

Code of practice for

Design and installation of sloping and vertical patent glazing

Committees responsible for this British Standard

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- Flat Glass Manufacturers' Association
- Glass and Glazing Federation
- Institution of Structural Engineers
- Patent Glazing Contractors' Association
- Royal Institute of British Architects
- Royal Institution of Chartered Surveyors

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Foreword

This British Standard has been prepared under the direction of the Elements and Components (of Diverse Materials) for Buildings Standards Policy Committee. It is a revision of BS 5516:1977, which is withdrawn.

This edition gives recommendations for the use of plastics glazing sheet materials as infilling and contains more detailed advice about the structural design of patent glazing. Subjects not previously dealt with and now included are human safety, security, thermal safety and finishes of materials.

Assessed capability. Users of this British Standard are advised to consider the desirability of assessment and registration of a supplier's quality systems against the appropriate Part of BS 5750 by a third party certification body.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 62, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

0 Introduction

Patent glazing is the term applied to a self-draining and ventilated system of dry glazing which does not rely necessarily for its watertightness upon external glazing seals. It consists essentially of a series of longitudinal supporting members, i.e. patent glazing bars, and an infilling of glass or other suitable infill material. Patent glazing bars are attached to and supported by structural members, either directly or indirectly, but are not usually connected together in the form of a frame.

Patent glazing systems are described by the number of edges by which the infilling is supported by the supporting members.

- a) *Two-edge systems* are those in which the infilling is fully supported by patent glazing bars on two opposite longitudinal edges only. Horizontal flashings or other weatherings are normally provided at the top and bottom edges and between panes.
- b) *Four-edge systems* are those in which the infilling is fully supported by patent glazing bars on two opposite longitudinal edges and additionally on the other two edges by transverse supporting members.

1 Scope

This standard gives recommendations for the design, manufacture, installation and maintenance of sloping and vertical patent glazing systems attached to and supported by structural members of adequate strength, stiffness and stability. All the recommendations apply to flat, including faceted, patent glazing. The recommendations also apply to curved patent glazing except for the structural design of curved patent glazing.

The patent glazing systems included in this standard comprise supporting members of aluminium or steel for two-edge and four-edge systems for single and double glazing, and other components. A range of transparent and opaque infillings of glass, plastics glazing sheet and other materials is included; specific information on plastics glazing sheet materials is given in Appendix J.

This standard covers the use of patent glazing in permanent buildings and structures, other than greenhouses. Clauses which are relevant also apply to the use of patent glazing inside buildings.

The procedure for structural design given in this standard is based on permissible stress design. Limit state design may be used but is not included in this standard.

This standard does not include the design of the supporting structure to which the patent glazing is attached.

NOTE The titles of the publications referred to in this standard are listed on page 62.

2 Definitions

For the purposes of this British Standard the following definitions apply, together with the symbols in Appendix A.

2.1

aspect ratio of pane

ratio of the longer to the shorter side of a rectangular pane

2.2

butt joint

joint between edges of adjacent panes of infilling, usually horizontal and weathered by a came or sealant

2.3

came

non-loadbearing member used to weather a horizontal butt joint in a two-edge system of patent glazing

2.4

cap

strip, which may retain infilling, fitted over a patent glazing bar to impede direct water penetration (See Figure 1)

2.5

fastener

mechanical device for securing patent glazing to the supporting structure, or for connecting or fastening one part to another

2.6

fixing

item or assembly of items which forms the attachment of patent glazing to the supporting structure

2.7

fixing bracket

fitting attached to a patent glazing bar and secured to a structural member by fasteners

NOTE Cleat, plate, shoe and slipper are deprecated terms for fixing bracket.

2.8

flashing

strip of impervious material, usually metal, dressed or fitted in order to exclude water from the junction between patent glazing and adjacent material or between joints in patent glazing

2.9

four-edge system

patent glazing with infilling fully supported on four edges

2.10

glazing stop

fitting attached to the lower end of a patent glazing bar to prevent the infilling from sliding

2.11

head

top member in patent glazing, usually horizontal

2.12

infilling

sheet material that occupies the space between supporting members

2.13

pane

infilling cut to size and shape

2.14

patent glazing bar

longitudinal supporting member in patent glazing that spans between structural members and incorporates water channels

2.15

setting blocks

pieces of resilient material used at the bottom edge of infilling

2.16

sill

bottom member in patent glazing, usually horizontal

2.17

sloping patent glazing

patent glazing at an angle of less than 75° to the horizontal

2.18

spacing

perpendicular distance between the centres of two adjacent parallel supporting members, measured in the plane of the glazing

2.19

span of infilling

perpendicular distance between two adjacent parallel supporting members, measured in the plane of the glazing

2.20

span of supporting member

parallel distance between the centres of two adjacent points of attachment of a supporting member to a structural member, or to another supporting member, measured in the plane of the glazing

2.21

storm clip

fitting attached to a patent glazing bar to restrain the infilling against negative wind pressure

2.22

supporting member

member that supports and retains the edge of infilling

2.23

transom

intermediate transverse supporting member in a four-edge system of patent glazing, spanning between patent glazing bars and incorporating a water channel

2.24

two-edge system

patent glazing with infilling fully supported on two opposite longitudinal edges

2.25

vertical patent glazing

patent glazing at an angle of 75° or more to the horizontal

2.26

water channel

groove within the section profile of a supporting member to collect and drain water to the outside of the building, either directly or indirectly (See Figure 1)

2.27

weathering

strip of material to control the passage of water and/or air through a joint in patent glazing, or between patent glazing and adjacent material

2.28

wing

metal strip fitted to the side of a patent glazing bar to retain infilling and impede direct water penetration (See Figure 1)

3 Provision of information

3.1 General

To ensure that the intentions of the building designer and the requirements of the patent glazing contractor are clearly understood, consultation is recommended at both the initial design and tender stages.

Information normally required by the patent glazing contractor is given in 3.2 to 3.4 and is usually best provided in the form of drawings, specifications, bills of quantities or other related documents.

3.2 Design and performance

Information which should be provided by the building designer includes the following:

- a) location, degree of exposure and the altitude of the site where the building is situated;
- b) intended use and occupancy of the building together with any specific performance criteria in respect of the following:
 - 1) fire (see clause 12);
 - 2) weather resistance (see clause 13);
 - 3) heat conservation (see clause 14);
 - 4) condensation (see clause 15);
 - 5) solar heat gain (see clause 16);
 - 6) thermal safety (see clause 17);
 - 7) transmission of light (see clause 18);
 - 8) sound reduction (see clause 19);
 - 9) durability (see clause 20);
 - 10) human safety (see clause 21);
 - 11) security (see clause 22);
- c) details of any environmental factors or atmospheric conditions which may have an adverse effect on the patent glazing, especially any corrosive conditions;
- d) position of the patent glazing on the building, the external dimensions of the building and details of any features which may affect the distribution of wind or snow;
- e) design loads for the particular situation of the patent glazing;
- f) details of supporting structure including the size, spacing, nature and dimensional and positional tolerances of structural members, surrounding construction and adjacent materials;
- g) dimensions of the patent glazing including angle of glazing to the horizontal and preferred spacings of patent glazing bars and any other supporting members;

h) type(s) of patent glazing bar, type(s) of infilling, type(s) of flashing and any decorative or protective finish(es) required;

i) details of any ventilation or other openings required and their method of operation;

j) details of any access equipment to be provided for cleaning/maintenance;

k) any other relevant information.

3.3 Site attendances and facilities

Responsibility for the following matters should be made clear to the patent glazing contractor at tender stage:

- a) provision of suitable scaffolding, working platforms, lifting gear or mobile towers as and when required to suit the progress of the patent glazing works;
- b) receiving and unloading materials at the site and distribution of materials to and from storage area;
- c) safe storage of materials on the site in a covered store;
- d) hoisting and/or carrying materials to the correct floor level or work area;
- e) provision where required of datum levels at not more than 15 m intervals and grid lines on each floor;
- f) provision of fixing holes, inserts or similar devices in the supporting structure when required and for any other preparatory work;
- g) provision of electric power (110 V 15 A) within a distance not exceeding 15 m from each work face;
- h) removal of any temporary protective masking, coating, wrapping, labels, stickers and the like;
- i) cleaning down, casing and protection of the patent glazing after installation;
- j) provision of safety, health and welfare facilities.

3.4 Time schedule

To assist in the preparation of a preliminary programme the following information should also be provided at the time of tendering:

- a) period(s) allowed for the completion of the patent glazing works including the approximate date when the patent glazing contractor will be required to commence on site;
- b) availability of all necessary details and information to enable working drawings to be prepared for submission for approval by the building designer;
- c) period required by the building designer to approve working drawings after submission.

Section 2. Components, materials and finishes

4 General

All components of a patent glazing system should be manufactured from materials or protected by finishes which are compatible, durable and capable of resistance to corrosion and degradation in the environmental and service conditions in which they are expected to be used. Specially corrosive conditions require particular attention and the patent glazing contractor should be provided with the necessary information at the initial design stage (see clauses 3 and 9).

Materials and finishes should satisfy the essential requirements of hygiene, health and safety in use. The selection of suitable materials and finishes should take into account performance criteria, visual considerations and the economic factors involved.

5 Supporting members, flashings, ancillary components and finishes

5.1 Patent glazing bars (longitudinal supporting members)

5.1.1 Types of patent glazing bars

Patent glazing bars should be one of the following types.

a) Aluminium bars

1) *traditional bars* in which the stalk or web projects to the outside and the infilling is retained either by wings of aluminium, lead or plastics, or by caps of aluminium or plastics [see Figure 1(a)];

2) *inverted bars* in which the stalk or web does not project to the outside and the infilling is retained by caps of aluminium or plastics [see Figure 1(b)].

b) **Lead-sheathed steel bars.** These bars have a steel core encased in an extruded lead sheath with integral lead wings. Sheaths are sealed at their ends by lead burning or soldering.

c) **Plastics-sheathed steel bars.** These bars have a steel core encased in an extruded plastics sheath which is sealed at the ends. The infilling is retained in position by an extruded plastics cap.

d) **Composite steel bars.** These bars consist of a steel flat, tee or other section to which is fitted an aluminium or a plastics carrier section. The infilling is retained in position by caps or wings of aluminium or plastics.

5.1.2 Materials for patent glazing bars, caps, wings and sheaths

Materials for patent glazing bars, caps, wings and sheaths should be as follows.

a) **Aluminium bars.** These should be extruded from alloy complying with designation 6063, temper T6 of BS 1474. Other alloys and tempers may be suitable and the patent glazing contractor should be consulted as to their use.

b) **Steel bars or cores.** These should be manufactured from hot rolled steel sections that, when tested in accordance with BS EN 10 002-1, have a minimum ultimate tensile strength of 355 N/mm². Rust and millscale should be removed before fabrication (cutting to length, drilling, notching, etc.). After fabrication, prior to lead or plastics sheathing, steel cores should be protected by the application of a suitable rust inhibiting material or inert coating.

c) **Aluminium caps and wings.** These should be extruded from alloy complying with designation 6063, temper T6, of BS 1474, or formed from sheet or strip aluminium complying with designation 1200 or from alloys designated 3103, 5005 or 5251 of BS 1470 in a temper suitable for the particular type of application and degree of forming to be adopted. Other alloys may be suitable and the patent glazing contractor should be consulted as to their use.

d) **Lead wings and sheaths.** These should be extruded from lead showing a medium grain size. Lead sheaths should be not less than 0.8 mm thick.

e) **Plastics caps, wings and sheaths.** These should be extruded from unplasticized polyvinyl chloride. Plastics sheaths should be not less than 0.75 mm thick.

f) **Other materials.** The suitability of other materials should be checked with the patent glazing contractor.

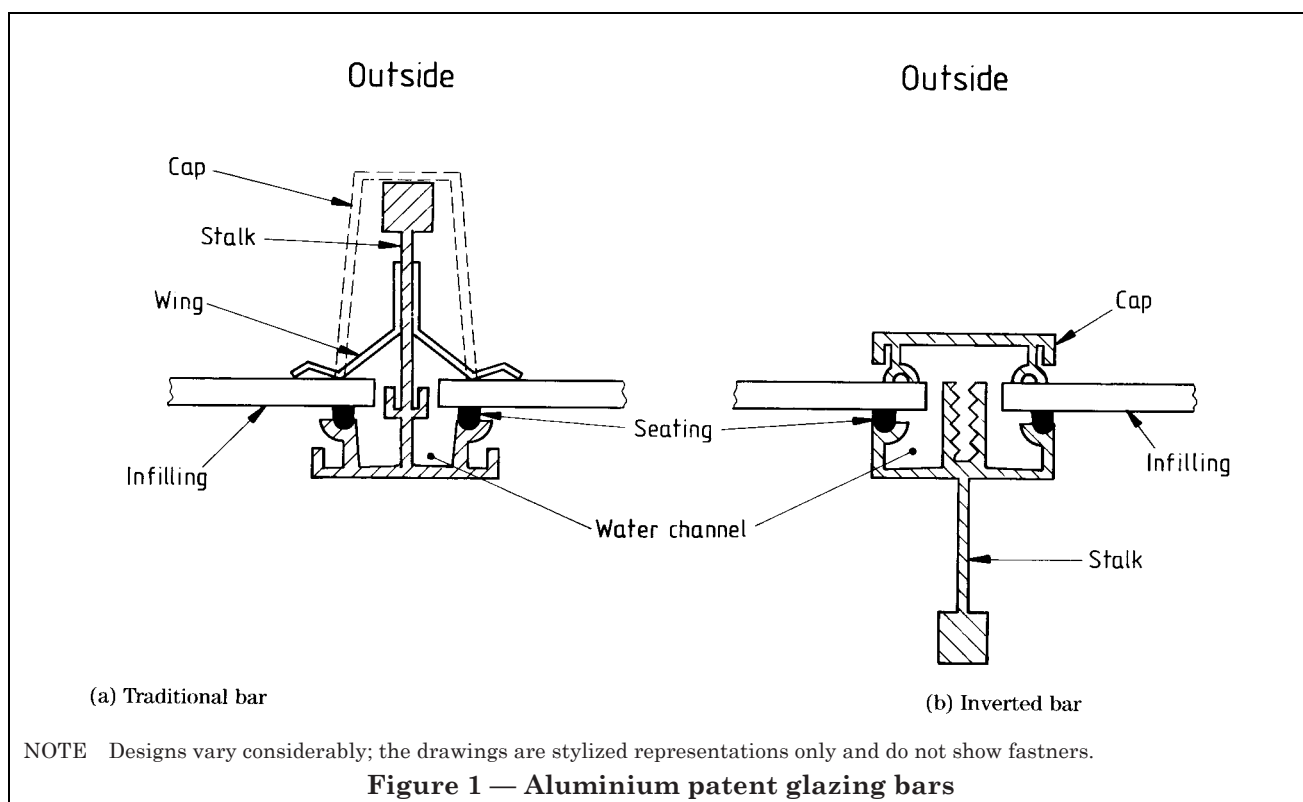
5.2 Transverse supporting members (head, sills and transoms)

Transverse supporting members should be made from one of the following materials.

a) Aluminium

1) *Extruded sections:* alloy complying with designation 6063, temper T6, of BS 1474. Other alloys and tempers may be suitable and the patent glazing contractor should be consulted as to their use.

2) *Formed sections:* sheet or strip aluminium complying with designation 1200 or alloys designated 3103, 5005 or 5251 of BS 1470 in a temper suitable for the particular type of application and degree of forming to be adopted.



b) Steel

1) *Hot-rolled sections*: steel that, when tested in accordance with BS EN 10 002-1, has a minimum ultimate tensile strength of 355 N/mm².

2) *Formed sections*: steel sheet complying with BS 1449-1 or galvanized steel sheet complying with BS 2989.

5.3 Flashings

Flashing materials should comply with one of the following specifications.

a) **Lead**: milled lead sheet complying with BS 1178 with a minimum thickness of 1.8 mm (code No. 4).

b) Aluminium

1) *Site formed flashings*: sheet or strip aluminium complying with designation 1050A, temper 0, of BS 1470 and not less than 0.8 mm thick.

2) *Preformed flashings*: sheet or strip aluminium complying with designation 1200 or alloys designated 3103, 5005 or 5251 of BS 1470 in a temper suitable for the particular type of application and degree of forming to be adopted and not less than 0.9 mm thick.

c) **Steel**: steel sheet complying with BS 1449-1 or galvanized steel sheet complying with BS 2989 and not less than 0.7 mm thick.

Other flashing materials are available but their suitability should be checked with the patent glazing contractor.

5.4 Ancillary components

5.4.1 Weatherings

Weatherings such as comes, weather bars, closures and fillers, if made from one of the materials described in 5.1.2 and 5.3, should comply with the relevant specification. Other materials should be compatible with other components of the patent glazing. Where wood is used, it should be of a durable type and, if necessary, treated with preservative of a type compatible with the other components of the patent glazing and adjacent materials.

5.4.2 Fittings

Fixing brackets, glazing stops, storm clips, etc. should be of materials, shapes and thicknesses adequate to withstand the loads imposed upon them and any likely movements.

NOTE A large variety of fittings may be used and it is not practicable to give detailed recommendations.

5.4.3 Fasteners

Bolts, screws, studs, nuts, rivets and other mechanical fasteners should have adequate strength for the particular condition in which they are to be used and should be made from one of the following materials.

a) **Brass:** alloy complying with designation CZ 121 Pb3 or CZ 121 Pb4 of BS 2874 or other suitable alloy of a composition not likely to show stress corrosion tendencies should be used.

NOTE Brass fasteners should not be used with aluminium.

b) **Aluminium:** bolt or screw stock alloy complying with designation 5056A, temper H4, of BS 1473 or other suitable alloy of a composition not likely to show stress corrosion tendencies should be used.

c) **Steel:** mild steel should be protected either by electroplating with zinc or cadmium complying with BS 3382 and chromate passivated and sealed in accordance with BS 6338, or by sherardizing to class 1 in accordance with BS 4921. Other protective treatments may be suitable and the patent glazing contractor should be consulted as to their use.

d) **Stainless steel:** austenitic steel complying with grade A2 or A4 of BS 6105 should be used.

NOTE The compositions of grades A2 and A4 in BS 6105 correspond approximately to 304S31 and 316S31 in BS 1449-2 respectively.

Where patent glazing is to be subjected to vibration, fasteners of a type which resist slackening should be used.

5.5 Finishes

NOTE The selection of suitable finishes for aluminium and steel will depend on the degree of protection and/or decorative effect required.

5.5.1 Finishes for aluminium

Aluminium components are available in the following types of finish.

a) **Mill.** This description applies to untreated aluminium surfaces. The rate at which the original bright, metallic appearance will become dull as the surface oxidizes and develops a roughened texture depends upon environmental conditions. Mill finish may not be suitable where appearance is important or where close fitting, moving parts are involved.

b) **Anodized.** Suitably prepared aluminium is treated electrochemically during which process the surface of the metal is converted to a hard, translucent film of aluminium oxide forming a protective coating. A range of colours is available.

The appearance of the anodic film depends upon material composition, form, temper or condition and surface texture and care should be taken in the selection of materials for components which are required to be closely matched. Special consideration should be given where anodized extrusions and anodized sheet or strip are used in conjunction.

For external applications anodic oxide coatings on aluminium should comply with BS 3987. For internal applications a thinner coating in accordance with the method described in BS 1615 may be used.

c) **Organic coated.** Pre-treated aluminium is coated with synthetic resin, commonly polyester or acrylic based, applied in powder or liquid form and stoved on to produce a protective film. A wide range of colours which can be closely matched on different substrates is available.

Organic coatings on aluminium should comply with BS 6496 for powder coatings and BS 4842 for liquid coatings.

5.5.2 Finishes for steel

Components made from steel (except stainless steel), which are not otherwise protected against corrosion, should be protected by one of the following types of finish.

a) **Hot-dip galvanized.** Cleaned steel is immersed in molten zinc which becomes chemically bonded to the base metal to produce a protective coating. The coating, which may have a bright, metallic appearance, is usually overpainted after installation to provide a coloured finish for decoration and added protection.

Hot-dip galvanized coatings on steel should comply with BS 729.

b) **Zinc sprayed.** Grit blasted steel surfaces are sprayed with particles of semi-molten zinc which become mechanically bonded to the abraded surface of the base metal to produce a protective coating. The coating has a roughened, dull, matt grey appearance which is usually primed and subsequently overpainted after installation to provide a coloured finish for decoration and added protection.

Zinc sprayed coatings on steel should comply with BS 2569-1.

c) **Organic coated.** Suitably prepared steel is coated with synthetic resin, commonly polyester based, applied in powder or liquid form and stoved on to produce a protective film. A range of colours which can be closely matched on different substrates is available.

Organic powder coatings on hot-dip galvanized steel should comply with BS 6497.

6 Infillings

6.1 Maximum size

Maximum size limits are determined more often by design considerations than by availability.

Important design factors influencing size limits are loadings (e.g. wind, snow), safety, fire and security considerations. Ease of handling and means of access to vertical or sloping patent glazing are further considerations which relate to both the weight and dimensions of the infilling.

Within two-edge systems, larger sizes may be achieved by incorporating horizontal butt joints with comes or suitably designed sealant joints.

The patent glazing contractor should be consulted about the suitability of the size of panes, shapes other than rectangles, or panes of unusual dimensions.

6.2 Glass

Glass for glazing is classified in BS 952-1. The designer should check the availability and viability of the glass chosen with the manufacturer and/or the patent glazing contractor. The following types of glass are normally used in patent glazing.

a) Annealed

1) *Transparent glass*: clear float, body tinted float, surface coated float and polished wired glass.

2) *Translucent glass*: clear cast (patterned) glass, body tinted cast (patterned) glass and cast wired glass.

b) Processed

1) *Toughened (tempered) glass*: any annealed glass, with the exception of wired glass, that has been subjected to a heating and rapid cooling process that imparts a greater strength to the material. The process makes the glass more resistant to mechanical and thermal stress.

2) *Opaque glass*: produced by firing in a ceramic frit during the toughening process.

3) *Laminated glass*: two or more panes of annealed or toughened glass usually laminated together by means of polymeric interlayers. The normal interlayer is poly (vinyl butyral), although a number of cast-in-place resin systems are now available. There are also available specialized laminated glasses incorporating intumescent interlayers for fire performance.

4) *Insulating glass units (double glazing units)*: factory made, hermetically sealed double glazing units which may incorporate any annealed, toughened or laminated glasses in any viable combination. The panes of glass are separated by a hermetically sealed space of dehydrated air or a special gas mixture. Surface coatings not suitable for single glazing may be incorporated in double glazing units with the coating on a cavity surface.

6.3 Plastics glazing sheet materials

Plastics glazing sheet materials are of various basic polymer types. The types marketed vary because of differences in their chemical composition or form, i.e. solid or hollow section. Whilst different types are normally available under their proprietary brand names, the basic types most commonly used in patent glazing are generically:

- a) polycarbonate (PC);
- b) polyvinyl chloride (PVC), commonly referred to as "rigid PVC"; "unplasticized PVC" or "uPVC";
- c) polymethyl methacrylate (PMMA), commonly referred to as "acrylic".

These are available in both solid sheet and hollow section form.

In addition to clear transparent, some of the above types are available as transparent colours, as opal whites and with patterned surfaces.

For further information on plastics glazing sheeting materials, see Appendix J.

6.4 Other materials

A wide range of materials, with or without insulating backings, may be used as infillings. These include:

- a) aluminium sheet;
- b) coated metal sheet;
- c) profiled plastics sheet material;
- d) glass fibre reinforced plastics sheet (GRP);
- e) composite panels.

For the full technical information required for these and other types of infill material, reference should be made to the manufacturer.

7 Sealing and glazing materials

7.1 General

There is a wide range of materials available for the seating of infilling and the weather sealing of joints in patent glazing and between patent glazing and adjacent materials. These materials should be of a resilient nature, capable of accommodating any likely movements, and be compatible with the substrates to which they are applied or with which they are in contact. Care should be taken in the selection of sealing and glazing materials to ensure that they are sufficiently resistant to climatic effects, especially ultraviolet light and atmospheric pollution in the conditions in which they are to be used (see also Appendix J).

NOTE 1 With some infillings, notably laminated and solar control glasses and double glazing units, correctly positioned setting blocks of adequate size, with or without glazing materials, should be used to prevent direct contact between the bottom edge of the glass and any metal component, continuous or otherwise.

NOTE 2 Suitable materials for use as setting blocks in patent glazing include plasticized polyvinyl chloride (with a softness no. of 35 to 45 ; see BS 2571) and extruded unplasticized polyvinyl chloride. However, plasticized polyvinyl chloride setting blocks are not recommended for use with plastics glazing sheet materials.

7.2 Types

7.2.1 *Preformed*

Preformed types are usually of substantially dry, non-viscous materials, commonly in reel or strip form, and include mastic tapes, greased cords, synthetic rubbers and plastics sections and gaskets, either solid or cellular. Such materials, which do not normally undergo a physical or chemical change, may require to be used under compression.

Preformed rubber gaskets should comply with the appropriate Part of BS 4255.

7.2.2 *Formed-in-place*

Formed-in-place types are usually of viscous materials for application by hand, knife or gun and include bulk mastics, glazing compounds and sealants. Such materials may undergo a physical or chemical change after initial placing and may also have adhesive properties.

One-part gun-grade polysulphide-based sealants should comply with BS 5215.

Two-part polysulphide-based sealants should comply with BS 4254.

Silicone-based sealants should comply with BS 5889.

Section 3. Design

8 General

Consideration should be given at the initial design stage, in consultation with the patent glazing contractor, to the dimensional and positional accuracy of the supporting structure and adjacent materials. It is especially important that the supporting structure for four-edge systems is built to a high degree of dimensional and positional accuracy over the whole area to which the patent glazing is to be attached.

Where thermal or other movement joints are required in a building it may be necessary to incorporate corresponding junctions in the patent glazing. The patent glazing contractor should be consulted at the design stage as to the specific movements involved, in order that these can be accommodated within the patent glazing system.

9 Selection of materials

9.1 General

When selecting materials and finishes for use in patent glazing, their compatibility with other components of the building should be considered. The compatibility of components within patent glazing systems should also be considered (see clause 4). Materials should be selected in consultation with the patent glazing contractor.

9.2 Performance criteria

The performance criteria which may influence the materials selected include the following:

- a) structural (clause 10);
- b) openings (clause 11);
- c) fire (clause 12);
- d) weather resistance (clause 13);
- e) heat conservation (clause 14);
- f) condensation (clause 15);
- g) solar heat gain (clause 16);
- h) thermal safety (clause 17);
- i) transmission of light (clause 18);
- j) sound reduction (clause 19);
- k) durability (clause 20);
- l) human safety (clause 21);
- m) security (clause 22);
- n) access for maintenance and cleaning (clause 23).

9.3 Visual considerations

The degrees of variation in the colour, texture, pattern and evenness of internal and external visible surfaces will depend upon the materials used and the surface finishes. The acceptable degree of variation in appearance should be established in consultation with the patent glazing contractor.

10 Structural

10.1 Structural support

Patent glazing should be attached to, and supported by, structural members of adequate strength, stiffness and stability. Deflection of a structural member should be limited to 1/360 of its span unless otherwise recommended in an appropriate British Standard code of practice, e.g. BS 5950-1, CP 118. The patent glazing contractor should be consulted with regard to those features of members affecting the accommodation of the patent glazing.

10.2 Structural function

The patent glazing system should be capable of sustaining and transmitting to the structure at its points of support the most adverse combination of loads likely to be encountered in service without damage or permanent deterioration of its performance. There should be no significant, irreversible deformation or excessive deflection of any of its parts resulting from the design loads.

Patent glazing bars are the longitudinal supporting members in a system of patent glazing. The primary structural requirements of a patent glazing bar are to resist the loads acting on the surface of the glazing in addition to its own weight and that of the infilling and to provide continuous support and retention to the longitudinal edges of the infilling against positive and negative pressure. Patent glazing bars may also be required to resist other specified loads such as those incidental to maintenance.

Transoms are intermediate, transverse secondary supporting members in four-edge systems of patent glazing. The principal structural requirements of a transom are to act in conjunction with the patent glazing bars in resisting the loads acting on the surface of the glazing in addition to its own weight and that of the infilling and to provide continuous support and retention to the transverse edges of the infilling against positive and negative pressure. Transoms have also to resist the dead load acting downwards in the plane of the glazing.

The infilling should be capable of sustaining the loads acting on the surface of the glazing in addition to its own weight and of transferring them to the supporting members.

Fixings should be capable of withstanding the maximum support and restraint loads to which they may be subjected and of resisting any likely movements.

10.3 Loading

Patent glazing is not designed to withstand loads imposed by the structure to which it is attached. The loads that normally have to be resisted by patent glazing are combinations of those due to the following.

- a) Wind exerted on the surface of the patent glazing, which may act either inwards (positive pressure) or outwards (negative pressure or suction) or both: negative and positive pressures are not necessarily equal in magnitude.
- b) Snow acting inwards on the surface of the patent glazing.
- c) Self-weight, usually acting inwards: the weight should also be considered as a load acting downwards in the plane of the glazing.
- d) Maintenance, if required, which should be taken as acting inwards on sloping patent glazing but which may act either inwards or outwards on vertical patent glazing.

10.4 Assessment of design loads

10.4.1 Wind load

The design wind loads, both positive and negative, for the particular situation of the patent glazing should be determined at the initial design stage (see 3.2).

Wind loads for external walls and roofs of normal, rectangular, clad buildings and for canopy roofs may be determined by the method described in CP 3:Chapter V-2. A summary of this procedure is given in Appendix B.

For buildings of unusual geometric shape or site location not covered by CP 3:Chapter V-2 and problems involving consideration of the excess pressure near ground level that may, in some circumstances, be generated by downdraught from tall buildings or high speed air currents such as may occur in narrow paths between buildings, the building designer should seek advice from the Building Research Establishment or the National Physical Laboratory.

10.4.2 Snow load

The design snow loads on roofs for the particular situation of the patent glazing should be determined at the initial design stage (see 3.2).

Snow loads on roofs may be determined by the method described in BS 6399-3. A summary of this procedure is given in Appendix C.

Exceptional local effects such as shelter from the wind or local configurations which funnel the snow may give rise to increased loading. If the building designer thinks that there may be unusual local conditions that may need to be taken into account then the nearest meteorological office or informed local sources should be consulted.

Where there is a risk of damage by impact from large masses of snow sliding off an adjoining roof at higher level, snowguards should be fitted and the building designer may refer to BS 6367 for detailed advice.

10.4.3 Dead load (self-weight)

Dead loads for supporting members and for the infilling should be calculated from the actual known mass of the materials.

When considering the dead load for supporting members, the weight taken should be that of the supporting member, together with that of the infill material. When considering the dead load for the infilling alone, the weight taken should be that of the infill material only. (See Appendix D.)

Self-weight should also be considered as a dead load acting downwards in the plane of the glazing.

10.4.4 Maintenance load

Safe and efficient means of access for the maintenance including cleaning of patent glazing, both inside and outside, should be considered by the building designer (see clause 26). It is essential that account should be taken of any loading on the patent glazing that might arise incidental to maintenance and the patent glazing contractor should be provided with the necessary information at the initial design stage (see 3.2).

Access systems which are independent of the patent glazing should be preferred especially for the maintenance of patent glazing at high level where, for example, long ladders may be difficult to handle safely.

Where direct access by temporary ladder or crawling boards is intended the patent glazing bars should, if required, be capable of supporting the loads imposed by their use and a method of assessing such loads is discussed in Appendix E. Maintenance loads should never be carried directly by the infilling.

For patent glazing at low level and certain forms of patent glazing at roof level, maintenance may be carried out from the ground or adjacent areas of solid, weight-bearing roof without the need to impose any maintenance load on the patent glazing itself.

Those responsible for the maintenance of patent glazing should be made aware of any load limits on which a particular design is based so that they may ensure that such limitations are not exceeded (see clause 26).

10.4.5 Other loads

Where loads other than those mentioned in 10.4.1 to 10.4.4 are anticipated, for example any permanent imposed loads or suspended loads, due allowance should be made and the patent glazing contractor should be provided with the necessary information at the initial design stage (see 3.2). Permanent imposed loads should never be carried directly by the infilling.

10.5 Determination of working pressures

10.5.1 General

In determining working pressures for patent glazing, account should be taken of the most adverse combination of design loads that is likely to occur in service in the particular situation of the patent glazing and an analysis of this procedure is given in Appendix F.

10.5.2 Supporting members

Working pressures for supporting members may be determined by the method described in Appendix G. The values so obtained should be used in the formulae given in Appendix H for determining the required geometric properties of section for supporting members.

10.5.3 Infilling

10.5.3.1 Glass

Glass is appreciably weaker when subjected to a sustained load such as snow and dead loads than to a load of short duration and, in determining working pressures for glass, it is essential that account should be taken of the effect of the duration of the various loads under consideration. The flexural strength of glass on which thickness computations such as are given in 10.8.1 are based is that for a uniform, momentary (3 s gust wind) load and the relative strength for a sustained load is approximately $\frac{2}{3}$ of that for a short-term load. When considering snow load and dead load in conjunction with wind load these sustained loads should be multiplied by a factor of 2.6 so that their effect on the strength of the glass may be considered in terms of a 3 s gust wind load. This factor is not applied to the dead load where it merely reacts against a negative wind pressure since the weight counters the wind suction only when the suction occurs.

Applying this adjustment for sustained loads to the combinations of design loads considered in Appendix F, the following expressions are obtained.

a) For sloping patent glazing:

$+p_w + 2.6(p_s + p_{di})$ and if a negative value for p_w is derived, i.e. wind suction conditions:

$-p_w + p_{di}$

b) For vertical patent glazing:

$+p_w + 2.6p_{di}$ and if a negative value for p_w is derived, i.e. wind suction conditions:

$-p_w + p_{di}$

In the expressions given in a) and b), to take account of windless conditions when no positive value for p_w is derived, zero should be substituted for $+p_w$.

Each load case should be considered and whichever of the resultant values is numerically the greater should be taken as the operative working pressure for glass, p_g , for the particular situation of the patent glazing. The values thus obtained are for use with the graphical data given in 10.8.1 for determining the recommended minimum thickness for glass.

The expressions given in a) and b) apply to glass in single glazing and to hermetically sealed double glazing units. With systems of double glazing comprising two separate and mechanically independent layers of glass, assuming some degree of air permeation between the panes, each pane should be designed to resist the full wind load, both positive and negative, in addition to its own weight. With such systems of double glazing, only the outer pane of glass needs to be capable of carrying the snow load.

10.5.3.2 Plastics glazing sheet materials

Under long-term, sustained loads, such as snow and dead loads, plastics glazing sheet materials can undergo a slight permanent deformation known as creep. This can manifest itself as a visible sagging of the infilling. In determining working pressures for plastics glazing sheet materials, it is essential that account should be taken of the effect of the duration of the various loads under consideration. The performance of plastics glazing sheet materials on which data given in 10.8.2 are based is that for a uniform, momentary (3 s gust wind) load. When considering snow load and dead load in conjunction with wind load, these sustained loads should be multiplied by a factor so that their effect on the performance of plastics glazing sheet materials may be considered in terms of a 3 s gust wind load. Based on experience and experimental knowledge, a factor of 2 is recommended. This factor is not applied to the dead load where it merely reacts against a negative wind pressure since the weight counters the wind suction only when the suction occurs.

Applying this adjustment for sustained loads to the combination of design loads considered in Appendix F, the following expressions are obtained.

- a) For sloping patent glazing:
 $+ p_w + 2(p_s + p_{di})$ and if a negative value for p_w is derived, i.e. wind suction conditions:
 $- p_w + p_{di}$
- b) For vertical patent glazing:
 $+ p_w + 2p_{di}$ and if a negative value for p_w is derived, i.e. wind suction conditions:
 $- p_w + p_{di}$

In the expressions given in a) and b), to take account of windless conditions when no positive value for p_w is derived, zero should be substituted for $+ p_w$.

Each load case should be considered and whichever of the resultant values is numerically the greater should be taken as the operative working pressure for plastics glazing sheet materials, p_p , for the particular situation of the patent glazing. The values thus obtained are for use with the data given in 10.8.2 for determining the recommended minimum thickness for solid sheet or the form of hollow section sheet, of the plastics glazing sheet materials.

The expressions given in a) and b) apply to solid plastics glazing sheet materials in single glazing and to hollow section plastics glazing sheet materials. With systems of double glazing comprising two separate and mechanically independent layers of plastics glazing sheet materials, assuming some degree of air permeation between the panes, each pane should be designed to resist the full wind load, both positive and negative, in addition to its own weight. With such systems of double glazing, the outer pane should be capable of carrying the snow load but the inner pane need not.

10.5.3.3 Other infill materials

For the determination of appropriate working pressures for other infill materials the manufacturer should be consulted.

10.5.4 Fixings

The combination of loads which induce critical stress in fixings may not be the same as those for supporting members and infilling and should be determined separately.

10.6 Strength and stiffness

10.6.1 Supporting members

10.6.1.1 General

Supporting members should be strong enough to withstand the working pressure without permanent bending or yielding of their material. They should also be stiff enough to restrict elastic deflection to an amount likely to be visually acceptable and prevent damage to, or displacement of, the infilling and other adjacent materials and components, or cause impairment to the functional performance of the patent glazing system.

10.6.1.2 Strength

Supporting members which are principally uniformly loaded and simply supported, if designed to resist bending stresses, will usually be satisfactory in respect of other mechanical stresses.

In determining working pressures for supporting members on the basis of the maximum 3 s gust wind load, as described in Appendix G, permissible stresses may be increased by one-third. The following design bending stresses should be used in calculations involving the strength of supporting members, such as are given in Appendix H.

- a) For extruded sections in aluminium alloy designation 6063 temper T6 of BS 1474, having minimum 0.2 % proof stress of 160 N/mm^2

$$f_m = 97 \text{ N/mm}^2 \times 1.33 = 129 \text{ N/mm}^2$$

- b) For hot rolled sections in mild steel having minimum yield stress of 240 N/mm^2

$$f_m = 165 \text{ N/mm}^2 \times 1.33 = 219 \text{ N/mm}^2$$

For other material specifications appropriate working stresses should be determined.

When supporting members are used as structural members, they should be designed fully in accordance with CP 118 and BS 5950-1 and suitable stresses adopted. The design of the infilling should be in accordance with this standard, however.

NOTE In the context of this code, supporting members should not be considered as structural members. In determining design bending stresses for supporting members as used in a system of patent glazing, lateral instability of section is not a criterion due to the restraint provided by the infilling.

10.6.1.3 Stiffness

For supporting members carrying glass and other similar infill material, the maximum allowable deflection normal to the plane of the glazing is usually determined by considerations of appearance as well as the flexibility of the infilling. To restrict stresses in the infill material, the following deflection limits (in mm) should not be exceeded.

a) For two-edge systems:

1) for single glazing and for double glazing other than hermetically sealed double glazing units

$$y_{m2} = \frac{S^2}{180} \times 10^3$$

or 50 whichever is the less;

2) for hermetically sealed double glazing units

$$y_{m2} = \frac{S^2}{540} \times 10^3$$

or 20 whichever is the less.

b) For four-edge systems:

1) for single glazing and double glazing when the span is less than or equal to 3 m, other than hermetically sealed double glazing units

$$y_{m4} = \frac{S}{125} \times 10^3$$

2) for single glazing and double glazing when the span is greater than 3 m, other than hermetically sealed double glazing units

$$y_{m4} = \left(\frac{S}{250} \times 10^3 \right) + 12$$

or 40 whichever is the less;

3) for hermetically sealed double glazing units

$$y_{m4} = \frac{S}{175} \times 10^3$$

or 40 whichever is the less.

The values given in a) and b) should be used in the formulae given in Appendix H.

When designing to these maximum values, account should be taken of the magnitude of deflection under sustained loading and of the possible effect on adjacent materials and finishes. If lower deflection limits are required, these should be specified by the building designer and the patent glazing contractor should be provided with the necessary information at the initial design stage (see 3.2).

For other infilling materials, especially those with inflexible coverings, the amount of deflection may need to be reduced and the manufacturer should be consulted.

Maximum recoverable deflection in the plane of the glazing of a transverse supporting member when carrying its full design load should not be such as to reduce design edge clearance between that member and the edge of the infilling or any other part immediately below it by more than 25 % and generally should not exceed 1/400 of the span of the member or 3 mm whichever is the less. Certain types of ventilators or fittings may make it necessary to reduce the amount of this deflection.

Recommended values for Young's modulus of elasticity in bending, for use in calculations involving the stiffness of supporting members such as are given in Appendix H, are as follows.

a) For aluminium alloys,

$$E_m = 65\,500 \text{ N/mm}^2$$

b) For mild steel,

$$E_m = 210\,000 \text{ N/mm}^2$$

10.6.2 Infilling

10.6.2.1 Glass

The strength of glass to withstand uniform loading is based on the safe tensile stress it can carry and depends on the type, size and thickness of the glass, the manner and the number of edges by which the glass is fully supported and, in the case of glass fully supported along all four edges, the aspect ratio of pane. Deflection in the glass should also be limited to an amount likely to be visually acceptable and not impair its performance or weather resistance at flashings and other weatherings. Greater flexural strength does not indicate greater stiffness.

When glass is fully supported along two opposite longitudinal edges only, transverse bending of the glass creates stress at the mid-span and this is controlled by limiting the unsupported span of the glass. However, the adoption of the strength of the glass as the criterion may result in excessive transverse deflection and this should be taken into account when determining the spacing of longitudinal supporting members.

When glass is fully supported along all four edges, up to an aspect ratio of pane of 3 : 1, the stress in the centre of the glass is controlled by limiting the area of the pane.

For an aspect ratio of pane greater than 3 : 1 the glass is considered to be effectively fully supported along two opposite long edges only.

10.6.2.2 *Plastics glazing sheet materials*

The strength of plastics glazing sheet materials to withstand uniform loading is based on adequate resistance to flexing and depends on the size and thickness of the plastics glazing sheet material and, in the case of hollow section sheets, the geometry of their structure. It also depends on the manner and number of edges by which the plastics glazing sheet material is fully supported, the edge cover provided by the supporting members and, in the case of plastics glazing sheet materials fully supported along all four edges, the aspect ratio of pane.

Failure of a pane of plastics glazing sheet material under mechanical load is more likely to be by displacement than by breakage. Deflection of the plastics glazing sheet material should be limited to an amount likely to be visually acceptable and not impair its performance or weather resistance at flashings or other weatherings. (See Appendix J.) Deflection of the plastics glazing sheet material results in reduction of edge cover. When the plastics glazing material is supported along two opposite longitudinal edges only, adequate edge cover is maintained by limiting the unsupported span of the pane. In the case of plastics glazing sheet materials fully supported along all four edges, having an aspect ratio of pane of not more than 3.5 : 1, adequate edge cover is maintained by limiting the area of the pane. Panes fully supported along all four edges having an aspect ratio of pane greater than 3.5 : 1 are considered to be supported along two opposite long edges only. In the case of a hollow section plastics glazing sheet material fully supported along all four edges, account should be taken of the different stiffness properties parallel to and perpendicular to the geometric profile which characterizes the sheet and reference should therefore be made to the manufacturer for design information.

10.6.2.3 *Other infill materials*

Strength and stiffness characteristics of other infill materials should be obtained from the manufacturer.

10.6.3 *Fixings*

The structural design of mechanical fixings will depend on the materials from which they are made, the way in which the loads are applied, the stresses involved (which may be a combination of stresses) and the method of attachment. If necessary, a detailed analysis should be made to ascertain the actual requirements in a particular case.

Fasteners which secure patent glazing to the supporting structure should be capable of sustaining and transmitting all design loads imposed upon them. The material to which they are attached should be capable of resisting all the forces exerted by the fasteners.

10.7 **Determination of required geometric properties of section for supporting members**

The strength of a supporting member in terms of its resistance to bending is a function of its modulus of section, while stiffness is a function of its second moment of area. Formulae for determining the required properties of section in a direction of bending normal to the plane of the glazing for straight supporting members in two-edge and four-edge systems of patent glazing are given in Appendix H.

The required properties of section for transverse supporting members in four-edge systems of patent glazing should also take into account the dead load acting downwards in the plane of the glazing; usually this will be transmitted by setting blocks as two equal and symmetrically placed point loads. These loads may not be directed through an axis of symmetry of the section and the required geometric properties about the neutral axis in a direction of bending parallel to the plane of the glazing should be determined from appropriate engineering formulae.

The critical bending stress in a supporting member is likely to be compressive and, as patent glazing may be subject to both positive and negative bending in the direction normal to the plane of the glazing, the compression face of the section may be either on the outside or on the inside. For simplicity of calculations therefore, in considering a supporting member which is not symmetrical about the axis of bending, the lesser of the two values for the actual modulus of section about the neutral axis should be taken so that extreme fibre stress is not exceeded.

10.8 Determination of recommended minimum thickness for infilling

10.8.1 Glass

Working pressures for glass determined on the basis of a 3 s gust wind load, taking account of sustained loading effects as described in **10.5.3.1**, are used to calculate the minimum thickness or maximum size of pane by a graphic technique. The procedure given below is for rectangular panes of annealed and processed flat glass, as described in BS 952-1, used in a system of patent glazing in which the supporting members provide a minimum edge cover of 7 mm and which do not deflect under maximum design load by more than the appropriate limits given in **10.6.1.3**. The procedure applies to glass in single glazing, to each pane of glass in double glazing comprising two separate and mechanically independent layers of glass and to hermetically sealed double glazing units.

The graphs may be used to determine the recommended minimum thickness of glass type for a given unsupported span or area of glass, according to the number of edges by which the glass is fully supported.

Figure 2(a) to Figure 2(e) are for glass which is fully supported on two opposite, longitudinal edges only and for glass which is fully supported on all four edges having an aspect ratio of pane greater than 3 : 1.

Figure 2(f) to Figure 2(m) are for glass which is fully supported on all four edges having an aspect ratio of pane not greater than 3 : 1. These graphs show a shaded band for each glass thickness. The lower edge of the shaded band should be used when the pane of glass is square, i.e. the aspect ratio of pane is 1 : 1; the upper edge of the shaded band represents the additional strength of a pane of glass whose shape is such that the length of the longer side is three times that of the shorter side, i.e. the aspect ratio of pane is 3 : 1; interpolation in direct proportion can be made for intermediate values of the aspect ratio of pane. As noted in **10.6.2.1**, if the aspect ratio of pane is greater than 3 : 1 the glass is considered to be fully supported on two opposite long edges only, the length of the shorter side being treated as the unsupported span of glass for use in Figure 2(a) to Figure 2(e). For glass to be considered as fully supported on all four edges, up to an aspect ratio of pane of 3 : 1, the deflection of each supporting member should not exceed the appropriate limits given in **10.6.1.3**. For other support conditions and for non-rectangular panes, the glass manufacturer should be consulted.

In the graphs, the minimum tolerances on glass thicknesses given in BS 952-1 have been used together with design stresses based on experience, experimental knowledge and statistical methods of analysis. Compliance of a glass design with working pressure does not imply suitability of use; other recommendations of this standard and other design requirements may also need to be followed. Glass having to withstand only low working pressure, notably in vertical patent glazing in sheltered situations or patent glazing used internally, may need to be increased in thickness or reduced in size in order to avoid excessive deflection under hand pressure, e.g. during cleaning operations. For design purposes, therefore, it is recommended that a minimum working pressure for glass of 800 N/m² should be allowed.

Figure 2(b), Figure 2(d), Figure 2(g) and Figure 2(j) for toughened (tempered) glass are based on the design stress for fully toughened (tempered) glass. This may lead to a glass design which, although mechanically safe, has large and possibly visually disturbing deflections under maximum load and detailed design consideration will be needed.

The laminated glasses referred to in Figure 2(c), Figure 2(e), Figure 2(h), Figure 2(j) and Figure 2(k) are symmetrical three-ply laminated glass incorporating an interlayer of polyvinyl butyral. Thicknesses shown are nominal and based on the total glass thicknesses only.

Figure 2(d), Figure 2(e) and Figure 2(i) to Figure 2(m) are for hermetically sealed double glazing units in which the supported edges are flush. If any of the supported edges of the unit are not flush then such units should be treated as though they are single glass of the type and thickness of the larger pane.

For other glass types and thicknesses, for other constructions of laminated glass and for other glass combinations in hermetically sealed double glazing units, reference should be made to the glass manufacturer for recommendations.

10.8.2 Plastics glazing sheet materials

10.8.2.1 General

Working pressures for plastics glazing sheet materials, determined on the basis of a 3 s gust wind load, taking account of sustained loading effects as described in **10.5.3.2**, are used to calculate the minimum thickness or maximum size of pane by a graphic technique in the case of solid plastics glazing sheet materials. In the case of hollow section plastics glazing sheet materials, these working pressures are used to determine the required form of hollow section sheet by reference to the plastics glazing sheet material manufacturer.