NZS 4223.1:2008

Incorporating Amendment No. 1

New Zealand Standard

Glazing in buildings

Part 1: Glass selection and glazing

Superseding NZS 4223:Part 1:1985

NZS 4223.1:2008

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COMMITTEE REPRESENTATION

This Standard was prepared under the supervision of the P4223 Committee for the Standards Council established under the Standards Act 1988.

The committee consisted of representatives of the following nominating organisations:

Building Research Association of New Zealand Limited
Department of Building and Housing
Glass Association of New Zealand
Institution of Professional Engineers New Zealand
New Zealand Safety Glass Association
Window Association of New Zealand

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AMENDMENTS

No.	*Date of issue*	*Description*	*Entered by, and date*
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REFERENCED DOCUMENTS

Reference is made in this document to the following:

New Zealand standards

NZS 1170	Structural design actions	
Part 5:2004	Earthquake actions – New Zealand Standard	
NZS 3504:1979	Specification for aluminium windows	
NZS 3619:1979	Specification for timber windows	
NZS 4211:2008	Specification for performance of windows	Amd 1 Feb '16
NZS 4223	Glazing in buildings	
Part 2:2016	Insulating glass units	Amd 1 Feb '16
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Part 4:2008	Wind, dead, snow, and live actions	
Supp 1:2008	Supplement 1 to NZS 4223.1:2008 and NZS 4223.4:2008	
NZS 4232	Performance criteria for fire resisting enclosures	
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Joint Australian/New Zealand standards

AS/NZS 1170	Structural design actions	
Part 0:2002	General principles	
Part 1:2002	Permanent, imposed and other actions	
Part 2:2002	Wind actions	
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AS/NZS 2208:1996	Safety glazing materials in buildings	
AS/NZS 4666:2012	Insulating glass units	Amd 1 Feb '16
AS/NZS 4667:2000	Quality requirements for cut-to-size and processed glass	
AS/NZS 4668:2000	Glossary of terms used in the glass and glazing industry	

Australian standards

AS 1288:2006	Glass in buildings – Selection and installation

American standards

ANSI Z97	Safety glazing materials used in buildings
Part 1:2004	Safety performance
ASTM C920:2005	Standard specification for elastomeric joint sealants
ASTM C1184:2005	Standard specification for structural silicone sealants
ASTM C1279:2005	Standard test method for non-destructive photoelastic measurement of edge and surface stresses in annealed, heat-strengthened, and fully tempered flat glass

ASTM C1281:2003	Standard specification for preformed tape sealants for glazing applications.
ASTM C1299:2003	Standard guide for use in selection of liquid-applied sealants
ASTM C1401:2014	Standard guide for structural sealant glazing

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British standards

BS 544:1969	Specification for linseed oil putty for use in wooden frames
BS 952	Glass for glazing
Part 1:1995	Classification
BS 6262	Glazing for buildings
Part 1:2005	General methodology for the selection of glazing
BS EN 1863-1:2011	Glass in building. Heat strengthened soda lime silicate glass. Definition and description
BS EN 12150-1:2015	Glass in building. Thermally toughened soda lime silicate safety glass. Definition and description
BS EN 12600:2002	Glass in building. Pendulum test. Impact test method and classification for flat glass
BS EN 14179-1:2005	Glass in building. Heat-soaked thermally toughened soda lime silicate safety glass. Definition and description
BS EN 14449:2005	Glass in building. Laminated glass and laminated safety glass. Evaluation of conformity/product standard

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Other documents

American Architectural Manufacturers Association (AAMA) *Voluntary specifications and test methods for sealants – Specification 810.1. 2005*. Retrieved from www.aamanet.org

BRANZ Study Report No. 17. *The development of a procedure and rig for testing the racking resistance of curtain wall glazing.* Wright, P.D. 1989.

BRANZ Study Report No. 39. *The behaviour of external glazing systems under seismic racking*; King A.B. and Lim, K.Y.S. 1991.

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Department of Building and Housing New Zealand Building Code and compliance documents

Nethercot, D.A. and Rockney, K.C. *'Unified approach to the elastic lateral buckling of beams.'* The Structural Engineer, Vol. 49, No. 7 (July 1971): pp. 321–30
(For erratum, see Vol. 52, No. 4 (April 1973): pp. 138–9)

Window Association of New Zealand (WANZ). *Glazing seals, including wedges, backing seals, and gaskets – Specification 170103;* 2012. Retrieved from www.wanz.org.nz

Window Association of New Zealand (WANZ). *Material specifications for glazing blocks – Specification 140307;* 2013. Retrieved from www.wanz.org.nz

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LATEST REVISIONS

The users of this Standard should ensure that their copies of the above-mentioned New Zealand Standards are the latest revisions. Amendments to referenced New Zealand and Joint Australian/New Zealand Standards can be found on www.standards.co.nz.

FOREWORD

NZS 4223 applies to glazing in buildings.

The Standard comprises four parts:

- Part 1:2008 – Glass selection and glazing;
- Part 2:2016 – Insulating glass units;
- Part 3:2016 – Human impact safety requirements;
- Part 4:2008 – Wind, dead, snow, and live actions.

This Standard applies to glazing in all buildings and applications other than those excluded in the scope.

This Standard, including Amendment No. 1, provides general guidance for designers and specifiers for glass selection and glazing in buildings.

Amd 1 Feb '16

These parts have been amended and revised to update the Standard and allow for New Zealand-specific considerations.

REVIEW OF STANDARDS

Suggestions for improvements of this Standard will be welcomed. They should be sent to the Chief Executive, Standards New Zealand, Private Bag 2439, Wellington 6140.

New Zealand Standard

Glazing in buildings

Part 1 – Glass selection and glazing

1 SCOPE AND GENERAL

1.1 Scope

NZS 4223.1 provides design criteria, guidance for specific design and procedures for glass selection, and glazing in buildings.

The following are excluded from the scope of NZS 4223 Parts 1, 2, 3, and 4:

(a) Glazing in lift cars and liftwells (see Appendix A for guidance);

(b) Furniture glass, cabinet glass, vanities, glass basins, refrigeration units, internal glass fitments and glass wall linings, framed internal wall mirrors, and mirrors not specifically covered by these parts;

(c) Buildings and structures with no public access intended for non-habitable building structures for horticultural or agricultural use;

(d) Restoration or repairs to existing decorated glass;

(e) Glazing applications that might fail due to stresses other than tensile stresses, such as glass floors;

(f) Plastic glazing materials;

(g) The construction and installation of windows (refer to NZS 3504, NZS 3619, and NZS 4232.2);

(h) Glass blocks, pavers, slumped, formed, or cast glass;

(i) Point-fixed or point-supported systems, used for glazing, cladding, signage, and the like, not specifically covered by these parts. Amd 1 Feb '16

1.2 Application

The type and thickness of glass required shall be determined on the basis of all the following criteria:

(a) For installations subject to wind loading, glass shall be selected using either first principles as set out in this Part, or using the simplified design as set out in NZS 4223.4;

(b) For human impact considerations, glass shall be selected according to NZS 4223.3;

(c) For sloped overhead glazing, glass shall be selected according to NZS 4223.4;

(d) For balustrades, glass shall be selected according to NZS 4223.3;

(e) For framed, unframed, and partly framed glass assemblies in buildings up to 10 m high, glass shall be selected in accordance with Section 5 of this part;

(f) Insulating glass units shall also be in accordance with NZS 4223.2.

The type and thickness of glass selected shall be in accordance with the most stringent requirements of the relevant Part of NZS 4223.

Amd 1 Feb '16

1.3 Compliance with NZBC

NZS 4223.1 is intended to provide a means of compliance with the New Zealand Building Code by citation in Acceptable Solution B1/AS1.

Amd 1 Feb '16

1.5 Interpretation

For the purposes of this Standard the word 'shall' identifies a mandatory requirement for compliance with the Standard. The word 'should' refers to practices which are advised or recommended.

The term 'Informative' has been used in this Standard to define the application of the Appendix to which it applies. An 'Informative' Appendix is only for information and guidance and does not form part of the mandatory requirements of the Standard.

Notes to the text contain information and guidance and are not considered to be an integral part of this Standard.

Statements expressed in mandatory terms in notes to figures and tables are deemed to be requirements of this Standard.

Amd 1 Feb '16

1.6 Definitions

For the purposes of this Standard the following definitions apply. Refer to AS/NZS 4668 for additional definitions. See also Figure 1.

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Area — The area of the panel between sightlines after glazing, calculated using the sight size.

Bead — A strip of wood, metal, sealant or other suitable material secured to the rebate to retain the glass. Also known as glazing bead or sealant bead.

Bite — The width of silicone used to bond the fin or frame member to the edge of the glass panel.

Block — A small piece of lead, rubber or other suitable material used to position the glass in the frame.

Decorated glass — Clear or pattened glass processed by craftsmen for decorative effect. Stained glass, leadlights and sandblasted, acid etched, embossed and printed glass fall into this category. Decorative interlayers may also be incorporated in laminated glass.

Distance piece — Small blocks of resilient, non-absorbent material (such as extruded rubber) used to prevent the displacement of glazing compound or sealant by external loading, such as wind pressure. They are positioned opposite each other between the glass and rebate, and glass and bead.

Door — A hinged, sliding, or otherwise supported openable barrier providing entrance to and exit from a building, corridor, or room. Doors may be framed or unframed.

Fin — A piece of glass positioned and fastened to provide lateral support.

Frame — A structure manufactured from timber, metal, glass, or other durable material or combinations of materials, such as glass fins and structural sealant, supporting the full length of a glazed panel edge.

Glazing

1. The installation of glass in prepared openings in windows, door panels, partitions, and the like.
2. Glass or plastics glazing sheet material for installation into a building.

Limit states — States beyond which the structure no longer satisfies the design criteria.

Serviceability limit states (SLS) — States that correspond to conditions beyond which specified service criteria for a structure or structural element are no longer met. The criteria are based on the intended use and may include limits on deformation, vibratory response, degradation or other physical aspects.

Ultimate limit states (ULS) — States associated with collapse, or with other similar forms of structural failure. This generally corresponds to the maximum load-carrying resistance of a structure or structural element but, in some cases, to the maximum applicable strain or deformation.

Location block — A block of resilient non-absorbent material used between the edges of the glass and the frame, other than the bottom, to prevent movement of the glass within the frame by thermal expansion or when the window or door is opened or closed. They are sometimes required to prevent the weight of the glass causing the frame to become out of square.

Minimum thickness — The thickness of a pane of glass at the minimum thickness tolerance. Amd 1 Feb '16

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Nominal thickness — The commonly used dimension by which the thickness of a pane of glass is generally described.

NOTE – The actual thickness of particular panes of glass may not coincide with the nominal thickness.

Pane — A single piece of glass cut to size for glazing.

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Panel — An assembly containing one or more panes.

NOTE –

1. Panels may be fully framed, partly framed or fully unframed (frameless).
2. Panels beside a door are 'side panels' and are sometimes known as sidelights or sidelites.

Rebate — The part of a frame into which the edge of glass is installed.

Setting block — A block of resilient non-absorbent material used to support the dead load of the glass on the rebate platform and prevent glass to frame contact. Setting blocks are normally used in pairs and located at the quarter points of the glass width.

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Span — The dimension between supports. For panels supported on all four edges, it corresponds to the smaller of the sight size dimensions. For panels supported on two opposite edges only, it is the sight size dimension between supports.

Structural silicone glazing — The use of silicone sealant not only as a weather seal but also for the structural transfer of loads from the glazing panel to its perimeter support system.

2 MATERIALS

2.1 Glass

2.1.1 General

The following glass types shall be classified in accordance with AS/NZS 4667. The glass types include:

(a) Clear ordinary annealed glass;

(b) Tinted heat-absorbing glass;

(c) Patterned annealed glass;

(d) Wired glass;

(e) Laminated glass; and

(f) Toughened glass.

Glass types not otherwise specified in AS/NZS 4667, AS/NZS 4668 or this Standard, which are used in buildings, shall be classified in accordance with BS 952.1.

2.1.2 Heat-strengthened glass

Glass that has been strengthened by a special heat treatment, so that the residual stresses lie between those of ordinary annealed glass and toughened glass.

When tested in accordance with ASTM C1279, heat-strengthened glass shall have a surface compression of 24 MPa – 52 MPa.

NOTE – Heat-strengthened glass with surface compressive stress between 52 MPa and 69 MPa can lead to an increased risk of spontaneous glass fracture (associated with material impurities).

Alternatively heat-strengthened glass shall comply with BS EN 1863-1. Amd 1 Feb '16

2.1.3 Safety glazing material

Safety glazing materials (such as toughened and laminated glass) shall comply with AS/NZS 2208, or ANSI Z97.1, or BS EN 12150-1, or BS EN 14449. Amd 1 Feb '16

Safety organic coatings applied to glazing, shall extend to the edge of the glass or within 3 mm of the sightline and shall be permanently bonded to the glass.

2.1.4 Insulating glass units (IGU)

Insulating glass units shall comply with NZS 4223.2. Amd 1 Feb '16

2.1.5 Glass material properties

For the purpose of this Standard, whether the glass is annealed, heat-strengthened, or toughened, the glass material properties shall be based on reliable test data.

In the absence of test data the following material properties shall be used:

(a) Density = 2500 kg/m^3;

(b) Poisson's ratio = 0.22;

(c) Linear elastic modulus (E) = 70 GPa;

(d) Torsional elastic modulus (G) = 28.7 GPa. Amd 1 Feb '16

2.2 Other glazing materials

2.2.1 General

Glazing materials, not otherwise specified in this Standard, shall be in accordance with the relevant requirements of BS 6262.

2.2.2 Putty and glazing compound

Putty and glazing compound containing linseed oil shall comply with BS 544 or equivalent.

2.2.3 Elastomeric sealant

Elastomeric liquid applied sealants such as silicone, polysulphide, and polyurethane shall comply with ASTM C1299 and ASTM C920 or equivalent.

2.2.4 Structural silicone sealant

Structural silicone sealant shall comply with ASTM C920 and ASTM C1184 or equivalent.

2.2.5 Preformed tape sealants

Preformed tape sealants such as butyl tapes shall comply with ASTM C1281 or equivalent.

2.2.6 Preformed foam tape

Preformed foam tapes shall comply with AAMA 810.1 specification or equivalent.

2.2.7 Glazing seals

Glazing seals, including wedges, backing seals, and gaskets shall comply with WANZ Specification 170103 or equivalent.

2.2.8 Setting blocks, location blocks, and distance pieces

Setting blocks, location blocks, and distance pieces shall comply with WANZ Specification 140307 or equivalent and shall be:

(a) Of resilient, durable, load-bearing and non-absorbent materials;

(b) Compatible with all other materials that may come in contact with them;

(c) Of Shore-A hardness suitable for the application; and

(d) At least as durable as the glazing system.

NOTE – Refer to Section 4 for details on position, hardness, size and installation requirements.

2.2.9 Other glazing materials

Other glazing materials are not covered by this Standard.

3 DESIGN CRITERIA

3.1 General

Glazing shall satisfy the design requirements for ultimate and serviceability limit states in accordance with the procedures given in this Standard, as appropriate.

3.2 Design loads and actions

3.2.1 Design actions

The design of a structure for strength and serviceability limit states shall account for the action effects directly arising from the following:

(a) Permanent and imposed, live, wind, snow and earthquake actions specified in AS/NZS 1170.0, AS/NZS 1170.1, AS/NZS 1170.2, AS/NZS 1170.3 and NZS 1170.5.

(b) Other specific actions, as required.

3.2.2 Load combinations

The design load combinations for the strength and serviceability limit states shall be as specified in AS/NZS 1170.0.

3.3 Limit states

3.3.1 General

The glazing and its connections shall be designed for the strength limit states as follows:

(a) The loads and actions shall be determined in accordance with 3.2.1;

(b) The design action effect (S^*) resulting from the strength limit state design loads shall be determined by elastic structural analysis;

NOTE – Where membrane action will occur (for example, glass plates supported on all edges with deflections greater than 75 % of the plate thickness), geometric non-linear analysis is required to predict peak stress magnitude and location.

(c) The ultimate design capacity ($øR_u$) shall be determined from the nominal capacity (R_u) determined from 3.3.2, where the capacity reduction factor ($ø$) shall be taken as 0.67;

(d) The characteristic capacity in regions where the distance from any edge or opening is less than the thickness of the glass shall be taken to be the characteristic capacity of the glass at the edge (see 3.3.2);

(e) All members and connections shall be proportioned so that the ultimate design capacity ($øR_u$) is not less than the design action effect (S^*), i.e., $S^* \leq øR_u$.

3.3.2 Ultimate design capacity

The ultimate design capacity shall be calculated as follows:

Ultimate design capacity = $øR_u = øc_1c_2c_3[f'_t X]$

where

$ø$	=	capacity reduction factor
R_u	=	nominal capacity
	=	$c_1c_2c_3\ [f'_t X]$
c_1	=	glass type factor (see Table 1)
c_2	=	surface type factor (see Table 2)
c_3	=	load duration factor (see Table 3)
$f'_t X$	=	characteristic capacity
f'_t	=	characteristic tensile strength of the glass, in megapascals
	=	−9.85 ln(t) + 71.34 MPa away from the edge of glass panes
	or	
	=	−7.88 ln(t) + 57.07 MPa at the edge of glass panes (including at the edges of holes in glass panes)

where

ln = natural logarithm

t = minimum thickness of glass, in millimetres;

(for example, for 3 mm nominal thickness glass, having a minimum thickness of 2.8 mm then f'_t = 61.2 MPa away from the edge of glass panes and f'_t = 49.0 MPa at the edge of glass panes).

X = geometric factor (based on the size, shape and support conditions of the glass) that relates the characteristic capacity of the glazing to the characteristic strength of the glass; for example, for bending of two-edge supported glass

$$X = \frac{wt^2}{6}$$

where

w = width of the pane, in millimetres (at right angles to span)

t = minimum glass thickness, in millimetres.

NOTE – The geometric factors for the determination of the bending stresses in glass with different aspect ratios and edge support conditions may be found in engineering literature with formulas for stress and strains. In the preparation of the charts for determining glass thickness in NZS 4223.4, finite element analysis methods have been used and some variation from the required glass thickness in the charts may be found if the calculation is undertaken from first principles, described in the literature.

Table 1 – Glass type factor c_1

Glass type	c_1
Ordinary annealed	1.0
Heat-strengthened*	1.6
Toughened*	2.5
Wired	0.5

*The glass type factors for heat-strengthened and for toughened glass are based on the minimum stresses specified in Section 2. For higher induced stress, correspondingly higher glass type factors may be used provided the level of safety is not reduced. The glass type factor may be determined from: $c_1 = (f'_t + \text{minimum induced surface compression stress}) / f'_t$.

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Table 2 – Surface type factor c_2

Type	c_2
Untreated (flat or curved)	1.0
Sand-blasted	0.4
Acid etched	1.0
Patterned*	1.0

*Use actual minimum thickness of glass at the deepest trough of the pattern (refer to AS/NZS 4667).

Table 3 – Load duration factor c_3

Load duration	c_3
Short-term load duration[1] (wind) on all glass types	1.0
Medium-term load duration[2] (e.g. access imposed actions on roof lights and actions on balustrades) on heat strengthened and toughened glass (monolithic or laminated)	1.0
Medium-term load duration[2] (e.g. access imposed actions on roof lights and actions on balustrades) on annealed glass (monolithic or laminated)	0.72
Long-term load duration[3] (e.g. dead, some components of live) on heat strengthened and toughened glass (monolithic or laminated)	0.5
Long-term load duration[3] (e.g. hydrostatic) on laminated toughened glass	0.5
Long-term load duration[3] (e.g. dead, hydrostatic, some components of live) on annealed glass (monolithic or laminated)	0.31

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NOTE –

1. Short-term load duration is any duration ≤ 3 seconds.
2. Medium-term load duration is any duration > 3 seconds and ≤ 10 minutes.
3. Long-term load duration is any duration > 10 minutes.
4. Where the load duration (d seconds) is accurately known then the load duration factor c_3 can be determined for annealed glass using $c_3 = (3/d)^{(1/16)}$.

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3.3.3 Serviceability limit states

Glass shall be designed for the serviceability limit states by controlling or limiting deflection.

The maximum deflection for glass under serviceability limit state actions shall be limited to span / 60 for two, three or four edge supported panels.

Glass designed in accordance with NZS 4223.4 and other relevant sections of this Part, as appropriate, is deemed to comply with the requirements of this clause.

NOTE – More stringent deflection limits, such as 20 mm maximum are often applied to glass design so the glass deflection does not become visually disturbing.

3.4 Laminated glass and insulating glass units

3.4.1 Laminated glass

The following applies:

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(a) For short-term and medium-term load durations, the actual total minimum glass thickness, as specified in NZS 4223.4 or Table 4, shall be used.

NOTE – Table 4 is applicable for both symmetrical and non-symmetrical laminates.

(b) For medium or long-term load durations, the strength of each sheet shall be checked where the proportion of the total load to be resisted by each sheet is k_{sheet}, taken as the larger of the following:

$$k_{sheet} = \left[\frac{t^3{}_{sheet}}{\sum_i t_i^3} \right]$$

or

$$k_{sheet} = \left[\frac{t^2{}_{sheet}}{\sum_i t_i^2} \right]$$

where

k_{sheet} = load-sharing factor of sheet being checked

t_{sheet} = thickness of sheet being checked. Unless known, minimum glass thickness, as per 3.6, shall be used

t_i = thickness of each sheet of glass within the assembly. Unless known, minimum glass thickness, as per Section 3.6, shall be used

i = total number of sheets within the assembly.

NOTE – For laminated glass with two sheets of equal thickness, k_{sheet} = 0.5.

Alternatively, a full non-linear analysis, modelling the glass-interlayer sheets behaviour, may be undertaken.

Table 4 – Minimum glass thickness

Nominal thickness (mm)	Minimum thickness (mm)
Monolithic glass	
3	2.8
4	3.8
5	4.8
6	5.8
8	7.7
10	9.7
12	11.7
15	14.5
19	18.0
25	23.5
Laminated glass[1,2]	
5	4.6
6	5.6
8	7.6
10	9.6
12	11.6
16	15.4
20	19.4
24	23.4
Wired glass	
6	5

NOTE –

1. For laminated glass, the thickness of glass shown in the Table does not include the thickness of interlayer, e.g. 6 mm may apply to 6.38 mm, 6.76 mm or 7.52 mm, etc.
2. This table applies to symmetrical and non-symmetrical glass.

3.4.2 Insulating glass units (IGU)

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For insulating glass units subjected to wind pressures, each pane shall be checked individually for strength and deflection under ultimate and serviceability limit design wind pressures respectively. The pressures acting on each pane shall be determined by multiplying the design wind pressures by k_{pane}, calculated as follows:

$$k_{pane} = \frac{1.25t^3_{pane}}{\sum_i t_i^3} \leq 1$$

where

k_{pane}	=	load-sharing factor of pane being checked
t_{pane}	=	thickness of pane being checked (including laminated glass as per 3.4.1 and glass thickness as per Section 3.6 or Table 4)
t_i	=	thickness of each pane of glass within the assembly (see Section 3.6)
i	=	total number of panes within the assembly.

NOTE – For insulating glass units with two panes of equal thickness k_{pane} = 0.625. Therefore, for a 2 kPa design wind pressure (p_u) for the sheet = 2 kPa × 0.625 = 1.25 kPa.

3.5 Frames

3.5.1 Deflection limits

When completely assembled and glazed, allowance shall be made for the secondary design action effects due to deflection of the frame member supporting the edge of the glass.

NZS 4211 sets the deflection limits for frames under serviceability loading.

3.5.2 Panels glazed into the building structure

A panel glazed directly into a building structure by means of appropriate beads or fittings shall be considered to be framed, provided the assembly complies with the deflection requirements of 3.5.1.

NOTE – See Section 3.8 for seismic design criteria (racking).

3.5.3 Mixed framing

Glass supported along the top and bottom edges by one means and along the vertical edges by another means shall be considered to be framed provided each frame member of the assembly complies with the deflection requirements of 3.5.1.

3.6 Design thickness of glass

3.6.1 Glass of standard nominal thickness

Limits on the standard nominal thickness of various types of glass are given in AS/NZS 4667 and NZS 4223.4. The design calculations shall be based on the actual glass thickness or, if that is not known, the minimum thickness of the range for the standard nominal thickness. See Table 4.

3.6.2 Glass of non-standard nominal thickness

Glass shall be considered of a non-standard thickness if the glass is of types listed in AS/NZS 4667 and falls outside the ranges given in that Standard. For non-standard glass thicknesses, either:

(a) Use the next lowest standard thickness from Table 4; or

(b) Interpolate between nominal thicknesses either side of the non-standard glass thickness.

3.6.3 Maximum area for 3 mm annealed glass

The minimum nominal thickness of annealed glass shall be 3 mm.

For 3 mm annealed glass the area shall be not greater than:

(a) 0.5 m^2 for monolithic annealed glass; or

(b) 0.75 m^2 for annealed glass IGUs.

3.7 Structural silicone

3.7.1 General

Where the tensile adhesion of a sealant is the mechanism for fixing the glazing to its supports and where failure of the sealant will cause the glazing to become overstressed or fall out, structural silicone in accordance with 2.2.4 shall be used.

3.7.2 Ultimate limit state

The ultimate limit state design stress (except for silicone sealants immersed in water) shall be limited to a maximum of:

(a) 0.011 MPa (11 kPa) for dead and live long-term loads; or

(b) 0.210 MPa (210 kPa) for ultimate limit state wind loads only.

NOTE –

1. For a structural silicone design example, see Appendix B.

2. The above values may not apply to structural silicones immersed in water. Refer to the manufacturers' specifications.

3.7.3 Serviceability limit state

Structural silicone movements under all loads shall be limited so that:

(a) Glazing is not displaced from setting blocks; and

(b) For butt glazing with glass fins, the combined joint and fin movement shall meet the deflection limit requirements of 3.5.1.

NOTE – For a structural silicone design example, see Appendix B.

3.8 Building movement

3.8.1 General

The building design movements and distortions, such as lateral building deflection, inter-storey drift, racking, vertical deflections of structural elements, shrinkage, and creep, shall be considered for the glazing and glazing system.

3.8.2 Glazing

All framed, partly framed or unframed (frameless) glazing shall comply with Section 3.

3.8.3 Design actions

3.8.3.1 Serviceability limit state

Under serviceability limit state (SLS) actions glass shall not be subject to in-plane forces and deformations.

3.8.3.2 Ultimate limit state

Where glass may be subjected to in-plane forces and deformations under ULS (ultimate limit state) racking actions (typically seismic) and, if broken, people in the vicinity may be endangered (see note 1) then one or more of the following shall be adopted:

(a) Use laminated safety glass (annealed, heat-strengthened, or toughened laminated safety glass) that is prevented from disengaging from its perimeter frame when broken (see note 2);

(b) Use monolithic toughened safety glass, provided the glass is no more than 5 m above the walking surface;

(c) Use specific design to:

(i) Demonstrate by design or testing that the glass is separated from the frame (see note 3) or building such that the ULS building deformations are not resisted by the glass or

(ii) Design the glass and frame systems to resist ULS actions without failure.

NOTE –

1. Examples of situations where people may be endangered by breaking glass are:

   (a) Glass in the exterior wall of a building that can fall on to occupied interior or exterior spaces;

   (b) Glass (vertical and sloped) above and within 2000 mm either side of internal or external exit routes in a building.

2. Glass can be captured mechanically in a frame system pocket with adequate edge cover, or with structural silicone sealant at the perimeter, or with other proprietary anchorage systems or fittings to ensure restraint of the fractured pane. If used, structural silicone sealant can have 6 mm minimum glueline and bite.

Amd 1
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3. Separation from the surrounding structure may be as follows:

   $\Delta_{fallout} \geq 1.25D_P$

   $\Delta_{fallout}$ = relative seismic displacement (drift) causing glass fallout from the curtain wall, storefront, or partition, as determined in accordance with an approved engineering analysis method

   D_P = relative seismic displacement that the component should be designed to accommodate

4. For IGUs consider both the outer and inner pane separately, the internal finished floor level may be considered as the walking surface in (b).

The 1.25 factor is applied to reflect the uncertainties associated with calculated inelastic seismic displacements in building structures. For more information refer to BRANZ Study Report No.17 and BRANZ Study Report No. 39.

3.9 Selection of glass for minimising the risk due to glass spontaneous fracture

The use of toughened glass and some heat-treated glasses involve a relatively small risk of breakage resulting from nickel sulphide or other inclusions. There are no specific requirements for minimising spontaneous fracture in this Standard. Guidance on glass selection to minimise the risk is given in Appendix E. Amd 1 Feb '16

4 GLAZING

4.1 Scope

This section sets out basic glazing requirements for single glass.

Amd 1 Feb '16 For insulating glass units, refer to NZS 4223.2.

NOTE –

1. This section does not preclude the use of other methods or systems for the glazing of glass, provided the alternate method or system can be demonstrated to satisfy the requirements for correctly supporting the glass within the frame, or glazing system. However, other methods or systems for the glazing of glass are outside the scope of this Standard.
2. Patent and other proprietary systems are not described in this section and are outside the scope of this Standard.
3. Amd 1 Feb '16 The glazing of insulating glass units is not covered in this section (refer to NZS 4223.2).

4.2 Damage of glass

The edges and surfaces of all glass types shall not be damaged.

4.3 Dimensional requirements

4.3.1 General

The dimensions for edge clearance, edge cover, and front and back clearance, as defined in Figure 1, shall be not less than the values given in Table 5 for different thicknesses of glazing materials.

4.3.2 Front putty width

The front putty width shall be not less than 10 mm for panels up to 1 m^2, and not less than 12 mm for panels between 1 m^2 and 2 m^2.

4.3.3 Dimensions of rebates and grooves

Dimensions of rebates and grooves shall accommodate the requirements of Table 5 and allow for the appropriate setting and location blocks and distance pieces as illustrated in Figure 2 to Figure 5.

4.3.4 Glass dimensional tolerance

The glass dimensional tolerance shall meet the requirements of AS/NZS 4667.

Figure 1 – Sizes and rebates

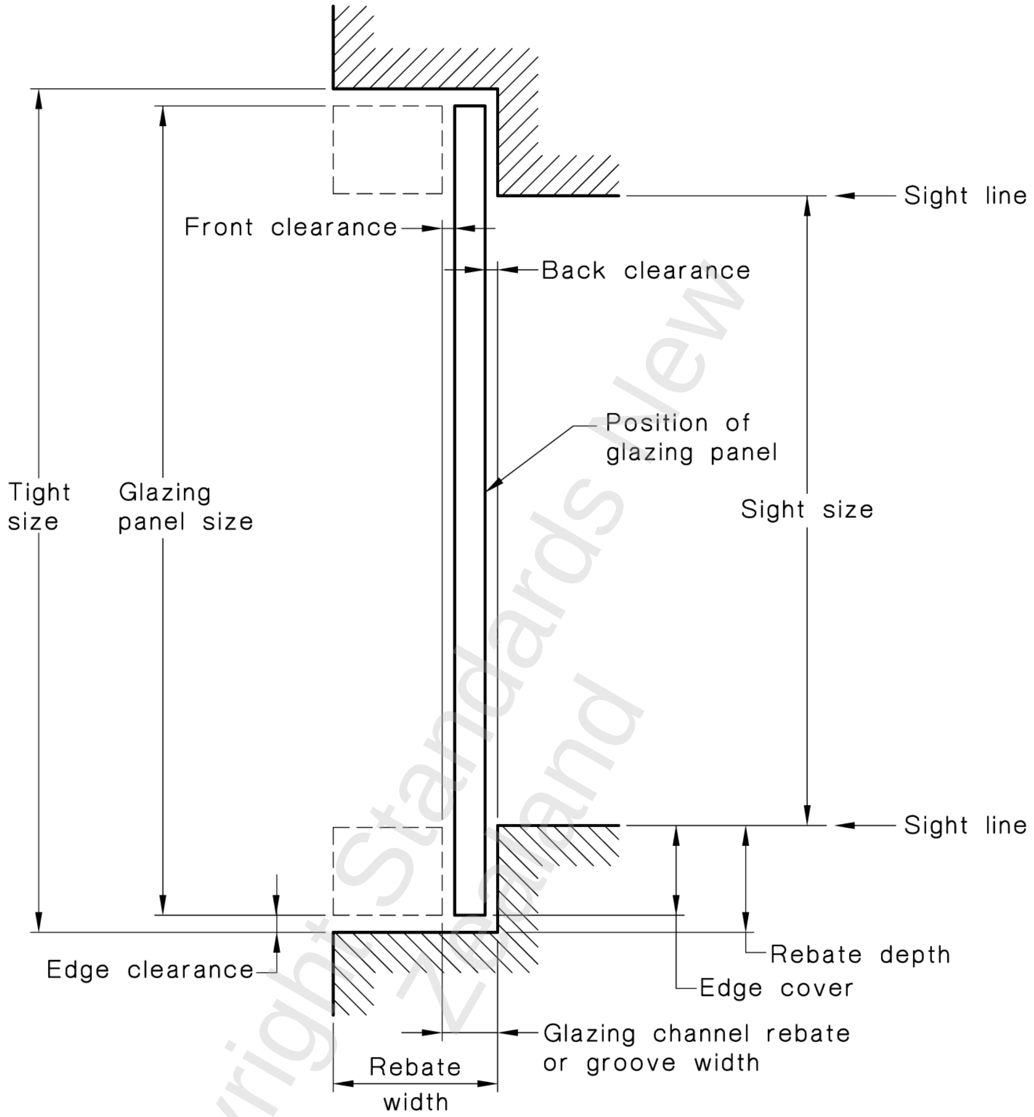


Table 5 – Minimum glazing dimensions for glazing materials

Nominal thickness	Front and back clearance			Edge clearance	Edge cover	Rebate depth
	Type (a)[1]	Type (b)[2]	Type (c)[3]			
(millimetres)						
3 (≤ 0.1 m^2)	2	–	–	2	4	6
3 (> 0.1 m^2)	2	–	–	2	6	8
3	–	2	1	3	6	9
4	2	–	–	2	6	8
4	–	2	1	3	6	9
5	2	2	2	4	6	10
6	2	2	2	4	6	10
8	–	3	2	5	8	13
10	–	3	2	5	8	13
12	–	3	2	6	9	15
15	–	5	4	8	10	18
19	–	5	4	10	12	22
25	–	5	4	10	15	25

NOTE –

1. Type (a) applies to putties or glazing compounds containing linseed oil.
2. Type (b) applies to elastomeric sealants and preformed strip materials.
3. Type (c) applies to glazing seals held in position by pressure.
4. The dimensions are the minimum necessary for the structural integrity of the glass only but do not apply to insulating glass units (refer to AS/NZS 4666).
5. For non-standard glass thicknesses the nearest values of nominal thickness shall be used.
6. Timber and PVC frames may not require the specified front and back clearances provided the waterproofing performance requirements are met.

4.4 Glazing materials

4.4.1 Suitability of materials

A glazing material shall be used only for the purposes recommended by the manufacturer.

4.4.2 Compatibility of materials

A glazing material shall be used only where compatible with contiguous materials, including the rebate surface finish, setting or location blocks, distance pieces and glass type.

4.4.3 Application of materials

The application of glazing materials shall be in accordance with the manufacturer's instructions.

4.4.4 Life expectancy of materials

A glazing material shall only be used where its life expectancy (durability) has been established.

NOTE –

1. The manufacturer's advice should be sought for information regarding life expectancy.
2. For durability requirements, refer to the New Zealand Building Code Clause B2.

4.5 Setting blocks

The position of setting blocks shall be as shown in Figure 2 and Figure 3. Generally, all setting blocks shall be:

(a) Positioned at quarter points or not less than 30 mm from the corner, whichever is less;

(b) The minimum width of each setting block shall be not less than the glass thickness; and

(c) The minimum thickness of the setting block for drained glazing systems shall be 6 mm.

Setting blocks shall be located to equally support all panes of glass.

Setting blocks shall be of resilient, load-bearing, non-absorbent, rot-proof, material that is compatible with all other glazing materials that may come into contact with the blocks.

The minimum length of each setting block (or blocks side by side) shall be 25 mm in length for every square metre of glass area.

Example:

For a 3.2 m^2 glass area, 3.2 × 25 mm = 80 mm long, i.e. 80 mm for each setting block.

NOTE –

1. Setting blocks are used between the bottom edge of the glass and the frame to centralise and equally support the glass.
2. Setting block width and location should not restrict water drainage.
3. Extruded material with 80 – 90 Shore-A hardness is recommended.
4. Shaped setting blocks will be required for a sloped glazing platform.

Figure 2 – Position of setting blocks

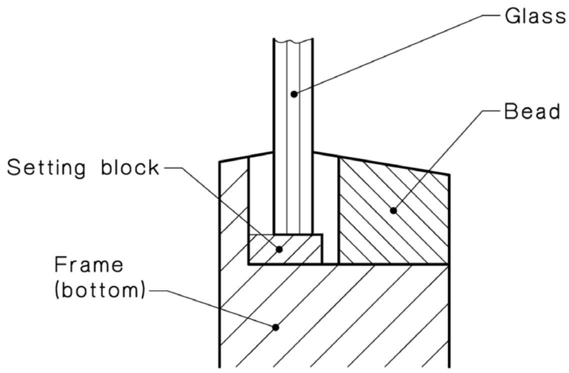
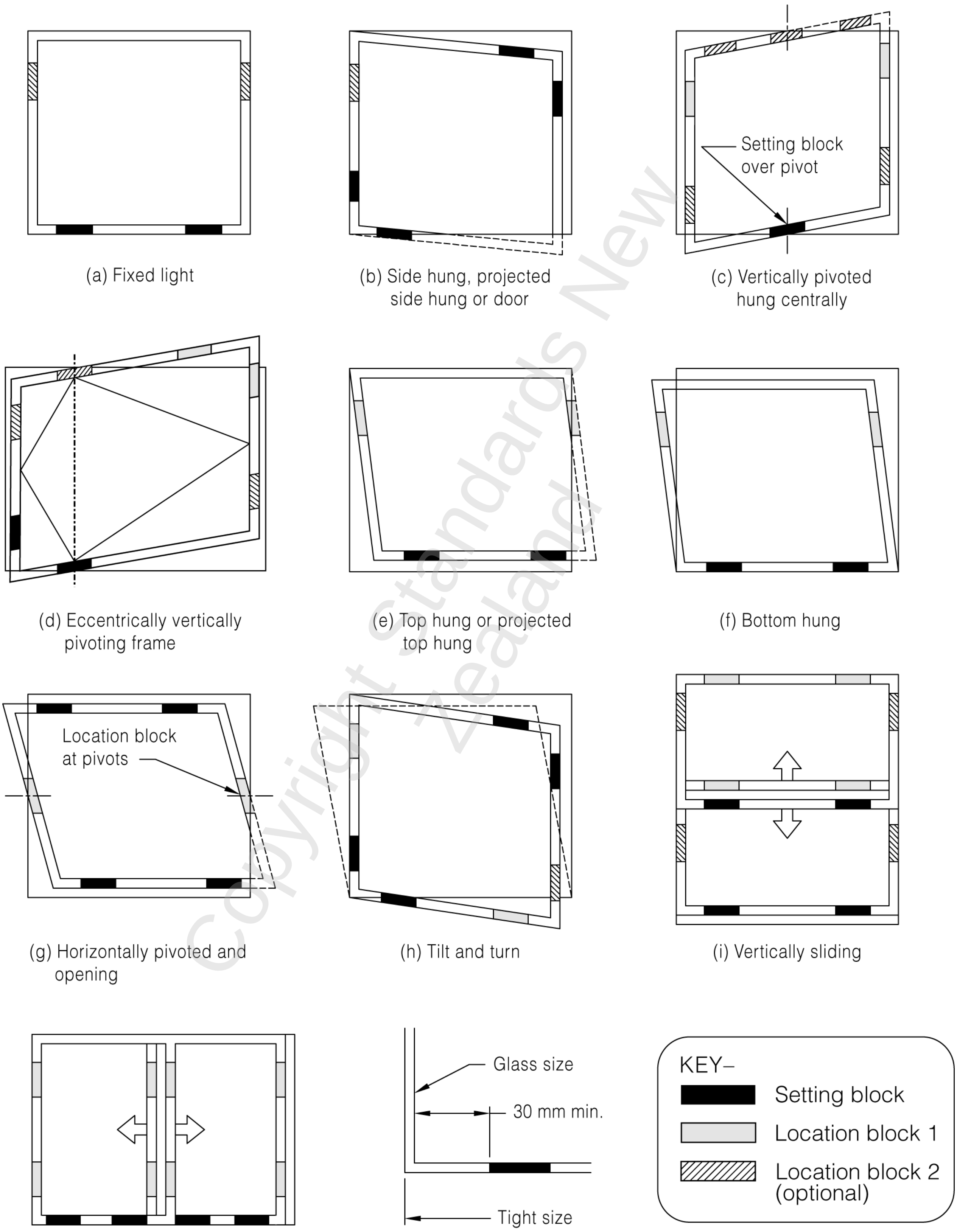


Figure 3 – Recommended positions of setting and location blocks for the glazing of typical doors and windows



(a) Fixed light
(b) Side hung, projected side hung or door
(c) Vertically pivoted hung centrally
(d) Eccentrically vertically pivoting frame
(e) Top hung or projected top hung
(f) Bottom hung
(g) Horizontally pivoted and opening
(h) Tilt and turn
(i) Vertically sliding
(j) Horizontal sliding
(k) Minimum positions of blocks

4.6 Location blocks

The position of location blocks shall be as shown in Figure 3 and Figure 4. Location blocks shall be:

(a) A minimum of 25 mm long;

(b) At least as wide as the glass thickness;

(c) Positively located to prevent displacement in service; and

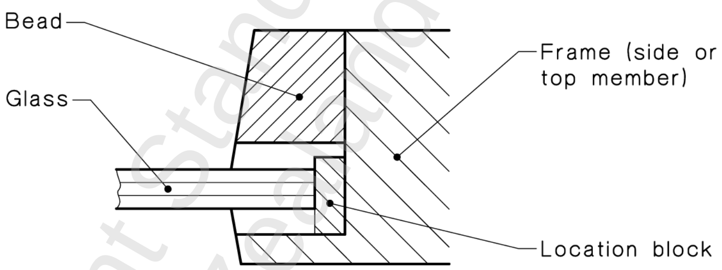
(d) Sufficiently resilient to accommodate movement within the frame, without imposing stress on the glass, and of resilient, non-absorbent material.

NOTE –

1. Location blocks are used between the edges of the glass and the frame to prevent movement of the glass within the frame by thermal expansion or when the window or door is opened or closed. They are required to prevent the weight of the glass from causing the frame to become out of square.

2. Extruded material with 55 – 75 Shore-A hardness is recommended.

Figure 4 – Position of location blocks



4.7 Distance pieces

Distance pieces, as shown in Figure 5, where required, shall be:

(a) Of resilient, non-absorbent material;

(b) 25 mm long and of a height to suit the depth of the rebate and the method of glazing; and

(c) Spaced opposite each other, approximately 50 mm from each corner at intervals of not more than 300 mm.

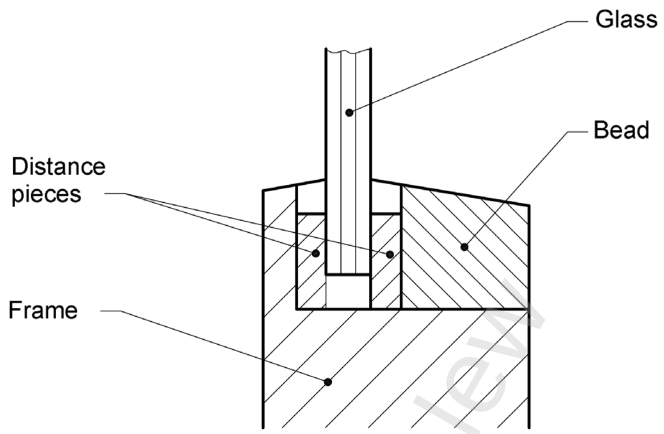
The thickness shall be equal to the front and back clearance, to retain the glass firmly in the frame.

NOTE –

1. Distance pieces are required to prevent displacement of glazing compounds or sealant by external loading, such as wind pressure.

2. Extruded material with 55 – 75 Shore-A hardness is recommended.

Figure 5 – Position of distance pieces



4.8 Preparation of rebates and grooves

Rebates, grooves and beads shall be cleaned and free from grease, moisture and other contaminants. All sealant surfaces shall be primed or sealed in accordance with the recommendations of the manufacturer of the glazing material.

The position of setting blocks, distance pieces and location blocks shall be as shown in Figure 3, Figure 4 and Figure 5 wherever necessary to maintain the requisite edge clearance. Each block shall support the full thickness of the glass.

4.9 Glazing beads

Where used, glazing beads shall provide the correct edge cover and shall be designed and fixed so they are capable of restraining the glass under all design actions.

4.10 Structural sealants

Structural sealants such as silicone shall be installed such that a full adhesive bond to the substrate is achieved. This may require cleaning and or priming of the substrate prior to silicone application.

Applied structural sealants shall not be installed adjacent to other materials that may be chemically incompatible with the structural sealant and cause a loss of adhesion or adverse chemical changes within the sealant that could lead to a loss of strength in the structural bond.

NOTE – For further guidance on installation of structural silicone, see Appendix B.

5 FRAMED, UNFRAMED, AND PARTLY FRAMED GLASS ASSEMBLIES

5.1 General

This section sets out requirements for framed, unframed, and partly framed glass assemblies that require a different installation technique to ordinary framed panels. The structural integrity of these assemblies depends upon interaction between the glass panels, the linking and supporting components and the surrounding supports. The types of assemblies covered by this section are:

(a) Faceted glazing;

(b) Fin-supported glazing; and

(c) Unframed toughened glass assemblies.

Where structural silicone is required, as specified in Section 5.3, and Section 5.4, the selection and application shall be in accordance with Section 5.2.

NOTE – This section covers only the tensile stresses in glasses.

5.2 Structural silicone glazing

5.2.1 General

Structural silicone shall be applied to adhere to both surfaces of the panels to be bonded together.

5.2.2 Selection

The structural silicone used shall be selected to ensure its design strength is in accordance with Section 3 of this Standard and that it is compatible with the glass to which it is to be applied.

5.2.3 Cleaning

Thorough and effective cleaning of the glass edge and surfaces shall be carried out before the application of silicone is commenced.

5.2.4 Bite design

The silicone bite thickness to support wind actions shall be calculated using the following formula:

$$\text{Bite thickness} = \frac{0.5 \times \text{short span length (mm)} \times \text{ultimate limit state wind pressure}}{\text{Silicone minimum tensile strength (kPa)}}$$

NOTE – An example is given in Appendix B.

In some applications the joint may be subject to tension and shear loading from dead loads and other actions, and the bite and joint thickness (glueline) may need to be designed to accommodate these loads. Calculation methods are available for these loading conditions from the silicone manufacturer and depend on the movement capacity of the sealant.

5.2.5 Application

The silicone application shall be capable of providing a silicone joint that is able to carry the loads imposed by the structural glazing.

5.2.6 Silicone curing

The glass shall be appropriately supported until the silicone has cured.

5.3 Faceted glazing

5.3.1 General

This clause provides the requirements for the selection and installation of faceted glazing. This clause applies to vertical glass only. All panels shall be of equal width. For unequal width panels, first principle design methods shall be used. Structural silicone shall be used.

NOTE –

1. The structural strength of the glass and the silicone that is used to bond the adjacent panels in the vertical plane are critical elements in this type of application. Consequently, the design analysis for glass selection requires consideration of the structural adequacy of the silicone used in this application.
2. The silicone acts as both a structural bond and a weather seal. External applications are subject to both positive and negative wind pressures and the glazing assembly performs differently when subjected to each of these pressure types.

5.3.2 Glass and silicone selection

The glass type (whether annealed, toughened or laminated safety glass, or heat-strengthened glass) shall be selected in accordance with all the relevant requirements of this Standard, as appropriate to the location of the assembly and application.

The required glass thickness for a given panel type, height and included angle may be determined from one of the methods given in 5.3.3, or using first principle design methods, or using the faceted glazing design table from NZS 4223.3.

A high or medium modulus structural silicone with a minimum tensile strength of 0.210 MPa shall be used.

5.3.3 Design of faceted panels

5.3.3.1 *Included angles between 90° to 160°*

Panels at an included angle γ from 90° to 160° inclusive shall be designed as four-edge supported panels in accordance with Section 4 of this Part. The minimum structural silicone bite thickness shall be determined using the following formula:

$$t = (F \times B \times p_z) / \sigma^s$$

where

F	=	factor for facet angle
	=	$\dfrac{1}{[2\cos(\gamma/2)]}$
γ	=	included angle between adjacent panels in degrees
B	=	width of each panel, in metres (distance between vertical silicone joints)
p_z	=	ultimate limit state design wind pressure, in kPa
σ_s	=	minimum tensile strength in silicone, 0.21 MPa
t	=	minimum required bite thickness of silicone, in millimetres (see Figure 6).

The calculated bite thickness is the minimum thickness of the silicone joint. The next minimum glass thickness available to accommodate the calculated bite thickness of silicone shall be used.

The silicone bite thickness for faceted panels is shown in Figure 6. The depth of the joint (glue line) shall be a minimum of 6 mm.

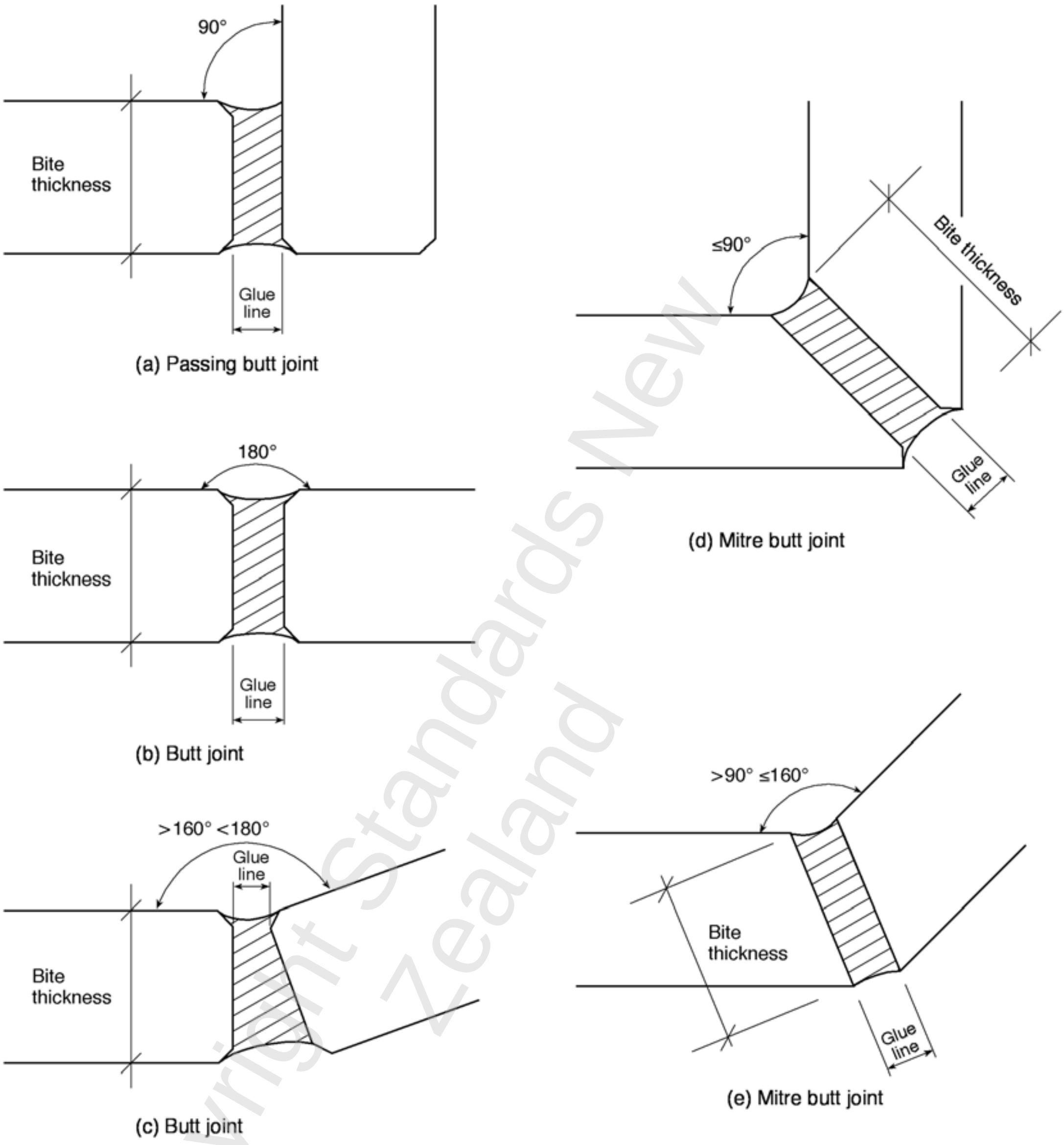
NOTE –

1. For example, if a bite thickness for silicone is calculated to be 7.2 mm then the next available glass thickness of 8 mm (minimum thickness = 7.8 mm) will have to be selected.
2. Table 6 gives an example of faceted glazing for a 135° included angle. Silicone bites less than 6 mm have been marked as 6 mm as this is the minimum nominal thickness generally used for faceted glazing. Silicone bites in excess of 23 mm have been marked 'N/A' as thicker glass is not generally used in faceted glazing.

The glass panel thickness shall be determined for the design wind load as a four-edge supported panel (see Section 4). It shall also comply with the requirements of NZS 4223.3.

The maximum glass thickness obtained from these methods shall be used.

Figure 6 – Silicone bite thicknesses



5.3.3.2 *Included angles greater than 160° and up to 180°*

For panels having an included angle γ greater than 160° and up to 180°, a fin shall be used on each vertical silicone joint, unless the glass panels are designed to resist the required loads with unsupported vertical edges. The fins shall be designed using the methods provided in Section 5.4. Alternatively first principle design methods shall be used.

NOTE – Tables for faceted glazing having other included angles are given in NZS 4223 Supplement 1.

Table 6 – Minimum silicone bite requirement (mm) for faceted glazing having 135° included angle

ULS wind pressure (kPa)	**Panel width** (mm)							
	300	**400**	**500**	**600**	**700**	**800**	**900**	**1000**
0.6	6	6	6	6	6	6	6	6
0.8	6	6	6	6	6	6	6	6
1.0	6	6	6	6	6	6	6	7
1.2	6	6	6	6	6	6	7	8
1.4	6	6	6	6	7	7	8	9
1.6	6	6	6	6	7	8	9	10
1.8	6	6	6	7	8	9	11	12
2.0	6	6	7	8	9	10	12	13
2.2	6	6	7	9	10	11	13	14
2.4	6	6	8	9	11	12	14	15
2.6	6	7	9	10	12	13	15	17
2.8	6	7	9	11	13	14	16	18
3.0	6	8	10	12	14	15	17	19
3.2	6	8	10	12	14	16	18	20
3.4	7	9	11	13	15	17	20	22
3.6	7	9	12	14	16	18	21	23
3.8	8	10	12	15	17	19	22	N/A
4.0	8	10	13	15	18	20	23	N/A
4.2	8	11	14	16	19	21	N/A	N/A
4.4	9	11	14	17	20	22	N/A	N/A
4.6	9	12	15	18	21	23	N/A	N/A
4.8	9	12	15	18	21	N/A	N/A	N/A
5.0	10	13	16	19	22	N/A	N/A	N/A

5.4 Fin-supported glazing

5.4.1 General

This clause provides the design methods for fin-supported glazing, in which the two adjacent vertical edges of the glass façade panels are bonded to a glass fin (mullion) using structural silicone and the other two edges, the head and sill, are conventionally glazed. A glass fin replaces a frame or mullion and is assessed as to size and thickness and securely fixed or supported at the head and sill. The fins are adhered to the façade glass with structural silicone sealant to accommodate both positive and negative loads. Any loading applied to the glass façade is transferred to the fin and then to the top and bottom fin shoes by way of a reaction load.

NOTE –

1. Inadequate fin shoe supports are a common problem. The fin shoes have to be securely anchored to the structure, frame or both and support all the loads. This means the fin has to have capped ends and setting blocks at both ends to isolate the various loads from the metal frame. The critical design parameter is the minimum fin bearing length or edge cover of the fin.
2. The amount of silicone used to bond the fin is known as the 'bite'. The depth of the joint is known as the glue line and is normally a minimum of 6 mm.

This clause is only applicable to installations up to 5 m in height and where the façade panels are of equal width. For other installations, first principle design methods shall be used and are outside the scope of this Standard.

NOTE –

1. For the purpose of glass selection, the façade panels may be taken as being supported on all four edges when using the methods prescribed in 5.4.2. The type and thickness of glass used for the façade panels shall be selected in accordance with the other relevant sections of this Standard.
2. The frames supporting the head and sill shall also be designed in accordance with the relevant requirements of NZS 3504. The stability and robustness of the rebates shall be such that they are able to withstand the effects of wind and glass weight.
3. The selection of the thickness and width of the supporting annealed glass fins may be carried out using the equations in 5.4.2.1 and 5.4.2.2 or in accordance with Section 3. These equations are based on a minimum tensile strength of 0.210 MPa for the structural silicone.

5.4.2 Design method

5.4.2.1 *Determination of façade panel glass type and thickness*

The glass type and thickness shall be determined using the methods prescribed in Section 3, NZS 4223.3 or NZS 4223.4 of this Standard. The glass panels shall be considered as four-edge supported panels.

5.4.2.2 *Determination of minimum fin thickness*

The minimum fin thickness required shall be calculated using the following equation:

$$T = [E \times p_u/(\sigma_s)] + G$$

where

G = gap, in millimetres, ≥3 mm

T = thickness of fin, in millimetres

E = effective width, in metres

σ_s = minimum tensile strength of the silicone, 0.21 MPa

p_u = ultimate limit state design pressure, in kPa.

The required glass thickness shall be taken as the next larger available minimum glass thickness.

Alternatively, the thickness of the fin may be determined from Figure 7 or the tables contained in NZS 4223 Supplement 1.

NOTE –

1. It should be noted that a more economical design may be obtained by following the design procedures given in this section.

2. The strength of the structural sealant joint depends on the width (and hence contact area) of the fin edge fixed to the glass it is required to support, the bite (see Figure 8) and the effective wind pressure width (E) (see Figure 9 and Figure 10). The bite depends on the gap (G) between façade panels and the thickness (T) of the fin (see Figure 8).

Figure 7 – Determination of fin thickness

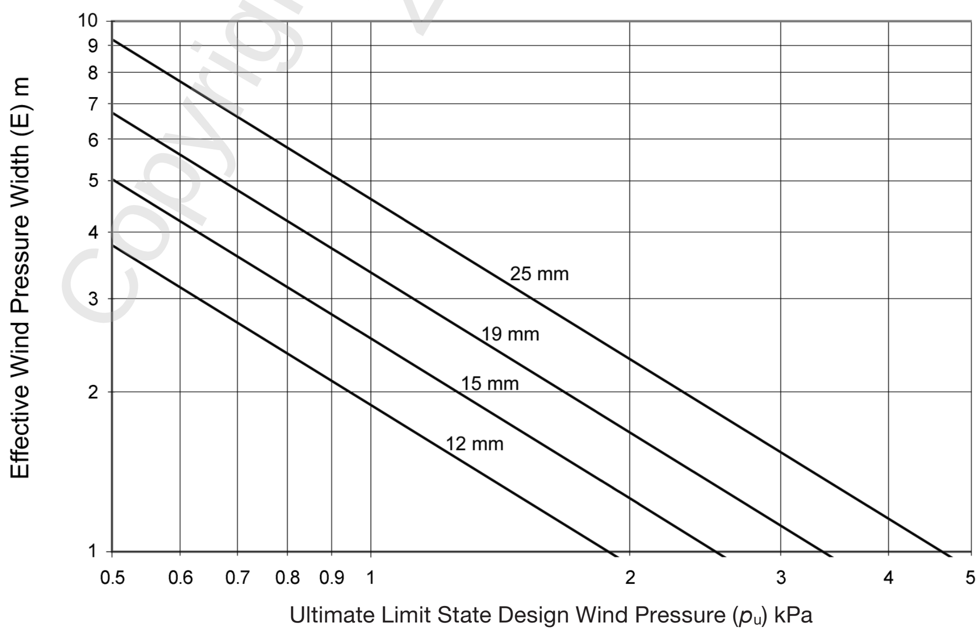
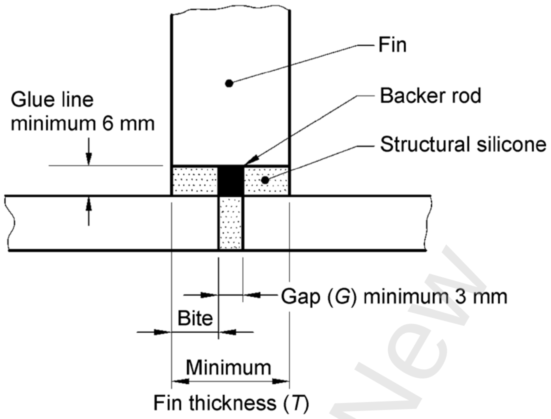
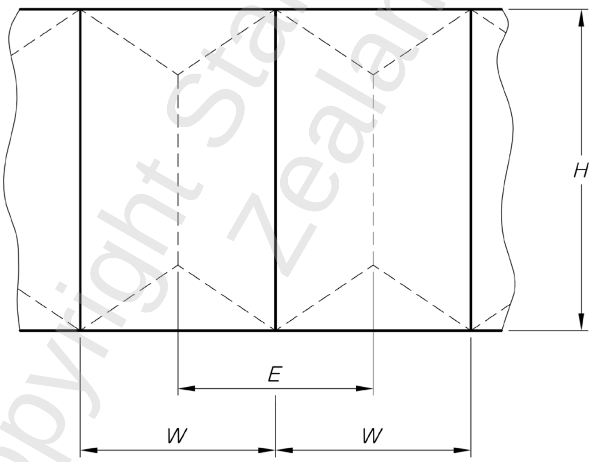


Figure 8 – Plan section of structural silicone joint



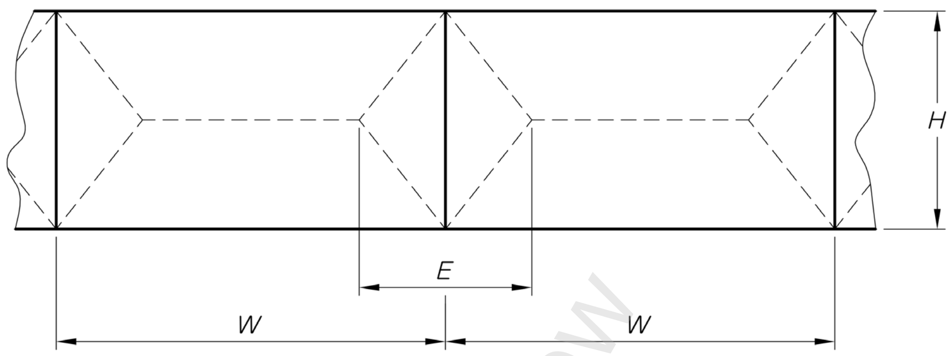
For situations where the height (*H*) of the façade panels is greater than their width (*W*) the effective wind pressure width (*E*) is equal to the width (*W*) of the façade panels (see Figure 9).

Figure 9 – Elevation view of glazing panels taller than their width



For situations where (*H*) is less than or equal to (*W*) the effective wind pressure width (*E*) is equal to the height (*H*) of the façade panels (see Figure 10).

Figure 10 – Elevation view of glazing panels wider than their height



5.4.2.3 *Determination of fin depth*

Given the ultimate limit state design wind pressure (*pu*), height (*H*) and the width (*W*), the depth of the fin shall be calculated using the following equation:

$$d = \sqrt{\frac{p_u H^3}{4\sigma_G t}\left(\frac{3}{R} - \frac{1}{R^3}\right)}$$

where

d = depth of fin, in metres

H = effective height, in metres

R = H/W, (where $H < W$, $R = 1.0$)

σ_G = ultimate limit edge strength of glass, in MPa (see 3.3.2) σ_G = 21.57 MPa for 25 mm (e.g. nominal thickness annealed glass.)

p_u = ultimate limit state design pressure in kPa

t = thickness of fin, in millimetres.

Alternatively, the depth of the fin may be determined from the tables contained in NZS 4223 Supplement 1.

NOTE – It should be noted that a more economical design may be obtained by following the design procedures given in this section, rather than using NZS 4223 Supplement 1.

5.5 Unframed toughened and toughened laminated glass assemblies

5.5.1 General

Toughened glass assemblies (in the form of an all-glass façade comprising toughened glass panels, most of which are fixed panels but some of which may be doors) provide a method of glazing large openings without the use of mullions or frames. These assemblies can be either fully or partially suspended from the building structure, depending on the size of the opening to be glazed. The glass itself becomes load-bearing withstanding self-weight and face loads only. Toughened glass assemblies require installation techniques quite different from those of framed panels.

In fully suspended assemblies, each panel is suspended with adjacent panels being joined at the panel corners by patch fittings bolted together through specially designed holes or notches in the glass. Each tier of panels except the top is suspended from the tier above, and the whole assembly, except for the doors, is suspended from and rigidly connected to a substantial structural member of the building, which has to be capable of fully supporting the dead weight of the assembly in addition to the forces due to wind loading.

The main limiting factor on the height of the suspended assembly is the 'pull out' strength of the holes in the top tier panels. Usually two holes in the glass share the load equally, although other oversize holes may be provided to give additional frictional grip support.

In special situations, the glass can be stacked or supported by other means.

5.5.2 Design considerations

5.5.2.1 *Fail safe requirements*

The design of toughened and toughened laminated glass assemblies shall be such that breakage of any component of the assembly will not initiate progressive collapse of the remainder.

5.5.2.2 *Components*

The façade shall be of toughened or toughened laminated glass and, where required, shall be supported against wind loads by fins or stiffeners of metal or toughened glass, not less than 12 mm thick, mounted on the edge adjacent to the façade glasses and generally located vertically. The fins shall be attached to the facade glass by patch fittings, and shall be attached to the building structure in such a way as to provide the façade with support against wind loads.

5.5.2.3 *Glass design stress*

The design stress used shall be in accordance with Section 3. The glass façade panels, the stiffening fins and the fixing points to the building structure shall be designed to withstand wind loading in accordance with AS/NZS 1170.2.

To prevent buckling, the fin width shall not exceed 18 times the glass thickness. When this limit is exceeded, the design is outside the scope of this Standard. A specific design method for the determination of fin design to prevent buckling is given in Appendix C.

All structural fins shall be designed to accommodate a friction grip joint. Simply bolting the cantilevered fin with high-strength structural steel bolts will not provide adequate resistance to the turning moment. Proprietary adhesives may be used to enhance the coefficient of friction in the structural joint.

NOTE –

1. Suitable equations for undertaking an analysis of fin stability are given in Appendix C.
2. The maximum design stress may give rise to deflections that are unacceptable for certain applications. The maximum deflections should be limited to span/60 in the panel and span/240 for the fin at the serviceability limit state design wind loading.

5.5.2.4 *Provision for expansion and structural movement*

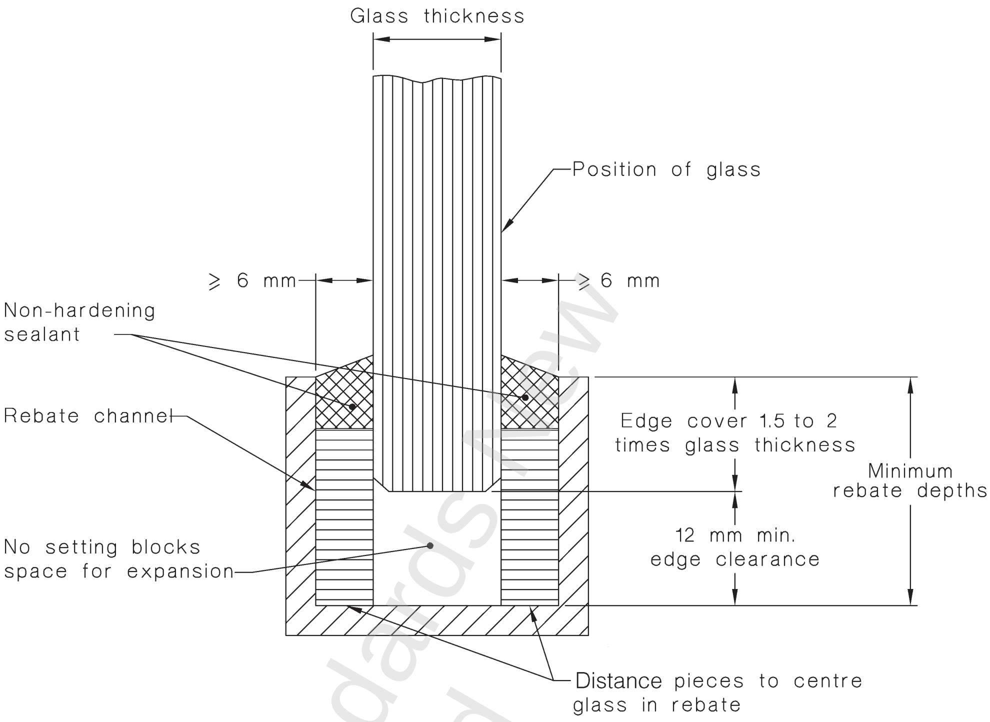
5.5.2.4.1 *Suspended assemblies*

Provision shall be made for thermal expansion building movement, and where required seismic movement, of a fully suspended glass façade by providing a rebate in the floor or sill for the bottom edge of the glass. Setting blocks shall not be used under the edge in this application although distance pieces to centre the glass in the rebate shall be used. A non-hardening sealant, plastic, or neoprene rubber or proprietary glazing system shall be used. The rebate shall be deep enough to provide edge cover of 1 to 1.5 times the glass thickness plus a clearance of not less than 12 mm between the lower edge of the façade glass and the bottom of the rebate (see Figure 11). The rebate shall be free from obstructions, and shall be strong enough to withstand safely the forces set up by wind pressures on the façade.

Rebates at each end of the façade or other adequate provision such as silicone butt jointing shall be provided to allow for horizontal thermal expansion, and where required seismic movement, of the glass façade. The amount of edge cover and edge clearance required shall be determined for each individual assembly.

The fittings joining fins to the façade panels shall be provided with a sliding feature wherever necessary to allow for differential movement due to thermal expansion or other structural movements of the fin and the façade, while still providing full lateral support against wind loading. This sliding feature may not be required for assemblies where a vertical fin is fixed to the head of the opening and the façade glasses are similarly fixed or suspended from the head of the opening, as the expansion or movement of the fin and façade panels will be in the same direction.

Figure 11 – Typical sill glazing for suspended toughened glass assemblies



5.5.2.4.2 *Doors supported directly from the floor and partially suspended assemblies*

Allowance shall be made for upwards thermal expansion of doors that are supported directly from the floor. A designed clearance of not less than 3 mm shall be allowed between the top of the door and the bottom of the transom for assemblies up to 5 m high with not less than 1 mm additional clearance for every 3 m or part thereof that the height of the assembly exceeds 5 m. The same allowance for thermal expansion shall be provided for partially suspended assemblies where the lower row of side panels is supported directly on the floor in a manner similar to doors.

5.5.2.4.3 *Vertical adjustment*

The suspension brackets for the façade panels shall provide for vertical adjustment to overcome minor irregularities in the opening, and to take up any deflection of the overhead structural support due to the weight of the glass.

5.5.3 Glazing techniques

5.5.3.1 *General*

Toughened and toughened laminated glass shall not be cut or worked after toughening. All necessary cutting, drilling, notching, and edge working shall be carried out to correct dimensions prior to toughening.

The installation of toughened glass assemblies shall be carried out by competent tradespeople. The edges and surfaces of toughened glass shall not be damaged during fixing.

The manufacturer's fixing instructions shall be followed explicitly.

5.5.3.2 *Sizing*

Glass size shall be verified against the opening size prior to ordering.

NOTE – The size and squareness of the opening into which the toughened glass assembly is to be glazed should preferably be accurately measured on site prior to commencement of manufacture.

5.5.3.3 *Glazing*

5.5.3.3.1 *Suspended assemblies*

Glazing shall start with the upper fins, which shall be plumbed for vertical and set with their lower edges all on one horizontal plane.

The central façade panel in the top tier shall be fitted next, followed by adjacent panels in the top tier. After completion of the top tier, successive tiers shall be fixed again starting in the centre of the façade.

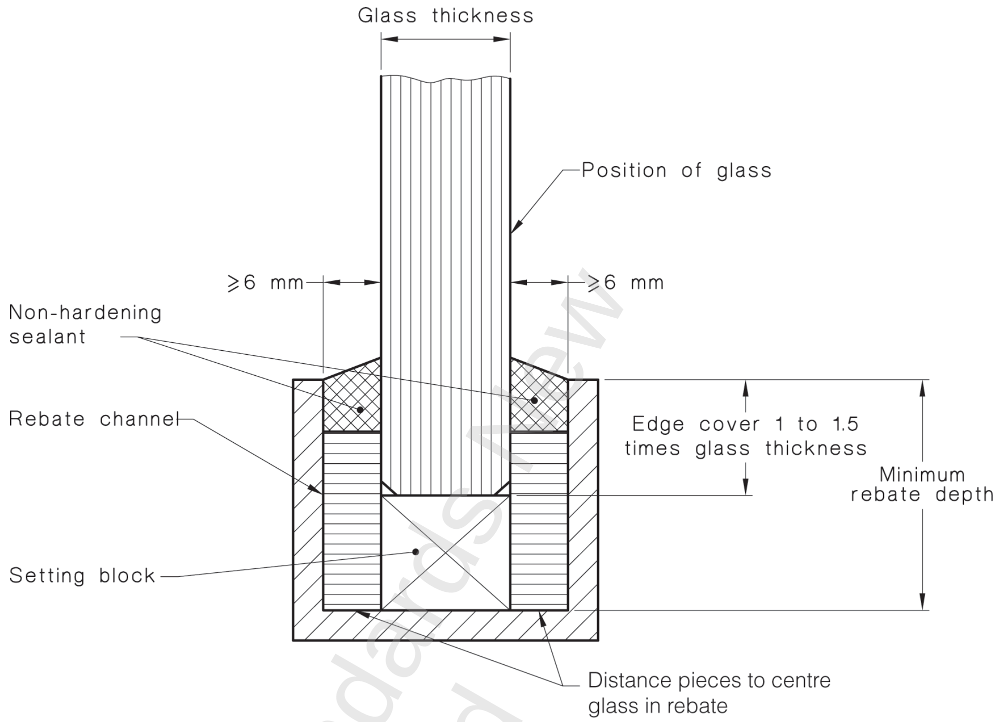
The metal brackets used to attach the glass fins to the building structure shall be securely bolted to the glass fin and the bolts shall be tightened accurately in accordance with the manufacturer's instructions.

During assembly, care shall be exercised at all fixing points, and fibre bushes and gaskets shall be used to ensure that there is no glass to glass or glass to metal contact. All panels and fins shall be fixed clear of each other, leaving a nominal gap of 3 mm or greater. This gap may be weatherproofed if desired with an H section extrusion in plastic or rubber, or a cold curing silicone building sealant may be gunned into the gap to make a flush joint.

5.5.3.3.2 *Sill-supported assemblies*

Where panels are supported from the sill, setting blocks of santoprene, neoprene or other suitable material shall be used (see Figure 12).

Figure 12 – Sill glazing for sill-supported toughened glass assemblies



5.6 Frameless glass showers

For frameless shower installation, see Appendix D.

For glass selection refer to NZS 4223.3.

APPENDIX A – LIFTWELLS AND LIFT CARS

(Informative)

Relevant clauses from NZS 4332

A1 Purpose

This Appendix sets out the relevant clauses from NZS 4332 that apply to glazing.

The relevant clauses include:

(a) Observation Liftwells

Glass shall be Grade A Safety Glass complying with NZS 4223.3.

Liftwells need not enclose the car throughout its entire travel but must extend 2.5 m from any public access level and have no toehold within 760 mm of the floor.

(b) Observation Lift Cars

Glass shall be 11.5 mm (minimum) Grade A laminated Safety Glass in accordance with NZS 4223.3. (Construction 5/1.5/5 mm).

Annealed glass can be used to cover small notices or certificates, or for annunciators, signal devices and lamps.

(c) Lining of Lift Cars

Glass shall be Grade A Safety Glass or Grade A Safety Mirror.

Where a supporting sub-panel is provided behind the glass the glass shall not be less than 6 mm.

Where no supporting sub-panel is provided behind the glass the glass shall be not less than 10 mm.

APPENDIX B – STRUCTURAL SILICONE GLAZING

(Informative)

B1 General

Structural silicone glazing (SSG) is an application where a sealant not only can function as a barrier against the passage of air and water through a building envelope, but also primarily provides structural support and attachment of glazing or other components to a window, curtain wall, or other framing system.

For common glass types and frame surface finishes (substrates), adhesion and compatibility have normally been established. However some substrates require primers as a result of adhesion testing, and therefore special procedures should be followed, which are not defined in this appendix.

It is normal on SSG projects to have compatibility and adhesion testing done before any glazing commences.

Detailed guidance is provided in ASTM C1401 and by the major sealant manufacturer; however, this appendix is a simple guide to some key design and glazing issues.

B2 Structural bite design

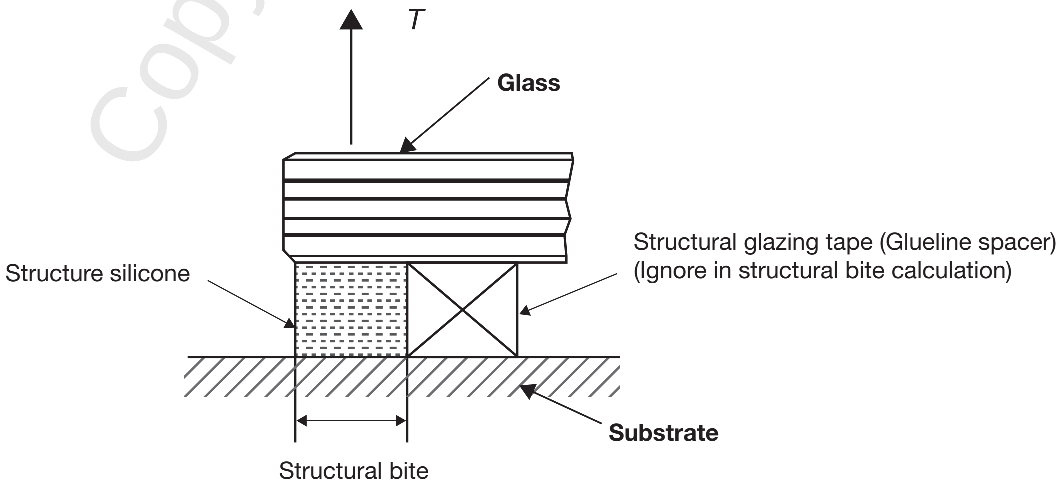
B2.1 Calculation

The minimum structural silicone bite (see Figure B1) required under wind load may be calculated using the following equation:

$$\text{Structural bite } (B) = \frac{0.5 \times \text{short span length (mm)} \times \text{ultimate limit state wind pressure (kPa)}}{\text{Silicone minimum tensile strength (kPa)}}$$

NOTE – For dead load design refer to the manufacturer.

Figure B1 – Structural bite



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T = tension

B2.2 For a wind load

B2.2.1 Example for glass supported along four edges

For a pane of vertical glass 2000 mm × 1200 mm supported along four edges with a ULS wind load of 2 kPa applied, the minimum structural silicone bite is calculated as follows:

$$\text{Structural bite } (B) = \frac{0.5 \times 1200 \times 2}{210} = 5.71 \text{ mm minimum (6 mm nominal)}$$

NOTE – Allowing for a typical 2 mm installation tolerance, a structural silicone bite of 8 mm would be selected.

B2.2.2 Example for glass supported along two edges

For a pane of glass supported along the top and bottom edges with an unsupported span of 1500 mm, with a ULS wind load of 2 kPa applied, the minimum structural silicone bite is calculated as follows:

$$\text{Structural bite } (B) = \frac{0.5 \times 1200 \times 2}{210} = 7.14 \text{ mm minimum (8 mm nominal)}$$

NOTE – Allowing for a typical 2 mm installation tolerance, a structural silicone bite of 10 mm should be selected.

B3 Movement design of structural silicone

Movement design of structural silicone is complicated due to its non-linear stress/strain behaviour. Approximations and associated calculation methods have been developed to allow for design assessments. These are available from the silicone manufacturer.

In some applications the joint may be subject to tension and shear loading from dead loads and other actions, and the structural bite and joint thickness (glueline) will need to be designed to accommodate these loads. Calculation methods are available for these loading conditions from the silicone manufacturer and depend on the movement capacity of the sealant.

B4 Glazing with structural silicone (without substrate primers)

B4.1 General

Silicone will bond very well to glass and compatible substrates provided the surface of the glass and substrates are clean. Unfortunately, surfaces within a factory or building site will be contaminated by residue from other materials and activities.

In such environments, it is essential that the glass and substrate surfaces be cleaned thoroughly just before the application of structural silicone. If silicone is applied to surfaces that have not been cleaned then the adhesive bond may become contaminated (for example, with dust) and greatly increase the risk of sealant joint failure.

Because of this, it is recommended that structural silicone be applied under factory conditions where quality is easier to control. Amd 1 Feb '16

Selecting the right silicone is critical to a successful application. Use of an unsuitable silicone can have serious consequences. For example, some silicones are not compatible with the interlayer of laminated glass, glass coatings, IGU seals, or the substrate finishing. There are numerous grades of silicone available, all with different performance characteristics. The manufacturers of these products have the best understanding of the performance capabilities of their products so their advice on which product to use should be sought for each application.

B4.2 Cleaning

Thorough and effective cleaning of the glass and substrate surfaces should be carried out before the application of silicone is commenced.

Successful cleaning of the glass and substrate surfaces depends on the use of an effective cleaning agent and the use of an appropriate cleaning method. An effective cleaning agent can only be chosen if the nature of the contaminant is known. The removal of dust, dirt, and cutting oils can be achieved using a solvent such as alcohol blends. The glazier should take suitable safety precautions when handling such solvents.

As the success of the silicone bond with the glass and substrate relies on the cleanliness of the glass edge and substrate, the procedure used for the cleaning is the responsibility of the glazier. It is recommended that clean, lint-free cloths or clean, silicone-free paper towels be used to apply the cleaner to the surface. The object is to remove the contaminants from the surface and not simply move them around and reapply them.

A typical cleaning procedure is as follows:

(a) Thoroughly clean the glass and substrate surface of any loose debris;

(b) Pour or dispense solvent onto a cloth or towel. Do not dip the cloth or towel into the solvent as this can contaminate the cleaning solvent;

(c) Wipe the glass and substrate surfaces vigorously to remove any contaminants. Check the cloth to see if it has picked up any contaminants. Rotate the cloth to a clean area and re-wipe until no additional dirt is picked up;

(d) Take a second clean, dry cloth and immediately wipe the cleaned area;

(e) Dispose of dirty cloths or towels.

B4.3 Silicone application

The silicone application will provide a silicone seal capable of carrying the loads imposed by the structural silicone joint design.

A typical application procedure is as follows:

(a) It is common to first mask the glass or frame either side of a joint to ease clean-up;

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(b) Cut the silicone tube or set the gun nozzle so that it is able to just enter the gap between the edges of the glass and substrate. Apply the silicone with a silicone gun or pump into the join so that it wets both edges of the glass and substrate, oozing out on both the far and near sides of the joint. It is essential that no air pockets be formed while the silicone is being gunned into the joint;

(c) For tooling the joint, select a tool that will minimise the concave shape of the finished surface of the silicone, this will ensure the maximum strength of the joint;

(d) Tool the silicone so that it is forced into the joint. This will further ensure that the edges of the glass and substrate are properly wetted. Each side will require to be tooled several times, as tooling will force some silicone out the other side of the join. Tooling should be completed before the silicone has formed a skin;

(e) Remove the tape and excess silicone, taking care not to spread the silicone or scratch the glass. Use a rag dampened with recommended solvent to wipe up the remainder. It is much easier to remove excess silicone before it has cured as trying to do so after curing greatly increases the risk of glass damage. If excess silicone has cured then it can be cut away using a blade and the remainder then has to be abraded away.

B4.4 Silicone curing

The glass should be properly supported until the silicone has cured. Any movement of a structural silicone seal prior to a full cure being achieved may reduce the section area of the silicone and reduce the strength of the seal. Support should therefore be maintained until the silicone has adequately cured.

There are two basic cure mechanisms for structural silicone:

(a) Two-part silicones include all the reactants within the silicone mix and can cure in a matter of hours; and

(b) One-part silicones are air-cured and may take some time to cure (a rule of thumb is 1 mm of cure per day).

Whichever type of silicone is used, the required curing time should be obtained from the silicone manufacturer.

B4.5 Structural silicone monitoring

It is recommended that quality assurance (QA) records and ongoing monitoring of structural silicone applications are maintained. Some project approving authorities require this as evidence and the sealant manufacturer may require it for a warranty.

The silicone manufacturer will provide guidance on typical QA procedures.

B5 Glazing with structural silicone (with substrate primers)

Where primers are required to ensure adhesion with the glass surface or frame substrate then the manufacturer should be consulted concerning the selection and application of the correct primer. Amd 1 Feb '16

APPENDIX C – GUIDANCE ON THE SPECIFIC DESIGN OF GLASS FINS TO PREVENT BUCKLING

(Informative)

C1 Introduction

In glass façades that use glass stiffening fins located on the inside to provide the necessary support for the façade panels, it is necessary to ensure that buckling of the fin will not occur when it is subjected to the design loads.

The specific design of glass fins is outside the scope of this Standard. However, this appendix provides guidance to support this process.

Since there are many possible configurations for glass stiffening fins, it is not practicable to provide a simplified design approach. Consequently, each design must be analysed in accordance with accepted engineering principles.

The analysis requires a knowledge of the critical elastic buckling moment (M_{CR}), and values for particular situations can be obtained from standard texts on structural analysis. However, as an aid to design, some values of the critical elastic moment are presented in this Appendix.

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The ultimate limit state design moment for a particular structural situation should not exceed the critical buckling moment (M_{CR}) divided by a safety factor of 1.14.

The following recommendations are applicable to end-supported beams of bisymmetrical cross section for which the contribution of warping stiffness to the buckling strength may be neglected.

The ends at supports are assumed to be effectively restrained against twisting. This condition will be satisfied if the supports possess a torsional stiffness in excess of 20 *GJ/L*, where *GJ* is the torsional rigidity of the beam and *L* is its length.

NOTE – For information on more general sections, including the effects of warping stiffness, refer to Nethercot, D.A. and Rockney, K.C.

C2 Beams with intermediate buckling restraints

The critical elastic value of the maximum moment between two buckling restraints may be taken as:

$$M_{CR} = (g_1/L_{ay})[(EI)_y(GJ)]^{1/2}$$

where

M_{CR} = critical elastic buckling moment

g_1 = constant obtained from Table 7

L_{ay} = distance between effectively rigid buckling restraints

$(EI)_y$ = effective rigidity for bending about the minor axis

(GJ) = effective torsional rigidity.

In computing the effective torsional rigidity of beams of solid rectangular cross section, the value of the torsional moment of inertia (*J*) may be taken as:

$$J = \frac{db^3}{3}\left(1 - 0.63\frac{b}{d}\right)$$

where

d and *b* are the depth and breadth of the fin respectively.

The value of torsional elastic modulus (*G*) may be taken as 28.7 GPa for glass fins.

The value of the linear elastic modulus (*E*) may be taken as 70.0 GPa for glass fins.

Table 7 – Coefficients for slenderness factor of bisymmetrical beams with intermediate buckling restraints

Moment parameter (β) (see Figure C1)	Slenderness factor (g_1)	
	Free restraint condition[1]	Fixed restraint condition[1]
1.0	3.1	6.3
0.5	4.1	8.2
0.0	5.5	11.1
–0.5	7.3	14.0
–1.0	8.0	14.0

NOTE –

1. The buckling restraints must prevent rotation of the beam about the z-axis. The terms 'free' and 'fixed' restraint condition refer to the possibility for rotation of the beam about *y-y* axis at the restraint locations, as shown in Figure C1.

C3 Beams with no intermediate buckling restraints

The critical elastic value of maximum moment of beams with no intermediate buckling restraints may be taken as:

M_{CR} = $(g_2/L_{ay})[(EI)_y(GJ)]^{½}[1 - g_3(y_h/L_{ay})[(EI)_y/(GJ)^{½}]$

where

M_{CR} = critical elastic buckling moment

g_2, g_3 = constants obtained from Table 8

L_{ay} = distance between effectively rigid buckling restraints (span of beam)

$(EI)_y$ = effective rigidity for bending about the minor axis

(GJ) = effective torsional rigidity

y_h = height above centroid of the point of load application.

NOTE – In Table 8, the values of the coefficients g_2 and g_3 apply to beams with lateral restraints only at their end points. However, these coefficients may be used for any other beam load system that has a similar shape of bending moment diagram between points of lateral restraint.

C4 Continuously restrained beams

For beams of bisymmetrical cross section continuously restrained against lateral displacement at a distance y_o from the neutral axis, the critical elastic moment M_{CR} may be taken as:

$$M_{CR} = \frac{(\pi / L_{ay})^2 (EI)_y \left[\frac{d^2}{12} + y_0^2\right] + (GJ)}{(2y_0 + y_h)}$$

where

M_{CR} = critical elastic buckling moment

L_{ay} = distance between points of effective rigid rotational restraints

$(EI)_y$ = effective rigidity for bending about the minor axis

d = depth of beam

(GJ) = effective torsional rigidity

y_h = location from the neutral axis of the loading point (see Figure C2).

NOTE – The parameter y_h may take on negative values, subject to the direction of the applied load and the position of the restraint.

C4.1 Buckling restraints

For most design situations, no check need be made on the effectiveness of buckling restraints. However, for an unusually light restraint system being used for a critical (i.e. non-load-sharing) engineered structure, it may be advisable to assess the effect and the capacity of the restraints.

For a design of slender beams having equally spaced buckling restraints, the restraint system is considered a lateral one as shown in Table 8 where the restraint stiffness (K_A) is defined as follows:

$$P_R = K_A \Delta_A$$

where

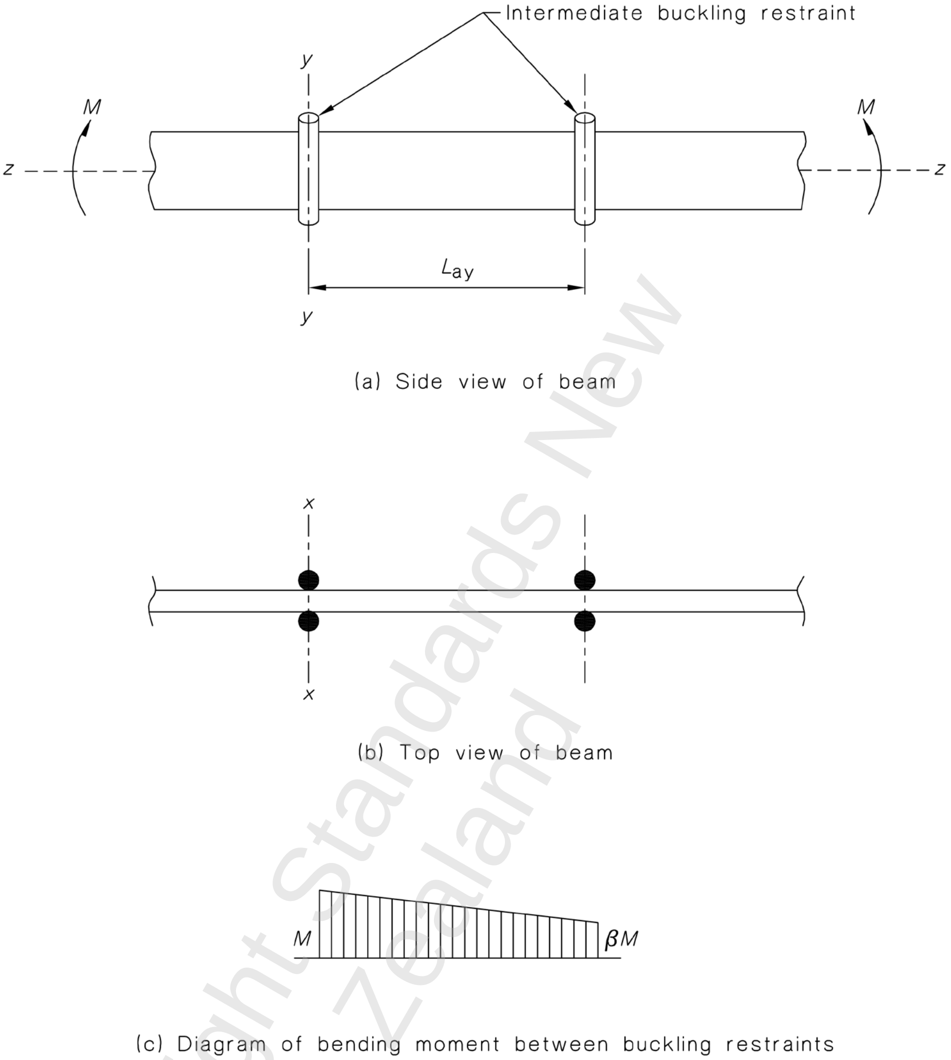
P_R = restraint force

K_A = restraint stiffness

Δ_A = beam displacement.

The restraint force (P_R) occurs when the point of attachment of the restraint to the beam undergoes a displacement (Δ_A). It is assumed that the ends of beams are effectively restrained against torsional rotation.

Figure C1 – Notation for beams with intermediate buckling restraints



For members of rectangular section and for box beams, the design force (P_R) on the lateral restraints is given by the following equation:

$$P_R = \frac{0.1\,M_a}{d(n+1)}\,g_4$$

where

M_a = the applied bending moment on the beam

g_4 = constant

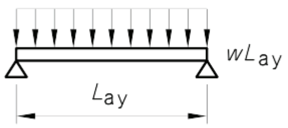
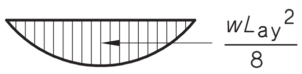
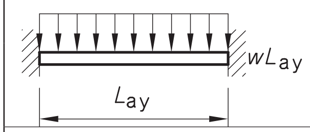
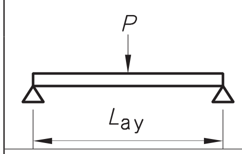
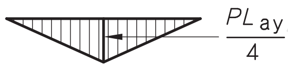
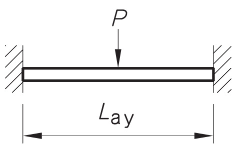
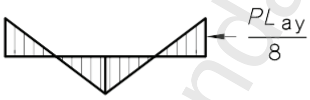
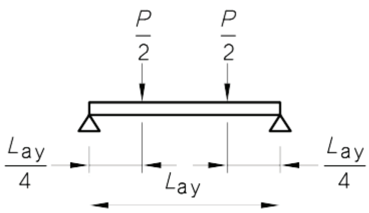
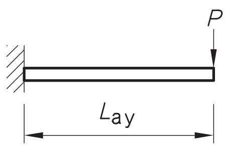
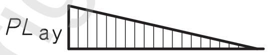
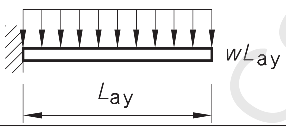
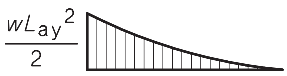
= lesser of (m + 1)/2 and 5

d = depth of beam

n = number of equally spaced intermediate restraints

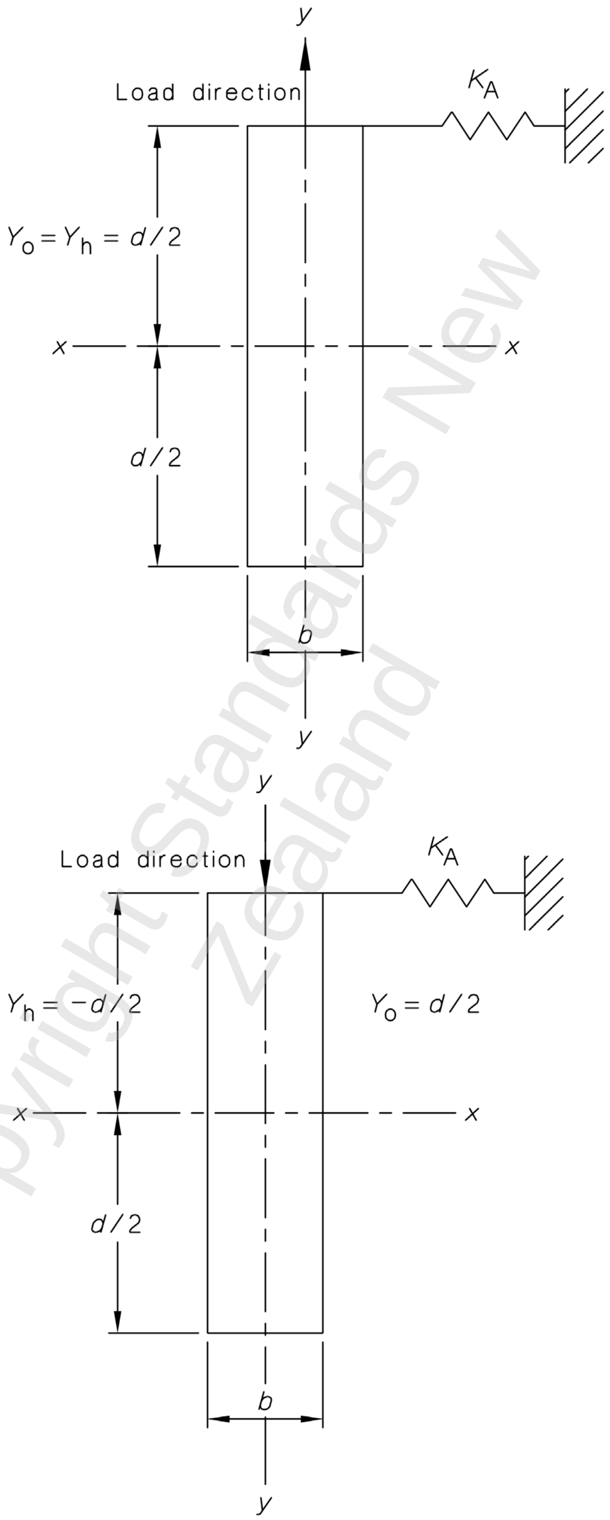
m = number of members supported by each restraint system

Table 8 – Coefficients for slenderness factor of bisymmetrical beams with no intermediate buckling restraints

Loading	Bending moment (*M*)	Condition of end restraint against rotation about *y-y* axis*	Slenderness factors g_2	Slenderness factors g_3
		Free Fixed	3.6 6.1	1.4 1.8
		Free Fixed	4.1 5.4	4.9 5.2
		Free Fixed	4.2 6.7	1.7 2.6
		Free Fixed	5.3 6.5	4.5 5.3
		Free Fixed	3.3 –	1.3 –
		Fixed	4.0	2.0
		Fixed	6.4	2.0

* See Figure C2

Figure C2 – Beam lateral restraints



APPENDIX D – RECOMMENDATIONS FOR FRAMELESS SHOWER INSTALLATION

(Informative)

D1

The following recommendations are provided for the benefit of fabricators, installers and users of partly framed and unframed (frameless) shower enclosures:

(a) NZBC E3/AS1 is a means of compliance for waterproofing wet areas and shower screen installation;

(b) Glass gussets, braces and supports at the head of the shower enclosure may be necessary to ensure the stability and safe performance of frameless shower screens;

(c) The fixed glass panels in a shower enclosure may be attached to the wall and floor with a securely fixed channel. The glass should be bonded firmly to the channel with silicone to prevent the glass falling out and water ingress into the channel;

(d) To prevent excessive deflection, fixed toughened safety-glass screens, partly framed continuously along two or three edges by channels, should not exceed the following spans between two opposite supported edges:

5 mm glass:	1300 mm
6 mm glass:	1600 mm
8 mm glass:	2000 mm
10 mm glass:	2400 mm
12 mm glass:	2800 mm;

(e) The hardware design should be such that the 'cut-outs' or fixing holes in toughened safety glass anchor the glass to the hardware thus reducing the potential for a frameless door to sag, which can result in glass-to-glass and glass-to-floor contact. The hardware design should also include gaskets to prevent glass to metal contact;

(f) Partly framed and unframed (frameless) doors should be installed in such a manner as to avoid the edge of the glass, which is the part of glass most vulnerable to breakage, from coming into contact with the stile or floor or other hardware, such as a vanity. The weight of unframed doors should not exceed the capacity of the hardware;

(g) A partly framed or unframed side panel or return panel up to 2100 mm high should have a minimum of two mechanical fixing brackets to the wall at 1700 mm maximum spacing. Panels exceeding 2100 mm high require additional fixings at 1700 mm maximum spacing. This is in addition to silicone, which provides some stability to the glass as well as sealing the glass to wall tiles, and so on. Screens can be attached to the floor allowing for a minimum 3 mm clearance with either structural silicone or a minimum of two mechanical fixing brackets at a maximum spacing of 1700 mm;

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(h) NZS 4223.3 requires Grade A safety glass.

D2

It is recommended that homeowners regularly inspect the following aspects of the operation of a frameless shower screen:

(a) Ensure a minimum of 3 mm clearance is maintained between all edges of a frameless glass door and the partly framed panel and or wall and the floor;

(b) Check the tightness of the screws in the hardware;

(c) Check the operation of the hinges to ensure that they hinge freely and are not bound;

(d) Replace scratched or damaged glass;

(e) Ensure that, when making alterations to a shower area, unframed shower door edges do not make contact with objects that may cause the glass door to fracture.

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APPENDIX E – GUIDANCE ON SELECTING GLASS TO MINIMISE THE RISK OF SPONTANEOUS GLASS FRACTURE

(Informative)

The use of toughened glass and some heat-treated glasses involves a relatively small risk of breakage resulting from nickel sulphide or other inclusions. The following provides guidance on the selection of glass to minimise this risk.

E1 Heat soaking

All monolithic-toughened glass and heat-strengthened glass, with a surface compression greater than 52 MPa, should be heat soaked in accordance with clauses 3, 5, 6, 12 and Annex A of BS EN 14179-1.

The heat-soaked glass should be marked in compliance with BS EN 14179-1. Alternatively, a certificate supplied by the manufacturer verifying that the toughened glass has been heat soaked in accordance with this Standard would be a suitable alternative to marking in compliance with BS EN 14179-1.

NOTE – Heat soaking will significantly reduce but not totally eliminate the small risk of fracture due to nickel sulphide.

E2 Other ways to minimise risk

Heat soaking in accordance with E1 should not be required in glazing that conforms to any one of the following:

(a) No part of the glass is glazed more than 5 m from the finished floor or ground level;

(b) Suitable protection by a balcony, awning or the like is provided such that, in the event of glass fracturing, the risk of injury or property damage is minimised;

(c) Laminated glass (including toughened laminated and heat-strengthened laminated) is used.

NOTE –

(1) For insulating glass units glazed vertically, greater than 5 m from the ground level, a laminated, monolithic annealed or monolithic heat-strengthened outer or inner pane as appropriate may be considered to provide suitable protection.

(2) For insulating glass units glazed in sloped overhead glazing greater than 5 m from the finished floor or ground level a laminated inner (lower) pane may be considered to provide suitable protection.

(3) A balcony that extends from the building a minimum two-thirds of the height of the adjacent panel may be considered to be suitable to minimise the risk. For example, for a 2.7 m high panel, the balcony or protection should extend a minimum of 1.8 m from the building.

Amd 1 Feb '16 (4) Refer to NZS 4223.3 for glass barriers.

NOTES

NOTES

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