performance

The fixing method should be capable of resisting the calculated weight of the subject material and the loads applied to it during fixing and use.

Combined stresses must also be considered and loads from cleaning cradles should not be overlooked.

3.9.3 Material to Accept Fixing

The material to which the fixing is made should be capable of resisting the forces exerted by plug expansion, expansion bolts, or the load transmitted by cast inserts. This should be established by the specifier from the data provided.

Care must be taken not to over-tighten fixings.

3.9.4 Tolerances

Due allowance must be made for manufacturing tolerances, agreed tolerances in the structure, and location of components.

3.10 Ancillary Members

The specifier should state whether the curtain walling should include components as appropriate to enclose the structure, such as copings at roof levels, soffit closers, jamb and column closers, sill members, internal trims and window boards.

Where such components are required to provide an air and/or water seal, they should be designed so that their joints provide the specified performance.

3.11 Fixed and Opening Lights

All fixed or opening lights should be in accordance with BS 7412.

Windows should be reinforced according to the recommendations of the BPFWG Code of Practice for the Reinforcement of High Impact Modified PVC-U Windows and Doors (Ref. 323/1) or the system supplier’s recommendations.

3.12 Requirements for Glazing

The curtain walling design should be capable of being glazed in accordance with BS 6262.

The glazing should be selected in accordance with the specified safety requirements from the recommendations given in BS 6262. Anti-bandit glazing to BS 5544 may be specified where a high degree of physical protection either to person or property is required.

3.13 Cleaning and Maintenance

The specifier should give consideration for the provision of access for cleaning and maintenance of the curtain walling system at the design stage.

Note: A curtain wall needs maintenance by regular cleaning. The frequency of cleaning depends on the local conditions and the recommendations of the curtain wall manufacturer.

3.14 Durability

The curtain walling should satisfy the performance criteria for the full stated design life provided that maintenance has been carried out as specified by the manufacturer.

Unless otherwise stated the curtain walling framing should be designed for a life of 30 years. Some components and materials used which do not affect the structural performance of the system may have a shorter life, for example, finishes and sealants, gaskets, sealed insulation glazing units etc.

4.0 Survey and Installation

4.1 Surveying

Surveying should take place generally in accordance with the BPFWG Code of Practice for Surveying (Ref. 347/1) and the relevant sections of the CWCT Standard, as agreed with the specifier.

4.2 Installation

Installation should take place generally in accordance with the BPFWG Code of Practice for Installation (Ref. 348/1) and the relevant sections of the CWCT Standard as agreed with the specifier.

Installation of curtain walling is generally a major project and requires a degree of technical management which is not normally required in conventional window replacement programmes. It is strongly recommended that additional controls such as increased training and site supervision be implemented to ensure that the project is managed in a professional manner. Section 9 of the CWCT Standard gives guidance on the controls and requirements for installation.

The skill of the installers carrying out the project is critical to a good installation. The CWCT has introduced a training programme which provides installers with core knowledge on curtain walling and product knowledge on specific systems. This programme results in installer certification for systems and a registration scheme for approved installers.
Specifiers are advised to seek assurance from the contractor that installers have been trained on the basics of curtain wall installation and have the required product specific knowledge.

4.2.1 Visual Quality of the Installation

Although details may be inspected closely during assembly and/or installation, the general appearance should be assessed from distances from which the curtain walling will be viewed on completion, for example, externally from ground level or other levels that provide normal access.

The assessment procedure should be agreed with the specifier prior to contract acceptance.

5.0 Materials

5.1 PVC-U

The materials used for unplasticised PVC products should comply with the materials requirements given in Table 1 of BS 7413 or Table 1 of BS 7414.

Extruded profiles for use in the manufacture of white PVC-U windows with heat welded joints should comply with the requirements of BS 7413 or BS 7414 depending on the material used.

Windows manufactured from PVC-U profiles should meet the requirements of BS 7412.

5.2 Aluminium Alloy Reinforcement and Framing

Extruded aluminium members should be fabricated from the most appropriate grade of designated alloys complying with BS 1474 (e.g. alloy 6063 - condition T6, T5 or T4 or alloy 6082 - condition TB, TE or TF).

Members and infill panels formed from sheet materials should be fabricated from designated alloys complying with BS 1470 (eg. 1200, 3103 or 5251) in a temper suitable for the particular type of application, degree of forming and finishing process to be adopted.

Aluminium profiles used for the structural framing members (excluding glazing beads, nibs, interlocks and similar features) should be designed in accordance with the guidelines given in BS 8118 and should satisfy the structural requirements of the particular application.

Aluminium members that are visible on completion of the installation may be finished by one of the following:

(a) anodising complying with BS 3987.

(b) a powder coating complying with BS 6496.

(c) a powder coating complying with BS 6496.

Assessment of colour matching of anodising should be made by comparison with samples of upper and lower colour limits submitted and agreed prior to manufacture.

Note 1: The specification given in b) can be used to specify Polynonylifugene Fluoride finishes.

Note 2: Where integral colour anodised finishes are required, special aluminium alloys that are not covered by the stated standards can be used, provided that they meet the required physical properties of the standards.

Note 3: Reinforcement for PVC-U frames should comply with the requirements of BS 7412.

5.3 Steel Reinforcement and Framing

Where steel is used as reinforcement of the curtain wall framing members or as a framing member it should be either:

(a) hot rolled steel that, when tested in accordance with BS EN 10 002-1 has an ultimate tensile strength of 355 N/mm² to 510 N/mm², or

(b) mild steel sheet complying with BS 1449: Part 1 (Grade HR 14).

All steel reinforcement should be hot dip galvanized after manufacture in accordance with BS 729 to a minimum coating mass of 460 g/m². Alternatively, pre-galvanized sheet may be used in areas where moisture is unlikely to form, or rust proofing by the application of paint or other surface treatment may be permissible.

Note: Reinforcement for PVC-U frames should comply with the requirements of BS 7412.

5.4 Framing Assembly Components

Where framing members are connected together with cleats, sleeves, spigots and the like, these should be fabricated from one of the following:

(a) aluminium of an alloy having mechanical strength properties at least equal to those described in Section 5.2 (above) or

(b) zinc diecasting complying with BS 1004 (Alloy A).

(c) stainless steel complying with Table 4 of BS 1449 Part 2. Stainless steel to be used externally should be of grade 316.

(d) mild steel meeting the requirements of Section 5.3.
5.5 Fixings

Fixing bolts, screws and nuts for framing members should be manufactured from one of the following:
(a) stainless steel complying with BS 6105 (Grade A2).
(b) mild steel bolts complying with BS 4190, rustproofed to BS 6338.
(c) aluminium alloy complying with BS 1474.

Straps, clips, brackets, lugs, washers, shims and other such fixings should be manufactured from one of the following:
(a) stainless steel complying with Table 4 of BS 1449 Part 2. Stainless steel to be used externally should be of grade 316.
(b) steel complying with BS 1449 Part 1 which has one of the following finishes:
   (i) zinc plated complying with classification number Zn3 or Zn10 of BS 1706 and chromate passivated complying with 1C or 2D of BS 6338.
   (ii) hot dip galvanizing complying with BS 729 to a minimum coating mass of 460 g/m².
   (iii) sprayed with a zinc coating complying with symbol Zn4 of BS EN 22063.
   (c) aluminium - The alloy should have mechanical strength properties at least equal to those described in Section 5.2 (above).
   (d) other materials - Fixing of other materials may be used, if they are appropriate for the required performance.

Note: Hardware and fixings for PVC-U window components should comply with the requirements of BS 7412.

5.6 Glass

Glass thickness and type should be selected, using the recommendations given in BS 6262, BS 952 and where relevant BS 5544, to withstand the calculated design wind pressure and any other specified requirements, for example safety.

Double glazing units should comply with BS 5713.

5.7 Infill Panels

The specification for materials and finish of infill panels including any thermal insulating materials should be agreed between the specifier and supplier. Where aluminium faced panels are used they should be in accordance with Section 5.2 (above).

The panels should be capable of resisting the loads imposed by the wind and glazing method without causing loss of performance of the curtain walling.

5.8 Perimeter Joint Sealing.

Joint sealing materials between the curtain walling and the building structure should be of a type suitable to form a seal against air and water penetration whilst catering for differential movements.

Guidance on the selection and application of sealants is given in BS 6213 and sealants should be selected from:
(a) Polysulphide sealants complying with BS 4254 or BS 5215.
(b) Polyurethane sealants complying with the test regimes of BS 4254 (two part products) or BS 5889 (one part products).
(c) Silicone sealants complying with BS 5889.

Note: There are no British Standard specifications for polyurethane sealants.

5.9 Frame Joint Sealing

Joint sealing materials within the framing should withstand stresses during assembly, transportation, installation and provide an air and watertight seal in service. The materials may be those listed in Section 5.8 (above) or other including:
(a) tapes or other compressible pads
(b) small joints sealants.
(c) adhesives

They should be selected for their suitability for the joint design and performance required.

5.10 Glazing Joints

Gaskets and weather stripping should conform to the performance and functional requirements of the BPFWG Standard for Gaskets and Weather Strips for Windows, Doors and Curtain Walling (Ref. 345/1).

Note: This Standard is an extension of the requirements of BS 7412 and products conforming to Table 1 of BS 7412 will comply with this requirement.

6.0 Testing and Performance Requirements

6.1 General

The relevant performance requirements for windows
are described in BS 6375: Parts 1 and 2. Testing of these products is carried out in accordance with BS 5368: Parts 1, 2 and 3 for air permeability, watertightness under static pressure and wind resistance respectively.

Whilst the general test methods given in these standards are considered appropriate it is generally accepted that the performance requirements of curtain walling should be more carefully assessed. The Centre for Window and Cladding Technology have produced the Standard and Guide to Good Practice for Curtain Walling which details more specific requirements for the performance of curtain walls. The page numbers of the CWCT Standard referred to in this document relate to the January 1993 edition.

These performance requirements apply to the whole area of the curtain wall including all junctions between it and adjacent structures, perimeter detailing, infill panels and perimeters of window frames etc.

6.2 Air Permeability

When tested in accordance with the CWCT Standard: Appendix B: Clause 4 (Page 81) the curtain wall shall satisfy the requirements of the CWCT Standard: Part 1: Clause 2.10 (Page 17).

6.3 Watertightness (Static Pressure)

When tested in accordance with the CWCT Standard: Appendix B: Clause 5 (Page 82) the curtain wall shall satisfy the requirements of the CWCT Standard: Part 1: Clause 2.11 (Page 19).

6.4 Wind Resistance (Serviceability)

When tested in accordance with the CWCT Standard: Appendix B: Clause 8 (Page 87) the curtain wall shall satisfy the requirements of the CWCT Standard: Part 1: Clause 2.12 (Page 20).

6.5 Wind Resistance (Safety)

When tested in accordance with the CWCT Standard: Appendix B: Clause 9 (Page 88) the curtain wall shall satisfy the requirements of the CWCT Standard: Part 1: Clause 2.13 (Page 22).

6.6 Discretionary Test Performance

The CWCT Standard: Part 1: Section 2 gives extensive detail relating to the acceptable performance of the curtain wall with respect to such items as dynamic pressure watertightness, building movement, thermal cycling, site hose testing, ultimate strength, etc. These criteria will apply only as and when specified by the client/specifier.

6.7 Strength Properties

6.7.1 Assessment of Wind Pressure and Suction

The specifier should state the design wind pressure which can be determined in accordance with CP 3, Chapter V, Part 2. A chart has been produced to assist in this and is shown in Appendix I of these Guidelines. In some cases it may be necessary to adjust the figures to allow for a dominant opening or to account for local micro-climates as indicated in CP 3: Chapter V: Part 2, Appendix E (2).

6.7.2 Distribution of Wind Pressure and Suction

It is assumed that the wind pressure and suction will be distributed on the basis of 4 edge support to the various supporting members in the form of trapezoidal loads. This is shown in Appendix 2 of these Guidelines.

6.7.3 Resistance to Windloads

The curtain walling should be capable of resisting the design wind pressure calculated by the method described in CP3 Chapter V Part 2.

When tested in accordance with the method described above, at the design wind pressure, the maximum deflection of framing members should be span/200 or 20mm whichever is the lesser measured between points of attachment to the building.

Note 1: Some insulating glass unit manufacturers place a further restriction on the deflection of the unit edge.

Note 2: CWCT Standard: Clause 2.12.3 (Page 21) should also be noted.

6.7.4 Resistance to Deadloads

The maximum vertical deflection of any horizontal member at mid span should not exceed 5mm.

In some circumstances, it may be necessary to reduce this, e.g. to allow for the use of certain fittings for inserted ventilator frames etc.

The points which should be considered when determining the effect of dead loads are:

i) Deflections due to dead loads from various ventilator frames or transmitted by glazing setting blocks.

ii) The amount of edge clearance around any glass or infill panel.
6.8 Test Requirements

6.8.1 Test Specimen

Details of the test specimen are given in the CWCT Standard: Part 1: Section 3, Testing (Page 35). Particular attention should be given to Clause 3.3 (Page 36).

6.8.2 Type Testing / Product Development

The specimen shall be of sufficient size to establish that all typical elements of curtain wall are capable of complying with the specified performance criteria.

For inter-floor testing the current CWCT proposals require a sample size of 7.5m wide by 8.0m high.

For intra-floor designs the sample to be tested should be the maximum recommended height by 3 bay widths. The systems supplier’s recommendations are to be sought in defining the test sample.

6.8.3 Contract Specific Testing

Under exceptional circumstances the specimen may be subjected to contract specific testing. In this situation the test sample should comply with the requirements of the CWCT Standard: Appendix B: Clause 3 (Page 80) and the details given in 6.8.1 above.

6.8.4 Sequence of Testing

The specimen shall be tested in accordance with the sequence given in the CWCT Standard: Part 1: Clause 3.8.1 (Page 39) Standard Sequence A, or, where special circumstances apply, Clause 3.8.2 (Page 39) Standard Sequence B.

It is anticipated that a typical sequence of test will be in accordance with the CWCT Standard Sequence A i.e.,

Air permeability

Watertightness

Wind Resistance (Serviceability)

Repeat air permeability

Repeat watertightness

Wind resistance (Safety)
APPENDIX 1 - SIMPLIFIED WIND PRESSURE MAP OF THE UK
(for use with inter-floor types of curtain walling)

Wind pressures for building height up to 12m from ground level.

<table>
<thead>
<tr>
<th>Wind speed (m/s)</th>
<th>Building height (m) less than</th>
<th>Ground roughness category (S2)</th>
<th>Ground pressure (W) (Pa)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>37</td>
<td>5</td>
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<td>960</td>
<td>773</td>
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<td>5</td>
<td>1062</td>
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<td>1373</td>
</tr>
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<td>1172</td>
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</tr>
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<td>1808</td>
<td>1514</td>
</tr>
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<td>1037</td>
</tr>
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<td>12</td>
<td>1782</td>
<td>1661</td>
</tr>
<tr>
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<td>5</td>
<td>1406</td>
<td>1133</td>
</tr>
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<td>12</td>
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<td>5</td>
<td>1531</td>
<td>1234</td>
</tr>
<tr>
<td></td>
<td>12</td>
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<td>1977</td>
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<td>1797</td>
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<td>2321</td>
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<td>2654</td>
<td>2503</td>
</tr>
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<td>1680</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>2855</td>
<td>2691</td>
</tr>
</tbody>
</table>
APPENDIX 2 - SAMPLE TRAPEZOIDAL LOAD CALCULATION

Required rigidity $E_{xx} \times 10^9$ Nmm$^2$ due to wind load.

$$
E_{la} = \frac{W \times a \times L^4}{1.92 \times 10^9 \times f} \left[ 25 - 40 \left( \frac{a}{L} \right)^2 + 16 \left( \frac{a}{L} \right)^4 \right]
$$

$$
E_{lb} = \frac{W \times b \times L^4}{1.92 \times 10^9 \times f} \left[ 25 - 40 \left( \frac{b}{L} \right)^2 + 16 \left( \frac{b}{L} \right)^4 \right]
$$

$$
E_{xx} = E_{la} + E_{lb}
$$

$W$ = Wind pressure (Pa)

$f$ = Maximum allowable deflection (L/200)

$L$ = Length of mullion or transom (mm)

$a$ = Load width (mm)

$b$ = Load width (mm)

**Worked example**

$W = 2000$ Pa

$L = 3000$ mm

$a = 600$ mm

$b = 600$ mm

$f = L/200 = 3000/200 = 15$ mm

$$
E_{la} = \frac{(2000)(600)(3000)^4}{1.92 \times 10^9 \times (15)} \left[ 25 - 40 \left( \frac{600}{3000} \right)^2 + 16 \left( \frac{600}{3000} \right)^4 \right]
$$

$$
E_{la} = \frac{9.720 \times 10^{19}}{2.880 \times 10^{10}} \left\{ 23.425 \right\}
$$

$$
E_{la} = 79.05 \times 10^9 \text{ Nmm}^2
$$

$$
E_{lb} = \frac{(2000)(600)(3000)^4}{1.92 \times 10^9 \times (15)} \left[ 25 - 40 \left( \frac{600}{3000} \right)^2 + 16 \left( \frac{600}{3000} \right)^4 \right]
$$

$$
E_{lb} = \frac{9.720 \times 10^{19}}{2.880 \times 10^{10}} \left\{ 23.425 \right\}
$$

$$
E_{lb} = 79.05 \times 10^9 \text{ Nmm}^2
$$

$$
E_{xx} = 158.12 \times 10^9 \text{ Nmm}^2
$$

Note: For full details on the calculation method and the assumptions made, please see the BPFWG Code of Practice for the Reinforcement of High Impact Modified PVC-U Windows and Doorsets (Ref. 323/1).
STANDARDS REFERRED TO:

BS 729 - Specification for hot dip galvanized coatings on iron and steel articles.
BS 952 : Part 1 - Glass for glazing.
BS 1004 - Specification for zinc alloys for die casting and zinc alloy die castings.
BS 1470 - Specification for wrought aluminium and aluminium alloys for general engineering purposes - plate, sheet and strip.
BS 1474 - Specification for wrought aluminium and aluminium alloys for general engineering purposes - bars, extruded round tubes and sections.
BS 1706 - Method for specifying electroplated coatings of zinc and cadmium on iron and steel.
BS 2569: Part 1 - Protection of iron and steel by aluminium and zinc against atmospheric corrosion.
BS 4190 - Specification for ISO metric black hexagon bolts, screws and nuts.
BS 4254 - Specification for two part polysulphide-based sealants.
BS 4842 - Specification for liquid organic coatings.
BS 5215 - Specification for one-part gun grade polysulphide-based sealants.
BS 5544 - Specification for anti-bandit glazing (glazing resistant to manual attack).
BS 5568 : Parts 1, 2 and 3 - Methods of testing windows.
BS 5713 - Specification for hermetically sealed flat double glazing units.
BS 5889 - Specification for one-part gun grade silicone-based sealants.
BS 6100 - Glossary of building and civil engineering terms.
BS 6105 - Specification for corrosion resistant stainless steel fasteners.
BS 6262 - Code of practice for glazing for buildings.
BS 6338 - Specification for chromate conversion coatings on electroplated zinc and cadmium coatings.
BS 6375 : Parts 1 and 2 - Performance of windows.
BS 6496 - Specification for powder organic coatings.
BS 7412 - Specification for plastics windows made from PVC-U extruded hollow profiles.
BS 7413 - Specification for white PVC-U extruded hollow profiles with heat welded corner joints for plastics windows : materials type A.
BS 7414 - Specification for white PVC-U extruded hollow profiles with heat welded corner joints for plastics windows : materials type B.
BS 8118 : Part 2 - Specification for materials, workmanship and protection.
BS 8200 - Code of practice for design of non-loadbearing external vertical enclosures of buildings.
BS 8233 - Code of practice for sound insulation and noise reduction for buildings.

BS EN 10 002-1 - Tensile testing of metallic materials : Method of test at ambient temperatures.
BS EN 22063 - Metallic and other inorganic coatings.
CP 3 : Chapter V : Part 2 - Loading - Wind loading.
PD 6484 - Commentary on corrosion at bimetallic contacts and its alleviation.

BPFWG Code of Practice for the Reinforcement of High Impact Modified PVC-U Windows and Doorsets (Ref. 323/1).
BPFWG Specification for Gaskets and Weatherstripping (Ref. 345/1).
BPFWG Code of Practice for Surveying (Ref. 347/1).
BPFWG Code of Practice for Installation (Ref. 348/1).