CHAPTER III

Design

August 2012

3. DESIGN

3.1 INTRODUCTION

The National Building Regulations and Building Standards Amendment Act 103 of 1977 (as amended) provides for the promotion of uniformity in the law relating to the erection of buildings in the areas of jurisdiction of Local Authorities; for the prescribing of building standards; and for matters connected therewith. The Regulations under the National Building Regulations and Building Standards Act, 1977 contain inter alia the following sections which influence to the structural design and glazing of Architectural Aluminium Products.

3.1.1 NATIONAL REGULATION BUILDINGS - PART B: STRUCTURAL DESIGN

3.1.1.1 REGULATION B1 DESIGN REQUIREMENT (Government Gazette # 31084 – 30 May 2008 No. R574)

(1) Any building and any structural element or component thereof shall be designed to provide strength, stability, serviceability and durability under all actions which can reasonably be expected to occur in accordance, with accepted principals of structural design, and so that it will not impair the integrity of any other building or property.

(2) Any such building shall be so designed that in the event of accidental overloading the structural system will not suffer disastrous or progressive collapse which is disproportionate to the original cause.

(3) The requirements of sub regulations (1) and (2) shall be deemed to be satisfied where such building is designed in accordance with SANS 10400-B

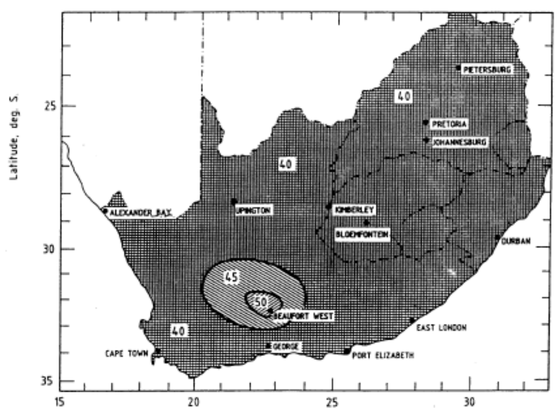
3.1.1.2 SANS 10400-B: THE APPLICATION OF THE NATIONAL BUILDING REGULATION PART B: STRUCTURAL DESIGN

This standard states that the Competent Person (Structures), in order to demonstrate that the functional regulations contained in Part B of the National Building Regulations pertaining to the structural system or part thereof are satisfied, shall undertake a rational design in accordance, amongst other, with:

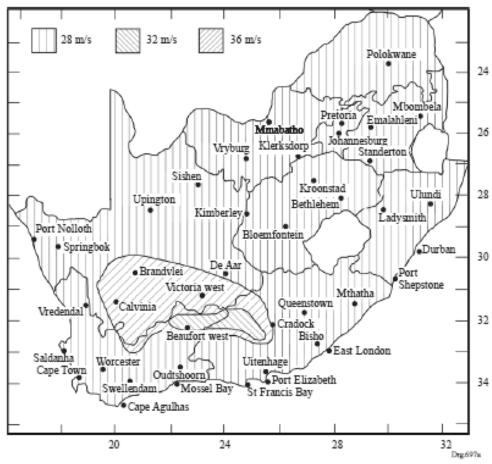
SANS 10160 – Basis of Structural Design and Actions for buildings and Industrial Structures
SANS 10160 – Part 1: Basis of Structural Design
SANS 10160 – Part 2: Self-weight and Imposed loads
SANS 10160 – Part 3: Wind Actions

We stress therefore that only Competent Persons (Structures) are competent in determining wind actions on Fenestration. The wind map is nominally updated.

From
SANS 10160-1989
Withdrawn



To
SANS 10160-3:2010
Current



Map of the fundamental value of the basic wind speed, $v_{b,0}$

Terrain categories are modified to present a more even distribution of wind exposure conditions.

From SANS 10160-1989 Withdrawn	To SANS 10160-3:2010 Current
Category 1 – Exposed smooth terrain with virtually no obstructions and in which the height of any obstructions is less than 1.5m. This category includes open sea coasts, lake shores and flat, treeless plains with little vegetation other than short grass.	Category A – Flat horizontal terrain with negligible vegetation and without any obstacles (for example coastal areas exposed to open sea or large lakes)
Category 2 – Open terrain with widely spaced obstruction (more than 100m apart) having heights and plan dimensions generally between 1.5m and 10m. This category includes large airfields, open parklands or farmlands and undeveloped outskirts of towns and suburbs, with few trees. This is the category on which the regional basic wind speed *V* is based.	Category B – Area with low vegetation such as grass and isolated obstacles (for example trees and buildings) with separations of at least 20 obstacle heights.
Category 3 – Terrain having numerous closely spaced obstructions generally having the size of domestic houses. This category includes wooded areas and suburbs, towns and industrial areas, fully or substantially developed.	Category C – Area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights (such as villages, suburban terrain and permanent forest)
Category 4 – Terrain with numerous large, tall, closely-spaced obstructions. This category includes large city centres.	Category D – Area in which at least 15% of the surface is covered with buildings and their average height exceed 15m.

Our Association has withdrawn all its recommendations in respect of the determination of wind load on fenestration. We followed the advice of Dr Adam Goliger and Dr Ron Watermeyer whose opinion on this matter are contained in Annex A.

Note! Fenestration Manufacturers/Contractors/Installers are not qualified to determine wind load and our Association discourages our members from taking responsibility for wind load design.

3.1.2 PART N – GLAZING

N1. TYPE AND FIXING OF GLAZING

(1) Any material used in the glazing of any building shall be of a secure and durable type and shall be fixed in a manner and position that will ensure that it will-

- (a) safely sustain any wind loads which can reasonably be expected;
- (b) not allow penetration of water to the interior of the building; and
- (c) be apparent, in the case of clear glazing, to any person approaching such glazing.

(2) Glass, plastics and organic coated glass shall be selected in order to provide, in the case of human impact, a degree of safety appropriate in relation to-

- (a) the position of the glazed area; and
- (b) the number and likely behaviour pattern of persons expected to be in close proximity to such glazed area.

(3) The requirements of sub regulations (1) and (2) shall be deemed to be satisfied where the glazing material is selected, fixed and marked in accordance with SANS 10400-N.

The South African National Standards SANS 10400 - The application of the National Building Regulations refers in its Part B: Structural Design and its Part N: Glazing, amongst other, to the following South African National Standards:

- SANS 10160 - General procedures and loading to be adopted in the design of building and
- SANS 10137 – Installation of glazing materials in building.

The Selection Guide follows the principles contained in the aforementioned standards.

It should be noted that a professional Engineer may execute a rational design for Glazed Architectural Products which is beyond the scope of this Selection Guide. However, this is not often the case, as SANS 10400 Part B states that any rational design of a structural system shall not preclude the use of SANS 10400 Part N (glazing).

Should the professional Engineer venture into a rational design for glazing his liability for the specification, design and installations of Glazed Architectural Products extend beyond that of the contract to subsequent owners. (Tsimatakopoulos v Hemingway, Isaacs & Coetzee cc and another 1993(4) SA 428 (CPD).

Therefore, in the normal run of events, the Contractor (Sub Contractor, Glazier, and Installer) is responsible that the installed Glazed Architectural Products meet the requirements of the National Building Regulations. Only strict adherence to aforementioned South African National Standards during the design, manufacture and installation of Glazed Architectural Products will ensure that the requirements contained in the National Building Regulations are deemed to be satisfied.

3.2 DESIGN – DEEMED-TO-SATISFY RULES (SANS 1040-N)

In the event that a Competent Person (Structures) registered with the Engineering Council of South Africa did not design and supervise the installation of the fenestration system, the installer of the fenestration system shall be deemed-to-satisfy the requirements of the National Building Regulations and Building Standards Amendments Act 103 of 1977 when adhering to the following:

3.2.1 DESIGN WIND LOAD

The minimum wind load for exterior application is 1000Pa (Refer Annex A). External wind load for all type (occupancies) of buildings must be determined by a Competent Person (Structures) in writing.

Caution must be taken when using A1 products in commercial environments as the former is less robust than products of higher categories. Also opening sizes for vents are usually larger for commercial applications than is the case in residential windows and therefore require A2 or higher classified products.

Note! Internal glazed screens (shopfronts, partitioning) are to be designed to withstand a design load of 600Pa. This design load represents all the impact forces which may occur in terms of SANS 10160. The framing of such screens must have a maximum deflection of 1/175th of the span.

3.2.2 DESIGN – GLAZING MATERIALS AND GLAZING

Glazing materials and glazing selection must be in accordance with SANS 10400:N – The application of the National Building Regulations – Part N Glazing ensure compliance. External glazing in structures exceeding 10m in height (3 storeys) do require the approval in writing of a Competent Person (Glazing) registered with the South African Glass Institute (SAGI) upon receipt of the applicable wind load from a Competent Person (Structures) in writing.

Similarly any glazing not detailed below, such as, but not limited to, overhead and sloped glazing, glass flooring, three and one edge supported glass, toughened glass assemblies and entrances, glass for balustrading supported by clamps and the like must be signed of in writing by a Competent Person (Structures) and Competent Person (Glazing).

In addition it is strongly recommended to take cognance of the site configuration to ensure that large and/or heavy glazing material panes can be handled and place on site safely and without damage to the panes concerned.

3.2.3 GLAZING INSTALLATIONS

3.2.3.1 Glazing materials shall comprise either glass that complies with the requirements of Parts 1 to 5 of SANS 50572, or polycarbonate sheeting.

3.2.3.2 Glazing shall comply with all the requirements of SANS 613 for the wind and impact loads as determined in accordance with the requirements of SANS 10400-B by a Competent Person (Structures).

Note: Obtain AAAMSA Performance Test Certificate to confirm compliance with SANS 613.

3.2.3.3 The thickness of panes of glass and flat solid polycarbonate sheeting, other than in lifts, shall:

a) Be not less than that given in tables 3.1 to 3.6

b) Be determined by a Competent Person (Glazing) in accordance with the requirements of SANS 10137, and be based on wind loads determined in accordance with the requirements of SANS 10400-B.

c) Be based on wind loads determined in accordance with the requirements of SANS 10400-B.

Note: SANS 10400-B requires that wind loads be determined by a Competent Person (Structures).

3.2.3.4 The top and bottom of glass fins (see figure 3.1) installed at butt joints of glass panes shall be fully fixed to the supporting structure and have overall dimensions as given in table 3.7. Silicone sealant that has a tensile strength of at least 1 MPa shall be used.

Note: A butt joint is assumed to have no structural strength. Therefore panels which incorporate a butt joint are not considered to be supported on all sides. A glass fin is necessary to provide the support at the joint so that the pane can be considered to be supported on four sides or on two opposite sides.

3.2.3.5 The thickness and type of pane glass panels in lifts shall be in accordance with the requirements of Tables 3.8 and 3.9, as relevant.

Table 3.1 - Dimensions for vertical glass supported by a frame on all sides in external walls in buildings here the height measured from the ground to the top of such wall does not exceed 10m

	Maximum Pane sizes in sq. m						
Nominal Glass Thickness (mm)	**3**	**4**	**5**	**6**	**8**	**10**	**12**
Monolithic Annealed Glass	0.75	1.5	2.1	3.2	4.6	6.0	6.0
Patterned Annealed & Wired Glass	-	0.75	1.2	1.9	2.6	3.4	-
Laminated Annealed Safety Glass	-	-	-	2.9	4.3	5.7	5.7
Toughened Safety Glass	-	1.9	3.0	4.5	8.0	8.0	8.0

Table 3.2 – Dimensions for vertical glass supported by a frame on all sides in internal walls.

	Maximum Pane sizes in sq. m						
Nominal Glass Thickness (mm)	**3**	**4**	**5**	**6**	**8**	**10**	**12**
Monolithic Annealed Glass	0.75	1.5	2.1	3.2	4.6	6.0	6.0
Patterned Annealed & Wired Glass	-	0.75	1.2	1.9	2.6	3.4	-
Laminated Annealed Safety Glass	-	-	-	4.1	6.0	7.2	7.2
Toughened Safety Glass	-	3.0	4.2	6.4	9.2	9.2	9.2

Table 3.3 – Dimensions for vertical glass supported by a frame on two opposite sides in external walls in buildings where the height measured from the ground to the top of such wall does not exceed 10m.

	Maximum Span between support in m						
Nominal Glass Thickness (mm)	**3**	**4**	**5**	**6**	**8**	**10**	**12**
Monolithic Annealed Glass	-	0.4	0.5	0.6	0.85	1.0	1.3
Patterned Annealed & Wired Glass	-	0.25	0.3	0.35	0.5	0.6	-
Laminated Annealed Safety Glass	-	-	-	0.55	0.8	0.95	1.2
Toughened Safety Glass	-	0.55	0.7	0.85	1.15	1.3	1.8

Table 3.4 – Dimensions for vertical glass supported by a frame on two opposite sides in internal walls.

	Maximum Span between support in m						
Nominal Glass Thickness (mm)	**3**	**4**	**5**	**6**	**8**	**10**	**12**
Monolithic Annealed Glass	-	0.65	0.8	0.95	1.3	1.55	2.0
Patterned Annealed & Wired Glass	-	0.4	0.48	0.57	0.78	0.9	-
Laminated Annealed Safety Glass	-	-	-	0.9	1.25	1.5	1.95
Toughened Safety Glass	-	0.9	1.1	1.3	1.75	2.0	2.7

Table 3.5 – Dimensions for polycarbonate panels supported by a frame on all sides in external walls where the height measured from the ground to the top of such wall does not exceed 10m.

1	2	3	4
Thickness mm	**Aspect ratio (short dimension: long dimension)**		
	1:1 ≤ 1,5:1	**> 1,5:1 ≤ 2,5:1**	**> 2,5:1 ≤ 3,5:1**
	Maximum pane area m^2		
2	0,2	0,24	0,32
2,5	0,275	0,52	0,44
3	0,425	0,52	0,70
4	0,625	0,78	1,05
5	0,85	1,05	1,45
15mm edge cover shall be provided.			

Table 3.6 – Dimensions for polycarbonate panels supported by a frame on all sides in internal walls.

1	2	3	4
Thickness mm	**Aspect ratio (short dimension: long dimension)**		
	1:1 ≤ 1,5:1	**> 1,5:1 ≤ 2,5:1**	**> 2,5:1 ≤ 3,5:1**
	Maximum pane area m^2		
2	0,35	0,4	0,525
2,5	0,45	0,55	0,725
3	0,725	0,84	1,2
4	1,05	1,3	1,75
5	1,4	1,75	2,75
15mm edge cover shall be provided.			

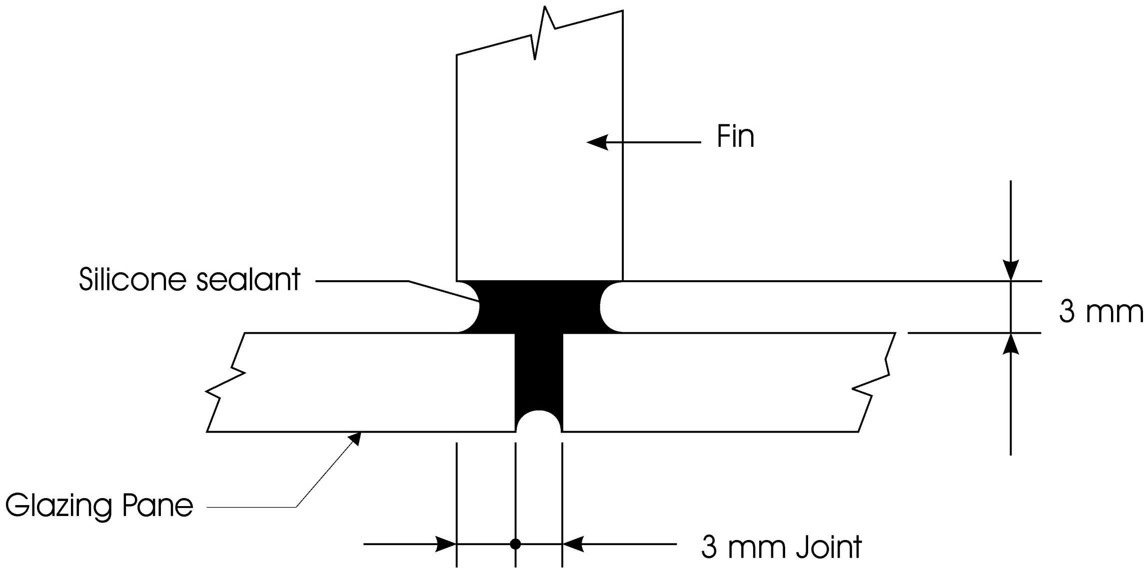


Figure 3.1 – Detail of fin assembly

Table 3.7 – Minimum glass fin dimensions

Fin Height in m	Internal	External
1.5	150 x 12	150 x 15
2	150 x 12	150 x 19
2.5	150 x 12	175 x 19
3	175 x 15	200 x 25
3.5	225 x 15	275 x 25
4	275 x 15	300 x 25
Note: A butt joint is assumed to have no structural strength. Accordingly panels, which incorporate a butt joint, are not considered to be supported on four sides. A glass fin is necessary to provide the support at the joint so that the pane can be considered to be supported along four sides. Should no fin be in place selection of glass must be in accordance with Tables for Vertical glazing – Two opposite sides supported.		

Table 3.8 – Flat glass panels to be used in walls of lifts

Type of glass	Diameter of inscribed circle 1m max.	Diameter of inscribed circle 2m max.
	Minimum thickness mm	
Laminated, toughened	8	10
	(4 + 4 + 0,76)	(5 + 5 + 0,76)
Laminated	10	12
	(5+ 5 + 0,76)	(6 + 6 + 0,76)

Table 3.9 – Flat glass panels to be used in horizontally sliding doors in lifts

Type of glass	Minimum thickness mm	Width mm	Free door height m	Fixing of the glass panels
Laminated, toughened	16 (8 + 8 + 0,76)	360 to 720	2,1 max.	Two fixings upper and lower
Laminated	16 (8 + 8 + 0,76)	300 to 720	2,1 max.	Three fixings upper/ Lower and one side
	10 (6 + 4 + 0,76) (5 + 5 + 0,76)	300 to 870	2,1 max.	All sides
Note: These values are only valid provided that, in the case of a three-side or four-side fixing, the fixings are rigidly connected to each other.				

3.2.4 TRANSPARENT GLAZING

Where transparent glazing is used and is not likely to be apparent to, or suspected by, any person approaching it, such glazing shall bear markings that shall render it apparent to such person.

3.2.5 SAFETY GLAZING

3.2.5.1 The performance of safety glazing material shall be in accordance with the requirements of SANS 1263-1 and the individual panes of safety glazing material shall be permanently marked by the installer in such a manner that the markings are visible after installation.

3.2.5.2 Safety glazing materials that comply with SANS 1263-1 shall be used where:

a) doors and sidelights form part of any entrance up to 2100mm from finished floor level;

b) a window has a sill height of less than 500mm from the floor or external ground level;

c) a window has a sill height of less than 800mm from the floor or external ground level without any permanent barrier that prevents persons from coming into contact with the glass panel, and is so placed that persons are likely, on normal traffic routes, to move directly towards such window.

NOTE: A barrier could be any feature, i.e. a heavy bar across a window or a flower box placed in front of the window, that will provide a physical or visual barrier between the glass and a person.

d) a bath enclosure or shower cubicle is glazed, or where glazing occurs immediately above and within a distance of 1800mm horizontally or vertically from a bath or shower;

e) glazing is used in any shop front or display window within 2100mm from the finished floor level;

f) glazing is used in any wall or balustrade to (or immediately adjacent to) a stairway, ramp, landing, pathway, patio, veranda or balcony;

g) glazing is used within 1800mm of the pitch line of a stairway or the surface of a ramp, landing, pathway, patio, veranda or balcony;

h) glazing applications are sloped or horizontal;

i) a mirror is installed as a facing to a cupboard door less than 800mm above floor level and there is no solid backing;

j) glazing is used around areas such as swimming pools and ice rinks; and

k) glazing is used in internal partitions, within 2100mm of floor level.

3.2.5.3 All glazing for occupancy or building classification is A3 (places of instruction), E1 (place of detention), E2 (hospital), E3 (other institutional (residential buildings) and H2 (dormitory), where such is associated with a building of occupancy classification A3, E1, E2 or E3 (see SANS 10400-A) shall be safety glazing material that complies with the requirements of SANS 1263-1.

3.2.5.4 Glass in balustrades shall be toughened safety glass unless rigidly supported on all sides. Glazing material in balustrades is subject to impact and line loads determined in accordance with the requirements of SANS 10160-2.

3.2.5.5 Glass in horizontal or sloping applications shall be laminated safety glass or toughened safety glass. Toughened safety glass shall only be used where individual panes are framed on all sides.

3.2.5.6 Wired glass having two-edge support may be used in vertical glazing in sawtooth roofs.

3.2.5.7 The thicknesses and maximum panel dimensions of frameless bath and shower enclosures shall be given in Table 3.10.

Table 3.10 – Dimensions for flat frameless glass shower enclosures

Toughened safety glass thickness mm	Maximum panel size m^2	
	Doors and panels supporting doors	Fixed panels
6	1.6	2.1
8	2	3.3
10	2.2	4.0
Note: This tables does not apply to curved glass		

Note: Figures 3.2 to 3.4 illustrate the conditions where safety-glazing materials are required in terms of 3.2.5.2 above.

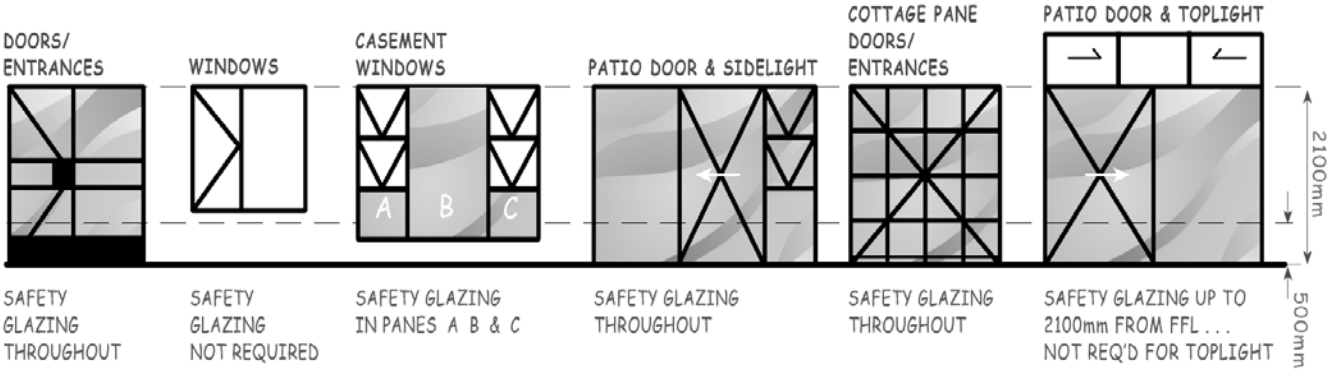


Figure 3.2 — Examples of safety glazing requirements in doors and windows

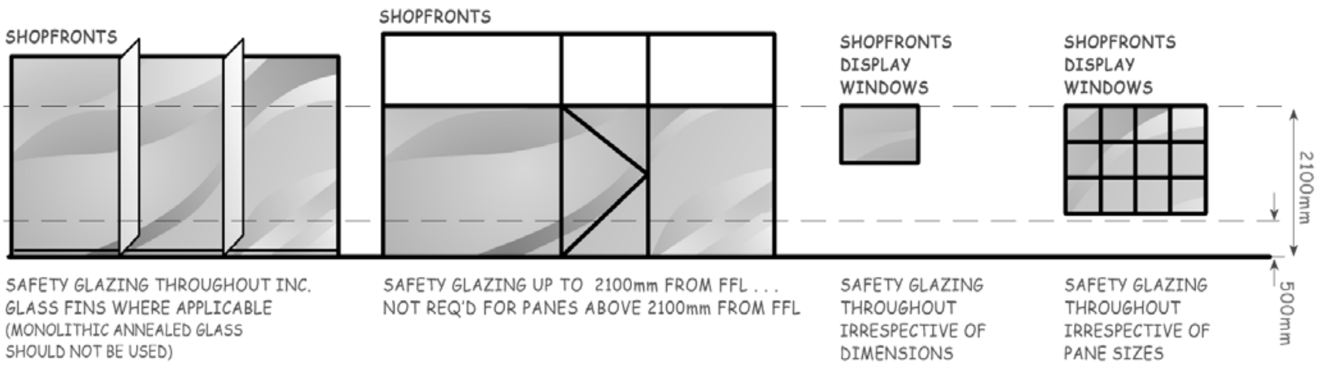


Figure 3.3 — Examples of safety glazing requirements in shop fronts and display windows

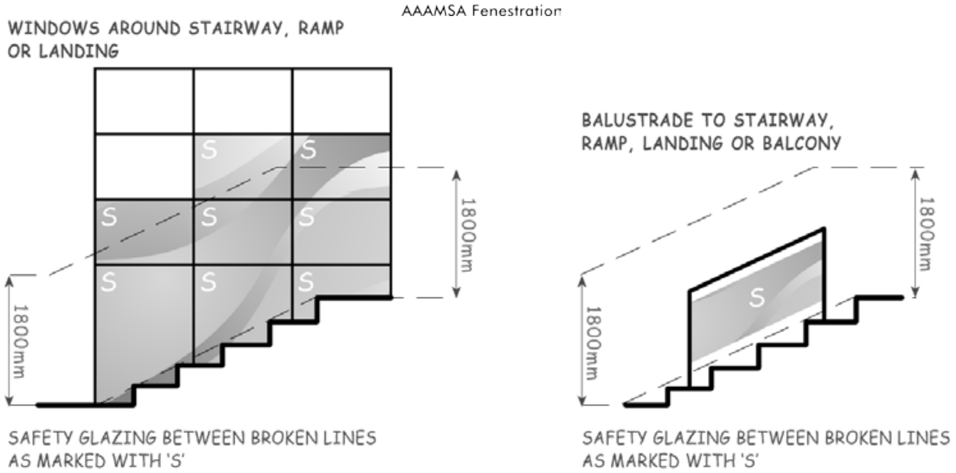


Figure 3.4 — Examples of safety glazing requirements around staircases and landings

3.3 DEFLECTION OF FRAMING

The Framing holding the glazing material is not intended to withstand loads imposed by the building structure, nor, unless otherwise specified, any loads other than those due to wind and mass of glass.

The maximum permissible deflection in the perpendicular to the span of the aluminium alloy frame, due to positive and negative wind load shall be $1/175^{th}$ of the span for framing members up to 4115mm. For spans greater than 4115mm, but less than 12.2m deflections shall be limited to $1/240^{th}$ of the span plus 6mm.

Other factors exists which could require a deflection limit less than those indicated above. The following is a list of those factors:

a. The anticipated movement of the framing members must not exceed the movement capabilities of adjoining sealants.
b. The anticipated movement of the framing members may need to be further limited to accommodate the properties and location of interior finishes (e.g. plaster, drywall, etc.)
c. The movement of the framing members must not cause disengagement of applied snap covers or trim.
d. The design of the framing members must accommodate differential movement in adjacent framing members such as might occur at jambs, parapets, unusual geometries and other similar conditions.
e. The stiffness of framing members must be adequate to support “brittle” infill material being continuously supported (e.g. stone panels).
f. The framing members must be able to resist any second in bending movements resulting from axial loads acting through eccentricities caused by large deflections (i.e. Delta effects).
g. In order to prevent engagement of the infill material design of systems incorporation large infill must also address the centre deflection of the infill in conjunction with the framing deflection.

The maximum deflection in the vertical plane, due to the dead load of the glazing materials, is 1/1000 of the span with a maximum of 2mm.

3.3.1 GLAZING REBATE DIMENSION

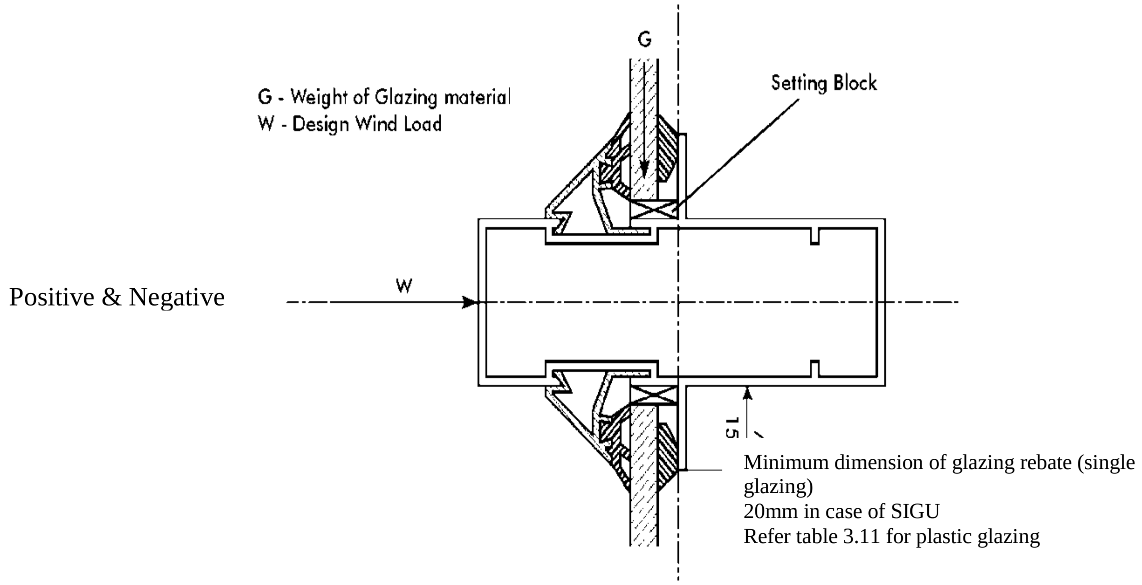


Figure 3.5: Typical loading in vertical glazing

All frame sections irrespective of material type shall have a minimum glazing rebate depth to accommodate a minimum glass bite of 10mm in the event of single glazing and a minimum glass bite of 15mm in case of sealed insulated glass units (SIGU).

All frame sections shall have appropriate glazing rebate widths to suite the thickness of the glazing material allowing for all glazing methods recommended by the manufacturers of the glass and specialized plastic glazing materials.

For glazing rebates accommodating specialized plastic glazing materials refer Table 3.11 below.

Table 3.11: Edge Clearance Bite, (sheet edge engagement) and Rebate Depth for Specialized Plastic Glazing Materials in mm

Dimensions in mm Width or height	Edge engagement "bite"	Edge Clearance in mm	Rebate depth Minimum
300	6	1	7
300 – 600	9	2	11
600 – 900	12	3	15
900 – 1200	15	4	19
1200 – 1500	18	5	23
1500 – 1800	20	6	26
1800 – 2100	20	7	27
2100 – 2400	20	8	28
2400 – 2700	20	9	29
2700 – 3000	20	10	30

The wall thickness of the aluminium extrusions must be suitable to meet the required section properties, i.e. the required inertia in both the X and Y axis (I_x & I_y) and must be suitable for proper mechanical assembly and fixing of all frame, mullion, transom members and hardware.

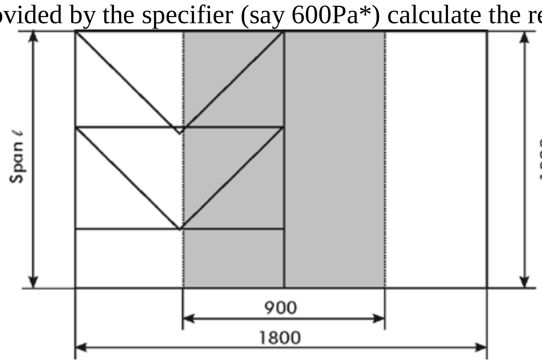
It is permissible to re-enforce the aluminium alloy extrusions by inserting steel sections (channels or tubes) which are suitably treated to prevent corrosion and reaction with the aluminium alloy extrusions. These reinforcing must be properly fixed to the aluminium section. It is recommended that the inertia of the aluminium section is ignored when determining the inertia of the steel section, i.e. the inertia of the steel insert should represent the total required inertia. The practice to use timber as re-enforcing is not acceptable.

3.3.2 DETERMINATION OF SECTION PROPERTIES

3.3.2.1 The simplest and most conservative method of calculating the required section properties, using the formula for equal distribution load, is as follows:

Step 1: Using the design wind load provided by the specifier (say 600Pa*) calculate the required inertia as follows:

*Note
Wind load of 600Pa is no longer applicable to exterior applications



$$I_x = \frac{5 \times Q \times l^3}{384 \times E \times f} = \frac{5 \times (0{,}9 \times 1{,}8 \times 600)\ 180^3}{384 \times 7 \times 10^6 \times (180/175)} = 10{,}84\text{cm}^4$$

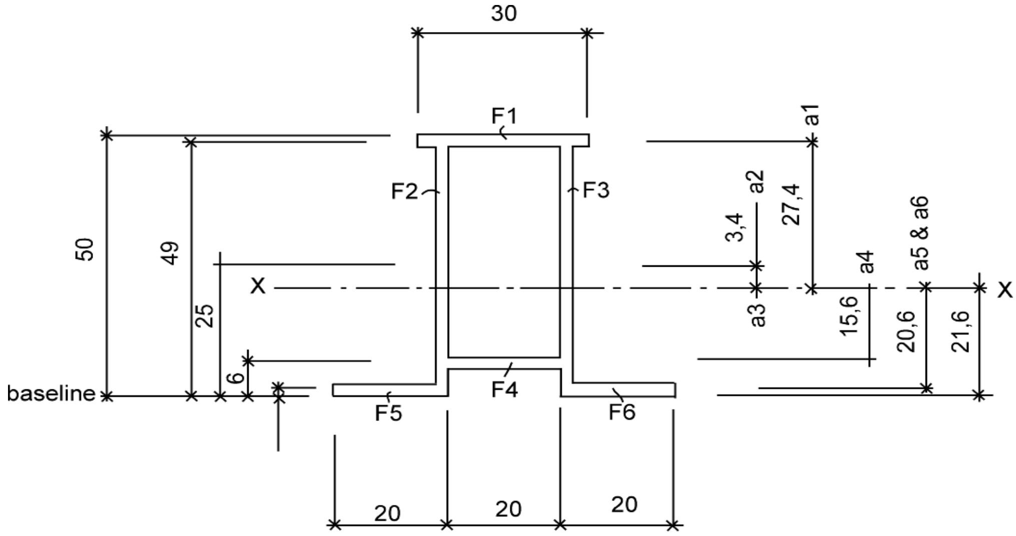
Where in:

I_x	=	Required Inertia in cm^4
Q	=	Total wind load in N
l	=	Span in cm
E	=	Young's Modulus in N/cm^2
		E aluminium = 7×10^6 N/cm^2
		E steel = $2{,}1 \times 10^7$ N/cm^2
		E glass = $7{,}17 \times 10^6$ N/cm^2
		E timber ± $1{,}2 \times 10^6$ N/cm^2
		E pvcu ± 4×10^5 N/cm^2
f	=	Deflection in cm ($1/175^{th}$ of span)

Thus: Any section having inertia ≥ 10,84cm^4 will be suitable.

Step 2: Mullion (and transom) designs are generally of tubular configuration. Using the following formulas, together with the overall dimensions with relevant wall thickness of the section, the required inertia can be calculated.

Undimensioned thickness 2mm



				Area cm^2		Distance from base line in cm		
F_1	=	3,0 x 0,2	=	0,6	x	4,9	=	2,94
F_2	=	0,2 x 4,6	=	0,92	x	2,5	=	2,30
F_3	=	0,2 x 4,6	=	0,92	x	2,5	=	2,30
F_4	=	2,0 x 0,2	=	0,4	x	0,6	=	0,24
F_5	=	2,0 x 0,2	=	0,4	x	0,1	=	0,04
F_6	=	2,0 x 0,2	=	0,4	x	0,1	=	0,04
				3,64 cm^2				7,86 cm^3

XX axis distance from base line $\frac{7,86}{3,64} = 2,16$ cm

$$I_1 = \frac{B \times H^3}{12} + F_1 \times a_1^2 = \frac{3 \times 0,2^3}{12} + 0,6 \times 2,74^2 = 4,51 \text{ cm}^4$$

$$I_2 = \frac{B \times H^3}{12} + F_2 \times a_2^2 = \frac{0,2 \times 4,6^3}{12} + 0,92 \times 0,34^2 = 1,73 \text{ cm}^4$$

$$I_3 = I_2 = 1,73 \text{ cm}^4$$

$$I_4 = \frac{B \times H^3}{12} + F_4 \times a_4^2 = \frac{2 \times 0,2^3}{12} + 0,4 \times 1,56^2 = 0,97 \text{ cm}^4$$

$$I_5 = \frac{B \times H^3}{12} + F_5 \times a_5^2 = \frac{2 \times 0,2^3}{12} + 0,4 \times 2,06^2 = 1,70 \text{ cm}^4$$

$$I_6 = I_5 = 1,70 \text{ cm}^4$$

Total Inertia I_x = 12,34 cm^4

Thus this section is suitable for the application. The maximum mullion deflection will be:

Actual deflection $\frac{10,84}{12,34} = 9,03$mm Is smaller than allowable $\frac{1800}{175} = 10.29$mm

Step 3: Confirm that the maximum allowable stress (τ) of 10400 N/cm^2 for aluminium alloy 6063T6 is not exceeded as follows:

$$\tau = \frac{M}{Z_x} = \frac{21870}{4,345} = 5034 \text{ N/cm}^2$$

Where in:

M = maximum moment in N cm according to

$$M = \frac{QL}{8} = \frac{(0,9 \times 1,8 \times 600)\ 180}{8} = 21870 \text{ Ncm}$$

Zx = Section Modulus in cm^3

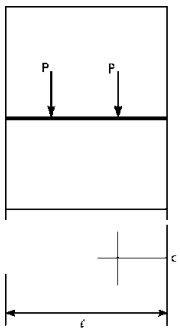
$$= \frac{\text{Moment of Inertia}}{\text{distance of extreme fibre}} = \frac{12,34}{2,84} = 4,345 \text{ cm}^3$$

To assist manufacturers and/or contractors with the calculations referred to in Step 1 we provide in Table 3.11 a diagram indicating required inertias. This diagram has been based on a trapezoidal wind load of 1000Pa. The inertias shown can be changed in direct relation with the 1000Pa should the actual design wind load differ, i.e. for 2000Pa multiply inertias by 2,0; for 1200Pa multiply inertias by 1,2 etc.

Manufacturers and contractors must insist on and receive the section properties for the aluminium extrusions used in the numerous Architectural Aluminium Systems available from the distributors and/or extruders of the systems. This satisfies Step 2 and will circumvent the elaborate calculations required to determine section properties for complex extrusions. Note that sections of similar and identical overall dimensions may not have the same section properties. In Step 2 above the overall dimensions are 30 x 50mm but having a wall thickness of 1,5mm has inertia of 7,76cm^4 and is therefore not suitable. Insist on information regarding section properties prior to selection of architectural system to be used.

3.3.2.2 Glass to metal contact must at all times be avoided. The vertical deflection of transoms is limited to 1/1000th of the length of the transom or maximum 2mm which ever is less. To calculate the required inertia in vertical direction (I_y) of a transom the following formula is used:

$$I_y = \frac{P\ c}{24\ Ef}\ (3l^2 - 4c^2)$$



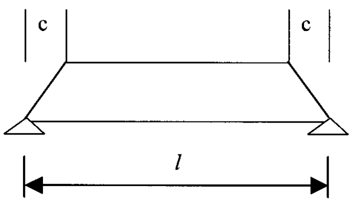
P = 0,5 x weight of glass in N
c = position of setting blocks in cm (maximum 15cm)
E = Young's Modules 7 x 10^6 N/cm^2
f = deflection in cm, 1/1000 x *l*, maximum 0,2cm
l = length of transom

To calculate maximum allowable stress refers to Step 3 above using the following formula for M (maximum moment).

$$M_{max} = P\ c \text{ (in Ncm)}$$

3.3.2.3 Other formulas for calculating required inertias and maximum moments are: (all units as described above).

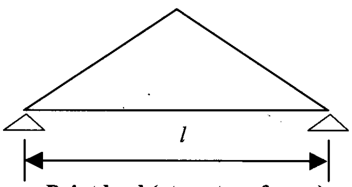
Trapezoidal load



$$I = \frac{Ql^4}{1920\ (l-c)\ Ef}\ (25 - 40c^2/l^2 + 16\ c^4/l^4)$$

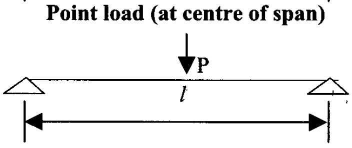
$$M_{max} = Q\ \frac{3l^2 - 4c^2}{24\ (l-c)}$$

Triangular load



$$I = \frac{Ql^3}{60\ Ef} \qquad M_{max} = \frac{Ql}{6}$$

Point load (at centre of span)



$$I = \frac{P\ l^3}{48\ E\ f} \qquad M_{max} = \frac{Pl}{4}$$

AAAMSA Fenestration

1000 Pa

Table 3.12

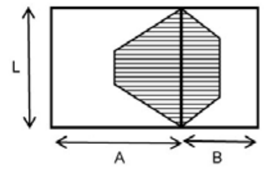
Example:	Mullion Length :	*2500* mm			Youngs Modulus : 700000 kg/sqcm
	Dimension A :	*1200* mm	Required Inertia :	28.32	
	Dimension B :	*1800* mm	Required Inertia :	37.50	
			Total Inertia :	***65.82***	

Warning : The total inertia required is the SUM of the inertia due to dimension A and the inertia due to dimension B

Distance A or B between members (mm)

	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400
500	0.04	0.06															
600	0.07	0.12															
700	0.11	0.20	0.25														
800	0.17	0.31	0.40														
900	0.24	0.45	0.60	0.69													
1000	0.33	0.62	0.86	1.01													
1100	0.44	0.84	1.17	1.41	1.54												
1200	0.57	1.10	1.55	1.90	2.13												
1300	0.72	1.40	2.01	2.49	2.83	3.01											
1400	0.90	1.76	2.54	3.18	3.67	3.98											
1500	1.11	2.18	3.15	3.99	4.65	5.11	5.35										
1600	1.35	2.65	3.85	4.91	5.78	6.43	6.83										
1700	1.62	3.19	4.65	5.96	7.06	7.93	8.53	8.83									
1800	1.93	3.80	5.55	7.14	8.52	9.64	10.47	10.98									
1900	2.27	4.47	6.56	8.47	10.16	11.57	12.66	13.41	13.79								
2000	2.64	5.23	7.68	9.95	11.98	13.72	15.12	16.15	16.78								
2100	3.06	6.06	8.92	11.59	14.01	16.11	17.86	19.21	20.13	20.60							
2200	3.52	6.98	10.29	13.40	16.24	18.76	20.90	22.61	23.86	24.63							
2300	4.03	7.98	11.79	15.38	18.70	21.67	24.24	26.36	27.99	29.10	29.65						
2400	4.58	9.08	13.42	17.55	21.38	24.85	27.90	30.47	32.53	34.03	34.94						
2500	5.17	10.27	15.20	19.91	24.30	28.32	31.89	34.97	37.50	39.44	40.75	41.41					
2600	5.82	11.56	17.13	22.46	27.47	32.09	36.24	39.87	42.92	45.35	47.11	48.18					
2700	6.52	12.95	19.22	25.22	30.90	36.17	40.95	45.18	48.81	51.78	54.05	55.58	56.35				
2800	7.27	14.45	21.46	28.20	34.60	40.57	46.03	50.93	55.19	58.76	61.58	63.63	64.87				
2900	8.08	16.07	23.87	31.40	38.58	45.30	51.51	57.12	62.07	66.29	69.73	72.36	74.13	75.02			
3000	8.95	17.80	26.46	34.84	42.84	50.39	57.39	63.77	69.46	74.40	78.52	81.78	84.14	85.56			
3100	9.87	19.65	29.22	38.51	47.41	55.83	63.69	70.91	77.40	83.11	87.97	91.92	94.93	96.95	97.97		
3200	10.86	21.62	32.17	42.43	52.28	61.64	70.42	78.53	85.90	92.44	98.10	102.81	106.53	109.21	110.84		
3300	11.91	23.72	35.32	46.60	57.47	67.84	77.60	86.67	94.96	102.41	108.93	114.46	118.96	122.37	124.67	125.82	
3400	13.03	25.95	38.65	51.04	63.00	74.43	85.24	95.33	104.62	113.03	120.48	126.91	132.25	136.46	139.50	141.33	
3500	14.21	28.32	42.20	55.74	68.86	81.42	93.35	104.54	114.89	124.34	132.79	140.17	146.43	151.50	155.35	157.94	159.24
3600	15.91	31.70	47.26	62.47	77.21	91.38	104.86	117.57	129.39	140.24	150.03	158.68	166.13	172.31	177.18	180.68	182.80
3700	17.75	35.38	52.76	69.77	86.29	102.21	117.40	131.76	145.19	157.58	168.85	178.91	187.68	195.10	201.12	205.67	208.72
3800	19.75	39.38	58.74	77.71	96.16	113.97	131.01	147.18	162.36	176.45	189.34	200.95	211.19	219.99	227.29	233.02	237.15
3900	21.92	43.70	65.20	86.29	106.84	126.71	145.77	163.91	181.00	196.93	211.61	224.92	236.78	247.10	255.82	262.88	268.22
4000	24.25	48.36	72.18	95.57	118.38	140.48	161.73	182.00	201.17	219.12	235.73	250.90	264.54	276.55	286.85	295.38	302.08
4100	26.77	53.40	79.71	105.57	130.83	155.33	178.95	201.53	222.96	243.09	261.82	279.03	294.61	308.46	320.51	330.68	338.89
4200	29.48	58.81	87.81	116.34	144.23	171.33	197.50	222.58	246.45	268.95	289.97	309.39	327.09	342.97	356.94	368.91	378.80
4300	32.40	64.62	96.52	127.91	158.63	188.53	217.45	245.22	271.72	296.79	320.30	342.11	362.12	380.21	396.27	410.22	421.98
4400	35.52	70.86	105.85	140.31	174.08	206.98	238.85	269.53	298.86	326.70	352.89	377.31	399.82	420.31	438.66	454.79	468.58
4500	38.86	77.54	115.84	153.60	190.63	226.75	261.79	295.59	327.97	358.78	387.87	415.10	440.32	463.41	484.26	502.75	518.79
4600	42.43	84.67	126.53	167.81	208.33	247.90	286.34	323.47	359.13	393.14	425.35	455.60	483.74	509.66	533.20	554.27	572.76
4700	46.25	92.29	137.93	182.98	227.22	270.48	312.56	353.27	392.43	429.88	465.43	498.93	530.24	559.19	585.66	609.53	630.67
4800	50.31	100.41	150.09	199.15	247.37	294.57	340.53	385.06	427.98	469.10	508.24	545.24	579.93	612.16	641.79	668.68	692.72
4900	54.64	109.06	163.04	216.37	268.83	320.22	370.32	418.93	465.86	510.91	553.89	594.63	632.96	668.72	701.75	731.91	759.07
5000	59.24	118.25	176.80	234.68	291.65	347.50	402.02	454.98	506.18	555.42	602.51	647.26	689.48	729.02	765.70	799.38	829.91
5100	64.12	128.01	191.42	254.12	315.89	376.49	435.69	493.28	549.04	602.75	654.22	703.24	749.64	793.22	833.82	871.28	905.45
5200	69.30	138.36	206.92	274.75	341.61	407.24	471.43	533.94	594.54	653.01	709.14	762.73	813.57	861.48	906.28	947.79	985.87
5300	74.79	149.33	223.35	296.61	368.86	439.84	509.32	577.04	642.78	706.32	767.41	825.85	881.44	933.97	983.25	1029.11	1071.37
5400	80.60	160.93	240.74	319.75	397.70	474.35	549.43	622.69	693.89	762.79	829.16	892.76	953.40	1010.85	1064.92	1115.41	1162.16
5500	86.74	173.20	259.12	344.21	428.20	510.84	591.85	670.97	747.96	822.55	894.51	963.61	1029.60	1092.29	1151.46	1206.90	1258.44
5600	93.22	186.16	278.53	370.04	460.42	549.39	636.67	722.00	805.10	885.72	963.61	1038.52	1110.22	1178.47	1243.06	1303.77	1360.42
5700	100.06	199.83	299.01	397.30	494.42	590.08	683.98	775.86	865.44	952.44	1036.60	1117.67	1195.41	1269.56	1339.91	1406.24	1468.32
5800	107.27	214.24	320.60	426.04	530.27	632.98	733.87	832.67	929.08	1022.82	1113.62	1201.21	1285.34	1365.75	1442.21	1514.49	1582.36
5900	114.87	229.42	343.34	456.31	568.02	678.16	786.43	892.52	996.14	1097.00	1194.80	1289.29	1380.18	1467.22	1550.15	1628.74	1702.76
6000	122.86	245.39	367.26	488.16	607.75	725.72	841.75	955.53	1066.75	1175.11	1280.31	1382.07	1480.10	1574.14	1663.93	1749.21	1829.75
6100	131.26	262.18	392.42	521.65	649.53	775.73	899.93	1021.80	1141.02	1257.28	1370.28	1479.71	1585.28	1686.72	1783.75	1876.11	1963.55
6200	140.08	279.81	418.84	556.83	693.42	828.28	961.07	1091.44	1219.08	1343.66	1464.87	1582.38	1695.91	1805.15	1909.83	2009.66	2104.40
6300	149.34	298.32	446.58	593.76	739.50	883.44	1025.25	1164.57	1301.06	1434.39	1564.23	1690.25	1812.15	1929.62	2042.36	2150.09	2252.54
6400	159.05	317.73	475.67	632.49	787.83	941.31	1092.59	1241.30	1387.08	1529.60	1668.52	1803.49	1934.20	2060.33	2181.57	2297.62	2408.21
6500	169.23	338.08	506.16	673.08	838.48	1001.97	1163.18	1321.74	1477.28	1629.45	1777.89	1922.27	2062.24	2197.48	2327.66	2452.49	2571.66
6600	179.89	359.38	538.09	715.60	891.54	1065.51	1237.12	1406.01	1571.78	1734.07	1892.52	2046.77	2196.47	2341.28	2480.87	2614.92	2743.13
6700	191.05	381.68	571.50	760.10	947.07	1132.01	1314.53	1494.23	1670.72	1843.62	2012.56	2177.16	2337.07	2491.94	2641.41	2785.17	2922.88
6800	202.71	405.00	606.45	806.64	1005.15	1201.58	1395.50	1586.52	1774.24	1958.25	2138.18	2313.64	2484.25	2649.66	2809.51	2963.46	3111.17
6900	214.90	429.37	642.98	855.28	1065.86	1274.29	1480.15	1683.01	1882.47	2078.11	2269.54	2456.37	2638.21	2814.67	2985.41	3150.05	3308.25
7000	227.64	454.83	681.13	906.09	1129.28	1350.25	1568.57	1783.82	1995.55	2203.36	2406.83	2605.56	2799.14	2987.19	3169.33	3345.18	3514.40
7100	240.93	481.40	720.95	959.13	1195.48	1429.55	1660.90	1889.07	2113.63	2334.16	2550.21	2761.38	2967.25	3167.43	3361.51	3549.12	3729.88
7200	254.79	509.11	762.49	1014.46	1264.54	1512.29	1757.22	1998.90	2236.86	2470.66	2699.86	2924.04	3142.76	3355.61	3562.19	3762.10	3954.96
	200	**400**	**600**	**800**	**1000**	**1200**	**1400**	**1600**	**1800**	**2000**	**2200**	**2400**	**2600**	**2800**	**3000**	**3200**	**3400**

Distance A or B between members (mm)



3.3.3 THERMAL BREAK ALUMINIUM EXTRUSIONS – DETERMINATION OF SECTION PROPERTIES

Thermal Break Aluminium Extrusions consist of interior and exterior extruded aluminium sections which are joined by a structural thermal barrier material to improve the thermal performance of the composite section.

There are two methods of creating Thermal Break Aluminium Extrusions:

3.3.3.1 THE POURED AND DEBRIDGED THERMAL BREAK ALUMINIUM EXTRUSIONS

The thermostat material is poured into the cavity of a single extrusion. After curing, the extruded bridge is removed. The resultant framing member is a composite member consisting of interior and exterior aluminium sections separated by architectural, insulating thermal barrier.

3.3.3.2 THE MECHANICALLY LOCKED THERMAL BREAK ALUMINIUM EXTRUSIONS

Individual interior and exterior aluminium extrusions are separated by a preformed thermal barrier. First, both the interior and exterior aluminium extrusions are knurled. The structural thermal barrier material is then inserted into the knurled extruded cavity of both the interior and exterior portions and after rolling (crimping) the mechanical locking process is complete.

3.3.3.3 SECTION PROPERTIES OF THERMAL BREAK ALUMINIUM EXTRUSIONS

The key structural difference between an all-aluminium extrusion and a thermal break aluminium extrusion is the core (thermal break) shear deformation.

The calculations shown in 3.3.2.1 step 2 and 3 above are NOT suitable for establishing the section properties of thermal break extrusions.

The section properties of thermal break extrusions are to be established empirically by subjecting the thermal break extrusions to midspan concentrated, uniform, triangular or trapezoidal loads.

For further reading refer AAMA TIR-A8-08 published by the American Architectural Manufacturers Association, www.aamanet.org .

3.4 DETERMINATION OF GLASS THICKNESS – RATIONAL DESIGN

Accurate analysis and design methods are generally unattractive for manual computation and it is unrealistic to expect the Engineer to perform laborious calculations throughout the whole of the iterative design process. This fuels the need for reliable rules of thumb for performing quick checks. Rules of thumb are a very useful tool for the structural engineer, but their use should be limited to scheme design purposes rather than as the basis for detailed design. Rules of thumb cannot replace detailed design. They simply help ensure that material selection, material quantity and consequently cost estimates are not too far from the final requirements. Furthermore, rules of thumb should be used as an approximate verification of the results obtained from detailed analysis.

Despite the inaccuracy of this over-simplistic approach and the fact that the concept of allowable stress is rarely used in current building design standards, allowable stress design methods are still widely used to design glass elements. It is mainly the extreme ease of use and the simplicity of these methods that make them attractive. The general verification format is:

$$\sigma_E \leq \sigma_{adm}$$

σ_E Maximum in-plane principal stress, calculated suing the characteristic values of the actions of the most unfavourable design scenario;

σ_{adm} Allowable principal in-plane stress (the facture strength found in experiments, divided by a global safety factor that accounts for all uncertainties and variances associated with actions, resistance and modelling).

There is no way of considering the effects of the element's size, the environmental conditions, the duration of load and the like, or of taking a specific target failure probability into account. These aspects must all be somehow "included" in the recommended σ_{adm} values.

Linear theory deflections may be calculated using formulae given by Roak's Formulas for Stress and Strain – Seventh Edition Table 11.4 Formulas for flat plates with straight boundaries and content thickness.

Table 3.13: Allowable stresses for glass panes exposed to uniform lateral load according to Deutsches Institut für Bautechnik

	Allowable stress σ_{adm} (MPa)	
	Vertical glazing	**Overhead glazing**
Annealed glass (ANG)	18	12
Fully tempered glass (FTG)	50	50
Laminated ANG	22.5	15 (25*)

*Only for the lower glass pane in the hazard scenario 'upper pane broken'

Table 3.14: Allowable stresses for initial design – recommendations by Pilkington

Load type	Loading example	Annealed glass (MPa)	Fully tempered glass (MPa)
Short-term body stress	Wind	28*	59
Short-term edge stress	Wind	17.8*	59
Medium term	Snow	10.75	22.7
Medium term	Floors	8.4	35
Long term	Self-weight, water, shelves	7	35

*Valid for annealed glass ≥ 10mm. For 6mm thick glass these values may be multiplied by a factor of 1.4

Table 3.15: Typical material properties of structural silicone sealants (manufacturers data)

Allowable tensile stress, short-term loads	$\sigma_{all,short}$	MPa	0.14
Allowable tensile stress, long term loads	$\sigma_{all,long}$	MPa	0.014
Allowable shear stress, short-term loads	$\tau_{all,short}$	MPa	0.070-0.128
Allowable shear stress, long term loads	$\tau_{all,long}$	MPa	0.070-0.011
Young's modulus of elasticity, short-term loads	E_{short}	MPa	1.0-2.5
Maximum allowable strain [215]	E_{all}	-	±12.5%
Poisson's ratio	v	-	0.49

To enable specialist contractors to be competitive at time of tender when the design wind load has been specified in the tender documents, or has been confirmed in writing to the specialist contractor by a Competent Person (Structures), we provide the following information to determine appropriate glass thicknesses in those events.

In the event that the specialist contractor is awarded the contract, written confirmation must be obtained from a Competent Person (Glazing) to confirm, in writing, the selected glass thicknesses for the contract.

This written confirmation must be provided/passed on to the Principle Agent/Main Contractor or Building Control Officer and should be included with the contract's glazing certificate.

All wind load graphs are based on:

- Maximum frame deflection of 1/175th
- A probability of breakage equal to 8 litres per 1000
- Vertical glazing only
- An aspect ratio of one on one (all round support only)

3.4.1 GLASS SUPPORTED ALL ROUND

Using the wind load graphs for the appropriate glass type, the procedure should be as follows:

a) Calculate the area A = a x b, and the aspect ration, r = a/b, where a is the longer dimension and b is the shorter. Note: If r is greater than 3, figures 3.5 to 3.10 do not apply; refer figure 3.11 to 3.16.
b) Calculate the shape factor for effective area $F = 4r/(r+1)^2$. Some values are given in table 3.16.

Table 3.16: Shape Factors	
r	**F**
1.0	1.000
1.25	0.988
1.5	0.960
1.75	0.926
2.0	0.889
2.5	0.816
3.0	0.750

c) Calculate the effective are of the glass A_e = F x A.
d) On the appropriate graph from figures 3.5 to 3.10, determine the point where the vertical line for the required wind loading intersects the horizontal line for the effective area.
e) If the point of intersection is above the line for the glass type being considered, then a stronger glass is required.
f) If the point of intersection is on or below the line for the glass type being considered, then the glass is adequate to resist the wind load.

In the event of Sealed Insulated Glass Units (SIGU) a factor of 1,5 may be applied to figure 3.5 in respect of the weakest pane in the combination to obtain the appropriate selection. Please consider the weight of the SAGU in respect of site handling.

3.4.2 GLASS DEFLECTION

Excessive deflection in the glass panes can cause air or water leaks. It also may cause metal to glass contact causing glass fracture. Also it will detract aesthetically from the structure.

The use of large safety glass panes may create an uncomfortable feeling to persons in the immediate proximity of such panes when these panes are subjected to wind load.

As the matter of "comfort" is an issue of individual interpretation the decision to use thicker glasses to reduce the deflection lies by the client/specifier. Sub-contractors/glaziers should declare the maximum centre of glass movement timely to prevent disputes after installation.

Table 3.17: Deflection limits		
Document	**Deflection limit**	**Notes**
BS 6262	*L*/125 (single glazing) or *L*/175 (insulating glass units)	Allowable deflections of the edges of four-edge fully supported glass
BS5516	Single glazing: (S^2 x 1000)/180 or 50mm, whichever is the less	Allowable deflection of the edges of 2-edge supported glass where *S* = span (m) of supporting edge
BS5516	Hermetically sealed double glazing: (S^2 x 1000)/540 or 20mm, whichever is the less	Allowable deflection of the edges of 2-edge supported glass where *S* = span (m) of supporting edge
BS5516	Single glazing: 8*S*	Allowable deflection of the edges of 4-edge supported glass where *S* = span (m) of supporting edge ($S \leq 3$m)
BS5516	Single glazing: 12 + (4*S*)	Allowable deflection of the edges of 4-edge supported glass where *S* = span (m) of supporting edge (*S*>3m)
BS5516	Hermetically sealed double glazing: (*S* x 1000)/175 or 40mm, whichever is the less	Allowable deflection of the edges of 4-edge supported glass where *S* = span (m) of supporting edge

The ASTM Standard Practice for determining load resistance of glass in buildings (ASTM E 1300-02) offers in its Annex X2 the following procedure for calculating the approximate centre of glass deflection (all round support).

$$w = t \text{ x } \exp (r_0 + r_1 \text{ x } x + r_2 \text{ x } x^2)$$

Wherein:

w = centre of glass deflection (mm) or (in.), and
t = Minimum glass thickness in mm (refer table 3.13)
$r_0 = 0{,}553 – 3{,}83\ (a/b) + 1{,}11\ (a/b)^2 – 0{,}0969\ (a/b)^3$
$r_1 = 2{,}29 – 5{,}83\ (a/b) + 2{,}17\ (a/b)^2 – 0{,}2067\ (a/b)^3$
$r_2 = 1{,}485 – 1{,}908\ (a/b) + 0{,}815(a/b)^2 – 0{,}0822\ (a/b)^3$

$$x = In\{ In[q(ab)^2 / Et^4] \}$$

Wherein:

q = uniform lateral load in kPa (wind load)
a = long dimension in mm
b = short dimension in mm
E = modulus of elasticity of glass = $71{,}7 \text{ x } 10^6$ kPa

Table 3.18 – Minimum Glass Thicknesses	
Nominal Thickness in mm	**Minimum Thickness in mm**
3,0	2,8
4,0	3,8
5,0	4,8
6,0	5,8
8,0	7,5
10,0	9,5
12,0	11,5

To illustrate the effect of the combined deflection of framing and centre of glass pane on the person in close proximity of glass panes subjected to wind load we quote the following examples:

Example 1 – Refer window quoted in paragraph 3.3.2.1 above

i)	Maximum Deflection Mullion	$\frac{1800}{175}$	=	+ and -	10mm
ii)	Maximum Glass Deflection 5mm glass thickness		=	+ and -	6mm
		Total		+ and -	16mm

Total centre of pane movement by 600Pa wind load = 32mm

Example 2 – Standard Patio Door 3021 wind load 1000Pa (A1)

i)	Maximum Deflection Interlock	$\frac{2100}{175}$	=	+ and - 12mm
ii)	Maximum Glass Deflection 5mm Toughened		=	+ and – 19mm
		Total		+ and - 31m

Total centre of pane movement by 1000Pa wind load = 62mm

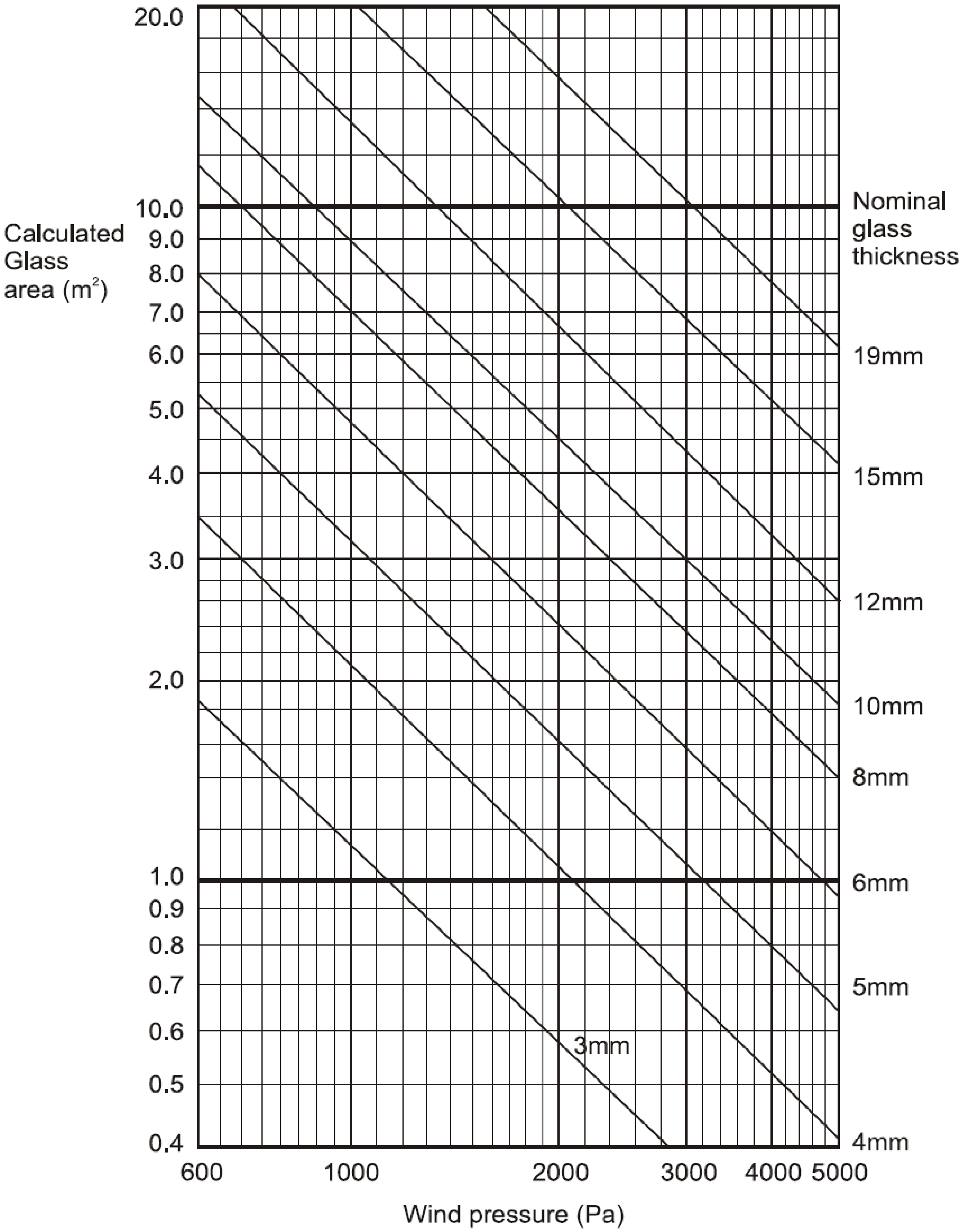


Figure 3.5 - Wind load on monolithic annealed glass supported all round (3s mean wind load)

Material selections made using this graph must be confirmed, in writing, by a Competent Person (Glazing)

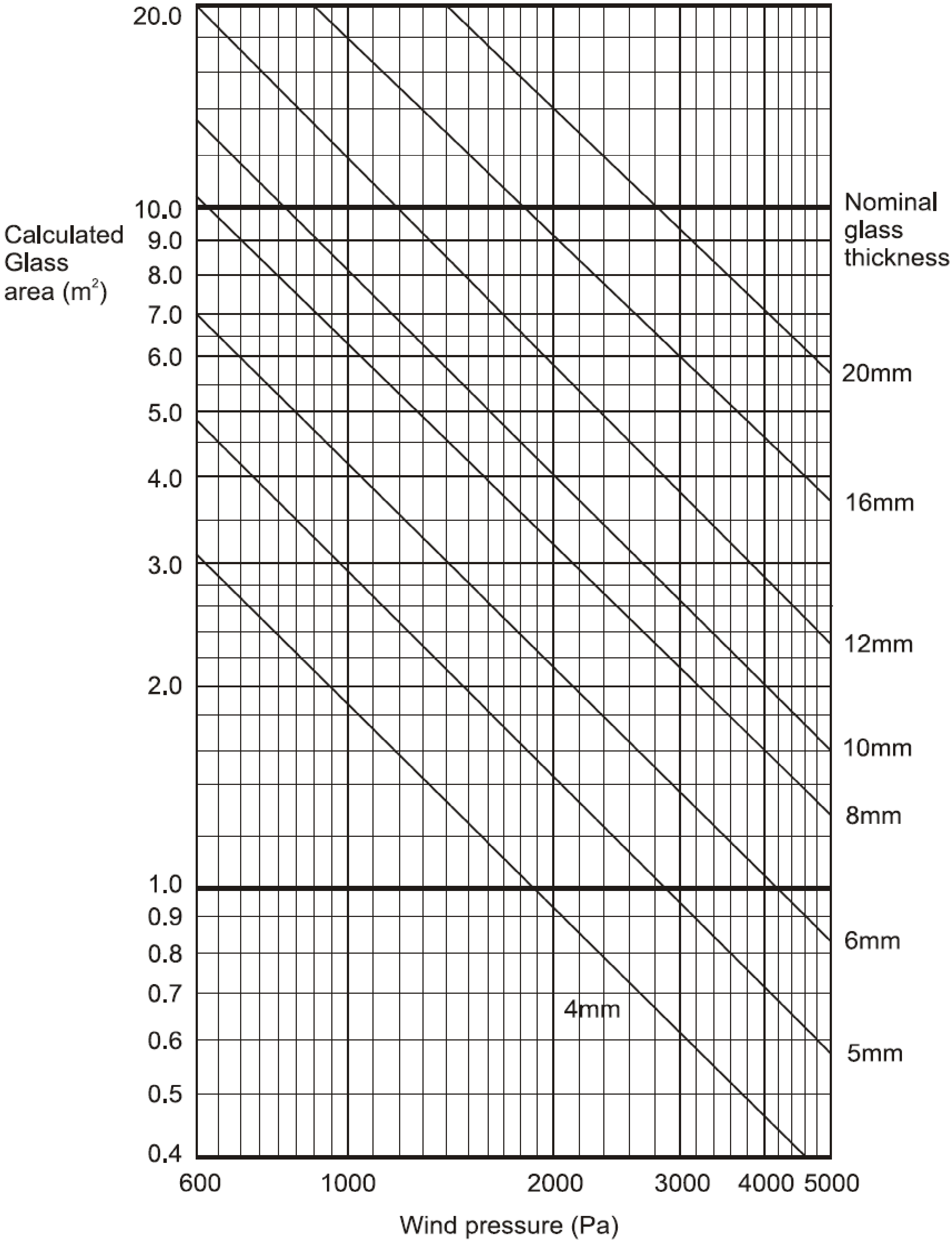


Figure 3.6 - Wind load on laminated annealed safety glass supported all round (3s mean wind load)

Material selections made using this graph must be confirmed, in writing, by a Competent Person (Glazing)

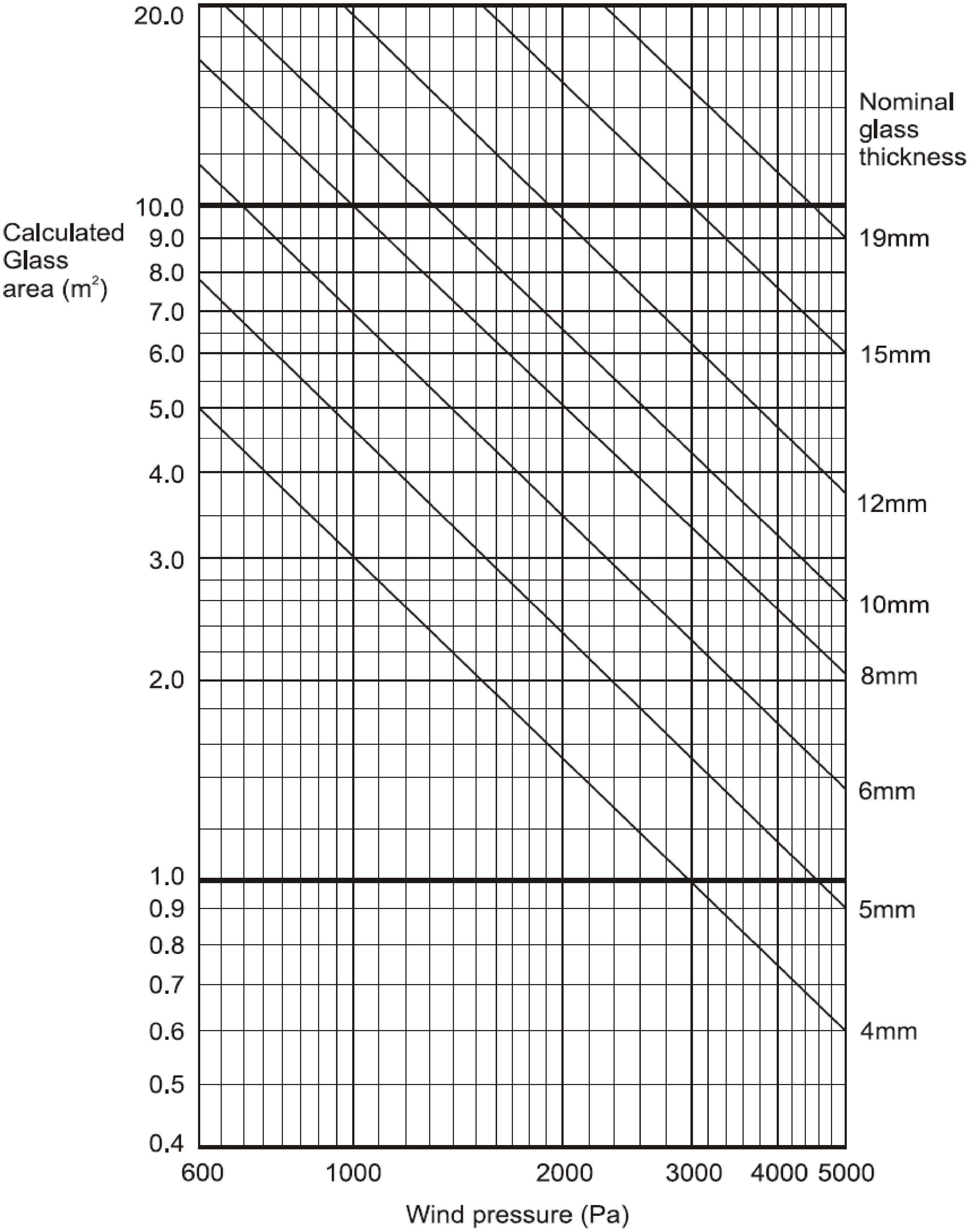


Figure 3.7 - Wind load on toughened safety glass supported all round (3s mean wind load)

Material selections made using this graph must be confirmed, in writing, by a Competent Person (Glazing)

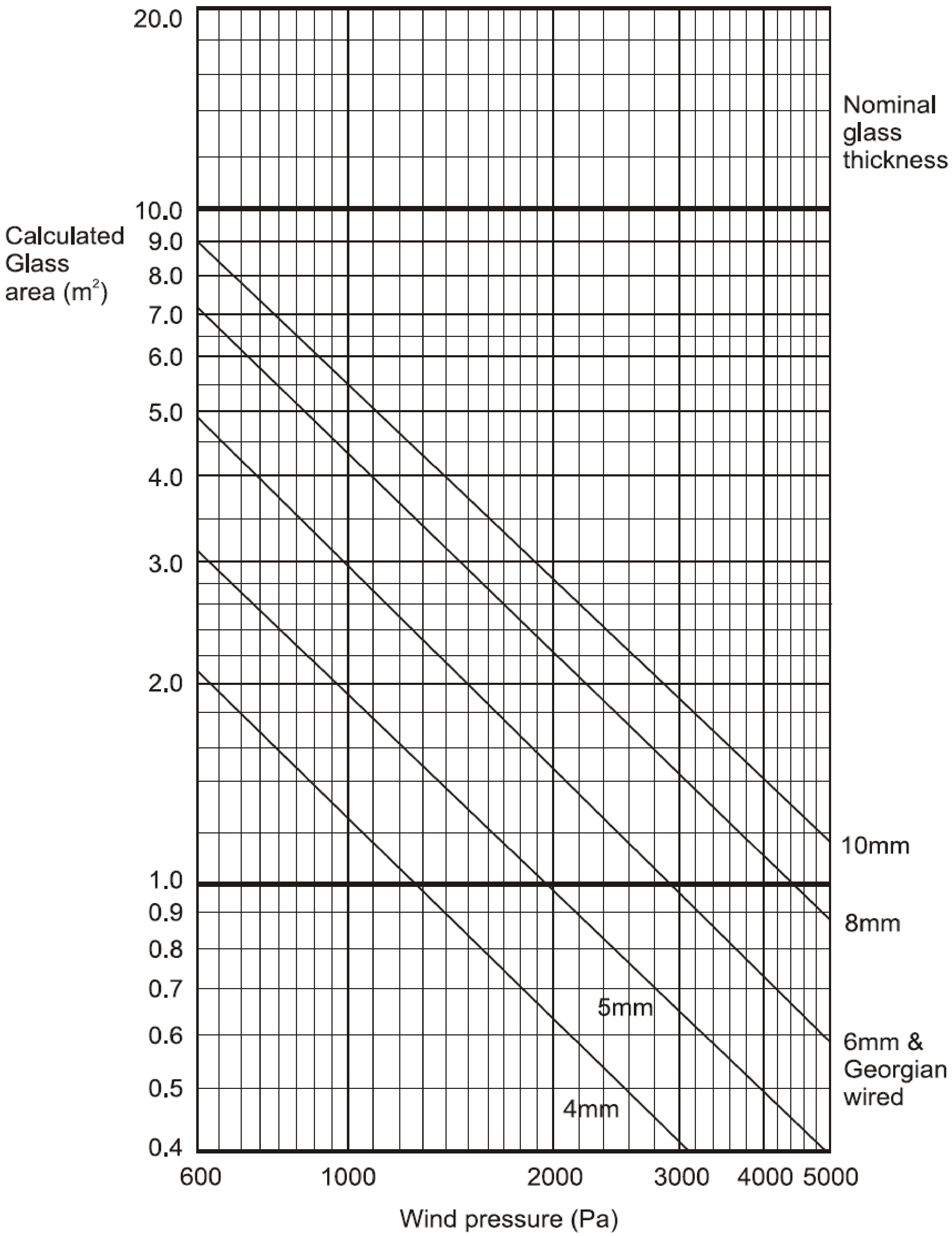


Figure 3.8 - Wind load on patterned & wired annealed glass supported all round (3s mean wind load)

Material selections made using this graph must be confirmed, in writing, by a Competent Person (Glazing)

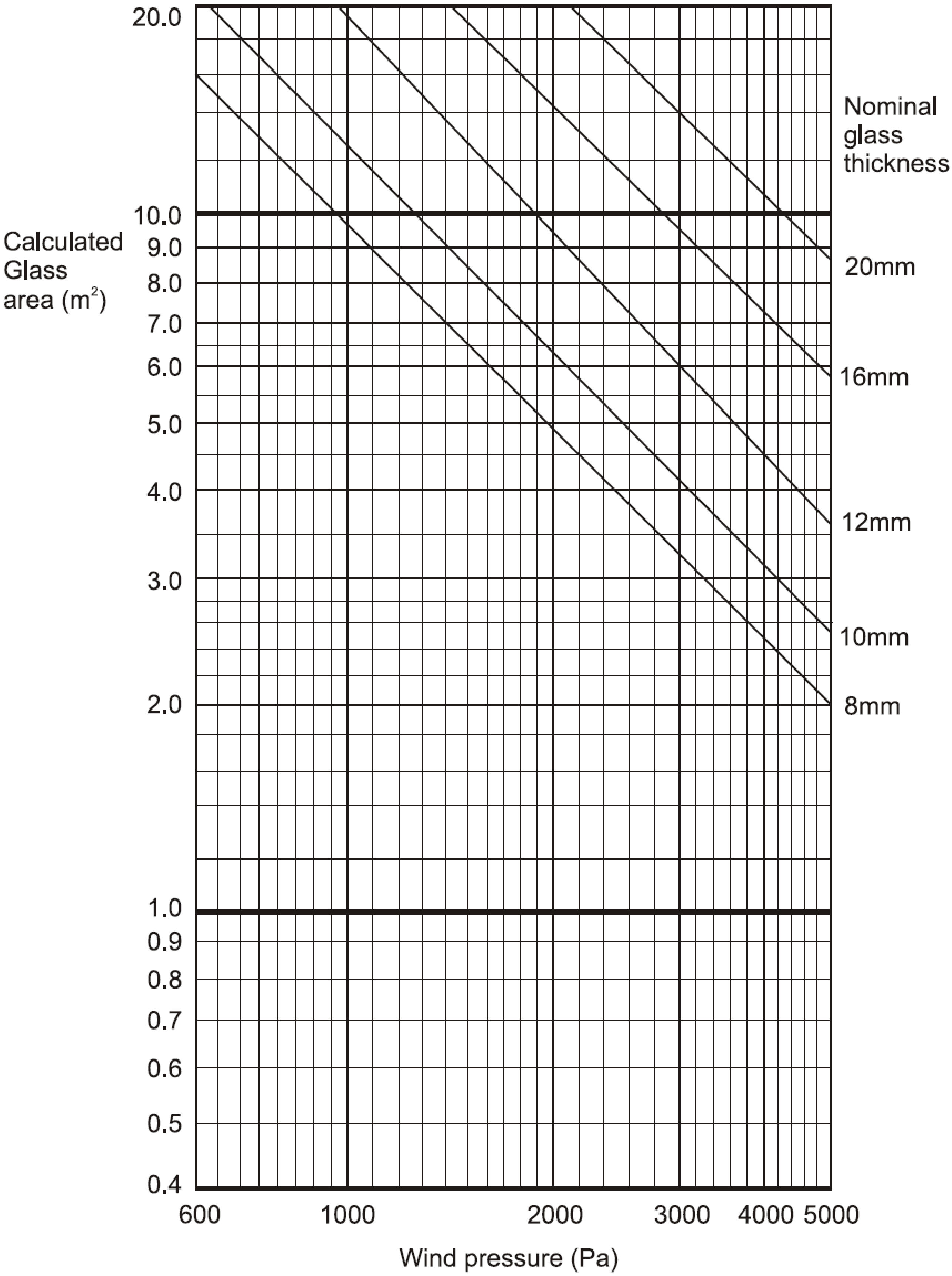


Figure 3.9 - Wind load on laminated toughened safety glass supported all round (3s mean wind load)

Material selections made using this graph must be confirmed, in writing, by a Competent Person (Glazing)

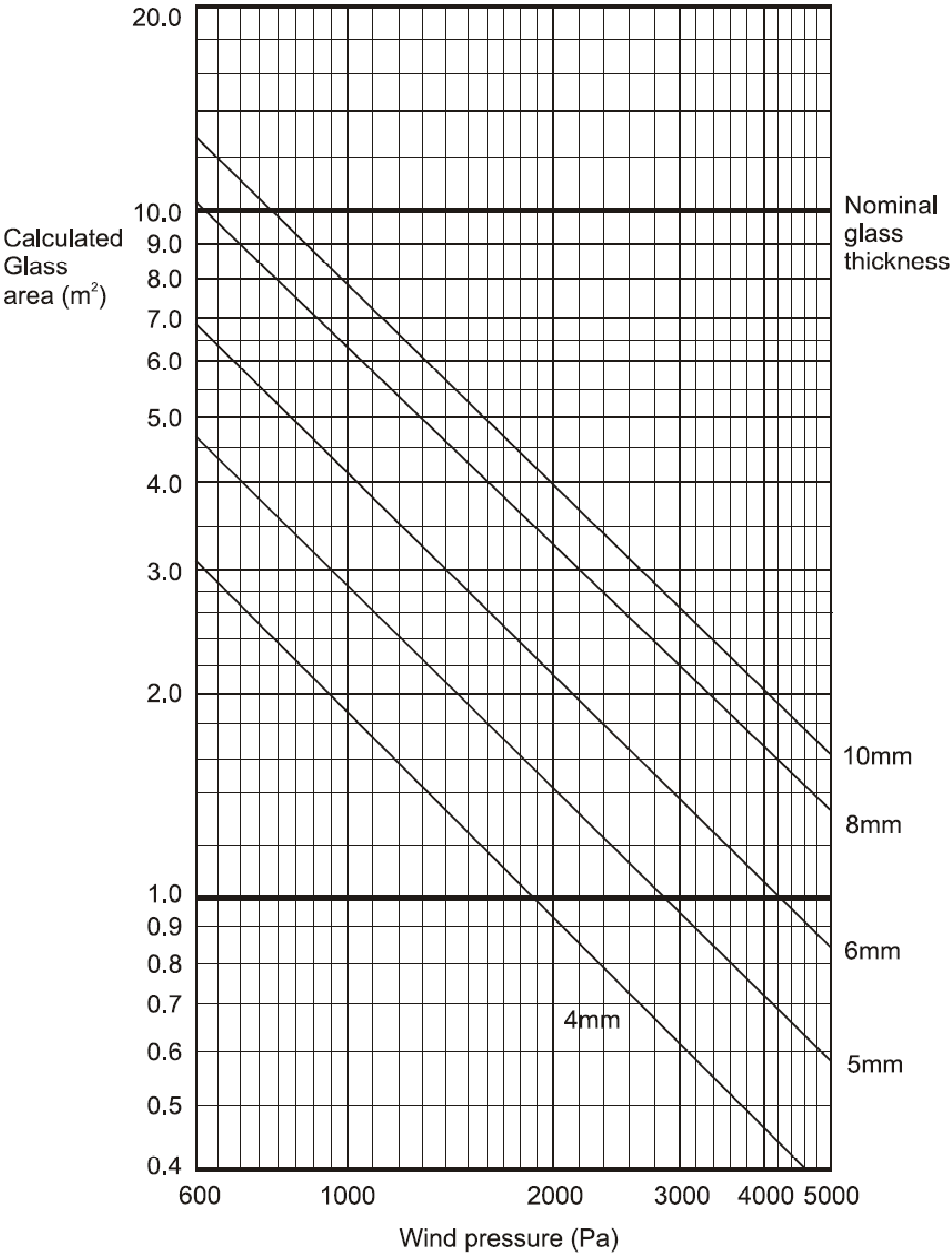


Figure 3.10 - Wind load on toughened patterned safety glass supported all round (3s mean wind load)

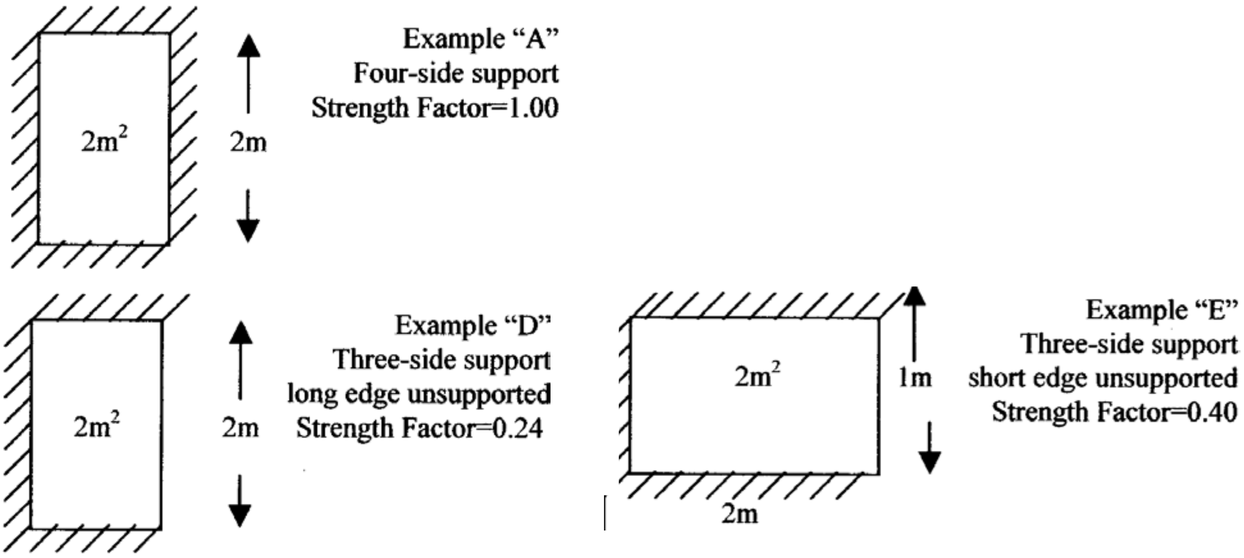
Material selections made using this graph must be confirmed, in writing, by a Competent Person (Glazing)

3.4.3 GLASS SUPPORTED ON THREE SIDES

One edge of the glass may be left unsupported in some glazing systems, creating a three-side support glazing condition. Such a condition is shown in Example "D" where one of the 2m vertical edges is unsupported. The strength factor for this condition is 0.24.

If the distance between the supported vertical edge and the unsupported vertical edge increases the strength of the three-side supported glass would be no greater than a piece of glass the same size with two unsupported edges.

Example "E" shows another three-side support condition with the 1m dimension left unsupported. The strength factor for this condition is 0.40. This glass is stronger than the glass shown in Example "D" because the unsupported span is reduced. In three-side support systems, the glass strength is dependent on the glass thickness, the glass height, the glass width, and which edge is unsupported.



3.4.4 GLASS SUPPORTED ON TWO OPPOSITE SIDES

The following figures are applicable to glass supported on two opposite sides:

Note: Hermetically sealed glass units a.k.a. Sealed Insulated Glass Units (SIGU) must always be installed with all round support.

Note: Frameless glass sliding doors are to be manufactured of toughened safety glass of thicknesses based on figure 3.13

Any deviation from figure 3.13 requires written approval of a Competent Person (Glazing).

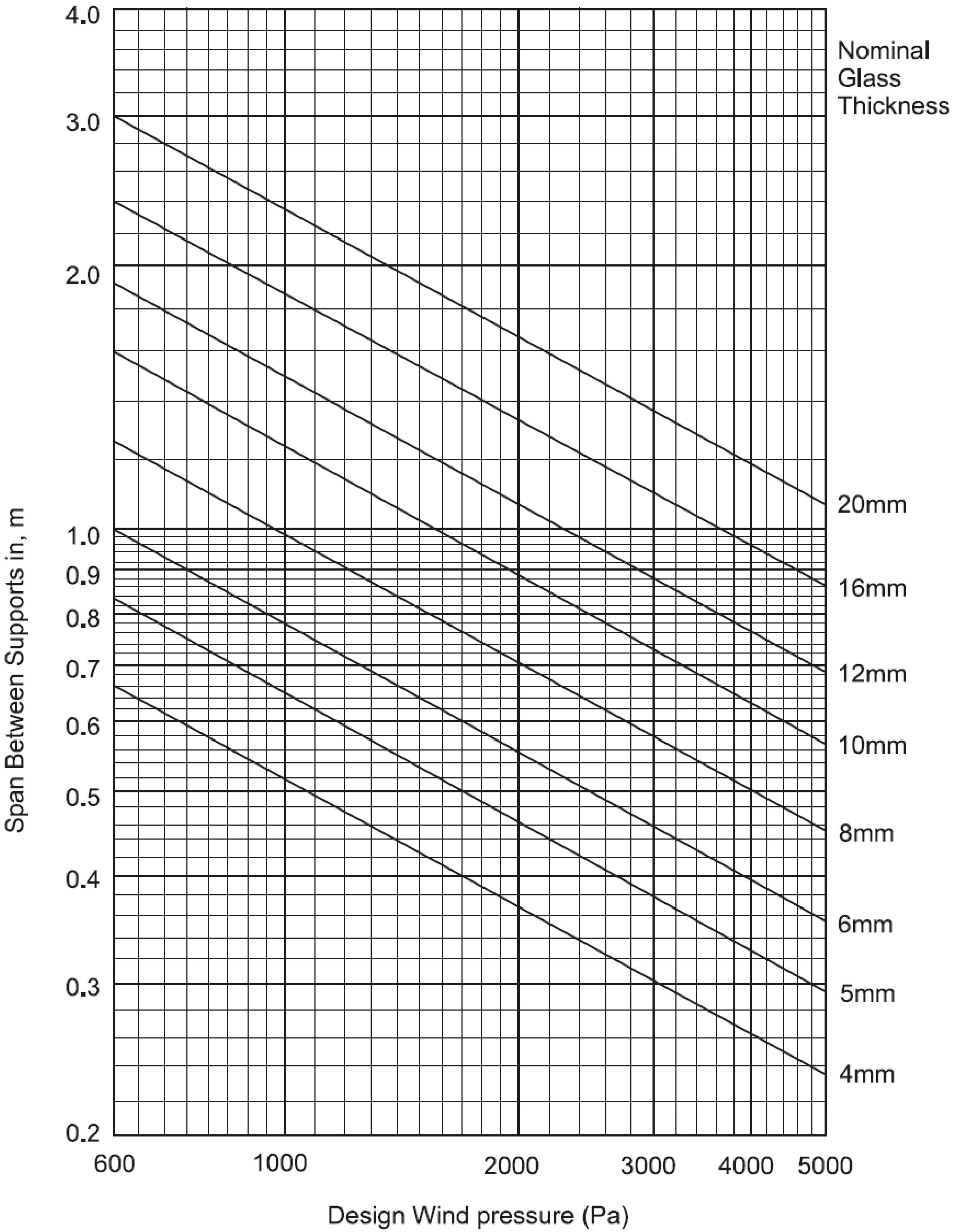


Figure 3.12 - Wind load on laminated annealed safety glass supported on two opposite sides (3s mean wind load)

Material selections made using this graph must be confirmed, in writing, by a Competent Person (Glazing)

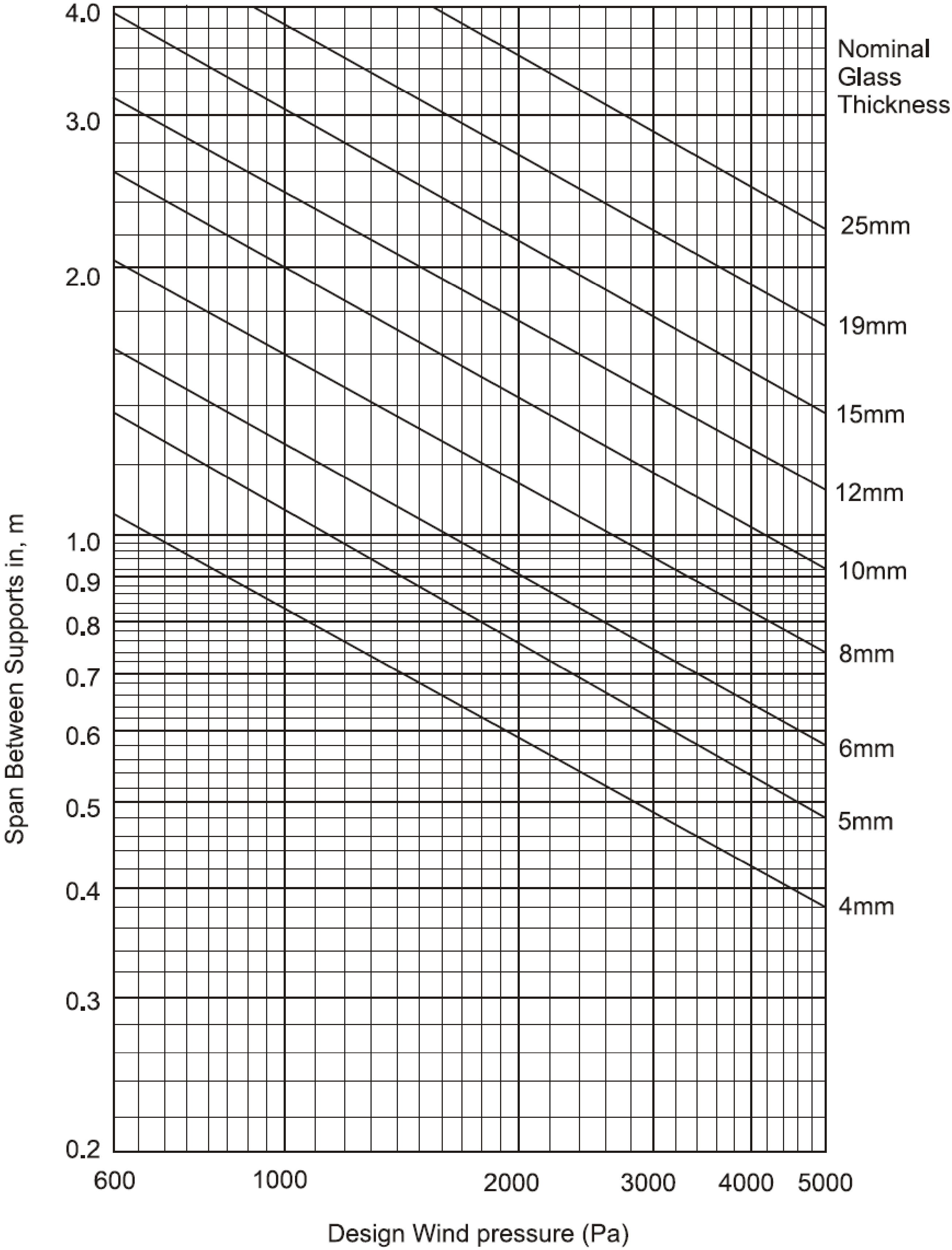


Figure 3.13 - Wind load on toughened safety glass supported on two opposite sides (3s mean wind load)

Material selections made using this graph must be confirmed, in writing, by a Competent Person (Glazing)

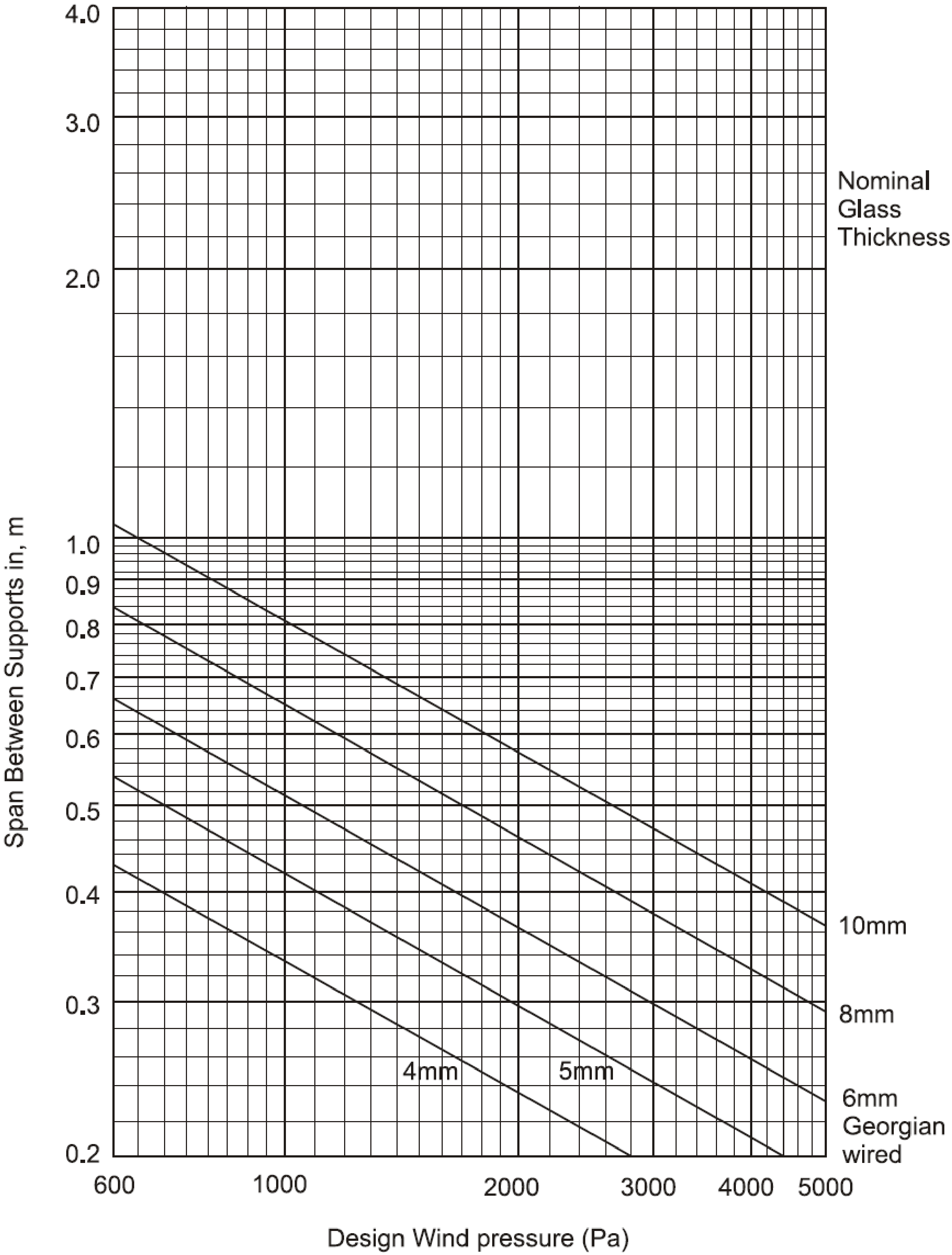


Figure 3.14 - Wind load on patterned annealed glass supported on two opposite sides (3s mean wind load)

Material selections made using this graph must be confirmed, in writing, by a Competent Person (Glazing)

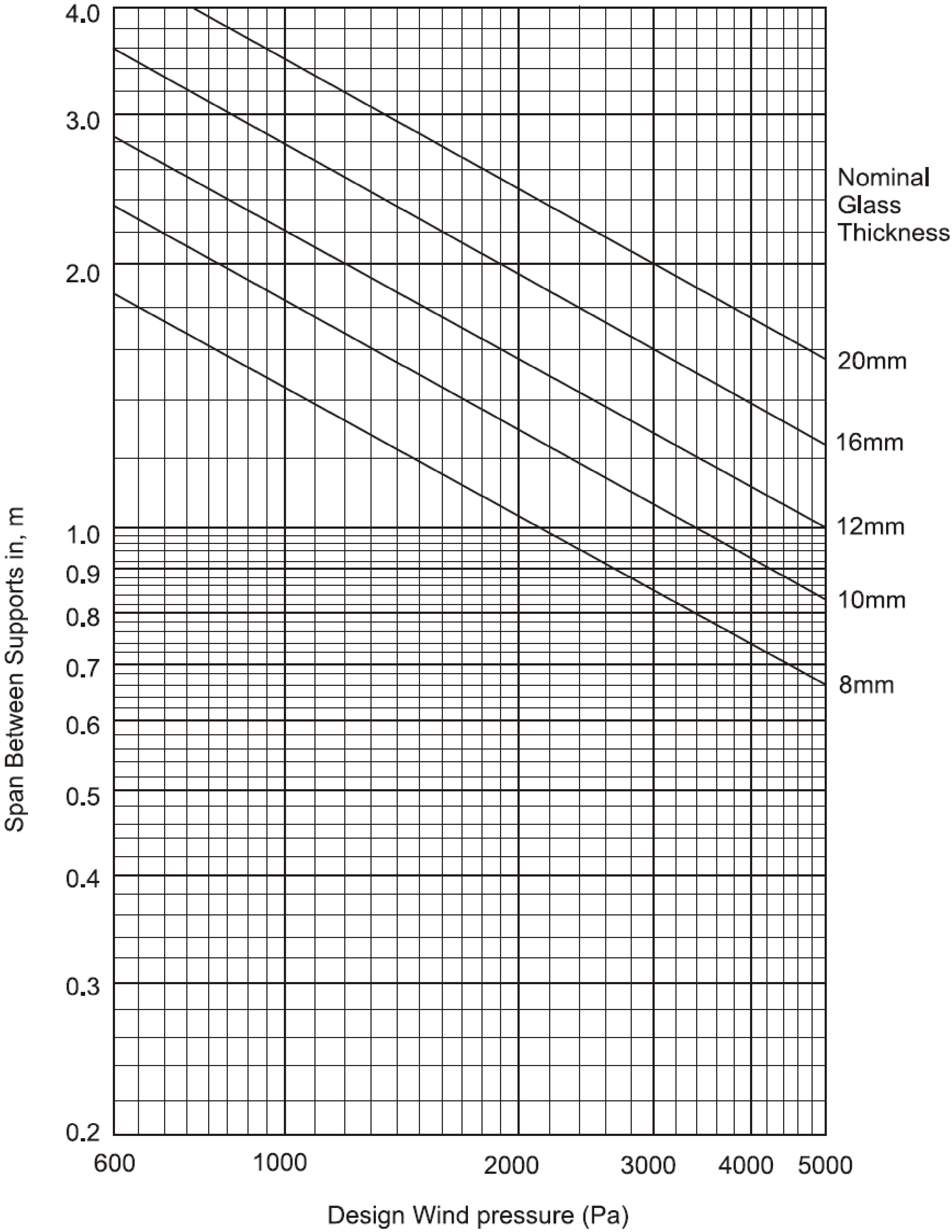


Figure 3.15 - Wind load on laminated toughened safety glass supported on two opposite sides (3s mean wind load)

Material selections made using this graph must be confirmed, in writing, by a Competent Person (Glazing)

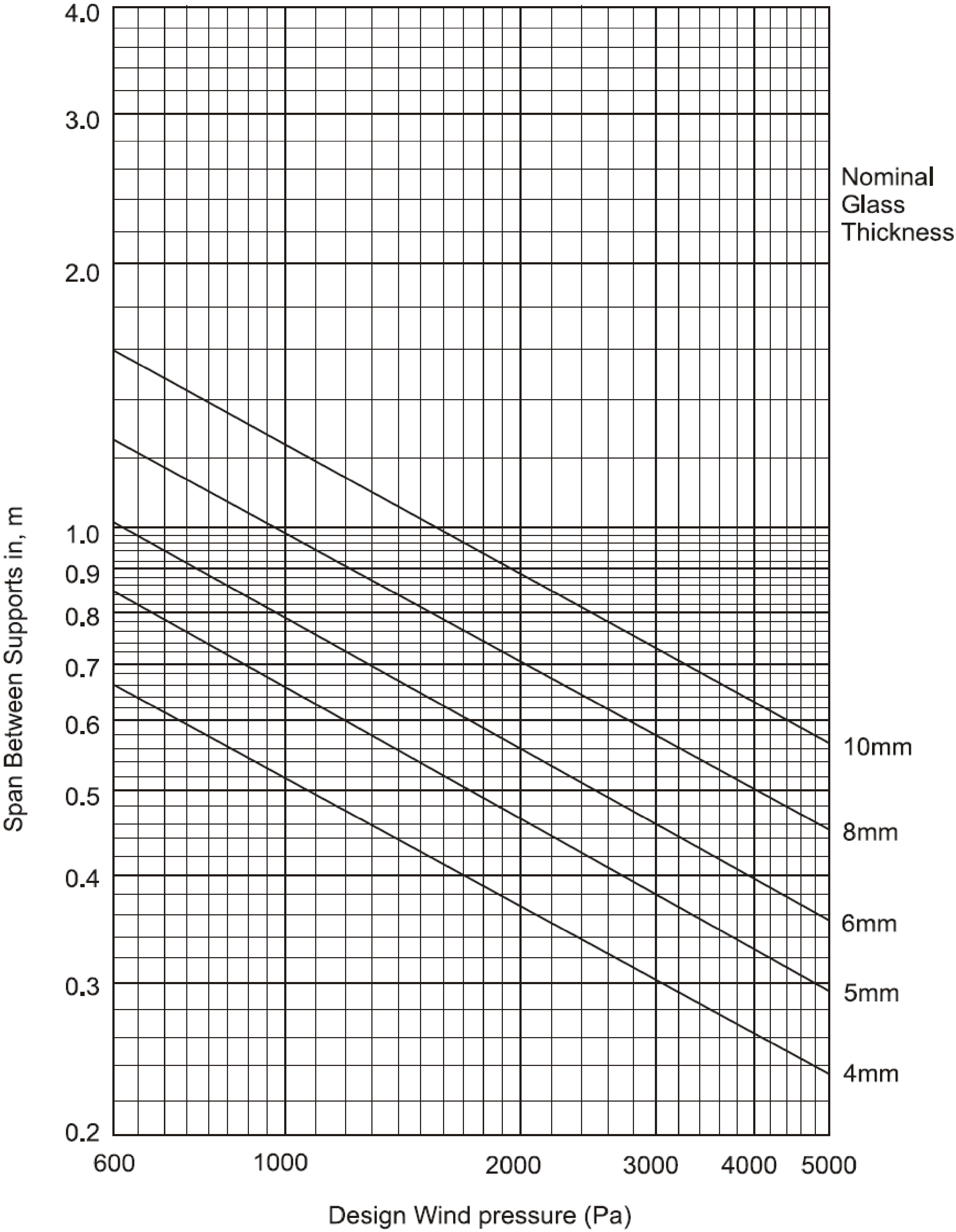


Figure 3.16 - Wind load on toughened patterned safety glass supported on two opposite sides (3s mean wind load)

Material selections made using this graph must be confirmed, in writing, by a Competent Person (Glazing)

3.4.5 BUTT JOINTED EDGES

Where glass panes in the same plane are butt-jointed without fins, they will not have the same wind resistance characteristics as a single pane of the same overall size and thickness. The thickness of such glass should be calculated on the assumption that the butt joint does not have any structural effect, i.e. the surround will be the only support.

If reinforcing is unavoidable due to the span and wind loading, it might be necessary to install fins attached to the structure at the butt joints as indicated in figure 3.17. A suitable adhesive sealant with sufficient bonding strength to allow movement due to wind loading shall be used.

Silicone sealants that have a tensile strength of at least 1 MPa are regarded as suitable for this purpose.

Fins would normally be installed on the inside of the building where there is likely to be less pedestrian traffic. Fin selection is covered in figures 3.19 and 3.20.

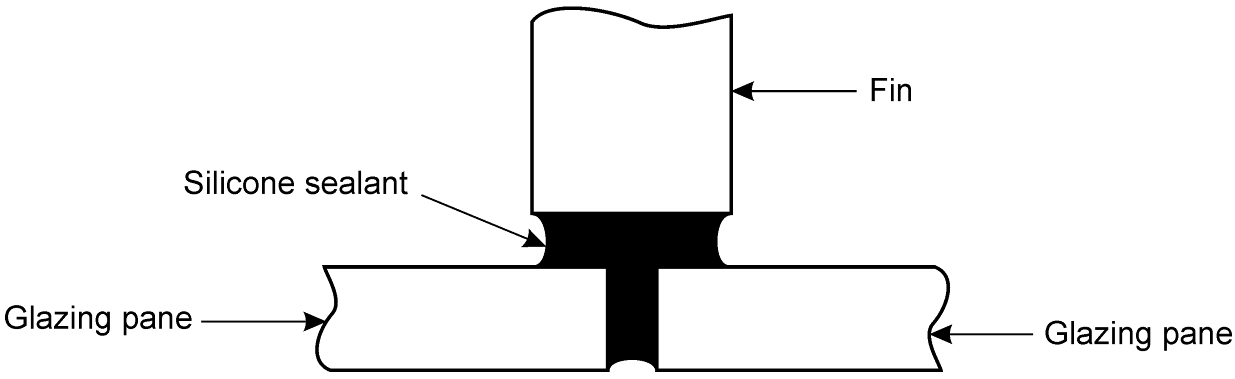


Figure 3.17 — Detail of fin assembly

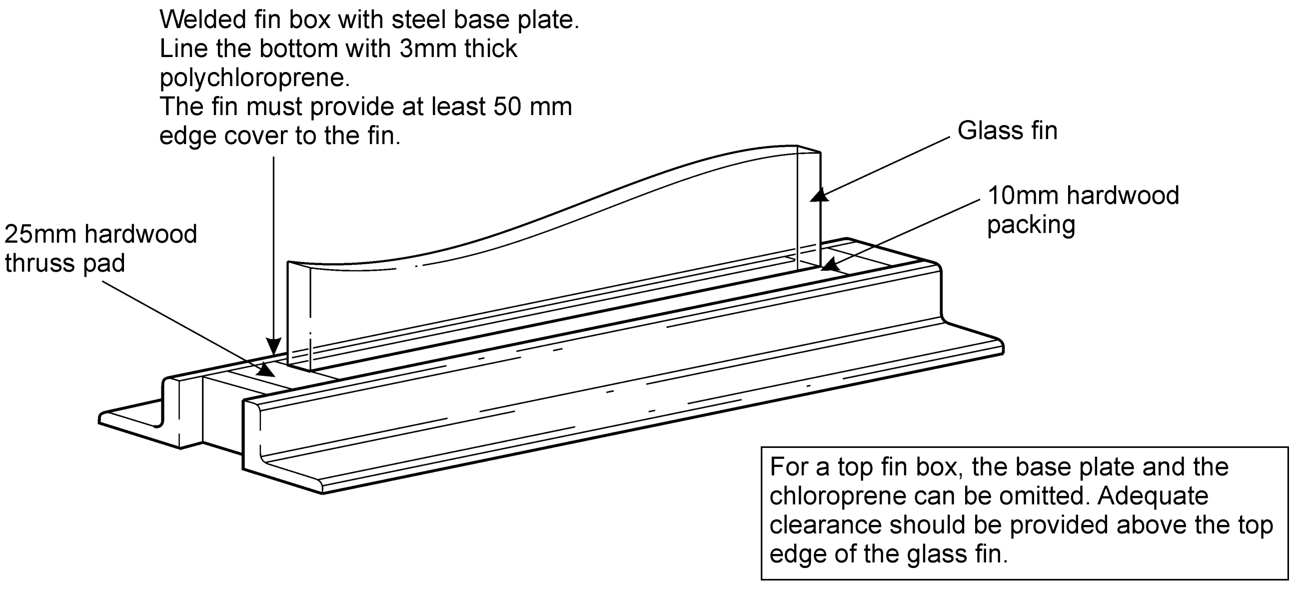


Figure 3.18 – Fin Detail

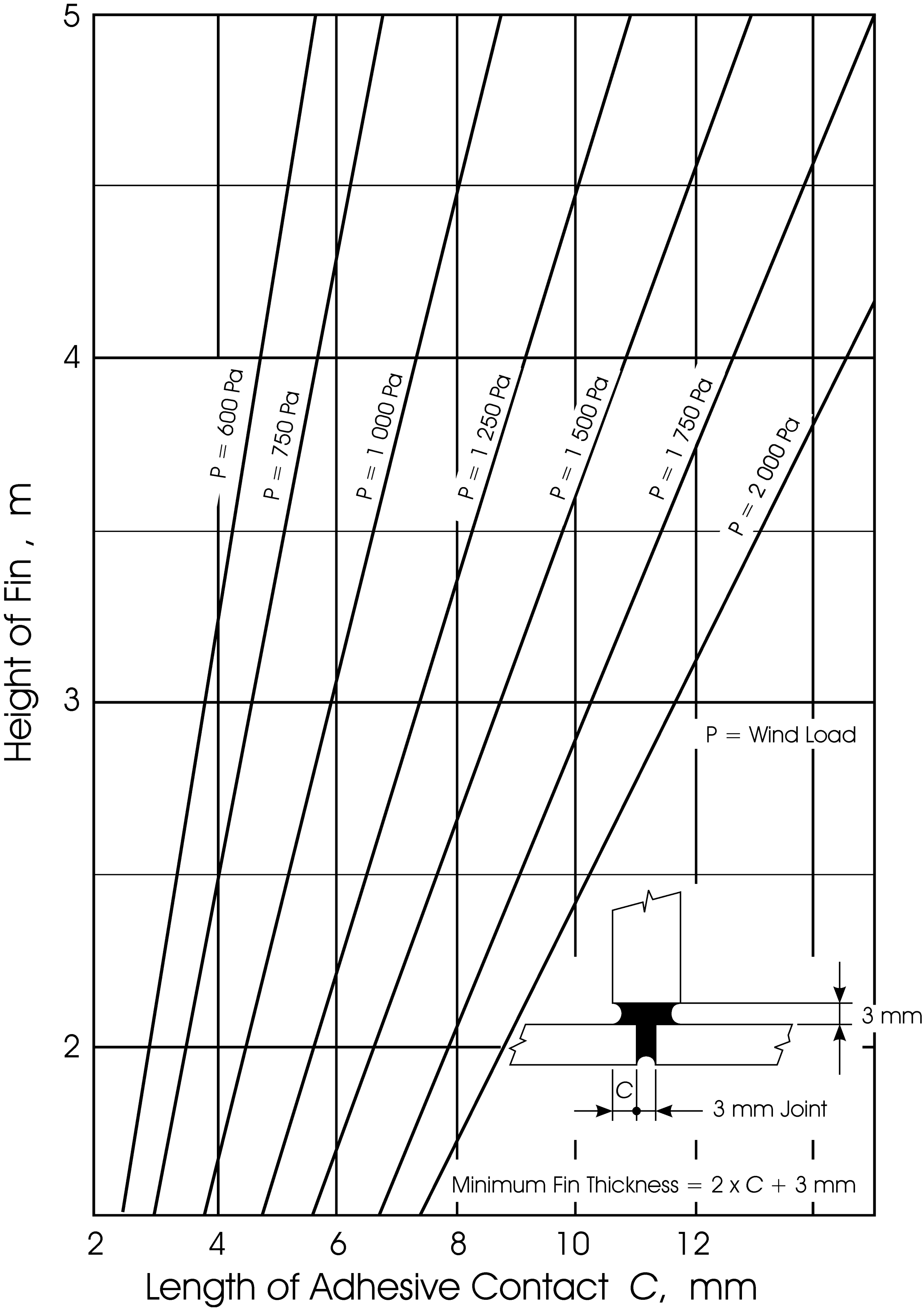


Figure 3.19 – Wind load on glass fin assemblies: Sizes of adhesive joint

Material selections made using this graph must be confirmed, in writing, by a Competent Person (Glazing)

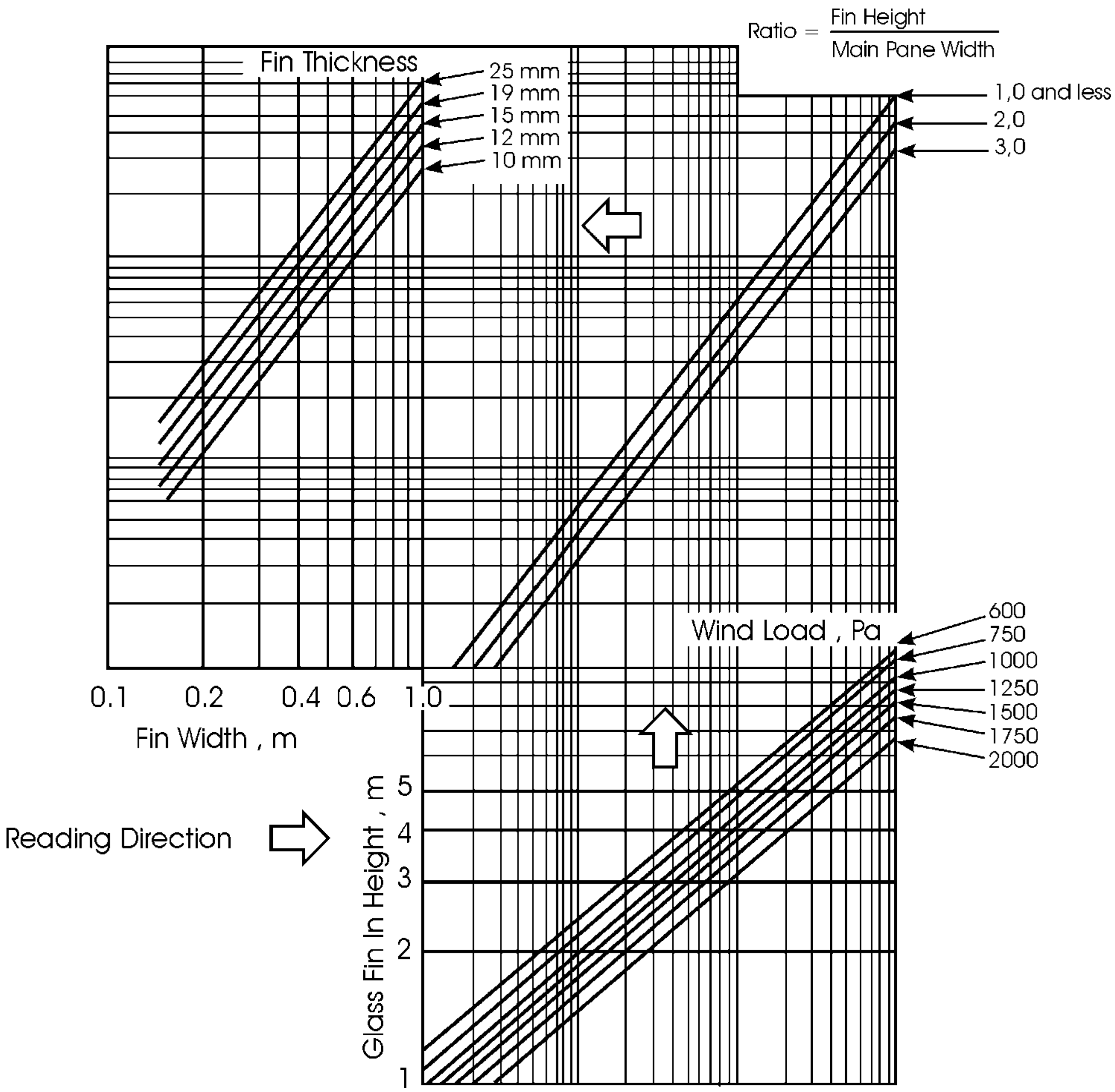


Figure 3.20 – Wind load on glass fin assemblies: Glass fin width (3 s means wind load)

Material selections made using this graph must be confirmed, in writing, by a Competent Person (Glazing)

3.5 PLASTICS – Rational Design

Design considerations as regards wind load on plastics materials have to be based on the fact that, under load (positive or negative), a pane is more likely to be displaced from its frame than to be fractured. When it is necessary to design for an anticipated wind load, obtain from the supplier the relevant material information about the relationship between the thickness of the material, the area of the glazing, the aspect ratio, the edge cover and the method of fixing for normal use, provided maximum deflection does not exceed 50mm. Polycarbonate is the plastics glazing material mostly used and figures 3.21 to 3.23 give the pane size and thickness against short dimension and wind load.

The graphs are:

Figure 3.21 – Plastics glazing panes: 15mm edge cover aspect ratio 1:0 $\leq$ 1,5 (3 s mean wind load)
Figure 3.22 – Plastics glazing panes: 15mm edge cover aspect ratio > 1,5 $\leq$ 2,5 (3 s mean wind load)
Figure 3.23 – Plastics glazing panes: 15mm edge cover aspect ratio > 2,5 $\leq$ 3,5 (3 s mean wind load)

The recommendations given in 3.5 are for flat, plane, solid plastics glazing sheet materials of uniform thickness, in rectangular shapes glazed with all four edges fully supported. Design recommendations for other forms, including pattered and hollow section, should be obtained from the manufacturers.

3.5.1 DESIGN CONSIDERATION

Failure of a pane of plastics glazing sheet material under load is most likely to be by displacement of the pane rather than by breakage. The recommendations on thickness for plastics glazing sheet material is related to minimum size of edge cover to prevent a pane of specified thickness from springing out under loading in normal glazing conditions. The design considerations are based on this. The procedure in 3.5.2 is for vertical four-edge fully supported glazing.

The design wind loadings for pressure and suction must be determined by a Competent Person (Structures) based on SANS 10160-Part 2, in writing. The values given in the sets of wind loading graphs, figures 3.21 to 3.23, have been derived from trade practice proven to be satisfactory over many years experience and experimental knowledge.

The aspect ratio of a pane has an effect on the thickness required to limit deflection under uniform load. The higher the aspect ratio the greater the resistance to deflection. For panes having an aspect ratio greater than 3,5:1 or when they are non-rectangular, the Competent Person (Glazing) should be consulted. In order to limit the deflection for larger panes, the Competent Person (Glazing) should be consulted where areas of individual panes exceed $2m^2$. If the absence of bowing under large increases in ambient temperature is an important aesthetic consideration, then the thermal expansion of plastics glazing sheet materials should be allowed for in the rebate size.

For plastics glazing sheet materials, a minimum edge cover of 15mm is normally recommended. To accommodate a smaller edge cover arising from small existing rebate depths, the designer should consider the possible following options:

a) use of increased thickness of glazing for edge covers other than 15mm edge cover the Competent Person (Glazing) should be consulted;

b) use of tight glazing by sacrificing edge clearance and accepting the possibility of bowing at elevated temperatures;

c) use of higher quality sealants to increase edge restraint;

d) use of mechanical fixing.

These options frequently arise in reglazing situations where plastics glazing sheet materials are used with existing rebates designed for glass, which are often inadequate for ideal glazing with these materials.

For glazing systems designed specifically for plastics glazing sheet materials, the use of an edge cover greater than 15mm may allow the use of materials thinner than those derived from figures 3.21 to 3.23, but the Competent Person (Glazing) should be consulted.

3.5.2 USE OF WIND LOADING GRAPHS TO DETERMINE THICKNESS OF SOLID PLASTICS GLAZING SHEET MATERIALS.

The following procedure should be used to determine the thickness of the plastics glazing sheet materials, in conjunction with the wind loading graphs, figures 3.21 to 3.23.

Note: Figures 3.21 to 3.23 are used for the normally recommended edge cover of 15mm.

a) Calculate the area of the pane, A = a x b and the aspect ratio, r = a/b, where a is the longer dimension and b is the shorter.

b) On the appropriate graph for the aspect ratio and edge cover from figures 3.21 to 3.23, determine the point where the vertical line for the required wind loading intersects the horizontal line for the required area.

c) If the point of intersection does not coincide with a thickness line, the recommended thickness for use with the corresponding size of edge cover is indicated by the line above.

If the pane is situated where it may be subject to accidental breakage or is intended to be of a thickness to withstand vandal attack, the thickness may need to be increased or the method of glazing modified to allow for this additional loading.

3.5.3 DESIGN OF HOLLOW SECTION PLASTICS GLAZING SHEET MATERIALS

The stiffness of a hollow plastic glazing sheet material is determined by the material from which it is made, the overall thickness and the geometry of the sheet. The deflection characteristics of a particular hollow section plastic glazing sheet material very according to which direction the webs runs in relation to the long edges of the pane. For further reading refer Chapter IV.

It is not practical, therefore to produce a set of graphs relating wind loading to hollow sections sheets because of the variety of profiles and thicknesses. Advice should be obtained from the Competent Person (Glazing).

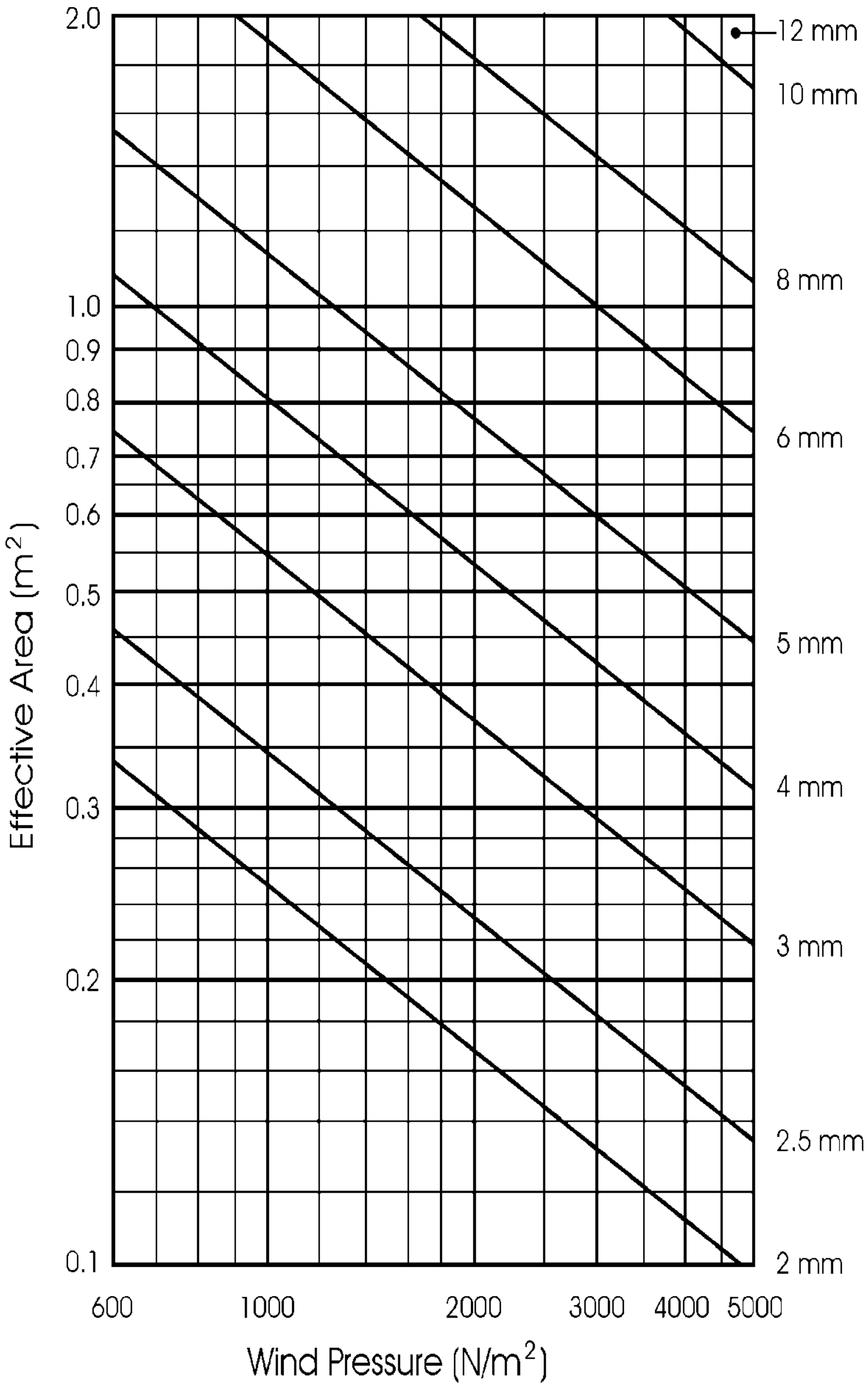


Figure 3.21: Wind loading graph for plastics glazing sheet materials, 15mm edge cover, and aspect ratio 1.0 to 1.5

Material selections made using this graph must be confirmed, in writing, by a Competent Person (Glazing)

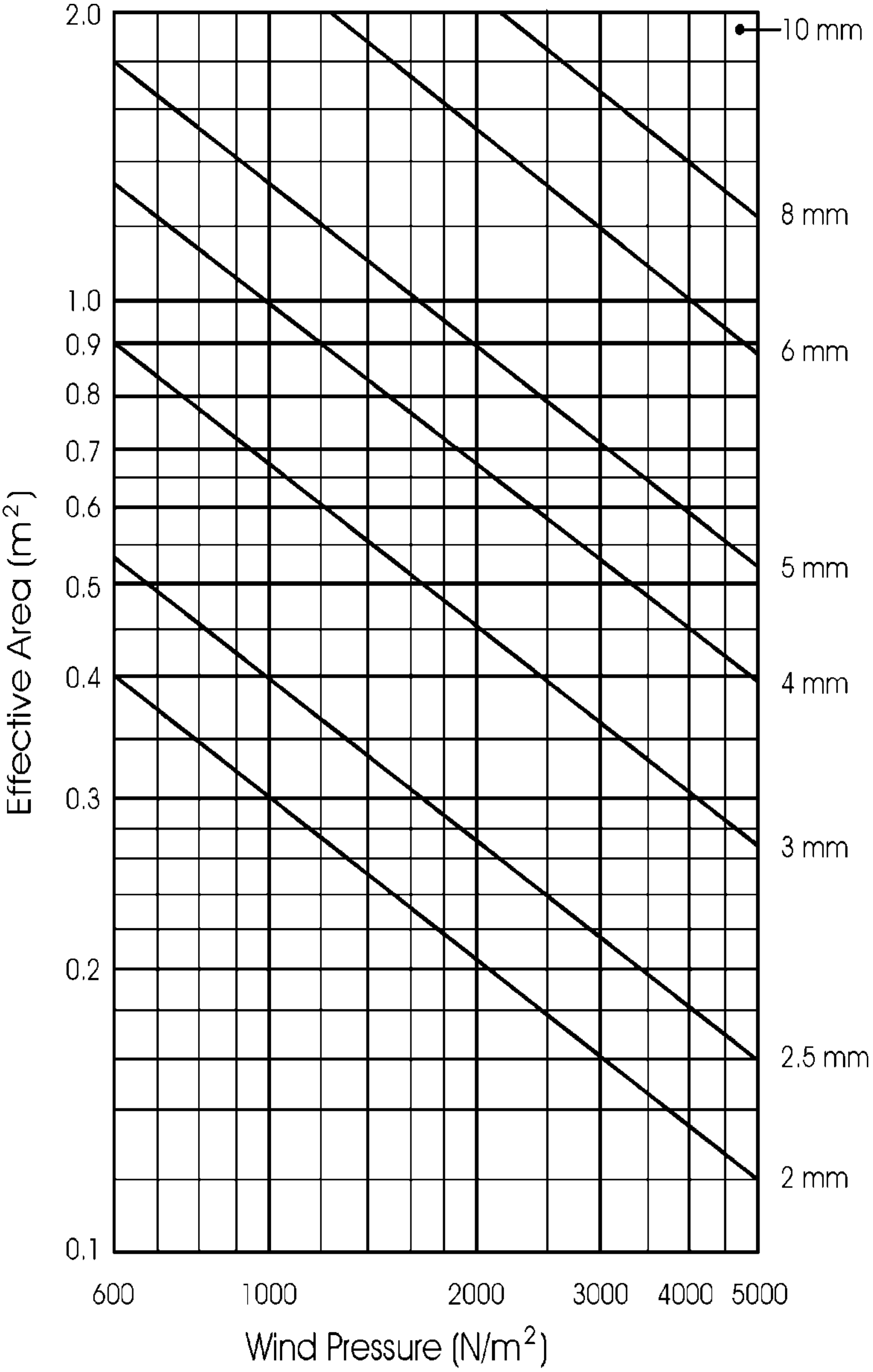


Figure 3.22: Wind loading graph for plastics glazing sheet materials, 15mm edge cover, aspect ratio greater than 1.5 up to and including 2.5

Material selections made using this graph must be confirmed, in writing, by a Competent Person (Glazing)

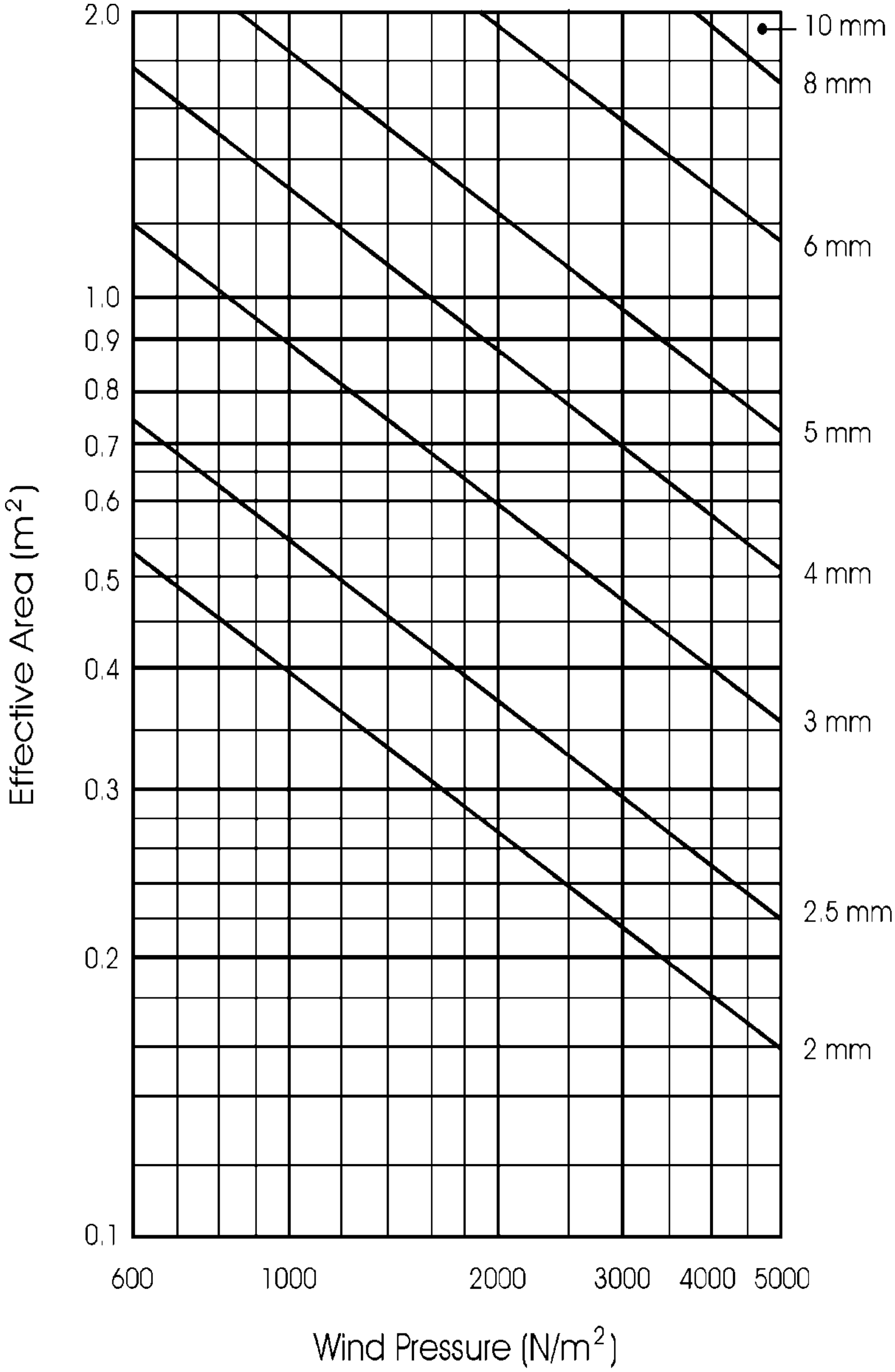


Figure 3.23: Wind loading graph for plastics glazing sheet materials, 15mm edge cover, aspect ration greater than 2.5 up to and including 3.5

Material selections made using this graph must be confirmed, in writing, by a Competent Person (Glazing)

3.6 SHOWER ENCLOSURES

Shower enclosures are to comply with the performance criteria as stated in SANS 549 – Shower Enclosures for Domestic purposes.

In respect of frameless Glass Shower Enclosures the following shall apply:

3.6.1 Maximum areas and mass for Frameless Glass Shower Enclosures

A.1 - Maximum frameless glass area per thickness

1	2	3
Thickness mm	**Door** m^2	**Fixed pane** m^2
6	1,600	2,100
8	2,000	3,300
10	2,200	4,000
12	n/a	4,800
Not possible	>2,200	

This table does not apply to curved glass

A.2 - Size limitations in sq.m for frameless shower doors and fixed panels supporting doors[ab]

1	2	3	4	5	6	7	8	9	10	11	12
Height mm	**Width** mm										
	500	550	600	650	700	750	800	850	900	950	1000
1880	0,940	1,034	1,128	1,222	1,316	1,410	1,504	1,598	1,692	1,786	1,880
1900	0,950	1,045	1,140	1,235	1,330	1,425	1,520	1,615	1,710	1,805	1,900
1950	0,975	1,073	1,170	1,268	1,365	1,463	1,560	1,658	1,755	1,853	1,950
2000	1,000	1,100	1,200	1,300	1,400	1,500	1,600	1,700	1,800	1,900	2,000
2050	1,025	1,128	1,230	1,333	1,435	1,538	1,640	1,743	1,845	1,948	2,050
2100	1,050	1,155	1,260	1,365	1,470	1,575	1,680	1,785	1,890	1,995	2,100
2150	1,075	1,183	1,290	1,398	1,505	1,613	1,720	1,828	1,935	2,043	2,150
2200	1,100	1,210	1,320	1,430	1,540	1,650	1,760	1,870	1,980	2,090	2,200
2250	1,125	1,238	1,350	1,463	1,575	1,688	1,800	1,913	2,025	2,138	
2300	1,150	1,265	1,380	1,495	1,610	1,725	1,840	1,955	2,070	2,185	
2350	1,175	1,293	1,410	1,528	1,645	1,763	1,880	1,998	2,155		
2400	1,200	1,320	1,440	1,560	1,680	1,800	1,920	2,040	2,160		

[a] Additional limitations**:**
Distance between hinges or fixing points not to exceed the following:
For 6 mm glass < 1,30 m
For 8 mm glass < 1,75 m
For 10 mm glass < 2,00 m.

[b] Size and weight specification of hardware to be adhered to in accordance with the manufacturer's instructions.

A.3 - Size limitations in sq. m for fixed frameless shower panels supported at all four corners[a]

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Height	**Width** mm												
mm	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800
1,800	1,128	1,316	1,504	1,692	1,880	2,068	2,256	2,444	2,632	2,820	3,008	3,196	3,384
1,900	1,140	1,330	1,520	1,710	1,900	2,090	2,280	2,470	2,660	2,850	3,040	3,230	3,420
1,950	1,170	1,365	1,560	1,755	1,950	2,145	2,340	2,535	2,730	2,925	3,120	3,315	3,510
2,000	1,200	1,400	1,600	1,800	2,000	2,200	2,400	2,600	2,800	3,000	3,200	3,400	3,600
2,050	1,230	1,435	1,640	1,845	2,050	2,255	2,460	2,665	2,870	3,075	3,280	3,485	3,690
2,100	1,260	1,470	1,680	1,890	2,100	2,310	2,520	2,730	2,940	3,150	3,360	3,570	3,780
2,150	1,290	1,505	1,720	1,935	2,150	2,365	2,580	2,795	3,010	3,225	3,440	3,655	3,780
2,200	1,320	1,540	1,760	1,980	2,200	2,420	2,640	2,860	3,080	3,300	3,520	3,740	3,960
2,250	1,350	1,575	1,800	2,025	2,250	2,475	2,700	2,925	3,150	3375	3,600	3,825	4,050
2,300	1,380	1,610	1,840	2,070	2,300	2,530	2,760	2,990	3,220	3,450	3,680	3,910	4,140
2,350	1,410	1,645	1,880	2,115	2,350	2,585	2,820	3,055	3,290	3,525	3,760	3,995	4,230
2,400	1,440	1,680	1,920	2,160	2,400	2,640	2,880	3,120	3,360	3,600	3,840	4,080	4,320
2,500	1,500	1,750	2,000	2,250	2,500	2,750	3,000	3,250	3,500	3,750	4,000	4,250	4,500
2,600	1,560	1,820	2,080	2,340	2,600	2,860	3,120	3,380	3,640	3,900	4,160	4,420	4,680

[a] **Additional limitations:**
If the panel is fitted at less than all four corners, the unsupported width at the top may exceed the following:

Glass thickness	Fixed panel	Panel supporting door
For 6 mm glass:	n/a	n/a
For 8 mm glass:	400 mm	200mm
For 10 mm glass:	500 mm	250mm
For 12 mm glass:	600 mm	300mm

3.7 REFERENCE LITERATURE

- SANS 10160: Basis of Structural Design and Actions for Buildings and Industrial Structures: Part 1: Basis of Structural Design
- SANS 10160: Basis of Structural Design and Actions for Buildings and Industrial Structures: Part 2: Self-weight and imposed loads
- SANS 10160: Basis of Structural Design and Actions for Buildings and Industrial Structures: Part 3: Wind Actions
- SANS 10137: The installation of glazing in buildings
- SANS 1263-1: Safety and Security glazing materials for buildings – Human Impact
- SANS 1263-2: Safety and Security glazing materials for buildings – Burglar/Vandal resistance
- SANS 1263-3: Safety and Security glazing materials for buildings – Bullet resistance
- SANS 17: Glass & Plastics in Furniture
- SANS 204: Energy Efficiency in Buildings
- SANS 680: Glazing putty for wooden and metal window frames
- SANS 1817: Work on glass
- SANS 50572-1: Glazing in Building – Definitions
- SANS 50572-2: Glazing in Building – Float Glass
- SANS 50572-3: Glazing in Building – Polished wire glass
- SANS 50572-4: Glazing in Building – Drawn sheet glass
- SANS 50572-5: Glazing in Building – Pattered glass
- SANS 10400: The application of the National Building Regulations

  Part A: General principles and requirements
  Part B: Structural Design
  Part N: Glazing
  Part T: Fire Protection
  Part XA: Energy usage in buildings

- SANS 613: Fenestration products – Mechanical performance criteria
- SANS 549: Shower Enclosures for domestic purposes
- SANS 1545: Safety rules for the construction and installation of lifts
- AAAMSA Selection Guide for Plastic Glazing Materials
- Selection Guide for glazed architectural Products – September 2011 - AAAMSA
- Structural use of glass in buildings – The Institute of Structural Engineers
- BS6206: Impact performance requirements for flat safety glass and safety plastics for use in buildings
- BS6262: Glazing for Buildings
- Australian Standard AS1288: Glass in Buildings
- American Standard ASTM E1300: Glass in Buildings
- Glass Structures – Ian Wurm
- Structural Engineer's Pocket Book
- Glass in Building – David Button/Brian Pye
- Window Systems for high-performance Buildings – John Carmody et.al.