

Patent glazing and sloping glazing for buildings —

Part 2: Code of practice for sloping glazing

ICS 81.040.20; 91.060.50

Committees responsible for this British Standard

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- Association of Building Engineers
- Consumer Policy Committee of BSI
- Council for Aluminium in Building
- Flat Glass Manufacturers' Association
- Glass and Glazing Federation
- Institution of Structural Engineers
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Foreword

This part of BS 5516 has been prepared under the direction of Technical Committee B/520. This part of BS 5516, together with BS 5516-1, supersedes BS 5516:1991, which is withdrawn. It revises all or part of Clauses **6, 7, 10.3** to **10.5, 10.6.2, 10.6.3, 10.8, 12, 14** to **19, 20.1, 20.3, 20.4, 21** to **24, 25.1, 25.2, 25.4, 25.6, 25.8, 25.9, 26** to **29**, and Annex A to Annex F and Annex J to Annex K of BS 5516:1991.

BS 5516:1991 has been revised and restructured to simplify its use and will be published in three parts covering the following areas:

- *Part 1: Code of practice for design and installation of sloping and vertical patent glazing;*
- *Part 2: Code of practice for sloping glazing;*
- *Part 3: Special applications.*

Requirements for standards of workmanship for glazing have been published separately as BS 8000-7 and, therefore, this subject is not dealt with in this standard.

Since the correct selection of materials to be used in glazing for buildings depends on many factors, attention is drawn to the other parts of this standard.

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its 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 and iv, pages 1 to 83 and a back cover.

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1 Scope

This part of BS 5516 gives recommendations for design, properties and maintenance of sloping glass and plastics glazing sheet materials in overhead situations in the envelope and interiors of buildings. It includes those situations where the sloping glazing extends down to floor level.

These recommendations apply only when the glass is installed in an appropriate glazing system.

These recommendations do not apply to:

- a) vertical glazing (see BS 6262);
- b) glazing for commercial greenhouses (see BS 5502-21);
- c) glazing for domestic greenhouses;
- d) sloping glazing which is to be used as a walking surface (see BS 5516-3);
- e) profiled plastics sheets.

NOTE There are occasions, as with some curved glazing, where parts of a pane might be vertical, while other parts might be sloping. In this case, attention is drawn to both BS 6262 and BS 5516.

Requirements for standards of workmanship for glazing have been published separately as BS 8000-7 and, therefore, this subject is not within the scope of this standard.

Since the correct selection of materials to be used in glazing for buildings depends on many factors, attention is drawn to the recommendations in the other parts of this standard.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the reference cited applies. For undated references, the latest edition of the referenced document (including any amendments).

BS 476-3:1958, *Fire tests on building materials and structures — Part 3: External fire exposure roof test.*

BS 476-4, *Fire tests on building materials and structures — Part 4: Non-combustibility test for materials.*

BS 476-6, *Fire tests on building materials and structures — Part 6: Fire tests on building materials and structures. Method of test for fire propagation for products.*

BS 476-7, *Fire tests on building materials and structures — Part 7: Method of test to determine the classification of the surface spread of flame of products.*

BS 476-20, *Fire tests on building materials and structures — Part 20: Method for determination of the fire resistance of elements of construction (general principles).*

BS 476-22, *Fire tests on building materials and structures — Part 22: Methods for determination of the fire resistance of non-loadbearing elements of construction.*

BS 952-1, *Glass for glazing — Part 1: Classification.*

BS 4254, *Specification for two-part polysulphide-based sealants.*

BS 4255, *Rubber used in preformed gaskets for weather exclusion from buildings.*

BS 5215, *Specification for one-part gun grade polysulphide-based sealants.*

BS 5357, *Code of practice for installation of security glazing.*

BS 5368, *Methods of testing windows.*

BS 5516-1:2004, *Patent glazing and sloping glazing for buildings — Part 1: Code of practice for design and installation of sloping and vertical patent glazing.*

BS 5713, *Specification for hermetically sealed flat double glazing units.*

BS 5889, *Specification for one-part gun grade silicone-based sealants.*

BS 6180, *Barriers in and about buildings — Code of practice.*

BS 6206, *Specification for impact performance requirements for flat safety glass and safety plastics for use in buildings.*

BS 6262 (all parts), *Code of practice for glazing for buildings.*

BS 6262-4, *Glazing for buildings — Part 4: Safety related to human impact.*

BS 6375, *Performance of windows.*

BS 6399-2:1997, *Loading for buildings — Part 2: Code of practice for wind loads.*

BS 6399-3, *Loading for buildings — Part 3: Code of practice for imposed roof loads.*

BS 8213-1, *Windows, doors and rooflights — Part 1: Code of practice for safety in use and during cleaning of windows and doors (including guidance on cleaning materials and methods).*

BS EN 356, *Glass in building — Security glazing — Testing and classification of resistance against manual attack.*

BS EN 572-2, *Glass in building — Basic soda lime silicate glass products — Part 2: Float glass.*

BS EN 572-3, *Glass in building — Basic soda lime silicate glass products — Part 3: Polished wired glass.*

BS EN 572-5, *Glass in building — Basic soda lime silicate glass products — Part 5: Patterned glass.*

BS EN 572-6, *Glass in building — Basic soda lime silicate glass products — Part 6: Wired patterned glass.*

BS EN 673, *Glass in building — Determination of thermal transmittance (U value) — Calculation method.*

BS EN 1063, *Glass in building — Security glazing — Testing and classification of resistance against bullet attack.*

BS EN 1096 (all parts), *Glass in building — Coated glass.*

BS EN 1279 (all parts), *Glass in building — Insulating glass units.*

BS EN 1363-1:1999, *Fire resistance tests — Part 1: General requirements.*

BS EN 1364-1:1999, *Fire resistance tests for non-loadbearing elements — Part 1: Walls.*

BS EN 1364-2:1999, *Fire resistance tests for non-loadbearing elements — Part 1: Ceilings.*

BS EN 1634-1:2000, *Fire resistance tests for door and shutter assemblies — Part 1: Fire doors and shutters.*

BS EN 1634-3:2001, *Fire resistance tests for door and shutter assemblies — Part 3: Smoke control doors and shutters.*

BS EN 1863 (all parts), *Glass in buildings — Heat strengthened soda lime silicate glass.*

BS EN ISO 10077-1, *Thermal performance of windows, doors and shutters — Calculation of thermal transmittance — Part 1: Simplified method.*

BS EN 12056, *Gravity drainage systems inside buildings. Roof drainage, layout and calculation.*

BS EN 12150 (all parts), *Glass in building — Thermally toughened soda lime silicate safety glass.*

BS EN 13501-1, *Fire classification of construction products and building elements — Classification using test data from reaction to fire tests.*

BS EN 13541, *Glass in building — Security glazing — Testing and classification of resistance against explosion pressure.*

BS EN 13823:2002, *Reaction to fire tests for building products — Building products excluding floorings exposed to the thermal attack by a single burning item.*

BS EN ISO 1182:2002, *Reaction to fire tests for building products — Non-combustibility test.*

BS EN ISO 1716:2002, *Reaction to fire test for building products — Determination of the heat of combustion.*

BS EN ISO 9239-1:2002, *Reaction to fire tests — Horizontal surface spread of flame on floor-covering systems — Part 1: Determination of the burning behaviour using a radiant heat source.*

BS EN ISO 11600, *Building construction — Jointing products — Classification and requirements for sealants.*

BS EN ISO 11925-2:2002, *Reaction to fire tests — Ignitability of building products subjected to direct impingement of flame — Part 2: Single flame source test.*

BS EN ISO 12543 (all parts), *Glass in building — Laminated glass and laminated safety glass.*

3 Terms and definitions

For the purposes of this part of BS 5516, the following terms and definitions apply.

3.1

aspect ratio

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

3.2

conservatory

construction which has not less than three-quarters of the area of its roof and not less than one half of the area of its external walls made of translucent material, and which is attached to and has direct access from a building

3.3

coupled glazing

two panes of glazing spaced apart in an opening, either in the same frame or glazed separately, to form an unsealed cavity

3.4

edge cover

distance between the edge of the glass and the sight line

NOTE See Figure 1.

3.5

fire resistant glass

glass that can resist the passage of flames and smoke through the glass for a period of time (normally 30 min or longer), when tested in accordance with BS 476-22 or BS EN 1364-1 or BS EN 1364-2

NOTE Fire resistant glass which can also resist the passage of heat through the glass for a period of time (normally 30 min or longer), when tested in accordance with BS 476-22 or BS EN 1364-1 or -2, without the unexposed surface temperature exceeding a specified limit is known as insulated glass. Fire resistant glass that does not have this resistance to heat is known as integrity only glass.

3.6

frame

member which continuously supports and retains the edge of the glazing

3.7

glazing

glass or plastics glazing sheet material for installation into a building

3.8

glazing bar

member, incorporating drainage channels, that supports and retains the edges of the glazing in patent glazing

3.9

glazing material

product or substance used as an intermediary to separate the glazing from the frame which supports and restrains it

NOTE Glazing materials might also restrict air and water ingress and might play an active part in restraining the glazing sealants; gaskets and glazing strips are the commonest types.

3.10

insulating glass unit

i.g.u.

two or more panes of glass manufactured to size and shape, spaced apart and then hermetically sealed in a factory, ready for glazing

NOTE The individual panes might be of different sizes and/or thicknesses.

3.11

nominal

<of dimensions> design size excluding tolerances

3.12

pane

single piece of glass or plastics glazing sheet material, in a finished size ready for glazing

3.13

pane size

dimensions of a pane

NOTE See Figure 1.

3.14

patent glazing

self draining and ventilated system of dry glazing, which does not rely entirely for its watertightness upon external seals. It consists essentially of a series of continuous longitudinal glazing bars with an infilling of glass or other suitable material

3.15

plastics glazing sheet material

plastics materials in the form of a single sheet, or a combination of sheets laminated together, or an extruded multi-wall sheet

3.16

sight size

dimensions of the opening which, when glazed with a transparent or translucent pane, admits light

NOTE See Figure 1.

3.17

sloping glazing

glazing which is horizontal or having a slope of 75° or less

NOTE Slopes are measured from the horizontal; thus a slope of 75° is 15° from true vertical.

3.18

tight size

rebated size

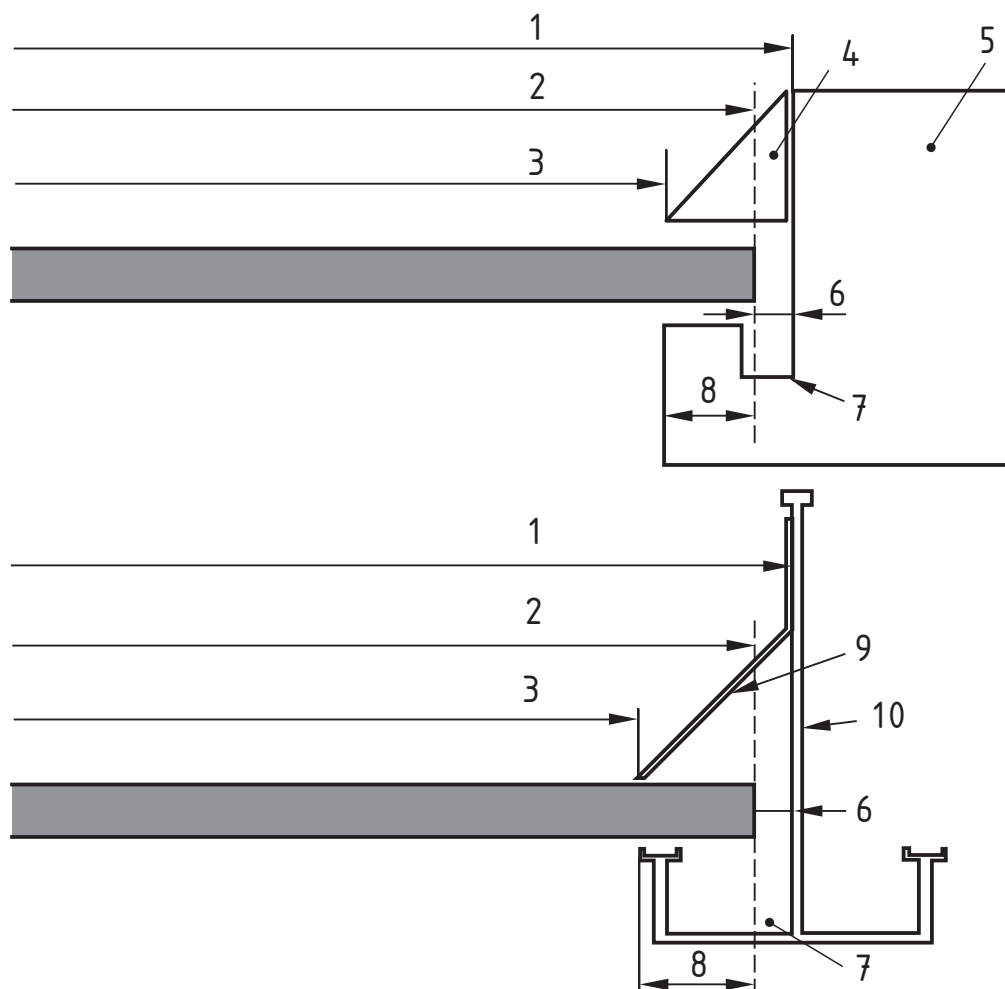
dimensions of the rebated opening

NOTE See Figure 1.

3.19

vertical glazing

glazing which is vertical, or within 15° of vertical

**Key**

- | | |
|--------------|------------------|
| 1 Tight size | 6 Edge clearance |
| 2 Pane size | 7 Drainage |
| 3 Sight size | 8 Edge cover |
| 4 Bead | 9 Wing |
| 5 Frame | 10 Glazing bar |

Figure 1 — Definition of sizes

4 Symbols

A	Area of glazing
A_e	Effective area of glazing
a	Longer dimension of four edge supported glazing
b	Span between supports for two edge supported glazing, or smaller dimension of four edge supported glazing
C	Sound reduction index modification factor
C_p	Combined pressure coefficient for calculating wind loads
C_{tr}	Sound reduction index modification factor for traffic noise
d_{all}	Maximum deflection of the glass or plastics glazing sheet material
f_c	Critical resonance
F	Shape factor
F_A	Altitude factor
F_T	Topographical factor
g_i	Dead weight per unit area of the glazing
h	Depth of valley in a valley roof
h_1	Height of abutting structure above roof or canopy
h_2	Height of abutting structure above roof or canopy
H_A	Altitude of the site
L	Unsupported length of glazing
p_{di}	Dead load, including self weight
$p_{g,f}$	Working pressure for glass strength calculation
$p_{g,y}$	Working pressure for glass deflection calculation
p_p	Working pressure for plastics glazing sheet material
p_s	Design snow load
p_w	Design wind load
q	Site dynamic wind pressure
q_0	Site dynamic wind pressure equivalent at sea level
r	Aspect ratio a/b of the glazing
R	Sound reduction index
R_m	Mean sound reduction index
R_{TRA}	Weighted sound reduction index against traffic noise
R_W	Weighted sound reduction index
s_0	Site snow load
s_{alt}	Snow load altitude factor
s_b	Basic snow load
s_d	Snow load
S	Span of a glazing bar between its support points
t	Glass thickness
α	Slope of the glazing

5 Glazing

5.1 Glass

Glass for glazing should conform to the classification of BS 952-1. The availability and viability of the glass should be checked with the manufacturer. The following are the types of glass normally used in sloping glazing.

- Float glass, clear or body tinted, which should conform to BS EN 572-2.
- Polished wired glass, which should conform to BS EN 572-3.
- Patterned glass, clear or body tinted, which should conform to BS EN 572-5.
- Wired patterned glass, which should conform to BS EN 572-6.
- Insulating glass units, which should conform to BS 5713 (or BS EN 1279).
- Coated glass, which should conform to BS EN 1096.
- Heat strengthened glass, which should conform to BS EN 1863.
- Thermally toughened glass, which should conform to BS EN 12150.
- Enamelled thermally toughened, which should conform to BS EN 12150.
- Heat soaked thermally toughened glass.
- Laminated glass, which should conform to BS EN ISO 12543.

NOTE A European Standard, prEN 14179, is being developed for heat soaked thermally toughened glass.

5.2 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 sloping glazing are generically:

- polycarbonate (PC);
- unplasticized polyvinyl chloride (PVC-U);
- polymethylmethacrylate (PMMA), commonly referred to as “acrylic”;
- glass reinforced plastic (GRP).

PC, PVC-U and PMMA are thermoplastics, available in both solid sheet and hollow section forms. In addition to being available as clear transparent form, some of them are available as transparent colours, as opal whites and with patterned surfaces.

GRP is a glass-reinforced thermoset, available only in translucent form, which may be coloured.

For further information on plastics glazing sheeting materials, see Annex A.

6 Glazing systems

6.1 General

Many types of glazing systems can be used for supporting sloping glazing. These include patent glazing (see BS 5516-1), slope glazed curtain walling, rooflights, sloping roof windows, structural sealant glazing and structural bolted systems.

In all of these systems, attention should be paid to weather resistance (see Clause 15), which is more difficult to achieve in sloping glazing than it is in vertical glazing, and appropriately dimensioned components should be used to adequately support and protect the glazing.

6.2 Patent glazing

Patent glazing should conform to the requirements of BS 5516-1.

6.3 Glazing systems using beaded frames or pressure plates with caps

This includes slope glazed curtain walling, rooflights, etc.

The rebate depth should be designed to give a nominal edge clearance of 6 mm all round the glazing and a nominal edge cover of at least 10 mm and not less than the thickness of the single pane or the thicker pane of an insulating glass unit.

To protect the edge seal of insulating glass units from the effects of UV exposure, the nominal edge cover should be at least 12 mm and preferably 16 mm, unless the edge seal is of a type (e.g. silicone dual seal) that can resist exposure to UV light. It is possible to enhance the effective edge cover by using chamfered gaskets. The frame should also be designed to drain any water that gets into the frame away from the edges of insulating glass units.

For plastics glazing sheet materials, the minimum edge cover should be 15 mm.

Glazing materials should be compatible with the glazing and the frame. Particular attention should be paid to compatibility with edge seal of insulating glass units and with plastics glazing sheet materials.

Transoms should be designed to avoid local ponding of water on the sloping glazing. This can be either by having a sufficiently low, chamfered profile or by incorporating a drainage mechanism.

6.4 Structural sealant glazing

This method of glazing uses the adhesive qualities of silicone sealants to retain glass in the frame by adhesion, without the necessity of any mechanical retention such as beads, clips or bolt fixings (although some specifiers insist on augmenting the system with retaining clips or other mechanical devices). The system can be either a two edge or four edge system. In a two edge system, two opposite edges are retained in a traditional frame with bead retention (see 6.3).

The glazing should be prepared in the factory by mounting a structural seal support frame onto the glass, complete with any appropriate setting blocks, location blocks and distance pieces. On site, the support frame is attached to the building structure by mechanical means and the gaps between the glazing are sealed (see Figure 2).

The inner pane of an insulating glass unit should not be manufactured from monolithic toughened glass, since, if this is accidentally fractured, there is a possibility that the rest of the unit will become detached from the adhesive.

The glass selection should take into account the likely loading, be appropriate for safety requirements and be appropriate for environmental factors, e.g. thermal insulation, solar control and sound insulation.

The adhesive sealant is the only or the main means of retaining the glazing in position, so the type of sealant is important. Only sealants recommended by the manufacturer for this purpose should be used.

The sealant bite should be determined from the design loads on the glass and the allowable stress in the sealant. With an insulating glass unit, both the unit hermetic seal and the structural seal serve a structural purpose in retaining the glass in position and the sealant bite for both of these should be not less than the calculated figure.

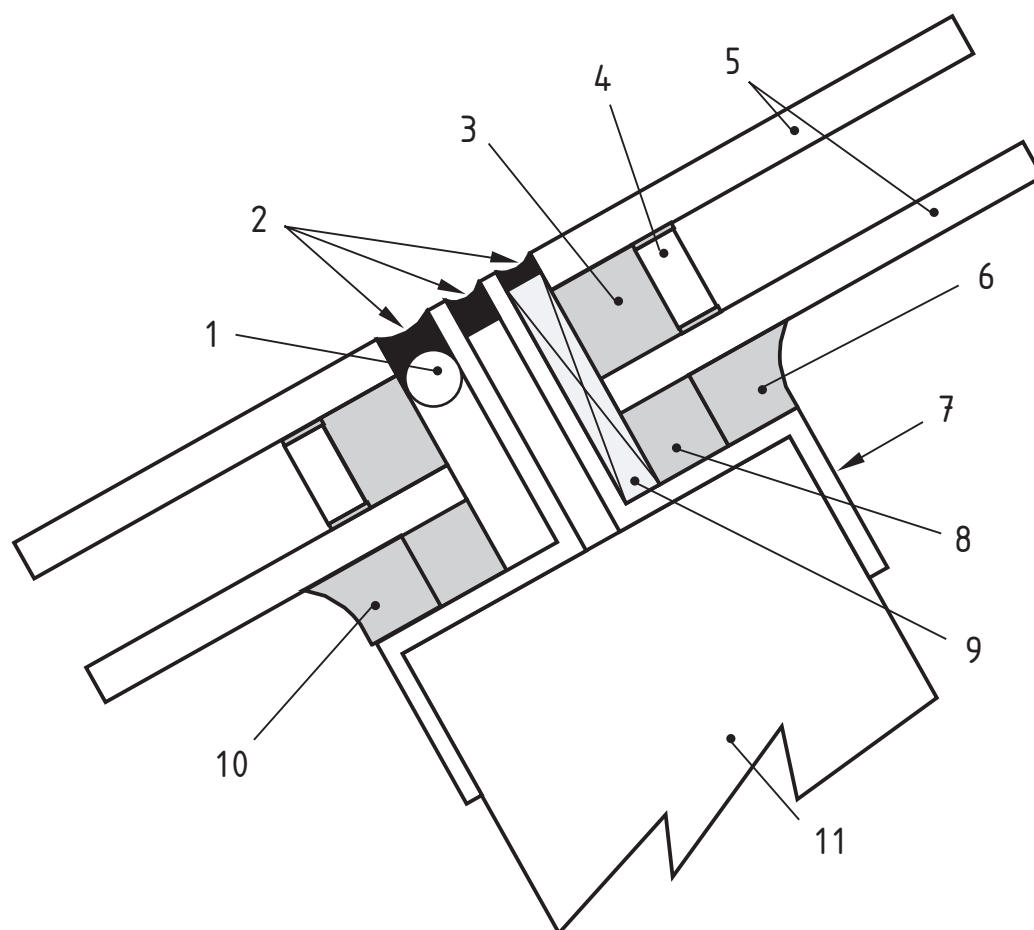
The glazing should be designed in such a way that the sealant is only subjected to short duration tensile forces, e.g. wind suction or live loads. Dead loads or sustained loads, such as snow, should be supported by the sealant in compression or by other means, e.g. setting blocks to carry the glass weight, unless the sealant is shown to be capable of sustaining the loads.

The design of the glazing should eliminate shear stresses on the structural sealant, unless it has been specifically designed for this purpose.

The sealant will only perform its function if the adhesive bonds between the sealant and the surfaces of the glass and the support frame are adequate and durable. The sealant supplier should perform tests on the adhesion at all the interfaces of the proposed products to ensure that the joint is capable of developing the required strength and that this can be maintained for the expected life of the glazing, assuming regular inspection.

Adhesion is product and surface specific. Once the adhesion tests have been completed satisfactorily, the specification for the glass, the support frame, the adhesive sealant and any primers should not be changed. If any changes are made, the full range of tests should be repeated.

Assembly of the glass and the support frame should be performed in controlled factory conditions, working to a prepared method statement. The adhesive qualities of the joint can be adversely affected by changes in temperature and humidity or the presence of moisture, so structural glazing adhesive joints should not be made on site.

**Key**

- | | |
|-----------------------|------------------------------------|
| 1 Backer rod | 7 Structural sealant support frame |
| 2 Weather seals | 8 Spacing material |
| 3 i.g.u. edge sealant | 9 Setting block |
| 4 Spacer bar | 10 Structural sealant |
| 5 Glass | 11 Building structure |
| 6 Structural sealant | |

Figure 2 — Structural sealant glazing

6.5 Structural bolted glazing

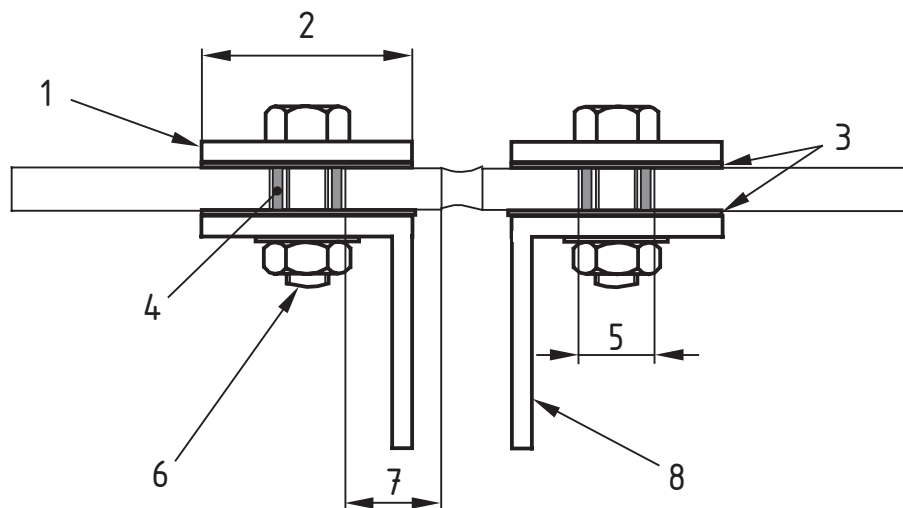
This method of glazing uses bolted fixings through glass to retain the glass in position. The panes are butt jointed to each other and weather sealing is achieved by using sealant, usually silicone, between the edges of the panes. At the edges of the glazing system, a rebated and beaded frame or a channel may be used.

For bolted fixings, toughened glass should be used for the main load bearing glazing, although heat strengthened glass may be used for non load bearing components with holes or cutouts. Annealed glass should never be used with bolted connections through holes or cutouts.

The fixings should be designed to limit the local bearing stress generated by the bolted connection, by having adequate bearing area and having suitable gaskets and bushes to prevent glass to metal contact and spread the loads. A fixing that can perform this function is shown in Figure 3.

Other types of fixing, such as countersunk bolted systems, may be used. The manufacturer should be consulted.

Where bolted fixings are used away from the corners of the glass, or with complex shapes, or with intermediate fixings, care should be taken to take into account the stress concentrations generated around holes and notches by bending the glass across them.



Key

- | | |
|--|---|
| 1 Minimum 6 mm thick metal plate | 5 Glass hole diameter = bolt diameter + 10 mm |
| 2 Plate diameter = glass hole diameter + 30 mm | 6 Bolt tightened to maximum torque |
| 3 1 mm incompressible fibre gaskets | 7 Minimum $2 \times$ glass thickness |
| 4 Nylon bush, 2 mm to 3 mm thick | 8 Minimum 6 mm thick metal angle fixed to structure |

Figure 3 — Example of a simple bolted fixing

7 Mechanical design

7.1 Loading

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

- wind pressure exerted on the surface of the sloping glazing, which can act either inwards (positive pressure) or outwards (negative pressure or suction) or both: negative and positive pressures are not necessarily equal in magnitude;
- snow acting inwards on the surface of the sloping glazing;
- self-weight, usually acting inwards: the weight should also be considered as a load acting downward in the plane of the glazing;
- maintenance, if required, which should be taken as acting inwards.

7.2 Assessment of design loads

7.2.1 Wind load

The design wind loads, both positive and negative, for the particular situation of the sloping glazing should be determined at the initial design stage.

Wind loads for external walls and roofs of normal, rectangular, clad buildings and for canopy roofs should be determined by the method described in BS 6399-2:1997. A summary of this procedure is given in Annex B, together with an approximate method for low rise buildings.

For buildings of unusual geometric shape or site location not covered by BS 6399-2:1997 and for problems involving consideration of the excess pressure near ground level that can, in some circumstances, be generated by downdraught from tall buildings or high speed air currents such as can occur in narrow paths between buildings, expert advice should be sought, e.g. from the Building Research Establishment.

7.2.2 Snow load

The design snow loads on roofs for the particular situation of the sloping glazing should be determined at the initial design stage.

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

Exceptional local effects such as shelter from the wind or local configurations which funnel the snow can give rise to increased loading. If there might be unusual local conditions that might 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, snow guards should be fitted and BS EN 12056 should be referred to for detailed advice.

7.2.3 Self-weight

Dead loads for the glazing should be calculated from the actual known mass of the glazing.

Self-weight should also be considered as a dead load acting downwards in the plane of the glazing (see Annex D).

7.2.4 Maintenance load

Safe and efficient means of access should be considered for the maintenance, including cleaning, of sloping glazing, both inside and outside.

NOTE Attention is drawn to the requirements of the Construction Design and Management Regulations and the HSE Book *Health and Safety in Roof Work*, HSG33 [1].

Maintenance loads should not be applied directly to the glazing, but to the frame, glazing bars or other supporting elements by means of crawler boards, spreaders, or through specifically designed attachments for maintenance. Where direct access by temporary ladder or crawling boards is intended, the frames or glazing bars should, if required, be capable of supporting the loads imposed by their use. If the glazing is required to carry maintenance loads directly, it should be designed specifically for this purpose.

NOTE BS 5516-3 is in preparation.

Access systems which are independent of the sloping glazing system are preferred, especially for the maintenance of sloping glazing at high level.

7.2.5 Other loads

Where loads other than those mentioned in 7.2.1, 7.2.2, 7.2.3 and 7.2.4 are anticipated, for example any permanent imposed loads or suspended loads, expert advice should be sought. These loads should not normally be applied directly to the glazing or the glazing bars, but to the supporting structure.

7.3 Determination of working pressures

7.3.1 General

In determining working pressures for sloping 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 glazing. Examples of this procedure are given in Annex E.

7.3.2 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 7.5.1, are based is that for a uniform, short duration (e.g. wind gust) load and the relative strength for a sustained load is approximately $\frac{1}{3}$ 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 short duration 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.

For the purpose of calculating deflections, the values of the longer duration loads need not be factored up. Extended duration of loads on glass does not lead to creep (i.e. increased deflection).

Applying this adjustment for sustained loads to combinations of design loads considered in Annex B, Annex C and Annex D, the following expressions are obtained.

a) Stress calculations:

- for positive (downward pressure) p_w : the higher of either: $+ 0.6p_w + 2.6(p_s + p_{di})$
or: $+ p_w + 2.6(0.6p_s + p_{di})$
- for negative (wind suction) p_w : $- p_w + p_{di}$

b) Deflection calculations:

- for positive (downward pressure) p_w : the higher of either: $+ 0.6p_w + p_s + p_{di}$
or: $+ p_w + 0.6p_s + p_{di}$
- for negative (wind suction) p_w : $- p_w + p_{di}$

To take account of wind-free conditions, zero should be substituted for $+ p_w$.

Each load case should be considered and whichever of the resultant values is numerically the greater for stress, $p_{g,f}$, and deflection, $p_{g,y}$, calculation should be taken as the operative working pressures for glass for the particular situation of the glazing. The values thus obtained should be used with the graphical data given in 7.5.1 for determining the recommended minimum thickness for glass.

The expressions apply to glass in single glazing and to insulating glass units.

With systems of coupled glazing comprising two or more 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 coupled glazing, only the outer pane of glass needs to be capable of carrying the snow load.

7.3.3 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 glazing. 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 7.5.2 are based is that for a uniform, short duration (e.g. wind gust) 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 short duration 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 Annex B, Annex C and Annex D, the following expressions are obtained.

For positive (downward pressure) p_w : the higher of either $+0.6p_w + 2(p_s + p_{di})$

or $+p_w + 2(0.6p_s + p_{di})$

For negative (wind suction) p_w :

$-p_w + p_{di}$

To take account of wind-free conditions, 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 glazing. The values thus obtained should be used with the data given in 7.5.2 for determining the recommended minimum thickness for solid sheet or the form of hollow section sheet, of the plastics glazing sheet materials.

The expressions apply to solid plastics glazing sheet materials in single glazing and to hollow section plastics glazing sheet materials. With systems of coupled 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 coupled glazing, the outer pane should be capable of carrying the snow load but the inner pane need not.

7.4 Strength and stiffness

7.4.1 Glass

The strength of glass to withstand uniform loading is based on the safe tensile stress it can carry and depends on the load duration, 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.

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 might result in excessive deflection and this should be taken into account when determining the spacing of glazing bars.

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.

Deflection in the glass should 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.

In the absence of any specified deflection limits, the glass deflection relative to its supports should be limited to $L/65$ when the glass is subjected to the working pressure determined from 7.3.2, where L is an appropriate unsupported length, e.g. the span, b , of two edge supported glazing, or the length, a , of four edge supported glazing.

7.4.2 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 glazing bars 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 Annex A). Deflection of the plastics glazing sheet material results in reduction of edge cover. When the plastics glazing sheet 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.

7.5 Determination of recommended minimum thickness for glazing

7.5.1 Glass

Working pressures for glass determined on the basis of a short duration load, taking account of sustained loading effects, as described in 7.3.2, should be used to calculate the minimum thickness or maximum size of pane by a graphic technique. The procedure given is for rectangular panes of annealed and processed flat glass, as described in BS 952-1, used in a glazing system with an appropriate edge cover and which does not deflect under maximum design load by more than the appropriate limits given in 7.6. The procedure applies to glass in single glazing, to each pane of glass in coupled glazing comprising two separate and mechanically independent layers of glass and to insulating glass units.

The graphs should 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, using the procedures given in Annex F.

Figure 4a) to Figure 4f) are for glass which is fully supported on two opposite edges only and for glass which is fully supported on all four edges having an aspect ratio of pane greater than 3:1.

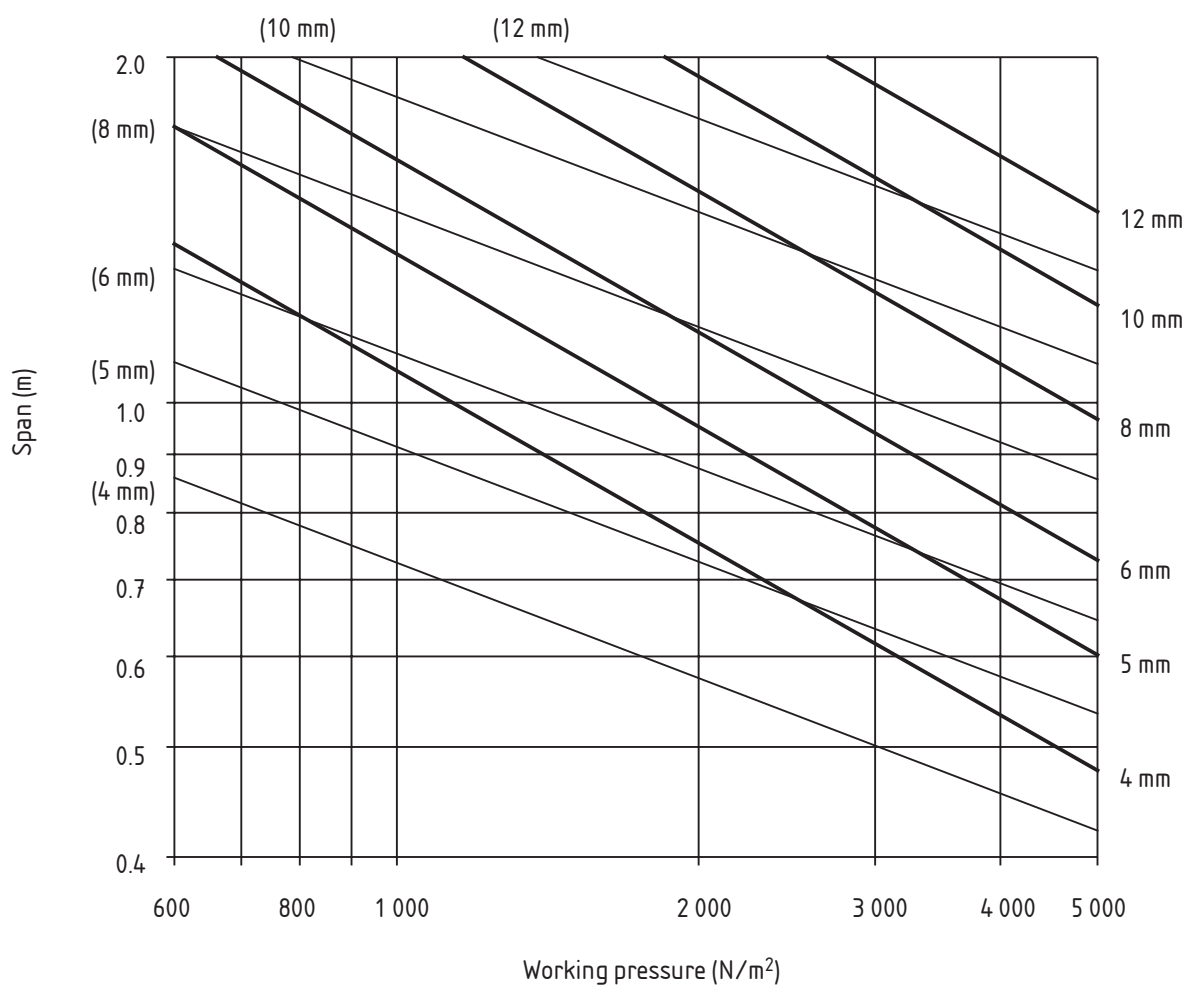
Figure 4g) to Figure 4l) are for glass which is fully supported on all four edges having an aspect ratio of pane not greater than 3:1. The effective area of the glazing is determined by the method in Annex F. As noted in 7.3.2, if the aspect ratio of pane is greater than 3:1 the glass is considered to 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 4a) to Figure 4f). 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 glazing bar or frame should not exceed the appropriate limits given in 7.6. 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 might also need to be followed. Glass having to withstand only low working pressure, notably in sheltered situations or used internally, might 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 600 N/m² is used.

The figures containing information on toughened glass are based on the design stress for fully toughened glass. This may lead to a glass design which, although mechanically safe, has large and possibly visually disturbing deflections under maximum load. The figures for two edge supported glass or insulating glass units also contain information on the thickness required to limit the deflection to the value suggested in 7.4.1.

The laminated glasses referred to are three-ply laminated glass incorporating an interlayer of polyvinylbutyral. Thicknesses shown are nominal and based on the total glass thicknesses only.

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



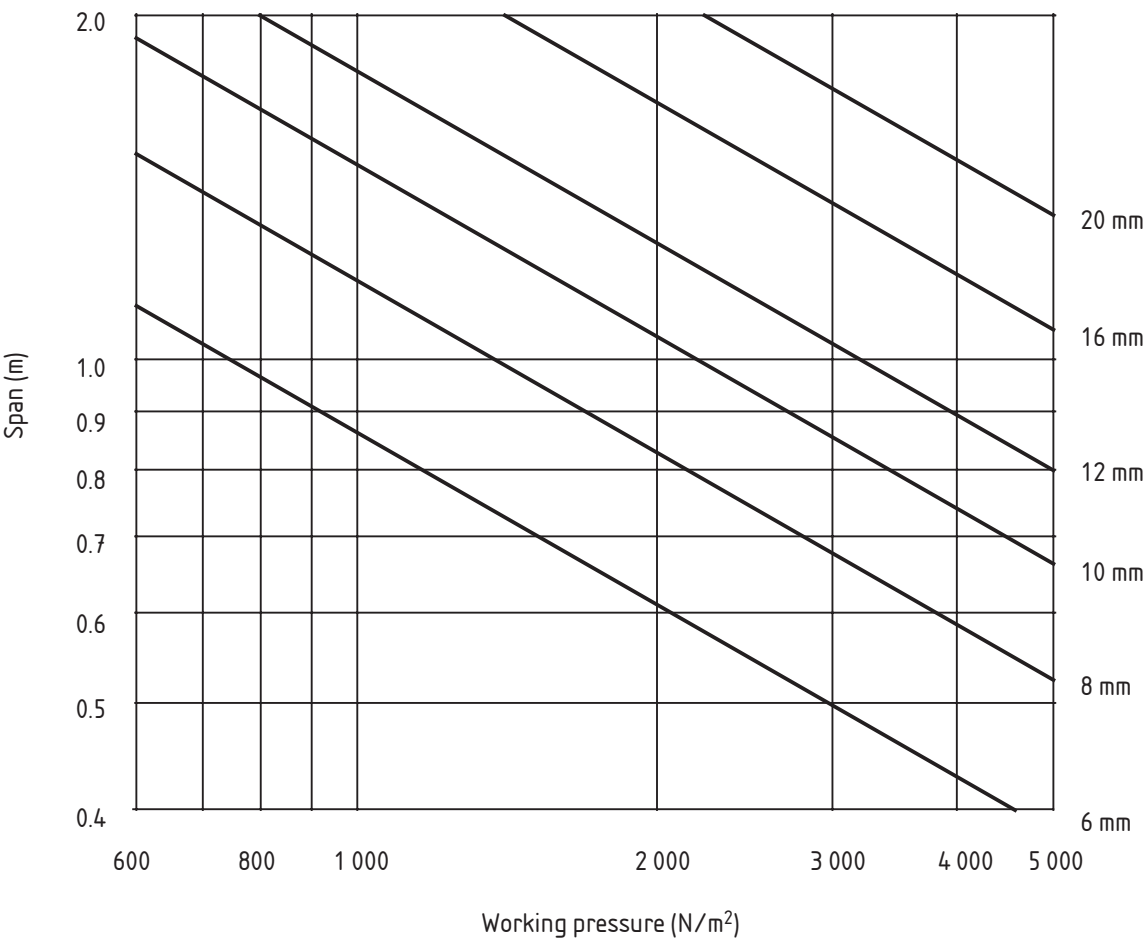
a) Toughened glass supported on two opposite edges only

Key

Stress limited ———

Deflection limited ———

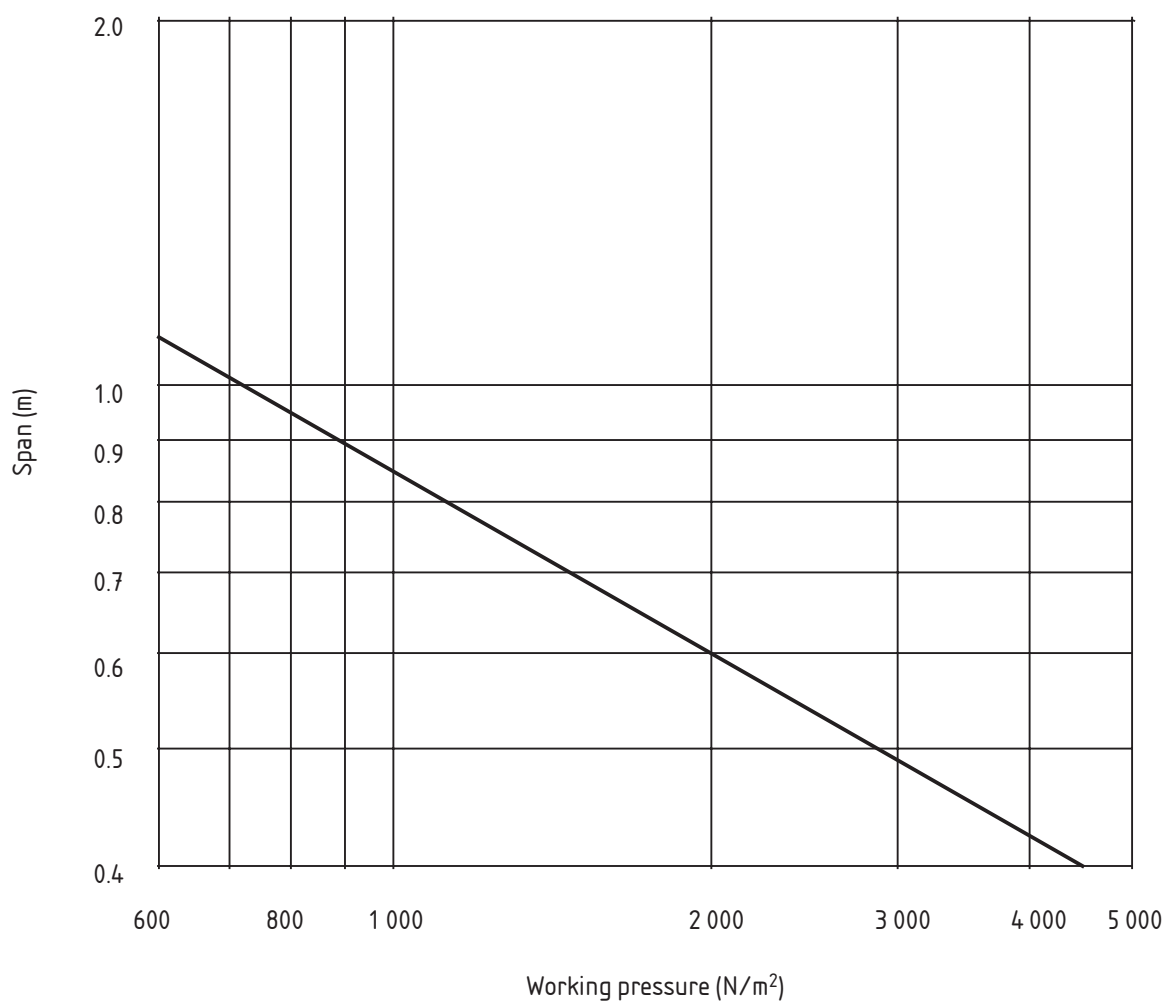
Figure 4 — Glass thickness selection chart



b) Laminated glass supported on two opposite edges only

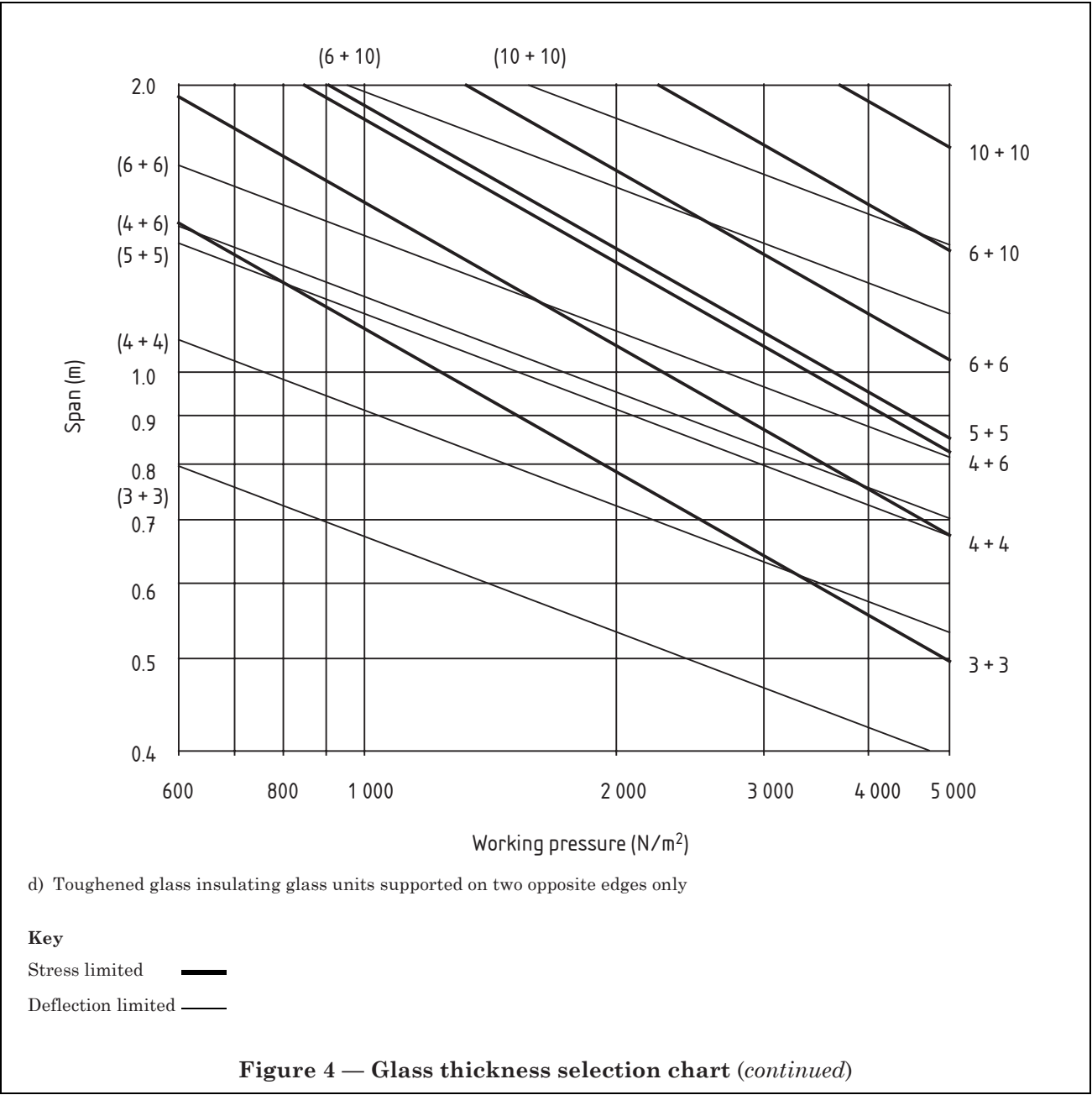
NOTE The thickness of laminated glass given in the figure is the sum total of the nominal glass thicknesses within a three-ply laminate made from float glass and PVB, irrespective of the laminate construction and discounting the thickness of the interlayer.

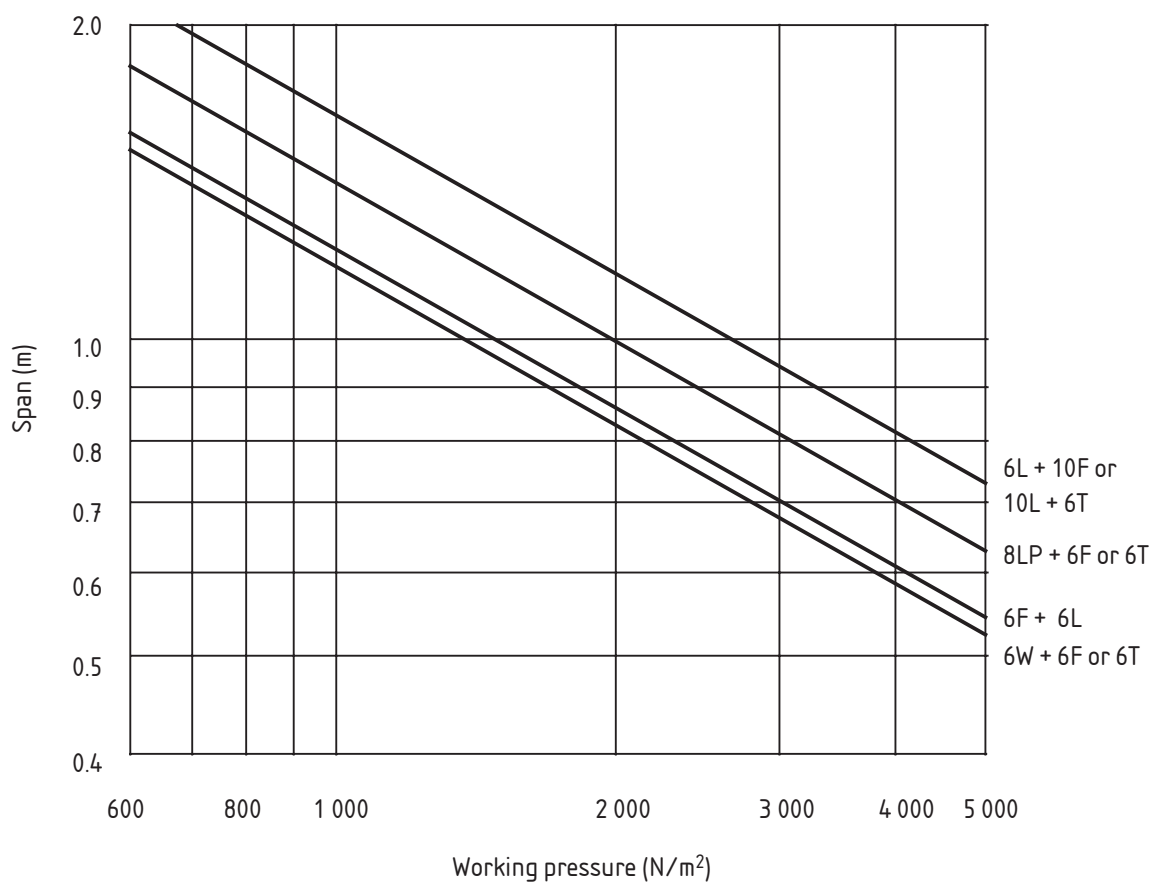
Figure 4 — Glass thickness selection chart (continued)



c) 6 mm polished wired glass or 7 mm wired patterned glass supported on two opposite edges only

Figure 4 — Glass thickness selection chart (*continued*)





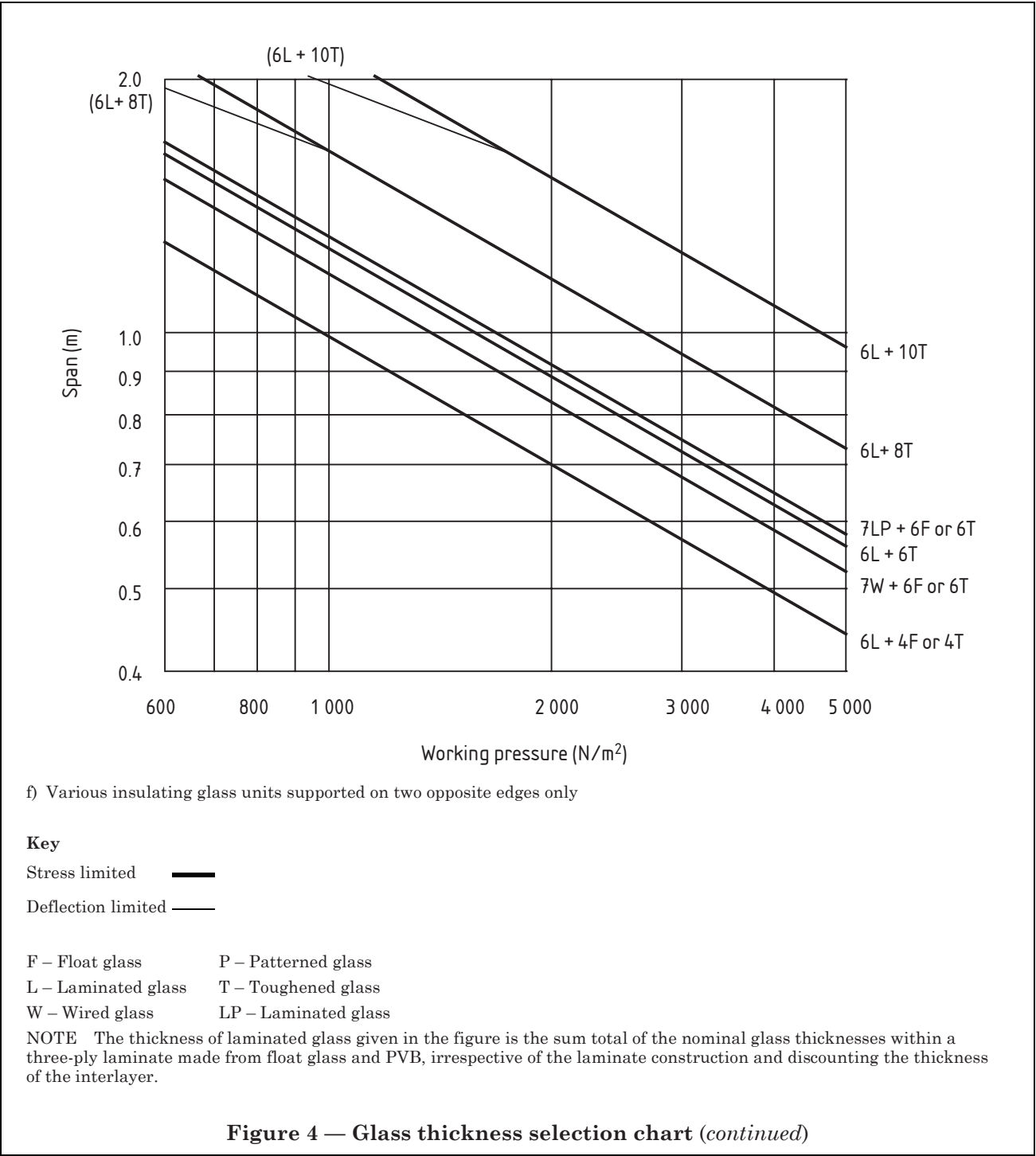
e) Various insulating glass units supported on two opposite edges only

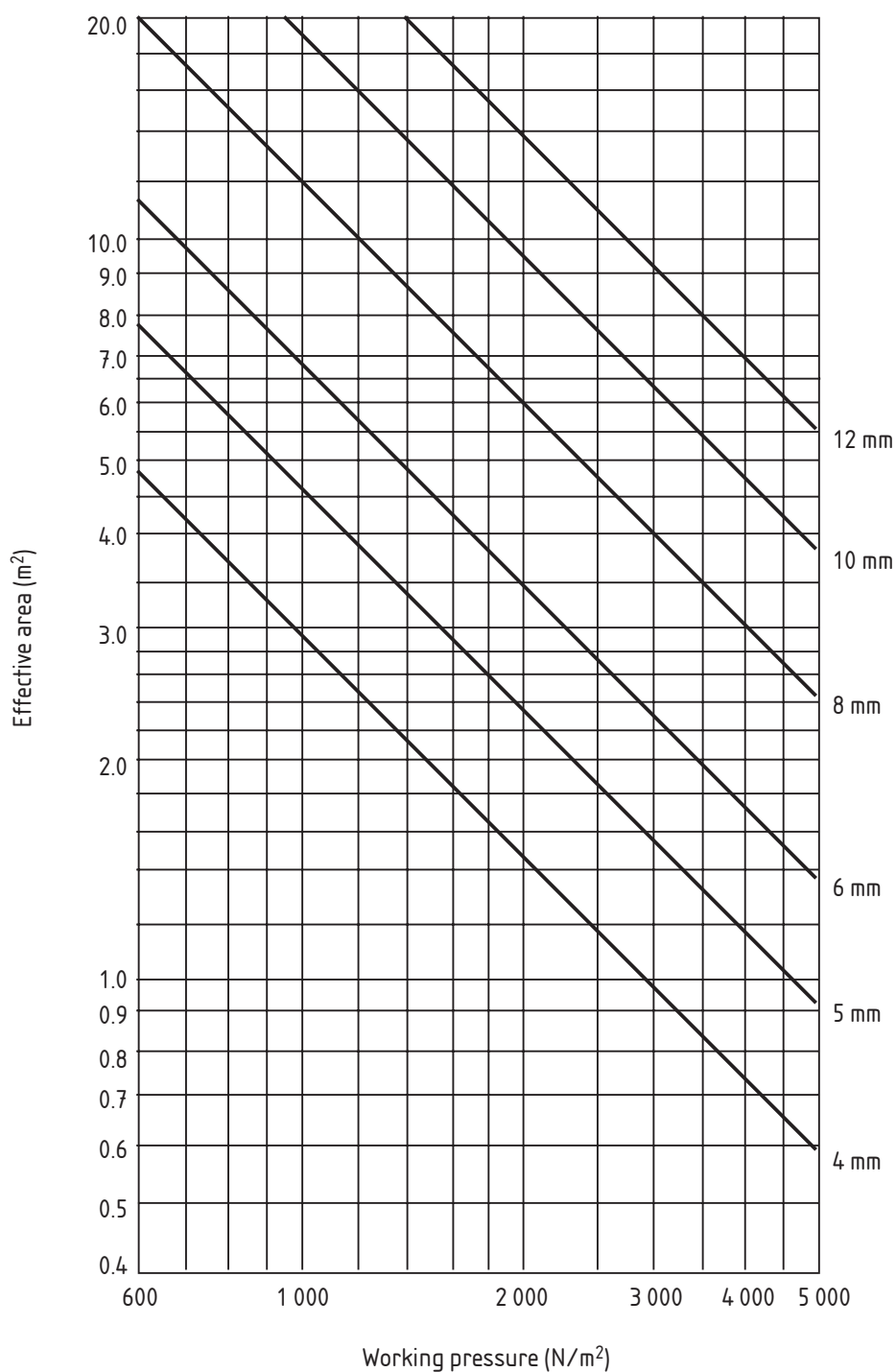
Key

F – Float glass P – Patterned glass
 L – Laminated glass T – Toughened glass
 W – Wired glass LP – Laminated glass

NOTE The thickness of laminated glass given in the figure is the sum total of the nominal glass thicknesses within a three-ply laminate made from float glass and PVB, irrespective of the laminate construction and discounting the thickness of the interlayer.

Figure 4 — Glass thickness selection chart (continued)





g) Toughened glass supported on all four edges

Figure 4 — Glass thickness selection chart (*continued*)