



BS 5516 : 1977

UDC 69.024.97

Code of practice for
Patent glazing

(formerly CP 145 : Part 1)

Code de bonne pratique relatif au vitrage sans mastic

Richtlinie für Beglasung ohne Kitt

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This Code of practice represents a standard of good practice and therefore takes the form of recommendations. Compliance with it does not confer immunity from relevant statutory and legal requirements.

Foreword

This British Standard is a revision of CP 145 : Part 1 : 1969 which is therefore withdrawn. In accordance with BSI policy, by which all new and revised codes of practice are to be published with BS numbers, this revision has been numbered BS 5516.

In this revision it has been found necessary to include design recommendations both for two-edge supported systems and for other systems now popular in which glass is supported on all four edges.

It should be noted that, in introducing four-edge supported systems into this code, care has been taken to align deflection limitations with those recommended in other codes covering windows. In considering two-edge supported systems, primarily used in roof glazing, the more conventional approach to span-squared relationships has been maintained.

The opportunity has also been taken to provide a graphically based presentation of design data based on the use of the working pressure concept for combining the various loads to which patent glazing is subjected. Appendix F gives a method for determining design requirements and includes worked examples.

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British Standard Code of practice for Patent glazing

Section one. General

1. Scope

This code deals with patent glazing, sloping and vertical, single and double. Recommendations are given for glazing bars, ancillary components and types of glass most commonly used. Information is also provided on such matters as fire resistance, thermal insulation and the use of special glasses.

Conventionally, patent glazing incorporates support for the glass by the bars along two edges only; but, with the increasing use of patent glazing used vertically in sidewall applications, systems have been introduced using four-edge support and four-edge restraint against positive and negative pressures. Within this code these two systems (two-edge and four-edge) are described as 'conventional' and 'four-edge' respectively.

Forces and pressures are given in metric units. The SI unit of force, the newton (symbol N), has been used. It is that force which, when applied to a body having a mass of one kilogram, gives it an acceleration of one metre per second squared. Further information on SI units is given in BS 3763 and in PD 5686.

2. References

The titles of the standards publications referred to in this code are listed on the inside back cover.

3. Definitions and notation

For the purposes of this code the following definitions apply.

3.1 aluminium wings. Preformed aluminium alloy strips fitted to the sides of the load-bearing element of a glazing bar and bearing on the glass.

NOTE. Aluminium wings are designed to form a barrier to penetration by water and to restrain the glass from moving away from the bar under suction forces.

3.2 bead or glazing bead. A strip of metal, wood or other suitable material attached to the rebate to retain the glass.

3.3 came. A light bar of suitable material used to weather a horizontal butt joint between two panes of glass held vertically in the same plane by glazing bars.

NOTE. A came is usually similar in section to the letter 'h'.

3.4 capping. A preformed metal or plastics strip fitted over the load-bearing element along its length and having the same function as aluminium wings.

3.5 depth of glazing. The distance between the top and bottom extremities of the glazed area measured in the plane of the glass.

3.6 draught fillet. A strip to fill the space between the inside surface of the glass and any principal member.

3.7 flashing. A length of impervious material, usually metal, dressed or fitted in order to exclude water from the junction between patent glazing and adjacent material.

3.8 glazing bar. The member by which the glass is supported, retained and made weathertight, i.e. the load-bearing element, plus any associated capping, wing or fitting*.

3.9 head. A horizontal member often used at the top of a tier or series of tiers of patent glazing.

3.10 lead wing. A projecting lead fin forming an integral part of a glazing bar, dressed down to the glass to form a barrier against penetration by water.

3.11 pane. A piece of glass, cut to size and shape ready for glazing (often called a square).

3.12 pitch. The angle of inclination of glazing bars to the horizontal.

3.13 shoe. A fitting securing the lower end of a glazing bar to a structural member.

NOTE. At the lower end of a bar such a fitting may also act as a stop for the glass.

3.14 sill. A horizontal member often used at the bottom of a tier or series of tiers of patent glazing.

3.15 span. The distance between the centres of upper and lower fixing holes of the glazing bar, measured in the plane of the patent glazing.

3.16 stop. A fitting attached to, or integral with, the lower end of a load-bearing element of a glazing bar to prevent the glass from sliding.

3.17 storm clip. A fitting external to the load-bearing element of a glazing bar to restrain the glass against suction forces.

3.18 transom. A horizontal patent glazing member.

3.19 water channel. A drainage channel within the section profile of the glazing bar, the purpose of which is to discharge water to the transom or to the exterior of the glazing.

3.20 door side panel. A fixed pane or panes of glass which could be mistaken for a door, adjacent to a door glazed into a patent glazing system.

*Also referred to as a mullion when positioned between head and sill.

3.21 Notation. The notation used in this code is as follows.

Symbol	Definition	Unit
A	angle of roof from horizontal	degree (°)
C_p	combined pressure coefficient	—
C_{pe}	external pressure coefficient	—
C_{pi}	internal pressure coefficient	—
d	design glass span between bars (conventional systems) or dimension of glass perpendicular to bar being considered (four-edge systems)	mm
d_{max}	permissible unsupported span of glass between glazing bars for conventional supported glass	m
ds_{max}	permissible area of pane for four-edge supported glass	m ²
E_b	Young's modulus of bar material	N/mm ²
h	height of building to eaves	m
H, L	areas of monopitch roofs considered for pressure coefficients†	—
I_b	second moment of area of bar	mm ⁴ × 10 ⁻⁴
K_l } K_z }	aspect ratio factors for four-edge supported systems	—
p_b	working pressure for bars	Pa
p_d	dead load perpendicular to glass	N/m ²
p_g	working pressure for glass, taking account of sustained loading effects	Pa
p_m	maintenance load perpendicular to glass	N/m ²
p_s	snow load perpendicular to glass	N/m ²
p_w	design wind pressure perpendicular to glass	Pa
q	dynamic wind pressure	Pa
R	aspect ratio of glass ($s \div d$) and always ≥ 1.0	—
s_1	topographical wind speed factor	—
s_2	exposure and height above ground; wind speed factor	—
s_3	statistical wind speed factor	—
s	span of glazing bars between fixing centres	m
t	thickness of glass	mm
U	thermal transmittance	W/(m ² K)
V	basic wind speed	m/s
V_s	corrected wind speed	m/s
W	total design load on bar	N
w	overall width of building	m
y_{b2}	deflection of bar for conventional supported systems	mm
y_{b4}	deflection of bar for four-edge supported systems	mm
y	local area of monopitch roofs not considered for pressure coefficients†	—
Z_b	section modulus of bars	mm ³ × 10 ⁻³
σ	design strength of glass type being considered	N/mm ²
σ_b	design strength of bar material being considered	N/mm ²

4. Exchange of information

Consultations should be arranged at an early date so that all parties concerned have full knowledge of the work to be done and are able to cooperate in producing a satisfactory job. It is recommended that in all cases where insufficient information is available to proceed with the design in accordance with this code, competent structural advice should be sought.

Information supplied by the designer of the building to those responsible for the patent glazing, on drawings or in the specification, should include:

- the location of the site;
- the number and dimensions of the areas to be glazed, and any relevant drawings of the building;
- the positions of the openings to be glazed and whether in roofs or walls;
- details of construction such as the spans and spacings of roof members or, for sidewall glazing,

the spacings and sizes of stanchions, piers, floors, sheeting rails, etc., sufficient to enable fixing details to be determined;

(e) the design loadings and parameters to be used (the data required are summarized in case 1 and case 2 below)*;

(f) the types of glazing bar, types of glass and whether the glazing is to be single or double;

(g) details of any ventilation required and method of operation;

(h) particulars of flashings or weatherings to be supplied and fixed by the patent glazing contractor;

(i) facilities and services to be provided by the general contractor.

*It is insufficient merely to specify wind speed.

†See also CP 3: Chapter V: Part 2: 1972

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Case 1. Buildings complying with the provisos in appendices A to C, which permit the simplified standard design procedure to be followed.

For the building and surroundings:

- (1) basic wind speed (m/s);
- (2) ground roughness category (1, 2, 3 or 4);
- (3) whether a dominant opening occurs in the building (yes/no);
- (4) height to width ratio for the building (dimensionless).

For each area of glazing:

- (5) height from ground level to top of glazing (m);
- (6) form of roof or wall containing glazing (ridged, monopitch, vertical);
- (7) roof or wall angle ($^{\circ}$);
- (8) glazing angle ($^{\circ}$).

Case 2. Buildings not complying with the provisos in the appendices. The information required in case 1 should be given, together with a statement of the amounts by which any of the provisos are exceeded. The statistical factor s_3 should be stated.

The detailed treatment of flashings and fixings should be agreed at an early stage in the design. Those who will be responsible for drilling steelwork, forming pockets in concrete or rebating timbers, or for other preparatory work for securing the glazing and the gearing for any opening lights, should agree details of all such work with the patent glazing contractor. To minimize delays, dimensions and details should be established as early as possible, and dimensional tolerances should be agreed for all parts of the structure affecting the fixing of the glazing (see 24.1).

5. Time schedule

The dates of commencement and completion of glazing operations on the site normally depend on:

- (a) the general sequence of glazing areas to be dealt with;
- (b) the availability of all agreed dimensions prior to the manufacture of the patent glazing;
- (c) the completion of work by preceding trades;
- (d) the readiness of hoisting equipment and scaffolding;
- (e) the availability of unloading and storage facilities.

6. Work off site

It is usual to prepare all patent glazing components off site. The glass should be cut to size ready for glazing.

Section two. Materials and components

7. Types of patent glazing bar

7.1 General. All patent glazing bars and ancillary components should be made from durable materials capable of protracted resistance to corrosion or degradation in the conditions in which they are to be used. Specially corrosive conditions require the careful selection of a suitable type of bar (see clause 15).

The alternative types of patent glazing bar described in 7.2 to 7.6 are in normal use and are available in sections

of graded rigidity to suit different combinations of pitch, span and loading.

7.2 Aluminium alloy bar, in which the load-bearing element is extruded to a profile that incorporates water channels and other features. Such bars are available in alternative forms in which:

- (a) aluminium or plastics caps or wings provided separately are fitted after the glass is in position, or
- (b) extruded lead wings are drawn into the profile and become integral with the bar.

7.3 Plastics-sheathed bar, which has a steel core or load-bearing element encased in an extruded plastics sheath sealed at the ends, incorporating water channels and other features. An extruded plastics cap provided separately is superimposed after the glass is in position.

7.4 Lead-clothed steel bar, which has a steel core or load-bearing element encased in an extruded lead sheath sealed at the ends, incorporating lead wings, water channels and other features.

7.5 Galvanized steel bar, in which the profile of the load-bearing element incorporates water channels and other features. A separate cap of corrosion resistant metal is superimposed after the glass is in position.

7.6 Composite timber and metal bar, consisting of a timber load-bearing element with light-gauge non-ferrous channelling and capping sections (now seldom used).

8. Materials for glazing bars and components

NOTE. Guidance on corrosion and its prevention at bimetallic contacts is given in PD 6484

8.1 Load-bearing elements

8.1.1 Aluminium bars. Aluminium bars should be extruded to the required profile from aluminium alloy HE9, condition TF (0.2 % proof stress = 160 N/mm² and Young's modulus of 65 500 N/mm²); other alloys are also suitable (see BS 1474) and the manufacturers should be consulted as to their use. Where supplied with associated lead wings, the profile should contain suitable grooves to secure the wings. The web of the bar (sometimes referred to as the 'stalk') should be not less than 1.8 mm thick.

8.1.2 Steel bars or cores. Steel bars or cores when tested as specified in BS 18 : Part 2 should have a tensile strength of not less than 360 N/mm². Rust and millscale should be removed before fabrication (cutting to length, drilling, notching, etc.). After fabrication, the steel bar should be protected by hot-dip galvanizing in accordance with BS 729, or, where enclosed in a sealed lead or plastics sheath, by the application of a suitable rust-inhibiting material or inert coating, such as bitumen. The yield stress for calculations is 216 N/mm² and the Young's modulus is 210 000 N/mm².

8.1.3 Wood bars. Wood bars should be machined from European Redwood or Whitewood, Western Hemlock or Douglas Fir, with defects limited as specified in BS 1186 : Part 1. Dimensions should be in accordance with CP 112 and, in addition, should afford sufficient stiffness to comply with the recommendations of clause 13 of this code. The timber should be treated with preservative in accordance with BS 5268 : Part 5, using an impregnant in group 2c of BS 1282, and by any customary means, as shown in this group.



8.2 Sheaths and wings

8.2.1 Lead sheaths. Lead sheaths should be extruded from lead manufactured to BS 602 and BS 1085 (minimum lead content 99.25 %) except that the antimony content should not exceed 0.30 %. The sheaths should be of a minimum thickness of 0.80 mm. The extrusions should show a medium grain size as described in BS 602 and BS 1085. Lead wings should be integral with the sheaths. After assembly with the steel core, all lead sheaths should be sealed at the ends by lead-burning or soldering. Lead wings on aluminium glazing bars should be securely held in the grooves provided.

8.2.2 Plastics sheaths. Plastics sheaths should be extruded from unplasticized polyvinyl chloride or its equivalent and should be of a minimum thickness of 0.75 mm. External and internal surfaces of the sheath should be clean, smooth and free from grooving and other defects. The ends should be cleanly cut and square with the axis of the sheath.

Test samples should comply with the requirements of the tests for dimensional stability on heating and for resistance to acetone, as specified in BS 3505.

8.2.3 Cappings and wings. Cappings and wings should, if made from one of the following materials, comply with the requirements of the relevant specification; reference should also be made to 15.2.

- (a) Aluminium for rolled or pressed and bolted-on cappings or wings: commercially pure aluminium SIC or the alloys NS3 or NS4 as specified in BS 1470, of thickness not less than 0.8 mm.
- (b) Aluminium for cover strips that snap in: aluminium alloy, NS3 or NS4 as specified in BS 1474, of thickness not less than 0.45 mm.
- (c) Aluminium for rigid extruded cappings: aluminium alloy HE9, condition TE, or TF if load-bearing, as specified in BS 1474.
- (d) Copper: sheet or strip copper complying with the requirements of BS 2870 and/or BS 4608.
- (e) Zinc cappings: sheet zinc as specified in part 1 of BS 849 : 1939, and of thickness not less than 0.91 mm (15 zinc gauge).
- (f) Plastics: polyvinyl chloride or equivalent in accordance with the recommendations for sheaths given in 8.2.2.

8.2.4 Fittings. In view of the large variety of fittings used to accommodate variations in application, ambient conditions and manufacturing methods, it is not practicable to give detailed recommendations. Generally, however, all fittings should be:

- (a) of materials or finishes of sufficient durability consistent with the design life of the glazing;
- (b) of materials unlikely to deteriorate significantly as a result of bimetallic action (see PD 6484)
- (c) of materials, shapes and thicknesses adequate to withstand the design loads and any likely movements (see clause 13).

8.2.5 Fastening. If of one of the following types, fastenings should comply with the requirements of the relevant specification.

- (a) Brass screws should be of a composition not likely to show stress corrosion tendencies in general building

service. Brass to alloy CZ 121 of BS 2874 complies with this requirement.

- (b) Aluminium screws, nuts and cotters should be of a suitable aluminium alloy as specified in BS 1473.

- (c) Steel screws and nuts should be electroplated with zinc in accordance with BS 3382 : Part 2.

- (d) Stainless steel screws and nuts should be in austenitic steel of type 302 in accordance with BS 970 : Part 4.

9. Glass

9.1 General. Glass should comply with the appropriate requirements of BS 952. In addition to the single glasses, some factory-made, double-glazing units with or without light-diffusing interlayers can be used. There are also systems of double patent glazing in which the glasses are separated by suitable spacers. (See 9.2.8.)

The recommendations in the design section of this code relating to glass are based on the minimum thickness allowed by the tolerances on the nominal thickness of the glass as defined in BS 952 : Part 1.

9.2 Choice of glass. The brief descriptions of the properties of various types of glass given in 9.2.1 to 9.2.8 are intended to assist in the choice of materials.

9.2.1 Transparent glass

9.2.1.1 Float glass and sheet glass. These two glasses differ primarily in the methods by which they are made. Both are fire-finished to give a brilliant lustrous finish, but the surfaces of sheet glass are not so flat as those of float glass, or so distortion-free either in reflection or transmission.

9.2.1.2 Solar control glasses. These glasses are made in various colours having differing absorptive, reflective and transmittive properties. They are intended for use in buildings where control of the indoor environment is required. By absorbing radiant heat or, ideally, by reflecting the heat before it enters the building, the temperature rise inside the building can be controlled. At the same time sky glare and ground reflectance glare are reduced. These glasses can also offer an architect some aesthetic control over the general colour effect created by a building. Heat-absorbing glasses are available in green, bronze and grey; heat-reflecting glasses in gold, bronze, blue and silver.

Some care is needed in installing solar control glasses and, when combinations of glass in double or multiple glazing systems are being considered, it is advisable to consult the glass supplier. In some situations certain glass combinations involve too high a risk of thermal fracture for their use to be approved (see clause 18).

9.2.2 Wired glass. Wired glass is available in two forms: 'polished' to allow maximum visibility through the glass, and 'rough cast' with a patterned diffusing surface. In the 'polished' form the impairment of vision by the wire is minimal. There are also two wire patterns available, Georgian square mesh and diamond mesh in 'polished', and Georgian only in 'rough cast', allowing the architect a choice where appearance is of consequence.

The two important properties of wired glass are:

- (a) that if the glass is broken other than by a force sufficient to snap the wires, the pane remains in position with the pieces held together by the wire mesh until the glass can be replaced: this is a valuable property for roof glazing;
- (b) that it can achieve a measure of fire resistance when supported on four edges and suitably glazed (see CP 153 : Part 4).

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9.2.3 Patterned glass and rough cast glass. These glasses are made by a rolling process in which a variety of surface patterns and types can be formed. Their main use is for obscuration and the various patterns give different degrees of obscuration. The glasses also diffuse the incoming daylight, according to their patterns, and can provide pleasing decorative effects.

9.2.4 Laminated glass. These glasses are made by bonding two glass panes together with a plastics interlayer. They may be transparent or diffusing and they may, in suitable circumstances, incorporate solar control glass or tinted interlayer. The plastics interlayer may be modified, where necessary, to give greater resistance to impact as, for example, in security glasses. When laminated glass is broken, except in cases of violent impact, most of the glass fragments should remain attached to the plastics interlayer. Laminated glass can be designed to the same design stress as float glass but account has to be taken of the reduction in substance due to tolerance differences that can occur in combining two thin glasses in place of one thicker glass. This results in laminated glass being slightly weaker than float glass of the same thickness.

9.2.5 Toughened glass (rough cast, float and solar control glass). As a result of the toughening process the resistance of these glasses to external forces such as impact, to rapid temperature changes, and to large temperature differentials is greatly increased. Thus, toughened glass can be successfully used in roofs over 'hot' processes in factories where annealed or wired glass would break thermally. Once toughened, the glasses cannot be cut or edge-worked. If fractured, toughened glass disintegrates completely into comparatively small pieces and these are much less likely to cause injury than are the pieces of broken annealed glass. Most solar control glasses can be toughened but it is not possible to toughen any form of wired glass.

9.2.6 Enamelled toughened glass. For use in infill panels, toughened glasses are available with coloured enamel fired on to their back surfaces. On rough cast glass the enamel is fired on to the smoother surface. The glasses should be fixed with the enamel surface facing inwards, either with a backing wall or with some other form of backing layer that could provide additional thermal insulation. The glasses are not intended for viewing by transmitted light.

9.2.7 Insulating glazing units. Factory-made, hermetically sealed double-glazing units have the edges sealed with specially designed spacers and compounds, and normally contain a dehydrating agent to maintain a dry airspace. Where such units are to be used for patent glazing, variation of the design considerations may be needed and the glazing specialist and glass manufacturer should be consulted. Most forms of glass can be incorporated in the units, as can translucent material between the panes. In units that absorb considerable heat thermal safety needs to be considered and specialist advice may be required.

9.8 Double patent glazing systems. These are formed on site by using metal or glazing compound spacers between the two glasses. The lower glass is glazed normally for patent glazing systems and carries the weight of the upper glass. Each glass should be designed to carry the full design wind load, but only the top glass needs to be capable of carrying the snow load. With such systems some penetration of water into the cavity, or some misting

within it, may at times occur. This may be tolerable, particularly on installations glazed with cast glass. There are some limitations on these glass combinations and on the amount of the overhang of the inner pane to ensure that the temperature of its edge is as near as possible to internal ambient temperature, and such considerations should be referred to the glazing contractor where there is any doubt.

10. Other infill materials

There are numerous other infill materials available, which can be used in opaque areas in vertical patent glazing. These include plastics, coated steel and aluminium, asbestos-cement and glass reinforced plastics (GRP); most of them can be used with insulating backings, in composite panels. Colour finishes can be applied to these materials.

Where necessary, manufacturers of the infill materials should be consulted on their sizes, colours, fire behaviour and structural properties, and on their suitability for incorporation in patent glazing.

Section three. Design*

11. Functions of a patent glazing bar

The functions of a patent glazing bar are to support and retain the glass and to provide a weathertight glazing joint. The bar should be rigid enough to preserve the integrity of the glass under the prescribed design loading.

In principle, patent glazing bars are designed to support and retain the glass generally without the aid of glazing compounds or like substances. The essential features of any patent glazing bar are:

- (a) a load-bearing element that should provide continuous edge support for the glass, directly against pressure and indirectly, through the wings, capping or storm clips, against suction;
- (b) wings or capping to retain the glass and impede direct water penetration;
- (c) channels to drain water that may penetrate beyond the wings or capping;
- (d) fittings for attachment to the structure or for the retention of the glass, or both.

As proprietary products, patent glazing bars vary in the ways in which these features are provided.

Glazing bars are not designed to withstand loadings imposed by the structure to which they are fastened and, in the context of this code, should not be considered as structural members. The stresses used apply to bars of traditional configuration where lateral stability is not a criterion.

Where glazing bars are to be considered as structural members, they should be designed fully in accordance with the appropriate code of practice for the structural use of the particular material from which they are made and suitable stresses used. The design of the infill, spacing of glazing bars, etc., should, however, be in accordance with this code.

12. Functions of a transom bar

Transom bars can support the top and bottom edges of the glass against pressure and can provide the necessary flashings. In conditions of four-edge support they can also provide restraint against suction.

*Tables and figures for calculations and typical calculation sheets showing worked examples are contained in appendix F.

13. Strength and stiffness

13.1 Loading. It is important that patent glazing should be supported by, and attached to, structural members of adequate strength and stiffness. The design of such members should not be the responsibility of the patent glazing contractor. Nevertheless, he should be consulted with regard to those features of the members affecting the accommodation of glazing bars, fastenings and weatherings.

The loads that normally have to be resisted by glazing bars and by their supports and fastenings are combinations of those due to:

- (a) *weight of bars and glass*, usually expressed as a pressure acting inwards ($+p_d$) for roof glazing: the weight has also to be considered as load in relation to the fixing for vertical glazing;
- (b) *wind*, expressed as pressure, which may act either inwards ($+p_w$) or outwards ($-p_w$): these may not be equal in magnitude;
- (c) *snow* (for roof glazing only), expressed as a pressure, acting inwards ($+p_s$);
- (d) *maintenance*, when necessary, should be taken as acting inwards ($+p_m$) on ordinary roof slopes, but may act inwards ($+p_m$) or outwards ($-p_m$) on vertical glazing or on pitches approaching the vertical.

In determining the design load, account should be taken of the most severe combination of (a) to (d) that is likely to occur in service in the particular situation of the glazing.

For sloping glazing on roofs it is recommended that maintenance of the glazing should not be undertaken when there is a strong wind or any snow lying on the roofs. The combinations of inward pressures that have to be considered are thus ($+p_d + p_w + p_s$) and ($+p_d + p_m$). On some parts of buildings there is also the likelihood of high suctions (outward pressures) due to wind. The worst combination is then $p_d - p_w$.

For vertical and steeply pitched glazing, only p_w and p_m need to be considered. As maintenance is unlikely to be done in windy conditions and the maintenance loading will usually be smaller than the maximum wind loading, the maximum wind pressure or suction, whichever is the greater numerically, should in general be taken as the working pressure.

13.1.1 Weight of bars and glass. The component of the assumed weight per unit area of bars and glass (two panes in double glazing) perpendicular to the plane of the glazing is as shown in appendix A. Figures are also given in this appendix for the weight of the glass alone.

13.1.2 Wind. The determination of wind loading should rest with the building designer. It should be based on the highest 3 s gust speed likely to be encountered, using the procedure described in CP 3 : Chapter V : Part 2. In brief, the maximum 3 s gust speed at a standard height of 10 m above ground and for a once-in-50-years probability of recurrence, is determined for the geographical location from figure 2. This is then multiplied by an appropriate factor to take account of topography, ground roughness and the height from ground level to the top of the glazing (see table 9); finally the wind speed is converted into a design pressure, making allowance for possible combination effects of pressure on one face of the glazing and suction on the other. Full details of these processes are given in appendix B.

13.1.3 Snow. The component of the snow loading perpendicular to the plane of the glazing should be calculated from the requirements for snow loading measured on plan as stated in CP 3 : Chapter V : Part 1. Details are given in appendix C.

13.1.4 Maintenance. Where maintenance loads may have to be carried out by patent glazing, suitable provision should be made in the original design in accordance with CP 3 : Chapter V : Part 1. No allowance has been made for maintenance loads in tables 10 to 17.

Generally, it can be assumed that isolated units or roof glazing, of area not exceeding 1.2 m^2 and on slopes of not more than 30° , can be cleaned or even replaced from the adjacent areas of solid roof without the need to impose any maintenance loading on the glazing.

On steeply sloping roof glazing it is not usually safe to use boards on the glazing bars. The maintenance load that needs to be accounted for is that of a ladder resting on one glazing bar, and this is unlikely to be other than in an inward direction. Similar conditions apply with vertical glazing in walls, but here the ladder load might be either inwards or outwards, i.e. positive or negative. It has been estimated that, in all circumstances, the ladder load, expressed as a pressure, is unlikely to exceed 350 N/m^2 , and this figure is assumed to include any small effects arising from the combined weights of the glass and bars. Comparison with the figures of table 7 shows that this maintenance loading is small compared with any likely maximum wind loading. It may also be assumed that extensive maintenance from ladders would not be done in very windy conditions.

13.1.5 Permanent imposed loads. Where any permanent loads, such as those from walkways and ventilators, have to be carried by the glazing bars, the bars and their fastenings should be designed to have the necessary strengths and stiffnesses. Separate consideration should be given to each problem.

13.2 Determination of design loads for glass and bars.

As explained in appendix B, within a set of stated conditions it is possible, without too much loss of accuracy, to draw up generally applicable tables of design loads for patent glazing in buildings of simple form, placed on sites where wind conditions are unlikely to be complex. The treatment described in the remainder of clause 13 relates to these relatively uncomplicated circumstances. Where the limiting conditions are not fully satisfied, each building has to be considered as a separate design problem.

13.2.1 Glass. All the components of the design loads discussed in appendices A to C have been expressed finally as pressures and it is now convenient to refer to the pressures p_d , p_w and p_s with positive or negative signs according to whether the loads are acting inwards or outwards.

Before proceeding further it is necessary to introduce an adjustment for the effect of sustained loading on glass. Under short-term loading, glass is considerably stronger than it is under long-term loading, and the strength factor between the 3 s loading of wind gust and the sustained loading caused by snow and the weight of glazing is approximately 2.6. In adding these sustained loads to wind loads, therefore, it is reasonable to recognize their more damaging effect by multiplying them by a factor of 2.6, where the weight merely serves to diminish the effect of a

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wind suction. The strength of glass on which thickness computations are usually based is that for 3 s wind loading. For maintenance loading the periods involved are probably not more than a few hours and a smaller strength factor 2.0 can be assumed.

Using these adjustments for sustained loading, the combinational design loads to be considered for glass on sloping roofs are:

$$+ 2.6 (p_d + p_s) + p_w,$$

$$+ p_d - p_w,$$

and if necessary

$$+ 2.6 p_d + 2.0 p_m,$$

$-p_w$ being used for suction conditions.

Whichever of these three values is numerically the greatest is taken as the operative design working pressure. Working pressures for a range of wind speeds and for two types and three slopes of roofs are given in tables 10 to 13, the pressure coefficients being taken from table 5.

Although referring, in this subclause, only to glass, the symbol p_d is based on the combined weights of the bars and glass, on the argument that the weight of the bars acts indirectly on the glass, in that the glass has to follow any curvature of the bars.

For vertical glazing the procedure is simpler, as the dead weight and snow loads can be ignored and only the wind loads have to be considered. For wind the pressure coefficients assumed are ± 1.5 . The working pressures for vertical glazing are included in tables 10 to 13.

13.2.2 Bars. The working pressures for bars are determined in similar ways to those for glass, but there is no need for the inclusion of the factors 2.0 and 2.6 for sustained loading. The results are given in tables 14 to 17. For mathematical convenience the values are given as multipliers intended to be applied to the corresponding pressures in tables 10 to 13.

13.3 Design strength of conventional (two-edge supported) patent glazing

13.3.1 If the glass is to be two-edge supported, the maximum allowable unsupported span between glazing bars can be obtained from figure 3 for the required type and thickness of glass using the working pressures given in tables 10 to 13. Values are given for 3 mm, 4 mm, 5 mm and 6 mm transparent glass, 3 mm and 5 mm patterned glass, 6 mm wired polished and 7 mm wired rough cast glass, and for factory-made, sealed double-glazing units containing one 6 mm wired glass and one 6 mm transparent glass. Double-glazing systems other than factory-made, sealed double-glazing units should be so designed that each glass can withstand the design working pressure singly. Recommendations for other glass types and thicknesses should be referred to the glass manufacturers.

13.3.2 The glazing bars have to fulfil two functions.

- They have to be stiff enough to prevent the glass bending excessively, which would result in the stresses in the glass exceeding the design stress.
- They have to be strong enough to prevent the stresses in the bars exceeding the design stress for the bar material.

In fact, (a) is a limit on the second moment of area of the bar while (b) is a limit on the section modulus of the bar.

13.3.3 The second moment of area of the patent glazing bars is calculated using the working pressures from tables 10 to 13. As is shown in appendix D it is possible to relate the second moment of area for the bars to the span of the bars for each type and thickness of glass. Figures 6 and 8 give the relationship between the basic I_b values of the aluminium and steel patent glazing bars and the span of the bar. To determine the operative second moment of area the basic value has to be multiplied by the following factors:

- the ratio of the span of the bar between its supports to the maximum allowable span of the glass between the bars for the design working pressure from figure 3;
- the ratio of the actual glass span between the bars to the maximum glass span allowable for the design working pressure from figure 3;
- the appropriate multiplier from tables 14 to 17.

The resultant I_b value is that needed for the aluminium or steel glazing bar to prevent the glass from being overstressed. It is essential that the maximum allowable glass span between bars is not exceeded in any design.

13.3.4 The section modulus is determined by a procedure similar to that for the second moment of area. Again as shown in appendix D, the basic section modulus can be expressed in terms of the bar span alone for each type and thickness of glass. Figures 7 and 9 give the relationships for aluminium and steel bars respectively. The basic Z_b value has then to be multiplied by exactly the same three factors as for the second moment of area. The resultant Z_b value is that needed for the aluminium or steel glazing bar to prevent the bar material from being overstressed.

13.4 Design strength of four-edge supported patent glazing

13.4.1 Where the glass is to be four-edge supported, the maximum allowable glass area in m^2 can be obtained from figure 4 using the working pressures given in tables 10 to 13 (see appendix E). Recommendations for glass types and thicknesses other than those shown in figure 4 should be referred to the glass manufacturers.

13.4.2 To obtain the required second moment of area of the patent glazing bars the basic I_b value is first determined from figure 10 or figure 12 according to whether the bars are made of aluminium or steel (see appendix E). This value is then multiplied by three factors:

- the ratio of the pane area to be used to the maximum allowable pane area given in figure 4;
- a factor K_1 for the long or short span of the pane, to be obtained from figure 5 for the actual area of the pane used; these two values account for the aspect ratio to give the necessary I_b values for the long and short spans;
- the appropriate multiplier taken from tables 14 to 17.

13.4.3 To obtain the required section modulus for four-edge supported glass the basic Z_b value of the bar is first determined from figure 11 or figure 13, according to whether the bars are made of aluminium or steel. This value is then multiplied by three factors:

- the ratio of the pane area to be used to the maximum allowable pane area given in figure 4;

(b) a factor K_z for the long or short span of the pane, to be obtained from figure 5 for the actual area of the pane used; these two values account for the aspect ratio to give the necessary Z_b values for the long and short spans;

(c) the appropriate multiplier taken from tables 14 to 17.

13.5 Retention of glass. Glass should be prevented from sliding down the bars by means such as shoes, stops and sills. It should be held against lifting by continuous cappings, strips or wings. These latter should allow for normal thermal movement, incorporate capillary checks and make continuous contact with the glass close to its edge. In severely exposed situations particular care will always be necessary on areas of roof glazing where strong suctional forces are to be expected. Care is also needed where it is known that mechanical vibration can occur.

Additional security against entry can be achieved by incorporating glazing bars of special design or by the use of special glass and/or specially adapted storm clips.

13.6 Fixing of glazing bars. All patent glazing bars should be firmly attached to a supporting structure at both top and bottom. They should normally be fixed by screws or bolts, but other forms of fixing are possible. Whatever form is adopted it should comply with the following recommendations.

- (a) The fastenings should be adequate to resist all the design loads imposed upon them.
- (b) The durability of the fastenings should be consistent with the expected service life of the patent glazing installation (see 8.2.5 and 15.3).
- (c) The loadings imposed by wind pressure should be calculated by the building designer with reference to CP 3 : Chapter V : Part 2 unless other loadings are specified from particular analyses of the building.

Fixing holes required in structural members for the attachment of patent glazing bars should be provided in accordance with the patent glazier's requirements and instructions, taking into account, if possible, the position of support members.

13.7 Safety of vertical patent glazing. Design recommendations for vertical patent glazing to provide an appropriate degree of safety in terms of accidental human impact, taking into account the intended use, are given in appendix G. These recommendations apply only to vertical patent glazing, i.e. truly vertical patent glazing or patent glazing sloping at an angle up to 15° from the vertical. They do not apply to:

- (a) patent glazing other than vertical patent glazing as defined above;
- (b) plastics glazing sheet materials;
- (c) doors included in vertical patent glazing (see figure 19);
- (d) side panels in a door composite included in vertical patent glazing (see figure 19).

14. Weathertightness

14.1 Recommendations for conventional and four-edge systems of support. To ensure adequate weather resistance, the matters raised in 14.1.1 to 14.1.9 should receive attention.

14.1.1 Water channels. Water channels or grooves should be provided in the glazing bars in order to drain off to the outside of the roof or wall-cladding any water that may seep under the external wings or cappings of the glazing bars. The exit for seepage at the lower ends of the bars should be free of obstruction so as not to provide places for silt to lodge.

14.1.2 Seating. All long edges of the glass should be supported continuously along their full lengths.

14.1.3 Pitch. Generally, the pitch should be not less than 15° . Lower pitches may be used, but it may then be necessary to take special precautions, for example, sealing the wings or cappings, and the weatherings, to the glass. Other circumstances in which these precautions are most likely to be needed are:

- (a) marine, estuarine, hillside and other severely exposed locations;
- (b) roofs on which a considerable area of sheeting conducts a large flow of rainwater to discharge over the glazing;
- (c) low pitches where wind is likely to hold a considerable quantity of water on the glass.

14.1.4 Draught fillets. Draught fillets should be used between the glass and the lower support to prevent the penetration of windblown water, snow and dust (but see 14.1.3). On vertical glazing, where preformed weatherings are used, an additional draught fillet should be provided at the top of the pane.

14.1.5 Bottom overhang. On sloping glazing, a glass overhang at the bottom edge of the glazing should be provided of at least 50 mm beyond the draught fillet or surface to be protected. In conditions of excessive exposure, or where the pitch of the glazing is below 15° , this overhang should be increased to ensure weather-tightness, up to a normal maximum of 100 mm. This may need to be increased in the case of solar control glasses.

14.1.6 Lap. In lapped glazing, the upper tier of glazing should overhang the lower tier by at least 50 mm. This should be increased in the special conditions mentioned in 14.1.5.

14.1.7 Flashings. All flashings should extend at least 75 mm over the glass. To prevent passage of water by capillarity or by wind pressure, an air space should be left between the flashing and the uppermost part of the glass.

14.1.8 Rainwater. Discharges from downpipes or other concentrations of rainwater should not be allowed to flow over patent glazing.

14.1.9 Pollution. Excessive dust, grit or dirt from sources such as the main stack of a solid-fuel-burning boiler house or stone or cement works is likely to silt up the water channels. Where pollution of this kind is likely, consideration should be given to the sealing of the wings or cappings to the glass.

14.2 Additional recommendations for four-edge supported systems

14.2.1 Seating. Each pane of glass should be supported continuously, and in one plane, around its whole perimeter.

14.2.2 Bar joints. The ends of all transoms, heads and sills should be designed to allow for adequate sealing in a manner that will accommodate thermal movement.

14.2.3 Pitch. In the design of these systems it is necessary to ensure that water cannot collect on horizontal members. This is particularly important on sloping glazing.

14.2.4 Sealing. Generally, these systems are expected to provide a higher resistance to both water and air penetration, and seals should be designed accordingly.

15. Durability

15.1 General. The durability of patent glazing depends mainly on the conditions of exposure and on the materials used in the component parts. Relevant information can be obtained from CP 3 : Chapter IX and CP 153 : Part 2.

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15.2 Glazing bars. Under conditions of normal exposure, and in mild industrial atmospheres, all the glazing bars described in clause 7 may be used. Consideration should be given to the type of atmospheric pollution likely to be encountered so that the most suitable kind of bar can be selected. For example, the use of lead in the presence of the fumes of an organic acid such as acetic acid should be avoided, and aluminium should not be used where alkaline pollution may be expected, and preferably (if the aluminium glazing bar incorporates a lead wing) not so close to the sea that salt spray may be encountered. It is important that the manufacturers of the bars should be notified at the design stage of any aggressive factor likely to be experienced in and around the proposed building.

The resistance to corrosion provided by galvanizing, under various conditions of exposure, is dealt with in BS 729. Galvanized steel patent glazing bars protected by non-ferrous metal cappings may be regarded, in this context, as being subjected to 'outdoors (sheltered)' conditions of exposure.

No two metals able to set up marked bimetallic corrosion should be used in proximity (see PD....*). Copper and its alloys should not be so situated that rain falling or running upon them subsequently reaches aluminium or zinc-based alloys.

15.3 Fastenings. Fastening devices such as screws, cotters and clips should have corrosion resistant finishes (see 8.2.5), particularly in aggressive environments.

Where glazing is subject to vibration from machinery within a building, nuts, screws or washers that resist slackening should be used.

15.4 Glass. Glass that complies with the composition requirements of BS 952 has a high resistance to corrosion.

15.5 Plastics sheeting. If plastics materials are to be used it is advisable to assess their durability prior to incorporation in the building.

16. Transmission of light

The transmittance of light into buildings by glass is affected by a number of variables. It is sufficient for most purposes to consider a simplified and approximate transmittance representing the proportion of visible light from a diffuse source such as an overcast sky, which emerges from the interior face of clean glass. Some figures for typical glasses used vertically are given in table 1 (see also CP 3 : Chapter 1 : Part 1).

The light transmittance of double glazing can be obtained by multiplying together the two transmittances of the individual panes of glass, whether they be of the same or of different types.

An accumulation of dirt on glazing can reduce the transmittance to a serious extent before becoming noticeable to the occupants of a building.

17. Heat loss and condensation

17.1 Heat insulation. A single pane of glass offers comparatively little resistance to the loss of heat by conduction. This can be improved by the use of double or multiple glazing by virtue of the cells of stationary air between the panes. The insulation increases with cavity width to a spacing of about 20 mm, beyond which there is no significant gain. A spacing of as little as 3 mm will, however, provide an insulation value about 70 % of this maximum. Surrounds of high thermal conductivity will provide direct paths for heat flow and thus appreciably impair the insulation value of the complete installation. Thermal transmittances for a variety of circumstances are given in table 2. When considering double glazing the greater weight of glass and the reduced light transmission should be taken into account.

Table 2. Thermal transmittances (*U* values) of glazing

Glazing			Exposure*		
Sloping or vertical	Single or double	Air space	Sheltered	Normal	Severe
			<i>U</i> values		
		mm	W/(m ² K)	W/(m ² K)	W/(m ² K)
Sloping (0° to 30°)	Single		5.7	6.6	7.9
	Double	6	3.4	3.8	4.2
	Double	12	3.1	3.3	3.6
	Double	20	2.8	3.0	3.2
Vertical	Single		5.0	5.6	6.7
	Double	6	3.2	3.4	3.8
	Double	12	2.8	3.0	3.3
	Double	20	2.8	2.9	3.2

*As designated in the IHVE Guidebook A, 1970.

Table 1. Transmission of light and solar radiant heat by various glasses in vertical glazing

Glass		Light		Solar radiant heat		
Type	Thickness	Approximate transmittance from a diffuse source	Approximate absorption	Approximate direct transmittance	Approximate total transmittance	
	mm					
Transparent	3 to 10	0.80 to 0.90	0.05 to 0.20	0.71 to 0.88	0.77 to 0.90	
Patterned (untinted)	3 to 6	0.68 to 0.87	0.06 to 0.13	0.78 to 0.88	0.82 to 0.90	
Wired rough cast	7	0.81 to 0.85	0.11 to 0.14	0.78 to 0.82	0.82 to 0.86	
Solar control:						
grey/bronze	6	0.39 to 0.52	0.50 to 0.52	0.42 to 0.46	0.58 to 0.62	
blue/green	6	0.73 to 0.77	0.48 to 0.50	0.43 to 0.47	0.58 to 0.62	
Transparent double glazing	6 + 6	0.74 to 0.78	0.23 to 0.25	0.62 to 0.66	0.71 to 0.75	

*See PD...., 'Commentary on corrosion at bimetallic contacts and its alleviation' (in course of preparation).

17.2 Condensation. Condensation will occur on any surface the temperature of which is less than the 'dew point' of the atmosphere near the surface. Thus, when the climatic conditions cause the temperature of the inner surface of patent glazing bars or glass to fall low enough, or the interior specific humidity (see BS 1339) is increased sufficiently, condensation will occur. Climatic conditions are likely to be most severe in this respect during periods of ground frost, cold rain and low temperature with high wind.

Inside buildings the humidity is commonly increased by the release of process moisture (including that from cooking) and by the moisture from people. It may reach high values where ventilation is inadequate.

Where the pitch of the glazing exceeds 30° and condensation is not severe, the condensate will generally run down the glazing without dripping; though with dirty patterned glass the condensate may sometimes drip at much steeper angles. Provision should be made for water running down the glass to be released at the draught fillet.

The less the depth of glazing the less is the tendency for droplets of condensate to fall. Consequently, where the daylighting requirements (see CP 3 : Chapter 1 : Part 1) indicate considerable depths of glazing, it should be provided in two or more tiers or in separated runs.

Where the interior atmosphere is warm and humid and the glazing is at low pitch, the possibility of falling droplets may be minimized by the use of double glazing. Under extreme or exacting conditions the parts of glazing bars in contact with the interior atmosphere should be covered with insulating material. In such circumstances it may be advisable to separate aluminium glazing bars from the supporting steel structure by suitable non-metallic backings or coatings.

18. Solar heat

18.1 General. The entry of solar heat into the building is influenced by the local climate, the configuration, structure and surroundings of a building, and the position and orientation of its glazed areas. Solar radiation can be subjectively stimulating and economically useful; but it can cause discomfort by overheating and glare, with consequent reduction in human efficiency. Direct solar radiation can also adversely affect some industrial processes.

18.2 Transmission of heat. The heat of the sun enters a building through glass in two major ways:

- (a) by direct transmission of radiation through the glass;
- (b) by conduction and convection from heat absorbed in the glass.

In table 1 the extent of the direct transmission of radiant heat is shown by the figures in the penultimate column. The approximate total transmittances in the final column are obtained by adding to the direct transmittances a proportion of the absorptive values to take account of the amount of the absorbed heat that finds its way inwards by conduction and convection in average external weather conditions. For vertical single glazing the proportion has been taken as one third. This value varies with the wind speed and corresponds to an average wind speed at roof level of 3 m/s. The higher the speed of the wind the less is the proportion of absorbed heat conducted into the building. However, for air conditioning calculations it is customary, in the United Kingdom, to use average conditions and the 3 m/s is generally adopted for design purposes.

18.3 Control of solar heat by choice of glazing

18.3.1 Solar control glasses. The heating and glare effects of solar radiation can be reduced by the use of solar control glasses. These vary in tint, absorptivity and reflectivity, but all become heated by whatever proportion of radiation they absorb, and some of this heat will still be transferred inwards, reducing the efficiency of the glasses, as explained in 18.2. Ideally, for maximum efficiency, solar control glasses with sizeable absorptivity values should be used in the outer leaves of double glazing, with ordinary glass in the inner leaves and the spaces between freely ventilated to the outside. Where design considerations prevent this arrangement being incorporated, it is important that the building itself should be well ventilated to prevent the accumulation of warm air heated by the glazing.

It is important, with solar control glasses, to minimize thermal stress, and for this reason the overhang of the glass should be not less than 150 mm. With such glasses it is also essential that the edges of panes should be clean cut. Glass with nipped or damaged edges should not be used, because of the risk of cracks starting from edge flaws. Manufacturers' literature should be consulted for methods of reducing the risks of thermal breakage with particular reference to the combination, in double glazing, of the more highly heat-absorbing solar control glasses with wired glass.

18.3.2 Double glazing with a light coloured and diffusive interlayer. The reflectivity of the interlayer reduces the total heat flow into the building. The radiation that passes through is well diffused, reducing localized heating effects. Diffusive glazings may appear very bright when sunlit, and care may be needed to avoid discomfort. Again, the thermal safety of such systems should be considered.

18.3.3 Diffusing glasses, including patterned and wired glasses. Diffusing glasses may not appreciably reduce the total amount of solar heat entering through the glazing, but they have the effect of spreading the radiation and of reducing intense localized heating.

18.4 Other screening methods

18.4.1 Reflective treatments. The application of whitewash or dilute white emulsion paint externally to the glass in early summer greatly reduces the amount of solar heat transmitted. The loss of daylight transmission is generally of little consequence in the summer. By autumn, much of the obscurant will have been removed by weather and the remainder can be cleaned off easily, preferably during regular maintenance cleaning (see clause 28). Specially formulated white obscurants are marketed that are suitable for this purpose. Obscurants should be carefully selected as they can make the glass heat-absorbing, thus increasing thermal stressing and, consequently, the risk of breakage. Care should also be taken to prevent excess material being brushed or swilled under lead wings, as this may cause subsequent leakage. Alkaline obscurants, e.g. cement washes, should not be used, as they may damage the surface of the glass and can attack aluminium glazing bars.

18.4.2 Blinds or louvre screens. These should preferably be controllable. Some louvre screens are, however, permanent fixed installations, and some systems may be installed for the summer season. In general the blinds or screens should be of light colour and will minimize the effective in excluding solar heat and will minimize the build up of thermal stress in the glazing system, if fixed externally.

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18.5 Effect of dirt. If glazing in sunny situations is allowed to become very dirty, either internally or externally, the dirt will absorb the solar heat. This may result in glass breakage, particularly where wired glass is used; the accumulation of dirt should therefore be avoided by regular cleaning. Toughened glass is not subject to the same risk, as it can withstand large temperature differentials (see 9.2.5).

19. Ventilation

Ventilation through patent glazing is normally provided by the following systems.

- (a) Top-hung opening lights of patent glazing construction, usually one or two panes wide: more common in roof glazing but can also be fitted into vertical glazing. Suitable operating gear has to be provided.
- (b) Continuous opening lights of patent glazing construction three or more panes wide, for vertical or near vertical glazing only. Suitable operating gear has to be provided.
- (c) Top-hung, side-hung or bottom-hung, or centre-hung horizontally pivoted, ventilators, in metal window sections of either steel or aluminium inserted into vertical patent glazing only. Suitable fittings or operating gear have to be provided.
- (d) Louvres, fixed or adjustable, made of glass or opaque material, inserted into vertical patent glazing only.
- (e) Ventilating units and extractor fans of suitable design, made of metals, plastics or other materials, inserted into patent glazing, either vertical or sloping according to the design of the component.

All forms of ventilators and their fittings should be designed for the same loadings as the surrounding patent glazing.

20. Fire protection

20.1 Roofs. For roofs, the principal fire protection requirement is that the roof deck and its covering shall prevent fire from entering the building. The danger may be from fire in adjoining buildings or in adjacent parts of the same building, and the roofs may have to withstand such hazards as radiation and burning brands. The protection afforded by a roof is of particular importance where there is overtopping by an adjoining higher building. BS 476 : Part 3 describes fire tests that enable roofs to be classified in relation to external fire. With patent glazing there should be no great difficulty in reaching the highest designation, provided that the glass, whether wired or unwired, has a nominal thickness of at least 4 mm.

In relation to internal fire there is generally no call for any particular fire resistance in roof glazing, but for roof lights that form parts of the ceilings in rooms, circulating spaces or protected shafts, there are restrictions on the flame-spread classification of their internal surfaces and on the number, area and disposition of the roof lights. Patent glazing comprising glass panes carried on aluminium or steel bars can be used without regard to such restrictions.

In certain buildings (particularly in large and high buildings in Inner London coming within the scope of Section 20

of the London Building Acts (Amendment) Act 1939) resistance to internal fire may be required where roof lights in a roof at low level are overtopped by adjacent higher parts of the same building. Resistance to internal fire may also be required in order to protect an adjacent route across a roof used as a means of escape in case of fire. In such cases the roof lights may be required to have a certain standard of fire resistance when tested in accordance with BS 476 : Part 8, and the local fire authority should be consulted where necessary.

Provision for the venting of fires can be included in areas of patent glazing, where required. The subject of fire venting is discussed in Fire Note no. 5*.

20.2 Walls. Vertical glazing in external walls (which is held to include roof glazing at slopes of 70° or more) is subject to the fire provisions of the appropriate Building Regulations and may, in whole or in part, have to be regarded as an unprotected area in relation to the transmission of fire to adjoining property. The extent to which an unprotected area is permitted is determined by the distance to the wall from the relevant boundary.

Wherever there is a requirement for fire resistance in an external wall, whether it be for full compliance with all three criteria of BS 476 : Part 8 (stability, integrity and insulation) or for the circumstances in which the internal fire resistance has to be maintained for only 15 min, any form of glazing, including patent glazing, will, in general, be inadmissible.

Where glazed areas are permitted it will often be advantageous to use wired glass because of its ability to delay the passage of fire, and, in patent glazing, to use glazing bars with steel load-bearing cores in conjunction with fittings and fastenings of comparable efficiency. Where necessary, further advice should be obtained from the local authority building surveyors, the local fire authorities or HM Inspectors of Factories.

20.3 Further information. Further information on the fire hazards associated with glazing in buildings can be obtained from CP 153 : Part 4.

21. Maximum size of glass

Maximum size limits are determined more often by design considerations than by availability (see clause 13). Sometimes it is necessary for deep vertical panels of glass to be made up by edge-butting two lengths, the joint being weathered by a came. The subject of pane size is related to that of safety. Therefore, where design considerations permit, panes of moderate dimensions should be used.

Most patent glazing contractors are accustomed to working with panes up to 2 m² in area. Where it is proposed to use larger panes, or panes of unusual dimensions, the glazing contractor should be consulted.

22. Walkways

Maintenance of a consistent standard of daylighting demands regular cleaning of the glass, a process facilitated by the provision of walkways where no other means of access is available. Walkways also provide access for other purposes, and roof operations generally are thereby rendered safer and less time-consuming. Where appropriate, attention should be paid to the recommendations of CP 153 : Part 1.

* LANGDON-THOMAS, G J and HINKLEY, P L. Fire venting in single-storey buildings. Department of the Environment and Fire Offices' Committee Joint Fire Research Organization, Fire Note no. 5, 1965.

External walkways should have standards of durability similar to those of the glazing bars and fittings. To achieve these standards, it will be necessary to paint or otherwise protect steel parts periodically. Fastenings to aluminium members should be of austenitic high-tensile stainless steel type 302, or of steel suitably protected against corrosion and electrically insulated from the aluminium. Steel walkway members should be protected by galvanizing in accordance with BS 729, and their fastenings also should have a corrosion resistant finish. Generally, it is inadvisable to incorporate dissimilar metals, e.g. aluminium tread plates with steel supporting members.

Examples of suitable forms of construction for walkways are shown in figure 17 for aluminium and steel bar systems. The I_b and Z_b values for the glazing bars in these two examples are:

	I_b ($\text{mm}^4 \times 10^{-4}$)	Z_b ($\text{mm}^3 \times 10^{-3}$)
aluminium (figure 17(a))	520	47
steel (figure 17(b))	174	23

These forms of construction take account of three men standing on any 1.8 m of supported length of walkway plus the dead weight of the components, and a handrail loading in accordance with the Building Regulations.

Section four. Work on site

23. Storage

Glass panes are normally stored either packed in crates or stacked loose, and it is important that they, and the packing, should be kept dry when stacked. If water is allowed to collect between adjacent panes, the surface of the glass may be permanently damaged. The effect is most serious with the clear glasses. It is good practice that all types of glass should be stored so that the glass and packing remain dry.

Glass should always be handled with great care. Edges should not be knocked and panes should be carried as nearly vertical as possible. Particular care should be taken with solar control glasses as their life will be reduced by edge damage. Panes stored loose should rest on the long edge and be raised from the ground by stout timber battens placed about 300 mm from each end.

Stacks should be as near vertical as is safe. The work should be checked to see that the horizontal width of the stack is approximately the same at the bottom as at the top, as untidy stacking may result in damage to inner panes or may cause a dangerous slip. The stack should lean on a stout and unyielding support such as a wall, from which it should be protected by further timber battens, with no protruding nails.

The handling and storage of factory-made, double-glazing units and solar control glasses should be carried out in accordance with the manufacturer's instructions.

Patent glazing bars should be handled and stored in such ways as to avoid damage to them and to any protective coatings or coverings.

24. Preparation for glazing

24.1 Structural tolerances. The types of structure to which patent glazing is fixed, and the dimensional tolerances to which these structures are actually built, vary widely.

It is possible to fix patent glazing to a structure that contains some dimensional deviations, although in extreme cases it may be necessary to modify glazing components to do this. Patent glazing can, in fact, be adapted to approximate more closely to intended planes than the structure to which it is fixed.

Since patent glazing is composed of glass panes that are relatively inflexible, there are clearly economic limits to the adjustments of this nature that can be made, and equally there are limits to the positional tolerances of supports that can be accepted. To set out these limits in three dimensions for every case is complex. Accordingly, some simplified general statements are given for guidance (see table 3) and specifiers should recognize that, where very high standards of accuracy are essential to the appearance of the finished patent glazing on a particular project, it is recommended that from a very early stage specific controls should be introduced on the positional accuracy of the supporting and abutting members, in consultation with the patent glazing contractor.

Table 3. Structural tolerances

Table 3. Structural tolerances

Roof glazing

Component	Centreline spacing of holes		Vertical hole alignment
	Along purlins	Down slope	
Steel purlins	± 1.5 mm	± 3 mm	± 3 mm
Timber purlins	Not critical	± 6 mm	Not critical

Vertical glazing

Component	Centreline spacing of holes		Vertical hole alignment	Horizontal alignment of rails
	Along rails	Vertically		
Steel purlins	± 1.5 mm	± 6 mm	± 3 mm	± 3 mm
Other rails	± 3 mm	± 6 mm	± 6 mm	± 6 mm

Vertical glazing

Condition	Face alignment in section (per 3 m)	Horizontal dimensions on plan (per 3 m)	Vertical dimensions (per 3 m)
Over faces, e.g. concrete or brickwork	± 6 mm	± 6 mm	± 6 mm
Between faces, e.g. concrete or brickwork	± 6 mm	± 6 mm	± 6 mm

24.2 Roof glazing. Any roofing below and at the ends of the glazing should be completed, and all gutters should be fixed before glazing is commenced. Also, joints should have been raked out, chases cut, and preparations made, as required, to take the flashings.

The drilling or punching of steel purlins is normally carried out by the steel workers to agreed details and this, together with the correct lining-up of the purlins, should be completed before the fixing of glazing commences.

All supporting members should be straight to the required tolerances and have sufficient stiffness to avoid the possibility of misalignment with resulting glass breakage and water leakage.

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Steel should not be drilled, concrete and timber should not be cut, nor should any other preparatory work be undertaken, in ways likely to impair the strength of the structure, without the specific approval of the architect or structural engineer concerned.

Where roofs are glazed on one slope only (e.g. north-light roofs), the covering of the unglazed slope should proceed concurrently with the glazing to minimize combined pressure and suction effects not allowed for in the design of the completed building. On a sheeted and glazed roof slope, the glazier should not begin his work until the sheets below the glass are fixed. The sheets above the glass should not be laid until the glazier has fixed the glazing and laid the top flashing.

24.3 Vertical glazing. In general, the considerations outlined in 24.1 and 24.2 also apply to vertical glazing. Particular attention should be paid, however, to checking the dimensional accuracy of the building fabric to which the patent glazing is to be attached.

25. Fixing flashings

The patent glazing contractor should supply and fix all flashings at the periphery of the glazing and within the glazing area, especially those to be dressed on to the glass. Where flashings intended to cover glass are laid by others, the patent glazing contractor should be left to dress down the flashings to the glass.

26. Fixing and glazing

All work in relation to patent glazing, including the fixing of glazing bars, flashings, draught fillets and glass, should, where possible, be carried out by the patent glazing contractor. It is undesirable to allow access to areas beneath glazing that is in course of erection. If it is impossible to keep such areas clear, protective measures should be taken.

The provision of scaffolding, ladders and cradles needed for fixing the patent glazing should be covered specifically in the contractual arrangements.

The correct spacing and alignment of the glazing bars should be carefully maintained to ensure adequate support for the glass and freedom for thermal movement. Where the two surfaces of the glass differ in texture, e.g. smooth/rough, the manufacturer's glazing instructions should be followed. In general patterned glasses should be glazed with the smoother surface to the outside to minimize the collection of dirt.

When double patent glazing is being fixed the surfaces of the glass bounding the air cavity should be clean before assembly.

Flashings should be carefully dressed down to the glazing bars and glass; an air space to break any capillary path should be left at the top of the glass.

Section five. Inspection

27. General

During inspection of the work, special attention should be paid to the following considerations.

- (a) *Glazing bars* should be undistorted and any sheathing or protective coating should be undamaged.

- (b) *Glazing bars* should be securely fixed to their supports and all screws or nuts should be tight.
- (c) *Lead flashings* should be properly dressed down.
- (d) *Storm clips*, where specified, should be firmly fixed.
- (e) *Glass* should be free from cracks and solar control glasses should have clean cut edges.
- (f) *Wings, cappings and cushions* should make close contact with the glass.
- (g) *All draught fillets, cords, sealing ribbons and spacers* should be firmly in place.

Section six. Maintenance

28. Cleaning

As dirt accumulates on glass, the loss of light can reduce illumination to an unsatisfactory level and can affect safety; the absorption of solar radiation by the dirt layer can also cause the glass to become heated in sunny weather. For these reasons the glass should be cleaned regularly, at time intervals depending on the rate of dirtying. If there is ever any doubt about the need for general cleaning, a test on a single pane may be helpful. (See BS 6262 and CP 153 : Parts 1 and 2.)

While cleaning glass, care should be taken not to disturb the wings or cappings of the bars, or the flashings. Strongly alkaline solutions should not be used. Warm water with added detergent, applied by cloth, wash-leather or brush will usually suffice to remove the dirt. This should be followed by a clean water rinse. Where this is not enough, as, for example, on the outer surface of glass that has been exposed for a long period in an industrial area without cleaning, dilute solutions of hydrofluoric acid (less than 5 %) or of acid ammonium fluoride (5 % to 25 %) may have to be used to dissolve away the dirtied surface of the glass. These materials are dangerous and should only be handled by specialist firms, by operatives in protective clothing. It may also be necessary to take precautions against the dripping of corrosive liquids through the glazing. As soon as the dirt has been dislodged, the acid should be sluiced off the glazing and any surrounding materials with an excess of water. Particular care should be taken to see that the glazing bars, water channels, gutters and downpipes are washed clear of all dirt and residual chemicals.

29. Other maintenance

It is advisable that periodic inspection should be carried out to detect any damage. Replacement of broken panes and other repair work required on the glazing should preferably be carried out by the firm responsible for the original installation.

30. Access for maintenance

All workmen engaged on maintenance work should use stepboards or other suitable equipment as required by the Construction (Working Places) Regulations, 1966, and any subsequent re-enactment. Equipment should be so constructed that the weight of workmen is well distributed, and over at least two patent glazing bars. Experienced workmen (men who know how and where to apply their weight) should be employed. Glass should never be walked upon.

Appendix A

Loads due to weights of bars and glass

The following loads due to bars and glass have been used in this code:

	Aluminium bars	Steel bars
	N/m ²	N/m ²
† 6 mm single glazing	180	240
† 6 mm + 6 mm double glazing	340	430

The load due to the 6 mm glass alone has been taken as 150 N/m². Where thinner glass is used the weight of the

glass assumed in the computations can, if desired, be reduced proportionally.

For the derivation of design loads the component of the weight perpendicular to the plane of the glazing is required. This is weight $\times \cos A$ and figures for a range of angles are given in table 4. The values underlined, at the angles 15°, 45° and 60°, are those used in compiling tables 10 to 13 of this code. Even when considering the design loads for the glass alone, the weight taken is that of the glass and bars together, as the curvature of the bars caused by their own weight is communicated to the glass and this effect can be regarded as an indirect load on the glass.

Table 4. Loads on patent glazing due to weights of bars and glass

Angle of glazing to horizontal (A)	Load perpendicular to the glass				
	Glass alone	Aluminium bars and glass		Steel bars and glass	
	Single glazing*	Single glazing	Double glazing*	Single glazing	Double glazing
°	N/m ²	N/m ²	N/m ²	N/m ²	N/m ²
0	150	180	340	240	430
5	149	179	339	239	428
10	148	177	335	236	423
15	<u>145</u>	<u>174</u>	<u>328</u>	<u>232</u>	<u>415</u>
20	141	169	319	226	404
25	136	163	308	218	390
30	130	156	294	208	372
35	123	147	279	197	352
40	115	138	260	184	329
45	<u>106</u>	<u>127</u>	<u>240</u>	<u>170</u>	<u>304</u>
50	96	116	219	154	276
55	86	103	195	138	247
60	<u>75</u>	<u>90</u>	<u>170</u>	<u>120</u>	<u>215</u>
65	63	76	144	101	182
70	51	62	116	82	147
75	39	47	88	62	111

*Single glazing based on 6 mm glass, double glazing on 6 mm + 6 mm glass.

Appendix B

Wind loading

B.1 The procedure for determining wind loadings is based on CP 3 : Chapter V : Part 2 and the symbols used in this appendix are as used in that code. The maximum 3 s gust speed to be expected at the building site, on a once-in-50-years probability of recurrence and at a standard height of 10 m above ground level, is corrected for topography (factor s_1), for ground roughness and height above ground (factor s_2), and for the probability of recurrence of the maximum condition (factor s_3), if the design life of the building is such that a probability of once-in-50-years would be inappropriate.

B.2 The corrected wind speed is then converted into a dynamic pressure, which in turn is multiplied by a pressure coefficient to take account of the building shape and of any possible reinforcing effects from internal pressure or

suction, resulting from air leakages through the outer envelope, and particularly from the effects of possible apertures. The final figure is the working pressure for wind at the selected point on the building.

B.3 For many buildings without undue complications of location and shape it is reasonable to assume average wind loading effects and to use overall safe values for the pressure coefficients, without the need for giving detailed consideration to each building.

B.4 The procedure described in **B.5** can be used to determine the limiting design requirements provided that the following conditions apply.

- The building is of rectangular shape with height less than 1.5 times the lesser horizontal dimension.
- Any large openings are not in areas of high local suction.

†This also includes the use of 7 mm wired rough cast glass.