PRELIMINARY DRAFT

NATIONAL BUILDING CODE OF INDIA

PART 6 STRUCTURAL DESIGN

Section 8 Glass and Glazing

BUREAU OF INDIAN STANDARDS

CONTENTS

National Building Code Sectional Committee, CED 46

FOREWORD

This Code (Part 6/Section 8) deals with the use of glass in buildings. Glazing has become an important item in building construction. Glass, the primary glazing element has to be selected to cater to several requirements and the glazing has to be designed to meet various engineering requirements. Fixing of glass a specialized operation, when properly done, will avoid the hazards of broken glass. Growing trend in resorting to glazed windows/doors in buildings and structures has considerably increased the importance of glazing and the need for proper workmanship. Considering all these, this Section was introduced in the third revision of the Code.

This Section provides guidance in the selection of appropriate glazing for various types for building construction; guidance on the energy and light aspects while choosing glazing; guidance on determining the appropriate thickness of glass used in building glazing and guidance with respect to human impact safety while using glazing in buildings.

Use of organic coated films including safety films on glass shall not classify the glass as safety glass as per this Code, and hence users should exercise caution in choosing their options.

Information on installation of glass mirrors and glass railings are given in the informative Annexes F and G, respectively.

A conformity assessment sheet for evaluating the compliance of glass and glazing systems with the requirements of this section has been included in informative Annexure K.

As a result of experience gained in implementation of 2016 version of this Section and feedback received as well as in view of formulation of new standards in the field of glass and glazing and revision of some existing standards, a need to revise this Section was felt. This revision was, therefore, prepared to take care of these aspects.

The significant changes incorporated in this revision include:

a) Definitions of various existing terms have been reviewed and updated, wherever required.
b) Provisions related to the requirements for laminated safety glass, toughened (tempered) safety glass and heat strengthened glass have been updated.
c) Clause **5** on Energy and Light has been reviewed and updated, including new provisions on energy design considerations and window design guidelines for non-conditioned / mixed mode buildings.
d) The types of glass permitted for fire-resistant glazing within the scope of the section have been updated.
e) Inclusion of provisions for determining the fire resistance performance of perimeter fire barrier joint systems, enhancing fire safety measures.

f) New provisions addressing anti-fallout features, window restrictors for child safety, and dynamic wind restraint mechanisms.
g) A new clause on security glass has been introduced, covering glass for security applications such as bullet resistance, burglary resistance, and blast resistance.
h) Provisions related to railings with glass infill panels and free-standing glass protective railings have been modified.
i) Incorporation of provisions for assessing curtain walls and storefront systems under inter-story drift conditions.
j) Addition of a conformity assessment sheet to evaluate the compliance of glass and glazing systems with the requirements outlined in this section.
k) References to all the concerned Indian Standards have been updated.

The information contained in this Section is largely based on the following Indian Standards:

IS No.	*Title*
IS 16231	Code of practice for use of glass in buildings:
(Part 1) : 2019	General methodology for selection
(Part 2) : 2019	Energy and light
(Part 3) : 2019	Fire and loading
(Part 4) : 2019	Safety related to human impact

Assistance has also been derived from the following publications in the formulation of this Section:

ISO 9845-1:2022	Solar energy – Reference solar spectral irradiance at the ground at different receiving conditions – Part 1: Direct normal and hemispherical solar irradiance for air mass 1,5
ISO 10291:1994	Glass in building – Determination of steady-state U-values (thermal transmittance) of multiple glazing – Guarded hot plate method
ISO 10292:1994	Glass in building – Calculation of steady-state U-values (thermal transmittance) of multiple glazing
ISO 10293:1997	Glass in building – Determination of steady-state U-values (thermal transmittance) of multiple glazing – Heat flow metre method

All standards, whether given herein above or cross-referred to in the main text of this Section, are subject to revision. The parties to agreement based on this Section are encouraged to investigate the possibility of applying the most recent editions of the standards.

For the purpose of deciding whether a particular requirement of this Section is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this Section.

Members are requested to share their inputs/comments on the draft particularly w.r.t the changes listed above in the foreword; and especially on those text highlighted in yellow in this draft.

Important Explanatory Note for Users of the Code

In any Part/Section of this Code, where reference is made to **'good practice'** in relation to design, constructional procedures or other related information, and where reference is made to **"accepted standard"** in relation to material specification, testing, or other related information, the Indian Standards listed at the end of the Part/Section shall be used as a guide to the interpretation.

At the time of publication, the editions indicated in the standards were valid. All standards are subject to revision and parties to agreements based on any Part/ Section are encouraged to investigate the possibility of applying the most recent editions of the standards.

In the list of standards given at the end of a Part/Section, the number appearing within parentheses in the first column indicates the number of the reference of the standard in the Part/Section. For example:

a) Good practices [6-8(1)] refers to the Indian Standard(s) give at serial number (1) of the list of standards given at the end of this Part/Section, that is, IS 14900:2018 'Specification for transparent float glass (first revision)'

PRELIMINARY DRAFT

NATIONAL BUILDING CODE OF INDIA

PART 6 STRUCTURAL DESIGN

Section 8 Glass and Glazing

1 SCOPE

1.1 This Code (Part 6/Section 8) covers,

a) selection and application of glass in buildings, different types of glass, their requirements and associated glazing materials;
b) guiding provision for glazing in buildings with respect to their effect on energy, visual (light) and solar environments in the building;
c) selection of glass in buildings, subject to wind loading, seismic loading and special considerations for fire rated glass and related materials;
d) provisions for the selection, manifestation of glass in buildings, subject to safety with respect to human impact of the occupants; and
e) provisions relating to glazing systems such as selection, design, fabrication, installation, testing and maintenance.

1.2 This Section does not cover patent glazing.

NOTE – The provision of this Section pertains to glass and installation thereof. However, parties, as per their mutual agreement, may appropriately utilize the relevant provisions for installation of alternative sheeting materials used for similar purposes such as plastic glazing sheets/polycarbonate sheets taking also into account requirements of safety issues as applicable with the specific material.

2 TERMINOLOGY

For the purpose of this Section, the following definitions shall apply, and for other terms those given in accepted standards [6-8(1)] shall apply.

2.1 Annealed Glass *(see* **Glass***)* – Also known as ‘normal’ glass, which has not been subjected to toughening, lamination and heat strengthening. It is the product obtained from the process of slow and steady cooling of hot glass in order to relieve internal stresses or thermal induced stresses.

NOTE – This term is most commonly used for flat glass.

2.2 Annealed Fire Resistant Glass – Type of glass which is made out of annealed glass combination and is tested for the required duration and satisfies the intended criteria of fire resistance. These types of glasses may not possess the best of the impact resistance characteristics and may be used as vision panels.

2.3 As-Cut Finished Sizes – Finished panes of flat glass cut from stock/standard sizes. They may be subject to further processing, such as edge working drilling, face decoration, etc.

2.4 Aspect Ratio – The ratio of a longer side of glass pane to its shorter side.

2.5 Balustrade – A low barrier forming a parapet to a stair, ramp, balcony, raised level or a change in level.

2.6 Beads or Glazing Beads – A strip of wood, metal or other suitable material attached to the rebate to retain the glass in position in the frame.

2.7 Bite – The minimum distance by which the inner edge of a frame (or a stop) overlaps the edge of the glass panel.

2.7.1 *Glazing Bite* – The dimension by which the framing system overlaps the edge of the glazing infill. Minimum glazing bite shall be 10mm, for non-structural sealant applications.

2.8 Block (Setting Block) – A small piece of wood, plastic, rubber or other suitable material used between the edges of the glass (generally the bottom edge only) to centralize the glass in the frame (frequently called a setting block).

2.9 Chair Rail – A fixed rigid bar that provides protection from human impact.

2.10 Clear Glass – A transparent glass with neutral/near colourless appearance.

2.11 Coefficient of Linear Expansion – It is expressed as the strain (change in length per unit length) per unit variation of temperature of a material.

2.12 Combustible Material – The material which when burnt adds heat to a fire when tested for combustibility in accordance with accepted standard [6-8(2)].

2.13 Corridor – A common passage or circulation space including a common hall.

2.14 Coupled Glazing (also known as Secondary Glazing) – Two panes of glazing spaced apart in an opening, either in the frame or glazed separately, to form an unsealed cavity.

2.15 Curtain Wall – Non-load bearing structure/partition of glass attached to the building frame, usually on the exterior face. Curtain wall vertical framing members run past the face of floor slabs, and provision for anchorage is typically made at vertical framing members only.

> NOTE – In contrast to combination assemblies and composite units, curtain wall systems often need to meet additional performance requirements for inter-story differential movement, seismic drift (*see* Annex H), dynamic water infiltration, etc. Operating vents and entrance doors are provided as separate inserts.

2.16 Curtain Wall Assembly – A fire rated or non-fire rated, non-load bearing exterior wall assembly secured to the structural members of the building.

2.17 Distance Piece – A small piece of wood or other suitable material used to locate the glass between the bead and the back of the rebate to prevent lateral movement.

2.18 Door or Shutter Assembly Door-Set – A pedestrian door-set or industrial type door-set including any frame or guide, door leaf or leaves, rolling or folding curtain, etc, which is provided to give a fire resisting capability when used for the closing of permanent openings in fire resisting separating elements, which includes any side panel(s), vision panel(s), flush over panel(s) and/or transom panel(s) together with the building hardware and any seals (whether provided for the purpose of fire resistance or smoke control or for other purposes such as draught or acoustics) which form the assembly.

2.19 Double Glazed Fire Resistant Glass – A fire resistant glass that is used in a double glazed unit.

NOTE – These shall be tested as a complete Double Glazed Unit (DGU) or other multiple glazed units as the case may be. Double glazed fire resistant glass can be a combination of intumescent laminated fire rated or tempered fire resistant glass. Fire resistant glass cannot be combined with another glass and used as a DGU unless the combined double glazed or multiple glazed units are also tested.

2.20 Double Glazing – Glazing formed by an assembly of two glass panes separated by a spacer and the gap may be filled by vacuum, air or inert gases and hermetically sealed along the periphery to improve the thermal insulation.

2.21 Edge Deterioration – The discolouration of the reflective coating at the edge of the silvered glass.

2.22 Edge Faults – The faults that affect the as-cut edge of the glass. They may include entrant/emergent faults, shelling, corners on/off and vents.

2.23 Edge Polished – It is usually applied to flat glass, the edges of which have been polished after cutting.

2.24 Edging – Grinding the edge of flat glass, to a desired shape or size.

2.25 Exposed Edge – A glass panes' edge that is not covered.

2.26 Facade – It is the front or face of the building which is part of framed or frameless system.

2.27 Faceted Glazing – It is a type of glazing in which flat panes of glass are installed vertically at an angle to each other to form a faceted surface.

2.28 Fenestration – All area (including frame) in the building envelope that let in light, including window, plastic panels, clerestories, skylight, fanlight and glass doors that are generally more than one-half the floor height, and glass block walls.

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

2.30 Fire Separation – The shortest distance, in metre, measured from the external wall of the building concerned to the external wall of any other building on the site, or from other site, or from the opposite side of street or other public space for the purpose of preventing the spread of fire.

2.31 Float Glass – Flat, transparent, clear or tinted soda-lime silicate glass having parallel and polished surfaces obtained by continuous casting and floatation on a metal bath.

NOTE – Flat glass is a general term covering sheet glass, float glass and various forms of rolled and plate glass in which shape of the glass is flat and commonly used for windows, glass doors, transparent walls and other architectural applications.

2.32 Flush Over Panel – A panel which is incorporated within a door-set or openable window and fitted above the leaf or leaves within the frame head and the jambs and with no transom.

2.33 Frame – An element made of timber/metal/aluminium or other durable material/combinations of materials, such as glass fins and structural sealant, supporting the full length of a glazed panel edge.

2.34 Frameless Glazing – An unframed glazing which maintains the integrity through pointed support structures.

2.35 Front Putty – The compound forming a triangular fillet between the surface of the glass and the front edge of the rebate.

2.36 Fully Framed Glazing – The glazing whose panels have all its four edges framed.

2.37 Gap – A clearance between two adjacent surfaces and/or edges, for example between the edge of the leaf and the reveal of the frame or between the face of the leaf and the frame stop.

2.38 Glass – An inorganic product of fusion which has cooled to a rigid condition without crystallizing. It is typically hard and brittle, and has a conchoidal fracture. It may be colourless or tinted and transparent to opaque. The term glass refers to monolithic glass unless specified otherwise.

2.39 Glass Appearance Faults – Faults such as spot and/or linear and/or enlarged area faults which alter the visual quality of glass.

2.40 Glazing – Act of securing of glass or other glazing material into a building in prepared openings in windows, door panels, partitions, etc.

2.41 Guard Rail – A permanent physical barricade used to prevent human impact on glass/glazing.

2.42 Hairline Scratch – Very fine scratch that can hardly be seen with naked eye and is associated with glass cleaning techniques.

2.43 Halo – It is the distortion zone around a spot fault.

2.44 Heat Soaking – It is done on toughened/tempered glass by reheating to a temperature of 290 ˚C and keeping it at this temperature for 8 h and cooling it gradually. The glass can break spontaneously and without provocation due to possible impurity of nickel sulphide in basic glass used for toughening/tempering. This risk of spontaneous breakage can be minimised by heat soaking process by forcing such glasses to break during the test itself.

2.45 Heat Strengthened Glass – A single piece of glass within which a permanent surface compressive stress, additionally to the basic mechanical strength, has been induced by a controlled heating and cooling process in order to give it increased resistance to mechanical and thermal stress and prescribed fracture characteristics {*see* **6.1.5** of accepted standard [6-8(25)]}.

2.46 Hermetic Seal – A complete seal (especially against the escape or entry of air which is impervious to outside interference or influence) done on insulating glass units.

2.47 High Activity Area – An area where multiple and major human activity takes place.

2.48 High Risk Area – An area prone to human injury and casualty.

2.49 Infill Balustrades – The balustrades in which the supported glass resists an infill pressure and/or point load applied to the glass panel.

2.50 Insulating Glass Unit (IGU) – An assembly consisting of at least two panes of glass, separated by one or more spaces, hermetically sealed along the periphery, mechanically stable and durable.

2.51 Interlayer – Layer or material acting as an adhesive and separator between plies of glass and/or plastic glazing sheets.

NOTE – It can be designed to give additional performance to the finished product, for example impact resistance, fire resistance, solar control and acoustic insulation.

2.52 Internal Partition – An interior dividing wall or such portion of an interior dividing wall that is not a door, side panel, shop front or atrium wall.

2.53 Light Transmission – It is the measure of light passing through a transparent or a translucent material.

2.54 Light Transmittance – It is the measure of percent of visible light transmitted through glass pane which depends on type of body substrate and coating done on glass.

2.55 Linear Defects – They are the scratches and extended spot faults on the glass.

2.56 Manifestation – Any technique for enhancing a person's awareness of the presence of transparent glass.

2.57 Maximum Thickness – The thickness of a pane of glass at the maximum thickness tolerance.

2.58 Minimum Thickness – The thickness of a pane of glass at the minimum thickness tolerance.

2.59 Modulus of Elasticity (Young's Modulus) – This modulus expresses the tensile force that theoretically has to be applied to a glass specimen to stretch it by an amount equal to its original length. It is expressed as a force per unit area (for glass, E = 0.7 x 10^5 N/mm^2 = 70 GPa).

2.60 Monolithic Glass – A single sheet of flat glass which could be either annealed, toughened or heat strengthened.

2.61 Mullion – Vertical framing member supporting the edge or surface of the glass. ~~separating and supporting two adjacent panes of glass or panels.~~ It is responsible for transferring loads to the sub-structure.

2.62 Nominal Thickness – A numeric designation that indicates the approximate thickness of glass.

2.63 Non-Combustible Material – A material not liable to burn itself or to add heat to a fire when tested for combustibility in accordance with good practice [6-8(2)].

2.64 Organic Coated Glass – A sheet of glass coated on one or both sides with an applied organic coating or sheeting.

2.65 Pane – A single piece of glass or plastic glazing sheet material in a finished size ready for glazing.

2.66 Panel – An assembly containing one or more panes of glass.

2.67 Partition – It means an interior non-load bearing divider, one storey in height or part.

2.68 Partly Framed or Unframed Glazing – The panels that have one or more edges unframed.

2.69 Passive Solar Gain – The solar radiation in the form of energy and light which is transmitted through the glazing into the building and which can be utilized as a source of energy to reduce the need for artificial lighting.

2.70 Patterned Glass – A rolled glass having a distinct pattern on one or both surfaces.

2.71 Perimeter Fire Barrier — The perimeter joint protection that provides resistance to prevent the passage of fire and/or from floor to floor within the building at the opening between the exterior wall assembly and the floor assembly.

2.72 Protective Coating(s) Faults –The faults where the metallic layer is exposed. They can be scratches or loss of adhesion of the protective coating(s).

2.73 Rebate – The part of a surround; the cross-section of which forms an angle into which the edge of the glass is received.

2.74 Reflective Coated Glass – It is a glass with reflective coating which uses the principle of increasing the direct reflection to maximize solar energy attenuation. In comparison with clear glass, its absorption of solar energy is also increased.

NOTE **–** In comparison with float glass surface, these reflecting coatings (due to their composition) exhibit lower level of emissivity which improves their *U*-value.

2.75 Reflective Silver Coating Faults – It is the fault on reflective silver layer which shall alter the appearance of the silvered glass. They consist of scratches, stains, colour spots and edge deteriorations.

2.76 Residual Protection – It is the protection provided to avoid the human impact on glass. It is provided on the side of glass where there are chances of human impact. It can be achieved by providing a sill structure or a grill inside.

2.77 Safety Glass

NOTE **–** The railing and overhead glazing shall consist exclusively of laminated safety glass.

2.77.1 *Laminated Safety Glass* – Two or more pieces of glass held together by an interleaving layer or layers of plastic sheet material. The laminated safety glass will crack and break under sufficient impact, but the pieces of glass tend to adhere to the plastic and do not fly.

2.77.2 *Toughened (Tempered) Safety Glass* – A single piece of specially heat treated glass, with a stress pattern such that the piece when fractured reduces to numerous granular fragments, with no large jagged edges.

2.78 Shading Coefficient – The ratio of the rate of solar heat gain through a specific unit assembly of glass to the solar heat gain through a single light of 3 mm clear glass in the same environment.

2.79 Sheet Glass – Glass made in large sheet directly from furnace or by making a cylinder and then flattening it.

NOTE – These transparent glass have a glossy, fire-finished, apparently plane and smooth surfaces, but having a characteristic waviness of surface.

2.80 Skylight – A fenestration surface having a slope of less than 60˚ from the horizontal plane. Other fenestration, even if mounted on roof of a building is considered as either a vertical glazing or sloped glazing depending upon the angle of the glazing.

2.81 Sloped Overhead Glazing – A glazing that is inclined at less than 75º to the horizontal and located, wholly or partially, directly above an area that may be used by people.

2.82 Solar Energy Absorption – The percentage of the solar spectrum energy (ultraviolet, visible, and near-infrared) from 300 nm to 2 500 nm that is absorbed by a glass product.

2.83 Solar Energy Transmittance (Direct) – The percentage of energy in the solar spectrum, ultraviolet, visible, and near-infrared energy, 300 nm to 2 500 nm, that is directly transmitted through the glass.

2.84 Solar Heat Gain Coefficient (SHGC) – The SHGC is the fraction of incident solar radiation admitted through a fenestration, both directly transmitted, and absorbed and subsequently released inward through conduction, convection and radiation.

2.85 Spandrel – A non-vision portion of the exterior wall of a building.

2.86 Spot Faults – The nuclei (solid or gaseous inclusions), deposits, crush marks, etc, in the glass. In certain instances spot faults are accompanied by a distortion zone called 'halo'. The nucleus of the spot fault is measurable.

2.87 Stain – An alteration of the reflective coating characterized by a more or less brownish, yellowish or greyish colouration of zones which can sometimes cover the whole reflective surface.

2.88 Stock/Standard Sizes – The panes of flat glass such as coated, mirror, enamelled glass, etc, supplied with as-cut edges which are intended for further processing. These are generally corresponded with manufacturer’s production size.

~~**2.87 Tempered or Toughened Glass** – Flat glass within which a permanent surface compressive stress has be induced by a controlled heating and cooling (quenching) process in order to give it greatly increased resistance to mechanical and thermal stress and prescribed fragmentation characteristics.~~

2.89 Tempered Fire Resistant Glass – A single piece of specially thermally-treated or chemically treated glass, tested for fire resistance for the required duration and having such a stress pattern that the piece when fractured, it reduces to numerous granular fragments, with no large jagged edges.

2.90 Test Assembly – The complete assembly of the test specimen together with the test apparatus.

2.91 Thermal Transmittance (*U*) – Thermal transmission through unit area of the given building unit divided by the temperature difference between the air or other fluid on either side of the building unit in steady state conditions. It is also called as *U*-value. Its unit is W/m^{2}K.

NOTES
1 Thermal transmittance differs from thermal conductance insofar as temperatures are measured on the two surfaces of a building unit in the latter case and in the surrounding air (or other fluid) of the material on the two sides, in the former case. Thermal conductance is a characteristic of the building unit whereas thermal transmittance depends on conductance and surface coefficients of the building unit under the conditions of use.
2 In the case of glazing, thermal transmission is taken through the central part of the glazing, that is, without edge effects.

2.92 Through Component/Connection – The internal spacer or fixing that either penetrates through the door-set or openable window from one face to another or directly connects the faces of one to the other.

2.93 Tinted Glass – A normal flat glass to which colourants (normally metal oxides) are added during manufacturing process to achieve tinting and solar radiation absorption properties. It is also referred to as body tinted glass.

2.94 Transom – A horizontal cross bar connecting two vertical members in a glazing frame.

2.95 Unframed Glazing – A glazing with one or more edges unframed.

2.96 UV Transmittance – The percentage of energy in the ultraviolet (UV) spectrum from 300 nm to 380 nm that is directly transmitted through the glass.

2.97 Vertical Fenestration – All fenestration other than skylights. Trombe wall assemblies, where glazing is installed within 300 mm of a mass wall are considered walls and not fenestration.

2.98 Wired Glass – It is a type of glass into which a wire mesh is embedded during production. Wired glass has an impact resistance similar to that of normal glass, but in case of breakage, the mesh retains the pieces of glass.

3 APPLICATION

The type of glass chosen shall satisfy the following criteria:

a) For a given application, the type and thickness of glass selected shall be in accordance with the requirements provided herein and the thickness calculation as subjected to wind load shall also satisfy requirements for human impact safety.
b) Installation of glass to the building is done in accordance with the various provisions available in this Section and in the absence of any specific provisions the same shall be as per manufacturer's instructions.
c) Optical, solar, thermal performance of glazing (clear/tinted/coated reflective glass) shall have the characteristic performances, such as:

    1) Spectral transmittance, external and internal spectral reflectance;
    2) Light transmittance, external and internal light reflectance;
    3) Solar direct transmittance and reflectance;
    4) UV transmittance; and

5) Better thermal transmittance (*U*-value).

4 GENERAL METHODOLOGY FOR SELECTION

4.1 Selection

4.1.1 Right from the initial project evaluation stage, a suitable methodology that incorporates the implications of use of glass materials and their influence on performance of the building shall have to be looked into. A typical flowchart outlining such a methodology is provided for the users of this Section (*see* Fig. 1).

It is assumed that,

a) the location of area to be glazed and its preliminary size/shape have been decided as part of normal building design process.
b) the designer has gained information on glass/and plastic glazing sheet materials used in similar circumstances.
c) the designer is cognizant of implications of any innovation in design.

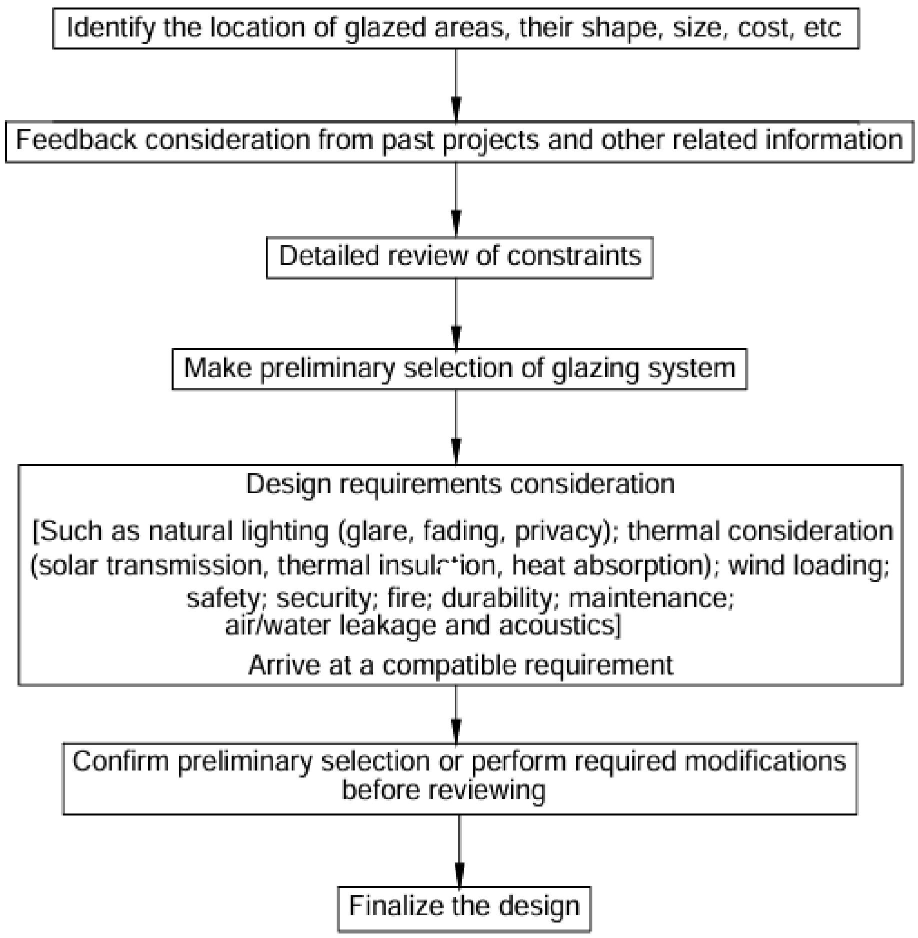


FIG. 1 TYPICAL SEQUENCE OF DESIGN EVALUATION FOR GLAZED AREAS

4.1.2 Design requirement including aesthetic considerations and client specified requirements such as security and maintenance to be considered.

4.1.3 Effect of design on cost such as initial cost of glazing (specification of glass/plastic sheeting material; glazing method; access for initial glazing; work schedule; protection during construction); effect of glass/plastic sheeting material on capital/running cost related to building heating/cooling, lighting and ventilation; and maintenance cost of glazed areas (access for cleaning and reglazing) should be considered.

4.1.4 Selection of appropriate glass may be done considering the cost benefit analysis in respect of the benefit accrued against the alternatives available. Also, the comparative cost of glazing materials should be considered together with their life expectancy and probability of need for maintenance. In the context of selection of glass, the provisions given in the Part 11 'Approach to Sustainability' of the Code may also be considered in addition to the cost benefit analysis on the use of glass *vis-à-vis* use of other alternatives. To suitably modify to indicate that the selection of appropriate glass may be made considering the cost benefit analysis in respect of the benefit accrued against the alternatives available

4.2 Types of Glass

4.2.1 The soda lime silicate glass is classified based on the type of internal stress which determines the strength of the glazing towards breakage, design and installation procedure and based on application. Table 1 gives the typical properties of various types of glass.

4.2.2 *Normal (Annealed) Glass*

For requirements including tests on nominal thickness of annealed (flat) glass {*see* Table 1 of accepted standard [6-8(3)]}. Flat transparent sheet glass shall conform to the following classes as specified in accepted standard [6-8(3)] namely; A quality or Selected Quality (SQ), B quality or Ordinary Quality (OQ) and C Quality or Greenhouse Quality (GQ). Transparent float glass shall be as per accepted standard [6-8(4)].

A transparent flat glass is designated as clear glass when it is not tinted and when its light transmittance after any necessary pre-treatment is greater than the value prescribed in Table 2 for the nominal thickness.

4.2.3 *Laminated Safety Glass*

Two or more pieces of glass held together by an interleaving layer or layers of plastic sheet material. The laminated safety glass will crack and break under sufficient impact, but the pieces of glass tend to adhere to the plastic and do not fly. For requirements of laminated safety glass, accepted standard [6-8(5)] shall be referred.

~~**4.2.3.1** Laminated glass is a glass configuration made of two or more pieces of glass bonded together by interlayer/interlayers. It is commonly used as a form of safety glass which cracks and breaks under sufficient impact, the broken glass fragments being still held together. When laminated glass is broken, fragments tend to adhere~~

~~to the interlayer. For requirements of laminated safety glass, accepted standard [6-8(5)] may be referred.~~

Table 1 Typical Properties of Various Types of Glass
(*Clause* 4.2.1)

Sl No.	Properties	Annealed Glass	Float Glass	Annealed Laminated Glass	Tempered or Toughened Glass
(1)	(2)	(3)	(4)	(5)	(6)
i)	Modulus of rupture	40 N/mm^2	40 N/mm^2	40 N/mm^2	120 to 200 N/mm^2
ii)	Thickness	As per accepted standard [6-8(3)]	As per accepted standard [6-8(4)]	6.38 - 19 mm	3 - 19 mm
iii)	Density (approximate)	← 2 400 – 2 550 kg/m^3 →			
iv)	Modulus of elasticity	← 70 GPa →			
v)	Coefficient of linear expansion	← 9 x 10^{-6} m/m K →			
vi)	Compressive strength	← 1 000 N/mm^2 →			

NOTE — Conventionally, the following types of glass exist:

a) Annealed (clear) glass.
b) Extra clear glass.
c) Body tinted glass.
d) Coated glass (including Lacquered glass).
   1) Online coated glass.
   2) Offline coated glass.
e) *Processed glass* - Each of the glasses (a) to (e) above can be subjected to further processing to produce the following types:
   1) Heat strengthened,
   2) Toughened or tempered,
   3) Double glazed unit,
   4) Laminated glass (Single laminated),
   5) Laminated double glass unit,
   6) Ceramic/screen printed fritted glass (patterned glass), and
   7) Fire safety glass.

Table 2 Minimum Light Transmittance Value
(Designating a Transparent Glass as Clear Glass)
(*Clause* 4.2.2)

Nominal Thickness, mm	2	3	4	5	6	8	10	12	15	19	25

Minimum Value of Light Transmittance, Percent	89	88	87	86	85	83	81	79	76	72	67

~~**4.2.3.2** Laminated glass does not shatter like ordinary glass. It absorbs impact, resists penetration, and remains intact even if broken, holding glass fragments in place and lowering the risk of injury. Laminated glass is capable to stop flying debris and limit or avoid splintering on opposite side of the impact. When exposed to heat from solar radiation resulting in unequal temperature in the pane, laminated glass breaks but stays in place longer. The risk of thermal breakage is reduced only when heat strengthened/ tempered laminated glass is used.~~

~~**4.2.3.3** Laminated glass can be made from the following typical combinations:~~

a) ~~Glass which is float/sheet/patterned/polished wired/wired patterned glass, and may be having the following properties:~~

   1) ~~clear, tinted or coated;~~
   2) ~~transparent, translucent or opaque;~~
   3) ~~annealed, heat strengthened or toughened; and~~
   4) ~~surface treated (such as acid etched or by sandblast).~~

b) ~~Plastic glazing sheet material which can be polycarbonate or acrylic and may be having the following properties:~~

   1) ~~clear, tinted or coated; and~~
   2) ~~transparent or translucent.~~

c) ~~Interlayers which differ based on material type and composition; mechanical characteristics; and optical characteristics, and may be having the following properties:~~

   1) ~~Clear or coloured;~~
   2) ~~Transparent, translucent or opaque; and~~
   3) ~~Coated.~~

~~NOTE – Until standards on plastic glazing sheet materials and interlayers are formulated, they will be subject to the specifications of manufacturers of laminated glazing materials.~~

4.2.4 *Toughened (Tempered) Safety Glass*

A single piece of specially heat treated glass, with a stress pattern such that the piece when fractured reduces to numerous granular fragments, with no large jagged edges. For requirements of toughened safety glass, accepted standard [6-8(5)] shall be referred.

~~**4.2.4.1** Toughened glass is a type of safety glass which is heat treated to a uniform temperature of approximately 650 ºC and rapidly cooled to induce compressive~~

stresses of 75.5 MPa (770 kg/cm^2) to 143.4 MPa (1 462 kg/cm^2) on the surfaces and edge compression of the order of 66.7 MPa (680 kg/cm^2). For requirements of toughened safety glass, accepted standard [6-8(5)] may be referred.

4.2.4.2 Toughened glass gains its added strength from the compressed surfaces. However, if a deep scratch or an impact penetrates the surface, the glass shall break into a number of small particles. Any attempt to cut, drill, grind or sand blast the glass after toughening may result in glass breakage. The heat treatment process does not change the light transmission and solar radiant heat properties of the glass.

4.2.4.3 Toughened glass provides greater thermal strength. It increases resistance to both sudden temperature changes and temperature differentials up to 250 °C compared with normal glass, which can withstand temperature differentials up to 40 °C only. Thermally toughened glass is approximately four times stronger than annealed glass of the same thickness and configuration, and shall comply with the requirements of accepted standard [6-8(5)]. Toughened glass is difficult to break and when broken, it breaks into many relatively small fragments, which are less likely to cause serious injury to people, as there are no jagged edges or sharp corners like in normal glass. On the contrary, the toughened glass is also susceptible to breakage when hit with a small tap at its edge using a hammer or a hard object. Toughened glass is often referred to as safety glass because it meets the requirements of the standards which apply to safety glass. Toughened glass cannot be subjected to further processing, such as cutting, drilling, edge grinding after toughening and any alterations such as sandblasting or acid etching will weaken glass and can cause premature failure (*see* Notes).

Float glass contains some level of imperfection. One type of imperfection is nickel sulphide (NiS) inclusions. Most NiS inclusions are stable and cause no problems. There is, however, the potential for NiS inclusions that may cause spontaneous breakage in fully tempered glass without any load or thermal stress being applied. Heat soak testing is a process that exposes critical NiS inclusions in fully tempered glass. The process involves placing the tempered glass inside a chamber and raising the temperature to approximately 290 ºC to accelerate nickel sulphide expansion. This causes glass containing nickel sulphide inclusions to break in the heat soak chamber, thus reducing the risk of potential field breakage. However, the heat soak process is not 100 percent effective.

NOTES

1 The process of toughening is used to increase the strength of glass and to produce fracture characteristics that are desirable in many situations. However, the process of toughening can also lead to an increased risk of spontaneous glass fracture (associated with material impurities). Accordingly, the possibility of spontaneous fracture should be taken into account when toughened glass is used.

2 Heat soaking may minimise the risk of nickel sulphide induced spontaneous fracture in toughened glass. Glass manufacturers maybe consulted for advice relating to anticipated nickel sulphide minimization.

4.2.5 *Heat Strengthened Glass*

Heat strengthened glass is a type of tempered glass which has been strengthened thermally by inducing a surface compression of about 44.3 MPa (422 kg/cm^2) to 64.5

~~MPa (658 kg/cm^2) as compared to a range of 75.5 MPa (770 kg/cm^2) to 143.4 MPa (1 462 kg/cm^2) in case of fully tempered glass. Heat strengthened glass is valued for its mechanical strength, which is twice that of normal annealed glass though half of toughened glass. With the exception of strength and thermal resistance characteristics, heat strengthened glass retains the normal properties of annealed glass. Heat strengthened glass provides necessary resistance to thermal stress associated with high performance glazing materials such as tinted glass and reflective glass. It also provides necessary resistance to heat building up when used as spandrel glass. Heat strengthened glass with its flatter surface also results in the facade having less optical distortions. Heat strengthened glass shall have a surface compression of 31 - 52 MPa.~~

A single piece of glass within which a permanent surface compressive stress, additionally to the basic mechanical strength, has been induced by a controlled heating and cooling process in order to give it increased resistance to mechanical and thermal stress and prescribed fracture characteristics {*see* **6.1.5** of accepted standard [6-8(25)]}. Heat strengthened glass shall have a surface compression between 31 and 52 MPa (4 500 and 7 500 psi) when tested as prescribed in **6.5** of accepted standard [6-8(25)]. For requirements of heat strengthened glass, accepted standard [6-8(14)] shall be referred.

~~NOTES~~

1. ~~Heat strengthening associated with relatively less residual stresses ≤ 52.0 MPa has lower risk of spontaneous glass fracture (associated with material impurities).~~
2. ~~Surface Compression including (fragmentation) four point bending, wrap and waviness tests are typically carried out to determine the characteristics of heat strengthened glass.~~

4.2.6 *Reflective Glass*

A metallic coating is applied to one side of the glass in order to significantly increase the amount of reflection by the glass of both the visible and infrared (light and heat) ranges of the electromagnetic spectrum. This metallic coating can be applied to clear or body tinted glass, without adversely affecting the transparency of the glass. The reflective glass imparts an enhanced appearance to the exterior of buildings due to the coating of metal oxides on the glass. It is widely applied as an aesthetic and energy efficient product in buildings for its highly reflective surface and wide palette of colours. It reduces heat gain and glare from the exterior and allows optimum visible light transmission to the interior. If designed/used properly, reflective glass can aid at reducing the air conditioning load of buildings

NOTE – Highly reflective glass should be avoided, especially in internal environments. The reflections from these surfaces can be particularly confusing for persons with vision impairment.

4.2.7 *Insulating Glass Unit*

Insulating glass unit, a prefabricated unit of glass having an edge seal that not only binds the individual sheets of glass together to maintain the mechanical strength of the joint but also protects the cavity between the glasses from outside influences. The moisture in the cavity between the two glasses is controlled by desiccants filled in the perforated spacer. The spacer may be aluminium, composites, plastics, etc. The spacer ensures the precise distance between the glass panes. The cavity is normally filled with dry air but can be also filled with gases such as argon or krypton for better thermal performance. The low heat conductivity of the enclosed dry gas between the glass panes drastically reduces the thermal heat transmission through the glass. ~~to 2.8 W/m²K (12 mm spacer between two 6 mm glass) as compared to 5.73 W/m²K for normal 6 mm glass.~~ It also helps in reducing the direct solar energy specifically when the outer pane is a solar control glass. For sizes greater than 3 m^2, the thickness of the spacer shall be chosen such that physical contact of glass panes (white spots) does not occur. The number of panes of glass may be two (double glazed unit) or three (triple glazed unit) or more depending upon the overall requirement.

NOTE – Moisture penetration test and argon/krypton gas level test are typically carried out to determine the characteristic of IGUs.

4.2.8 *Wired Glass*

The general requirements including thickness, dimensional tolerance and tests for wired glass as specified in accepted standard [6-8(6)] are valid.

4.2.9 *Glass Fins*

When glass fins are used as a decorative member, it can be either toughened (tempered) or laminated glass.

When glass fins are used as a structural member, it shall be toughened and laminated. The depth and thickness may vary as per elevation and wind load requirements. Design should also accommodate movements. It is recommended to use finite element analysis to determine the appropriate glass fin sizes.

4.3 Application

Glass can be designed/suited to use in building occupancies such as in residential, assembly and mercantile in elements such as façades, windows, doors, partitions, display units, shop fronts, greenhouses (where plants are grown), atrium. Different types of glass are selected based on requirements. For safety against accidental breakage and strength requirement (mechanical and thermal), toughened glass or laminated glass may be considered over annealed glass. For increased high security requirements, acoustic insulation, sloped glazing and skylights, laminated glass may be considered.

4.4 Associated Glazing Materials

4.4.1 *Structural Sealant*

The structural sealant could be of silicone type with requirements meeting the design criteria. Structural sealant shall be shelf-stable, natural-cured, elastomeric adhesive exhibiting the desired adhesion to building substrates. The structural sealant may require cleaning and or priming to get good adhesion for structural glazing application.

For laminated glass applications where glass edges are sealed with a sealant, compatibility shall be ensured with the interlayer to avoid delamination.

(*Note: A reference to the code on Structural Sealant shall be included in this clause upon its publication.)

4.4.2 *Gaskets*

Gasket is a mechanical seal that fills the space between two mating surfaces, to prevent leakage from or into the joined objects and will be able to deform while under compression and tightly fills the space it is designed for, including any slight irregularities. Gaskets shall be as per **5.10** of accepted standard [6-8(26)].

4.4.3 *Preformed Tape*

Typical requirements of preformed butyl and foam tapes shall be as given in Table 3.

4.4.4 *Setting Blocks, Location Blocks and Distance Pieces*

Setting blocks, location blocks, and distance pieces shall be designed in accordance with **6** which are,

a) resilient, load-bearing, non-absorbent and rot-proof materials; and
b) compatible with all other materials that may come in contact with them.

4.5 General Requirements

4.5.1 Glazing and associated materials used for the proper installation shall satisfy the minimum dimensional and framing requirements in accordance with the procedures given in this Section. The dimensional and thickness tolerance of the glass used in exterior and interior is determined from the provisions given hereunder.

4.5.2 *Dimensional Requirement*

4.5.2.1 The dimensions for edge clearance, edge cover, and front and back clearance, as defined in Fig. 2, shall be not less than the values given in Table 4.

NOTE – For glazing systems where the framing member is aluminium or steel and gaskets are used to capture the glazing, minimum glazing bite of 12.7 mm is recommended for architectural glazing.

4.5.2.2 *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.

Table 3 Typical Properties of Preformed Tapes
(*Clause* 4.4.3)

Sl No.	Properties	Requirement

(1)	(2)	(3)
i)	Low temperature flex	No cracks at -23° C
ii)	Weight loss	2 percent, *Max*
iii)	Vehicle migration	1 paper stained maximum and this stain shall be no more than 3.2 mm from edge of sample maximum
iv)	Backing removal	No transfer of tape compound to the paper
v)	Yield strength	41.4 kPa, *Min*
vi)	Compression/Recovery	Compression index, 1.22 N/mm^2, *Max*
vii)	Water absorption	Weight gain maximum after boiling, 40 kg/m^3
viii)	Flow test	Loss of height, 60 percent, *Max*

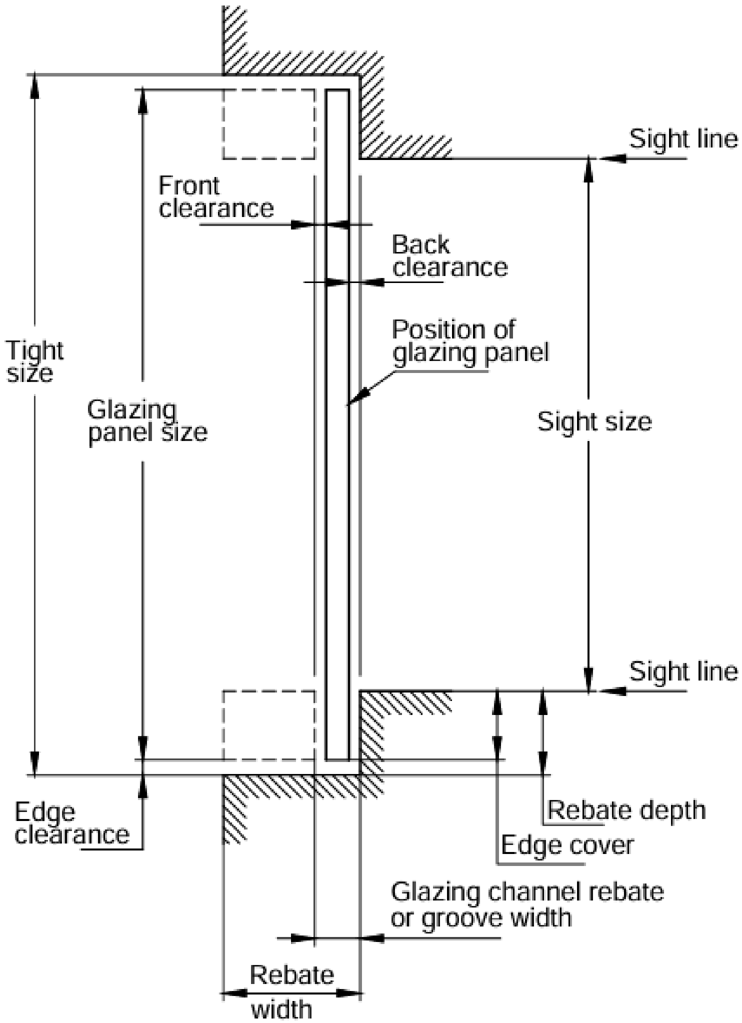


FIG. 2 SIZES AND REBATES

4.5.2.3 *Dimensions of rebates and grooves (width and depth)*

Dimensions of rebates and grooves shall accommodate the requirements of Table 4 and allow for the appropriate setting and location blocks (*see also* **6**).

4.5.2.4 *Glass dimensional tolerance*

The tolerance for dimensions shall be as per those in the respective list of Indian Standards.

4.6 Frame Requirements

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

4.6.2 *Deflection Limits*

The frame deflection limits under serviceability loading shall satisfy the conditions for four sided frames as given in **6.3.6.2**(c).

NOTE – In framing members, where reinforcement/fixing brackets are required to meet the deflection/stress criteria, it may be of aluminium or steel. When steel is used, proper dielectric galvanic separation shall be used. The material chosen for reinforcement shall be in close proximity in the galvanic series, to ensure dielectric separation.

4.6.3 *Panels Glazed into the Building Structure*

A panel glazed directly into a building structure by means of appropriate beads or stops shall be considered to be framed, provided the assembly complies with the deflection requirements of **4.6.2**.

4.6.4 *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 **4.6.2**.

4.7 Glass Dimensions

4.7.1 The actual thickness for ~~exterior and interior~~ each pane of glass ~~[other than DGU (Double Glazing Unit)]~~ ~~use~~ shall be measured using screw caliper {for example as per **5.1** of accepted standard [6-8(3)]}.

The actual thickness of glass, rounded to the nearest 0.1 mm shall not vary from the nominal thickness by more than the tolerances specified in respective Indian Standard or the values provided in this Section (unless Indian Standard specification are developed).

The minimum thickness allowed in insulated glass unit (IGU) should be the sum of minimum thickness allowed of two panes as per accepted standard [6-8(4)] plus thickness of air-gap.

The minimum thickness allowed in laminated glass should be the sum of minimum thickness allowed of two panels as per accepted standard [6-8(4)] plus thickness of interlayer (*see* Table 5).

Table 4 Minimum Dimensions for Glazing Material
(*Clause* 4.5.2.1)

All dimensions in millimetres.

Sl No.	**Nominal Thickness**	**Front and Back Clearance**			**Edge Clearance**	**Edge Cover**	**Rebate Depth**
		Type A (*See* Note 1)	Type B (*See* Note 2)	Type C (*See* Note 3)			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	3 (for pane area up to 0.1 m^2)	2	-	-	2	4	6
ii)	3 (for pane area > 0.1 m^2)	2	-	-	3	6	9
iii)	3	-	2	1	3	6	9
iv)	4	2	-	-	2	6	8
v)	4	-	2	1	3	6	9
vi)	5	2	2	2	4	6	10
vii)	6	2	2	2	4	6	10
viii)	8	-	3	2	5	8	13
ix)	10	-	3	2	5	8	13
x)	12	-	3	2	6	9	15
xi)	15	-	5	4	8	10	18
xii)	19	-	5	4	10	12	22
xiii)	25	-	5	4	10	15	15

NOTES

1 Type A applies to linseed oil and metal casement putties.

2 Type B applies to non-setting glazing compounds, plastic glazing compounds, two-part rubberizing compounds, sealants and preformed strip materials.

3 Type C applies to gaskets made from extruded materials such as butyl strip, PVC, neoprene and sanoprene held in position by pressure upon the glass.

4 For non-standard glass thicknesses the nearest values of nominal thickness, shall be used.

5 Timber and PVC frames may not require the specified front and back clearances provided the waterproofing performance requirements are met.

6 The dimensions are the minimum necessary for the structural integrity of glass only but do not apply to insulating glass units.

Table 5 Thickness and Tolerances for Laminated Glass
(*Clause* 4.7.1)
All dimensions in millimetres.

Thickness	6	8	10	12	16	20	24

Tolerance	± 0.6	± 0.6	± 0.6	± 0.6	± 1.2	± 1.2	± 1.2

4.7.2 Length and width are defined with reference to the direction of draw of the flat glass ribbon (*see* Fig. 3).

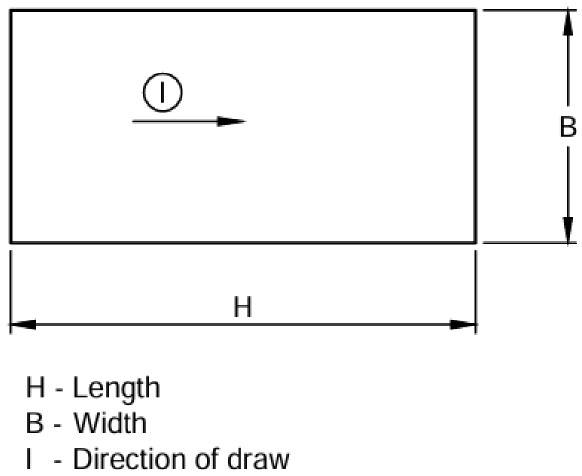


FIG. 3 REPRESENTATION OF LENGTH, WIDTH AND DIRECTION OF DRAW

4.7.3 *Jumbo Sizes*

Glass is available commonly in the following sizes of nominal length, *H*, 4 500 mm to 6 000 mm and nominal width, *B*, 3 660 mm or 3 210 mm.

NOTE **–** The usual width is 3 660 mm or 3 210 mm. Other sizes may be mutually agreed to between the manufacturer and the user based on their requirement.

4.7.4 *Stock Size*

Glass is available commonly in the following sizes nominal length, *(H*), 2 250 mm or 2 440 mm and nominal width, (*B*), 3 660 mm or 3 210 mm.

NOTE **–** Maximum glass size available from manufacturer are one consideration, the processing equipment limitation, capabilities of contract fabricator to install unit, availability of specialized transport and handling equipment to deliver unit should be checked in addition.

4.7.5 *Split Sizes*

Glass is delivered in equal or unequal split sizes from the jumbo or stock size.

4.7.6 *Squareness*

The nominal dimensions for length (*H*), and width (*B*), be given, the pane shall not be larger than a prescribed rectangle resulting from the nominal dimensions increased by the permissible plus tolerance or smaller than a prescribed rectangle reduced by the permissible minus tolerance.

The sides of the prescribed rectangles (*see* Fig. 4) shall be parallel to one another and these rectangles shall have a common centre. For stock/standard sizes the tolerances on nominal dimensions length (*H*), and width (*B*), are ± 5 mm.

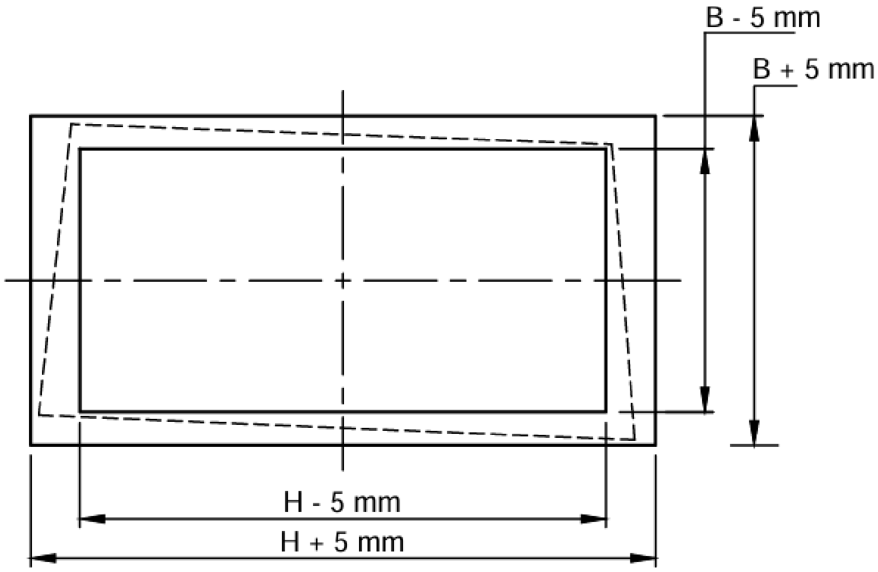


FIG. 4 DETERMINATION OF LENGTH, WIDTH AND SQUARENESS FOR STOCK/SQUARENESS DIRECTION OF DRAW

4.7.7 *As-Cut Finished Size*

The nominal dimension for width and length being given, the finished pane or as-cut finished size shall not be greater than the prescribed rectangle from the nominal dimension increased by the tolerance '*t*' or smaller than the prescribed rectangle reduced by the tolerance '*t*'. The sides of the prescribed rectangles are parallel to one another and these shall have a common centre in accordance with Fig. 5. The limits of the squareness are also mentioned. Tolerances are given in Table 6.

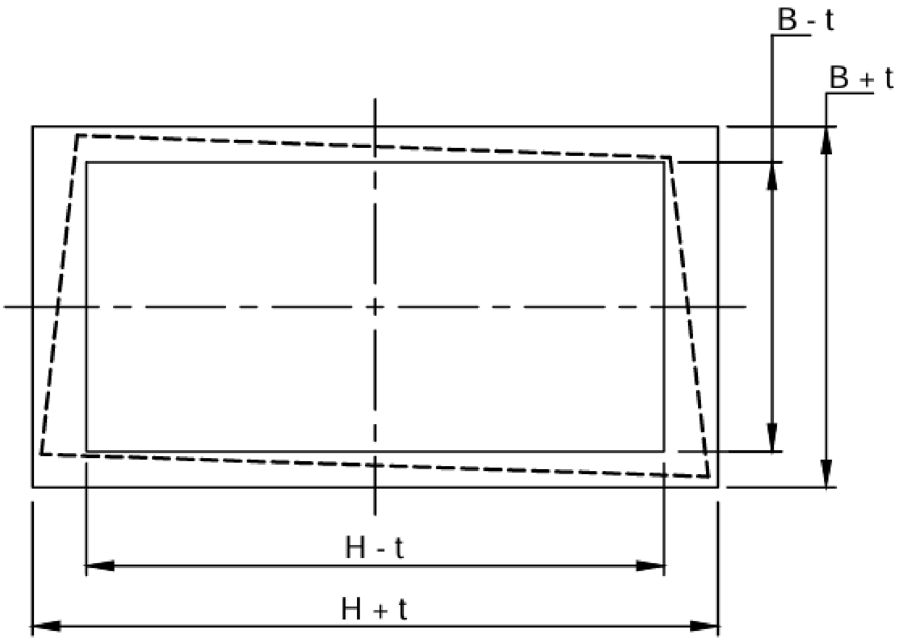


FIG. 5 TOLERANCE (t) FOR WIDTH (B) AND LENGTH (H)

Table 6 Tolerance on Width (*B*) and Length (*H*)
(*Clause* 4.7.7)

Sl No.	**Nominal Dimension** mm	**Tolerance 't'**	
		Nominal Glass Thickness d ≤ 8 mm	**Nominal Glass Thickness d> 8** mm
(1)	(2)	(3)	(4)
i)	≤ 2 000	± 2.5	± 3.0
ii)	2 000 < *B* or *H* ≤ 3 000	± 3.0	± 4.0
iii)	> 3 000	± 4.0	± 4.0

NOTE – While the above tolerances are generally applicable, with the advancements in manufacturing, the following suggested tolerance may be suitably decided between the concerned parties:

a) For glass of thickness up to 8 mm, tolerance shall be 1 mm per linear metre.
b) For glass of thickness above 8 mm and up to 16 mm, tolerance shall be 1.5 mm per linear metre.
c) For glass of thickness above 16 mm, tolerance shall be 2 mm per linear metre.
d) However, upper limit of tolerance shall be:
   1) ± 2.0 mm (for glass thickness ≤ 8 mm),
   2) ± 3.0 mm (for glass thickness ≤ 16mm), and
   3) ± 5.0 mm (for glass thickness > 16 mm).

5 ENERGY AND LIGHT

5.1 Energy and Thermal Properties of Glass

5.1 General

The energy and thermal properties of glass is defined by light transmission, internal and external reflection, solar heat gain coefficient and *U*-value. Energy performance of glazing system is defined in terms of U-value, solar heat gain coefficient, visible light transmission, internal and external reflection. The overall performance is determined by the efficiency of glass, frame, shading systems and the airtightness of the system. The performance requirement for glazing system shall be suitably selected. Minimum performance requirement is mentioned in the Annex A.

Specific methods of calculating light and energy factors for glass in buildings are covered here and their characteristic data can serve as a basis for light, heating and ventilation calculations of rooms and can permit comparison between different types of glazing. It is applicable to all flat glass material.

5.2 Thermal Energy Transmission

5.2.1 *General*

Glazed areas in buildings should be designed so that account is taken of the overall energy balance in relation to the effects on the thermal comfort of occupants and the total annual energy implications of solar gain and energy loss.

These should be examined separately, since factors affecting one aspect of performance might have no effect on the other. Energy gain is due to transmission of solar radiant energy through the glass into the building. Solar energy is all at relatively short wavelengths and is controlled by using the glass to absorb or reflect the energy. Energy loss is due to the transfer of energy by conduction, convection and long wavelength radiation and can be influenced by a number of factors, for example incorporating air cavities, including gases of low thermal conductivity and/or low emissivity glass.

Glazed areas in buildings should be designed considering overall energy balance, the effects on thermal comfort of occupants and the cooling & heating energy requirements. Energy gain is due to transmission of solar radiant energy through the glass into the building. Solar energy is all at relatively short wavelengths and is controlled by using the glass to absorb or reflect the energy. Energy loss is due to the transfer of energy by conduction, convection and long wavelength radiation. The energy gain and losses can be regulated by several factors, for example incorporating air cavities, including low emissivity glass and use of shading systems. Solar energy gain through glazing systems can be advantageous in cold climates for improving thermal comfort and reducing the heating energy requirements.

5.2.2 *Thermal comfort*

Energy transmission through glazing can significantly influence occupant comfort by raising or lowering room air temperatures. For example, hot sunny weather can lead to excessive energy gains and energy losses can occur through the glazing during cold weather or at night. Thermal comfort can also be influenced by direct solar radiation through the glazing and/or by radiation exchange between the glazing and the occupants. Appropriate choice of glazing and opaque wall systems is essential to avoid radiant asymmetry related thermal discomfort.

5.2.3 *Solar energy gain*

The solar energy transmitted through the glass from the outside environment is the part of solar radiation which is transmitted directly through the glass and the part which is re-emitted from the glass after being absorbed. In warm and hot climates, this heat energy which is transmitted through the glass has to be limited in-order to achieve thermal comfort for the occupants and also to reduce the energy demands of the building. Factors that can influence the amount of solar gain through the glazing include,

a) orientation;
b) glazed area;
c) shading devices, both internal and external; and
d) properties of the glazing.

5.2.4 *Total solar energy transmittance*

Total solar energy transmittance is the proportion of solar radiation at normal incidence transferred through the glazing. It is composed of the direct transmittance (short wave component) and the part of the solar absorptance dissipated inwards by long wave radiation and convection (long wave component). The total solar energy transmission properties of solar control glazing can be described by their shading coefficients and solar heat gain coefficient (SHGC) / solar factor (SF). The shading coefficient is derived by comparing the properties of the solar control glazing with a clear float glass having a total solar energy transmittance of 0.87 (that is clear glass between 3 mm and 4 mm thick).

Solar heat gain coefficient (SHGC)/solar factor (SF) is the measure of amount of heat transfer from outside to inside by direct transmission (Short Wave Radiation) and internal remitted radiation (Long Wave Radiation). The SHGC (*see* Fig. 6) or SF depends on the tint of the substrate and the type of coating that is done on the base glass. The amount of solar energy gained through glass is between 0 and 1. Multiplying the SHGC or SF by 100 gives the percentage of solar energy allowed into the building.

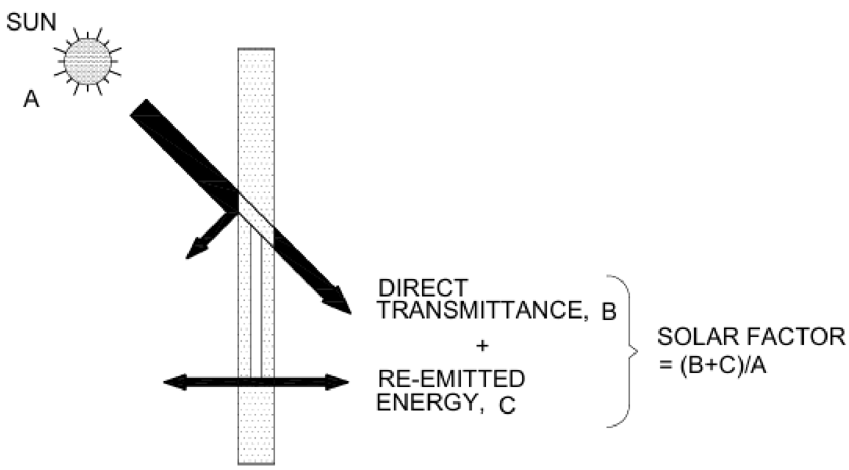


FIG. 6 SOLAR HEAT GAIN COEFFICIENT

The total solar energy transmittance *g* is the sum of the solar direct transmittance τ_e and the secondary heat transfer factor q_i towards the inside, the latter resulting from heat transfer by convection and long-wave IR-radiation of that part of the incident solar radiation which has been absorbed by the glazing and is expressed as:

$$g = \tau_e + q_i$$

~~NOTE — Total solar energy transmittance is also known as '*g*' value.~~

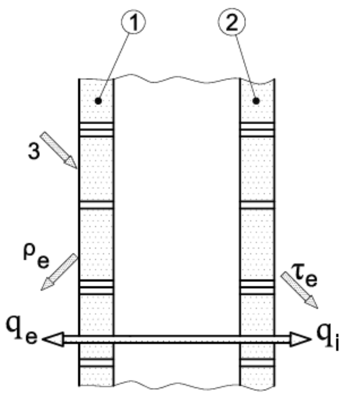
5.2.5 *Division of Incident Solar Radiation Flux*

The incident solar radiant flux per unit area φ_e is divided into the following three parts (*see* Fig. 7):

a) Transmitted part, $\tau_e \varphi_e$;
b) Reflected part, $\rho_e \varphi_e$; and
c) Absorbed part, $\alpha_e \varphi_e$;

where

τ_e = solar direct transmittance,
ρ_e = solar direct reflectance, and
α_e = solar direct absorptances.



KEY :
1 OUTER PANE
2 SECOND INNER PANE
3 UNIT INCIDENT RADIANT FLUX
ρ_e = 0.38; q_e = 0.17;
τ_e = 0.41; q_i = 0.04; therefore g = 0.45

FIG. 7 COMPONENTS OF INCIDENT SOLAR RADIANT FLUX

The relationship between the three characteristics is:

$$\tau_e + \rho_e + \alpha_e = 1$$

The absorbed part $\alpha_e \varphi_e$ is subsequently divided into two parts $q_i \varphi_e$ and $q_e \varphi_e$, which are energy transferred to the inside and outside, respectively:

$$\alpha_e = q_i + q_e$$

where

q_i = secondary heat transfer factor of the glazing towards the inside; and
q_e = secondary heat transfer factor of the glazing towards the outside.

5.2.6 *Solar Direct Transmittance*

The solar direct transmittance τ_e of glazing shall be calculated using the following formula:

$$\tau_e = \frac{\sum_{\lambda = 300 \text{ nm}}^{2\,500 \text{ nm}} \tau(\lambda) S_\lambda \, \Delta\lambda}{\sum_{\lambda = 300 \text{ nm}}^{2\,500 \text{ nm}} S_\lambda \Delta\lambda}$$

where

S_λ = relative spectral distribution of the solar radiation;
$\tau(\lambda)$ = spectral transmittance of the glazing; and

$\Delta\lambda$ = integration procedure are the same as in **5.4.5.4** except that the data points shall be chosen at the wavelengths given in Table 7.

5.2.7 *Solar Direct Reflectance*

The solar direct reflectance ρ_e of the glazing shall be calculated using the following formula:

$$\rho_e = \frac{\sum_{\lambda = 300\ \text{nm}}^{2\,500\ \text{nm}} \rho_o(\lambda)\, S_\lambda\, \Delta\lambda}{\sum_{\lambda = 300\ \text{nm}}^{2\,500\ \text{nm}} S_\lambda\, \Delta\lambda}$$

where

S_λ = relative spectral distribution of the solar radiation (*see* **5.2.6**);
$\rho_o(\lambda)$ = spectral external reflectance of the glazing; and
$\Delta\lambda$ = integration procedure are the same as in light transmittance except that the data points shall be chosen at the wavelengths given in Table 7.

In the case of multiple glazing, the spectral external reflectance ρ_o (λ) is calculated in accordance with **5.5.1**.

Table 7 Normalized Relative Spectral Distribution of Global Solar Radiation
(*Clauses* 5.2.6, 5.2.7, 5.2.9.3 *and* 5.2.9.4)

λ nm (1)	**$S_\lambda\Delta\lambda$** (2)
300	0
305	0.000 057
310	0.000 236
315	0.000 554
320	0.000 916
325	0.001 309
330	0.001 914
335	0.002 018
340	0.002 189
345	0.000 260
350	0.002 445
355	0.002 555
360	0.002 683
365	0.003 020
370	0.003 359
375	0.003 509
380	0.003 600
385	0.003 529
390	0.003 551

λ nm (1)	***S***$_{\lambda}$**Δ*****λ*** (2)
395	0.004 294
400	0.007 812
410	0.011 638
420	0.011 877
430	0.011 347
440	0.013 245
450	0.015 343
460	0.016 166
470	0.016 178
480	0.016 402
490	0.015 794
500	0.015 801
510	0.015 973
520	0.015 357
530	0.015 857
540	0.015 827
550	0.015 844
560	0.015 590
570	0.015 255
580	0.014 745
590	0.014 330
600	0.014 663
610	0.015 030
620	0.014 859
630	0.014 622
640	0.014 526
650	0.014 445
660	0.014 313
670	0.014 023
680	0.012 838
690	0.011 788
700	0.012 453
710	0.012 798
720	0.010 589
730	0.011 233
740	0.012 175
750	0.012 181
760	0.009 515
770	0.010 479
780	0.011 381
790	0.011 262
800	0.026 718
850	0.048 240
900	0.040 297
950	0.021 384
1 000	0.036 097
1 050	0.034 110

λ nm (1)	$S_\lambda \Delta\lambda$ (2)
1 100	0.018 861
1 150	0.013 228
1 200	0.022 551
1 250	0.023 376
1 300	0.017 756
1 350	0.003 743
1 400	0.000 741
1 450	0.003 792
1 500	0.009 693
1 550	0.013 693
1 600	0.012 203
1 650	0.010 615
1 700	0.007 255
1 750	0.007 183
1 800	0.002 157
1 850	0.000 395
1 900	0.000 082
1 950	0.001 087
2 000	0.003 024
2 050	0.003 988
2 100	0.004 229
2 150	0.004 142
2 200	0.003 690
2 250	0.003 592
2 300	0.003 436
2 350	0.003 163
2 400	0.002 233
2 450	0.001 202
2 500	0.000 475

NOTE – The values in this table are calculated according to the trapezoidal rule.

5.2.8 *Solar Direct Absorptance*

The solar direct absorptance α_e shall be calculated from the following formula:

$$\tau_e + \rho_e + \alpha_e = 1$$

5.2.9 *Secondary Heat Transfer Factor Towards the Inside*

5.2.9.1 *Boundary conditions*

For the calculation of the secondary heat transfer factor towards the inside, q_i, the heat transfer coefficients of the glazing towards the outside, h_e, and towards the inside, h_i, are needed. These values mainly depend on the position of the glazing, wind velocity, inside and outside temperatures and, furthermore, on the temperature of the two external glazing surfaces.

As the purpose of this Section is to provide basic information on the performance of glazing, the following conventional conditions have been stated for simplicity:

a) Position of the glazing: vertical;
b) Outside surface: wind velocity approximately 4 m/s; corrected emissivity 0.837;
c) Inside surface: natural convection; emissivity optional; and
d) Air spaces are unventilated.

Under these conventional, average conditions, standard values for h_e and h_i are obtained:

$$h_e = 23 \text{ W/(m}^2\text{K)}$$

$$h_i = \left(3.6 + \frac{4.4\varepsilon_i}{0.837}\right) \text{W/(m}^2\text{·K)}$$

where

ε_i = corrected emissivity of the inside surface [for soda lime glass, ε_i = 0.837 and h_i = 8 W/(m^{2}K)].

If other boundary conditions are used to meet special requirements they shall be stated in the test report. Values for ε_i lower than 0.837 (due to surface coatings with higher reflectance in the far infrared) should only to be taken into account if condensation on the coated surface can be excluded.

5.2.9.2 *Single glazing*

The secondary heat transfer factor towards the inside, q_i, of single glazing shall be calculated using the following formula:

$$q_i = \alpha_e \frac{h_i}{h_e + h_i}$$

where

α_e	=	solar direct absorptance obtained from the in accordance with **5.2.5**, and
h_e, h_i	=	heat transfer coefficients towards the outside and inside, respectively, in accordance with **7.1.6.1**.

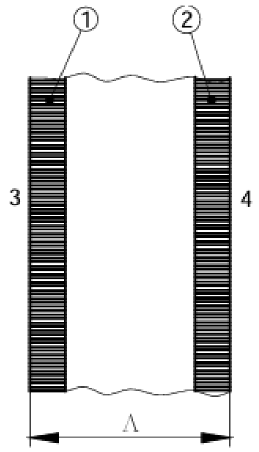
5.2.9.3 *Double glazing*

The secondary heat transfer factor towards the inside, q_i, of double glazing shall be calculated using the following formula:

$$q_i = \frac{\left(\frac{\alpha_{e1} + \alpha_{e2}}{h_e} + \frac{\alpha_{e2}}{\Lambda}\right)}{\left(\frac{1}{h_i} + \frac{1}{h_e} + \frac{1}{\Lambda}\right)}$$

where

α_{e1}	=	solar direct absorptance of the outer (first) pane within the double glazing;
α_{e2}	=	solar direct absorptance of the second pane within the double glazing;
Λ	=	thermal conductance between the outer surface and the innermost surface of the double glazing (*see* Fig. 8), in watts per square metre per Kelvin (W/m^2.K); and
h_e, h_i	=	heat transfer coefficients towards the outside and the inside, respectively in accordance with **5.2.9.1**.



KEY :
1 PANE 1
2 PANE 2
3 OUTSIDE
4 INSIDE

FIG. 8 ILLUSTRATION OF THE MEANING OF THERMAL CONDUCTANCE, Λ

Characteristics α_{e1} and α_{e2} are calculated as follows:

$$\alpha_{e1} = \frac{\sum_{\lambda = 300\ \text{nm}}^{2\,500\ \text{nm}} \left\{\alpha_1(\lambda) + \frac{\alpha_1'(\lambda)\,\tau_1(\lambda)\,\rho_2(\lambda)}{1-\rho_1'(\lambda)\,\rho_2(\lambda)}\right\} S_\lambda\,\Delta\lambda}{\sum_{\lambda = 300\ \text{nm}}^{2\,500\ \text{nm}} S_\lambda\,\Delta\lambda}$$

$$\alpha_{e2} = \frac{\sum_{\lambda = 300\text{ nm}}^{2\,500\text{ nm}} \left\{ \frac{\alpha_2(\lambda)\,\tau_1(\lambda)}{1 - \rho'_1(\lambda)\,\rho_2(\lambda)} \right\} S_\lambda\,\Delta\lambda}{\sum_{\lambda = 300\text{ nm}}^{2\,500\text{ nm}} S_\lambda\,\Delta\lambda}$$

where

$\tau_1(\lambda), \tau_2(\lambda), \rho_1(\lambda), \rho'_1(\lambda), \rho_2(\lambda)$ are as defined in light transmittance.

$\alpha_1(\lambda)$ = spectral direct absorptance of the outer pane, measured in the direction of the incident radiation, given by the relationship:
$\alpha_1(\lambda) = 1 - \tau_1(\lambda) - \rho_1(\lambda)$

$\alpha'_1(\lambda)$ = spectral direct absorptance of the outer pane, measured in the opposite direction to the incident radiation, given by the relationship:
$\alpha_1'(\lambda) = 1 - \tau_1(\lambda) - \rho'_1(\lambda)$

$\alpha_2(\lambda)$ = spectral direct absorptance of the second pane, measured in the direction of the incident radiation, given by the relationship:
$\alpha_2(\lambda) = 1 - \tau_2(\lambda) - \rho_2(\lambda)$

$\Delta\lambda$ and the integration procedure are the same as in **5.4.5.4** except that the data points shall be chosen at the wavelengths given in Table 7.

The thermal conductance Λ shall be determined for a temperature difference of ΔT = 15°C across the sample and a mean temperature of the sample of 10°C, or by measuring methods using the standard guarded hot plate method, or the standard heat flow metre method.

If another temperature difference ΔT across the sample and/or another mean temperature of the sample is used for the determination of the thermal conductance Λ to meet special requirements, this shall be stated in the test report.

5.2.9.4 *Multiple glazing with n > 2 components*

The secondary heat transfer factor towards the inside, q_i, of a multiple glazing with more than two components shall be calculated using the following formula:

$$q_i = \frac{\frac{\alpha_{e1} + \alpha_{e2} + \alpha_{e3} + \cdots + \alpha_{en}}{h_e} + \frac{\alpha_{e2} + \alpha_{e3} + \cdots + \alpha_{en}}{\Lambda_{12}} + \frac{\alpha_{e3} + \cdots + \alpha_{en}}{\Lambda_{23}} + \cdots + \frac{\alpha_{en}}{\Lambda_{(n-1)n}}}{\frac{1}{h_i} + \frac{1}{h_e} + \frac{1}{\Lambda_{12}} + \frac{1}{\Lambda_{23}} + \cdots + \frac{1}{\Lambda_{(n-1)n}}}$$

where

α_{e1} = solar direct absorptance of the outer (first) pane within the *n*-fold glazing;

α_{e2} = solar direct absorptance of the second pane within the *n*-fold glazing;

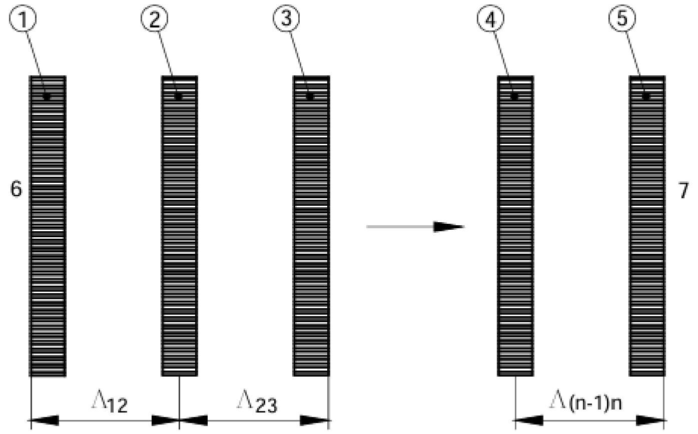
α_{en} = solar direct absorptance of the n^{th} (inner) pane of the *n*-fold glazing;

h_e, h_i = heat transfer coefficients towards the outside and towards the inside, respectively in accordance with **5.2.9.1**;

Λ_{12} = thermal conductance between the outer surface of the outer (first) pane and the centre of the second pane (*see* Fig. 9);

$\Lambda_{(n-1)n}$ = thermal conductance between the centre of the $(n-1)^{th}$ pane and the outer surface of the n^{th}(inner) pane (*see* Fig. 9); and

Λ_{23} = thermal conductance between the centre of the second pane and the centre of the third pane (*see* Fig. 9);



KEY :
1 PANE 1
2 PANE 2
3 PANE 3
4 PANE (n - 1)
5 PANE n
6 OUTSIDE
7 INSIDE

NOTE – For triple glazing, pane 3 corresponds to pane n

FIG. 9 ILLUSTRATION OF THE MEANING OF THE THERMAL CONDUCTANCES Λ_{12}, Λ_{23}........$\Lambda_{(n-1)n}$

The thermal conductances Λ_{12}, Λ_{23}........$\Lambda_{(n-1)n}$ shall be determined by iteration technique. The calculation of the direct solar absorptances α_{e1}, α_{e2},...α_{en} shall be performed using the methods given in **5.2.9.3**.

As an example for the calculation of the direct solar absorptances the following procedure is given which consist of the following (*n*-1) steps for a glazing consisting of *n* components.

a) first step – calculate the spectral characteristics of a unit consisting of (*n*-1) components 2,3,.......*n* according to what has been prescribed in **5.4.5.4** and **6.1**. Then combine this unit with the first (outer) pane as a double glazing.

b) second step – calculate the spectral characteristics of a unit consisting of the (n-2) components 3,....,n and furthermore, those of a double glazing consisting of pane 1 and pane 2. These units are then combined as a double glazing. The sum $\alpha_{e1} + \alpha_{e2}$ is then obtained. This procedure is continued up to the last (n-1)th step.

c) (n-1)th step – combine the (n-1) panes 1,2,... (n-1) and determine the spectral characteristics of this unit. This unit is then combined with the nth (inner) pane as a double glazing. From the second equation in **5.2.9.3**, the sum $\alpha_{e1}, \alpha_{e2} ... \alpha_{e(n-1)}$ is obtained, that is with the known values $\alpha_{e1}, \alpha_{e2}, ... \alpha_{e(n-2)}$ from the previous steps $\alpha_{e(n-1)}$ is determined. α_{en} is obtained according to the expression of α_{e2} in **5.2.9.3**.

In the case of triple glazing for the solar absorptances α_{e1}, α_{e2} and α_{e3} as a function of the spectral characteristics of the individual components of the unit, the following formulae are obtained:

$$\alpha_{e1} = \frac{\sum_{\lambda = 300\text{ nm}}^{2\,500\text{ nm}} \left\{ \alpha_1(\lambda) + \frac{\tau_1(\lambda)\,\alpha'_1(\lambda)\,\rho_2(\lambda)\left[1-\rho'_2(\lambda)\,\rho_3(\lambda)\right] + \tau_1(\lambda)\,\tau_2^2(\lambda)\,\alpha'_1(\lambda)\,\rho_3(\lambda)}{\left[1-\rho'_1(\lambda)\,\rho_2(\lambda)\right]\cdot\left[1-\rho'_2(\lambda)\,\rho_3(\lambda)\right] - \tau_2^2(\lambda)\,\rho'_1(\lambda)\,\rho_3(\lambda)} \right\} S_\lambda\,\Delta\lambda}{\sum_{\lambda = 300\text{ nm}}^{2\,500\text{ nm}} S_\lambda\,\Delta\lambda}$$

$$\alpha_{e2} = \frac{\sum_{\lambda = 300\text{ nm}}^{2\,500\text{ nm}} \left\{ \frac{\tau_1(\lambda)\,\alpha_2(\lambda)\left[1-\rho'_2(\lambda)\,\rho_3(\lambda)\right] + \tau_1(\lambda)\,\tau_2(\lambda)\,\alpha'_2(\lambda)\,\rho_3(\lambda)}{\left[1-\rho'_1(\lambda)\,\rho_2(\lambda)\right]\cdot\left[1-\rho'_2(\lambda)\,\rho_3(\lambda)\right] - \tau_2^2(\lambda)\,\rho'_1(\lambda)\,\rho_3(\lambda)} \right\} S_\lambda\,\Delta\lambda}{\sum_{\lambda = 300\text{ nm}}^{2\,500\text{ nm}} S_\lambda\,\Delta\lambda}$$

$$\alpha_{e3} = \frac{\sum_{\lambda = 300\text{ nm}}^{2\,500\text{ nm}} \left\{ \frac{\tau_1(\lambda)\,\tau_2(\lambda)\,\alpha_3(\lambda)}{\left[1-\rho'_1(\lambda)\,\rho_2(\lambda)\right]\cdot\left[1-\rho'_2(\lambda)\,\rho_3(\lambda)\right] - \tau_2^2(\lambda)\,\rho'_1(\lambda)\,\rho_3(\lambda)} \right\} S_\lambda\,\Delta\lambda}{\sum_{\lambda = 300\text{ nm}}^{2\,500\text{ nm}} S_\lambda\,\Delta\lambda}$$

where

$\tau_1(\lambda)$, $\tau_2(\lambda)$, $\tau_3(\lambda)$, $\rho_1(\lambda)$, $\rho'_1(\lambda)$, $\rho_2(\lambda)$, $\rho'_2(\lambda)$, $\rho_3(\lambda)$ are as defined in light transmittance;

$\alpha_1(\lambda)$, $\alpha'_1(\lambda)$ and $\alpha_2(\lambda)$ are as defined in **5.2.9.3** double glazing;

$\alpha'_2(\lambda)$ = spectral direct absorptance of the second pane, measured in the opposite direction to the incident radiation, given by the relationship:

$\alpha'_2(\lambda) = 1 - \tau_2(\lambda) - \rho'_2(\lambda)$

$\alpha_3(\lambda)$ = spectral direct absorptance of the third pane, measured in the direction of the incident radiation, given by the relationship:

$\alpha_3(\lambda) = 1 - \tau_3(\lambda) - \rho_3(\lambda)$

$\Delta\lambda$ and the integration procedure are the same as in **5.4.5.4** except that the data points shall be chosen at the wavelengths given in Table 5.

For a glazing with more than three components, the formulae for the solar absorptances α_{e1}, α_{e2}, …, α_{en} as a function of the individual components.

5.2.9.5 *Mean radiant temperature (MRT)*

Besides solar energy transmittance, heat gain and losses occur by radiation exchange between the glazing which influences thermal comfort of the occupants. Mean radiant temperature (MRT), which is defined as the uniform temperature of an imaginary enclosure in which radiant heat transfer from the human body is equal to the radiant heat transfer in the actual non-uniform enclosure, is used as a metric in thermal comfort assessment. MRT can be calculated by various methods, among which measuring with globe thermometer is the most common and is given by:

$$MRT = \sqrt[4]{T_g^{\,4} + \frac{h_{cg}}{\varepsilon_g \sigma}(T_g - T_a)^4}$$

where

T_a = air temperature, in Kelvin;
T_g = black globe temperature, in Kelvin;
ε_g = emissivity of black globe;
σ = Stefane-Boltzmann constant; and
h_{cg} = convective heat transfer coefficient of the black globe.

5.2.10 *Thermal transmittance due to temperature difference*

The other part to be looked at is the transfer of heat from outside to inside environment through the glass, due to the temperature difference. This is known as U-value, which is the rate of heat flow through one square metre of glazing when there is a temperature difference of 1°C. The lower the U-value, the lesser is the heat transfer.

5.2.11 *Total Solar Energy Transmission*

The total solar energy transmitted into the room per unit area of glazing φ_{ei} is given by the relationship:

$$\varphi_{ei} = \varphi_e g$$

where

φ_e = incident solar radiation flux per unit area;
g = total solar energy transmittance of the glazing; and

The values of φ_e can be obtained from appropriate tables in meteorological literature.

NOTE – The SHGC/SF requirement for the glazing should be selected based on the prescriptive requirements are mentioned in Annex A.

5.2.11.1 *Additional Heat Transfer*

If the room temperature T_i differs from the outside temperature T_o, an additional heat transfer occurs in addition to φ_{ei}. This additional heat flow q_z can be calculated as follows:

$$q_z = U (T_o - T_i)$$

where *U* is the *U*-value (thermal transmittance) of glazing.

5.2.12 *Frames*

Frames can contribute to a significant amount of energy gain and energy loss through the glazing system. For improved efficiency, some frames are designed with internal thermal breaks that reduce energy flow through the frame (*see* Fig. 10). The sealing between the openings and the window frames and between the opening sashes of windows and fixed portions are important areas to be addressed as major heat loss happens from this area due to poor design of sealant material. Adequate provision shall also be made to ensure that the frames are not susceptible to water ingress in case of driving rain.

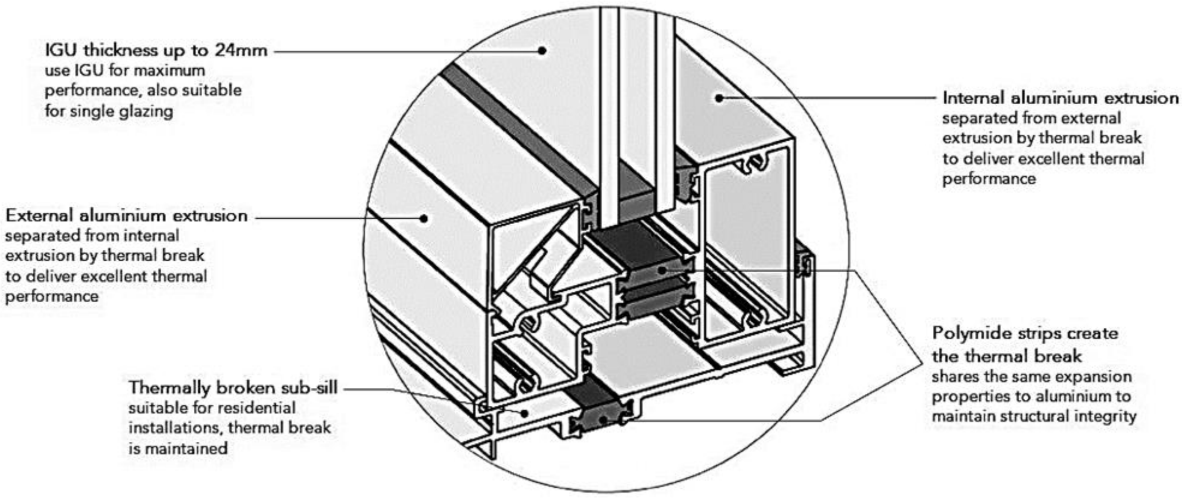


FIG. 10 Thermally Broken Aluminium Frame Assembly for Improved Thermal Performance in Glazing Systems

5.2.13 *Shading Systems*

Shading systems regulate the solar radiation incident on the glazing thereby reducing the effective solar heat gain coefficient of the glazing system. Besides reduction in direct solar gains inside the building, shading systems reduce the radiant heat gain from the glazing surface. Shading system design requires due consideration for the geographic location of the building, orientation of the façade, location of the system, and solar geometry. External shading systems are effective in solar control compared to internal shading systems (*see* Fig. 11). Shading systems may impact the daylight availability and the views available for occupants. Kinetic systems, either automated or manually operated, can be used to vary shading system positions dynamically based on solar position, daylight requirements and occupant preferences.

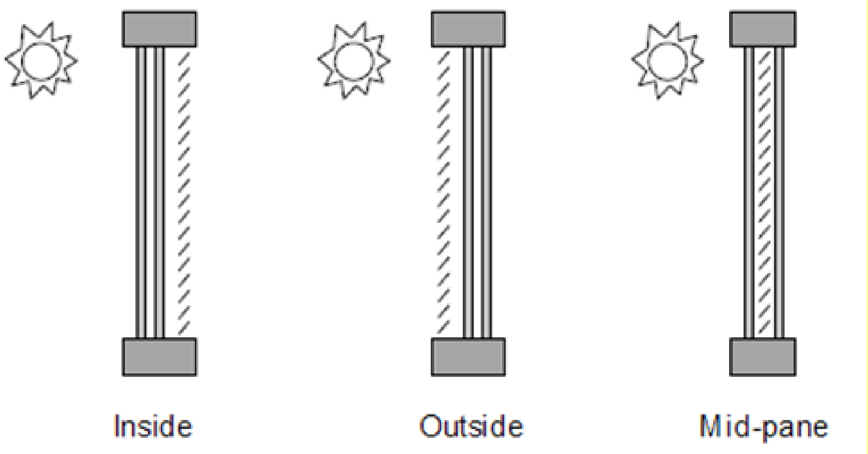


FIG. 11 PLACEMENT OF SHADING DEVICES FOR OPTIMAL SUN CONTROL IN GLAZING SYSTEMS

5.2.14 *Air Infiltration*

Inadequate control of airflow through the building envelope is often a primary factor contributing to premature building envelope failures. Air infiltration may be caused by wind pressure, stack pressure or fan pressure (*see* Fig. 12). Wind creates a positive pressure on the windward face and negative pressure on the leeward face, causing infiltration and exfiltration. Besides the positive or negative pressure created by the heating, ventilation and air conditioning system may lead to exfiltration or infiltration respectively.

The stack effect is when warm air moves upward in a building because it's lighter than cold air and escapes out of the upper levels of the building, through penetrations and cracks in the building envelope or other openings. The rising warm air reduces the pressure in the base of the building, forcing cold air to infiltrate through open doors, windows, or other openings. The stack effect basically causes air infiltration on the lower portion of a building and exfiltration on the upper part. Mechanical equipment such as fans and blowers cause the movement of air within buildings and through enclosures, which can generate pressure differences. If more air is exhausted from a building than is supplied, a net negative pressure is generated, which can induce unwanted airflow through the building envelope.

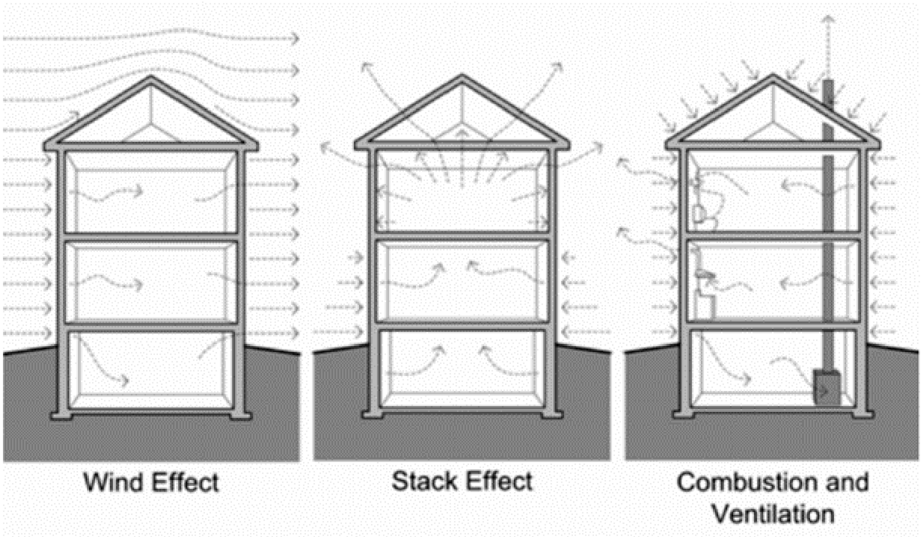


FIG. 12 MECHANISMS OF AIR INFILTRATION: WIND EFFECT, STACK EFFECT, AND COMBUSTION AND VENTILATION IN BUILDING ENCLOSURES

5.2.14.1 *Considerations for controlling air infiltration*

a) Ensuring the continuity of each component serving its role in resisting infiltration, such as a window assembly or a curtain, and ensuring they are interconnected to prevent air leakage at the joints between materials, components, assemblies, and systems.

b) Effective structural support shall be ensured so that all components can resist the positive or negative structural loads imposed on them by wind, stack effect, and HVAC fan pressures without rupture, displacement or undue deflection, thereby resisting air infiltration through them. Design considerations shall ensure that these loads are safely transferred to the structure and provision of adequate resistance to these pressures by use of fasteners, tapes, adhesives, etc.

Inadequate sealing of the glazing system may lead to energy gains and losses, thereby affecting thermal comfort and increasing the cooling and heating energy demand. If moisture-laden air infiltrates through the glazing system, the moisture may, under certain environmental conditions condense, especially in cold climates.

5.3 Methods for improving thermal insulation

Glass readily conducts energy and so is a poor insulator. To improve resistance to energy transfer, insulating glass units, coupled glazing or special coatings can be used. Increasing the thickness of the glass makes little difference to the *U*-value of the glazing.

5.3.1 *Use of low emissivity coatings*

Low emissivity (low-E) coatings have surface emissivity of less than 0.2. The use of such a coating on glass improves the thermal insulation. They are most efficient when used on the cavity surfaces of insulating glass units. Two types of low-E coatings are used, namely soft coating and hard coating. ~~Certain types of low-E glasses such as silver based~~ Soft coated low-E glasses are used in double glazed units only,~~ as the silver oxide coating will get oxidized if used in single glazed.~~ while hard coated low-E glasses can be used as single glazing.

5.3.2 *Solar control glass*

Solar control glass can be manufactured in several forms. The function of solar control glass is to reduce the total solar energy transmittance, which usually leads to a decrease in the transmission of the visible part of the solar spectrum. However, some tints and coatings are able to attenuate preferentially non-visible solar radiation, leaving the transmission of the greater proportion of the visible radiation largely unchanged.

The application of ceramic frit-fired into the surface of the glass can also be used to modify the energy and light transmission of the glass. The effect can be varied across a pane depending on the screen print pattern. Manufacturers should be consulted for specific details.

Solar control glass can be used in single glazed or double glazed unit depending upon the site requirements. The relationship between light transmission and total solar energy transmission is expressed as the light/energy ratio.

There is no optimum light/energy ratio. The selection of an appropriate product depends on the requirements of the building. Solar gain may be relatively high – for making use of passive solar gains, or low – to reduce air conditioning loads. Light transmission will depend on the extent to which daylight is used to obviate artificial lighting.

Some solar control glasses can be toughened or heat strengthened and gives a means of raising the design stress and ensuring safety from thermal fracture. The following are the common varieties.

NOTE – Some manufacturers use this as a descriptive code, quoting a light transmission figure followed by a total solar energy transmission figure.

a) *Body tinted glass (for increased absorption)* – Solar control properties and colour vary with the thickness of the glass. When used in insulating glass units, body tinted glass should be positioned as the outer pane because the energy due to the absorbed radiation is more easily dissipated to the outside.

b) *Reflective coated glass* – It uses the principle of increasing the direct reflection to maximize solar energy attenuation. In comparison with clear glass, its absorption of solar energy is also increased. An informative annex on test requirements is given at Annex B.

   The advantages of such glass types are:

   1) Greater performance range than body tinted glass;
   2) Higher performances (greater solar energy attenuation);

3) Light/energy ratios nearer to the theoretical limit; and
4) A range of colour appearances in transmission and reflection.

The coatings may be placed on to body-tinted glass to extend the range of performances.

NOTES

1 Compared with a float glass surface, these reflective coatings (owing to their composition) exhibit lower levels of emissivity which improves their *U*-value.
2 Performance data in comparison to clear glass can be had from manufacturers.

c) *Laminated glass* - It is commonly manufactured with clear glass and clear interlayers, but solar control properties can be incorporated into laminated glass by including either solar control glass or tinted interlayers or both.

Laminated glass with clear interlayers and solar control glass exhibits similar properties to the solar control glass from which it is made.

Laminated glass with a tinted interlayer acts in a similar manner to body tinted glass, by absorbing the solar radiation, but with a different range of colours and performances.

NOTE – Performance data in comparison to clear glass can be had from manufacturers. Performances of a typical range of laminated glass products with clear glass and tinted interlayers can be had from manufacturers.

d) *Insulating glass units* - These are used primarily for improved thermal transmittance (*U*-value) (*see* **5.2.10**), can also improve the total solar energy transmittance. This improvement is a result of the incorporation of a second pane of glass together with the hermetically sealed air space. The second glass pane can be of any glass type. The main glasses used as the inner pane are clear glass, hard coat low emissivity glass or soft coat low emissivity glass.

NOTES
1 Soft coat low emissivity glass can be used as the hermetically sealed airspace protects the coating.
2 Performances of a typical range of insulating glass units with clear float inner pane or with hard/soft coat low emissivity glass inner pane can be had from manufacturers.

~~**5.1.2.4.3** *Solar control plastics glazing sheet materials*~~

~~Various coloured plastics glazing sheet materials having ability to reduce the transmission of solar radiation can be used in consultation with the manufacturers.~~

~~**5.1.2.4.4** *Blinds and louvres*~~

~~The use of blinds or louvres in windows affects the window shading coefficient. This depends upon the solar optical properties of the glazing and the material of the blind, on the coefficients of energy transfer at the window surfaces, on the geometry and location of the blind, and the angular position of the sun. Manufacturers' advice may be consulted for use of these materials.~~

~~**5.1.3** *Energy Loss*~~

~~**5.1.3.1** *General*~~

~~Energy loss is quantified by the thermal transmittance or *U*-value.~~

~~Glass and thin plastics glazing sheet materials readily conducts energy and so is a are poor insulator. To improve resistance to energy loss, insulating glass units or coupled glazing should be used, since the air cavities provide extra thermal resistance.~~

~~Increasing the thickness of the glass or plastics glazing sheet material makes little difference to the *U*-value of the glazing.~~

~~**5.1.3.2** *Methods for improving thermal insulation*~~

~~**5.1.3.2.1** *Use of low emissivity coatings*~~

~~Low emissivity (low-E) coatings have surface emissivity of less than 0.2. The use of such a coating on glass improves the thermal insulation. They are most efficient when used on the cavity surfaces of insulating glass units. Two types of low-E coatings are used, namely soft coating and hard coating. Certain types of low-E glasses such as silver based Soft coated low-E glasses are used in double glazed units only, as the silver oxide coating will get oxidized if used in single glazed. while hard coated low-E glasses can be used as single glazing.~~

5.3.3 *Reducing thermal transmittance of glazing system*

5.3.3.1 *Increasing the width of the air space*

Enhanced thermal insulation can be achieved by increasing the width of the airspace. However, there is a convection of the gas in the cavity.

5.3.3.2 *Using gases of lower thermal conductivity*

Replacing the air in the cavity with, for example, argon/krypton, can improve the thermal insulation.

5.3.3.3 *Inhibiting convection within the air space*

Filling the cavity with ~~cellular~~ cellulose material reduces convection and makes the cavity a more efficient insulator. However, this usually results in loss of vision, since the materials are, at best, translucent.

5.3.3.4 *Evacuation of the air space*

In theory, a vacuum shall eliminate energy transfer by conduction and convection. However, a vacuum puts high demands on the glass from the external air pressure.

NOTE **–** Evacuation of the air space is currently considered to be technically impractical.

5.3.3.5 *Evaluation of type of spacer used in double glazed unit*

Thermal performance of the glazing system for conduction can be improved by changing the material of the spacer especially when other options have been exhausted.

5.3.3.6 *Typical U-values of Glass Products*

Tables 8, 9 and 10 give typical *U*-values.

Table 8 Thermal Transmittance (*U*-Value) of Glass Products: Single Glazing
(*Clause* 5.3.3.6)

Sl No. (1)	**Glass Thickness** mm (2)	***U*-Value** W/m^2K (3)
i)	4	5.8
ii)	6	5.7
iii)	10	5.6
iv)	12	5.5

Table 9 Thermal Transmittance (*U*-Value) of Glass Products: Insulating Glass Units
(*Clause* 5.3.3.6)

Sl No.	**Clear glass Thickness and type** mm	**Cavity Width** mm	***U*-Value** W/m^2K	
			Air	Argon
(1)	(2)	(3)	(4)	(5)
i)	4+4	6	3.3	3.1
		12	2.9	2.7
		16	2.7	2.6
		20	2.8	2.6
ii)	4+4 Low E (ϵ_d = 0.15)	6	2.7	2.3
		12	1.9	1.6
		16	1.7	1.5
		20	1.7	1.5
iii)	4 + 4 Low E (ϵ_d = 0.04)	6	2.5	2.0
		12	1.6	1.3
		16	1.4	1.2
		20	1.4	1.2
iv)	4+4+4	6	2.4	2.1

		12	1.9	1.8
		16	1.8	1.7
		20	1.8	1.7
v)	4 Low E (ϵ_d = 0.15) + 4 + 4 Low E (ϵ_d = 0.15)	6	1.7	1.4
		12	1.7	1.0
		16	1.0	0.8
		20	0.9	0.8
vi)	4 Low E (ϵ_d = 0.04) + 4 + 4 Low E (ϵ_d = 0.04)	6	1.6	1.2
		12	1.0	0.7
		16	0.8	0.6
		20	0.7	0.6

NOTES

1 *U*-values for argon gas-filled cavity based on 90 percent argon/10 percent air.
2 ϵ_d is the declared (normal) emissivity.

Table 10 Thermal Transmittance (*U*-Value) of Glass Products: Coupled Glazing
(*Clause* 5.3.3.6)

Sl No.	**Clear Glass Thickness and Type** mm	**Separation** mm	***U*-Value** W/m²K
(1)	(2)	(3)	(4)
i)	4 + 4	25	2.8
		75	2.8
ii)	4 + 4 Low E	25	1.7
		75	1.9

NOTE — ϵ_d is the declared (normal) emissivity.

The *U*-value requirement for the glazing system should be selected in accordance with the Table 11 and Annex A.

Table 11 Thermal Performance of Different Glass Shading Devices
(*Clause* 5.3.3.6)

Sl No.	**Name of the Shading Device**	**Transmittance, *U*-Value**	**Shade Factor**
(1)	(2)	(3)	(4)
i)	Plain glass sheet (3.0 mm thick)	5.23	1.00
ii)	Plain glass + Wire mesh outside	5.00	0.65

iii)	Painted glass:		
	a) White paint	5.22	0.35
	b) Yellow paint	5.22	0.37
	c) Green paint	5.22	0.40
iv)	Heat absorbing glass	4.65	0.45
v)	Plain glass sheet + Venetian blind inside:	3.14	
	a) Light colour		0.35
	b) Dark colour		0.40
vi)	Plain glass sheet which is,	5.23	
	a) 100 percent shaded		0.14
	b) 75 percent shaded		0.34
	c) 60 percent shaded		0.56

NOTE – Indicative values, actual value of the system to be measured using either approved simulation software or testing laboratory

5.3.4 *Thermal Safety of Glass*

Thermal safety of glass should be assessed considering the amount of radiation incident on the surface and the thermal capabilities of the glass. For example, the solar radiation intensity on the glass surface should be determined along with the air temperature range applicable to the location of the building. These measurements, together with the energy transfer coefficients and the glass absorption allow determination of the appropriate basic temperature difference between the central area of the glass and its edge. The difference is related to the thermal stress and then modified for the type of glazing system, taking account of extraneous effects resulting from curtains, blinds, back-up walls, proximity to heaters, etc, to derive a stress of actual service conditions.

NOTES

1 High air temperatures, low rates of air movement, and the insulation provided by curtains, blinds, back-up walls and multiple glazing tend to reduce the loss of energy and uphold the centre temperature. Low temperatures at the edges are maintained by conduction from the glass through the frame to a cold building structure with a large thermal capacity.

2 Advice may be sought from the manufacturer of glass as to the methods for assessing the thermal safety of the glass.

The resultant service stress should then be compared with the design stress for the glass. If on comparison, the service stress is less than or equal to the design stress, the glass and glazing system may be accepted as thermally safe provided, that the edges of the glass are of adequate quality.

NOTE – Where the application of a solar control film is being considered to existing glazing, advice should be sought from the manufacturer on the effect of any additional thermal stress likely to be induced in the glass.

The normal mode of thermal breakage of glass is by the action of tensile stress located in and parallel to an edge, and so the breaking stress of the glass is mainly dependent on the extent and position of flaws in the edges. The condition of the glass edge is therefore extremely important.

Solar control glasses should not be nipped to size and any panes with shelled or vented edges should not be accepted for glazing in orientations subject to direct sunlight. Although a wheel-cut edge is the most satisfactory, laminated glasses with worked edges may be used.

Where clean-cut edges are not permitted, arrises should be created by a wet process, working parallel to the edge and not across the thickness, and the design implications of such an action should be examined.

Where solar control glasses are to be used in sliding doors and windows there is always the possibility that, when opened during sunny periods, the overlapping will function as double glazing with little ventilation in the air space, and it is this condition that should be assumed in assessing the thermal safety of glass.

Thermal safety assessment is based on the behaviour of glass in good condition and properly glazed. Even if the glass is shown to be thermally safe, this depends on close adherence to the recommend glazing procedures. All necessary precautions should be taken to see that only glass with edges of an acceptable condition is used. The glass should be stored and handled so that no contact with hard bodies can damage the edges and each pane or insulating glass unit should be carefully examined immediately before glazing.

5.3.5 *UV-Transmittance*

The UV-transmittance of glazing is the fraction of the incident solar radiation transmitted by the glazing in the 300 nm to 380 nm range (UV-B range from 300 nm to 315 nm and UV-A range from 315 nm to 380 nm). The UV-transmittance τ_{UV} is calculated as follows:

$$\tau_{UV} = \frac{\sum_{\lambda = 300\text{ nm}}^{380\text{ nm}} \tau(\lambda)\, S_{\lambda}\, \Delta\lambda}{\sum_{\lambda = 300\text{ nm}}^{380\text{ nm}} S_{\lambda}\, \Delta\lambda}$$

where

S_{λ}	=	relative spectral distribution of UV radiation;
$\tau(\lambda)$	=	spectral transmittance of the glazing; and
$\Delta\lambda$	=	and the integration procedure are the same as **5.4.5.4** except that the data points shall be chosen at the wavelength given in Table 12.

This average extends over the defined UV-portion of the solar spectrum. It may not be correlated with solar radiation damage of materials and skin.

Table 12 Normalized Relative Spectral Distribution of Global Solar Radiation
(*Clause* 5.3.5)

Sl No.	**λ** nm	**$S_\lambda \Delta\lambda$**
(1)	(2)	(3)
i)	300	0
ii)	305	0.001 859
iii)	310	0.007 665
iv)	315	0.017 961
v)	320	0.029 732
vi)	325	0.042 466
vii)	330	0.062 108
viii)	335	0.065 462
ix)	340	0.071 020
x)	345	0.073 326
xi)	350	0.079 330
xii)	355	0.082 894
xviii)	360	0.087 039
xix)	365	0.097 963
xx)	370	0.108 987
xxi)	375	0.113 837
xxii)	380	0.058 351

NOTE – The values in this table are calculated according to the trapezoidal rule.

5.4 Daylight Transmission

Good glazing system design can, by reducing reliance on artificial lighting, can be one of the largest single means of saving energy and should be carefully considered.

Account should be taken of shape of the room, window orientation, occupancy patterns and task, together with the relationship of windows to surrounding buildings and other obstruction. As with task lighting, possible solar overheating might result and similar precautions should be taken.

5.4.1 *Light Transmission Properties of Window*

Light transmission is defined as the fraction of visible light at normal incidence transmitted through the glazing. For properties of plastic glazing sheet materials, manufacturers may be consulted.

Dirt on glazing reduces the light transmission, often by an appreciable extent before becoming noticeable. To ensure day lighting levels are adequate, an allowance for the reduced light transmission should be made in day lighting calculation by introducing a 'dirt factor' between 0.7 and 1.0. Regular cleaning of glass and plastic glazing sheet materials therefore call their importance.

5.4.2 *Glare*

5.4.2.1 *General*

Glare results from excessive contrast of illumination, or from an excess of illumination in the field of view. Reaction to it is subjective. When correctly designed, natural lighting should not be a glare problem.

NOTE – Contrasts in excess of 10 : 1 in illumination in different parts of the field of view might give rise to glare in some form.

5.4.2.2 *Disability glare*

Reducing the light transmission of glazing from 87 percent to 60 percent produces a just perceptible reduction in disability glare caused by direct sunlight. Even when the light transmission of the glazing is as low as 10 percent some 10 000 lux can still be experienced and glare shall almost certainly occur.

Glare can be reduced by some form of mechanical shading, for example a canopy, an overhanging floor, a balcony or a louvre system. Alternatively, internal screening can be provided by louvres or blinds.

NOTE – Any fixed shading system reduces the amount of natural light entering the building throughout the year, irrespective of whether there is a glare problem at any particular time.

It may also be possible to re-orientate the glazing to avoid entry of direct solar radiation. Alternatively, the interior layout can be suitably designed to eliminate glare.

5.4.2.3 *Discomfort glare*

Glazing products with light transmission lower than 50 percent can ameliorate discomfort glare. These products decrease the sky luminance components but permanently reduce the admission of daylight. Alternatively, shading devices, internal or external, movable or fixed, may be used.

Other methods of reducing the problems of glare should be considered, including,

a) installation of windows in more than one wall to raise the general background illumination and, in so doing, to reduce the contrast between a window and its surrounding surfaces;
b) use of light coloured matt finishes for the window frames and the surrounding surfaces;
c) splayed reveals, to assist in reducing the contrast between the window and its surroundings;
d) use of slender glazing bars and transoms of high reflectance; and
e) lowering window sills to allow increased illumination to enter, which increases the adaptation level and reduces the likelihood of discomfort glare.

5.4.3 *Diffusion and Obscuration*

The nature of some glazing products (for example, patterned or acid etched glass) can cause the direct incident solar beam to be scattered diffusely. Hence the window might assume an uncomfortable high brightness and become a discomfort glare source in its own right. Diffusing glazing used within the normal field of view should be used with caution.

5.4.4 *Fading*

Most materials can fade when subjected to either daylight (particularly direct sunlight) or artificial light. Fading is a complex phenomenon involving many chemical reactions, initiated or accelerated by light of different wavelengths. Generally, the better quality dyes and pigments fade relatively slowly and react only to the shorter wavelengths (ultraviolet and the blue end of the visible spectrum). Other materials can fade quickly and might do so under light of much longer wavelengths. It is the combination of wavelength, available light and transmission which determines glass selection to minimise fading, not simply the UV transmission.

5.4.5 *Determination of Characteristic Parameters*

5.4.5.1 *General*

The characteristic parameters are determined for quasi-parallel, almost normal radiation incidence.

5.4.5.2 *Test setup*

The samples shall be irradiated by a beam whose axis is at an angle not exceeding 10° from the normal to the surface. The angle between the axis and any ray of the illuminating beam shall not exceed 5°.

The characteristic parameters are as follows:

a) Spectral transmittance $\tau(\lambda)$, the spectral external reflectance $\rho_o(\lambda)$ and the spectral internal reflectance $\rho_i(\lambda)$ in the wavelength range of 300 nm to 2 500 nm;
b) Light transmittance τ_V, the external light reflectance $\rho_{v,0}$ and the internal light reflectance $\rho_{v,i}$ for illuminant D65;
c) Solar direct transmittance τ_e and the solar direct reflectance ρ_e;
d) Total solar energy transmittance (solar heat gain co efficient SHGC) *g*; and
e) UV-transmittance τ_{UV};

When calculating the characteristic parameters of multiple glazing, the spectral data of each glass component is to be used instead of integrating data of the complete unit.

5.4.5.3 *Performance requirements of optical measurements*

Optical measurements in transmission and reflection require special care to achieve accuracy in transmittance and reflectance of about ±0.01.

The wavelength calibration and the photometric linearity of commercial spectrophotometers shall be checked periodically using reference materials obtained from metrological laboratories.

The wavelength calibration shall be performed by measuring glass plates which feature relatively sharp absorption bands at specified wavelengths; the photometric linearity shall be checked using grey filters with a certified transmittance.

For reflectance measurements, reference materials having reflection behaviour (that is, reflectance level and ratio of diffuse and direct reflectance).

Thick samples (that is laminated glass or insulating units) can modify the optical path of the instrument's beam as compared to the path in air and therefore the sample beam hits an area of the detector having a different responsivity.

A similar source of inaccuracy occurs in case of samples with significant wedge angles which deflect the transmitted (and reflected) beams. It is recommended to check the reproducibility by repeating the measurement after rotating the sample.

Additionally, in the case of reflectance measurements, glass sheets cause a lateral shear of the beam reflected by the second surface, causing reflectance losses (whose extent is particularly evident in the case of thick and/or wedged samples). This source of inaccuracy shall be taken into account particularly in the case of reflectance measurements through the uncoated side. In order to quantify and correct systematic errors, it is recommended to use calibrated reflectance standards with a thickness similar to the unknown sample.

In the case of diffusing samples (or samples with a non-negligible diffusing component or wedged samples), transmittance and reflectance measurements shall be performed using integrating spheres whose openings are sufficiently large to collect the entire diffusely transmitted or reflected beam. The sphere diameter shall be adequate and the internal surface adequately coated with a highly diffusing reflectance material, so that the internal area can provide the necessary multiple reflections. Reference materials with characteristics similar to the unknown sample as specified above shall be used. If the transmittance or reflectance curve recorded by the spectrometer exhibits a high level of noise for some wavelengths, the values to be considered for those wavelengths should be obtained after a smoothing of the noise.

5.4.5.4 *Light transmittance*

Light transmittance is the measure of the amount of light passing through the glazing. The visible light lies between the wavelength 380 nm and 780 nm. The light transmission of the glazing depends on the substrate type and coating layer done on the base glass.

The light transmittance τ_V of glazing shall be calculated using the following formula:

$$\tau_V = \frac{\sum_{\lambda = 380\text{ nm}}^{780\text{ nm}} \tau(\lambda)\, D_\lambda\, V(\lambda)\, \Delta\lambda}{\sum_{\lambda = 380\text{ nm}}^{780\text{ nm}} D_\lambda\, V(\lambda)\, \Delta\lambda}$$

where

D_λ = relative spectral distribution of illuminant D65;

$\tau(\lambda)$ = the spectral transmittance of glazing;

$V(\lambda)$ = spectral luminous efficiency for photopic vision defining the standard observer for photometry; and

$\Delta\lambda$ = wavelength interval.

Table 13 indicates the values for $D_\lambda V(\lambda)\Delta\lambda$ for wavelength intervals of 10 nm. The table has been drawn up in such a way that $\Sigma D_\lambda V(\lambda)\Delta\lambda = 1$.

In the case of multiple glazing, the spectral transmittance τ(λ) shall be obtained by calculation from the spectral characteristics of the individual components. Alternatively, measurements on non-diffusing multiple units may be performed using an integrating sphere. This may be achieved after reducing the interspaces under conditions that allow the collection of the whole transmitted beam.

The calculation of the spectral transmittance τ(λ) shall be performed using methods such as algebraic manipulation. Any algorithm that can be shown to yield consistently the correct solution is acceptable.

For the calculation of τ(λ) as well as for the calculation of spectral reflectance the following symbols for the spectral transmittance and spectral reflectance of the individual components are used:

$\tau_1(\lambda)$ = spectral transmittance of the outer (first) pane;

$\tau_2(\lambda)$ = spectral transmittance of the second pane;

$\tau_n(\lambda)$ = the spectral transmittance of the n^{th} (inner) pane (for example, for triple glazing n= 3);

$\rho_1(\lambda)$ = spectral reflectance of the outer (first) pane measured in the direction of incident radiation;

$\rho'_1(\lambda)$ = spectral reflectance of the outer (first) pane measured in the opposite direction of incident radiation;

$\rho_2(\lambda)$ = spectral reflectance of the second pane measured in the direction of incident radiation;

$\rho'_2(\lambda)$ = spectral reflectance of the second pane measured in the opposite direction of incident radiation;

$\rho_n(\lambda)$ = spectral reflectance of the n^{th} (inner) pane measured in the direction of incident radiation;

$\rho'_n(\lambda)$ = spectral reflectance of the n^{th} (inner) pane measured in the opposite direction of incident radiation.

For the spectral transmittance $\tau(\lambda)$ as a function of the spectral characteristics of the individual components of the unit, the following formulae are obtained:

a) *For double glazing*, and
b) *For triple glazing*

For multiple glazing with more than three components, relationships similar to above expressions are found to calculate $\tau(\lambda)$ of such glazing from the spectral characteristics of the individual components.

As an example for calculating $\tau(\lambda)$ according to the procedures of this Section, a glazing composed of five components may be treated as follows:

1) First consider the first three components as triple glazing and calculate the spectral characteristics of this combination;
2) Next, run the same procedure for the next two components as double glazing; and
3) Then calculate $\tau(\lambda)$ for the five component glazing, considering it as double glazing consisting of the preceding triple and double glazing.

The light transmission requirement for the glazing should be selected in accordance with relevant Indian Standards.

Table 13 Normalized Relative Spectral Distribution $D_\lambda V(\lambda)\Delta\lambda$
(*Clause* **5.4.5.4**)

Sl No.	**λ** nm	**$D_\lambda V(\lambda)\Delta\lambda \times 10^2$**
(1)	(2)	(3)
i)	380	0
ii)	390	0.000 5
iii)	400	0.003 0
iv)	410	0.0103
v)	420	0.035 2
vi)	430	0.094 8
vii)	440	0.227 4
viii)	450	0.419 2
ix)	460	0.666 3
x)	470	0.985 0
xi)	480	1.518 9
xii)	490	2.133 6
xiii)	500	3.349 1
xiv)	510	5.139 3
xv)	520	7.052 3
xvi)	530	8.799 0
xvii)	540	9.442 7
xviii)	550	9.807 7
xix)	560	9.430 6
xx)	570	8.689 1
xxi)	580	7.899 4
xxii)	590	6.330 6
xxiii)	600	5.354 2
xxiv)	610	4.249 1
xxv)	620	3.150 2

xxvi)	630	2.081 2
xxvii)	640	1.381 0
xxviii)	650	0.807 0
xxix)	660	0.461 2
xxx)	670	0.248 5
xxxi)	680	0.125 5
xxxii)	690	0.053 6
xxxiii)	700	0.027 6
xxxiv)	710	0.014 6
xxxv)	720	0.005 7
xxxvi)	730	0.003 5
xxxvii)	740	0.002 1
xxxviii)	750	0.000 8
xxxix)	760	0.000 1
xxxx)	770	0.000 0
xxxxi)	780	0.000 0

NOTE – Normalized relative spectral distribution D_λ of illuminant D65 multiplied by the spectral luminous efficiency $V(\lambda)$ and by the wavelength interval Δλ. The values in this table are calculated according to the trapezoidal rule.

5.5 Light Reflectance

5.5.1 *External Light Reflectance of Glazing*

External light reflectance corresponds to the amount of sunlight reflected by the external glass surface. The amount of light reflection depends on the type of base glass (substrate tint) and the position of coating on the glass surface.

The external light reflectance of glazing $\rho_{v,o}$ shall be calculated using the following formula:

$$\rho_{v,o} = \frac{\sum_{\lambda = 380\ nm}^{780\ nm} \rho_o(\lambda)\, D_\lambda\, V(\lambda)\, \Delta\lambda}{\sum_{\lambda = 380\ nm}^{780\ nm} D_\lambda\, V(\lambda)\, \Delta\lambda}$$

where

$\rho_o(\lambda)$ = spectral external reflectance of glazing, and D_λ, $V(\lambda)$, Δλ and the integration procedure are defined in **5.4.5.4**.

For multiple glazing, the calculation of the spectral external reflectance $\rho_o(\lambda)$ shall be performed using the same methods as given in **5.4.5.4** for the calculation of the spectral transmittance $\tau(\lambda)$.

For the spectral external reflectance $\rho_o(\lambda)$ as a function of the spectral characteristics of the individual components of the unit, the following formulae are applied:

a) *For double glazing*:

$$\rho_o(\lambda) = \rho_1(\lambda) + \frac{\tau_1^2(\lambda)\,\rho_2(\lambda)}{1 - \rho'_1(\lambda)\,\rho_2(\lambda)}$$

b) *For triple glazing:*

$$\rho_o(\lambda) = \rho_1(\lambda) + \frac{\tau_1^2(\lambda)\,\rho_2(\lambda)\left[1 - \rho'_2(\lambda)\,\rho_3(\lambda)\right] + \tau_1^2(\lambda)\,\tau_2^2(\lambda)\,\rho_3(\lambda)}{\left[1 - \rho'_1(\lambda)\,\rho_2(\lambda)\right]\cdot\left[1 - \rho'_2(\lambda)\,\rho_3(\lambda)\right] - \tau_2^2(\lambda)\,\rho'_1(\lambda)\,\rho_3(\lambda)}$$

For multiple glazing with more than three components, relationships similar to above equations are found to calculate $\rho_o(\lambda)$ of such glazing from the spectral characteristics of the individual components.

As an example for calculating $\rho_o(\lambda)$, a glazing composed of five components may be treated in the same way as described in **5.4.5.4**.

5.5.2 *Internal Light Reflectance of Glazing*

Internal light reflectance corresponds to the amount of light reflected by the inner glass surface. The amount of light reflection depends on the type of base glass (substrate tint) and the position of coating on the glass surface.

The internal light reflectance of glazing $\rho_{v,i}$ shall be calculated using the following formula:

$$\rho_{v,i} = \frac{\sum_{\lambda = 380\text{ nm}}^{780\text{ nm}} \rho_i(\lambda)\, D_\lambda\, V(\lambda)\, \Delta\lambda}{\sum_{\lambda = 380\text{ nm}}^{780\text{ nm}} D_\lambda\, V(\lambda)\, \Delta\lambda}$$

where

$\rho_i(\lambda)$ = spectral internal reflectance of glazing, and
$D\lambda$, $V(\lambda)$, $\Delta\lambda$ and the integration procedure are as defined in light transmittance.

For multiple glazing, the calculation of the spectral internal reflectance $\rho_i(\lambda)$ shall be performed using the same methods as given in **5.4.5.4** for the calculation of the spectral transmittance $\tau(\lambda)$.

For the spectral internal reflectance $\rho_i(\lambda)$ as a function of the spectral characteristics of the individual components of the unit, the following formulae are applied.

b) *For double glazing:*

$$\rho_i(\lambda) = \rho'_2(\lambda) + \frac{\tau_2^2(\lambda)\,\rho'_1(\lambda)}{1 - \rho'_1(\lambda)\quad \rho_2(\lambda)}$$

c) *For triple glazing:*

$$\rho_i(\lambda) = \rho'_3(\lambda) + \frac{\tau_3^2(\lambda)\,\rho'_2(\lambda)\left[1-\rho_2(\lambda)\,\rho'_1(\lambda)\right] + \tau_3^2(\lambda)\,\tau_2^2(\lambda)\,\rho'_1(\lambda)}{\left[1-\rho_3(\lambda)\,\rho'_2(\lambda)\right]\cdot\left[1-\rho_2(\lambda)\,\rho'_1(\lambda)\right] - \tau_2^2(\lambda)\,\rho_3(\lambda)\,\rho'_1(\lambda)}$$

For multiple glazing with more than three components, relationships similar to above expressions are found to calculate $\rho_i(\lambda)$ of such glazing from the spectral characteristics of the individual components.

5.3 Total Solar Energy Transmittance (Solar Heat Gain Coefficient)

5.3.1 Solar heat gain coefficient (SHGC)/solar factor (SF) is the measure of amount of heat transfer from outside to inside by direct transmission (Short Wave Radiation) and internal remitted radiation (Long Wave Radiation). The SHGC (*see* Fig. 6) or SF depends on the tint of the substrate and also the type of coating that is done on the base glass. The amount of solar energy gained through glass is between 0 and 1. Multiplying the SHGC or SF by 100 gives the percentage of solar energy allowed into the building.

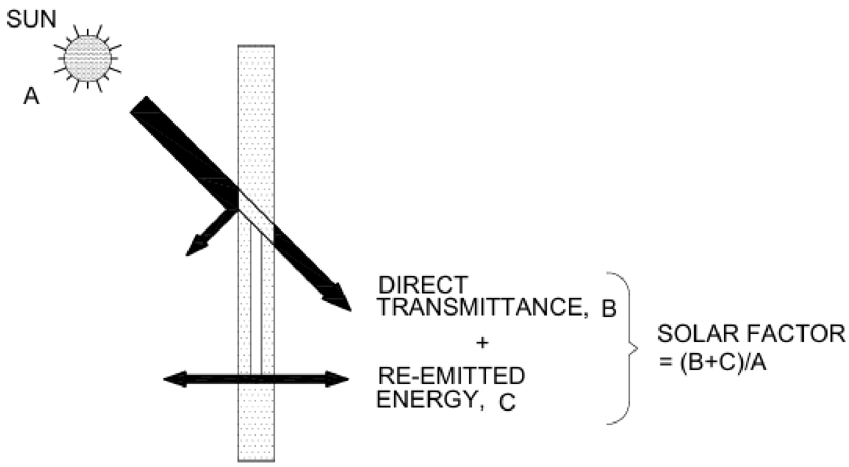


FIG. 6 SOLAR HEAT GAIN COEFFICIENT

The total solar energy transmittance g is the sum of the solar direct transmittance τ_e and the secondary heat transfer factor q_i towards the inside, the latter resulting from heat transfer by convection and long-wave IR-radiation of that part of the incident solar radiation which has been absorbed by the glazing and is expressed as:

$$g = \tau_e + q_i$$

5.3.2 *Division of Incident Solar Radiation Flux*

The incident solar radiant flux per unit area φ_e is divided into the following three parts (*see* Fig. 7):

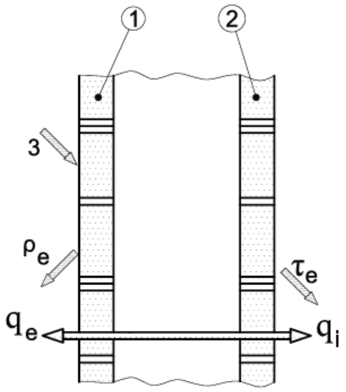
d) Transmitted part, $\tau_e \varphi_e$;

e) Reflected part, $\rho_e \varphi_e$; and

f) Absorbed part, $\alpha_e\varphi_e$;

where

τ_e = solar direct transmittance,
ρ_e = solar direct reflectance, and
α_e = solar direct absorptances.



KEY :
1 OUTER PANE
2 SECOND INNER PANE
3 UNIT INCIDENT RADIANT FLUX
ρ_e = 0.38; q_e = 0.17;
τ_e = 0.41; q_i = 0.04; therefore g = 0.45

FIG. 7 COMPONENTS OF INCIDENT SOLAR RADIANT FLUX

The relationship between the three characteristics is:

$$\tau_e + \rho_e + \alpha_e = 1$$

The absorbed part $\alpha_e\varphi_e$ is subsequently divided into two parts $q_i\varphi_e$ and $q_e\varphi_e$, which are energy transferred to the inside and outside, respectively:

$$\alpha_e = q_i + q_e$$

where

q_i = secondary heat transfer factor of the glazing towards the inside; and
q_e = secondary heat transfer factor of the glazing towards the outside.

5.3.3 *Solar Direct Transmittance*

The solar direct transmittance τ_e of glazing shall be calculated using the following formula:

$$\tau_e = \frac{\sum_{\lambda=300\text{ nm}}^{2\,500\text{ nm}} \tau(\lambda) S_\lambda \, \Delta\lambda}{\sum_{\lambda=300\text{ nm}}^{2\,500\text{ nm}} S_\lambda \Delta\lambda}$$

~~where~~

~~S_λ = relative spectral distribution of the solar radiation;~~
~~$\tau(\lambda)$ = spectral transmittance of the glazing; and~~
~~$\Delta\lambda$ = integration procedure are the same as in **5.1.11.4** except that the data points shall be chosen at the wavelengths given in Table 11.~~

~~**5.3.4** *Solar Direct Reflectance*~~

~~The solar direct reflectance ρ_e of the glazing shall be calculated using the following formula:~~

$$\rho_e = \frac{\sum_{\lambda=300\text{ nm}}^{2\,500\text{ nm}} \rho_o(\lambda) \, S_\lambda \, \Delta\lambda}{\sum_{\lambda=300\text{ nm}}^{2\,500\text{ nm}} S_\lambda \, \Delta\lambda}$$

~~where~~

~~S_λ = relative spectral distribution of the solar radiation (*see* **5.3.3**);~~
~~$\rho_o(\lambda)$ = spectral external reflectance of the glazing; and~~
~~$\Delta\lambda$ = integration procedure are the same as in light transmittance except that the data points shall be chosen at the wavelengths given in Table 11.~~

~~In the case of multiple glazing, the spectral external reflectance $\rho_o(\lambda)$ is calculated in accordance with **5.2.1**.~~

~~**Table 11 Normalized Relative Spectral Distribution of Global Solar Radiation**~~
~~(*Clauses* 5.3.3, 5.3.4, 5.3.6.3 *and* 5.3.6.4)~~

~~*λ*~~ ~~nm~~ ~~(1)~~	~~$S_\lambda \Delta\lambda$~~ - ~~(2)~~
~~300~~	~~0~~
~~305~~	~~0.000 057~~
~~310~~	~~0.000 236~~
~~315~~	~~0.000 554~~
~~320~~	~~0.000 916~~
~~325~~	~~0.001 309~~
~~330~~	~~0.001 914~~
~~335~~	~~0.002 018~~
~~340~~	~~0.002 189~~

~~λ~~	~~$S_\lambda \Delta\lambda$~~
~~nm~~	-
~~(1)~~	~~(2)~~
~~345~~	~~0.000 260~~
~~350~~	~~0.002 445~~
~~355~~	~~0.002 555~~
~~360~~	~~0.002 683~~
~~365~~	~~0.003 020~~
~~370~~	~~0.003 359~~
~~375~~	~~0.003 509~~
~~380~~	~~0.003 600~~
~~385~~	~~0.003 529~~
~~390~~	~~0.003 551~~
~~395~~	~~0.004 294~~
~~400~~	~~0.007 812~~
~~410~~	~~0.011 638~~
~~420~~	~~0.011 877~~
~~430~~	~~0.011 347~~
~~440~~	~~0.013 245~~
~~450~~	~~0.015 343~~
~~460~~	~~0.016 166~~
~~470~~	~~0.016 178~~
~~480~~	~~0.016 402~~
~~490~~	~~0.015 794~~
~~500~~	~~0.015 801~~
~~510~~	~~0.015 973~~
~~520~~	~~0.015 357~~
~~530~~	~~0.015 857~~
~~540~~	~~0.015 827~~
~~550~~	~~0.015 844~~
~~560~~	~~0.015 590~~
~~570~~	~~0.015 255~~
~~580~~	~~0.014 745~~
~~590~~	~~0.014 330~~
~~600~~	~~0.014 663~~
~~610~~	~~0.015 030~~
~~620~~	~~0.014 859~~
~~630~~	~~0.014 622~~
~~640~~	~~0.014 526~~
~~650~~	~~0.014 445~~
~~660~~	~~0.014 313~~
~~670~~	~~0.014 023~~
~~680~~	~~0.012 838~~
~~690~~	~~0.011 788~~
~~700~~	~~0.012 453~~
~~710~~	~~0.012 798~~
~~720~~	~~0.010 589~~
~~730~~	~~0.011 233~~
~~740~~	~~0.012 175~~
~~750~~	~~0.012 181~~

λ nm (1)	**$S_λ$Δλ** - (2)
760	0.009 515
770	0.010 479
780	0.011 381
790	0.011 262
800	0.026 718
850	0.048 240
900	0.040 297
950	0.021 384
1 000	0.036 097
1 050	0.034 110
1 100	0.018 861
1 150	0.013 228
1 200	0.022 551
1 250	0.023 376
1 300	0.017 756
1 350	0.003 743
1 400	0.000 741
1 450	0.003 792
1 500	0.009 693
1 550	0.013 693
1 600	0.012 203
1 650	0.010 615
1 700	0.007 255
1 750	0.007 183
1 800	0.002 157
1 850	0.000 395
1 900	0.000 082
1 950	0.001 087
2 000	0.003 024
2 050	0.003 988
2 100	0.004 229
2 150	0.004 142
2 200	0.003 690
2 250	0.003 592
2 300	0.003 436
2 350	0.003 163
2 400	0.002 233
2 450	0.001 202
2 500	0.000 475

NOTE — The values in this table are calculated according to the trapezoidal rule.

5.3.5 *Solar Direct Absorptance*

The solar direct absorptance $α_e$ shall be calculated from the following formula:

$$\tau_e + \rho_e + \alpha_e = 1$$

5.3.6 *Secondary Heat Transfer Factor Towards the Inside*

5.3.6.1 *Boundary conditions*

For the calculation of the secondary heat transfer factor towards the inside, q_i, the heat transfer coefficients of the glazing towards the outside, h_e, and towards the inside, h_i, are needed. These values mainly depend on the position of the glazing, wind velocity, inside and outside temperatures and, furthermore, on the temperature of the two external glazing surfaces.

As the purpose of this Section is to provide basic information on the performance of glazing, the following conventional conditions have been stated for simplicity:

e) Position of the glazing: vertical;
f) Outside surface: wind velocity approximately 4 m/s; corrected emissivity 0.837;
g) Inside surface: natural convection; emissivity optional; and
h) Air spaces are unventilated.

Under these conventional, average conditions, standard values for h_e and h_i are obtained:

$$h_e = 23 \text{ W/(m}^2\text{K)}$$

$$h_i = \left(3.6 + \frac{4.4\varepsilon_i}{0.837}\right) \text{W/(m}^2\cdot\text{K)}$$

where

ε_i = corrected emissivity of the inside surface [for soda lime glass, ε_i = 0.837 and h_i = 8 W/(m^{2}K)].

If other boundary conditions are used to meet special requirements they shall be stated in the test report.

Values for ε_i lower than 0.837 (due to surface coatings with higher reflectance in the far infrared) should only to be taken into account if condensation on the coated surface can be excluded.

5.3.6.2 *Single glazing*

The secondary heat transfer factor towards the inside, q_i, of single glazing shall be calculated using the following formula:

$$q_i = \alpha_e \frac{h_i}{h_e + h_i}$$

where

α_e	=	solar direct absorptance obtained from the in accordance with **5.3.2**, and
h_e, h_i	=	heat transfer coefficients towards the outside and inside, respectively, in accordance with **7.6.1**.

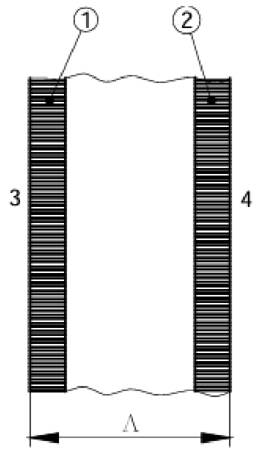
5.3.6.3 *Double glazing*

The secondary heat transfer factor towards the inside, q_i, of double glazing shall be calculated using the following formula:

$$q_i = \frac{\left(\frac{\alpha_{e1} + \alpha_{e2}}{h_e} + \frac{\alpha_{e2}}{\Lambda}\right)}{\left(\frac{1}{h_i} + \frac{1}{h_e} + \frac{1}{\Lambda}\right)}$$

where

α_{e1}	=	solar direct absorptance of the outer (first) pane within the double glazing;
α_{e2}	=	solar direct absorptance of the second pane within the double glazing;
Λ	=	thermal conductance between the outer surface and the innermost surface of the double glazing (*see* Fig. 8), in watts per square metre per Kelvin (W/m^2.K); and
h_e, h_i	=	heat transfer coefficients towards the outside and the inside, respectively in accordance with **5.3.6.1**.



KEY :
1 PANE 1
2 PANE 2
3 OUTSIDE
4 INSIDE

FIG. 8 ILLUSTRATION OF THE MEANING OF THERMAL CONDUCTANCE, Λ

Characteristics α_{e1} and α_{e2} are calculated as follows:

$$\alpha_{e1} = \frac{\sum_{\lambda = 300\text{ nm}}^{2\,500\text{ nm}} \left\{ \alpha_1(\lambda) + \frac{\alpha'_1(\lambda)\,\tau_1(\lambda)\,\rho_2(\lambda)}{1-\rho'_1(\lambda)\,\rho_2(\lambda)} \right\} S_\lambda\,\Delta\lambda}{\sum_{\lambda = 300\text{ nm}}^{2\,500\text{ nm}} S_\lambda\,\Delta\lambda}$$

$$\alpha_{e2} = \frac{\sum_{\lambda = 300\text{ nm}}^{2\,500\text{ nm}} \left\{ \frac{\alpha_2(\lambda)\,\tau_1(\lambda)}{1-\rho'_1(\lambda)\,\rho_2(\lambda)} \right\} S_\lambda\,\Delta\lambda}{\sum_{\lambda = 300\text{ nm}}^{2\,500\text{ nm}} S_\lambda\,\Delta\lambda}$$

Where

$\tau_1(\lambda), \tau_2(\lambda), \rho_1(\lambda), \rho'_1(\lambda), \rho_2(\lambda)$ are as defined in light transmittance.

$\alpha_1(\lambda)$ = spectral direct absorptance of the outer pane, measured in the direction of the incident radiation, given by the relationship:

$\alpha_1(\lambda) = 1 - \tau_1(\lambda) - \rho_1(\lambda)$

$\alpha'_1(\lambda)$ = spectral direct absorptance of the outer pane, measured in the opposite direction to the incident radiation, given by the relationship:

$\alpha_1'(\lambda) = 1 - \tau_1(\lambda) - \rho'_1(\lambda)$

$\alpha_2(\lambda)$ = spectral direct absorptance of the second pane, measured in the direction of the incident radiation, given by the relationship:

$\alpha_2(\lambda) = 1 - \tau_2(\lambda) - \rho_2(\lambda)$

$\Delta\lambda$ and the integration procedure are the same as in **5.1.11.4** except that the data points shall be chosen at the wavelengths given in Table 11.

The thermal conductance Λ shall be determined for a temperature difference of ΔT = 15°C across the sample and a mean temperature of the sample of 10°C, or by measuring methods using the standard guarded hot plate method, or the standard heat flow metre method.

If another temperature difference ΔT across the sample and/or another mean temperature of the sample is used for the determination of the thermal conductance Λ to meet special requirements, this shall be stated in the test report.

5.3.6.4 *Multiple glazing with n > 2 components*

The secondary heat transfer factor towards the inside, q_i, of a multiple glazing with more than two components shall be calculated using the following formula:

$$q_i = \frac{\dfrac{\alpha_{e1} + \alpha_{e2} + \alpha_{e3} + \cdots + \alpha_{en}}{h_e} + \dfrac{\alpha_{e2} + \alpha_{e3} + \cdots + \alpha_{en}}{\Lambda_{12}} + \dfrac{\alpha_{e3} + \cdots + \alpha_{en}}{\Lambda_{23}} + \cdots + \dfrac{\alpha_{en}}{\Lambda_{(n-1)n}}}{\dfrac{1}{h_i} + \dfrac{1}{h_e} + \dfrac{1}{\Lambda_{12}} + \dfrac{1}{\Lambda_{23}} + \cdots + \dfrac{1}{\Lambda_{(n-1)n}}}$$

where

α_{e1} = solar direct absorptance of the outer (first) pane within the *n*-fold glazing;

α_{e2} = solar direct absorptance of the second pane within the *n*-fold glazing;

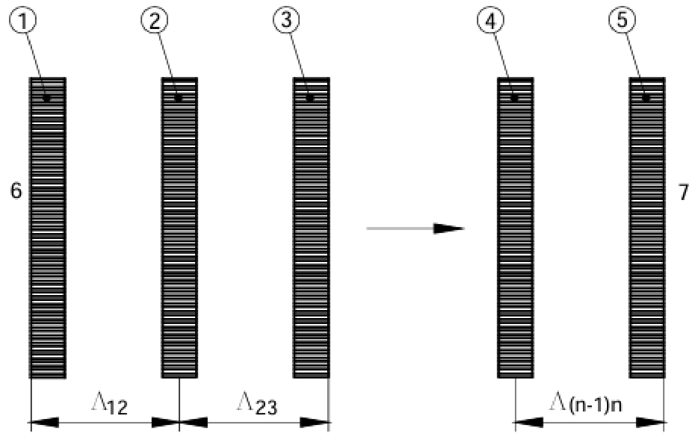
α_{en} = solar direct absorptance of the n^{th} (inner) pane of the *n*-fold glazing;

h_e, h_i = heat transfer coefficients towards the outside and towards the inside, respectively in accordance with **5.3.6.1**;

Λ_{12} = thermal conductance between the outer surface of the outer (first) pane and the centre of the second pane (*see* Fig. 9);

$\Lambda_{(n-1)n}$ = thermal conductance between the centre of the $(n-1)^{th}$ pane and the outer surface of the n^{th}(inner) pane (*see* Fig. 9); and

Λ_{23} = thermal conductance between the centre of the second pane and the centre of the third pane (*see* Fig. 9);



KEY :
1 PANE 1
2 PANE 2
3 PANE 3
4 PANE (n - 1)
5 PANE n
6 OUTSIDE
7 INSIDE

NOTE – For triple glazing, pane 3 corresponds to pane n

FIG. 9 ILLUSTRATION OF THE MEANING OF THE THERMAL CONDUCTANCES A_{12}, A_{23}.........$A_{(n-1)n}$

The thermal conductances A_{12}, A_{23}.........$A_{(n-1)n}$ shall be determined by iteration technique. The calculation of the direct solar absorptances α_{e1}, α_{e2},...α_{en} shall be performed using the methods given in **5.3.6.3**.

As an example for the calculation of the direct solar absorptances the following procedure is given which consist of the following (*n*-1) steps for a glazing consisting of *n* components.

a) first step – calculate the spectral characteristics of a unit consisting of (*n*-1) components 2,3,.......*n* according to what has been prescribed in **5.1.11.4** and **6.1**. Then combine this unit with the first (outer) pane as a double glazing.

b) second step – calculate the spectral characteristics of a unit consisting of the (*n*-2) components 3,....,*n* and furthermore, those of a double glazing consisting of pane 1 and pane 2. These units are then combined as a double glazing. The sum $\alpha_{e1} + \alpha_{e2}$ is then obtained. This procedure is continued up to the last $(n-1)^{th}$ step.

c) $(n-1)^{th}$ step – combine the (*n*-1) panes 1,2,... (*n*-1) and determine the spectral characteristics of this unit. This unit is then combined with the n^{th} (inner) pane as a double glazing. From the second equation in **5.3.6.3**, the sum α_{e1}, α_{e2} ...$\alpha_{e(n-1)}$ is obtained, that is with the known values α_{e1}, α_{e2}, ... $\alpha_{e(n-2)}$ from the previous steps $\alpha_{e(n-1)}$ is determined. α_{en} is obtained according to the expression of α_{e2} in **5.3.6.3**.

In the case of triple glazing for the solar absorptances α_{e1}, α_{e2} and α_{e3} as a function of the spectral characteristics of the individual components of the unit, the following formulae are obtained:

$$\alpha_{e1} = \frac{\sum_{\lambda=300\text{ nm}}^{2\,500\text{ nm}} \left\{ \alpha_1(\lambda) + \frac{\tau_1(\lambda)\,\alpha'_1(\lambda)\,\rho_2(\lambda)\left[1-\rho'_2(\lambda)\,\rho_3(\lambda)\right] + \tau_1(\lambda)\,\tau_2^2(\lambda)\,\alpha'_1(\lambda)\,\rho_3(\lambda)}{\left[1-\rho'_1(\lambda)\,\rho_2(\lambda)\right]\cdot\left[1-\rho'_2(\lambda)\,\rho_3(\lambda)\right] - \tau_2^2(\lambda)\,\rho'_1(\lambda)\,\rho_3(\lambda)} \right\} S_\lambda\,\Delta\lambda}{\sum_{\lambda=300\text{ nm}}^{2\,500\text{ nm}} S_\lambda\,\Delta\lambda}$$

$$\alpha_{e2} = \frac{\sum_{\lambda=300\text{ nm}}^{2\,500\text{ nm}} \left\{ \frac{\tau_1(\lambda)\,\alpha_2(\lambda)\left[1-\rho'_2(\lambda)\,\rho_3(\lambda)\right] + \tau_1(\lambda)\,\tau_2(\lambda)\,\alpha'_2(\lambda)\,\rho_3(\lambda)}{\left[1-\rho'_1(\lambda)\,\rho_2(\lambda)\right]\cdot\left[1-\rho'_2(\lambda)\,\rho_3(\lambda)\right] - \tau_2^2(\lambda)\,\rho'_1(\lambda)\,\rho_3(\lambda)} \right\} S_\lambda\,\Delta\lambda}{\sum_{\lambda=300\text{ nm}}^{2\,500\text{ nm}} S_\lambda\,\Delta\lambda}$$

$$\alpha_{e3} = \frac{\sum_{\lambda=300\text{ nm}}^{2\,500\text{ nm}} \left\{ \frac{\tau_1(\lambda)\,\tau_2(\lambda)\,\alpha_3(\lambda)}{\left[1-\rho'_1(\lambda)\,\rho_2(\lambda)\right]\cdot\left[1-\rho'_2(\lambda)\,\rho_3(\lambda)\right] - \tau_2^2(\lambda)\,\rho'_1(\lambda)\,\rho_3(\lambda)} \right\} S_\lambda\,\Delta\lambda}{\sum_{\lambda=300\text{ nm}}^{2\,500\text{ nm}} S_\lambda\,\Delta\lambda}$$

~~where~~

~~$\tau_1(\lambda)$, $\tau_2(\lambda)$, $\tau_3(\lambda)$, $\rho_1(\lambda)$, $\rho'_1(\lambda)$, $\rho_2(\lambda)$, $\rho'_2(\lambda)$, $\rho_3(\lambda)$ are as defined in light transmittance;~~

~~$\alpha_1(\lambda)$, $\alpha'_1(\lambda)$ and $\alpha_2(\lambda)$ are as defined in **5.3.6.3** double glazing;~~

~~$\alpha'_2(\lambda)$ = spectral direct absorptance of the second pane, measured in the opposite direction to the incident radiation, given by the relationship:~~

~~$\alpha'_2(\lambda) = 1 - \tau_2(\lambda) - \rho'_2(\lambda)$~~

~~$\alpha_3(\lambda)$ = spectral direct absorptance of the third pane, measured in the direction of the incident radiation, given by the relationship:~~

~~$\alpha_3(\lambda) = 1 - \tau_3(\lambda) - \rho_3(\lambda)$~~

~~$\Delta\lambda$ and the integration procedure are the same as in **5.1.11.4** except that the data points shall be chosen at the wavelengths given in Table 5.~~

~~For a glazing with more than three components, the formulae for the solar absorptances α_{e1}, α_{e2}, …, α_{en} as a function of the individual components.~~

~~**5.3.6.5** *Mean radiant temperature (MRT)*~~

~~MRT can be calculated by various methods, among which measuring with globe thermometer is the most common and is given by:~~

$$MRT = \sqrt[4]{T_g^{\,4} + \frac{h_{cg}}{\varepsilon_g \sigma}\left(T_g - T_a\right)^4}$$

~~where~~

~~T_a = air temperature, in Kelvin;~~
~~T_g = black globe temperature, in Kelvin;~~
~~ε_g = emissivity of black globe;~~
~~σ = Stefane-Boltzmann constant; and~~
~~h_{cg} = convective heat transfer coefficient of the black globe.~~

5.4 Total Solar Energy Transmission

The total solar energy transmitted into the room per unit area of glazing φ_{ei} is given by the relationship:

$$\varphi_{ei} = \varphi_e g$$

where

φ_e	=	incident solar radiation flux per unit area;
g	=	total solar energy transmittance of the glazing; and

The values of φ_e can be obtained from appropriate tables in meterological literature.

NOTE – The SHGC/SF requirement for the glazing should be selected based on the prescriptive requirements are mentioned in Annex A.

5.4.1 *Additional Heat Transfer*

If the room temperature T_i differs from the outside temperature T_o, an additional heat transfer occurs in addition to φ_{ei}. This additional heat flow q_z can be calculated as follows:

$$q_z = U\,(T_o - T_i)$$

where U is the U-value (thermal transmittance) of glazing.

5.5 UV-Transmittance

The UV-transmittance of glazing is the fraction of the incident solar radiation transmitted by the glazing in the 300 nm to 380 nm range (UV-B range from 300 nm to 315 nm and UV-A range from 315 nm to 380 nm). The UV-transmittance τ_{UV} is calculated as follows:

$$\tau_{UV} = \frac{\sum_{\lambda = 300\text{ nm}}^{380\text{ nm}} \tau(\lambda)\, S_\lambda\, \Delta\lambda}{\sum_{\lambda = 300\text{ nm}}^{380\text{ nm}} S_\lambda\, \Delta\lambda}$$

where

S_λ	=	relative spectral distribution of UV radiation;
$\tau(\lambda)$	=	spectral transmittance of the glazing; and
$\Delta\lambda$	=	and the integration procedure are the same as **5.1.11.4** except that the data points shall be chosen at the wavelength given in Table 12.

This average extends over the defined UV-portion of the solar spectrum. It may not be correlated with solar radiation damage of materials and skin.

5.6 *U*-Value

Heat transmittance through a surface by conduction, convection, and radiation is expressed by its *U*-value. *U*-value is the amount of heat transferred that is lost or gained due to a temperature differential of 1 K through 1 m^2. The rate of heat transfer (*U*-value) is minimised by the use of double glazing, using gas inside cavity or by using low-E glass for inside pane of double glazed unit.

The *U*-value requirement for the glazing system should be selected in accordance with the Table 13 and Annex A.

Table 12 Normalized Relative Spectral Distribution of Global Solar Radiation
(*Clause* 5.5)

Sl No. (1)	λ nm (2)	$S_\lambda \Delta\lambda$ - (3)
i)	300	0
ii)	305	0.001 859
iii)	310	0.007 665
iv)	315	0.017 961
v)	320	0.029 732
vi)	325	0.042 466
vii)	330	0.062 108
viii)	335	0.065 462
ix)	340	0.071 020
x)	345	0.073 326
xi)	350	0.079 330
xii)	355	0.082 894
xviii)	360	0.087 039
xix)	365	0.097 963
xx)	370	0.108 987
xxi)	375	0.113 837
xxii)	380	0.058 351

NOTE – The values in this table are calculated according to the trapezoidal rule.

Table 13 Thermal Performance of Different Glass Shading Devices
(*Clause* 5.6)

Sl No. (1)	Name of the Shading Device (2)	Transmittance, *U*-Value (3)	Shade Factor (4)
i)	Plain glass sheet (3.0 mm thick)	5.23	1.00

~~ii)~~	~~Plain glass + Wire mesh outside~~	~~5.00~~	~~0.65~~
~~iii)~~	~~Painted glass:~~		
	~~a) White paint~~	~~5.22~~	~~0.35~~
	~~b) Yellow paint~~	~~5.22~~	~~0.37~~
	~~c) Green paint~~	~~5.22~~	~~0.40~~
~~iv)~~	~~Heat absorbing glass~~	~~4.65~~	~~0.45~~
~~v)~~	~~Plain glass sheet + Venetian blind inside:~~	~~3.14~~	
	~~a) Light colour~~		~~0.35~~
	~~b) Dark colour~~		~~0.40~~
~~vi)~~	~~Plain glass sheet which is,~~	~~5.23~~	
	~~a) 100 percent shaded~~		~~0.14~~
	~~b) 75 percent shaded~~		~~0.34~~
	~~c) 60 percent shaded~~		~~0.56~~

~~NOTE – Indicative values, actual value of the system to be measured using either approved simulation software or testing laboratory~~

5.6 Energy Design Considerations

5.6.1 *General*

Glass and glazing system design shall enhance daylighting into the building, improve the views to outdoor environments for the occupants, minimize the energy gains in hot climates, energy losses in cold climates and facilitate air movement in naturally ventilated spaces.

Fenestration, glazing and shading systems shall be designed by considering the climate characteristics, solar geometry, design sky conditions, orientation of the façade and building use. Effective design of the glazing system can minimize energy gains during summer and energy losses during winter. Height of the vision panel and the lintel height can be effectively adjusted to optimize the daylight penetration into the building.

5.6.2 *Design factors*

The following factors / components of a glazing system shall be considered during design for achieving energy efficiency:

a) Light transmittance and glare
b) Thermal Transmittance (Solar Heat Gain co-efficient and U value)
c) Fenestration size and placement
d) Thermal properties of the frames
e) Shading devices

f) Air infiltration

5.6.3 *Analysis for Glazing System Selection*

5.6.3.1 *Building orientation and solar geometry analysis*

Optimal building orientation is a critical aspect for climate responsive design. Knowledge of solar geometry in a site is essential for designing building facades to regulate energy and daylight transmission as well as reduce glare and overheating inside the building. Choice of glass and the shading system can considerably vary based on orientation of the façade and the solar geometry. A well–oriented building maximises daylighting through its facades, thereby reducing the need for artificial lighting. Such building regulates the energy gains and losses through the façade, thereby minimizing thermal discomfort and cooling and heating energy demand.

5.6.3.2 *Solar insolation and shading analysis*

Design of glazing system is driven by the insolation levels on the façade, the desirable energy gains/losses and daylight requirements for a given building. Solar insolation varies with geographic location, orientation of the façade, time of the day and season. Direct solar incident radiation is the energy transmitted from the sun, which lies between the wavelength range of 250 and 2500 nm. Solar radiation typically consists of 3% ultraviolet light, 42% visible light, and 55% infrared light. Infrared radiation is the major heat carrying radiation, followed by visible light. Analysing solar radiation helps to assess its impact on the building's elevations, allowing for a better understanding of how this influences the building's performance. Solar insolation and shading analysis are employed for determining optimum SHGC & U-Value of glass, U-value of the frame and the design of shading system necessary for minimizing the energy gains and losses through the façade.

5.6.3.3 *Daylight analysis*

Daylight analysis is used to assess the penetration of natural light on the building floor plan or at the working plane level. A good lighting strategy involves optimizing the glazed area, increasing the daylight autonomy and thereby reducing the dependency on artificial lighting. Using a glass with optimal light transmission can go a long way in curtailing the dependence on artificial lighting. Additionally, the presence of natural light alleviates the claustrophobic feeling often associated with buildings that have limited glazing and outdoor views. Daylight calculations are conducted for overcast conditions to represent the worst-case scenario for outdoor lighting levels. Detailed methods for daylight analysis are provided in good practice [6-8(42)].

Any glass with enhanced energy performance will inevitably reduce the amount of daylight transmitted, even though it remains transparent for outward vision. The higher the demand for energy performance, the greater the compromise on daylight. Therefore, the selection of glass should begin by assessing the daylight requirements and deciding the optimum VLT. This approach helps narrow down the options, allowing for the selection of glass that provides the best performance for the specified VLT while also considering cost and aesthetics.

Floor plate geometry plays an important role as the daylight distribution will depend on the depth of the plate from the glazed area. Planforms incorporating courtyard and atrium have a great advantage of harnessing maximum daylight.

5.6.4 *Integrated design approach*

Glass and glazing system design shall duly consider the trade-offs in enhancing daylight availability, maximizing or minimizing the heat gains/losses, reduction in glare and improving views for the occupants. Table 14 provides the relation between glazing system parameters and different performance attributes.

Table 14 Relation between glazing system parameters and different performance attributes
(Clause 5.6.4)

	VLT	U-Value	SHGC	Shading system	Fenestration size
Daylight	↗	-	-	↙	↗
View	↗	-	-	↙	↗
Heat transfer	-	↗	↗	↙	↗
Ventilation	-	-	-	↙	↗

NOTE – The effects may vary depending on the geographic location, orientation of the façade and on-site & off-site features. The factors also have inter-dependencies.

5.7 Window design guideline for Non-Conditioned / Mixed Mode Buildings

In non-conditioned spaces, windows typically use single-glazed units, as they are often opened to allow ventilation. In such buildings, shading devices play a critical role in the thermal performance of windows. Considerations for selecting type of window and the necessary design considerations for energy efficiency and natural ventilation shall be made in accordance with **8.1.3.2** of Part 11 ‘Approach to Sustainability’ of the Code.

6 FIRE AND LOADING

6.1 Determination of Appropriate Glass Thickness

6.1.1 *General*

This Section gives provisions to determine the minimum glass thickness to be used to resist the ultimate limit state design wind pressures. However, the location of the glass within the building require additional considerations, such as safety with respect to human which may impose either a minimum glass thickness above the basic calculation of this part or a provision for a specific glass type or both.

In addition to the provisions herein, the design requirements such as wind loads determined in accordance with good practice [6-8(7)] and the serviceability deflection requirement limit given in this Section shall have to be complied.

The provisions under **6** are applicable provided the following parameters are satisfied:

a) Ultimate limit state wind pressure shall not be greater than 10 kPa.
b) For laminated glass, the two sheets ~~are~~ may be of equal or unequal thickness and the interlayer material is either polyvinyl butyral or an equivalent type of interlayer with a modulus of elasticity of about 24 MPa and a Poisson's ratio of 0.50 at 20 °C.
c) Design flexural tensile strength of glass depends upon the design strength obtained after applying a factor of safety of 2.5. The minimum design strength of normal glass for thickness up to 6 mm is 16.7 N/mm^2 and for thickness above 6 mm is 15.2 N/mm^2.

6.1.2 *Design Considerations*

The following design considerations shall be considered in determination of appropriate thickness of glass:

a) Maximum area of glass panel is restricted to 15 m^2.
b) Maximum span of window is restricted to 4 m.
c) Aspect ratio of the glass panel should be greater than 1.5. If it is less than 1.5, next higher available thickness should be selected in order to reduce the stress level.
d) Factor of safety used is 2.5 considering the variability in strength of glass.
e) Applicable to normal, reflective, laminated, tempered and insulating glass.
f) Applicable to rectangular panels properly secured.
g) Design minimum thickness of laminated glass will be the maximum value of thickness in accordance with the Table 5.
h) Any recognized method of analysis may be used for design, in consultation with the manufacturer and the expert in the field.

6.1.3 *Empirical Relationship*

Empirical relation between the wind pressure, area of the glass panel and the required glass thickness can be used:

$$P_{net}.A = 200T^{k} \text{ (for } T \leq 6 \text{ mm)}$$
$$P_{net}.A = 200T^{k} + 1\,900 \text{ (for } T > 6 \text{ mm)}$$

where

P_{net} = Net design wind pressure as per **6.1.4**, in N/m^2;
A = Area of glass panel, in m^2;
T = Standard nominal thickness (SNT) of glass from Table 15, in mm; and
k = Constant from the Table 15.

Table 15 Value of k for the Corresponding Standard Nominal

Thickness of Float Glass
(*Clause* 6.1.3)

T, mm	3	4	5	6	8	10	12	15	19	25
k	1.683	1.732	1.753	1.765	1.57	1.578	1.583	1.579	1.569	1.569

6.1.3.1 *Glass supported on two opposite sides*

a) Normal and laminated glass panels supported on two opposite sides can be designed using following empirical relations:

1) For *T* ≤ 6 mm :

$$b = \frac{4.39\,T}{\sqrt{\left(\frac{P_{\text{net}}}{P_{\text{f}}}\right)}}$$

2) For *T* > 6 mm :

$$b = \frac{4.22\,T}{\sqrt{\left(\frac{P_{\text{net}}}{P_{\text{f}}}\right)}}$$

b) Tempered/toughened panel supported on two opposite sides can be designed using following empirical relations:

1) For *T* ≤ 6 mm :

$$b = \frac{3.268\,8\,T}{\sqrt{\left(\frac{P_{\text{net}}}{P_{\text{f}}}\right)}}$$

2) For *T* > 6 mm :

$$b = \frac{2.906\,9\,T}{\sqrt{\left(\frac{P_{\text{net}}}{P_{\text{f}}}\right)}}$$

where

b = span, in m; and
P_f = strength factors as in Table 16.

For insulated glass, thickness of only one glass pane shall be considered. If the glass panes are of different thickness, the minimum of the two thicknesses shall be considered.

For laminated glass, the thickness of PVB has not been considered. The value to be used is;

T = Standard nominal thickness – Thickness of PVB.

For non-linear analysis, specialist literature may be consulted.

6.1.4 *Determination of Design Wind Pressure*

Net design wind pressure (P_{net}) is an important parameter governing the thickness of glass to be used in the window panels. It depends on factors as given below:

a) Location of the building (wind zone);
b) Construction patterns around buildings (terrain category);
c) Topography of site;
d) Building plan and height, etc.

Net design wind pressure (P_{net}), may be defined using the following equation:

$P_{net} = p_z.C_p$

where

C_p= net pressure coefficient as per good practice [6-8(7)]; and
p_z = design wind pressure as per good practice [6-8(7)], in N/m^2.
= 0.6 V_z^2

$V_z = V_b.k_1.k_2.k_3.k_4$

where
V_b= basic wind speed based on Location [as per Fig. 1 of good practice [6-8(7)];
k_1 = risk co-efficient factor;
k_2 = terrain factor;
k_3 = topography factor;
k_4 = importance factor for the cyclonic region and
V_z = design wind speed, in m/s.

6.1.4.1 *Laminated/tempered/insulating glass*

To determine the thickness of laminated/ tempered/ insulating glass, the design wind pressure P_{net} is modified by dividing it with the strength or pressure factor P_f, dependent on the type of glass. The values of the P_f are given in Table 16.

Using the modified values of P_{net}, the thickness of other glass types can be obtained in accordance with **6.1.3**.

Table 16 Strength Factor, P_f
[*Clause* 6.1.3.1(b)]

Sl No. (1)	**Glass Type** (2)	P_f (3)
i)	Normal (Annealed)	1.00

ii)	Laminated	0.80
iii)	Tempered	2.50
iv)	Insulated	1.50
v)	Heat strengthened	1.60
vi)	Wired glass	0.50

6.1.5 *Aspect Ratio (AR_{max})*

The design of the thickness using empirical relation in accordance with **6.1.3** shall be valid up to a limiting aspect ratio AR_{max}. The value of AR_{max} for different thickness (T) of glass is given in Table 17.

Table 17 Thickness and Corresponding AR_{max} Values
(*Clause* 6.1.5)

T, in mm	3	4	5	6	8	10	12	15	19	25
AR_{max}	7.3	6.8	6.5	6.3	5.9	4.9	4.3	3.8	3.3	2.9

6.1.6 Seismic Design

6.1.6.1 *Seismic load (EQ)*

The design for seismic forces shall be performed in steps to establish upper and lower bound force and movement response parameters. In addition, the response of the structure sensitive to certain parameters such as the damping and the stiffness of the support points may be evaluated.

The principal design criteria for the seismic design are,

a) Structure will remain elastic during the design seismic event.
b) 'Hangers' will stiffen the cantilever 'tree' structure.
c) 'Hangers' will not go slack.

6.1.6.2 *Architectural elements and utilities* ~~*Non-structural elements*~~

Depending on response sensitivity, ~~non-structural elements~~ architectural elements and utilities can be classified as deformation sensitive, acceleration sensitive, or both deformation and acceleration sensitive. Table 18 classifies non-structural elements according to their response sensitivity

Table 18 Response Sensitivity of Architectural Component
(*Clause* 6.1.6.2)

Sl No.	**Component**	**Sensitivity**	
		Acceleration Sensitive	Deformation Sensitive
(1)	(2)	(3)	(4)

i)	Exterior skin:		
	a) Adhered veneer	S	P
	b) Anchored veneer	S	P
	c) Glass blocks	S	P
	d) Prefabricated panel	S	P
	e) Glazing system	S	P
ii)	Partitions:		
	a) Heavy	S	P
	b) Light	S	P
iii)	Interior veneers:		
	a) Stone, including marble	S	P
	b) Ceramic tile	S	P
iv)	Parapets and appendages	P	-
v)	Canopies and marquees	P	-
vi)	Stairs	P	S

NOTES

1 P = Primary response.
2 S = Secondary response.

6.1.6.3 *Design seismic force*

Design seismic force on the architectural elements and utilities shall be calculated as per Part 6 'Structural design, Section 1, Loads, Forces and Effects' of the Code.

Design seismic force, F_p, on the non-structural element shall be calculated using the following expression:

$$F_p = \frac{Z}{2}\left(1 + \frac{x}{h}\right)\frac{a_p}{R_p} I_p W_p$$

$$\geq 0.10 W_p$$

where

Z = seismic zone factor {as per Table 2 of good practice [6-8(8)]};
x = height of point of attachment of the non-structural element above the foundation;
h = height of the structure;
a_p = component amplification factor given in Table 18;
R_p = component response factor of the non-structural modification factor given in Table 18;
I_p = importance element (to be taken as 1.5); and
W_p = weight of the non-structural element.

Table 18 Modification Factors

(*Clause* 6.1.6.3)

Sl No.	Architectural Component or Element	a_p (see Note)	R_p
(1)	(2)	(3)	(4)
i)	Interior non-structural walls and partitions:		
	a) Plain (unreinforced) masonry walls	1.0	1.5
	b) All other walls and partitions	1.0	2.5
ii)	Cantilever elements (braced to structural frame above its centre of mass):		
	a) Parapets	1.0	1.5
	b) Chimneys and stacks	1.0	2.5
	c) Exterior non-structural walls	1.0	2.5
iii)	Exterior non-structural wall elements and connections:		
	a) Wall element	1.0	2.5
	b) Body of wall panel connection	1.0	2.5
	c) Fasteners of the connecting system	1.25	1.0
iv)	Veneer:		
	a) High deformability elements and attachments	1.0	2.5
	b) Low deformability elements and attachments	1.0	1.5

NOTE — A lower value of a_p is permitted provided a detailed dynamic analysis is performed which justifies a lower value. The value of a_p shall not be less than 1.0. The value of a_p = 1.0 is for equipment generally regarded as rigid and rigidly attached. The value of a_p = 2.5 is for flexible components or flexibly attached components.

6.1.6.4 *Seismic relative displacement*

a) For two connection points on the same structure '*A*', one at a height h_x, and other at a height h_y, seismic relative displacement shall be determined as:

$$D_p = \delta_{xA} - \delta_{yA}$$

D_p is not required to be taken as greater than $R(h_x - h_y)\dfrac{\Delta_{aA}}{h_{sx}}$

where

δ_{xA} = deflection at building level x of structure A due to design seismic load determined by elastic analysis, and multiplied by response reduction factor R of the building as per Table 9 of good practice [6-8(8)];

δ_{yA} = deflection at building level y of structure A due to design seismic load determined by elastic analysis, and multiplied by response reduction factor R of the building as per Table 9 of good practice [6-8(8)];

h_x = height of level x to which upper connection point is attached;

h_y = height of level y to which lower connection point is attached;

Δ_{aA} = allowable storey drift for structure A calculated as per **7.11.1.1** of good practice [6-8(8)]; and

h_{sx} = storey height below level x.

b) For two connection points on separate structures A and B, or separate structural systems, one at height, h_x, and the other at a height, h_y , D_p shall be determined as:

$$D_p = |\delta_{xA}| + |\delta_{yA}|$$

D_p is not required to be taken as greater than

$$R\left(h_x \frac{\Delta_{aA}}{h_{sx}} + h_y \frac{\Delta_{aB}}{h_{sx}}\right)$$

where

δ_{yB} = deflection at building level y of structure *B* due to design seismic load determined by elastic analysis, and multiplied by response reduction factor, R, of the building as per Table 9 of good practice [6-8(8)]

Δ_{aB} = allowable storey drift for structure *B* calculated as per **7.11.1.1** of good practice [6-8(8)]

6.1.7 *Imposed Loads*

The uniform distributed load and point load is to be considered based on application and is to be selected in accordance with good practice [6-8(9)]. Appropriate uniform distributed load (UDL) and concentrated load are selected in accordance to good practice [6-8(9)] based on nature of building (for example, residential, institutional, industrial building, etc) and nature of activity under each building type.

6.1.8 *Load Contribution*

6.1.8.1 *Wind load*

The wind load is the effect of wind pressure which is dependent on the location, building height, topography and ground roughness factor. The wind speed is taken from good practice [6-8(7)] for the geographic location.

6.1.8.2 *Dead load*

In case of inclined sloped glazing, the dead weight of the glazing should be considered. In case of component of sloped glazing, the following corresponding component of the total glazing may be used:

a) Point load shall be applied as a uniformly distributed load over a circular area of 0.01 m^2.
b) For a glazed panel supported on all edges, the point loading shall be applied at the centre.
c) For free glazing edges, the point load shall be applied adjacent to the centre of the free edge.
d) Ultimate limit state design wind pressure shall not be greater than 1.2 kPa. For greater design wind pressures, the glass shall be separately designed to withstand wind loading in accordance with **6.1.4**.

6.1.9 *Reference Chart Relating Wind Load, Maximum Allowable Area for a Thickness of Glass with Respect to Terrain Category*

Table 19 to Table 27 provides relation between design wind pressure and maximum allowable area for a thickness of glass with respect to specific terrain category. User may select the type of glass depending on the support conditions.

Specialist literature may be consulted for use of non-linear analysis. ~~and the like for laminated glass~~. Specialist literature shall mean any national/international publication, codes or peer reviewed research papers on the topic.

The deflection at the centre of glass pane can be calculated using the formula in accordance to Annex C.

Typical model calculation to calculate thickness and determine wind load and deflection at the centre of the glazing is given at Annex D.

Table 19 Maximum Areas for Annealed Glass Fixed on All Four Sides, m^2
(*Clause* 6.1.9)

Design Wind Pressure N/m^2	**Nominal Thickness of Glass, *T*** mm								
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
500	2.13	3.86	6.03	8.63	13.06	15.00	15.00	15.00	15.00
550	1.93	3.51	5.48	7.85	11.88	15.00	15.00	15.00	15.00
600	1.77	3.21	5.02	7.19	10.89	14.61	15.00	15.00	15.00
650	1.64	2.97	4.64	6.64	10.05	13.48	15.00	15.00	15.00
700	1.52	2.75	4.31	6.17	9.33	12.52	15.00	15.00	15.00
750	1.42	2.57	4.02	5.76	8.71	11.69	14.75	15.00	15.00
800	1.33	2.41	3.77	5.40	8.16	10.96	13.83	15.00	15.00
850	1.25	2.27	3.55	5.08	7.68	10.31	13.01	15.00	15.00
900	1.18	2.14	3.35	4.80	7.26	9.74	12.29	15.00	15.00

Design Wind Pressure N/m²	**Nominal Thickness of Glass, *T*** mm								
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
950	1.12	2.03	3.17	4.54	6.88	9.23	11.64	15.00	15.00
1 000	1.06	1.93	3.01	4.32	6.53	8.76	11.06	15.00	15.00
1 050	1.01	1.84	2.87	4.11	6.22	8.35	10.53	14.38	15.00
1 100	0.97	1.75	2.74	3.92	5.94	7.97	10.06	13.73	15.00
1 150	0.93	1.68	2.62	3.75	5.68	7.62	9.62	13.13	15.00
1 200	0.89	1.61	2.51	3.60	5.44	7.30	9.22	12.58	15.00
1 250	0.85	1.54	2.41	3.45	5.23	7.01	8.85	12.08	15.00
1 300	0.82	1.48	2.32	3.32	5.02	6.74	8.51	11.61	15.00
1 350	0.79	1.43	2.23	3.20	4.84	6.49	8.19	11.18	14.98
1 400	0.76	1.38	2.15	3.08	4.67	6.26	7.90	10.78	14.44
1 450	0.73	1.33	2.08	2.98	4.50	6.04	7.63	10.41	13.95
1 500	0.71	1.29	2.01	2.88	4.35	5.84	7.37	10.07	13.48
1 550	0.69	1.24	1.94	2.78	4.21	5.65	7.14	9.74	13.05
1 600	0.67	1.21	1.88	2.70	4.08	5.48	6.91	9.44	12.64
1 650	0.64	1.17	1.83	2.62	3.96	5.31	6.70	9.15	12.25
1 700	0.63	1.13	1.77	2.54	3.84	5.16	6.51	8.88	11.89
1 750	0.61	1.10	1.72	2.47	3.73	5.01	6.32	8.63	11.55
1 800	0.59	1.07	1.67	2.40	3.63	4.87	6.14	8.39	11.23
1 850	0.58	1.04	1.63	2.33	3.53	4.74	5.98	8.16	10.93
1 900	0.56	1.01	1.59	2.27	3.44	4.61	5.82	7.95	10.64
1 950	0.55	0.99	1.55	2.21	3.35	4.49	5.67	7.74	10.37
2 000	0.53	0.96	1.51	2.16	3.27	4.38	5.53	7.55	10.11
2 050	0.52	0.94	1.47	2.11	3.19	4.28	5.40	7.36	9.86
2 100	0.51	0.92	1.44	2.06	3.11	4.17	5.27	7.19	9.63
2 150	0.49	0.90	1.40	2.01	3.04	4.08	5.14	7.02	9.40
2 200	0.48	0.88	1.37	1.96	2.97	3.98	5.03	6.86	9.19
2 250	0.47	0.86	1.34	1.92	2.90	3.90	4.92	6.71	8.99
2 300	0.46	0.84	1.31	1.88	2.84	3.81	4.81	6.56	8.79
2 350	0.45	0.82	1.28	1.84	2.78	3.73	4.71	6.42	8.60
2 400	0.44	0.80	1.26	1.80	2.72	3.65	4.61	6.29	8.43
2 450	0.43	0.79	1.23	1.76	2.67	3.58	4.51	6.16	8.25
2 500	0.43	0.77	1.21	1.73	2.61	3.51	4.42	6.04	8.09
2 550	0.42	0.76	1.18	1.69	2.56	3.44	4.34	5.92	7.93
2 600	0.41	0.74	1.16	1.66	2.51	3.37	4.25	5.81	7.78
2 650	0.40	0.73	1.14	1.63	2.46	3.31	4.17	5.70	7.63
2 700	0.39	0.71	1.12	1.60	2.42	3.25	4.10	5.59	7.49
2 750	0.39	0.70	1.10	1.57	2.38	3.19	4.02	5.49	7.35
2 800	0.38	0.69	1.08	1.54	2.33	3.13	3.95	5.39	7.22
2 850	0.37	0.68	1.06	1.51	2.29	3.08	3.88	5.30	7.09
2 900	0.37	0.66	1.04	1.49	2.25	3.02	3.81	5.21	6.97
2 950	0.36	0.65	1.02	1.46	2.21	2.97	3.75	5.12	6.85

Design Wind Pressure N/m^2	Nominal Thickness of Glass, *T* mm								
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
3 000	0.35	0.64	1.00	1.44	2.18	2.92	3.69	5.03	6.74
3 050	0.35	0.63	0.99	1.42	2.14	2.87	3.63	4.95	6.63
3 100	0.34	0.62	0.97	1.39	2.11	2.83	3.57	4.87	6.52
3 150	0.34	0.61	0.96	1.37	2.07	2.78	3.51	4.79	6.42
3 200	0.33	0.60	0.94	1.35	2.04	2.74	3.46	4.72	6.32
3 250	0.33	0.59	0.93	1.33	2.01	2.70	3.40	4.65	6.22
3 300	0.32	0.58	0.91	1.31	1.98	2.66	3.35	4.58	6.13
3 350	0.32	0.58	0.90	1.29	1.95	2.62	3.30	4.51	6.04
3 400	0.31	0.57	0.89	1.27	1.92	2.58	3.25	4.44	5.95
3 450	0.31	0.56	0.87	1.25	1.89	2.54	3.21	4.38	5.86
3 500	0.30	0.55	0.86	1.23	1.87	2.50	3.16	4.31	5.78
3 550	0.30	0.54	0.85	1.22	1.84	2.47	3.12	4.25	5.70
3 600	0.30	0.54	0.84	1.20	1.81	2.43	3.07	4.19	5.62
3 650	0.29	0.53	0.83	1.18	1.79	2.40	3.03	4.14	5.54
3 700	0.29	0.52	0.81	1.17	1.77	2.37	2.99	4.08	5.47
3 750	0.28	0.51	0.80	1.15	1.74	2.34	2.95	4.03	5.39
3 800	0.28	0.51	0.79	1.14	1.72	2.31	2.91	3.97	5.32
3 850	0.28	0.50	0.78	1.12	1.70	2.28	2.87	3.92	5.25
3 900	0.27	0.49	0.77	1.11	1.67	2.25	2.84	3.87	5.18
3 950	0.27	0.49	0.76	1.09	1.65	2.22	2.80	3.82	5.12
4 000	0.27	0.48	0.75	1.08	1.63	2.19	2.77	3.77	5.06
4 050	0.26	0.48	0.74	1.07	1.61	2.16	2.73	3.73	4.99
4 100	0.26	0.47	0.74	1.05	1.59	2.14	2.70	3.68	4.93
4 150	0.26	0.46	0.73	1.04	1.57	2.11	2.67	3.64	4.87
4 200	0.25	0.46	0.72	1.03	1.56	2.09	2.63	3.59	4.81
4 250	0.25	0.45	0.71	1.02	1.54	2.06	2.60	3.55	4.76
4 300	0.25	0.45	0.70	1.00	1.52	2.04	2.57	3.51	4.70
4 350	0.24	0.44	0.69	0.99	1.50	2.01	2.54	3.47	4.65
4 400	0.24	0.44	0.69	0.98	1.48	1.99	2.51	3.43	4.60
4 450	0.24	0.43	0.68	0.97	1.47	1.97	2.49	3.39	4.54
4 500	0.24	0.43	0.67	0.96	1.45	1.95	2.46	3.36	4.49
4 550	0.23	0.42	0.66	0.95	1.44	1.93	2.43	3.32	4.44
4 600	0.23	0.42	0.66	0.94	1.42	1.91	2.40	3.28	4.40
4 650	0.23	0.41	0.65	0.93	1.40	1.88	2.38	3.25	4.35
4 700	0.23	0.41	0.64	0.92	1.39	1.86	2.35	3.21	4.30
4 750	0.22	0.41	0.63	0.91	1.38	1.85	2.33	3.18	4.26
4 800	0.22	0.40	0.63	0.90	1.36	1.83	2.30	3.15	4.21
4 850	0.22	0.40	0.62	0.89	1.35	1.81	2.28	3.11	4.17
4 900	0.22	0.39	0.62	0.88	1.33	1.79	2.26	3.08	4.13
4 950	0.21	0.39	0.61	0.87	1.32	1.77	2.23	3.05	4.08
5 000	0.21	0.39	0.60	0.86	1.31	1.75	2.21	3.02	4.04

Design Wind Pressure N/m²	**Nominal Thickness of Glass, *T*** mm								
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Maximum aspect ratio	7.3	6.8	6.5	6.3	5.9	4.9	4.3	3.8	3.3

Table 20 Maximum Areas for Laminated Glass Fixed on All Four Sides, m²
(*Clause* 6.1.9)

Design Wind Pressure N/m²	**Nominal Thickness of Laminated Glass, *T*** mm					
	5.38	6.38	8.38	10.38	12.38	16.38
(1)	(2)	(3)	(4)	(5)	(6)	(7)
500	4.47	6.28	10.45	14.02	15.00	15.00
550	4.06	5.71	9.50	12.75	15.00	15.00
600	3.72	5.23	8.71	11.69	15.00	15.00
650	3.44	4.83	8.04	10.79	13.93	15.00
700	3.19	4.48	7.46	10.02	12.94	15.00
750	2.98	4.19	6.97	9.35	12.08	15.00
800	2.79	3.92	6.53	8.76	11.32	15.00
850	2.63	3.69	6.15	8.25	10.66	15.00
900	2.48	3.49	5.81	7.79	10.06	14.21
950	2.35	3.30	5.50	7.38	9.53	13.46
1 000	2.23	3.14	5.23	7.01	9.06	12.79
1 050	2.13	2.99	4.98	6.68	8.63	12.18
1 100	2.03	2.85	4.75	6.37	8.23	11.63
1 150	1.94	2.73	4.54	6.10	7.88	11.12
1 200	1.86	2.62	4.35	5.84	7.55	10.66
1 250	1.79	2.51	4.18	5.61	7.25	10.23
1 300	1.72	2.41	4.02	5.39	6.97	9.84
1 350	1.66	2.33	3.87	5.19	6.71	9.47
1 400	1.60	2.24	3.73	5.01	6.47	9.14
1 450	1.54	2.16	3.60	4.84	6.25	8.82
1 500	1.49	2.09	3.48	4.67	6.04	8.53
1 550	1.44	2.03	3.37	4.52	5.84	8.25
1 600	1.40	1.96	3.27	4.38	5.66	7.99
1 650	1.35	1.90	3.17	4.25	5.49	7.75
1 700	1.31	1.85	3.07	4.12	5.33	7.52
1 750	1.28	1.79	2.99	4.01	5.18	7.31
1 800	1.24	1.74	2.90	3.90	5.03	7.11
1 850	1.21	1.70	2.82	3.79	4.90	6.91
1 900	1.18	1.65	2.75	3.69	4.77	6.73
1 950	1.15	1.61	2.68	3.60	4.64	6.56

Design Wind Pressure N/m^2	**Nominal Thickness of Laminated Glass, *T*** mm					
	5.38	6.38	8.38	10.38	12.38	16.38
(1)	(2)	(3)	(4)	(5)	(6)	(7)
2 000	1.12	1.57	2.61	3.51	4.53	6.40
2 050	1.09	1.53	2.55	3.42	4.42	6.24
2 100	1.06	1.49	2.49	3.34	4.31	6.09
2 150	1.04	1.46	2.43	3.26	4.21	5.95
2 200	1.02	1.43	2.38	3.19	4.12	5.81
2 250	0.99	1.40	2.32	3.12	4.03	5.68
2 300	0.97	1.36	2.27	3.05	3.94	5.56
2 350	0.95	1.34	2.22	2.98	3.85	5.44
2 400	0.93	1.31	2.18	2.92	3.77	5.33
2 450	0.91	1.28	2.13	2.86	3.70	5.22
2 500	0.89	1.26	2.09	2.80	3.62	5.12
2550	0.88	1.23	2.05	2.75	3.55	5.02
2 600	0.86	1.21	2.01	2.70	3.48	4.92
2 650	0.84	1.18	1.97	2.65	3.42	4.83
2 700	0.83	1.16	1.94	2.60	3.35	4.74
2 750	0.81	1.14	1.90	2.55	3.29	4.65
2 800	0.80	1.12	1.87	2.50	3.23	4.57
2 850	0.78	1.10	1.83	2.46	3.18	4.49
2 900	0.77	1.08	1.80	2.42	3.12	4.41
2 950	0.76	1.06	1.77	2.38	3.07	4.34
3 000	0.74	1.05	1.74	2.34	3.02	4.26
3 050	0.73	1.03	1.71	2.30	2.97	4.19
3 100	0.72	1.01	1.69	2.26	2.92	4.13
3 150	0.71	1.00	1.66	2.23	2.88	4.06
3 200	0.70	0.98	1.63	2.19	2.83	4.00
3 250	0.69	0.97	1.61	2.16	2.79	3.94
3 300	0.68	0.95	1.58	2.12	2.74	3.88
3 350	0.67	0.94	1.56	2.09	2.70	3.82
3 400	0.66	0.92	1.54	2.06	2.66	3.76
3 450	0.65	0.91	1.51	2.03	2.63	3.71
3 500	0.64	0.90	1.49	2.00	2.59	3.65
3 550	0.63	0.88	1.47	1.98	2.55	3.60
3 600	0.62	0.87	1.45	1.95	2.52	3.55
3 650	0.61	0.86	1.43	1.92	2.48	3.50
3 700	0.60	0.85	1.41	1.90	2.45	3.46
3 750	0.60	0.84	1.39	1.87	2.42	3.41
3 800	0.59	0.83	1.38	1.85	2.38	3.37
3 850	0.58	0.82	1.36	1.82	2.35	3.32
3 900	0.57	0.80	1.34	1.80	2.32	3.28
3 950	0.57	0.79	1.32	1.78	2.29	3.24
4 000	0.56	0.78	1.31	1.75	2.26	3.20

Design Wind Pressure N/m²	Nominal Thickness of Laminated Glass, *T* mm					
	5.38	6.38	8.38	10.38	12.38	16.38
(1)	(2)	(3)	(4)	(5)	(6)	(7)
4 050	0.55	0.78	1.29	1.73	2.24	3.16
4 100	0.55	0.77	1.27	1.71	2.21	3.12
4 150	0.54	0.76	1.26	1.69	2.18	3.08
4 200	0.53	0.75	1.24	1.67	2.16	3.05
4 250	0.53	0.74	1.23	1.65	2.13	3.01
4 300	0.52	0.73	1.22	1.63	2.11	2.97
4 350	0.51	0.72	1.20	1.61	2.08	2.94
4 400	0.51	0.71	1.19	1.59	2.06	2.91
4 450	0.50	0.71	1.17	1.58	2.04	2.87
4 500	0.50	0.70	1.16	1.56	2.01	2.84
4 550	0.49	0.69	1.15	1.54	1.99	2.81
4 600	0.49	0.68	1.14	1.52	1.97	2.78
4 650	0.48	0.68	1.12	1.51	1.95	2.75
4 700	0.48	0.67	1.11	1.49	1.93	2.72
4 750	0.47	0.66	1.10	1.48	1.91	2.69
4 800	0.47	0.65	1.09	1.46	1.89	2.66
4 850	0.46	0.65	1.08	1.45	1.87	2.64
4 900	0.46	0.64	1.07	1.43	1.85	2.61
4 950	0.45	0.63	1.06	1.42	1.83	2.58
5 000	0.45	0.63	1.05	1.40	1.81	2.56
Maximum aspect ratio	6.5	6.2	5.7	4.8	4.3	3.6

Table 21 Maximum Areas for Tempered Glass Fixed on All Four Sides, m²

(*Clause* 6.1.9)

Design Wind Pressure N/m²	Nominal Thickness of Tempered Glass, *T* mm								
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
500	5.32	9.64	15.00	15.00	15.00	15.00	15.00	15.00	15.00
550	4.84	8.76	13.70	15.00	15.00	15.00	15.00	15.00	15.00
600	4.43	8.03	12.56	15.00	15.00	15.00	15.00	15.00	15.00
650	4.09	7.42	11.59	15.00	15.00	15.00	15.00	15.00	15.00
700	3.80	6.89	10.77	15.00	15.00	15.00	15.00	15.00	15.00
750	3.55	6.43	10.05	14.39	15.00	15.00	15.00	15.00	15.00
800	3.33	6.03	9.42	13.49	15.00	15.00	15.00	15.00	15.00
850	3.13	5.67	8.87	12.70	15.00	15.00	15.00	15.00	15.00
900	2.96	5.36	8.37	11.99	15.00	15.00	15.00	15.00	15.00

Design Wind Pressure N/m²	**Nominal Thickness of Tempered Glass, *T*** mm								
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
950	2.80	5.07	7.93	11.36	15.00	15.00	15.00	15.00	15.00
1 000	2.66	4.82	7.54	10.79	15.00	15.00	15.00	15.00	15.00
1 050	2.53	4.59	7.18	10.28	15.00	15.00	15.00	15.00	15.00
1 100	2.42	4.38	6.85	9.81	14.84	15.00	15.00	15.00	15.00
1 150	2.31	4.19	6.55	9.38	14.20	15.00	15.00	15.00	15.00
1 200	2.22	4.02	6.28	8.99	13.61	15.00	15.00	15.00	15.00
1 250	2.13	3.86	6.03	8.63	13.06	15.00	15.00	15.00	15.00
1 300	2.05	3.71	5.80	8.30	12.56	15.00	15.00	15.00	15.00
1 350	1.97	3.57	5.58	7.99	12.10	15.00	15.00	15.00	15.00
1 400	1.90	3.44	5.38	7.71	11.66	15.00	15.00	15.00	15.00
1 450	1.83	3.32	5.20	7.44	11.26	15.00	15.00	15.00	15.00
1 500	1.77	3.21	5.02	7.19	10.89	14.61	15.00	15.00	15.00
1 550	1.72	3.11	4.86	6.96	10.53	14.14	15.00	15.00	15.00
1 600	1.66	3.01	4.71	6.74	10.21	13.69	15.00	15.00	15.00
1 650	1.61	2.92	4.57	6.54	9.90	13.28	15.00	15.00	15.00
1 700	1.56	2.84	4.43	6.35	9.61	12.89	15.00	15.00	15.00
1 750	1.52	2.75	4.31	6.17	9.33	12.52	15.00	15.00	15.00
1 800	1.48	2.68	4.19	6.00	9.07	12.17	15.00	15.00	15.00
1 850	1.44	2.61	4.07	5.83	8.83	11.84	14.95	15.00	15.00
1 900	1.40	2.54	3.97	5.68	8.59	11.53	14.55	15.00	15.00
1 950	1.36	2.47	3.86	5.53	8.37	11.24	14.18	15.00	15.00
2 000	1.33	2.41	3.77	5.40	8.16	10.96	13.83	15.00	15.00
2 050	1.30	2.35	3.68	5.26	7.97	10.69	13.49	15.00	15.00
2 100	1.27	2.30	3.59	5.14	7.78	10.43	13.17	15.00	15.00
2 150	1.24	2.24	3.51	5.02	7.59	10.19	12.86	15.00	15.00
2 200	1.21	2.19	3.43	4.91	7.42	9.96	12.57	15.00	15.00
2 250	1.18	2.14	3.35	4.80	7.26	9.74	12.29	15.00	15.00
2 300	1.16	2.10	3.28	4.69	7.10	9.53	12.02	15.00	15.00
2 350	1.13	2.05	3.21	4.59	6.95	9.32	11.77	15.00	15.00
2 400	1.11	2.01	3.14	4.50	6.80	9.13	11.52	15.00	15.00
2 450	1.09	1.97	3.08	4.40	6.66	8.94	11.29	15.00	15.00
2 500	1.06	1.93	3.01	4.32	6.53	8.76	11.06	15.00	15.00
2 550	1.04	1.89	2.96	4.23	6.40	8.59	10.84	14.80	15.00
2 600	1.02	1.85	2.90	4.15	6.28	8.43	10.64	14.52	15.00
2 650	1.00	1.82	2.84	4.07	6.16	8.27	10.43	14.24	15.00
2 700	0.99	1.79	2.79	4.00	6.05	8.12	10.24	13.98	15.00
2 750	0.97	1.75	2.74	3.92	5.94	7.97	10.06	13.73	15.00
2 800	0.95	1.72	2.69	3.85	5.83	7.83	9.88	13.48	15.00
2 850	0.93	1.69	2.64	3.79	5.73	7.69	9.70	13.24	15.00
2 900	0.92	1.66	2.60	3.72	5.63	7.56	9.54	13.02	15.00
2 950	0.90	1.63	2.55	3.66	5.54	7.43	9.37	12.79	15.00

Design Wind Pressure N/m^2	**Nominal Thickness of Tempered Glass, *T*** mm								
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
3 000	0.89	1.61	2.51	3.60	5.44	7.30	9.22	12.58	15.00
3 050	0.87	1.58	2.47	3.54	5.35	7.18	9.07	12.38	15.00
3 100	0.86	1.56	2.43	3.48	5.27	7.07	8.92	12.18	15.00
3 150	0.84	1.53	2.39	3.43	5.18	6.96	8.78	11.98	15.00
3 200	0.83	1.51	2.36	3.37	5.10	6.85	8.64	11.79	15.00
3 250	0.82	1.48	2.32	3.32	5.02	6.74	8.51	11.61	15.00
3 300	0.81	1.46	2.28	3.27	4.95	6.64	8.38	11.44	15.00
3 350	0.79	1.44	2.25	3.22	4.87	6.54	8.25	11.27	15.00
3 400	0.78	1.42	2.22	3.17	4.80	6.44	8.13	11.10	14.87
3 450	0.77	1.40	2.18	3.13	4.73	6.35	8.02	10.94	14.65
3 500	0.76	1.38	2.15	3.08	4.67	6.26	7.90	10.78	14.44
3 550	0.75	1.36	2.12	3.04	4.60	6.17	7.79	10.63	14.24
3 600	0.74	1.34	2.09	3.00	4.54	6.09	7.68	10.48	14.04
3 650	0.73	1.32	2.06	2.96	4.47	6.00	7.58	10.34	13.85
3 700	0.72	1.30	2.04	2.92	4.41	5.92	7.47	10.20	13.66
3 750	0.71	1.29	2.01	2.88	4.35	5.84	7.37	10.07	13.48
3 800	0.70	1.27	1.98	2.84	4.30	5.77	7.28	9.93	13.30
3 850	0.69	1.25	1.96	2.80	4.24	5.69	7.18	9.80	13.13
3 900	0.68	1.24	1.93	2.77	4.19	5.62	7.09	9.68	12.96
3 950	0.67	1.22	1.91	2.73	4.13	5.55	7.00	9.56	12.80
4 000	0.67	1.21	1.88	2.70	4.08	5.48	6.91	9.44	12.64
4 050	0.66	1.19	1.86	2.66	4.03	5.41	6.83	9.32	12.48
4 100	0.65	1.18	1.84	2.63	3.98	5.34	6.74	9.21	12.33
4 150	0.64	1.16	1.82	2.60	3.93	5.28	6.66	9.09	12.18
4 200	0.63	1.15	1.79	2.57	3.89	5.22	6.58	8.99	12.04
4 250	0.63	1.13	1.77	2.54	3.84	5.16	6.51	8.88	11.89
4 300	0.62	1.12	1.75	2.51	3.80	5.10	6.43	8.78	11.76
4 350	0.61	1.11	1.73	2.48	3.75	5.04	6.36	8.68	11.62
4 400	0.60	1.10	1.71	2.45	3.71	4.98	6.28	8.58	11.49
4 450	0.60	1.08	1.69	2.43	3.67	4.92	6.21	8.48	11.36
4 500	0.59	1.07	1.67	2.40	3.63	4.87	6.14	8.39	11.23
4 550	0.58	1.06	1.66	2.37	3.59	4.82	6.08	8.30	11.11
4 600	0.58	1.05	1.64	2.35	3.55	4.76	6.01	8.21	10.99
4 650	0.57	1.04	1.62	2.32	3.51	4.71	5.95	8.12	10.87
4 700	0.57	1.03	1.60	2.30	3.47	4.66	5.88	8.03	10.76
4 750	0.56	1.01	1.59	2.27	3.44	4.61	5.82	7.95	10.64
4 800	0.55	1.00	1.57	2.25	3.40	4.56	5.76	7.86	10.53
4 850	0.55	0.99	1.55	2.23	3.37	4.52	5.70	7.78	10.42
4 900	0.54	0.98	1.54	2.20	3.33	4.47	5.64	7.70	10.32
4 950	0.54	0.97	1.52	2.18	3.30	4.43	5.59	7.63	10.21
5 000	0.53	0.96	1.51	2.16	3.27	4.38	5.53	7.55	10.11

Design Wind Pressure N/m²	Nominal Thickness of Tempered Glass, *T* mm								
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Maximum aspect ratio	7.3	6.8	6.5	6.3	5.9	4.9	4.3	3.8	3.3

Table 22 Maximum Areas for Insulating Glass Fixed on All Four Sides, m²
(*Clause* 6.1.9)

Design Wind Pressure N/m²	Nominal Thickness of Glass, *T* mm						
	3+3	4+4	5+5	6+6	8+8	10+10	12+12
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
500	3.19	5.78	9.04	12.95	15.00	15.00	15.00
550	2.90	5.26	8.22	11.77	15.00	15.00	15.00
600	2.66	4.82	7.54	10.79	15.00	15.00	15.00
650	2.46	4.45	6.96	9.96	15.00	15.00	15.00
700	2.28	4.13	6.46	9.25	14.00	15.00	15.00
750	2.13	3.86	6.03	8.63	13.06	15.00	15.00
800	2.00	3.62	5.65	8.09	12.25	15.00	15.00
850	1.88	3.40	5.32	7.62	11.53	15.00	15.00
900	1.77	3.21	5.02	7.19	10.89	14.61	15.00
950	1.68	3.04	4.76	6.82	10.31	13.84	15.00
1 000	1.60	2.89	4.52	6.48	9.80	13.15	15.00
1 050	1.52	2.75	4.31	6.17	9.33	12.52	15.00
1 100	1.45	2.63	4.11	5.89	8.91	11.95	15.00
1 150	1.39	2.52	3.93	5.63	8.52	11.43	14.43
1 200	1.33	2.41	3.77	5.40	8.16	10.96	13.83
1 250	1.28	2.31	3.62	5.18	7.84	10.52	13.27
1 300	1.23	2.22	3.48	4.98	7.54	10.11	12.76
1 350	1.18	2.14	3.35	4.80	7.26	9.74	12.29
1 400	1.14	2.07	3.23	4.63	7.00	9.39	11.85
1 450	1.10	1.99	3.12	4.47	6.76	9.07	11.44
1 500	1.06	1.93	3.01	4.32	6.53	8.76	11.06
1 550	1.03	1.87	2.92	4.18	6.32	8.48	10.70
1 600	1.00	1.81	2.83	4.05	6.12	8.22	10.37
1 650	0.97	1.75	2.74	3.92	5.94	7.97	10.06
1 700	0.94	1.70	2.66	3.81	5.76	7.73	9.76
1 750	0.91	1.65	2.58	3.70	5.60	7.51	9.48
1 800	0.89	1.61	2.51	3.60	5.44	7.30	9.22
1 850	0.86	1.56	2.44	3.50	5.30	7.11	8.97
1 900	0.84	1.52	2.38	3.41	5.16	6.92	8.73
1 950	0.82	1.48	2.32	3.32	5.02	6.74	8.51

Design Wind Pressure N/m²	Nominal Thickness of Glass, *T* mm						
	3+3	4+4	5+5	6+6	8+8	10+10	12+12
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2 000	0.80	1.45	2.26	3.24	4.90	6.57	8.30
2 050	0.78	1.41	2.21	3.16	4.78	6.41	8.09
2 100	0.76	1.38	2.15	3.08	4.67	6.26	7.90
2 150	0.74	1.35	2.10	3.01	4.56	6.11	7.72
2 200	0.73	1.31	2.06	2.94	4.45	5.98	7.54
2 250	0.71	1.29	2.01	2.88	4.35	5.84	7.37
2 300	0.69	1.26	1.97	2.82	4.26	5.72	7.21
2 350	0.68	1.23	1.92	2.76	4.17	5.59	7.06
2 400	0.67	1.21	1.88	2.70	4.08	5.48	6.91
2 450	0.65	1.18	1.85	2.64	4.00	5.37	6.77
2 500	0.64	1.16	1.81	2.59	3.92	5.26	6.64
2 550	0.63	1.13	1.77	2.54	3.84	5.16	6.51
2 600	0.61	1.11	1.74	2.49	3.77	5.06	6.38
2 650	0.60	1.09	1.71	2.44	3.70	4.96	6.26
2 700	0.59	1.07	1.67	2.40	3.63	4.87	6.14
2 750	0.58	1.05	1.64	2.35	3.56	4.78	6.03
2 800	0.57	1.03	1.61	2.31	3.50	4.70	5.93
2 850	0.56	1.01	1.59	2.27	3.44	4.61	5.82
2 900	0.55	1.00	1.56	2.23	3.38	4.53	5.72
2 950	0.54	0.98	1.53	2.19	3.32	4.46	5.62
3 000	0.53	0.96	1.51	2.16	3.27	4.38	5.53
3 050	0.52	0.95	1.48	2.12	3.21	4.31	5.44
3 100	0.51	0.93	1.46	2.09	3.16	4.24	5.35
3 150	0.51	0.92	1.44	2.06	3.11	4.17	5.27
3 200	0.50	0.90	1.41	2.02	3.06	4.11	5.18
3 250	0.49	0.89	1.39	1.99	3.01	4.05	5.11
3 300	0.48	0.88	1.37	1.96	2.97	3.98	5.03
3 350	0.48	0.86	1.35	1.93	2.92	3.92	4.95
3 400	0.47	0.85	1.33	1.90	2.88	3.87	4.88
3 450	0.46	0.84	1.31	1.88	2.84	3.81	4.81
3 500	0.46	0.83	1.29	1.85	2.80	3.76	4.74
3 550	0.45	0.81	1.27	1.82	2.76	3.70	4.67
3 600	0.44	0.80	1.26	1.80	2.72	3.65	4.61
3 650	0.44	0.79	1.24	1.77	2.68	3.60	4.55
3 700	0.43	0.78	1.22	1.75	2.65	3.55	4.48
3 750	0.43	0.77	1.21	1.73	2.61	3.51	4.42
3 800	0.42	0.76	1.19	1.70	2.58	3.46	4.37
3 850	0.41	0.75	1.17	1.68	2.54	3.41	4.31
3 900	0.41	0.74	1.16	1.66	2.51	3.37	4.25
3 950	0.40	0.73	1.14	1.64	2.48	3.33	4.20
4 000	0.40	0.72	1.13	1.62	2.45	3.29	4.15

Design Wind Pressure N/m²	**Nominal Thickness of Glass, *T*** mm						
	3+3	4+4	5+5	6+6	8+8	10+10	12+12
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
4 050	0.39	0.71	1.12	1.60	2.42	3.25	4.10
4 100	0.39	0.71	1.10	1.58	2.39	3.21	4.05
4 150	0.38	0.70	1.09	1.56	2.36	3.17	4.00
4 200	0.38	0.69	1.08	1.54	2.33	3.13	3.95
4 250	0.38	0.68	1.06	1.52	2.31	3.09	3.90
4 300	0.37	0.67	1.05	1.51	2.28	3.06	3.86
4 350	0.37	0.66	1.04	1.49	2.25	3.02	3.81
4 400	0.36	0.66	1.03	1.47	2.23	2.99	3.77
4 450	0.36	0.65	1.02	1.46	2.20	2.95	3.73
4 500	0.35	0.64	1.00	1.44	2.18	2.92	3.69
4 550	0.35	0.64	0.99	1.42	2.15	2.89	3.65
4 600	0.35	0.63	0.98	1.41	2.13	2.86	3.61
4 650	0.34	0.62	0.97	1.39	2.11	2.83	3.57
4 700	0.34	0.62	0.96	1.38	2.08	2.80	3.53
4 750	0.34	0.61	0.95	1.36	2.06	2.77	3.49
4 800	0.33	0.60	0.94	1.35	2.04	2.74	3.46
4 850	0.33	0.60	0.93	1.34	2.02	2.71	3.42
4 900	0.33	0.59	0.92	1.32	2.00	2.68	3.39
4 950	0.32	0.58	0.91	1.31	1.98	2.66	3.35
5 000	0.32	0.58	0.90	1.30	1.96	2.63	3.32
Maximum aspect ratio	7.3	6.8	6.5	6.3	5.9	4.9	4.3

Table 23 Maximum Area for Heat Strengthened Glass Fixed on Four Sides, m²

(*Clause* 6.1.9)

Design Wind Pressure N/m²	**Nominal Thickness of Heat Strengthened Glass, *T*** mm								
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
500	3.41	6.17	9.65	13.81	15.00	15.00	15.00	15.00	15.00
550	3.10	5.61	8.77	12.56	15.00	15.00	15.00	15.00	15.00
600	2.84	5.14	8.04	11.51	15.00	15.00	15.00	15.00	15.00
650	2.62	4.75	7.42	10.63	15.00	15.00	15.00	15.00	15.00
700	2.43	4.41	6.89	9.87	14.93	15.00	15.00	15.00	15.00
750	2.27	4.11	6.43	9.21	13.93	15.00	15.00	15.00	15.00
800	2.13	3.86	6.03	8.63	13.06	15.00	15.00	15.00	15.00
850	2.00	3.63	5.67	8.13	12.29	15.00	15.00	15.00	15.00
900	1.89	3.43	5.36	7.67	11.61	15.00	15.00	15.00	15.00
950	1.79	3.25	5.08	7.27	11.00	14.76	15.00	15.00	15.00

Design Wind Pressure N/m^2	**Nominal Thickness of Heat Strengthened Glass, *T*** mm								
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1 000	1.70	3.09	4.82	6.91	10.45	14.02	15.00	15.00	15.00
1 050	1.62	2.94	4.59	6.58	9.95	13.36	15.00	15.00	15.00
1 100	1.55	2.80	4.38	6.28	9.50	12.75	15.00	15.00	15.00
1 150	1.48	2.68	4.19	6.01	9.09	12.19	15.00	15.00	15.00
1 200	1.42	2.57	4.02	5.76	8.71	11.69	14.75	15.00	15.00
1 250	1.36	2.47	3.86	5.53	8.36	11.22	14.16	15.00	15.00
1 300	1.31	2.37	3.71	5.31	8.04	10.79	13.61	15.00	15.00
1 350	1.26	2.29	3.57	5.12	7.74	10.39	13.11	15.00	15.00
1 400	1.22	2.20	3.45	4.93	7.46	10.02	12.64	15.00	15.00
1 450	1.17	2.13	3.33	4.76	7.21	9.67	12.21	15.00	15.00
1 500	1.14	2.06	3.22	4.60	6.97	9.35	11.80	15.00	15.00
1 550	1.10	1.99	3.11	4.46	6.74	9.05	11.42	15.00	15.00
1 600	1.06	1.93	3.01	4.32	6.53	8.76	11.06	15.00	15.00
1 650	1.03	1.87	2.92	4.19	6.33	8.50	10.73	14.64	15.00
1 700	1.00	1.81	2.84	4.06	6.15	8.25	10.41	14.21	15.00
1 750	0.97	1.76	2.76	3.95	5.97	8.01	10.11	13.80	15.00
1 800	0.95	1.71	2.68	3.84	5.81	7.79	9.83	13.42	15.00
1 850	0.92	1.67	2.61	3.73	5.65	7.58	9.57	13.06	15.00
1 900	0.90	1.62	2.54	3.64	5.50	7.38	9.31	12.71	15.00
1 950	0.87	1.58	2.47	3.54	5.36	7.19	9.08	12.39	15.00
2 000	0.85	1.54	2.41	3.45	5.23	7.01	8.85	12.08	15.00
2 050	0.83	1.50	2.35	3.37	5.10	6.84	8.63	11.78	15.00
2 100	0.81	1.47	2.30	3.29	4.98	6.68	8.43	11.50	15.00
2 150	0.79	1.43	2.24	3.21	4.86	6.52	8.23	11.24	15.00
2 200	0.77	1.40	2.19	3.14	4.75	6.37	8.04	10.98	14.71
2 250	0.76	1.37	2.14	3.07	4.64	6.23	7.87	10.74	14.38
2 300	0.74	1.34	2.10	3.00	4.54	6.10	7.69	10.50	14.07
2 350	0.72	1.31	2.05	2.94	4.45	5.97	7.53	10.28	13.77
2 400	0.71	1.29	2.01	2.88	4.35	5.84	7.37	10.07	13.48
2 450	0.69	1.26	1.97	2.82	4.27	5.72	7.22	9.86	13.21
2 500	0.68	1.23	1.93	2.76	4.18	5.61	7.08	9.66	12.94
2 550	0.67	1.21	1.89	2.71	4.10	5.50	6.94	9.47	12.69
2 600	0.65	1.19	1.86	2.66	4.02	5.39	6.81	9.29	12.44
2 650	0.64	1.16	1.82	2.61	3.94	5.29	6.68	9.12	12.21
2 700	0.63	1.14	1.79	2.56	3.87	5.19	6.55	8.95	11.98
2 750	0.62	1.12	1.75	2.51	3.80	5.10	6.44	8.78	11.76
2 800	0.61	1.10	1.72	2.47	3.73	5.01	6.32	8.63	11.55
2 850	0.60	1.08	1.69	2.42	3.67	4.92	6.21	8.48	11.35
2 900	0.59	1.06	1.66	2.38	3.60	4.84	6.10	8.33	11.16
2 950	0.58	1.05	1.63	2.34	3.54	4.75	6.00	8.19	10.97
3 000	0.57	1.03	1.61	2.30	3.48	4.67	5.90	8.05	10.78

Design Wind Pressure N/m²	Nominal Thickness of Heat Strengthened Glass, *T* mm								
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
3 050	0.56	1.01	1.58	2.26	3.43	4.60	5.80	7.92	10.61
3 100	0.55	1.00	1.56	2.23	3.37	4.52	5.71	7.79	10.44
3 150	0.54	0.98	1.53	2.19	3.32	4.45	5.62	7.67	10.27
3 200	0.53	0.96	1.51	2.16	3.27	4.38	5.53	7.55	10.11
3 250	0.52	0.95	1.48	2.13	3.22	4.31	5.45	7.43	9.95
3 300	0.52	0.93	1.46	2.09	3.17	4.25	5.36	7.32	9.80
3 350	0.51	0.92	1.44	2.06	3.12	4.19	5.28	7.21	9.66
3 400	0.50	0.91	1.42	2.03	3.07	4.12	5.21	7.10	9.52
3 450	0.49	0.89	1.40	2.00	3.03	4.06	5.13	7.00	9.38
3 500	0.49	0.88	1.38	1.97	2.99	4.01	5.06	6.90	9.24
3 550	0.48	0.87	1.36	1.95	2.94	3.95	4.99	6.80	9.11
3 600	0.47	0.86	1.34	1.92	2.90	3.90	4.92	6.71	8.99
3 650	0.47	0.85	1.32	1.89	2.86	3.84	4.85	6.62	8.86
3 700	0.46	0.83	1.30	1.87	2.82	3.79	4.78	6.53	8.74
3 750	0.45	0.82	1.29	1.84	2.79	3.74	4.72	6.44	8.63
3 800	0.45	0.81	1.27	1.82	2.75	3.69	4.66	6.36	8.51
3 850	0.44	0.80	1.25	1.79	2.71	3.64	4.60	6.27	8.40
3 900	0.44	0.79	1.24	1.77	2.68	3.60	4.54	6.19	8.30
3 950	0.43	0.78	1.22	1.75	2.65	3.55	4.48	6.12	8.19
4 000	0.43	0.77	1.21	1.73	2.61	3.51	4.42	6.04	8.09
4 050	0.42	0.76	1.19	1.71	2.58	3.46	4.37	5.96	7.99
4 100	0.42	0.75	1.18	1.68	2.55	3.42	4.32	5.89	7.89
4 150	0.41	0.74	1.16	1.66	2.52	3.38	4.26	5.82	7.80
4 200	0.41	0.73	1.15	1.64	2.49	3.34	4.21	5.75	7.70
4 250	0.40	0.73	1.13	1.63	2.46	3.30	4.16	5.68	7.61
4 300	0.40	0.72	1.12	1.61	2.43	3.26	4.12	5.62	7.52
4 350	0.39	0.71	1.11	1.59	2.40	3.22	4.07	5.55	7.44
4 400	0.39	0.70	1.10	1.57	2.38	3.19	4.02	5.49	7.35
4 450	0.38	0.69	1.08	1.55	2.35	3.15	3.98	5.43	7.27
4 500	0.38	0.69	1.07	1.53	2.32	3.12	3.93	5.37	7.19
4 550	0.37	0.68	1.06	1.52	2.30	3.08	3.89	5.31	7.11
4 600	0.37	0.67	1.05	1.50	2.27	3.05	3.85	5.25	7.03
4 650	0.37	0.66	1.04	1.49	2.25	3.02	3.81	5.19	6.96
4 700	0.36	0.66	1.03	1.47	2.22	2.98	3.77	5.14	6.88
4 750	0.36	0.65	1.02	1.45	2.20	2.95	3.73	5.09	6.81
4 800	0.35	0.64	1.00	1.44	2.18	2.92	3.69	5.03	6.74
4 850	0.35	0.64	0.99	1.42	2.15	2.89	3.65	4.98	6.67
4 900	0.35	0.63	0.98	1.41	2.13	2.86	3.61	4.93	6.60
4 950	0.34	0.62	0.97	1.40	2.11	2.83	3.58	4.88	6.54
5 000	0.34	0.62	0.96	1.38	2.09	2.80	3.54	4.83	6.47

Design Wind Pressure N/m²	**Nominal Thickness of Heat Strengthened Glass, *T*** mm								
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Maximum aspect ratio	7.3	6.8	6.5	6.3	5.9	4.9	4.3	3.8	3.3

Table 24 Maximum Span for Annealed Glass Fixed on Two Opposite Sides, m

(*Clause* 6.1.9)

Design Wind Pressure N/m²	**Nominal Thickness of Annealed Glass, *T*** mm								
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
500	0.53	0.73	0.92	1.12	1.40	1.77	2.11	2.68	3.36
550	0.51	0.69	0.88	1.07	1.33	1.69	2.02	2.56	3.20
600	0.48	0.66	0.84	1.02	1.27	1.62	1.93	2.45	3.07
650	0.46	0.64	0.81	0.98	1.22	1.56	1.85	2.35	2.95
700	0.45	0.61	0.78	0.95	1.18	1.50	1.79	2.26	2.84
750	0.43	0.59	0.75	0.91	1.14	1.45	1.73	2.19	2.74
800	0.42	0.57	0.73	0.88	1.10	1.40	1.67	2.12	2.66
850	0.41	0.56	0.71	0.86	1.07	1.36	1.62	2.06	2.58
900	0.40	0.54	0.69	0.83	1.04	1.32	1.58	2.00	2.50
950	0.38	0.53	0.67	0.81	1.01	1.29	1.53	1.94	2.44
1 000	0.37	0.51	0.65	0.79	0.99	1.25	1.49	1.89	2.38
1 050	0.37	0.50	0.64	0.77	0.96	1.22	1.46	1.85	2.32
1 100	0.36	0.49	0.62	0.75	0.94	1.20	1.43	1.81	2.26
1 150	0.35	0.48	0.61	0.74	0.92	1.17	1.39	1.77	2.22
1 200	0.34	0.47	0.60	0.72	0.90	1.15	1.36	1.73	2.17
1 250	0.34	0.46	0.58	0.71	0.88	1.12	1.34	1.69	2.12
1 300	0.33	0.45	0.57	0.69	0.87	1.10	1.31	1.66	2.08
1 350	0.32	0.44	0.56	0.68	0.85	1.08	1.29	1.63	2.04
1 400	0.32	0.43	0.55	0.67	0.83	1.06	1.26	1.60	2.01
1 450	0.31	0.43	0.54	0.66	0.82	1.04	1.24	1.57	1.97
1 500	0.31	0.42	0.53	0.65	0.81	1.02	1.22	1.55	1.94
1 550	0.30	0.41	0.52	0.64	0.79	1.01	1.20	1.52	1.91
1 600	0.30	0.41	0.52	0.63	0.78	0.99	1.18	1.50	1.88
1 650	0.29	0.40	0.51	0.62	0.77	0.98	1.16	1.48	1.85
1 700	0.29	0.39	0.50	0.61	0.76	0.96	1.15	1.45	1.82
1 750	0.28	0.39	0.49	0.60	0.75	0.95	1.13	1.43	1.80
1 800	0.28	0.38	0.49	0.59	0.74	0.93	1.11	1.41	1.77
1 850	0.28	0.38	0.48	0.58	0.73	0.92	1.10	1.39	1.75

Design Wind Pressure N/m^2	**Nominal Thickness of Annealed Glass, *T*** mm								
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1 900	0.27	0.37	0.47	0.57	0.72	0.91	1.08	1.37	1.72
1 950	0.27	0.37	0.47	0.57	0.71	0.90	1.07	1.36	1.70
2 000	0.27	0.36	0.46	0.56	0.70	0.89	1.06	1.34	1.68
2 050	0.26	0.36	0.46	0.55	0.69	0.88	1.04	1.32	1.66
2 100	0.26	0.35	0.45	0.55	0.68	0.87	1.03	1.31	1.64
2 150	0.26	0.35	0.44	0.54	0.67	0.86	1.02	1.29	1.62
2 200	0.25	0.35	0.44	0.53	0.67	0.85	1.01	1.28	1.60
2 250	0.25	0.34	0.43	0.53	0.66	0.84	1.00	1.26	1.58
2 300	0.25	0.34	0.43	0.52	0.65	0.83	0.99	1.25	1.57
2 350	0.24	0.34	0.43	0.52	0.64	0.82	0.97	1.24	1.55
2 400	0.24	0.33	0.42	0.51	0.64	0.81	0.96	1.22	1.53
2 450	0.24	0.33	0.42	0.51	0.63	0.80	0.95	1.21	1.52
2 500	0.24	0.32	0.41	0.50	0.62	0.79	0.95	1.20	1.50
2 550	0.23	0.32	0.41	0.50	0.62	0.79	0.94	1.19	1.49
2 600	0.23	0.32	0.40	0.49	0.61	0.78	0.93	1.18	1.47
2 650	0.23	0.32	0.40	0.49	0.61	0.77	0.92	1.16	1.46
2 700	0.23	0.31	0.40	0.48	0.60	0.76	0.91	1.15	1.45
2 750	0.23	0.31	0.39	0.48	0.60	0.76	0.90	1.14	1.43
2 800	0.22	0.31	0.39	0.47	0.59	0.75	0.89	1.13	1.42
2 850	0.22	0.30	0.39	0.47	0.58	0.74	0.89	1.12	1.41
2 900	0.22	0.30	0.38	0.46	0.58	0.74	0.88	1.11	1.39
2 950	0.22	0.30	0.38	0.46	0.57	0.73	0.87	1.10	1.38
3 000	0.22	0.30	0.38	0.46	0.57	0.72	0.86	1.09	1.37
3 050	0.21	0.29	0.37	0.45	0.57	0.72	0.86	1.09	1.36
3 100	0.21	0.29	0.37	0.45	0.56	0.71	0.85	1.08	1.35
3 150	0.21	0.29	0.37	0.45	0.56	0.71	0.84	1.07	1.34
3 200	0.21	0.29	0.36	0.44	0.55	0.70	0.84	1.06	1.33
3 250	0.21	0.28	0.36	0.44	0.55	0.70	0.83	1.05	1.32
3 300	0.21	0.28	0.36	0.44	0.54	0.69	0.82	1.04	1.31
3 350	0.20	0.28	0.36	0.43	0.54	0.69	0.82	1.04	1.30
3 400	0.20	0.28	0.35	0.43	0.54	0.68	0.81	1.03	1.29
3 450	0.20	0.28	0.35	0.43	0.53	0.68	0.80	1.02	1.28
3 500	0.20	0.27	0.35	0.42	0.53	0.67	0.80	1.01	1.27
3 550	0.20	0.27	0.35	0.42	0.52	0.67	0.79	1.01	1.26
3 600	0.20	0.27	0.34	0.42	0.52	0.66	0.79	1.00	1.25
3 650	0.20	0.27	0.34	0.41	0.52	0.66	0.78	0.99	1.24
3 700	0.19	0.27	0.34	0.41	0.51	0.65	0.78	0.99	1.23
3 750	0.19	0.27	0.34	0.41	0.51	0.65	0.77	0.98	1.23
3 800	0.19	0.26	0.33	0.41	0.51	0.64	0.77	0.97	1.22
3 850	0.19	0.26	0.33	0.40	0.50	0.64	0.76	0.97	1.21

Design Wind Pressure N/m²	Nominal Thickness of Annealed Glass, *T* mm								
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
3 900	0.19	0.26	0.33	0.40	0.50	0.64	0.76	0.96	1.20
3 950	0.19	0.26	0.33	0.40	0.50	0.63	0.75	0.95	1.20
4 000	0.19	0.26	0.33	0.40	0.49	0.63	0.75	0.95	1.19
4 050	0.19	0.26	0.32	0.39	0.49	0.62	0.74	0.94	1.18
4 100	0.19	0.25	0.32	0.39	0.49	0.62	0.74	0.94	1.17
4 150	0.18	0.25	0.32	0.39	0.48	0.62	0.73	0.93	1.17
4 200	0.18	0.25	0.32	0.39	0.48	0.61	0.73	0.92	1.16
4 250	0.18	0.25	0.32	0.38	0.48	0.61	0.72	0.92	1.15
4 300	0.18	0.25	0.31	0.38	0.48	0.60	0.72	0.91	1.15
4 350	0.18	0.25	0.31	0.38	0.47	0.60	0.72	0.91	1.14
4 400	0.18	0.24	0.31	0.38	0.47	0.60	0.71	0.90	1.13
4 450	0.18	0.24	0.31	0.38	0.47	0.59	0.71	0.90	1.13
4 500	0.18	0.24	0.31	0.37	0.47	0.59	0.70	0.89	1.12
4 550	0.18	0.24	0.31	0.37	0.46	0.59	0.70	0.89	1.11
4 600	0.17	0.24	0.30	0.37	0.46	0.58	0.70	0.88	1.11
4 650	0.17	0.24	0.30	0.37	0.46	0.58	0.69	0.88	1.10
4 700	0.17	0.24	0.30	0.36	0.46	0.58	0.69	0.87	1.10
4 750	0.17	0.24	0.30	0.36	0.45	0.58	0.69	0.87	1.09
4 800	0.17	0.23	0.30	0.36	0.45	0.57	0.68	0.86	1.08
4 850	0.17	0.23	0.30	0.36	0.45	0.57	0.68	0.86	1.08
4 900	0.17	0.23	0.29	0.36	0.45	0.57	0.68	0.86	1.07
4 950	0.17	0.23	0.29	0.36	0.44	0.56	0.67	0.85	1.07
5 000	0.17	0.23	0.29	0.35	0.44	0.56	0.67	0.85	1.06

Table 25 Maximum Span for Laminated Glass Fixed on Two Opposite Sides, m

(*Clause* 6.1.9)

Design Wind Pressure N/m²	Nominal Thickness of Laminated Glass, *T* mm					
	5.38	6.38	8.38	10.38	12.38	16.38
(1)	(2)	(3)	(4)	(5)	(6)	(7)
500	0.79	0.95	1.25	1.59	1.92	2.50
550	0.75	0.90	1.19	1.51	1.83	2.38
600	0.72	0.87	1.14	1.45	1.76	2.28
650	0.69	0.83	1.10	1.39	1.69	2.19
700	0.67	0.80	1.06	1.34	1.63	2.11
750	0.65	0.77	1.02	1.30	1.57	2.04
800	0.62	0.75	0.99	1.25	1.52	1.98

Design Wind Pressure N/m²	**Nominal Thickness of Laminated Glass, *T*** mm					
	5.38	6.38	8.38	10.38	12.38	16.38
(1)	(2)	(3)	(4)	(5)	(6)	(7)
850	0.61	0.73	0.96	1.22	1.48	1.92
900	0.59	0.71	0.93	1.18	1.43	1.86
950	0.57	0.69	0.91	1.15	1.40	1.81
1 000	0.56	0.67	0.88	1.12	1.36	1.77
1 050	0.55	0.65	0.86	1.09	1.33	1.72
1 100	0.53	0.64	0.84	1.07	1.30	1.68
1 150	0.52	0.63	0.82	1.05	1.27	1.65
1 200	0.51	0.61	0.81	1.02	1.24	1.61
1 250	0.50	0.60	0.79	1.00	1.22	1.58
1 300	0.49	0.59	0.77	0.98	1.19	1.55
1 350	0.48	0.58	0.76	0.97	1.17	1.52
1 400	0.47	0.57	0.75	0.95	1.15	1.49
1 450	0.46	0.56	0.73	0.93	1.13	1.47
1 500	0.46	0.55	0.72	0.92	1.11	1.44
1 550	0.45	0.54	0.71	0.90	1.09	1.42
1 600	0.44	0.53	0.70	0.89	1.08	1.40
1 650	0.43	0.52	0.69	0.87	1.06	1.38
1 700	0.43	0.51	0.68	0.86	1.04	1.35
1 750	0.42	0.51	0.67	0.85	1.03	1.34
1 800	0.42	0.50	0.66	0.84	1.01	1.32
1 850	0.41	0.49	0.65	0.82	1.00	1.30
1 900	0.41	0.49	0.64	0.81	0.99	1.28
1 950	0.40	0.48	0.63	0.80	0.97	1.27
2 000	0.40	0.47	0.62	0.79	0.96	1.25
2 050	0.39	0.47	0.62	0.78	0.95	1.23
2 100	0.39	0.46	0.61	0.77	0.94	1.22
2 150	0.38	0.46	0.60	0.77	0.93	1.20
2 200	0.38	0.45	0.60	0.76	0.92	1.19
2 250	0.37	0.45	0.59	0.75	0.91	1.18
2 300	0.37	0.44	0.58	0.74	0.90	1.16
2 350	0.36	0.44	0.58	0.73	0.89	1.15
2 400	0.36	0.43	0.57	0.72	0.88	1.14
2 450	0.36	0.43	0.56	0.72	0.87	1.13
2 500	0.35	0.42	0.56	0.71	0.86	1.12
2 550	0.35	0.42	0.55	0.70	0.85	1.11
2 600	0.35	0.42	0.55	0.70	0.84	1.10
2 650	0.34	0.41	0.54	0.69	0.84	1.09
2 700	0.34	0.41	0.54	0.68	0.83	1.08
2 750	0.34	0.40	0.53	0.68	0.82	1.07
2 800	0.33	0.40	0.53	0.67	0.81	1.06
2 850	0.33	0.40	0.52	0.66	0.81	1.05

Design Wind Pressure N/m²	**Nominal Thickness of Laminated Glass, *T*** mm					
	5.38	6.38	8.38	10.38	12.38	16.38
(1)	(2)	(3)	(4)	(5)	(6)	(7)
2 900	0.33	0.39	0.52	0.66	0.80	1.04
2 950	0.33	0.39	0.51	0.65	0.79	1.03
3 000	0.32	0.39	0.51	0.65	0.79	1.02
3 050	0.32	0.38	0.51	0.64	0.78	1.01
3 100	0.32	0.38	0.50	0.64	0.77	1.00
3 150	0.31	0.38	0.50	0.63	0.77	1.00
3 200	0.31	0.37	0.49	0.63	0.76	0.99
3 250	0.31	0.37	0.49	0.62	0.75	0.98
3 300	0.31	0.37	0.49	0.62	0.75	0.97
3 350	0.31	0.37	0.48	0.61	0.74	0.97
3 400	0.30	0.36	0.48	0.61	0.74	0.96
3 450	0.30	0.36	0.48	0.60	0.73	0.95
3 500	0.30	0.36	0.47	0.60	0.73	0.94
3 550	0.30	0.36	0.47	0.60	0.72	0.94
3 600	0.29	0.35	0.47	0.59	0.72	0.93
3 650	0.29	0.35	0.46	0.59	0.71	0.92
3 700	0.29	0.35	0.46	0.58	0.71	0.92
3 750	0.29	0.35	0.46	0.58	0.70	0.91
3 800	0.29	0.34	0.45	0.58	0.70	0.91
3 850	0.28	0.34	0.45	0.57	0.69	0.90
3 900	0.28	0.34	0.45	0.57	0.69	0.89
3 950	0.28	0.34	0.44	0.56	0.68	0.89
4 000	0.28	0.34	0.44	0.56	0.68	0.88
4 050	0.28	0.33	0.44	0.56	0.68	0.88
4 100	0.28	0.33	0.44	0.55	0.67	0.87
4 150	0.27	0.33	0.43	0.55	0.67	0.87
4 200	0.27	0.33	0.43	0.55	0.66	0.86
4 250	0.27	0.33	0.43	0.54	0.66	0.86
4 300	0.27	0.32	0.43	0.54	0.66	0.85
4 350	0.27	0.32	0.42	0.54	0.65	0.85
4 400	0.27	0.32	0.42	0.53	0.65	0.84
4 450	0.26	0.32	0.42	0.53	0.65	0.84
4 500	0.26	0.32	0.42	0.53	0.64	0.83
4 550	0.26	0.31	0.41	0.53	0.64	0.83
4 600	0.26	0.31	0.41	0.52	0.63	0.82
4 650	0.26	0.31	0.41	0.52	0.63	0.82
4 700	0.26	0.31	0.41	0.52	0.63	0.81
4 750	0.26	0.31	0.41	0.51	0.62	0.81
4 800	0.26	0.31	0.40	0.51	0.62	0.81
4 850	0.25	0.30	0.40	0.51	0.62	0.80
4 900	0.25	0.30	0.40	0.51	0.61	0.80

Design Wind Pressure N/m²	Nominal Thickness of Laminated Glass, *T* mm					
	5.38	6.38	8.38	10.38	12.38	16.38
(1)	(2)	(3)	(4)	(5)	(6)	(7)
4 950	0.25	0.30	0.40	0.50	0.61	0.79
5 000	0.25	0.30	0.40	0.50	0.61	0.79

Table 26 Maximum Span for Tempered Glass Fixed on Two Opposite Sides, m

(*Clause* 6.1.9)

Design Wind Pressure N/m²	Nominal Thickness of Tempered Glass, *T* mm							
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
500	0.62	0.86	1.09	1.32	1.52	1.93	2.30	2.92	3.66
550	0.60	0.82	1.04	1.26	1.45	1.84	2.20	2.78	3.49
600	0.57	0.78	0.99	1.20	1.39	1.76	2.10	2.66	3.34
650	0.55	0.75	0.95	1.16	1.33	1.69	2.02	2.56	3.21
700	0.53	0.72	0.92	1.11	1.29	1.63	1.95	2.47	3.09
750	0.51	0.70	0.89	1.08	1.24	1.58	1.88	2.38	2.99
800	0.49	0.68	0.86	1.04	1.20	1.53	1.82	2.31	2.89
850	0.48	0.66	0.83	1.01	1.17	1.48	1.77	2.24	2.81
900	0.47	0.64	0.81	0.98	1.13	1.44	1.72	2.18	2.73
950	0.45	0.62	0.79	0.96	1.10	1.40	1.67	2.12	2.65
1 000	0.44	0.60	0.77	0.93	1.08	1.37	1.63	2.06	2.59
1 050	0.43	0.59	0.75	0.91	1.05	1.33	1.59	2.01	2.52
1 100	0.42	0.58	0.73	0.89	1.03	1.30	1.55	1.97	2.47
1 150	0.41	0.56	0.72	0.87	1.00	1.27	1.52	1.92	2.41
1 200	0.40	0.55	0.70	0.85	0.98	1.25	1.49	1.88	2.36
1 250	0.39	0.54	0.69	0.83	0.96	1.22	1.46	1.85	2.31
1 300	0.39	0.53	0.67	0.82	0.94	1.20	1.43	1.81	2.27
1 350	0.38	0.52	0.66	0.80	0.93	1.18	1.40	1.78	2.23
1 400	0.37	0.51	0.65	0.79	0.91	1.15	1.38	1.74	2.19
1 450	0.37	0.50	0.64	0.77	0.89	1.13	1.35	1.71	2.15
1 500	0.36	0.49	0.63	0.76	0.88	1.12	1.33	1.69	2.11
1 550	0.35	0.49	0.62	0.75	0.86	1.10	1.31	1.66	2.08
1 600	0.35	0.48	0.61	0.74	0.85	1.08	1.29	1.63	2.05
1 650	0.34	0.47	0.60	0.73	0.84	1.06	1.27	1.61	2.01
1 700	0.34	0.46	0.59	0.71	0.82	1.05	1.25	1.58	1.98
1 750	0.33	0.46	0.58	0.70	0.81	1.03	1.23	1.56	1.96
1 800	0.33	0.45	0.57	0.69	0.80	1.02	1.21	1.54	1.93
1 850	0.32	0.44	0.56	0.68	0.79	1.00	1.20	1.52	1.90
1 900	0.32	0.44	0.56	0.68	0.78	0.99	1.18	1.50	1.88
1 950	0.32	0.43	0.55	0.67	0.77	0.98	1.17	1.48	1.85
2 000	0.31	0.43	0.54	0.66	0.76	0.97	1.15	1.46	1.83

Design Wind Pressure N/m²	**Nominal Thickness of Tempered Glass, *T*** mm								
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2 050	0.31	0.42	0.54	0.65	0.75	0.95	1.14	1.44	1.81
2 100	0.30	0.42	0.53	0.64	0.74	0.94	1.12	1.42	1.79
2 150	0.30	0.41	0.52	0.64	0.73	0.93	1.11	1.41	1.76
2 200	0.30	0.41	0.52	0.63	0.73	0.92	1.10	1.39	1.74
2 250	0.29	0.40	0.51	0.62	0.72	0.91	1.09	1.38	1.72
2 300	0.29	0.40	0.51	0.61	0.71	0.90	1.07	1.36	1.71
2 350	0.29	0.39	0.50	0.61	0.70	0.89	1.06	1.35	1.69
2 400	0.28	0.39	0.50	0.60	0.69	0.88	1.05	1.33	1.67
2 450	0.28	0.39	0.49	0.60	0.69	0.87	1.04	1.32	1.65
2 500	0.28	0.38	0.49	0.59	0.68	0.86	1.03	1.31	1.64
2 550	0.28	0.38	0.48	0.58	0.67	0.86	1.02	1.29	1.62
2 600	0.27	0.38	0.48	0.58	0.67	0.85	1.01	1.28	1.60
2 650	0.27	0.37	0.47	0.57	0.66	0.84	1.00	1.27	1.59
2 700	0.27	0.37	0.47	0.57	0.65	0.83	0.99	1.26	1.57
2 750	0.27	0.36	0.46	0.56	0.65	0.82	0.98	1.24	1.56
2 800	0.26	0.36	0.46	0.56	0.64	0.82	0.97	1.23	1.55
2 850	0.26	0.36	0.46	0.55	0.64	0.81	0.96	1.22	1.53
2 900	0.26	0.36	0.45	0.55	0.63	0.80	0.96	1.21	1.52
2 950	0.26	0.35	0.45	0.54	0.63	0.80	0.95	1.20	1.51
3 000	0.25	0.35	0.44	0.54	0.62	0.79	0.94	1.19	1.49
3 050	0.25	0.35	0.44	0.53	0.62	0.78	0.93	1.18	1.48
3 100	0.25	0.34	0.44	0.53	0.61	0.78	0.92	1.17	1.47
3 150	0.25	0.34	0.43	0.52	0.61	0.77	0.92	1.16	1.46
3 200	0.25	0.34	0.43	0.52	0.60	0.76	0.91	1.15	1.45
3 250	0.24	0.34	0.43	0.52	0.60	0.76	0.90	1.14	1.44
3 300	0.24	0.33	0.42	0.51	0.59	0.75	0.90	1.14	1.42
3 350	0.24	0.33	0.42	0.51	0.59	0.75	0.89	1.13	1.41
3 400	0.24	0.33	0.42	0.51	0.58	0.74	0.88	1.12	1.40
3 450	0.24	0.33	0.41	0.50	0.58	0.74	0.88	1.11	1.39
3 500	0.24	0.32	0.41	0.50	0.57	0.73	0.87	1.10	1.38
3 550	0.23	0.32	0.41	0.49	0.57	0.73	0.86	1.10	1.37
3 600	0.23	0.32	0.40	0.49	0.57	0.72	0.86	1.09	1.36
3 650	0.23	0.32	0.40	0.49	0.56	0.72	0.85	1.08	1.35
3 700	0.23	0.31	0.40	0.48	0.56	0.71	0.85	1.07	1.34
3 750	0.23	0.31	0.40	0.48	0.56	0.71	0.84	1.07	1.34
3 800	0.23	0.31	0.39	0.48	0.55	0.70	0.84	1.06	1.33
3 850	0.22	0.31	0.39	0.47	0.55	0.70	0.83	1.05	1.32
3 900	0.22	0.31	0.39	0.47	0.54	0.69	0.82	1.05	1.31
3 950	0.22	0.30	0.39	0.47	0.54	0.69	0.82	1.04	1.30
4 000	0.22	0.30	0.38	0.47	0.54	0.68	0.81	1.03	1.29
4 050	0.22	0.30	0.38	0.46	0.53	0.68	0.81	1.03	1.29

Design Wind Pressure N/m²	**Nominal Thickness of Tempered Glass, *T*** mm								
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
4 100	0.22	0.30	0.38	0.46	0.53	0.67	0.80	1.02	1.28
4 150	0.22	0.30	0.38	0.46	0.53	0.67	0.80	1.01	1.27
4 200	0.22	0.30	0.37	0.45	0.52	0.67	0.79	1.01	1.26
4 250	0.21	0.29	0.37	0.45	0.52	0.66	0.79	1.00	1.25
4 300	0.21	0.29	0.37	0.45	0.52	0.66	0.79	1.00	1.25
4 350	0.21	0.29	0.37	0.45	0.52	0.66	0.78	0.99	1.24
4 400	0.21	0.29	0.37	0.44	0.51	0.65	0.78	0.98	1.23
4 450	0.21	0.29	0.36	0.44	0.51	0.65	0.77	0.98	1.23
4 500	0.21	0.29	0.36	0.44	0.51	0.64	0.77	0.97	1.22
4 550	0.21	0.28	0.36	0.44	0.50	0.64	0.76	0.97	1.21
4 600	0.21	0.28	0.36	0.43	0.50	0.64	0.76	0.96	1.21
4 650	0.20	0.28	0.36	0.43	0.50	0.63	0.75	0.96	1.20
4 700	0.20	0.28	0.35	0.43	0.50	0.63	0.75	0.95	1.19
4 750	0.20	0.28	0.35	0.43	0.49	0.63	0.75	0.95	1.19
4 800	0.20	0.28	0.35	0.43	0.49	0.62	0.74	0.94	1.18
4 850	0.20	0.27	0.35	0.42	0.49	0.62	0.74	0.94	1.17
4 900	0.20	0.27	0.35	0.42	0.49	0.62	0.74	0.93	1.17
4 950	0.20	0.27	0.35	0.42	0.48	0.61	0.73	0.93	1.16
5 000	0.20	0.27	0.34	0.42	0.48	0.61	0.73	0.92	1.16

Table 27 Maximum Span for Heat Strengthened Glass Fixed on Two Opposite Sides, m
(*Clause* 6.1.9)

Design Wind Pressure N/m²	**Nominal Thickness of Heat Strengthened Glass, *T*** mm								
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
500	0.50	0.68	0.87	1.05	1.22	1.55	1.84	2.34	2.93
550	0.48	0.65	0.83	1.00	1.16	1.47	1.76	2.23	2.79
600	0.46	0.62	0.79	0.96	1.11	1.41	1.68	2.13	2.67
650	0.44	0.60	0.76	0.92	1.07	1.36	1.62	2.05	2.57
700	0.42	0.58	0.73	0.89	1.03	1.31	1.56	1.97	2.47
750	0.41	0.56	0.71	0.86	0.99	1.26	1.50	1.91	2.39
800	0.39	0.54	0.69	0.83	0.96	1.22	1.46	1.85	2.31
850	0.38	0.52	0.67	0.81	0.93	1.19	1.41	1.79	2.24
900	0.37	0.51	0.65	0.79	0.91	1.15	1.37	1.74	2.18
950	0.36	0.50	0.63	0.76	0.88	1.12	1.34	1.69	2.12
1 000	0.35	0.48	0.61	0.75	0.86	1.09	1.30	1.65	2.07
1 050	0.34	0.47	0.60	0.73	0.84	1.07	1.27	1.61	2.02

Design Wind Pressure N/m²	**Nominal Thickness of Heat Strengthened Glass, *T*** mm								
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1 100	0.34	0.46	0.59	0.71	0.82	1.04	1.24	1.57	1.97
1 150	0.33	0.45	0.57	0.69	0.80	1.02	1.21	1.54	1.93
1 200	0.32	0.44	0.56	0.68	0.79	1.00	1.19	1.51	1.89
1 250	0.32	0.43	0.55	0.67	0.77	0.98	1.16	1.48	1.85
1 300	0.31	0.42	0.54	0.65	0.75	0.96	1.14	1.45	1.82
1 350	0.30	0.42	0.53	0.64	0.74	0.94	1.12	1.42	1.78
1 400	0.30	0.41	0.52	0.63	0.73	0.92	1.10	1.40	1.75
1 450	0.29	0.40	0.51	0.62	0.71	0.91	1.08	1.37	1.72
1 500	0.29	0.40	0.50	0.61	0.70	0.89	1.06	1.35	1.69
1 550	0.28	0.39	0.49	0.60	0.69	0.88	1.05	1.33	1.66
1 600	0.28	0.38	0.49	0.59	0.68	0.86	1.03	1.31	1.64
1 650	0.27	0.38	0.48	0.58	0.67	0.85	1.01	1.29	1.61
1 700	0.27	0.37	0.47	0.57	0.66	0.84	1.00	1.27	1.59
1 750	0.27	0.37	0.46	0.56	0.65	0.83	0.98	1.25	1.56
1 800	0.26	0.36	0.46	0.56	0.64	0.81	0.97	1.23	1.54
1 850	0.26	0.36	0.45	0.55	0.63	0.80	0.96	1.21	1.52
1 900	0.26	0.35	0.45	0.54	0.62	0.79	0.94	1.20	1.50
1 950	0.25	0.35	0.44	0.53	0.62	0.78	0.93	1.18	1.48
2 000	0.25	0.34	0.43	0.53	0.61	0.77	0.92	1.17	1.46
2 050	0.25	0.34	0.43	0.52	0.60	0.76	0.91	1.15	1.45
2 100	0.24	0.33	0.42	0.51	0.59	0.75	0.90	1.14	1.43
2 150	0.24	0.33	0.42	0.51	0.59	0.75	0.89	1.13	1.41
2 200	0.24	0.33	0.41	0.50	0.58	0.74	0.88	1.11	1.40
2 250	0.24	0.32	0.41	0.50	0.57	0.73	0.87	1.10	1.38
2 300	0.23	0.32	0.41	0.49	0.57	0.72	0.86	1.09	1.36
2 350	0.23	0.32	0.40	0.49	0.56	0.71	0.85	1.08	1.35
2 400	0.23	0.31	0.40	0.48	0.56	0.71	0.84	1.07	1.34
2 450	0.23	0.31	0.39	0.48	0.55	0.70	0.83	1.05	1.32
2 500	0.22	0.31	0.39	0.47	0.54	0.69	0.82	1.04	1.31
2 550	0.22	0.30	0.38	0.47	0.54	0.68	0.82	1.03	1.30
2 600	0.22	0.30	0.38	0.46	0.53	0.68	0.81	1.02	1.28
2 650	0.22	0.30	0.38	0.46	0.53	0.67	0.80	1.01	1.27
2 700	0.21	0.29	0.37	0.45	0.52	0.67	0.79	1.00	1.26
2 750	0.21	0.29	0.37	0.45	0.52	0.66	0.79	1.00	1.25
2 800	0.21	0.29	0.37	0.45	0.51	0.65	0.78	0.99	1.24
2 850	0.21	0.29	0.36	0.44	0.51	0.65	0.77	0.98	1.23
2 900	0.21	0.28	0.36	0.44	0.51	0.64	0.76	0.97	1.22
2 950	0.21	0.28	0.36	0.43	0.50	0.64	0.76	0.96	1.21
3 000	0.20	0.28	0.35	0.43	0.50	0.63	0.75	0.95	1.19
3 050	0.20	0.28	0.35	0.43	0.49	0.63	0.75	0.95	1.19
3 100	0.20	0.27	0.35	0.42	0.49	0.62	0.74	0.94	1.18

Design Wind Pressure N/m²	Nominal Thickness of Heat Strengthened Glass, *T* mm								
	3	4	5	6	8	10	12	15	19
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
3 150	0.20	0.27	0.35	0.42	0.48	0.62	0.73	0.93	1.17
3 200	0.20	0.27	0.34	0.42	0.48	0.61	0.73	0.92	1.16
3 250	0.20	0.27	0.34	0.41	0.48	0.61	0.72	0.92	1.15
3 300	0.19	0.27	0.34	0.41	0.47	0.60	0.72	0.91	1.14
3 350	0.19	0.26	0.34	0.41	0.47	0.60	0.71	0.90	1.13
3 400	0.19	0.26	0.33	0.40	0.47	0.59	0.71	0.90	1.12
3 450	0.19	0.26	0.33	0.40	0.46	0.59	0.70	0.89	1.11
3 500	0.19	0.26	0.33	0.40	0.46	0.58	0.70	0.88	1.11
3 550	0.19	0.26	0.33	0.40	0.46	0.58	0.69	0.88	1.10
3 600	0.19	0.25	0.32	0.39	0.45	0.58	0.69	0.87	1.09
3 650	0.18	0.25	0.32	0.39	0.45	0.57	0.68	0.86	1.08
3 700	0.18	0.25	0.32	0.39	0.45	0.57	0.68	0.86	1.08
3 750	0.18	0.25	0.32	0.38	0.44	0.56	0.67	0.85	1.07
3 800	0.18	0.25	0.32	0.38	0.44	0.56	0.67	0.85	1.06
3 850	0.18	0.25	0.31	0.38	0.44	0.56	0.66	0.84	1.05
3 900	0.18	0.24	0.31	0.38	0.44	0.55	0.66	0.84	1.05
3 950	0.18	0.24	0.31	0.37	0.43	0.55	0.66	0.83	1.04
4 000	0.18	0.24	0.31	0.37	0.43	0.55	0.65	0.83	1.03
4 050	0.18	0.24	0.31	0.37	0.43	0.54	0.65	0.82	1.03
4 100	0.17	0.24	0.30	0.37	0.42	0.54	0.64	0.82	1.02
4 150	0.17	0.24	0.30	0.37	0.42	0.54	0.64	0.81	1.02
4 200	0.17	0.24	0.30	0.36	0.42	0.53	0.64	0.81	1.01
4 250	0.17	0.23	0.30	0.36	0.42	0.53	0.63	0.80	1.00
4 300	0.17	0.23	0.30	0.36	0.41	0.53	0.63	0.80	1.00
4 350	0.17	0.23	0.29	0.36	0.41	0.52	0.62	0.79	0.99
4 400	0.17	0.23	0.29	0.36	0.41	0.52	0.62	0.79	0.99
4 450	0.17	0.23	0.29	0.35	0.41	0.52	0.62	0.78	0.98
4 500	0.17	0.23	0.29	0.35	0.41	0.52	0.61	0.78	0.98
4 550	0.17	0.23	0.29	0.35	0.40	0.51	0.61	0.77	0.97
4 600	0.16	0.23	0.29	0.35	0.40	0.51	0.61	0.77	0.97
4 650	0.16	0.22	0.28	0.35	0.40	0.51	0.60	0.77	0.96
4 700	0.16	0.22	0.28	0.34	0.40	0.50	0.60	0.76	0.95
4 750	0.16	0.22	0.28	0.34	0.39	0.50	0.60	0.76	0.95
4 800	0.16	0.22	0.28	0.34	0.39	0.50	0.59	0.75	0.94
4 850	0.16	0.22	0.28	0.34	0.39	0.50	0.59	0.75	0.94
4 900	0.16	0.22	0.28	0.34	0.39	0.49	0.59	0.75	0.94
4 950	0.16	0.22	0.28	0.33	0.39	0.49	0.59	0.74	0.93
5 000	0.16	0.22	0.27	0.33	0.38	0.49	0.58	0.74	0.93

6.2 Installation

6.2.1 Basic installation requirements and materials used for glass are given hereunder.

NOTES

1 The provisions under this item do not include the use of other methods or systems for glazing, provided the alternate method or system can be demonstrated to satisfy the requirements for correctly supporting the glass within the frame, or glazing system.
2 Patent and other proprietary systems are not described/ covered here.
3 Installation technique for frameless glazing system is not covered here.

6.2.2 *Site Working and Glass Machining Operation*

6.2.2.1 Heat-strengthened and toughened glass shall not be cut or worked after heat treatment. All necessary cutting, drilling, notching and edge-working shall be carried out to correct dimensions prior to value addition to the glass, such as toughening/tempering/heat strengthening. The edges and surfaces of all glass types shall not be damaged during fixing.

6.2.3 *Dimensional Requirement*

The dimensions for edge clearance, edge cover, front and back clearance, rebate depth is selected in accordance with the requirements in **4.5.2**.

6.2.4 *Glazing Materials*

6.2.4.1 *Compatibility of materials*

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

6.2.4.2 *Application of materials*

The application of glazing materials shall be in accordance with relevant/available Indian Standard or manufacturer's recommendations.

6.2.4.3 *Life expectancy of materials*

A glazing material shall only be used where its life expectancy (durability) has been established. The manufacturers' advice/guarantee should be sought for information regarding life expectancy.

6.2.5 *Setting Blocks*

The number and location of setting blocks shall be as shown in Figs. 13 and 15. Generally, setting blocks shall be,

a) positioned at quarter points or not less than 30 mm from the corner, whichever is lesser;
b) the minimum width of each setting block shall be not less than the glass thickness; and

c) If a glazing bridge is used then the thickness of the glazing bridge can be added to the thickness of the setting block to achieve the minimum gap of 6 mm between the edge of glass and the framing member.

Setting blocks shall be located to equally support all panes of glass, and shall be fixed to prevent displacement during installation and service. The minimum length of each setting block (or two blocks side by side) shall be 25 mm in length for every square metre of glass area, with a minimum length of 50 mm. When wood is used as the material for setting blocks, only the seasoned ones should be used as green wood may shrink laterally (in the process of attaining equilibrium moisture content over a period of time) and result in loosened installations.

For example, a 3.0 m^2 glass area, 3.0 × 25 mm = 75 mm long, that is, 75 mm is the length of each setting block.

Setting blocks shall be of resilient, load-bearing, non-absorbent, rot-proof, and material that is compatible with all other glazing materials conforming to available standards (if any) that may come into contact with the blocks.

NOTES

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

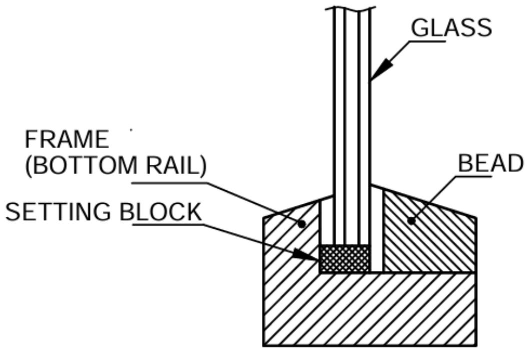


FIG. 13 POSITION OF SETTING BLOCK

6.2.6 *Location Blocks*

The number and position of location blocks shall be as shown in Figs. 14 and 15.

Location blocks shall be,

a) of minimum of 25 mm in length;
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.

NOTES

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 rubber material with 55 - 65 shore A hardness is recommended.

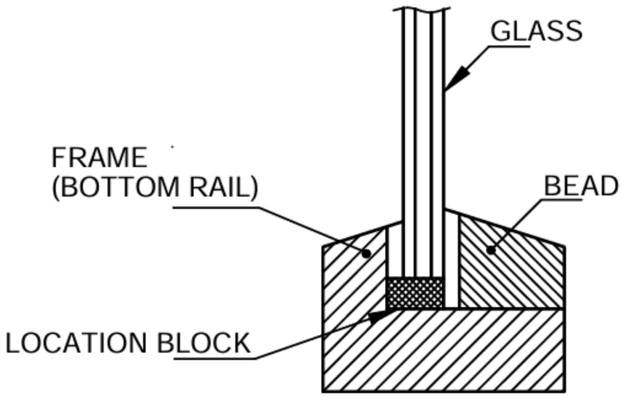


FIG. 14 POSITION OF LOCATION BLOCK

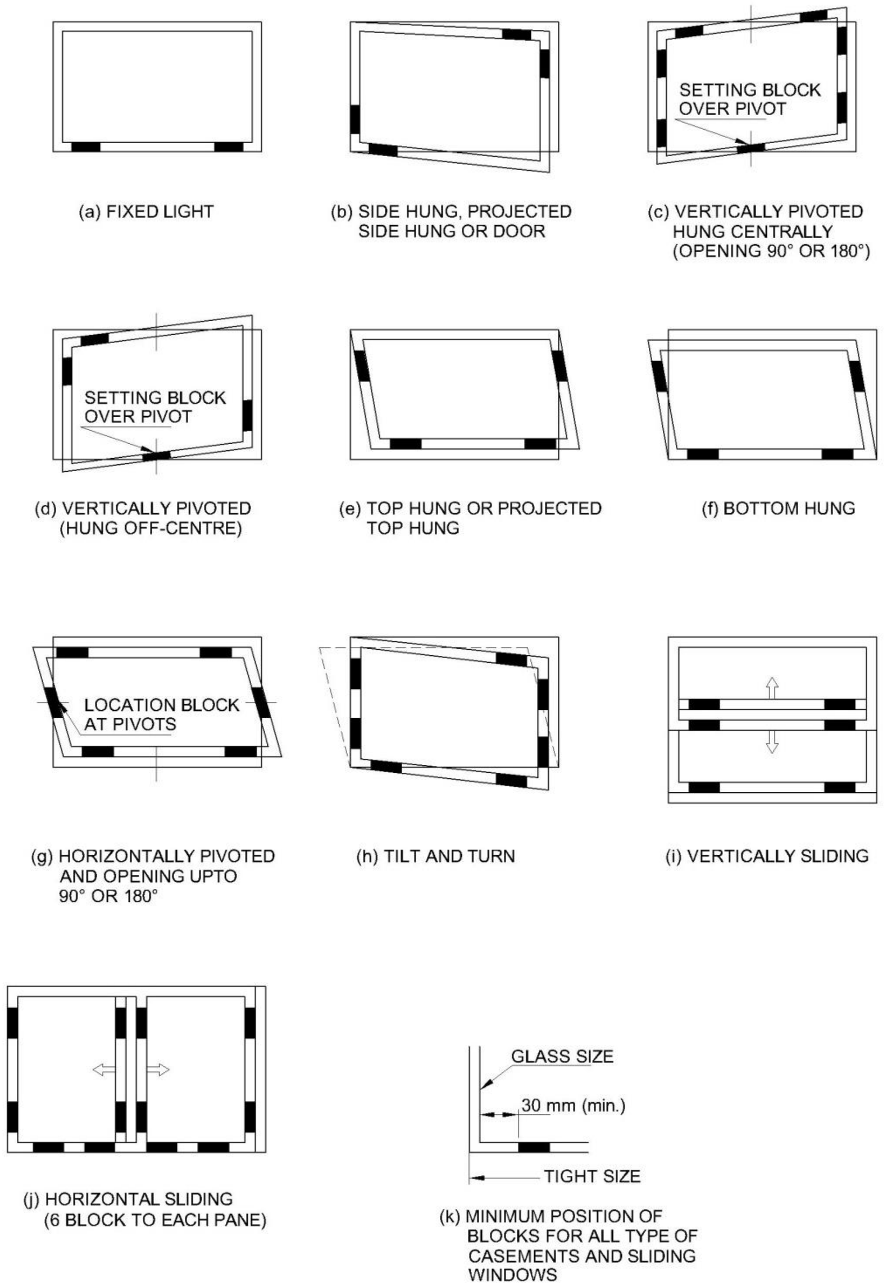


FIG. 15 RECOMMENDED POSITIONS OF SETTING AND LOCATION BLOCKS FOR THE SITE GLAZING OF SOME TYPES OF DOORS AND WINDOWS

6.2.7 *Distance Pieces*

Distance pieces, as shown in Fig. 16, used 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.

NOTES

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

2 Extruded rubber material with 55 - 65 shore A hardness is required.

6.2.8 *Rebates and Grooves for Installation*

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 number and location of setting blocks and location blocks shall be as shown in Fig. 13 to 15, wherever necessary to maintain the requisite edge clearance. Each block shall support the full thickness of the glass.

6.2.9 *Glazing Beads*

Where used, glazing beads shall be capable of restraining the glass under all design forces.

6.2.10 *Structural Sealants*

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

Applied structural silicones 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 structural silicone that could lead to a loss of strength in the structural silicone. For guidance on the installation of structural silicone, reference to available standards/literatures may be made.

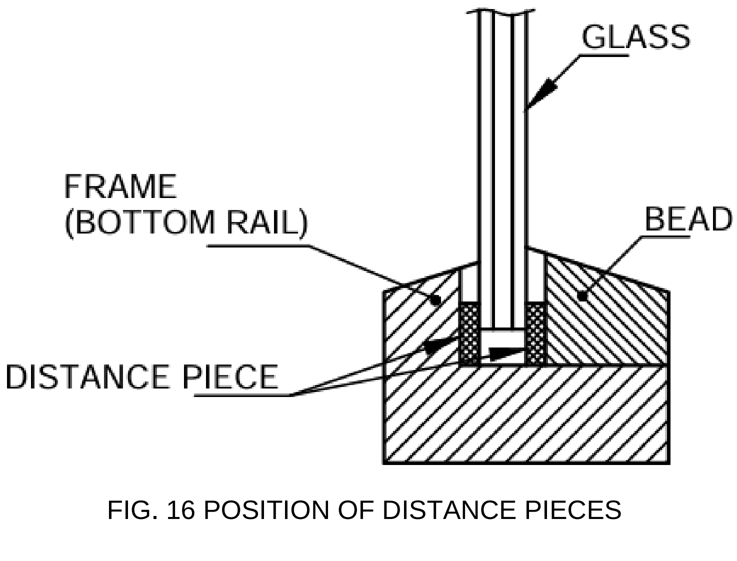


FIG. 16 POSITION OF DISTANCE PIECES

6.3 Design Criteria

6.3.1 *Frame Support Condition*

6.3.1.1 *Maximum area of glass panels subjected to wind loading*

The maximum span for a given standard nominal thickness of ordinary annealed, laminated, heat-strengthened and toughened glass for a given panel size shall be determined in accordance with **6.3.2**, **6.3.3** and **6.3.4** as applicable for the relevant support conditions. For heat strengthened laminated and toughened laminated glass, maximum allowable span shall be determined in accordance with **6.3.5**. For 3 mm monolithic annealed glass, the maximum area shall not exceed 0.85 m^2.

The minimum thickness of the nominal glass size shall be as per the accepted practice in accordance with Indian Standard specifications.

For laminated glass composites, the combined minimum thickness of the glass sheets may be used excluding the interlayer thickness. Alternatively, reference to specialist literature may be drawn for the same purpose.

6.3.2 *Rectangular Glass Supported on All Four Edges*

For rectangular glass supported on all four edges, the maximum area for the design wind pressure shall be determined using the corresponding tables provided for each type of glass. Linear interpolation may be used for any value in between those given therein while maintaining the aspect ratio.

6.3.3 *Rectangles of Glass Supported on Two Opposite Edges*

For rectangles of glass supported on two opposite edges, the maximum glass area for the design wind pressure shall be determined from Tables 22 to 25 for ordinary annealed, laminated, heat-strengthened and toughened glass, respectively.

6.3.4 *Rectangles of Glass Supported on Three Edges*

For rectangles of glass supported on three edges, the maximum glass area shall be determined as for two-edge support spanning along the unsupported edge. Alternatively, basic engineering principles shall be adopted in determining the glass thickness for all applications where only three edges of the panel are supported.

> NOTE – Butt glazing of adjacent panels in the same plane should not be considered as a support.

6.3.5 *Heat-Strengthened Laminated and Toughened Laminated Glass*

For heat-strengthened laminated and toughened laminated glass, the maximum span for a given standard nominal thickness for a given panel size shall be determined from Tables 23 and 27, and Tables 20 and 25, respectively with the design wind pressure being divided by the appropriate glass type factor, P_f (*see* Table 16), as applicable for the relevant support conditions.

6.3.6 *Serviceability Checks*

6.3.6.1 Glass complying to Tables 19 to 27 are deemed to meet, the serviceability deflection limits specified (in the absence of any other specified values) or the following values may be had for guidance.

6.3.6.2 *Maximum allowable deflection of framing members*

a) *For mullions*:
   1) Single height glazing – Span/175 or 19 mm, whichever is less.
   2) Double height glazing – For spans up to 4 110 mm, same as single height glazing; and for spans above 4 110 mm, the same shall be (Span/240) + 6.35 mm.

b) *For transoms*:
   1) Span/500 or 3 mm, whichever is the least for dead load.
   2) Span/175 or 19 mm, whichever is the least for wind load.

c) *Deflection at the centre of the glass*:
   1) Monolithic glass – Shortest span/60 or 19 mm, whichever is the least.
   2) Double glazed unit – Shortest span/90 or 19 mm, whichever is the least.

d) *Deflection at edge of the glass*:
   Shall be limited to 15 mm.

6.3.6.2.1 *Dielectric separation of dissimilar metals*

When the framing member for the glazing is aluminium and reinforcement is required to meet the deflection criteria, the reinforcement may be of aluminium or galvanized steel (red oxide coating being not recommended) with an insulating material between them at contact points. It is recommended to choose materials as close to each other in the galvanic series as possible.

6.3.7 *Ultimate Stresses*

The ultimate stresses for various types of glass are given in Table 28.

Table 28 Ultimate Limit State Design Stresses for Glass Subjected to Wind Loading
(*Clause* 6.3.7)

Sl No.	Glass Type	Standard Nominal Thickness ‘*T*’	Ultimate Limit State Design Stress at Given Location	
			Away from Edge	At Edge
		mm	MPa	MPa
(1)	(2)	(3)	(4)	(5)

i)	Annealed	3	41.00	32.8
		4	38.99	31.19
		5	37.45	29.96
		6	36.2	28.96
		8	34.33	27.46
		10	32.8	26.24
		12	31.57	25.25
		15	30.15	24.12
		19	28.72	22.98
		25	26.96	21.57
ii)	Toughened	4	97.47	77.97
		5	93.61	74.97
		6	90.49	72.39
		8	85.82	68.65
		10	82.01	65.61
		12	78.91	63.13
		15	75.37	60.3
		19	71.81	57.45
		25	67.41	53.93
iii)	Heat strengthened	3	65.6	52.48
		4	62.38	49.9
		5	59.91	47.93
		6	57.91	46.33
		8	54.92	43.94
		10	52.48	41.99
		12	50.51	40.4
iv)	Annealed laminated	5	37.73	30.18
		6	36.43	29.14
		8	34.41	27.53
		10	32.87	26.3
		12	31.62	25.3
		16	29.75	23.8
		20	28.23	22.58
		24	26.99	21.59

6.3.8 *Insulating Glass Units*

6.3.8.1 *Determining thickness of structural silicone*

The structural bite requirement is directly proportional to the wind load and the dimension of glass. Higher the wind load and larger the dimensions of the glass are, the greater the amount of structural bite required. The controlling variables which affect the structural bite requirement are the maximum short span dimension of glass and the design wind load which the structural glazing system shall be designed to accommodate.

a) *Structural bite calculation for wind load and glass dimension*

$$\text{Minimum Structural Bite} = \frac{\text{Glass Short Span Dimension x Wind Load x 0.5}}{\text{Maximum allowable design stress}}$$

NOTES

1 Glass' short span dimension (SSD) is the shorter of the two dimensions (in m) of the rectangular glass panel.

2 Wind load is the maximum wind pressure, in Pascal, for a return period of 10 years based on local regulations.

3 The maximum allowable design stress for type of the structural sealant is selected as per manufacturer's recommendations.

4 The minimum structural bite shall be not less than 6 mm for single glass and for double-glazed units (DGU) with equal glass thickness.

b) *Determination of thickness of structural silicone* – With a sealed IGU, there may be load sharing between the two lites (panes) of glass. If so and both panes are of the same thickness, the lateral load (*P*) is shared almost equally; thus the secondary seal bite is calculated as one half that of the structural sealant bite, but should meet the minimum requirement. If of unequal thickness, the load shared by each pane will vary, depending on the difference in thicknesses. Further details are to be obtained from the manufacturer.

c) *Structural bite calculation for dead load*

$$\text{Minimum Bite (m)} = \frac{\text{Weight of glass (Kg)}}{\text{Perimeter of the glass (m) x Sealant dead load design strength (kg/m}^2\text{)}}$$

$$= \frac{\rho g T A}{P s}$$

ρ = 2 500 kg/m^3 is the specific mass of flat glass corresponding to approximately of specific weight.

g = 9.81 m/s^2

s = Allowable design stress for dead load (DL) for selected sealant considered for design, Pa.

T = thickness of the bite, m.

P = perimeter (if the horizontal frame members do not support the glass or deflect under the dead load of the glass, consider 2 times of its height only).

A = area of glass panel, m^2.

6.3.8.2 *Maximum allowable span for glass and type*

Maximum allowable span is dependent on the thickness of the glass selected and type of glass used (for example annealed, toughened or heat strengthened glass). The maximum span is calculated in accordance with **6.1.9** (*see* Fig. 17 for details).

6.3.9 *Safety during installation*

Glass and the coating layer (if any) should not be, exposed to/in direct contact, with aggressive materials such as acid, solvent, cement mortar, etc.

The fixing system of the panel should, in no case, cause shear stresses in the panel, and particularly the bonding interface between the glass sheet and the frame, either under the effect of external forces or due to differential expansion of components.

The protection of glass panel by means of a polyethylene sheet is recommended and shall provide ventilation for the glass in order to prevent thermal breakage.

Workers involved in the installation process shall be provided with adequate training and awareness about safety practices related to the handling and installation of glass panels. They shall be equipped with appropriate personal protective equipment (PPE), including but not limited to safety gloves, helmets, safety goggles, and footwear designed for the work environment, to minimize risks of injury during installation activities.

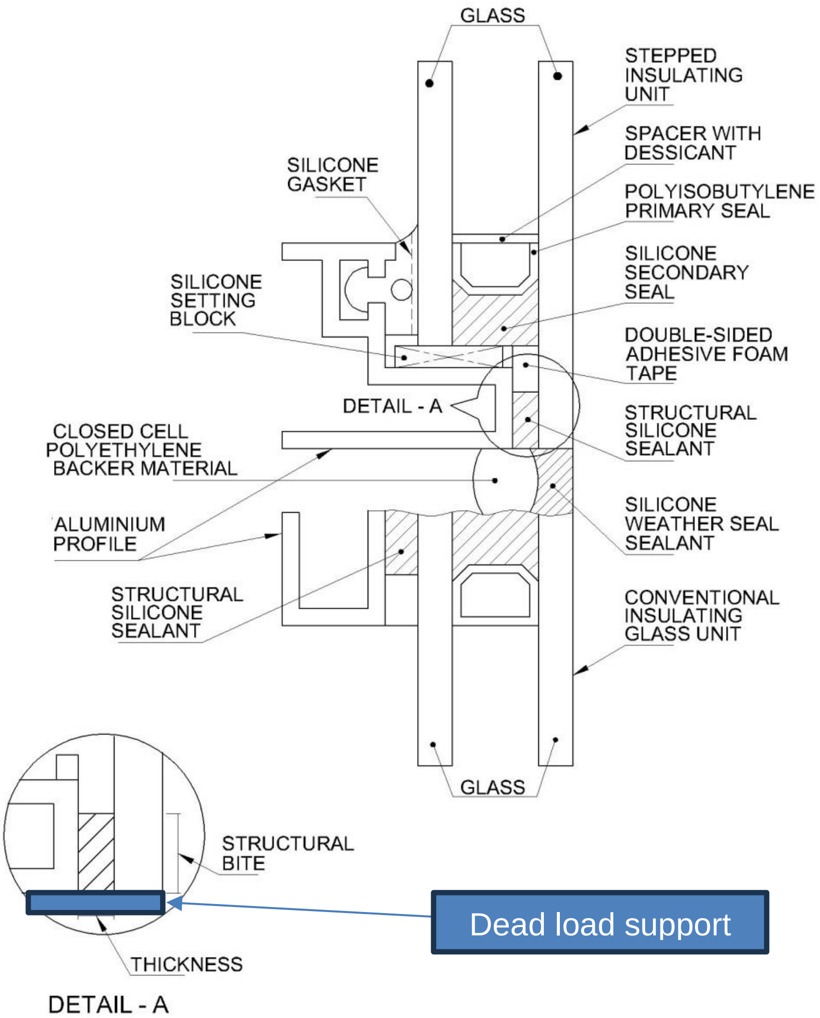


FIG. 17 TYPICAL STRUCTURAL GLAZING DETAIL

NOTE – Dead load support for the glass or infill shall be determined based on **6.3.8.1 (c)**. Minimum 50 percent of thickness of external glass pane shall be supported at be bottom, in the case of structural glazed systems.

6.3.10 *Handling and Transportation*

6.3.10.1 *Transportation*

During the transportation of the flat glass (clear, tinted), coated glass (solar control and mirror), lacquered or painted glass the following methods (if other standard packaging specifications are not available) of storage, packing and interleaving shall be followed:

a) Flat glass shall be transported vertically;
b) Glass panes should not come into direct contact with each other by using appropriate interleaving such as powder or foam or paper. The lacquer opacified/ enamel coated/ screen printed glasses shall be separated by paper or foam; and
c) The packing and packing material shall be protected from water and if the glass is wrapped and sealed, the seal should remain closed until the product is used and precautions taken to not damage the packing while handling with a hoisting apparatus.

Workers involved in the transportation of glass shall be provided with adequate training on transportation safety practices. They shall be equipped with appropriate personal protective equipment (PPE), including but not limited to safety gloves, helmets, and safety footwear to minimize risks of injury during transportation activities.

6.3.10.2 *Handling*

During the handling of the flat glass (clear, tinted), coated glass (solar control and mirror), lacquered or painted glass, the following guidelines shall be followed:

a) Glass shall be handled with dry, clean gloves, specifically after washing to prevent stain marks on them.
b) Care shall be taken to avoid contact or friction of the coating or the opacified/ enamel/screen printed side with any rough surface or hard objects.
c) A better practice is to handle glass with vacuum cups, and ensure that the vacuum cups and the glass are clean; and
d) It is recommended to keep it clean, if glass sheets are stored again before their processing or installation in the facade.

6.3.11 *Storage at Site*

To prevent staining, the storage area at site shall be,

a) a dry, well ventilated location at a sufficiently constant temperature;
b) protected from rain and running water;
c) protected from wide changes in temperature or humidity;
d) protected from alkaline material;
e) protected from direct contact of aggressive products such as corrosive vapors, acids, etc; and
f) glass panes are stored vertically on a soft surface such as wooden boards/battens.

6.3.12 *Storage after Cutting*

6.3.12.1 While stacking of coated glass/ mirror in the unpacked condition, the glass surface shall be facing towards the front (paint/coating backing towards the back).

6.3.12.2 Direct stacking of the mirror/coated glass one above the other should be prevented and suitable inter-leaving material as mentioned in **6.3.9** should be used between two glass panes.

6.3.12.3 The support material for glass storage should not have affinity towards moisture absorption.

6.4 Fire Safety

6.4.1 This Section covers the requirement and selection of fire safety glass for buildings. General fire safety provisions for buildings can be had from Part 4 'Fire and Life Safety' of the Code. It is important for any fire rated glass to provide sufficient amount of human impact safety feature even during fire or in general situations. The level of human impact safety of glass in buildings shall be in accordance with **7.1**. It is necessary that the fire rated system shall withstand the standard time-temperature curve during a fire test and shall give adequate time to the occupants for safe evacuation. This Section does not deal with the safety and security of people or goods in relation to risks of,

a) vandalism, riots, burglary or break in protection;
b) protection from explosion (terrorist attack);
c) natural disasters like earthquakes, cyclone, etc; and
d) plastic glazing, safety and security glazing, etc.

The requirements given here are minimum fire resistance requirements. In circumstances wherein the requirements of other Indian Standards exceed the requirements of this Section, in such cases the higher requirements shall become applicable.

6.4.2 *Glass for Fire Resistance*

6.4.2.1 Glazing system shall be so constructed, treated, or combined with other materials as to reduce loss of life or property during an event of fire, in comparison with ordinary sheet or flat glass, thereby preventing the passage of flame, hot gases, and smoke.

6.4.2.2 The following are the products in the scope of this Section that may be used for fire resistance provided they meet the requirements of accepted standard [6-8(15)]:

a) Wired fire resistant glass,
b) Glass-Ceramic fire resistant glass,
c) Borosilicate fire resistant glass,
d) Thermally super toughened soda lime silicate fire resistant glass,
e) Laminated fire resistant glass,

f) Intumescent interlayer laminated fire resistant glass,
g) Gel-filled fire resistant glass, and
h) Low-E coated fire resistant glass.

~~**6.4.2.2** The following are the products in the scope of this Section that may be used for fire resistance in glazing provided they meet the relevant available standards:~~

~~a) Wired glass,~~
~~b) Annealed fire resistant glass (AFG),~~
~~c) Tempered fire resistant glass (TFG),~~
~~d) Intumescent laminated fire resistant glass (LFG), and~~
~~e) Double glazed fire resistant glass (DFG).~~

~~**6.4.2.2.1** *Wired glass* (*Not recommended in doors except as vision panel and for window sizes not greater than in Table 29*)~~

~~It is a type of glass into which a wire mesh is embedded during production. Wired glass has an impact resistance similar to that of annealed glass, but in case of breakage, the mesh retains the pieces of glass. Value addition such as tempering and lamination is not possible using wired glass.~~

~~**6.4.2.2.2** *Annealed fire-resistant glass*~~

~~A single piece of fire resistant glass (borosilicate glass) that is tested for fire resistance for the required duration. These types of glasses can be used only in areas where human impact safety is not an issue, typically in areas like vision panels of doors, oven doors, etc. This type of glass has lower coefficient of expansion and cannot be tempered.~~

~~**6.4.2.2.3** *Tempered fire-resistant glass*~~

~~A single piece of specially heat-treated or chemically treated glass that is tested for fire resistance for the required duration and which has a stress pattern such that the piece when fractured reduces to numerous granular fragments, with no large jagged edges. Additionally these glasses should have a impact resistance of highest classification.~~

~~**6.4.2.2.4** *Intumescent laminated fire resistant glass*~~

~~Two or more pieces of glass held together by an interleaving layer or layers of materials and that as a complete system is tested for fire resistance. Fire side of the glass shall crack and break during the fire or under sufficient impact, but the pieces of glass tend to adhere to the inter-layered material and do not allow the fire to penetrate the last layer of glass.~~

~~**6.4.2.2.5** *Double glazed fire resistant glass*~~

~~Fire resistant glass that is used as a double glazed unit has to be tested as a complete Double Glazed Unit (DGU) or other multiple glazed units as the case may be. Double glazed fire resistant glass can be a combination of intumescent laminated fire rated or~~

~~tempered fire resistant glass. Fire resistant glass cannot be combined with another glass and used as a DGU unless the combined double glazed or multiple glazed units are also tested. Both the panes of the double glazed unit will need to satisfy the required impact safety as mentioned in **7**.~~

~~NOTE – It should be noted that use of any fire rated glass has to be installed in a tested system. Fire rated glass alone cannot provide the desired fire resistance since the fire resistance of a partition or a door assembly or any glazed building element is a function of the glass, frames, hardware, gaskets and fixings which forms the glazed system.~~

~~**Table 29 Limiting Size of Wired Glass Panel**~~
~~(*Clause* 6.4.2.2.1)~~

~~**Sl No.**~~	~~**Opening Fire Protection Rating**~~ min	~~**Maximum Area**~~ m^2	~~**Maximum Height**~~ m	~~**Maximum Width**~~ m
~~(1)~~	~~(2)~~	~~(3)~~	~~(4)~~	~~(5)~~
~~i)~~	~~60 to 90~~	~~0.064 5~~	~~0.838~~	~~0.254~~
~~ii)~~	~~45~~	~~0.836~~	~~1.372~~	~~1.372~~
~~iii)~~	~~20~~	~~No limit~~	~~No limit~~	~~No limit~~

6.4.2.3 *Testing procedures*

Any fire rated glazed building element needs to be tested as per accepted standard [6-8(10)]. The fire rating criteria of any building element shall be in accordance with Part 4 'Fire and Life Safety' of the Code.

6.4.2.4 *Identification of glass used for fire resistance*

a) All glass used for resisting fire shall conform to and preferably certified against available Indian Standards.
b) Since a fire resistant glass is not easily distinguishable from normal types of glass, it is imperative that every fire rated glass panel/unit should preferably have an indelible mark on all the panels/units of fire resistant glass showing the name of the manufacturer and the name of the product.
c) Rating of the glass panel may also be provided, although the rating of glazing system is of primary concern.

The glass used for fire resistance shall be in accordance with the requirements of Part 4 'Fire and Life Safety' of the Code.

6.4.3 *Precautions*

6.4.3.1 Fire resistant glass alone shall not be enough to protect occupants from fire. Glass is only one component of the complete system.

6.4.3.2 Fire test certificate report conducted for one application shall not be substituted for any other application. For example, a report for a partition shall not be used for a door application although the glass used and the fire ratings are the same. Approval in vertical orientation cannot be considered for acceptance in horizontal or inclined orientation.

6.4.3.3 The maximum glass size as mentioned in the test report should not be exceeded in practice with respect to the bigger linear dimension or area, unless otherwise validated by an assessment report issued by the testing lab. The aspect ratio may be modified provided that none of the linear sides has a dimension greater than that of the largest dimension of originally tested glass.

6.4.3.4 The dimensions of the profile need to be the same as that tested.

6.4.3.5 In case of any change in hardware they should be replaced following the guidelines laid down in the standard against which the test was conducted.

6.4.3.6 Factors like edge cover, types of gaskets and type of fixtures also play a very vital role in achieving the fire performance of the building element. These have to be used and installed as per the test report/available standards.

6.4.3.7 Buildings having non-structural joints between floor slabs and external perimeter walls, pose an associated risk of smoke and fire traversing between adjacent floors is not uncommon. The use of suitable materials to seal such joints needs careful consideration towards fire safety as the same is part of the compartment/fire barrier.

All gaps between floor-slabs and façade assembly shall be sealed at all levels by tested system of equal fire rating as that of floor slab to prevent fire and smoke propagation from one floor to another. Accepted standard [6-8(43)] specifies the test method to determine the fire resistance performance of perimeter fire barrier joint system based on the length of time the system being tested to resist the fire before development of through openings or flaming and transmission of heat on the unexposed surface.

7 SAFETY RELATED TO HUMAN IMPACT, ANTI-FALLOUT, WINDOW RESTRICTOR FOR CHILDREN AND DYNAMIC WIND RESTRAINT

7.1 Safety Related to Human Impact

7.1.1 *General*

The provisions herein are limited to the behaviour of glass when subjected to various kinds of human impact, precautions against risk of fall and falling glass. Conditions outside of ‘human impact’ are not covered under the scope of this Section.

This Section does not assume that the glass used in accordance to this Section will not be broken under all human impact conditions, rather,

a) it will not be broken under most likely forms of human impact; and
b) even if it breaks, the likelihood of cutting or piercing injuries will be minimised by virtue of the protection given to the glass, or by the limited size, or by the fracture characteristics of the glass.

Further, this Section does not deal with the safety and security of people or goods in relation to risks of,

1) vandalism, riots, burglary or break in protection;
2) fire arm protection;
3) protection from explosion (terrorist attack);
4) natural disasters like earthquakes, cyclone, fire, etc; and
5) plastic glazing material, safety and security glazing, etc.

In circumstances wherein the requirements of any referred standard(s) exceeds the requirements of this Section, in such cases the higher requirement shall become applicable.

The use of this Section shall also be in conformity with all other relevant standards on fire safety, structural stability, natural disasters, safety and security, etc, in force.

7.1.2 *Safety Glass*

Glazing material that are constructed, treated, or combined with other materials so as to reduce, in comparison with ordinary sheet/ float/ plate glass, the likelihood of injury to persons by objects from exterior sources or by these safety glasses when they may be cracked or broken.

The following are the products in the scope of this Section that may be used in safety glazing provided they meet the conformity requirements of accepted standard [6-8(5)]. Safety glass according to this Section shall be of following types:

a) Toughened safety (Tempered) glass, and
b) Laminated safety glass.

7.1.2.1 All ~~heat-treated/heat strengthened glasses, laminated, toughened, coated glasses and annealed glasses are not classified as safety glasses unless laminated to~~ safety glasses shall meet the requirement of tests specified in accepted standard [6-8(5)] ~~for safety glass~~.

7.1.2.2 In atria where there is no impact loads above 10 m, suitable toughened glass is adequate. *See* **4.2.9,** in case of use of glass fins as a structural member.

7.1.3 *Critical Location*

Where any glazing is within 1.5 m above the floor level of a building, it is considered likely to be subjected to human impact and hence, shall comply with the human impact safety requirements of this Section. Safety glazing should also be used,

a) where there is danger of falling infill glass material(s) from overhead glazing;
b) the danger of falling due to a change in floor level; and
c) in case of balustrades, stairs and floors.

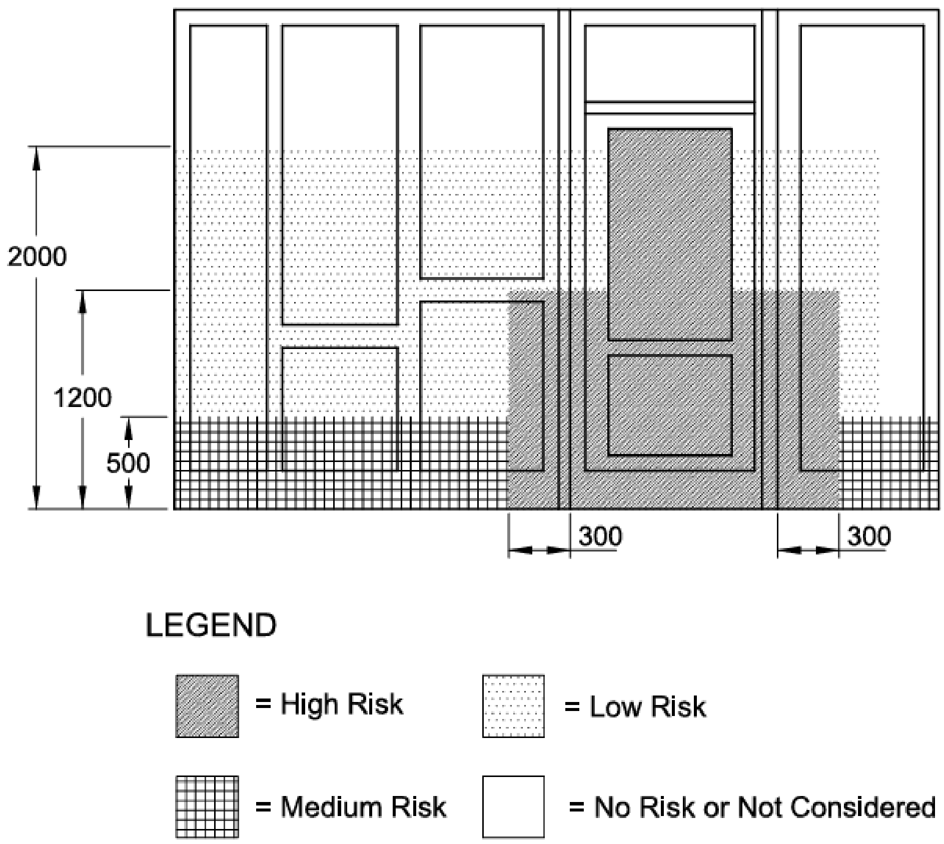
Based on typical accidents in glazed buildings, certain locations in buildings are found to be more vulnerable to human impact than others. Some of such critical locations are shown in Fig. 18, where necessary precautions given below have to be followed:

1) In-and-around doors, low windows;
2) Door side panels;
3) Panels mistaken for a doorway or opening;
4) Panels at low levels in walls and partitions;
5) Bathrooms;
6) Building associated with special activities, for example, gymnasia, enclosed swimming pools, etc;
7) Schools and child care facilities; and
8) Nursing homes and care facilities for the aged and infirmed.

Suitable precautions should be taken to reduce the injuries that can result from glass breakage by,

i) selecting glass of a suitable type, thickness and size;
ii) enhancing a person's awareness of presence of glass by making glass visible (manifestation of glass); and
iii) minimizing manual handling of large pieces of glass during installation.

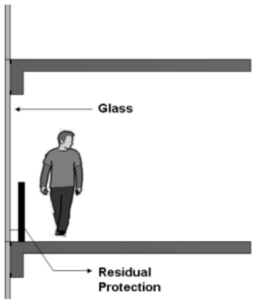
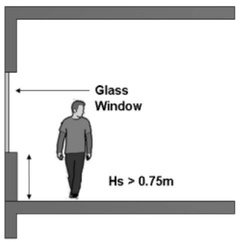
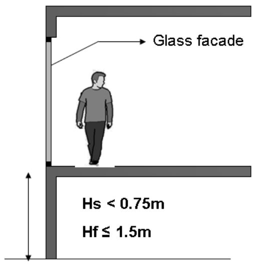
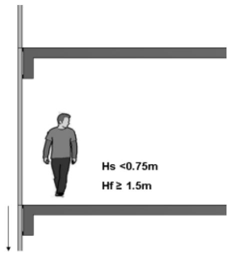
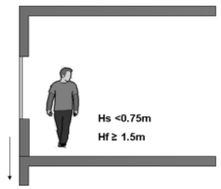
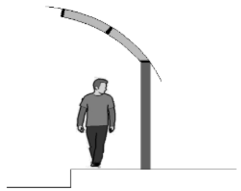
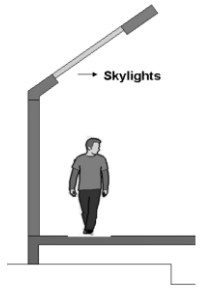
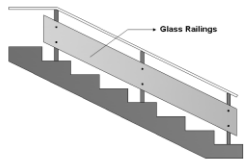
Based on the above, a comprehensive Table 29 is provided for information.



All dimensions in millimetres.

FIG. 18 CRITICAL LOCATIONS

Table 29 Type of Glass Suggested for Use at Different Critical Locations/Cases in Buildings
(*Clause* 7.1.3)

	CASE 1 Vertical Walls with Residual Protection or $H_s \geq 0.75$ m(not Likely to be Subjected to Human Impact)	CASE 2 Vertical Walls H_s<0.75m and H_f≤1.5m (Human Impact but no Risk of Fall)	CASE 3 Vertical Walls H_s<0.75m and H_f>1.5m (Human Impact and Risk of Fall)	CASE 4 Horizontal or Sloped Glazing Glass (Risk of Fall)	CASE 5 Glass Acting as a Balustrade/ Railing (Human Impact and Risk of Fall)
	(1)	(2)	(3)	(4)	(5)
	 		 	 Glass Shelter 	
Type of glass	Any glass[1)]	Safety glass[2)]	Safety glass[2)]	Laminated safety glass	Laminated safety glass

Examples	Residual protection is the safeguard provided to avoid the impact of human being on glass. It is provided on the side of the glass where there are chances of human impact. It can be achieved by providing protection in the form of a sill structure or transom, chair rail or grill work inside	a) Doors b) Side panels c) Curtain walls d) Glazed area e) Doors in bathroom 1) Fully framed 2) Partially framed 3) Frameless f) Façade g) Windows h) Internal partitions and doors i) External façade and doors on ground floor, above floor with terrace outside.	a) Curtain walls b) Façade c) Spandrels d) High activity area e) High risk area f) To avoid risk	a) Roof (Skylights) b) Ceilings c) Bus shelters d) Floors e) Stairs f) Sloped façade	a) Balustrades b) Balcony c) Railings

1) Safety glass is not mandatory.
2) Laminated float glass is preferred.

NOTES

1 ‘H_f’ corresponds to height of fall of human being or glass in case of change in level and ‘Hs’ corresponds to the sill height with reference to floor height.
2 In case of mirror glazing, it should conform to the requirements of other safety glasses unless it is fully backed by a solid material.
3 In Case 2 and Case 3, if the smaller dimension of the pane is 250 mm or less and its area is 0.5 m^2 or less, glass other than safety glass may be used, provided that its nominal thickness is not less than 6 mm (applicable to vertical glazing).
4 Toughened or laminated safety glass should meet respective test requirements as given in respective Indian Standard specifications.
5 The effective toughened safety glass thickness and/or laminated safety glass configuration shall be determined case by case with regard to,
   a) other solicitations (wind load, snow load, dead load, and human load);
   b) the overall dimension (length, width of surface);
   c) the aspect ratio of the glass; and
   d) the glazing fixing type (framing, bolted system, structural system, etc).
6 Precautions against chances of injuries due to broken glass falling on people include:

a) Broken annealed glass falling on people can cause grievous or even fatal injuries; hence it is recommended to use safety glass in locations other than defined in case 1 where the risk of people getting hurt by falling glass is high.
b) Toughened safety (tempered) glass has a safe breakage pattern, as it breaks and disintegrates into small and relatively harmless particles. However, thick toughened glass particles may stay interlocked, and fall as lumps of these multiple particles and can cause a minor or medium injury mainly due to the weight of the cluster.
c) Laminated safety glass shall generally not fall out of fixing. However, where laminated glass with both glasses toughened, used for horizontal or sloped glazing, in case of failure of both toughened glasses, it may crumble as a blanket and fall out of fixing. This factor needs to be considered while designing horizontal and sloped glazing. Further, when the slope is acute, inner pane facing the floor should be laminated; and when the slope is obtuse, the outer pane facing the ground / floor should be laminated and all obtuse angle sloped glazing shall be continuously capped for safety reasons.
d) Any broken glass in any glazing should be removed immediately on breakage.
e) Strength of the glazing system should be such that it has the ability to hold glass in place and prevent it from falling out as a whole.
f) For over-head applications like skylights, canopies for the safety of maintenance workers and people underneath, the broken laminated glass shall be capable of sustaining a load of 100 kg for a minimum duration 30 min.

7 In case of external laminated glass facades, openable portions have to be left at regular distances for fire fighting and smoke exhaust. This portion should be of toughened (safety tempered) glass and clearly indicated by suitable visible marking. See also Part 4 ‘Fire and Life Safety’ of the Code.

8 If insulating glass unit (IGU) is used in situations mentioned in this Section, then one of the following shall apply:
a) If IGU is installed in areas subjected to human impact on either side, then both the panes of the unit shall meet the requirements of this Section.
b) In situations where access is restricted to one side of the unit, then only the accessible side should meet the requirements of this Section.

9 Enhance person’s awareness of presence of glass by making visible manifestation.

10 For specific provisions relating to smoke evacuation, Part 4 ‘Fire and Life Safety’ of the Code may be referred.

7.1.4 *Manifestation (Making Glass Visible)*

7.1.4.1 Presence of glass in a door, side panel or a panel capable of being mistaken for a doorway or opening, which is not made apparent by transoms, colonial bars, door frames, large door handles, stall or other components of glazing system, should be made apparent by some form of manifestation. Decorative treatment, such as being opaque, or patterned are the other common manifestation options.

The manifestation employed should be of a sufficient size to make it immediately obvious. The manifestation should preferably be permanent, for example etching of the glazing; alternatively, if applied materials are used, they should be durable and not easily removed.

Manifestation shall be in the form of an opaque band in accordance with **B-5.3.13** of Part 3 'Development Control Rules and General Building Requirements' of the Code.

7.1.4.2 A band or marking may not be required, where any one of the following applies:

a) Width of the glass is not greater than 500 mm at any part (this applies to overall panel assembly – not individual glass pieces as in faceted glazing).
b) Glass is provided with at least one fixed glazing bar, firmly attached to the styles to locate and protect each face of the glass. At least one transom (glazing bar) shall be located with its upper edge not less than 500 mm and its bottom edge not more than 1 000 mm above the floor level. The glazing bar shall have a face of width 40 ± 3 mm; and
c) Alternatively, patterns may be used as an acceptable form of marking provided it meets the other criteria in this Section.

7.1.5 *Identification*

All safety glasses shall be procured from certified manufacturers and the product shall conform to relevant Indian Standards and shall carry all relevant information through the approved label/ permanent (indelible) markings on the glass surface.

7.1.6 *Test Requirements*

7.1.6.1 Safety glass shall confirm to all the test methods mentioned in the accepted standard [6-8(5)]. ~~relevant Indian Standards or as listed in Table 30~~.

7.1.6.2 *Mechanical Strength*

The required mechanical strength values (*see* Table 30) apply to quasi-static loading over a short time like wind loading relate to 5 percent probability of breakage at the lower limit and 95 percent confidence intervals.

If the glass satisfy the relevant impact test performance requirements (or fragmentation test for toughened glass), in addition to all other appropriate tests mentioned in available Indian Standards or as listed in Table 30, these materials can be classified as safety glass.

Table 30 Test Requirement
(*Clause* 7.6.1)

Sl No.	Requirements	Laminated Safety Glass	Toughened Safety Glass	Test Requirement as per
(1)	(2)	(3)	(4)	(5)
i)	Impact/ Resistance to shock	YES	YES	↑
ii)	Fragmentation test	–	YES	
iii)	Warp test	–	YES	
iv)	Boil test	YES	–	Accepted Standard [6-8(5)]
v)	Fracture and Adhesion test	YES	–	
vi)	Light stability test	YES	–	
vii)	UV light test	YES (for glass used in the exterior portions and subject to natural light)	–	↓
viii)	Shot bag impact test	YES	YES	*see* Annex E

NOTES
1 Bake test (high temperature) and humidity test may also be carried out as an option to determine the characteristics of laminated safety glass.
2 Surface compression test, four point bending test and waviness may also be carried out to determine such characteristics.

Table 30 Minimum Mechanical Strength Required for Fully Toughened Glass
(*Clause* 7.1.6.2)

Sl No.	Type of Glass	Mechanical Strength N/mm^2
(1)	(2)	(3)
i)	Float (Clear/ Tinted/ Coated/ Mirror)	120

ii)	Enameled flat (Based on enamelled surface in tension)	75
iii)	Patterned glass	90

7.2 Anti-Fallout — shall be applicable as per the following:

a) For all open out windows in buildings up to 5 storey height (< 15 m) anti fall out secondary safety device is optional.

b) For all open out windows in buildings more than 5 storey height (> 15 m) anti fall out secondary safety device is mandatory.

7.2.1 In the case of a fall out due to the sash getting completely disengaged from the hinges/stay arms/ restrictors, the anti-fallout device shall be capable of withstanding the self-weight of the sash. The drop height for the test shall be between 100 mm. Design and testing for the mechanism to take into consideration jerk load with a factor of safety 2.0.

7.3 Window Restrictor for Children

For windows which are non-emergency exits, projected top hung window, parallel opening window, vertical sliding hung window, side hung window and pivot window (except when used as an access door), the window restrictor shall be located such that the clear opening shall not exceed 100 mm (for human life safety especially for anti-fallout for children). When a force of 250 N is applied in opening condition to any part of the sash a sphere of 100 mm shall not pass through any part of the opening. Key releasable window restrictor can be used for the purpose of cleaning/maintenance. The side hung opening shall be restricted to be used in low rise buildings {20 m *see* good practice [6-8(7)]}. For buildings above 20 m height, projected top hung or parallel opening with an opening restriction of 100 mm shall be used.

NOTES

1 For fire access panels/window, the local authority regulations will be applied and same will supersede the above.

2 The above requirement of window restrictor for children is mandatory for residential apartments and optional for commercial establishment. However, it is recommended to limit the opening to 100 mm for commercial establishments as well especially for high rise buildings.

7.4 Dynamic Wind Restraint

This is applicable for open out windows in buildings more than 5 storey height (> 15m) and where the dynamic wind load is high due to the adjacent structures or terrain. Additional hardware is to be installed which shall be capable of self-locking the open window upon first time closure of the window due to wind conditions; in order to avoid fatigue failure on the hinges and stays. The mechanism can be releasable either using existing handle or additional release trigger.

8 GLAZING SYSTEM

8.1 The provisions relating to glazing system are covered hereunder. The details and procedure for selection, design, fabrication, installation, testing and maintenance of glazing system and its materials, considering the performance factors, including structural, seismic, acoustic insulation, fire resistance and energy efficiency are covered here under.

8.2 Design and Selection

The ~~This performance criteria~~ design considerations and parameters for the design and selection of a glazing system and the components involved, along with its associated materials used in buildings are listed below.

8.2.1 ~~*Performance Criteria*~~ *Design Considerations*

The following table 31 covers the various design considerations for glazing systems. ~~The performance criteria to be satisfied by the glazing system are:~~

- ~~a) Structural stability and safety,~~
- ~~b) Energy efficiency (performance),~~
- ~~c) Visual comfort (light transmittance and reflection),~~
- ~~d) Fire protection (ability to resist/withstand fire),~~
- ~~e) Sound insulation,~~
- ~~f) Air infiltration (wind pressure, stack pressure, fan pressure), and~~
- ~~g) Water penetration (static, dynamic and cyclic pressures).~~
- ~~h) Seismic movement comfort/protection test~~

~~*See* Annex F for general guidance on the above.~~

Table 31 Design Considerations
(*Clause* 8.2.1)

Sl. No.	**Design Considerations / Criteria**	**Reference Standards**
(1)	(2)	(3)
1	**Structural Aspects and Parameters**	
i)	Design Load and Wind Load Classification	As per good practice [6-8(7)] and accepted standard [6-8(18)]
ii)	Other Loads – Live Load, Dead Load, etc	As per good practice [6-8(29)]
iii)	Air Infiltration / Exfiltration and its classification	As per accepted standard [6-8(18)]
iv)	Deflection	As per **6** and accepted standard [6-8(18)] and [6-8(26)]
v)	Seismic Performance	As per **6.1.6** and good practice [6-8(8)]
vi)	Water Tightness and its classification	As per accepted standard [6-8(18)]

Sl. No.	**Design Considerations / Criteria**	**Reference Standards**
(1)	(2)	(3)
vii)	Glass thickness	As per good practice [6-8(30)]
viii)	Structural Sealant	As per **4.4.1**
ix)	Frame/ profile specifications:	
	1. Aluminium	As per accepted standard [6-8(26)]
	2. uPVC	As per accepted standard [6-8(31)]
	3. steel	As per accepted standard [6-8(32)]
x)	Hardware and Fixing	As per **5.4** of accepted standard [6-8(26)]
2	**Energy Aspects and Parameters**	
i)	Window to Wall Ratio	Part 11, 'Approach to Sustainability' of the Code
ii)	Building Orientation	
iii)	Window to Floor Ratio	Part 11, 'Approach to Sustainability' of the Code
iv)	Thermal Performance: (Roofs and Fenestration)	
	1. U Value of Glazing 2. Solar Heat Gain Co-efficient (SHGC) / Solar Factor of Glazing 3. Visible Light Transmittance (VLT)	**8.1.2**, **8.1.3** and **9.2.3** of Part 11, 'Approach to Sustainability' of the Code
	4. Glass – Thermo – Optical properties: U Value, Solar Heat Gain Co-Efficient, Visible light transmittance, Internal and External (Heat and Light) Reflectance and Transmittance, Shading Co-Efficient	As per **5**
v)	Lighting	As per Part 8, 'Building Services, Section 1, Lighting and Natural Ventilation' of the Code
3	**Safety**	
i)	Safety related to Human Impact	As per **7.1**
ii)	Window Restrictor for Children	As per **7.3**
iii)	Anti-Fallout	As per **7.2**
iv)	Fire Safety	As per **6.4** and Part 4, 'Fire and Life Safety' of the Code
v)	Security Glazing a. Bullet Resistance b. Ballistics Resistance c. Resistance to Explosion d. Burglar Resistance	As per **9**
4	**Acoustics Parameters**	
i)	Airborne sound insulation	As per accepted standard [6-8(33)]
ii)	Impact sound insulation	As per accepted standard [6-8(34)]

8.2.2 *Design Parameters*

To achieve the performance criteria, care should be taken so that components in the system are selected and designed for the following parameters, such that the necessary performance criteria is met both individually and as a system

a) Loading,
b) Deflections and allowable stress,
c) Movements,
d) Impact resistance,
e) Acoustic and sound insulation, and
f) Energy performance.

8.2.2.1 *Loading*

Wind load, live load, dead load, load combinations as per good practice [6-8(11)], seismic load as per good practice [6-8(8)], and other consequential loading may be considered.

8.2.2.2 *Deflections and allowable stress*

The deflection of framing members, members supporting brittle materials, metal panels, glass panels and the allowable stress shall be in accordance with **6.3.6.2**. The allowable stress shall be in accordance with [6-8(11)].

8.2.2.3 *Movements*

The glazing system (and its framing elements) shall be able to accommodate the movements caused due to wind loads, seismic loads, live loads, dead load deflection, thermal expansion and contraction of members, and slab deflection, etc.

8.2.2.4 *Impact resistance*

Any glazing (in the glazing system) within 1 500 mm above the floor level of a building is considered likely to be subjected to human impact and hence, shall comply with the human impact safety requirements given in **7.1**.

8.2.2.5 *Acoustics and sound insulation*

The recommendations on acoustics and sound insulation given in Part 8 'Building Services, Section 4 Acoustics, Sound Insulation and Noise Control' of the Code shall be applicable.

8.2.2.6 *Energy performance*

The recommendations on the principal energy performance characteristics of the glazing system shall meet the provisions given in **5**.

The primary characteristics required in general are reducing thermal losses and solar gains. For additional reference to visible light transmittance (VLT), solar heat gain coefficient (SHGC) and thermal transmittance (U factor) features, Part 11 'Approach to Sustainability' of the Code shall be referred.

8.2.3 *Types of Structural Frame Materials*

For the framed/semi-framed systems, materials such as aluminium, stainless steel, uPVC and timber, which are commonly employed are listed hereunder.

8.2.3.1 *Aluminium alloy*

Extruded aluminium alloy used for structural framing members, shall be fabricated from the most appropriate grade of alloy complying with the relevant standard(s). The thickness of the aluminium sections should be in accordance with structural and hardware fastening requirements and shall be capable enough to meet the design requirements and satisfy the performance requirements.

Such extrusions in framing members and trims shall preferably be extruded aluminium grade 6063-T5, 6063-T6, 6060-T66, similar or stronger. Where 6063-T5 is to be used in shaped structures, supporting structural calculations particularly the stress criteria be ensured. Extrusion alloy 6061 or 6105 are commonly used for higher strength. Aluminium brackets shall be extruded aluminium grade 6061-T6 or approved equivalent. All aluminium alloys used as extruded rods/bars, tubes and profiles shall be compliant with accepted standard [6-8(12)].

Sheets and plates may be obtained from the following alloys of aluminium which also lists their primary characteristics:

a) 1100 **–** A low strength alloy suitable for applications requiring a high degree of formability.
b) 1135 **–** Brighter finish when anodized.
c) 3003 **–** General purpose sheet alloy with fair mechanical properties and excellent formability, susceptible to structural streaking when anodized (noticeable in large flat areas).
d) 5005 **–** Excellent workability, weldability and corrosion resistance.
e) 5052 **–** Slightly better mechanical properties and excellent corrosion resistance and weldability.

Other alloys can be used provided that they meet the required physical properties and the specified performance requirements.

8.2.3.2 *Stainless steel*

Mullions, panels, fascia, column covers, windows, doors, trim, roofing, gutters, flashing, hardware and other items where minimum maintenance is anticipated, shall be of austenitic stainless steels of Type 301, 302 and 304 complying with accepted standard [6-8(13)] and employed for their mechanical properties as they are highly corrosion resistant for all normal exposures.

For interior decorative applications, where regular maintenance will be provided, Type 430 may be used as it has lesser corrosion resistance properties. For external applications like in coastal regions where maximum resistance to corrosion is required, stainless steel shall be of type 316. Particular attention shall be paid to the direction of the rolling grain on self-finished stainless steel components where the finish is aesthetically important. All screws, nuts, bolts, washers, self-tapping screws and other fastenings, including those used for the hardware, shall be of stainless steel type 304, 316, 430 complying with accepted standard [6-8(13)]. Type 316 based steel fasteners, etc shall be preferable when they are used in coastal regions on the exposed side.

8.2.3.3 *uPVC*

A relatively flexible material, PVC which is internally reinforced with steel or aluminium to give it the required strength and stiffness may also be used. The inherent ability to make a variety of profiles, easier maintenance, corrosion resistance ability and heat resistance when used may be considered when choosing uPVC sections.

8.2.3.4 *Timber*

Timber frames are relatively stiff and particularly treated timber combined with good design and workmanship give an acceptable life. They are adopted for their inherent thermal insulation property, light weight and improved sound insulation. Tenderness to absorb moisture, if not carefully treated prior to use can lead to possible rotting or even warping resulting in air and water infiltration and regular painting and maintenance are the factors to be considered while choosing timber as the framing material.

8.2.4 *Surface Finishes*

The commonly employed surface finishes are listed hereunder:

a) *Aluminium frame* – The main types of aluminium frame coatings are as follows:

   1) Anodized finish,
   2) Powder paint finish, and
   3) PVDF coating.

b) *Steel frames* – Surface finish on stainless steel frames plays a major role in its resistance to corrosion and hence it is an important design aspect to be clearly specified. The types of surface finishes listed here shall be in accordance with applicable relevant standards:

   1) Mill,
   2) Ground,
   3) Brushed,
   4) Polished,
   5) Bead blasted,
   6) Electro polished,
   7) Coloured, and
   8) Patterned.

   Electro polishing of steel frames shall be done in accordance with available standards.

c) *Timber frames* – The function of finishes on timber is two-fold, first to improve the durability of the frame and second to add to the aesthetics. Unfinished, unprotected timber weathers as a result of gradual changes to its physiochemical structure brought about by temperature and moisture content variations. The finishes may be of the following types:

1) *Conventional opaque systems* – Water and solvent borne,
2) *Natural finishes* – Semi-transparent and opaque, and
3) Water repellent preservatives, wood primers, undercoats and finishing coats (gloss, semi-gloss, flat and low sheen).

Based on the application, the appropriate type of finish shall be chosen.

8.2.5 *Types of Anchorages*

~~Anchorages are used primarily to join the mullions and transoms to the beam or slab through an appropriate bracket. The two basic types of anchors commonly used are:~~

~~a) Stud anchors – Used where the mullions have to be fixed to the face of the beam or slab.~~
~~b) Flush anchors – Used where the mullions have their start point or termination at a slab/beam or skirting.~~

Post-installed anchors are used primarily to join the mullions and transoms to the beam or slab through an appropriate bracket. The most common types of post-installed anchors are torque controlled expansion anchors and adhesive anchors. The selection of the appropriate anchor depends on the load requirement. For details on the types of post-installed anchors, reference may be made to good practice [6-8(27)].

~~Factors influencing the selection of anchors and to ensure proper performance of the anchor during its service life are:~~

There are different factors which influence the selection of anchors and to ensure proper performance of the anchor during its service life. These include

1) *Diameter* **–** The following parameters shall be calculated for the selection of the anchor diameter:
   i) Dead load acting on the anchor,
   ii) Live load incident to the anchor (wind load- tensile or shear), and
   iii) Weight of bracket, aluminium channels and other associated components.
   iv) Performance against earthquake load.

2) *Length* **–** The overall length of the anchor is based on the effective embedment length into the concrete and the total thickness of the glazing components which have to be fastened to the base material. Insufficient embedment length shall lead to pull-out failure of the anchor.

3) *Material* **–** Stainless steel and galvanized iron are the two main types of materials used in the manufacturing of anchors. The selection of anchor material shall be based on the location of the anchors, considering factors such as interior or exterior application, exposure to weather, or enclosed conditions.

4) *Coating* **–** The following type of coating shall be used based on the specific environmental condition met with:

Environmental Condition	*Coating to be Used*
Particular influence of moisture	Zinc plated
Occasional exposure to condensation and in coastal areas/ slightly corrosive	Hot-dip galvanized
Heavy condensation/ corrosion and in coastal areas	
a) areas with high corrosion risk	Stainless steel (SS 316)
b) risk of exposure to corrosion is medium	Stainless steel (SS 304)

5) *Load direction* **–** Based on the orientation of the anchor, they are incident to shear loading, tensile loading and combined loading. ~~of force and hence the proper diameter and depth of anchorage shall be selected.~~

6) *Base material* **–** The material characteristic of the base material (concrete) also plays a major role in avoiding failure in the anchorage. The material shall be of suitable grade, have minimum thickness, shall be properly cured and have the necessary compressive stress. Unless otherwise mentioned by the concerned structural engineer, the concrete shall be considered as cracked for all design purposes. Reference shall be made to good practice [6-8(27)] for more details in this regard.

7) *Anchor spacing and edge distance* **–** Anchor spacing is the centre to centre distance between the anchors. Edge distance is the distance from the centre of the anchor perpendicular to the respective edge of the concrete member. Reference shall be made to good practice [6-8(27)] for more details in this regard.

   ~~Anchor spacing is the minimum distance between two anchor centre lines without an influence on the tensile or shear failure load of either anchor. The load bearing capacity of an anchor is influenced by an adjacent anchor and thus the minimum anchor spacing specified by the manufacturer shall be adhered. Due to reduced material volume, a minimum edge distance shall be maintained to prevent the edge from breaking away prematurely when the anchor is installed, and also to achieve the full load bearing capacity of the anchor.~~

8) *Effective embedment depth* **–** It is the effective depth which actually transfers the forces passing through the anchor into the concrete. Reference shall be made to good practice [6-8(27)] for more details in this regard.

~~A critical factor in determining load capacity. Anchors installed less than minimum depth will stress the base material above its limits and may cause failure during installation or expansion of the anchor.~~

9) *Environmental condition* – Environmental conditions like temperature, humidity, salinity, etc, will affect the performance of the anchors and may lead to pre mature failure. Hence, careful selection of the material and coating should be done when selecting anchors which are to be installed in location subjected to adverse environmental impact such as coastal region.

10) All the anchors shall be designed as per the recommendations of good practice [6-8(27)].

8.2.6 *Hardware Materials*

The material, geometry and finish of all the hardware materials shall be as per the requirement and should not affect the performance of the glazing system. All materials and finishes shall be as per relevant Indian Standards and tested before installing into the system in accordance to relevant Indian Standards.

8.3 Fabrication

8.3.1 *Factory*

The manufacturer shall ensure that proper internal control, documentation including records of test results performed be maintained about the production. The above shall enable quality assurance of the materials and process involved.

8.3.2 *Handling of Materials on Site*

The following lists among others, the important features to be considered:

a) All materials shall be handled by workers who have been provided appropriate training and awareness on the techniques to handle the materials and shall operate with a full set of PPE (Personal Protection Equipment).
b) Large glass panes or panels shall be handled with vacuum cups. Care shall be taken to ensure that the vacuum cups and the glass are perfectly clean. An additional rope or belt is recommended to support the dead load as a fall arrestor.
c) All materials shall be handled with dry, clean, gloves and shall not come in contact with rough surfaces or hard objects, in order to avoid scratches, dents or breakage.
d) Labels and marking shall not be put on the coated side of glass, and any relative movement of the coating with the next glass pane shall be avoided.

8.3.3 *Transportation and Logistics*

While transporting materials from vendor to factory, within the factory, to and from surface finish coater, finished goods to site and movement of finished goods at site care should be taken to ensure the following:

a) Finished surface is adequately protected with a protective tape which can be easily removed without leaving any residue.

NOTE – Most protective tapes either peel off or adhere to the substrate when exposed to UV for more than three months.

b) Suitable blocking, edge protection, crating, etc, are done to avoid dents and gouges.
c) Hardware is secured and not damaged in transit.
d) Material is adequately secured in the truck/container especially when the goods are sent as loose container load (LCL) or partial shipment avoiding any damages.
e) Lifting equipment's shall be adequately engineered for capacity, safety and balance (especially when units are very heavy).
f) Suitable 'A' frames or customized transport support shall be used.
g) Recommendations from glass supplier towards the protective film shall be followed.

8.4 Installation

8.4.1 *Site Survey of Building*

a) Measuring the elevation width and height, ascertaining the grid pattern including position of vision and spandrel frames, the levels of concrete and masonry in x, y and z axis, checking and recording the presence of any difference in plumb ness of jambs, beam and column fascia and steel structures are the key activities necessary in deciding the final fabrication measurements.

b) Leveling (setting x-axis, common sill level for all elevation and adjustment in bracket depth) and Surveying (measuring x-axis distance and setting the width and height for all elevation) are involved in the process of site survey of building. The key processes are listed below:

   1) *Processes in levelling:*

      i) The sill bottom level of all the glazing elevations is to be checked by fixing a common benchmark and the reading should be recorded at minimum one metre distance.
      ii) After taking the reading we can locate the highest and lowest point and then we can decide upon common level of all glazing elevations.
      iii) The benchmark shall be a permanent mark, hence we shall be using oil paint mark in form of upside triangle
      iv) The levels of all beam bottoms and up stand, if any, coming across the glazing elevations at all floors are to be measured.
      v) Any other point that can affect fabrication drawings to be noted.

   2) *Processes in surveying:*

      i) The total width shall be measured using a theodolite and recorded at one plane.

ii) It shall be cross checked by measuring existing column to column (at other plan) distance.
iii) The two end point RCC shall be measured for plumbness. If any difference is observed, adjust the reading of first two steps.

8.4.2 *Installation Tolerance*

The effect of installation tolerance is vital for any type of glazed system to perform as per the requirement and the specified performance. For structural glazing, the installation tolerances shall be strictly followed in order to assure that the sealant joint opening meets the specified minimum and maximum joint opening dimensions.

8.4.3 *Good Installation Practices*

The good practices involved in installing a glazing system have been categorized hereunder.

8.4.3.1 *Anchorage*

The anchor installation shall be undertaken by installers who have been adequately trained by the manufacturer to install the specific type of anchor. The installer should be familiar with the correct installation procedures and ensure that the correct drilling and setting tools are available for the proper installation of the anchor.

For details with respect to the right installation procedure, reference shall be made to good practice [6-8(44)].

a) ~~Anchor installation shall be carried out by appropriately qualified personnel and under the supervision of the person responsible for technical matters of the site.~~
b) ~~Installation shall be in accordance with the manufacturer's specifications and drawings using the tools indicated in the technical documents.~~
c) ~~Use of the anchor shall be only as per that supplied by the manufacturer and without changing/exchanging the components of an anchor.~~
d) ~~Checks before placing the anchor to ensure that the strength class of the concrete in which the anchor is to be placed is in the range given and is not lower than that of the concrete to which the characteristic loads apply.~~
e) ~~Edge distance and spacing shall be not less than the specified values without minus tolerances.~~

8.4.3.2 *Sub-structures*

a) In order to avoid physical contact with the panels and frames during sealant application, which might cause adhesion loss, use of powder-free latex gloves shall be used, during panel placement.
b) Proper alignment and setting out of the sub-frame is critical in ensuring the ease of operation of the window/door.
c) Anchor/bolt heads and joints between external wall and sub-frame should be sealed with sealant for effective water tightness.
d) Prior to fixing the main frame, the sub frame should be checked for any physical damages and any damaged sub-frame should be repaired or replaced.

e) Setting out of the sub-frame should also be verified before the installation of the main frame.
f) Dust and debris accumulated in the sub-frame could affect the alignment and fixing of the main frame and may also cause blockage to the weep holes, resulting in overflow of any incidental water into the interior, and so it shall be properly cleaned before assembly.

8.4.3.3 *Sealants*

a) All components (glass and framing member such as aluminium) receiving the structural glazing silicone sealant shall be wiped thoroughly with a clean cloth dampened with a cleaner recommended by the manufacturer, and immediately followed by a dry wipe, using clean cloth.
b) All surfaces once cleaned/primed shall be handled carefully so as not to contaminate the surface.
c) The substrates shall be kept free from moisture, condensation, dust and other impurities.
d) An application temperature range of +10°C to +40°C (or as specified by the manufacturer) is recommended and shall be adhered to.
e) Substrate temperatures in excess of +50°C will adversely affect curing process and also the adhesion of the sealant to the substrate.
f) Minimal time shall be taken for cleaning, placement and sealing of panels since environment conditions at job site cannot be controlled.
g) Temporary fasteners may be used to keep the joints stable during the curing process of the sealants and they shall be removed only after complete cure and adhesion has been achieved by the sealant.
h) Tooling of the sealant shall be done with light pressure, within 5 to 10 min, before a skin forms on the sealant.
i) Avoid the use of wet tooling aids such as soaps and solvents. Dry tooling is appropriate.
j) Masking tape shall be used in ensuring neat straight-line application and avoiding smears.
k) The masking tape shall be removed immediately after tooling has taken place and before the sealant starts to cure.
l) The general recommendation for the application of structural sealant required for a 4 sided system, bonding the glass to the aluminium frame should be done in a factory atmosphere.
m) Complete quality control process with respect to surface preparation, storage, sealant application and quality check are to be implemented in the factory with full traceability. In most cases sealant manufacturers have quality requirements and documentation process related to warranties which need to be followed.
n) *In-situ* application may be required for 2 sided system, retrofit, repair and small areas in a façade. Sealant manufacturers should be contacted to get job specific recommendation on sealant application for *in-situ* application.

8.4.3.4 *Installation*

The framing and fixing system of the panel should, in no case, cause shear stresses in the panel, either under the impact of external forces or due to differential expansion of components. The following shall be taken care of:

a) All framing shall be checked prior to glazing to assure that the opening is square, plumb and secure so that the uniform sealant bite, face and edge clearances are maintained.
b) Inspect all butt and mitre joints and if found open, they shall be sealed using sealants prior to glazing.
c) Minimum edge clearances shall be maintained between glass and sash, as mentioned by the manufacturer.
d) Setting blocks shall be used to support the glass unit which shall prevent the addition of stress applied on the structural tensile bead due to the self-weight of glass.
e) Adhesion tests shall be performed by the contractor/agency at the beginning and during the installation process.

8.5 Testing

The Table 32 lists the tests to be carried out for glazing systems including curtain walls, windows, skylights, sliders, doors, etc.

~~**8.5.1** *Laboratory Testing*~~

~~The glazing system is subjected to various adverse environmental conditions and impacts during its service life. A properly designed and installed glazing system may be able to resist any major damage to its stability or performance under any condition within its effective life time. The glazing system and its component materials shall be tested for the required parameters and performance.~~

~~**8.5.2** *Field/On-Site Testing*~~

~~Testing of the glazing system as a whole unit in site (the field) subject to loads and effects such as water infiltration, wind (air) infiltration, acoustic insulation, fire insulation, thermal performance, structural performance, etc, may be carried out for specific cases as mutually agreed to between the parties concerned, to ensure homogeneity.~~

~~The following performance tests are to be conducted on structural glazing system, if area of structural glazing exceeds 2 500 m^2 from the certified laboratories, as per the specialist literature:~~

~~a) Performance Laboratory Test for Air Leakage Test (–50 Pa to –300 Pa) and (+50 Pa to +300 Pa) for a range of testing limit 1 to 200 mVh.~~
~~b) Static Water Penetration Test (50 Pa to 1 500 Pa) for a range up to 2 000 ml.~~
~~c) Dynamic Water Penetration (50 Pa to 1 500 Pa) for a range up to 2 000 ml.~~
~~d) Structural Performance Deflection and deformation by static air pressure test (1.5 times design wind pressure without any failure) for a range up to 50 mm.~~
~~e) Seismic Movement Test (up to 30 mm).~~

Table 32 Testing of Glazing Systems including Curtain Walls, Windows, Skylights, Sliders, Doors, etc
(Clause 8.5)

Sl. No. (1)	**Test Parameters** (2)	**Testing Method** (3)
i)	Air Permeability	As per accepted standard [6-8(20)]
ii)	Water penetration – Static air pressure difference	As per accepted standard [6-8(21)]
iii)	Water penetration – dynamic air pressure difference	As per accepted standard [6-8(22)]
iv)	Standard Operating Forces	As per accepted standard [6-8(23)]
v)	Window and Doors Resistance to repeated opening and closing	As per accepted standard [6-8(24)]
vi)	Wind resistance for curtain walls, windows, sliders and skylights	
vii)	Structural Load Test (100 percent Design Wind Load)	As per accepted standard [6-8(35)]
viii)	Structural Proof Load Test (150 percent Design wind load and seismic force, if applicable)	
ix)	Seismic Racking Test	As per Annex E
x)	Water Penetration – Field	As per accepted standard [6-8(20)]
xi)	Thermal performance of windows, doors and shading devices – detailed calculations	As per accepted standard [6-8(36)]
xii)	Calculation of thermal transmittance – numerical method of frames	As per accepted standard [6-8(37)]
xiii)	Mechanical tests for standard windows and door height windows	As per accepted standard [6-8(38)]
xiv)	Fire resistance tests – door and shutter assemblies	As per accepted standard [6-8(39)]
xv)	Fire resistance test for glass walls	As per accepted standard [6-8(40)]
xvi)	Fire resistance test for doors with glass panes, openable glass windows and sliding glass doors	As per accepted standard [6-8(41)]
xvii)	Forced Entry Security Glazing	As per accepted standard [6-8(16)]
xviii)	Bullet Resistant Glass	As per accepted standard [6-8(17)]
xix)	Acoustics – Sound Insulation	As per accepted standard [6-8(33)] and [6-8(34)]
xx)	Blast Resistant Security Glass	Annex K

8.6 Maintenance ~~and Durability~~

8.6.1 *Maintenance Infrastructure*

Regular maintenance of the building facades plays an important role in the holistic building maintenance. The access systems shall provide sufficient approach which enables all parts of the façade to be reached safely for the purpose of cleaning, inspection and maintenance and also offer high work efficiency to the maintenance workers, without also hindering the aesthetics of the building. The provisions of Part 12 'Asset and Facility Management' of the Code may also be referred.

The means of access and supporting infrastructure should be established at the design stage so that the loads are properly envisaged for.

Façade access requirements come in many varieties and may present challenges. Powered access cradles for facade access, cleaning of the glass directly from the ground, hoists based access and window based cleaning/access from inside the building are some of the common techniques employed. Recently, access techniques using ropes have been used for facade access and are generally considered to be safe, provided the workers have been trained and are using all the correct safety equipment and precautions.

In nearly all cases, façade access and maintenance requires a worker to be exposed to working at height with its associated risks. Therefore, use of height safety equipment, anchor point attachments (like the fall restraint or fall arrest system) and those given below should be employed:

a) *Roof guardrails* – When choosing equipment for working at heights, collective protection like roof guardrails may also be considered. Roof guardrails ensure that all users are protected from falling without the need for specialised training and/or equipment. They also eliminate the need for rescue procedures to be put in place. Roof guardrails are available in fixed, free standing, straight upright, cranked upright or collapsible.
b) *Fall arrest systems and fall prevention cable systems* – Fall arrest systems allow safe access to roof areas for maintenance and inspections to be carried out by workers. Users of the fall arrest systems require wearing of full body harnesses and attachment to the cable/fall arrest system via a lanyard (rope) and shuttle device which allows them to walk the full length of the system without having to detach from the system. Fall arrest systems shall be of types horizontal, overhead, sloping and vertical lifeline type and shall comply to the relevant/available standards.

Depending on the project requirement, the maintenance infrastructure shall consist of the following systems:

1) *Roof trolley/Cradles* – Fixed or adjustable jib, telescopic jib, cradle with pantograph.
2) *Rail systems* – Hooked, anchored, turntables, rotary plates.
3) *Other systems* – Additional winches for glass replacement, parking positions/lifting platforms.

8.6.2 *Maintenance of Materials*

The glazing system and the associated materials require a suitable degree of maintenance, if they are to fulfill their intended working life. Early detection of defects can mitigate expensive repairs or replacement later. The degree of inspection and maintenance required will depend on the type of glazing system and its intended design life.

8.6.3 *Common Practices for Maintenance*

The common principle maintenance practices to be followed shall be as given below.

a) When using the cleaning equipment or carrying out maintenance on the exterior of the building, the risk to personnel and property, prior to the start of work shall be assessed at first.
b) Where applicable, qualified personnel to carry out routine or complex maintenance shall be employed.
c) Power supplies may need to be isolated prior to maintaining electrically operated equipment such as motors to opening vents, roller blinds to atrium roof and main entrance pass doors.
d) While accessing the external façade, fall arrest systems shall always be used even while working in the house cradle.
e) Manufacturer's instructions shall be followed when using cleaning fluids and shall not be mixed up with drinking water or the like. To deal with instances of contact with eyes, skin, etc, necessary eyewash arrangement and first aid equipment shall be at place.
f) Loosened fixing or bolts shall be identified, reported and attended to immediately, and shall never be tampered with.
g) Unauthorized loosening or removing of the fixings may prove dangerous and can result in structural damage and displacement of the system.
h) When lifting equipment such as hoists and sucker machines are used, it shall be ensure that they are capable of lifting the loads required. Further, the recommended safe working loads of any equipment shall never be exceeded.
j) When handling any insulation of firebreak material, ensure gloves, goggles and masks are worn as fibrous materials (if any) may cause irritation.
k) Prior to the commencement of work involving glues or sealants (particularly in confined spaces), manufacturer's advice/special instructions shall be adhered to before exposing the product to air. Such materials shall preferably be worked with, in a well-ventilated area.
m) In the case of coated glass, the following precautions shall particularly be adhered to:
   1) Any scratching will penetrate the surface of the coating and cannot be repaired.
   2) Any excessive mechanical treatment might remove the coating in localised areas.
   3) Avoid all contact with metal objects.
   4) Avoid all chemicals that may attack the surface and damage it irreparably.

9 SECURITY GLASS

9.1 This section covers the requirements and selection criteria for security glass in buildings. The general methodology for selecting types of security glass shall be in accordance with **4**. It is essential for any security glass in addition to its required function to provide adequate human impact safety features. The level of human impact safety for glass in buildings shall be in accordance with **7.1**. Furthermore, the security glass shall meet the classification standards to which it has been tested, ensuring the safety and security of occupants and goods. This Section deals with the safety and security of people or goods in relation to risks of,

a) vandalism, riots, burglary or break in protection;
b) protection from firearm shooting;
c) protection from explosion (terrorist attack);
d) protection from ballistic attacks.

The requirements given below pertain to glass used in areas with high-security needs. In circumstances wherein the requirements of other Indian Standards exceed the requirements of this Section, in such cases the higher requirements shall become applicable.

9.2 Glass and Related Material for Security

Glass used for security purpose are laminated glass with different combination of glass panes including annealed glass, heat strengthened glass, toughened glass, and interlayers (including Polyvinyl butyral, Ethylene Vinyl Acetate, Plastic Sheets, Polycarbonate sheets, etc) as in accordance with **4**.

9.3 Selection Criteria

The selection criteria is based on the threat levels / risks (Firearm shooting, Ballistic attacks, Explosion, Burglary, etc) and stages of protection as per the requirements of the buildings and the user.

9.4 Testing procedures

9.4.1 *Burglary Resistance of Glazing Systems*

The framing member along with it's hardware and glass to comply for the burglar resistance requirements as a whole. The glass to be used should comply with the testing requirements of accepted standard [6-8(16)]. The following table 33 lists the minimum requirments for various resistance classes of glazing.

Table 33 Minimum Requirments for Glazing
(*Clause* 9.4.1)

Sl. No.	**Resistance class**	**Minimum resistance class of glazing as per accepted standard [6-8(45)]**
(1)	(2)	(3)
i)	RC 1 N	Any glass (test is for hardware manipulation for entry)
ii)	RC 1	P4A
iii)	RC 2 N	Any glass (test is for hardware manipulation for entry)
iv)	RC 2	P4A
v)	RC 3	P5A
vi)	RC 4	P1B
vii)	RC 5	P2B

viii)	RC 6	P3B

If a glass unit with a higher security level is used within the specimen used for the tests, it may not be possible to assess the use of glass units with a lower grade within those products without conducting further tests. This is because higher grades of glass can increase the rigidity of the product.

The following table 34 lists the criteria for the selection of the resistance class (offender type, offender behavior, location, risk and recommendation for use).

Table 34 Criteria for the Selection of the Resistance Class
(*Clause* 9.4.1)

Sl. No.	**Resistance class**	**Expected offender type, suspected offender behavior**	**Recommended place of use of the burglar-resistant component**		
			A Residential properties	**B Commercial properties, public properties**	**C Commercial properties, public properties (high risk)**
(1)	(2)	(3)	(4)	(5)	(6)
i)	RC 1 N / RC 1	Components of resistance class RC 1 N/RC 1 provide basic protection against attempts to break in with physical force such as kicking in, jumping, shoulder slamming, pushing up and tearing out (mainly vandalism). Components of resistance class RC 1 N/RC 1 only have a low level of protection against the use of lever tools.	If burglar resistance is required, the use of resistance class RC 1 N/RC 1 is only recommended for building components where no direct access (not ground level access) is possible.		
ii)	RC 2 N / RC 2	The occasional offender tries in addition to break open the component with simple tools such as screwdrivers, pliers and wedges. (RC 2 N is only	Average risk attack on the glazing used is to be expected.	Average risk	

		recommended for building components where no direct attack on the glazing used is to be expected.)			
iii)	RC 3	The offender tries in addition to break open the component with a second screwdriver and a crow bar.	High risk	High risk	
iv)	RC 4	The experienced burglar uses in addition tools such as a hand saw, heavy hammer, axe, chisels, and a battery-powered drill.			Low risk
v)	RC 5	The experienced burglar uses in addition electric tools such as an electric drill, jig saw, or sabre saw and an angle			Average risk
vi)	RC 6	The experienced burglar uses in addition heavy-duty electric tools, such as a heavy-duty drill, jig saw or sabre saw and angle grinder			High risk

NOTES

1 This table is only an approximate guide. Expert advice, for example, from the local police advice centres, is essential. The assessment of the risk should be done on your own responsibility, taking into account the location of the building (protected/unprotected), use and the value of the goods inside. In case of high risk, tested and certified burglar alarm systems should be used in addition.

2 When selecting burglar-resistant elements of resistance classes RC 4 to RC 6, it should be noted that when selecting such elements in escape and rescue routes, the use of tools by the fire brigade is made more difficult and shall therefore be taken into account.

3 External sockets, for example, in the hallway, in the garden or in the patio area should be de-energized to prevent their use by the burglar.

In addition, parties to agreement may mutually decide on testing arrangement based on specialist literature.

NOTE – Specialist literature may be EN 1630:2021 'Pedestrian doorsets, windows, curtain walling, grilles and shutters - Burglar resistance - Test method for the determination of resistance to manual burglary attempts'.

9.4.2 *Bullet Resistance Glazing*

The framing member along with it's hardware and glass to comply for the bullet resistance requirements as a whole. The glass to be used should comply with the testing requirements of accepted standard [6-8(17)]

The testing of framing member shall follow the same parameters of spall, no spall as well as threat levels described in accepted standard [6-8(17)] but with penetration points in the framing member. Glazing system classification will hold good only if both the framing member and glass complies. In case either glass or frame achieves a lower classification, then the whole glazing system shall be classified to the lower class that has been achieved.

9.4.3 Blast resistant security glass shall be tested as per the requirements given in Annex J.

ANNEX A
(*Clause* 5.1.1)

MINIMUM PERFORMANCE REQUIREMENT OF GLAZING FOR EXTERIORS

A-1 The panel size design of the exterior glass for the building is done in accordance with this Section considering the effect due to wind load, other imposed load, seismic design. The type of glazing to be installed is determined considering human safety in **7.1**.

In the determination of the energy and thermal performance of the glazing, the three compliance approaches prescriptive in nature, defines the minimum glazing/glazing system requirement to be met.

The prescriptive values are specified with respect to the geographic climatic zone and glazing area of the building.

A-2 BUILDING FENESTRATIONS

The fenestration shall comply with the maximum glazing area weighted on *U*-value and solar factor as given in Table 35.

The window wall ratio (WWR) is defined by the total fenestration area to the total gross area of the building envelope which is limited to 70 percent. The corresponding minimum visible light transmission is given below. For fenestration area greater than 70 percent, *see* other specialist literature.

WWR	*Minimum Visible Light Transmission* Percent
0 – 0.3	27
0.31 – 0.4	20
0.41 – 0.5	16
0.51 – 0.6	13
0.61 – 0.7	11

Table 35 *U*-Value Requirement for Glazing System
(*Clause* A-2)

Sl No.	**Climate**	**Maximum *U*-Value** W/m^2 K	**Maximum SHGC**	
			WWR ≤ 40 percent	40 percent < WWR ≤ 60 percent
(1)	(2)	(3)	(4)	(5)
i)	Composite	3.30	0.25	0.20
ii)	Hot and dry	3.30	0.25	0.20
iii)	Warm and humid	3.30	0.25	0.20
iv)	Moderate	6.90	0.40	0.30

v)	Cold	3.30	0.51	0.51

A-3 WEATHER PERFORMANCE

Air infiltration from the fix litres shall be permitted within 1.5 $m^3/h.m^2$ and from operable sash 2 $m^3/h.m$.

Water should be contained in the gutter and drained back to the exterior. Any uncontrolled water in excess of 15 ml or more on the top surface of any exposed interior shall be considered as leakage.

ANNEX B

[*Clause* 5.1.2.4.2(c)]

TEST REQUIREMENTS FOR COATED GLASS

B-1 The coated glass that is used for the exterior building of commercial and non-commercial (residential building) should meet the test requirement listed in this Annex.

B-2 MEASUREMENTS OF PERFORMANCE

The performance factors and spectral details of the coated glass shall be determined using standard accepted spectrophotometer equipment. The actual size shall be dependent on the type of equipment being used for the measurements. The transmittance of the measurement sample shall be measured with radiation of normal incidence at the following wavelengths:

a) 550 nm (representative wavelength for light and solar transmittance); and
b) 900 nm (representative wavelength for solar transmittance).

For glass claiming to have a low emissivity coating, a measurement of the reflectance shall be made at 8 µm using radiation of nearly normal incidence.

B-3 CONDENSATION RESISTANCE TEST

B-3.1 This test consists of subjecting the coated glass to a water saturated atmosphere at constant temperature. The samples have condensation continually forming on them and it is this condensation that may cause surface degradation.

B-3.2 Test apparatus should have a provision of four test pieces and the materials used for the inner walls shall be corrosion-resistant and shall not affect the test pieces.

B-3.3 Procedure

a) The water tank shall be filled with demineralized water, having conductivity lower than 30 µS and a *p*H higher than 5. The internal temperature of the cabinet shall be controlled by means of the reference thermocouple keeping a temperature of the reference glass piece of 40 ± 1.5°C.
b) The test cabinet shall be in a room with an ambient temperature of 23 ± 3°C. Care shall be taken to ensure that draughts, dust, moisture and solar radiation do not interfere with the test cabinet.
c) The reference temperature shall be reached within 2 h of commencing heating. Condensation shall be seen to form on the glass pieces. The test is continued without interruption for the required time. Both the internal reference and the external air temperature shall be regularly checked.

B-3.4 Requirements

a) No defect, greater than 3 mm length.
b) Maximum one defect between 2 mm and 3 mm length.
c) Maximum five defects between 1 mm and 2 mm length.

d) No scratches, staining of the coating or clusters of pinholes greater than 1 mm.
e) When compared with the reference test piece, in both reflection and transmission, there shall be no significant colour change. This observation shall be made within 20 s.
f) The transmittance measured at 550 nm and 900 nm shall differ by no more than ± 0.03 from the corresponding measured value on the reference test piece.

B-4 ACID RESISTANCE TEST

B-4.1 This test consists of subjecting the coated glass to a sulphur dioxide saturated atmosphere at constant temperature. The samples shall have condensation continually forming on them. It is this condensation together with the quantity of sulphur dioxide that may cause surface degradation. Test apparatus should have a provision of four test pieces and the material used for the inner walls shall be corrosion-resistant and shall not affect the test pieces.

B-4.2 Procedure

a) The test cabinet contains 2 litre of demineralized water having conductivity lower than 30 µS. When the cabinet is closed 0.2 litre of SO_2 shall be added and the heating system switched on.
b) The test consists of a repetition of 24 h cycles (*see* Fig. 19).
c) Each cycle consists of high temperature plus condensation period and an ambient temperature without condensation period.
d) The temperature shall increase to 40 ± 1.5°C in less than 1.5 h. During the next 6.5 h the test pieces shall be subjected to condensation in the SO_2 atmosphere.

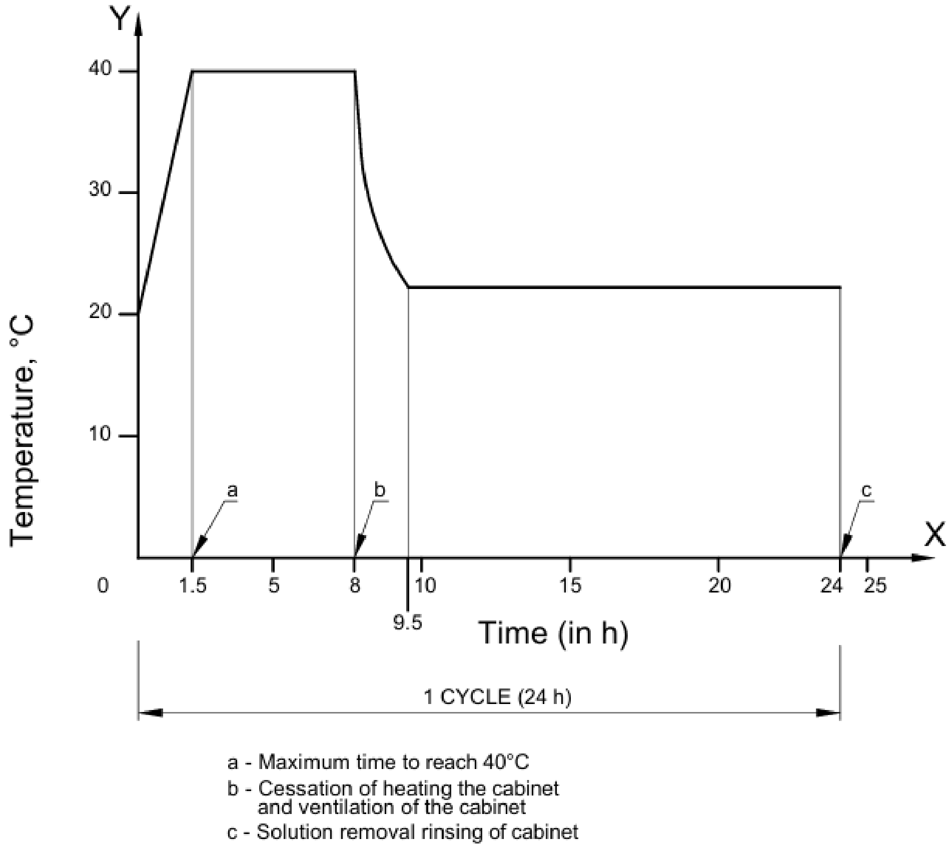


FIG. 19 24-HOUR CYCLE OF HEATING

B-4.3 Requirement

The transmittance measured at 550 nm and 900 nm shall differ by no more than ± 0.03 nm from the corresponding measured value on the reference test piece.

B-5 NEUTRAL SALT SPRAY

B-5.1 This test consists of subjecting the coated glass to neutral, water saline atmosphere at constant temperature. It is the water saline spray that may cause surface degradation.

Test apparatus should have a provision of four test pieces and the material used for the inner walls shall be corrosion-resistant and shall not affect the test pieces.

B-5.2 Procedure

a) The test cabinet shall be prepared and run for a minimum period of 24 h before the test pieces are placed within it. The neutral salt solution is made up by dissolving NaCl, in demineralized water having conductivity lower than 30 µs, to produce a concentration of 50 ± 5 g/l at 25 ± 2°C.
b) The compressed air supplied to the spray nozzle shall be passed through a filter to remove all traces of oil or solid matter and shall be at an absolute pressure of 70 kPa to 170 kPa through a saturator at 40 ± 1.5°C. The spray

nozzle shall be made of inert material, with baffles to prevent direct impact of spray on the test pieces.

B-5.3 Requirements

a) No defect, greater than 3 mm length;
b) Maximum one defect between 2 mm and 3 mm length;
c) Maximum five defects between 1 mm and 2 mm length;
d) No scratches, staining of the coating or clusters of pinholes greater than 1 mm;
e) When compared with the reference test piece, in both reflection and transmission, there shall be no significant colour change. This observation shall be made within 20 s; and
f) The transmittance measured at 550 nm and 900 nm shall differ by no more than ± 0.03 nm from the corresponding measured value on the reference test piece.

B-6 ABRASION RESISTANCE TEST

B-6.1 This test consists of subjecting the coated surface of the coated glass to rubbing with a felt pad in dry condition. It is the type of pad, the loading on it and the number of strokes that may cause surface degradation.

B-6.2 Procedure

a) The metal finger shall be approximately 15 mm to 20 mm in diameter and shall be driven so as to produce a frequency of 60 strokes/min + 6 strokes/min alternating forwards and backwards. The stroke length shall be 120 ± 5 mm. The strokes shall be parallel and ensure a constant pressure over the zone to be tested.
b) A circle shape with a diameter of 14.5 ± 0.5 mm.
c) The test sequence shall commence within 30 min of the sample being cleaned.
d) The metal finger containing the felt pad shall be lowered on to the glass surface and a load of 4 N applied perpendicular to the glass surface *via* the felt pad.

B-6.3 Requirements

a) Ensure that the abraded area is uniform.
b) The transmittance measured at 550 nm and 900 nm shall differ by no more than ± 0.03 nm from the corresponding measured value on the reference test piece.

B-7 DURATION OF TESTS

The duration of tests shall be as per the following:

Sl No.	*Test*	*Test Duration for Class*		
		A	B	S
(1)	(2)	(3)	(4)	(5)
i)	Condensation resistance	21 days	4 days	14 days
ii)	Acid resistance	5 cycles	1 cycle	5 cycle
iii)	Neutral salt spray	21 days	10 days	–
iv)	Abrasion resistance	500 stokes	50 stokes	500 stokes

NOTES

1 *Class A* – The coated surface of the glass can be positioned on the outer or the inner face of the building.

2 *Class B* –The coated glass can be used as monolithic glazing but the coated surface shall be on the inner face of the building.

3 *Class S* – The coated surface of the glass can be positioned on the outer or the inner face of the building but these types of coated glasses can only be used in specifically defined applications.

ANNEX C

(*Clause* 6.1.9)

PROCEDURE FOR CALCULATING THE APPROXIMATE DEFLECTION AT CENTRE OF GLASS PANEL

C-1 Maximum glass deflection as a function of plate geometry and load may be calculated using the following:

Deflection, $w = t \cdot \exp(r_0 + r_1 X + r_2 X^2)$

where

$X = \ln\{\ln[q(a.b)^2/Et^4]\}$

$r_0 = 0.553 - 3.83(a/b) + 1.11(a/b)^2 - 0.0969(a/b)^3$

$r_1 = -2.29 + 5.83(a/b) - 2.17(a/b)^2 + 0.206\,7(a/b)^3$

$r_2 = 1.485 - 1.908(a/b) + 0.815(a/b)^2 - 0.082\,2(a/b)^3$

where

E = Young's modulus of glass, N/mm^2;
q = net pressure on the pane, N/mm^2;
a = longer dimension, mm;
b = shorter dimension, mm; and
t = thickness of the glass pane calculated.

Example :

Lateral deflection calculation — Determine the maximum lateral deflection (w) of a vertical 1 200 mm x 1 500 mm x 6 mm rectangular glass plate subjected to a uniform lateral load of 1.80 kPa. The actual thickness of the glass is 5.60 mm as determined through direct measurement.

a = 1 500 ; b = 1 200
$r_0 = -2.689$
$r_1 = 2.011$
$r_2 = 0.213$
$q = 1.80 \times 10^{-3}$ N/mm^2
$E = 71.73 \times 10^3$ N/mm^2
$t = 5.60$
$x = 1.490$

Therefore maximum deflection at the centre of glass is:

$$w = 5.6 \times \exp(-2.689 + 2.111 \times 1.490 + 0.213 \times 1.490^2)$$

$$w = 12.2 \text{ mm}$$

ANNEX D
(*Clause* 6.1.9)

MODEL CALCULATION OF GLASS THICKNESS

D-1 MODEL CALCULATION

D-1.1 Glass panel dimension width 1 200 mm and height 1 800 mm for location Chennai for annealed glass type.

D-1.1.1 *General Checks has to be done for Safety Performance*

a) The maximum area of glass panel is restricted to 15 m^2.
b) The maximum span of window is restricted to 4 m.
c) Applicable to normal, reflective, laminated, tempered and insulating glass.
d) Applicable to rectangular panels properly fixed.

The procedure for calculating glass thickness is described below:

1) *Step 1* – Calculate aspect ratio (AR_{max}) from Table 16.

Aspect ratio (AR_{max}) = Longer side/shorter side of glass
Aspect ratio = 1 800/1 200 = 1.5

2) *Step 2* – Wind load calculation

For wind load calculation, reference shall me made to good practice [6-8(7)].

$$p_z = 0.6\, V_z^2$$
$$V_z = V_b . k_1 . k_2 . k_3 . k_4$$

where

V_b = basic wind speed based on location {*see* Fig. 1 of good practice [6-8(7)]}.
k_1 = probability factor (risk co-efficient) {*see* **6.3.1** of good practice [6-8(7)]}.
k_2 = terrain roughness and height factor {*see* **6.3.2** of good practice [6-8(7)]}.
k_3 = topography factor {see **6.3.3** of good practice [6-8(7)]}.
K_4 = importance factor for the cyclonic region {*see* **6.3.4** of good practice [6-8(7)]}.
V_z = design wind speed at height z, in m/s
p_z = wind pressure at height z, in N/m^2

The design wind pressure (p_d) can be obtained as

$$p_d = K_d . K_a . K_c . p_z$$

where

K_d = wind directionality factor {*see* **7.2.1** of good practice [6-8(7)]}.
K_a = area averaging factor {*see* **7.2.2** of good practice [6-8(7)]}.

K_c = Combination factor {see **7.3.3.13** of good practice [6-8(7)]}.

The value of p_d, however shall not be taken less than 0.70 p_z.

Design wind speed for Chennai location (Basic wind speed = 50 m/s taken from good practice [6-8(7)] = 1 750 N/m^2

3) *Step 3* – Strength factor

Based on the types of glass (Laminated/Tempered/Insulating Glass) pressure factor is calculated. To determine the thickness of laminated/ tempered/insulating glass, the design wind pressure P_{net} is modified as below:

$$P_{net} = p_d/P_f$$

where

P_f = pressure factor dependent on the type of glass.

The values of the pressure factor P_f can be taken from Table 2.

For annealed units, P_f = 1.0, therefore,

$$P_{net} = 1\ 750/1.0 = 1\ 750 \text{ N/m}^2$$

At this stage the glass thickness value shall be calculated from the table and then the deflection and stress check be done as described below:

4) *Deflection Check*

The deflection of the glass can be calculated using the formula in Annex C. Actual deflection for the pane shall be obtained as below:

Deflection, $w = t.\ \exp(r_0+r_1X+r_2X^{\ 2})$

$$X = \ln\{\ln[q(a*b)^{\ 2}/Et^4]\}$$

$$r_0 = 0.553 - 3.83(a/b) + 1.11(a/b)^{\ 2} - 0.0969(a/b)^3$$

$$r_1 = -2.29 + 5.83(a/b) - 2.17(a/b)^2 + 0.206\ 7(a/b)^3$$

$$r_2 = 1.485 - 1.908(a/b) + 0.815(a/b)^2 - 0.082\ 2(a/b)^3$$

where

E = Young's modulus (71.7 x 10^3 N/mm^2),
Q = net pressure on the pane (N/mm^2),
A = longer dimension (mm),
B = shorter dimension (mm), and

T = thickness of the glass pane calculated.

The actual deflection is, 4 mm < 11 mm maximum allowable.

Result: 1 800/175 = 10.3 mm, which is the maximum allowable deflection.

Hence the glass thickness calculated is safe against deflection.

Glass thickness calculation:

$P_{net}.A = 200.0\ T^{k}$ (let $T \leq 6$ mm)
$P_{net} = 1750$
$A = 2.16\ m^2$
$K = 1.765$
$T = 5.28$ mm, therefore choose the thickness of glass as 6 mm.

~~ANNEX E~~

~~(*Table* 31)~~

~~SHOT BAG IMPACT TEST~~

~~E-1 OBJECTIVE~~

~~The shot bag impact test addresses the capability of glass rails, guards, and balustrades in one, two, three and four sided support systems to continue in their function as a barrier by remaining in the designed framing system after impact or glass breakage.~~

~~E-1.1 Glazing Retention~~

~~The property of maintaining the glass or glazing material, post breakage, in a system, such that the glass is held in the framing system with no opening sufficient to pass a 75 mm solid steel sphere through the system using a horizontally applied force of 18 N.~~

~~E-2 APPARATUS~~

~~E-2.1 Instrumentation~~

~~Load and time-measuring devices with an accuracy of 62 percent or the full scale shall be incorporated in the test setups. The scale ranges used shall assure that the performance levels are within an accuracy of 65 percent.~~

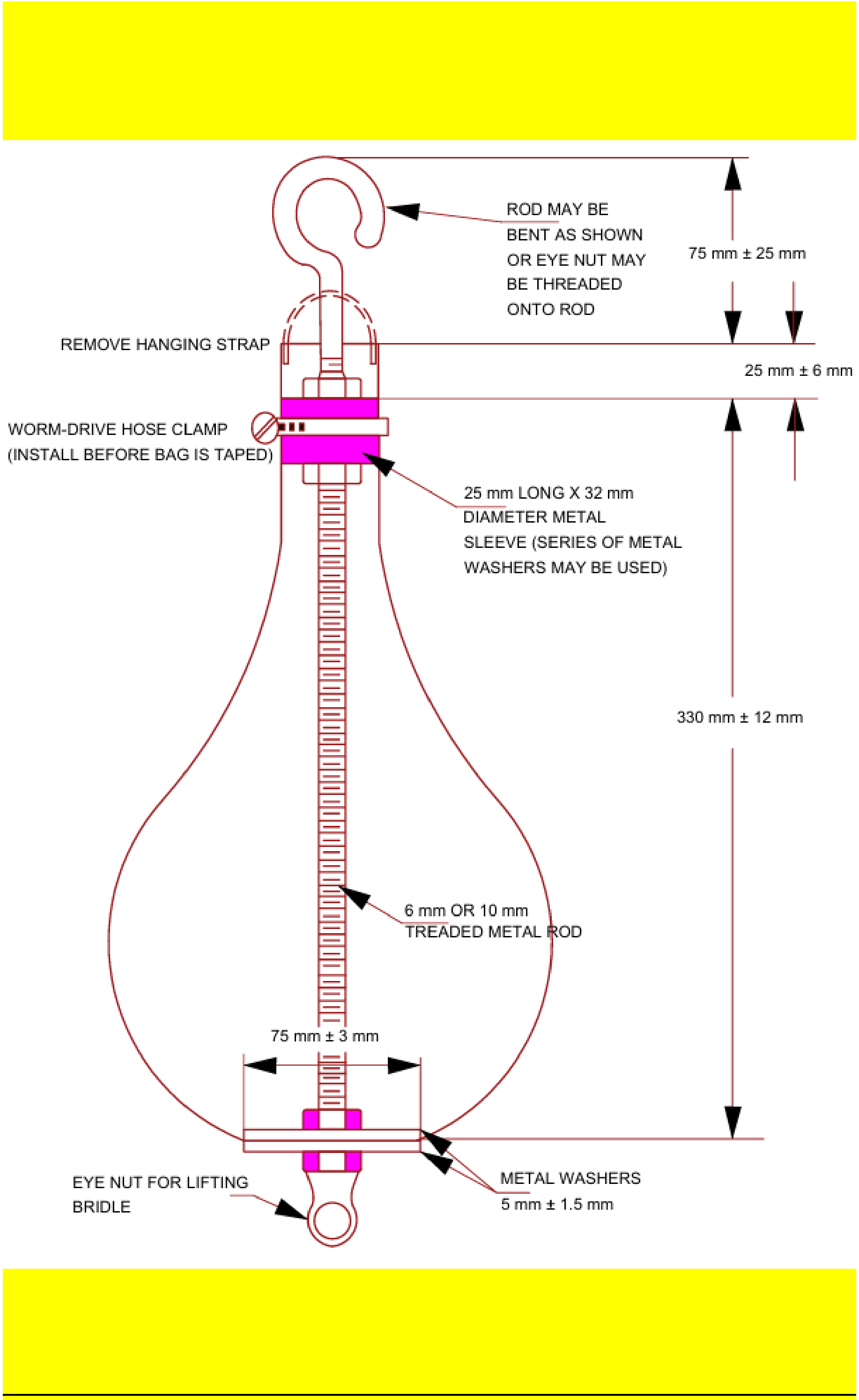
~~E-2.2 Load Attachments~~

~~Brackets, fasteners, or other devices used in performing these tests shall be designed and attached so as to minimize their influence on the test results.~~

~~E-2.3 Shot Bag, Traction and Release System~~

~~The test apparatus shall be capable of supporting a 45.4 kg shot bag and allowing unimpeded swinging of the shot bag from a drop height of 1 220 mm. The impactor system consists of the impactor, traction, release, and suspension devices. The impactor shall consist of the leather bag described in Fig. 22, a commercial punching bag with its bladder left in place, or any other leather bag of nominally identical shape and size. The bag shall be filled with lead shot of $24^{+0.1}_{0}$ mm diameter and taped. After filling with lead shot, the top shall be either pulled over the metal sleeve and tied with a cord; or twisted around the threaded eyebolt shaft and tied below the metal sleeve, or both. To reduce bag damage during testing, the exterior of the leather bag surface shall be completely covered with glass filament reinforced pressure sensitive polyester adhesive tape, 12 to 15 mm in width and 0.15 mm thick. Tape the entire bag, using three rolls or 165 m total length, and taping in a diagonal overlapping manner. Tape the neck of the bag separately, with additional glass filament reinforced tape of the same kind. The total mass of the impactor assembly shall be $45.4^{+0.1}_{0}$ kg, excluding traction system attachments. A traction system shall be used which enables the~~

~~impactor to be brought into its launch position. The launch position depends on the drop height selected. The traction cable shall be connected to the impactor traction system by a release mechanism, with provisions for rotating the impactor.~~



~~FIG. 22 SHOT BAG IMPACTOR~~

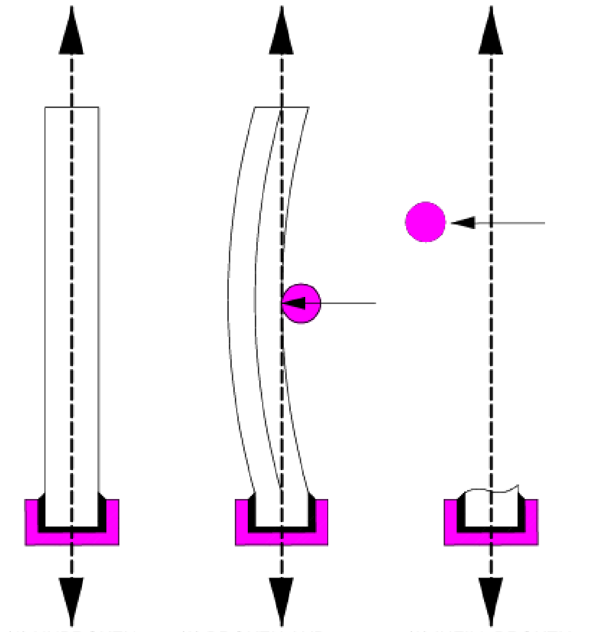
~~E-3 SHOT BAG IMPACT TEST~~

E-3.1 Procedure

Any protective masking or decorative components shall be removed from the glazing material. To position the impactor at the selected drop height, a traction force shall be applied to raise the impactor such that the axis of the impactor shall be aligned with the suspension cable, with the cable remaining taut. To ensure this, the top and bottom ends of the impactor shall be connected to the release device by a suitable link. To reduce bag deformation during testing, the bag shall be rotated about the axis of its suspension device before each specimen or sample set, by no less than 30˚, and by no more than 90˚. To reduce bag damage during testing, a thin homogeneous or non-woven plastic film no more than 0.13 mm thick or a loosely draped woven cloth towel weighing no more than 0.005 kPa shall be permitted to be suspended vertically from its top edge directly in front of the surface of the specimen at a distance no more than 10 mm. When at rest the maximum diameter of the impactor shall be located no more than 12 mm from the surface of the specimen and no more than 50 mm from the centre of the specimen. The impactor shall be suspended from an overhead mm from the surface of the specimens and no more than 50 mm from the centre of the specimen. Raise the impactor to the required height (460 or 1 220 mm) and stabilize it. The suspension device shall be taut and the axes of the impactor and cable shall be aligned. The impactor, stabilized in the launch position in a vertical plane normal to the test specimen, shall be released and falls without initial velocity or axial rotation. One impact with a force of 1.8 kN shall occur on each glazing configuration of the test specimen. Each test specimen shall be inspected after each impact and report condition of specimen.

E-3.2 Reporting of Results

Impact performance shall be classified as: (a) unbroken, (b) broken and retained, or (c) infill broken and not retained (*see* Fig. 23). Retention of the product in the frame is based on the definition of glazing retention given in **E-1.1**.



~~FIG. 18 GLAZING RETENTION~~

ANNEX E
(*Table* 32)

PERFORMANCE TESTS FOR GLAZING SYSTEM

E-1 The following enlists the performance tests for glazing systems. The general test requirements shall be as per **7.1** of accepted standard [6-8(18)]. The test specimen size and direction facing the pressurised chamber shall be mutually agreed to between the parties concerned or specified without ambiguities in the tender documents.

F-2 AIR INFILTRATION/EXFILTRATION TEST

Permissible air leakages shall be 1.5 $m^3/h.m^2$ for fix area and 2 $m^3/h.m$ for crack length of operable panel. The crack length is the maximum height of the shutter per interlock or per meeting stile in a slider or per overlap joint in a double leaf door or vent, in addition to the jambs. Along the width, crack length is the maximum width of the shutter at top and bottom. All operable panels shall be opened and closed 5 times prior to commencement of test.

For facade, strip glazing, skylights and insert vents in facades, the pressure differential shall be ±150 Pa for up to buildings of height 70 m and shall be ±300 Pa for buildings of height beyond 70 m.

For strorefront, operable windows, sliding windows, sliding doors and doors, the pressure differential shall be +150 Pa.

NOTE — Preload of 50 percent of design load for 10 s to be applied before commencement of the test.

F-3 STATIC AND DYNAMIC WATER PENETRATION TEST

If water is observed in the operable vent drainage path and the same is drained through slots after the spray is stopped it shall be considered as pass. Any water on the top surface of any exposed interior shall be considered as leakage. For sliders, only water overflowing to the interior is considered as failure. In case of leakage the remedy needs to be carried out and the retest shall be conducted. The rate of water spray shall be 3.4 $litre/min.m^2$ for a period of 15 min. The spray shall be located at a distance of 400 mm from the glass and 700 mm centre-to-centre horizontally and vertically. The pressure differential up to 35 m height shall be 300 Pa, beyond 35 m up to 70 m shall be 450 Pa and beyond 70 m shall be 600 Pa.

NOTES

1 Cyclic water penetration is optional and the parameters are to be agreed mutually between the relevant stakeholders. However, cyclic water penetration is not applicable to sliding doors and windows.

2 Between each test, water should be drained and if required 450 Pa pressure applied for a period of 2 min to flush out the water from the system. There should also be a minimum of 10 min at zero pressure between tests.

F-4 STRUCTURAL LOAD TEST (100 PERCENT DESIGN WIND LOAD)

~~The deflection criteria of glass and framing members shall be as specified in **6.3.6.2**. No damage or harmful permanent deformation of any parts except sealing materials shall be found at the maximum testing pressure. Residual displacement of structural member shall not exceed span /1 000. The slippage at supports and fixing shall not exceed 1 mm.~~

E-2 SEISMIC RACKING TEST

Criteria shall be the movement of the sub-structure in the horizontal (+/-) directions. Optional testing for vertical movements (+/-) shall be based on sub-structure movement to accommodate live load, long term creep, column shortening and thermal elongation or contraction. No glass breakage or fall out is allowed. ~~Any damage shall be easily reparable without any part replacements required.~~ No wall component fallout is allowed. The system shall comply with the requirements of air permeability and static water penetration tests as per the designed performance criteria. Post proof load testing, air permeability testing and static water penetration testing shall not be required unless specified otherwise.

E-3 BUILDING MAINTENANCE UNIT (BMU) PULL OUT TEST (WHEN APPLICABLE)

A tensile load of minimum 1.5 kN shall be applied on the BMU restraint in the following directions:

a) Outward and held for a period of 1 min.
b) Horizontally to the right and held for a period of 1 min.
c) Horizontally to the left and held for a period of 1 min.
d) Vertically upward and held for a period of 1 min.
e) Vertically downward and held for a period of 1 min.

After each step the BMU restrain should not fail or have permanent deformation.

NOTE — If the load on the BMU restraints required by the BMU supplier is higher, the higher load shall apply.

~~F-7 OPERATING FORCES TEST (OPTIONAL)~~

~~Maximum force required to initiate opening of a sliding door is 180 N and the maximum force to maintain the motion of a sliding door or window is 115 N. For a projected top hung or parallel open vent the maximum force to maintain motion is 135 N.~~

~~F-8 STRUCTURAL PROOF LOAD TEST (150 PERCENT DESIGN WIND LOAD AND SEISMIC FORCE, IF APPLICABLE)~~

~~Under proof load test there shall be no collapse which means any one or any combination of the following:~~

~~a) Dislodgement of any glass.~~
~~b) Dislodgement of any frame, panel or any component thereof.~~

c) ~~Failure of any fixing that connect the façade to the building structure, such that the test sample is unstable.~~
d) ~~Failure of any stop, locking device, fastener or support which may allow an opening light to come through.~~

~~The permanent deformation in framing members in excess of span/1 000 is not permissible and considered as failure.~~

~~NOTE — For on-site testing, the parameters shall be tested for two/third of the laboratory values.~~

ANNEX F
(Foreword)

INSTALLATION OF MIRRORS

F-1 This annex provides general guidelines, which is to be followed during the installation of mirror. Mirrors (Piece of glass silvered on one side, with a protective paint coating) are used in shops, gymnasiums, etc, where it is predominantly used as wall cladding. The mirror panels in such application use large panel size and it is recommended to follow the installation procedure in accordance with this Section.

F-1.1 The mirror should always be mounted on a perfectly flat, clean and dry surface free from acids and aggressive substances such as acid, solvent and cement mortar.

F-1.2 The mirror shall be mounted on wall or plywood and care is taken that the mirror is never stuck over unstable support (painted paper, paint or old plaster). It is recommended that the mirror installation is not done directly on the mirror supports. In order to have good ventilation, the following spacing behind the mirror is recommended depending on the height of the mirror panel:

a) A space of 5 mm for a mirror less than 1 m height.
b) A space of 10 mm for a mirror greater than 1 m height.

Figure 20 gives typical details of the installation of mirrors. During the installation of mirror panels at several levels that is, one above the other, it is recommended to provide a space of 10 mm at the top and at the bottom for circulation of air. The side of the mirror is designed with a minimum 1 or 2 mm of interleaving space. When mirror is fixed in a profile (frame), care is to be taken to maintain perfectly dry and clean frame. It is recommended that mirror is supported on hard non-metallic/plastic wedges of at least 3 mm, to raise the mirror and thus avoid contact with the condensed water which could accumulate in the profile. If the mirror is screwed on, the screws of a suitable dimension is designed, with the interleaving and washers (*see* Fig. 21) made of plastic to avoid any direct glass-metal contact. To minimize the risk of breakage, cracks and splinters during screw-mounting the mirror, it is recommended to use synthetic protective collars.

F-1.3 The adhesive used to mount mirrors, care should be taken to ensure that the adhesive is compatible with the protective coatings on the mirror. It is recommended to use only neutral binding agents such as alkoxy silicone, oxime silicone, etc. Avoid use of acid silicones, such as acetoxy silicones which contain acetic acid or water/rubber/polyurethane-based glues.

F-1.4 In the high humidity areas (for example bathrooms), it is recommended to seal the edges with neutral silicone to protect the backing paint from damage due to moisture and enhanced protection from moisture. It is recommended to use double sided adhesive tapes to fix the mirror on the mounting surface (*see* Fig. 22). The adhesive tapes used for installation shall be certified to be compatible with the mirror and the adhesive or the adhesive tapes shall always be fixed vertically.

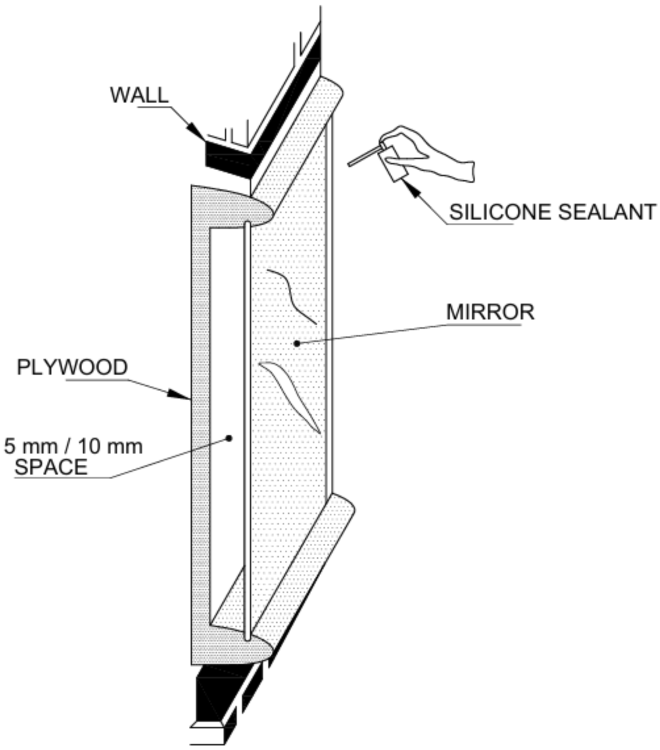


FIG. 20 INSTALLATION OF MIRRORS

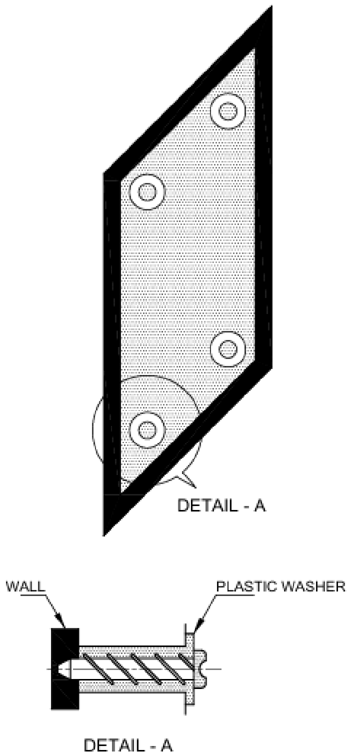


FIG. 21 DETAILS OF USE OF SCREWS AND INTERLEAVING WASHERS FOR INSTALLING MIRRORS

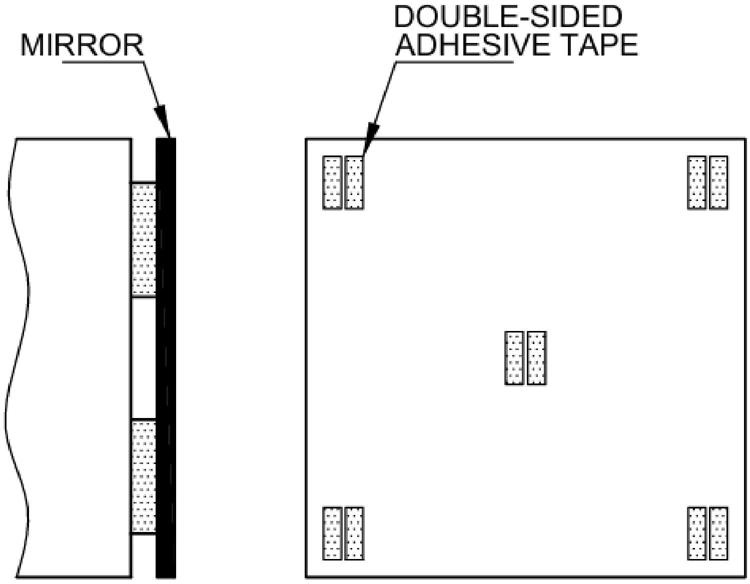


FIG. 22 DETAILS OF USE OF DOUBLE SIDED ADHESIVE TAPES FOR INSTALLING MIRRORS

ANNEX G
(Foreword)

GLASS RAILINGS

G-1 GENERAL

Glass railings are generally sought in institutional, commercial, residential buildings and special structures like stadiums, foot over bridges etc. ~~applications (such as in malls) and in certain domestic villas, etc.~~ Glass of appropriate thickness when used as a railing can provide transparency and when engineered properly can provide structural performance too. In public places such as stadiums, foot over bridges, shopping malls etc., use of frameless glass railing shall be avoided and framed systems with vertical balustrades and glass infill panel may be used with proper design as per the design provisions.

The basic requirement of a parapet which a glass railing (if so used) intends to substitute shall be met with. This includes protecting people from falling and in some cases to control movement. Careful consideration including in design shall be made/determined where glass railing are used.

NOTE – Notwithstanding the above, the potential benefits including safety (through psychological aspects) of regular railings shall be borne in mind.

G-2 PRELIMINARY CONSIDERATIONS

In the assessment of the need for a railing and the type of railing to be provided, the designer should give consideration to the likely hazards, the building use and the risks to building users. Where, in a building, more than one use of the building is anticipated, either the railing design should be chosen to suit the worst case, or more than one type of railing should be provided, as appropriate, to the location. Generally when there is a change in adjacent levels (600 mm in dwellings, 380 mm in other buildings) a railing is needed to restrict movement of people.

The railing adopted should be designed so as to minimize the risk of persons falling, rolling, sliding or slipping through gaps in the railing. In dwellings and other buildings which can be accessed by children, gaps in railing or infill should not be large enough to permit a sphere of 100 mm diameter to pass through, making due allowance for deflection under load.

The designer should ensure all the elements of the railing system satisfy the criteria given in available relevant standards.

For general safety, the finished barrier should have no sharp edges or projections that could cause injury to persons or clothing. Infill panels and balusters are intended to provide support and protection to users, and should be designed to restrain people without causing additional injury from sharp edges, thin sections, open-ended tubes, projecting details, etc.

The design shall be based on the horizontal UDL (uniformly distributed load) should be applied at a notional height of 1.1 m above finished floor level, even though the minimum permissible height of the railing may be less (The notional design height of 1.1 m is chosen as being representative of the height of the centre of gravity of a human being above the datum level).

G-3 GLASS RAILING TYPES

There are four common types of railing that used to fix glass.

a) *Full height railing* - Where glass forms part or whole of a wall element, the railing should be carefully designed as per the relevant existing standards and as per this Section, if any part of the glass comes below the minimum railing height (see Table 36).

b) *Railings with a glass infill panel* - In this type of railing, the main frame of the railing (that is, top rail and baluster) should be designed to withstand the loads applied to the top rail and the glass should be used to form infill panels. It should be noted that the glass provides no support to the main frame. The designer shall ensure that, irrespective of the fixing type, in the event of glass breakage, the broken glass remains securely attached to its framing or supporting structure, thereby preventing safety hazards. This can be further sub-categorized into 4 types:

   1) *Glass supported on vertical edges only* — This may involve the vertical edges of the glass being supported in a rebate into the side of each vertical post. The top and bottom edges of the glass are exposed. The glass may also be supported by patch fittings fixed to the posts. In all cases a handrail is required.

   2) *Glass supported on horizontal edges only* — This may involve a handrail at the top, and a channel or a rail at the base of the glass. In this case the handrail should be designed to carry the railing load with the glass designed to carry the infill load.

   3) Glass supported on all four edges.

   4) *Glass fixed by patch/bolted fittings* — This system requires the use of two rows of bolts (commonly) to provide a stiff fixing which minimizes panel deflection. There are a variety of bolt fixing types available in the market so design and performance information should be sought for each type. The purpose of these fixings is to transfer the force applied to the railing into the support structure. These fixings occupy a small surface area on the glass which can produce high stresses in the glass, so careful analysis is required to determine suitable glass thickness, fixing spacing and size. Glass fixings shall be designed to avoid high local stresses and minimize the risk of failure. Minimum fixing sizes shall be used, and for large panels exceeding 2 meters in dimension or under high wind pressure exceeding 2.5 kPa, fixings shall accommodate rotations by using articulated fixings.

c) *Free standing glass protective railing* — In this type of railing, the glass should be designed to withstand the design loads. Each glass plate should be rigidly clamped to the structure along its bottom edge, the handrail attached to the top edge of the glass and there should be no balusters. In the event that a free standing railing is supplied without a handrail, each panel should be able to withstand the entire appropriate design load. This applies to vertical glazing and glass within 15˚ of vertical. Adequate provision for drainage of water should be made in the base structure to avoid any water ponding which may cause delamination issue. Laminated safety glass shall be used for this application. Clamping and brackets shall be designed with adequate anchorage, and the main supporting building elements (beam/slab) shall be verified to meet the required minimum thickness. The bottom glass clamping embedment shall be a minimum of 100 mm, regardless of railing size. The bottom clamping member shall provide continuous support along the glass bottom edge. In the event of glass breakage, the glass panel shall remain securely in place without risk of detachment or falling.

d) *Bracket Systems* — These systems are an extension of the bolt fixed system where the bolts are part of a bracket and the bracket is fixed to the floor or the face of a concrete slab, steel or timber structure. The use of these systems shall be investigated carefully as they can develop very high stresses in the glass where the brackets are located. The design shall balance glass thickness and bracket location to produce an adequate system. Some systems may be designed to produce test data, to justify their use. This data shall be studied carefully as there have been some cases where such data has been shown to be inadequate. Proper interpretation of these test data shall also become necessary.

Table 36 Minimum Barrier Heights
[*Clause* G-3 (a)]

Sl No. (1)	Use (2)	Position (3)	Heights mm (4)
i)	Single-Family dwelling	a) Barriers in front of a window up to 10 floors	800
		b) Barriers in front of a window from 11th floor to 20th floor	1 100
		c) Barriers in front of a window above 21st floor	1 200
		d) Stairs, landings, ramps, edges of internal floors	900
		e) External balconies including *balconet*, edges of roofs:	
		1) up to 20th floor	1 100
		2) 21st floor and above	1 200
ii)	All other uses	a) Barrier in front of a window	800
		b) Stairs	900
		c) Balconies and stands, etc, having fixed seating within 530 mm of the barrier	800

d)	Balconies and stands, etc, having fixed seating within 530 mm of the barrier, provided the sum of the barrier width and the barrier height is greater than 975 mm	750
e)	Other positions including balconets	1 100

NOTE - Height shall be measured from the top edge of the railing to the highest point of the floor where occupants can stand. This measurement shall be from the top of any ledges, up-stands, or toe walls, if present at the base.

G-4 DESIGN CONSIDERATIONS

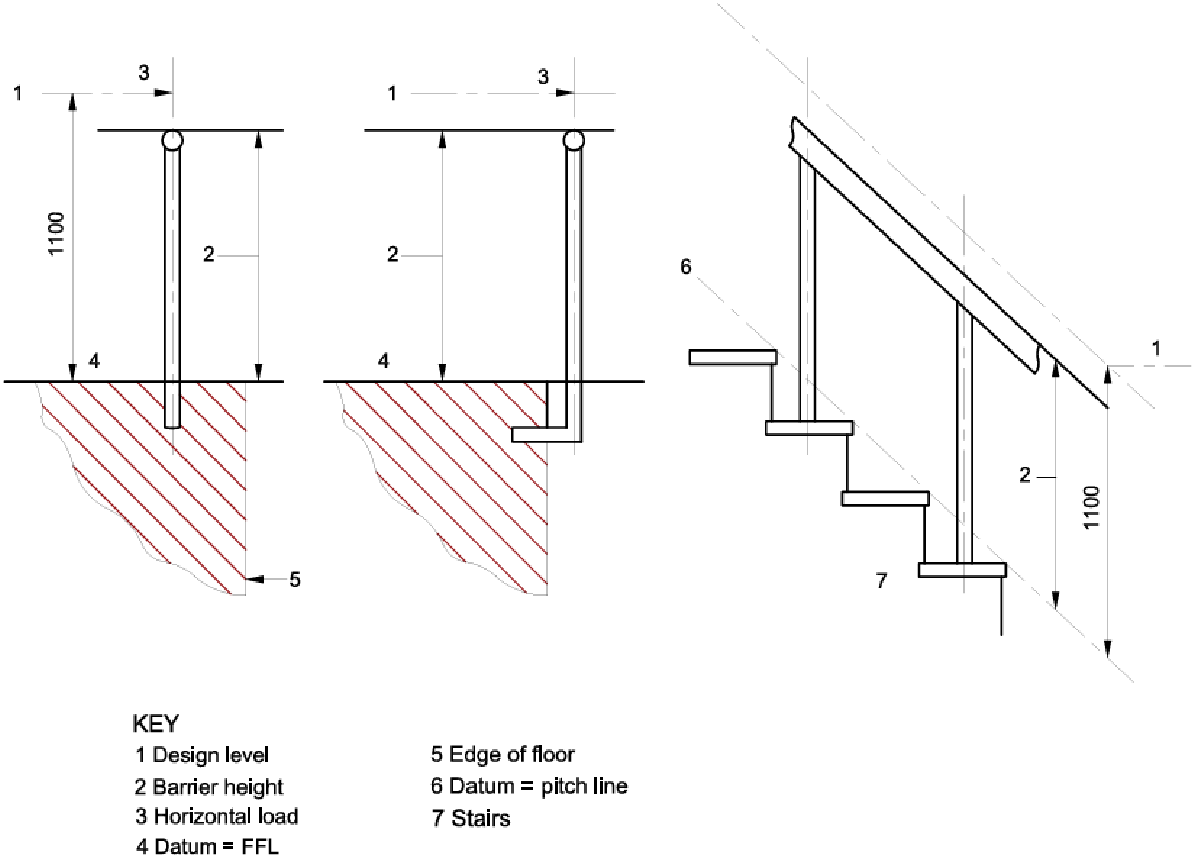
The designer shall first determine the purpose of the railing. Once this is done, the appropriate load requirement can be derived. Typical values (minimum requirements) of railing loads to be chosen are given in Table 37. (If so desired by the designer, higher values than that in the Table 37 may also be chosen.)

G-4.1 General

Railings should be designed to resist the most unfavourable likely imposed loads and wind loads separately without unacceptable deflections or distortions. Heights of railings shall be same as that for parapet walls as per other Parts of the Code. The railing height above datum is defined in Fig. 23. The minimum heights for each railing location shall be as given in Table 36.

The height of glass railings installed on top of low parapet walls should be measured from the top of the parapet and not at walk level.

For railings, either permissible stress or limit state design procedure should be used, according to the recommended procedures. When using limit state design, the partial safety factors for loads and materials should be those recommended by the appropriate standard for relevant materials. The deflection of the railing shall be determined as per serviceability limit state.



NOTE – In design, the horizontal uniformly distributed line load acts at a height of 1.1 m above datum level, irrespective of the actual height of the element.

FIG. 23 DATUM, BARRIER HEIGHT AND DESIGN HEIGHT

G-4.2 Loadings

Minimum horizontal imposed loads appropriate to the design of parapets, railings, balustrades and other elements of structure intended to retain, stop or guide people, should be determined in accordance with Table 37, which recommends a uniformly distributed line load for the railing and a uniformly distributed and point load applied to the infill.

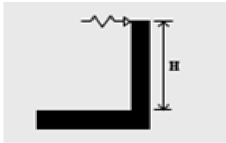
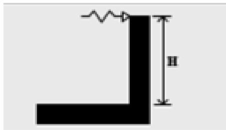
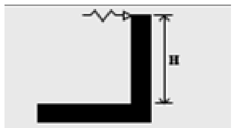
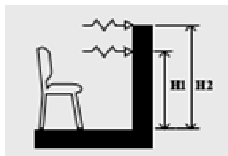
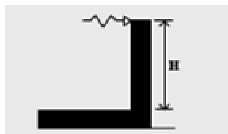
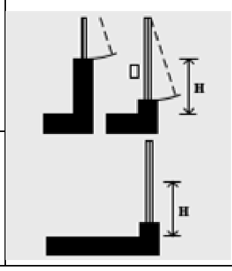
NOTE — These are not additive and should be considered as three separate load cases, all loads being determined according to the type of occupancy which reflects the possible in-service conditions.

Horizontal uniformly distributed line load should be applied at design height as presented in Table 37 or at design level (1 100 mm) for railings higher than the design height.

Uniformly distributed load should be applied to the area below the design height.

Point load should be applied at the most onerous point anywhere on the railing structure.

NOTE — For clarity, the design level (the level at which the horizontal uniformly distributed line load ought to be considered to act) is shown in Fig. 24.

Building	**Element**	**Strength**	**Height (H)**	
Single family dwelling	Stairs landings, ramps edges of internal floors	0.36 kN/m	900 mm for all elements	
	External balconies and edges of roofs	0.74 kN/m	1 100 mm	
Factories and warehouses (light traffic)	Stairs, ramps	0.36 kN/m	900 mm	
	Landing and edges of floor	0.36 kN/m	1 100 mm	
Residential institutional, educational, office and public building	All location	0.74 kN/m	900 mm for flights otherwise 1 100 mm	
Assembly	Within 530 mm in front of fixed seating	1.5 kN/m	800 mm (H1)	
	All other locations	3.0 kN/m	900mm for flights elsewhere 1 100 mm (H2)	
Retail	All locations	1.5 kN/m	900 mm for flights otherwise 1 100 mm	
All buildings	At opening windows		800 mm	
	At glazing to changes of level	To provide containment	Below 800 mm	

NOTE – *H* is the height at which the applied load (horizontal design load) is located and it need not be the height of the barrier itself.

FIG. 24 HEIGHT LIMIT FOR THE UNIFORM LOADING FOR VARIOUS CATEGORY OF BUILDINGS

Table 37 Minimum Horizontal Imposed Loads for Parapets, Barriers and Balustrades
[*Clauses* G-4.2 and G-4.4]

Sl No.	**Type of Occupancy for Part of the Building or Structure**	**Examples of Specific Use**	**Horizontal Uniformly Distributed Line load** kN/m	**Uniformly Distributed Load Applied to the Infill** kN/m^2	**A Point Load Applied to Part of the Infill** kN
(1)	(2)	(3)	(4)	(5)	(6)
i)	Domestic and residential activities	a) All areas within or serving exclusively one single family dwelling including stairs, landings, etc, but excluding external balconies and edges of roofs	0.36	0.5	0.25
		b) Other residential, that is, houses of multiple occupancy and balconies, including Juliette balconies and edges of roofs in single family dwellings	0.74	1.0	0.5
ii)	Offices and work areas not included elsewhere, including storage areas	a) Light access stairs and gangways not more than 600 mm wide	0.22	—	—
		b) Light pedestrian traffic routes in industrial and storage buildings except designated escape routes	0.36	0.5	0.25
		c) Area not susceptible to overcrowding in office and institutional buildings, also industrial and storage buildings except as given above	0.74	1.0	0.5

Sl No.	**Type of Occupancy for Part of the Building or Structure**	**Examples of Specific Use**	**Horizontal Uniformly Distributed Line load** kN/m	**Uniformly Distributed Load Applied to the Infill** kN/m^2	**A Point Load Applied to Part of the Infill** kN
(1)	(2)	(3)	(4)	(5)	(6)
iii)	Areas where people might congregate	Areas having fixed seating within 530 mm of the barrier, balustrade or parapet	1.5	1.5	1.5
iv)	Area with tables or fixed seatings	Restaurants and bars	1.5	1.5	1.5
v)	Areas without obstacles for moving people and not susceptible to overcrowding	a) Stairs, landings, corridors, ramps	0.74	1.0	0.5
		b) External balconies including Juliette balconies and edges of roofs. Footways and pavements within building curtilage adjacent to basement/sunken areas	0.74	1.0	0.5
vi)	Areas susceptible to overcrowding	a) Footways or pavements less than 3 m wide adjacent to sunken areas	1.5	1.5	1.5
		b) Theatres, cinemas, discotheques, bars, auditoria, shopping malls, assembly areas, studio. Footways or pavements greater than 3 m wide adjacent to sunken areas.	3.0	1.5	1.5
vii)	Retail areas	All retail areas including public areas of banks/building societies or betting shops	1.5	1.5	1.5
viii)	Vehicular	Pedestrian areas in car parks, including stairs, landings, ramps, edges or internal floors, footways, edges of roofs	1.5	1.5	1.5

In general, the following load combinations as described in **G-4.2.1** to **G-4.2.3** should be applied.

G-4.2.1 *Free Standing Glass Protective Railing (Without any Balusters)*

It requires five design loadings to be taken into account:

a) Line load (horizontal UDL), in kN/m
b) UDL (Infill UDL), in kN/m^2.
c) Concentrated load, in kN.
d) Impact force.
e) Shot bag test load ~~(*see* Annex E).~~

G-4.2.2 *Railing with Glass Infill Panel*

It requires three design loadings to be taken into account:

a) UDL (Infill UDL), in kN/m^2.
b) Concentrated load, in kN.
c) Impact force, in kN.

G-4.2.3 *Full Height railing*

It requires three design loadings to be taken into account:

a) Line load (Horizontal UDL), in kN/m
b) UDL (Infill UDL), in kN/m^2
c) Concentrated load, in kN

G-4.3 Wind Loads

External railings should be designed to resist the wind loads given in good practice [8-5(7)].

G-4.4 Deflection

Railings for the protection of people should be of adequate strength and stiffness to sustain the applied loads given in Table 35. In addition, a railing that is structurally safe should not possess flexibility to such an extent so as to create a false alarm to building users when subject to normal service conditions. Therefore, for serviceability considerations, the limiting condition for deflection appropriate for a railing for the protection of people is that the total horizontal displacement of the railing at any point from its original unloaded position and should not exceed the deflection limits determined from the relevant structural design code (where applicable) for the material used, or 25 mm, whichever is the smaller. Where the infill of a railing is subjected to the imposed loads given in Table 37, or if appropriate, other calculated design loads, the displacement of any point of the railing should not exceed H/65 or 25 mm, whichever is lower. These deflection limits shall apply to the deflection of the cantilevered top edge of the railing, measured perpendicular to the glass plane or the direction of the wind load.

G-4.5 Fixings, Attachments and Anchorage

The strength of fixings, attachments and anchorage securing the railing to a substrate should be adequate to sustain a loading greater than that to which the railing will be subjected. All joints should be designed to provide the full strength of the members being joined. To that end, where any uncertainty exists with regard to the strength of any component in the fixing, the design loading factors should be increased by 50 percent.

While designing fixings, particular care should be taken to account for the material into which the fixing is placed, the spacing between fixings, the edge distance, and where the substrate is concrete, the position of reinforcement. Building elements (beam/slab/up-stand) shall have adequate thickness and shall be composed of structural reinforced cement concrete (RCC) or steel. The designer shall exercise caution when the thickness of the concrete element is less than 100 mm, as adequate embedment may not be achievable. The designer shall ensure that the concrete element is cast with high quality and shall refrain from fixing to any loose concrete. Design of anchors shall conform to the requirements of accepted standard [6-8(27)].~~based on the pull-out capacity of a single fixing should be avoided.~~

NOTES

1 The recommendation of an additional load factor of 1.5 is intended to ensure that under an extreme load condition, railings give an indication of failure by deflection distortion and not by total collapse, as may be brought about by a failure of the fixing, attachment or anchorage system. Where the design strength of a proposed system of fixing to an existing substrate cannot be determined with reasonable accuracy by theoretical consideration, load testing should be used to validate the design.

2 A factor greater than 1.5 on railing load design might also be chosen based on the importance desired by the designer/parties concerned.

G-4.6 Testing

The standard tests, performance criteria of glass in permanent glass railing systems, guards and balustrades shall be mutually decided between the parties concerned.

G-5 GLASS

The use of glass in railings, the type and thickness of glass required for various support conditions shall be as given below. If designed properly, glass can form a structural component of the railing, or the railing may be designed to have a structural component made from another material such as steel or aluminium, with glass acting as an infill panel only. This places a lesser load on the glass as the major load is taken by the structural component.

NOTE — There are certain situations, particularly under some lighting conditions, where the presence of transparent glass is not readily evident and suitable manifestation should be provided.

G-5.1 Types of Glass

For the purpose of this annex, safety glass used in railing shall be laminated glass only. any of the following:

a) Laminated glass,
b) Heat strengthened laminated glass, and
c) Toughened laminated glass.

The designer shall ensure that in the case of accidental or deliberate damage, there is no glass fallout to rule out any kind of danger to public. In these situations, it is recommended to use a toughened laminated glass or fully framed laminated glass. Exposed edges of laminated glass are not recommended unless it is with a non-hygroscopic layer.

It is recommended that all monolithic toughened glass used in frameless or bolted structural railings be specified as heat soak treated.

The type of glass should be chosen to suit the design of the railing. For the use of laminated glass, where the glass is not fully framed, the manufacturer should be consulted. Toughened glass and laminated toughened glass should be used for all railings where the glass is fully or partially framed or is free standing. The selection of glass should include consideration of the post breakage behaviour.

NOTES

1 Laminated safety glass can be used for all railings, where the glass is used, fully framed.
2 Monolithic toughened glass might fall from its retention system if broken in free-standing and infill railings. In such cases, additional protection shall be required if this type of glass is used above areas of fixed seating.

G-5.2 Working of Glass

The size, position and shape of holes and notches in toughened glass, and the production of shapes other than rectangles, should be decided in consultation with the manufacturer, as shaping, drilling, cutting, etc should be undertaken prior to toughening.

G-5.3 Fixing of Glass

Contact between glass and any other hard material (including other glass parts) should be prevented. Rubber gaskets or other glazing materials should be used with frame sections. The frame section should give a minimum of 15 mm edge cover to the glass unless it can be shown by test or calculation that the frame will retain the glass under load while conforming to design requirements.

The frame and/or fastenings should be designed so that they do not tend to distort the glass panel. This is particularly important with bolted connections, which can exert considerable forces on the glass, where particular attention should be paid to the alignment and position of the fasteners in order to avoid unnecessary stresses being developed.

G-5.3.1 *Bolt Fixing of Infill Panels*

At the bolted connections there should be clamping plates and gaskets on both sides of the glass that provide a minimum of 50 mm diameter cover to the glass. These plates should be not less than 6 mm thick in steel or 10 mm thick in other suitable metals.

Where the length of a glass pane is greater than the span between the bolted connectors, giving rise to a cantilevered portion of the pane, the cantilevered portion should be less than one-quarter of the span between the bolted connectors.

Under the design loads, the railing should be designed so that the relative in-plane movement of the bolted connections in the same panel is not greater than 2 mm.

The glass, framing system and connections of railings and infill panels should be capable of sustaining and safely transmitting the design loads to the supporting structure.

G-5.4 Design of Glass

G-5.4.1 *Design of Glass in Full Height Protective Railings*

Glass partly or totally below the minimum railing height should be designed to satisfy the appropriate design criteria. Any part of a glass pane below the minimum railing height should sustain the infill loads. Where there is glass at the minimum railing height given in Table 37, the glass should also sustain the line load applied at the design level.

For any specific information on the glass size relative to the glass type, support system, loadings and thickness, available standards or the manufacturer recommendations should be sought.

G-5.4.2 *Design of Glass Infill Panels*

Infill panels should be designed to satisfy the appropriate design criteria as below:

a) *Fully framed infill panels* – The deflection of the glass in fully framed infill panels should be as per recommended deflections.

b) *Two-edge framed infill panels* – The deflection of the glass in two-edge framed infill panels should be as recommended under **G-4.4** taking *L* as the distance between the supports.

c) *Clipped infill panels* – The clips should be positioned around the periphery of the infill panel, at a maximum spacing of 600 mm. Each clip should be not less than 50 mm in length and should give a minimum depth of cover to the glass of 25 mm.

d) *Bolt fixing of glass infill panels* – Where glass is supported by bolted connections through holes in the glass, toughened/toughened laminated glass should be used.

e) *Position of infill panels relative to the main frame* – Infill panels should be fully contained within the supporting structure. In order not to apply unintended loads to the infill panels, they should have handrails above the glass or attached to the side to which the public have access.

G-5.4.3 *Design of Free-Standing Glass Protective Railings*

The glass should be designed to satisfy the appropriate design criteria given in **G-4**. The deflection of the glass should not be more than 25 mm at any point.

G-5.4.3.1 *Handrail attachment*

Where the railing protects a difference in level greater than 600 mm, a handrail shall be used unless a laminated toughened glass construction is used that remains *in-situ*, if a panel fails. Continuous fixing should be used for fixing the handrail to the glass, or individual fixings where calculations or tests demonstrate that component failure will not occur.

Where handrail is not desired, the laminated toughened glass should have a stiff interlayer such as ionoplast interlayer or structural PVB interlayer.

The handrail should be attached to the glass in such a manner that, should a glass panel gets fractured, the handrail,

a) will remain in position; and
b) will not fail if the design load is applied across the resulting gap.

NOTE – The above condition (b) can be relaxed where the glass pane is an end pane and protects a difference in level of 600 mm or less, for example at the foot of a flight of stairs. In cases where an end pane protects a difference in level greater than 600 mm, there may normally be some adjacent structure to which the handrail could be attached, thus enabling it to meet condition (b).

G-5.4.4 *Base Fixing of Free-Standing Railings*

G-5.4.4.1 *Point of fixing clamps*

The fixing clamps on each side of the glass should be not less than 100 mm to 150 mm and should be made of a suitable metal of minimum thickness 12 mm. There should be not less than two fixing clamps for every 1 m length of railing.

G-5.4.4.2 *Continuous fixing clamps*

The fixing clamps on each side of the glass should be not less than 100 mm wide and should be made of a suitable metal of minimum thickness 12 mm. The clamps should be continuous for the entire length of the glass pane and have a maximum bolt spacing of 500 mm.

G-5.4.4.3 *Other clamping systems*

Different clamping methods could be used, provided they cater for an effective continuous clamping over the length of the glass pane. Where a clamping system that does not rely on bolts through the glass is used, the depth over which the clamping force operates should be not less than 75 mm, unless specific tests have been carried out to prove the integrity of the system and that it meets the design criteria given.

G-5.4.4.5 *Structural movement*

The structural movement due to live or dead loads or creep of the structure to which a railing pane is clamped should be not greater than 2 mm over the length of any railing panel, if more than two bolts are used to clamp that panel.

G-5.4.4.6 *Fixing clamps*

The attachment of the fixing clamps to the structure should be capable of withstanding the turning moment induced at the fixing clamps.

G-6 IMPACT RESISTANCE AND CONTAINMENT

G-6.1 General

In addition to resisting the design loads given, glass below the minimum railing height (*see* Table 1) should also be able to resist impact forces appropriate to whether the railing indicates a route or protects people from a hazard.

G-6.2 Glass in Full Height Railings

The glass in full height railings should be selected to resist the appropriate design loads given and for its impact performance in accordance with the safety glazing recommendations.

G-6.3 Railing with Glass In-fills or Free-Standing Balustrades

The glass in railings with glass in-fills or free-standing should be selected to resist the appropriate design loads given, and to provide containment, that is, it should meet the recommended impact class without penetration.

G-7 INSTALLATION

The installation of a railing should be supervised by a suitably qualified person or persons, who should ensure that the design assumptions have been effectively implemented. Inspections and investigations should be carried out as necessary to establish the integrity of the materials and the elements of construction used.

G-7.1 Fasteners and Fittings

Fasteners and fittings should be of stainless steel, or should be hot-dip galvanized. Thin zinc plated or cadmium plated coatings should not be used for external exposure without additional protection.

G-8 MAINTENANCE

All glass should be regularly cleaned and fixings should be checked for corrosion and loosening. Maintenance recommendations, and the frequency with which railings should be inspected, are be governed by environment, usage, incidence of malicious damage and the protection applied. Protective railings assembled entirely from metal-coated steel and situated in normal environments should not require any maintenance for a very long period. They should, however, be inspected regularly and the residual coating thickness should be measured.

ANNEX H
(*Clause* 2.15)

TEST METHOD FOR ASSESSING CURTAIN WALLS AND STOREFRONT SYSTEMS UNDER INTER-STORY DRIFT CONDITIONS

H-1 OBJECTIVE

This test method provides a means of evaluating the performance of window wall, curtain walls and storefront systems when subjected to specified horizontal displacements in the plane of the wall. This test is applicable to window wall, curtain wall and/or storefront mock-ups consisting of supports and components, with glass panels fixed across more than one story (hereinafter referred to as exterior wall systems). This test method is applicable to window systems only when included as part of a full-size wall mockup. This test method describes the apparatus and the procedure to be used for displacing a specimen horizontally. The displacement cycle time is not limited and is intended to duplicate the inter-story displacement rates associated with dynamic building sway / seismic / wind events. This test shall be applicable for seismic zone IV and V. However, depending upon application and for tall structures, it shall be performed for other seismic zones as well.

This annexure does not support to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this test method to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.

H-2 TERMINOLOGIES

H-2.1 Lateral movement – A sideway displacement of a structure or part of the structure.

H-2.2 Test specimen – The test element is referred to as the specimen. The test specimen for a wall shall be of sufficient size to determine the required performance of all typical parts of the wall system.

H-2.3 Specimen area – The area calculated from the overall dimensions of the test specimen.

H-2.4 Floor height – Height of one floor of the sample to be tested.

H-2.5 Horizontal displacement - The relative displacement of the curtain wall in the horizontal direction when subjected to horizontal movement.

H-2.6 Window Wall – It sits between floor slabs and are anchored at the sill and head.

H-3 APPARATUS

H-3.1 The description of the apparatus in this section is general. Any suitable apparatus arrangement during the laboratory accreditation process is permitted.

H-3.2 The displacement(s) may be accomplished using hydraulic or pneumatic cylinders or jacks of sufficient load and stroke capacity, or mechanical devices, such as ratchet pulleys or a chain hoist.

H-3.3 Test chamber members that are representative of the building structure shall be designed to accomplish the specified displacement(s). This may be done through a system of sleeves, fixtures, pins, or any system capable of accomplishing the displacement(s) directed by the specifier.

H-3.4 The displacement measuring system shall be accurate to within 1.5 mm (0.06 in).

H-4 CALIBRATION

All test equipment shall be calibrated periodically, at least once every six months. Calibration should be done from NABL accredited laboratory or any other laboratory provided traceability to NPL is established through the calibration certificates.

H-5 TEST SPECIMEN

H-5.1 The exterior wall system test specimen shall be of sufficient size and configuration to determine the performance of all typical parts of the exterior wall system. A minimum of three vertical bays in two adjoining floors of the exterior wall system shall be tested. If the wall has inside and/or outside corner, one set of corner bay's shall also be included in the testing specimen. For glazing that is anchored within the floor/story such as windows, doors, sliders and horizontal strip façade, the test specimen can be of a single floor.

H-5.2 All parts of the exterior wall system test specimen shall be full size, using the same materials, type of glass, detailing, methods of construction and anchorage as those used on the actual building.

H-5.3 The test chamber structure shall simulate the main structural supports of the actual building. However, the test chamber and/or support structure may differ from the actual building, as required, to perform the required displacement. For multi-story mock-ups, the test chamber shall be constructed so that the anchorage at the simulated floor structure at an intermediate level of the test specimen is moveable in the horizontal direction(s). For single story mock-ups, the test chamber shall be constructed so that the anchorage at the top or bottom is moveable in the horizontal direction(s).

H-5.4 The test lab shall minimize unintended torsional or flexural movements of chamber and/or support structure that could affect test results.

H-6 PROCEDURE

H-6.1 Prior to conducting the displacement tests, the test specimen shall be, at a minimum, characterized for serviceability by conducting air leakage and water penetration tests. The air leakage and water penetration tests shall be conducted at the differential pressures specified for the project.

H-6.2 Conduct specified displacement test(s).

H-6.2.1 Test chamber elements representing the primary building structure shall be displaced to produce the specified movements. Each test shall consist of minimum three full cycles. A cycle is defined as a full displacement in one direction, back to the originating point, full displacement in the opposite direction, and back to the originating point. (*see* Fig. 25)

H-6.2.2 Hold the specimen at displaced position not more than 60 s at each direction.

H-6.2.3 An inspection to be conducted during and after every cycle and recorded.

H-6.2.4 At the conclusion of the test, technicians and witnesses shall visually inspect the mock-up for evidences of failure.

H-6.2.5 The Test Agency shall record all areas of visual distress, such as disengagement, metal distortion, sealant or glazing failure, gap between framing members, or permanent deformation.

H-6.2.5.1 If glass breakage occurs during displacement tests, the Test Agency personnel shall carefully examine the test specimen and document the extent of this glass breakage.

H-6.2.6 Elements representing the building structure shall be displaced in a manner and method as determined by the Test Agency and may be subject to review by the design professional. Movement shall be parallel to the primary plane of the wall.

H-6.2.7 Changes in displacement direction(s) shall allow for movement of equipment, stops, measuring devices, etc. The Test Agency shall displace the chamber elements in a manner that is not intended to induce sudden acceleration and deceleration.

H-6.2.8 Additional cycles and/or displacement direction(s) may be specified by the design professional. The chamber elements shall be returned to their nominal position after completion of each cycling test, before further tests are conducted.

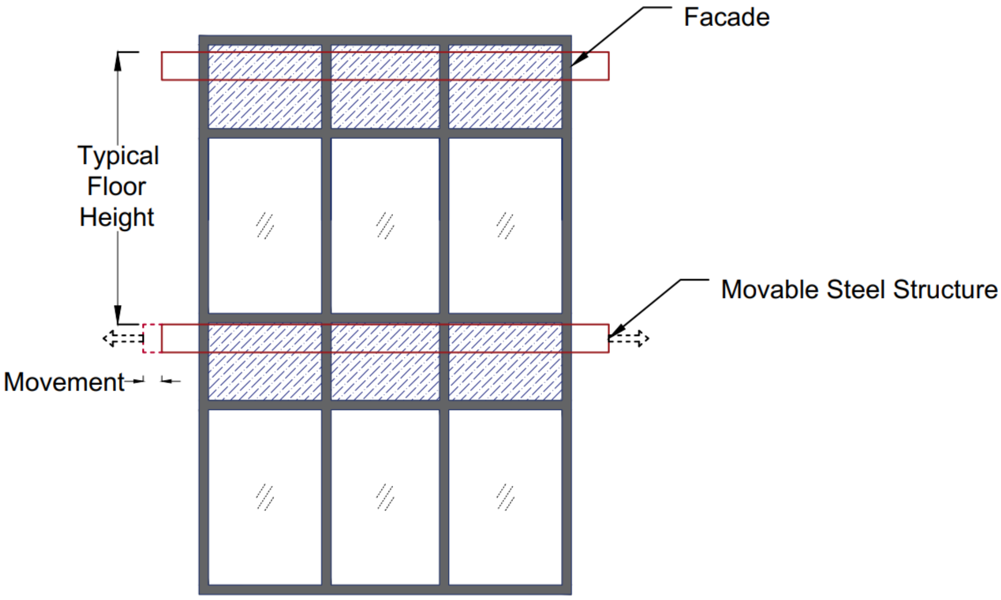


FIG. 25 Illustration of Movable Structural Elements in Curtain Wall Systems Under Inter-Story Drift Conditions

H-6.2.9 The elastic design displacement shall be as provided by the building engineer of record, determined by elastic analysis or other suitable method for a specific building. The displacement shall be measured at the movable floor element, not at the test specimen. For multi-story mock-ups, the displacement between levels may vary due to different story heights. If unspecified in contract documents, for testing, elastic design displacement in each direction shall be as follows:

a) H/500, for curtainwall systems that span from floor-to-floor and primarily accommodate movement through racking or tipping.

H-6.3 Serviceability tests for air leakage as per accepted standard [6-8(19)] and static water penetration as per accepted standard [6-8(21)] may be conducted after the static elastic design displacement tests. The air leakage and static water penetration tests should be conducted at the pressures specified for the project.

H-6.4 The displacement shall be measured at the movable chamber member that represents the floor element, not at the test specimen or its anchorage.

H-7 CRITERIA

H-7.1 The project specifications shall state detailed performance criteria for the windows, window wall, curtain wall or storefront system. If detailed performance criteria are not included in the project specification, the criteria outlined in this test method shall be utilized.

H-7.2 Unless otherwise specified, an exterior wall system test specimen subjected to the elastic design displacement test shall be considered as passing the inter-story drift provisions of this test method if the specimen meets the following criteria:

a) No visible damage to framing or trim components or assemblies is allowed
b) No glass breakage or glass fallout is allowed
c) Full disengagement of gaskets or weather seals is not allowed at any location
d) Any gap between framing members shall be notified.
e) Air infiltration and static water penetration resistance shall remain within specified allowable limits without adjustments or repair for serviceability conditions.

Note – If any of air infiltration or static water penetration test failed, then seismic test has to repeated before proceeding with air infiltration or static water penetration retests.

f) No wall components may fall off.

H-8 REPORTING

The information to be duly reported after testing are given hereunder.

H-8.1 General

Testing agency, date and time of test, and date of report.

H-8.2 Specimen Details

H-8.2.1 *Specimen Description*

Manufacturer, model, operation type, materials, and other pertinent information; description of the locking and operating mechanisms if applicable; glass thickness, type and method of glazing; weather seal dimensions, type, weep holes, and material; and crack perimeter or specimen area, or both.

H-8.2.2 *Drawings of Specimen*

Detailed drawings of the specimen showing dimensioned section profiles, framing location, panel arrangement, installation and spacing of anchorage, weather stripping, locking arrangement, hardware, sealants, glazing details, weep holes, drainage path detail, and any other pertinent construction details. Any modifications made on the specimen to obtain the reported test values shall be noted.

H-8.3 For window, door components, a description of the locking and operating mechanism.

H-8.4 Identification of glass thickness and type and method of glazing.

H-8.5 Test Parameter

H-8.6 List of Equipment's used

List the equipment's name, identification number, calibration validity of all the equipment's used at the time of testing.

H-8.7 Test Observation

A visual record of the test observations

H-8.8 Photographs or drawings of the test chamber and the wall system test specimen mock-up indicating location of measuring devices and movement devices.

H-8.9 Compliance Statement

A statement that the tests were conducted in accordance with this test method, or a complete description of any deviation from this test method. When the tests are conducted to check for conformity of the specimen to a particular performance specification, the specification shall be identified.

H-9 INFORMATION OF DESIGN LOADS

In order to design and detail exterior wall systems and their attachments to meet the inter storey drift requirements, the design load shall be as per good practice [6-8(28)].

Inter-story drift can result from either seismic loads or by wind loads.

ANNEX J
(*Clause* 9.4.3)

TESTING REQUIREMENTS FOR BLAST RESISTANT GLAZING SYSTEMS

J-1 OBJECTIVE

J-1.1 The purpose of this section is to provide general guidelines about equipment, range conditions and procedures used to conduct the blast evaluation of glazing systems against the designed blast load and to verify that it meets the defined blast pressure load.

J-1.2 The glazing system is evaluated for its structural integrity by visual inspection only.

J-1.3 The safety precautions and regulations undertaken during blast resistant tests of glazing systems shall be as specified by the test agency.

J-1.4 Blast resistant test of glazing systems shall be carried out only by the accredited institutions/laboratories authorized by the Government of India.

J-2 TERMINOLOGY

J-2.1 Test Sponsor – Party requesting and sponsoring the test. The test sponsor may be its manufacturer or user.

J-2.2 Test Agency – Party performing the testing and documenting the test results.

J-2.3 Test specimen – The test specimen is provided as a complete assembly by test sponsor to the test agency. It may include glazing systems like glass door, glass windows/frames, glass panels etc.

J-2.4 Trial Officer – Individual identified by the test agency responsible to complete the specified tests as required and to document the results in accordance with this test method. The test director shall sign all of the test reports.

J-2.5 Trial Safety Officer – Individual identified by the test agency nominated by the means of Trial Plan approved by the competent authority. The trial safety officer is responsible for all the safety aspects during the trial time and safe conduct of trials.

J-3 APPARATUS

J-3.1 High Explosive – The high explosive charge (prepared by using TNT/equivalent charge) as mentioned by the test sponsor is used to generate the desired blast parameters for the performance evaluation of test specimen.

J-3.2 Instrumentation – The instrumentation system used for measurement of blast pressure comprises of piezoelectric based pressure sensors, signal conditioner, low noise anti-microphonic cables and data acquisition systems. The details are as follows:

J-3.2.1 *Pressure Sensor* – Pressure sensor is used to record pressure-time history of blast wave. The sensor contains piezoelectric crystal as a sensing element which produces an electric charge proportional to impinging pressure. The pressure sensor has an in-built circuitry that converts pressure to voltage signal. It requires ICP constant current power supply which is provided by compatible signal conditioner.

J-3.2.2 *Low Noise Cables* – A special low noise anti-microphonic cable is used to transmit the signal from sensor to recording system. These cables are immune to tribo-electric effect and electromagnetic interference.

J-3.2.3 *Data Acquisition System (DAS)* – The DAS consists of an analog or digital recording system with a sufficient number of data channels to accommodate the pressure sensor(s) and any other electronic measuring devices. The DAS shall operate at a sufficiently high frequency to record reliably positive pressure and positive phase duration. The triggering of recording system is synchronized with explosion by using Transistor Transistor Logic System.

J-3.3 Photographic Equipment – Each test is documented with still photography. Video or high speed photography of the testing is deployed, if required.

J-4 PROCEDURE

J-4.1 The trial officer along with all team members will be responsible for the execution of the test. The trial safety officer along with the range safety team will take care of the safety of personnel and property during the conduct of test.

J-4.2 The trial site location and range safety distance shall be decided by the test agency.

J-4.3 The parameters (identification number, shape, weight, dimensions etc.) are verified before trial. The documentary proof for the same shall be submitted by the test sponsor to the test agency.

J-4.4 The test specimen is held on to the wall with the help of supporting frame such that no additional pressure gets generated on the glass panel when it is fixed to the frame using nuts & bolts.

J-4.5 The attack face of the test specimen will be towards the explosive charge (TNT/equivalent charge).

J-4.6 Photographic records of details of the glazing assembly and the test configuration are taken prior to the test. If a video photographic record of the response of glazing assembly during the test is desired, video cameras are deployed.

J-4.7 The explosive charge (TNT/equivalent charge) is prepared as per the threat levels based on weight of explosive & standoff (*see* Table 38) or as defined by the Test sponsor.

J-4.8 The explosive charge (TNT/equivalent charge) is positioned at a certain height of burst (HOB) and at distance *d* from the test specimen (as shown in Fig. 26 (isometric view) and Fig. 27 (top view)).

Table 38 Classification, charge (TNT/equivalent charge) mass, distance (*d*) and height of burst (HOB)
(*Clause* J-4.7)

Sl No.	**Threat level**	**TNT/Equivalent charge mass (kg)**	**Distance of explosive charge (TNT/equivalent charge) from the test specimen (*d*) (in m)**	**Height of burst (HOB) (in m)**
(1)	(2)	(3)	(4)	(5)
i)	1	2	4.5	0
ii)	2	3	5.0	0.5 ± 0.05
iii)	3	3	3.0	0.5 ± 0.05
iv)	4	12	5.5	0.8 ± 0.05
v)	5	12	4.0	0.8 ± 0.05
vi)	6	20	4.0	0.8 ± 0.05
vii)	Special	Any other requirement by the user.		

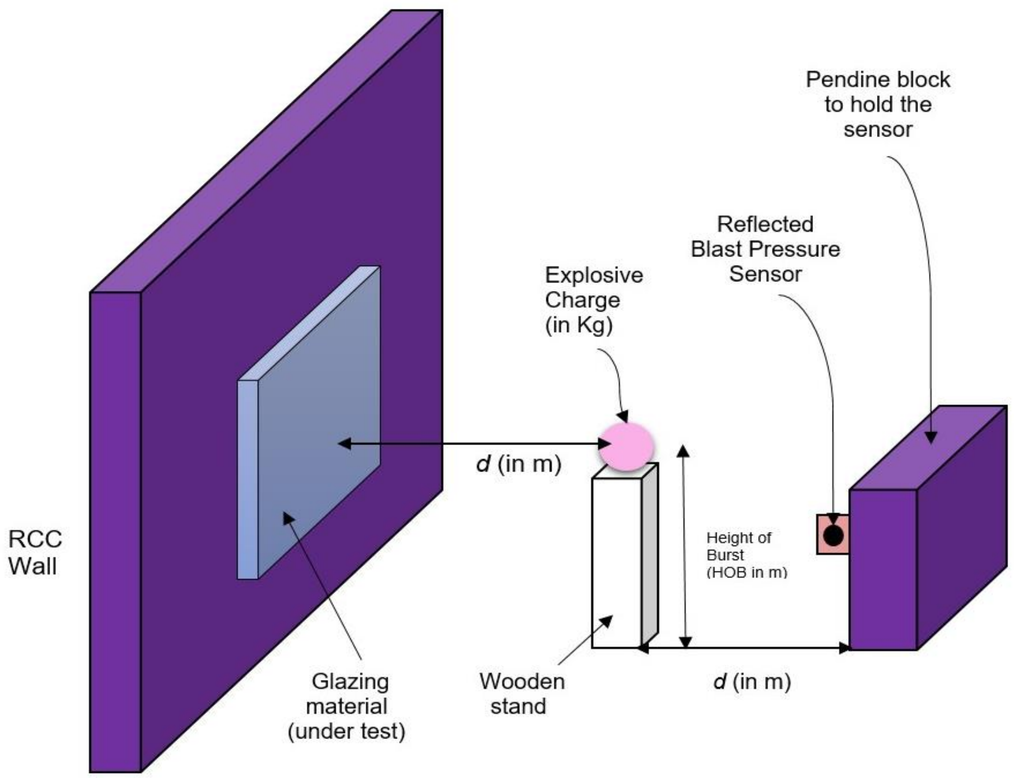


FIG. 26 ISOMETRIC VIEW – SCHEMATIC OF TEST SETUP

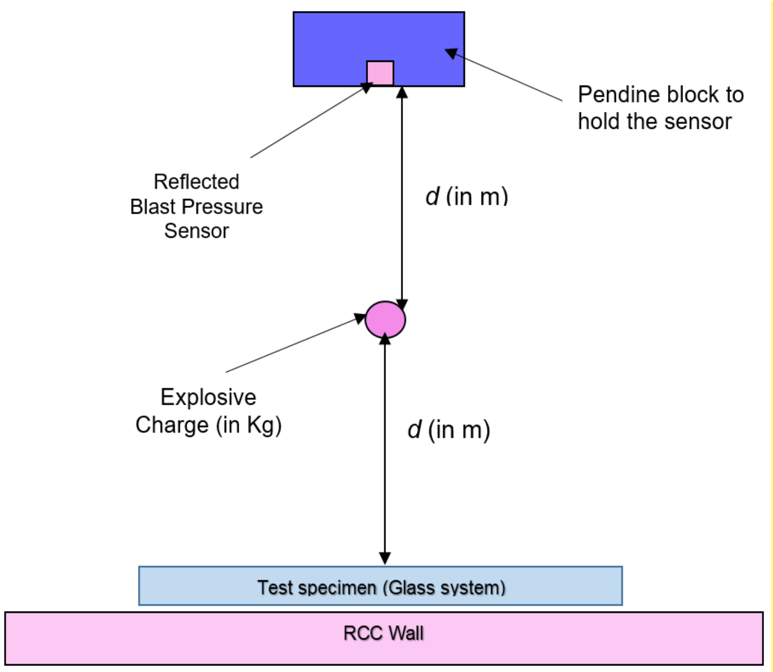


FIG. 27 TOP VIEW – SCHEMATIC OF TEST SETUP

J-4.9 The pressure sensor to measure the reflected blast pressure is deployed at distance *d* (as shown in Fig. 26 and Fig. 27). The pressure sensor is deployed in such a way that its sensing element is directed towards the explosive charge (TNT/equivalent charge).

J-4.10 The distance *d* and Height of Burst (HOB) varies depending on the threat level.

J-4.11 The pressure sensor is then connected to the data acquisition system through signal conditioner via low noise cables and tested to verify proper functioning.

J-4.12 The explosive charge (prepared by using TNT/equivalent) is then detonated by following all safety precautions ensured by trial safety officer and range safety team.

J-4.13 After the test, the visual inspection of the glazing assembly is done to evaluate its structural integrity. Adequate photography is taken after each test.

J-4.14 In case of misfire, the second attempt is done as per misfire drill of the test agency.

J-5 OUTCOMES

The structural integrity of glass system test specimen after the trial is evaluated by visual inspection in the following categories of outcome:

J-5.1 Category A – No damage to the glass and the frame of glass system.

J-5.2 Category B – The entire system is bent or deformed leading to the overall jamming or dis-functioning of the system.

J-5.3 Category C – Formation of cracks on the glass system and no damage to the frame of the glass system.

J-5.4 Category D – Cracking/Shattering of different glass layers and damage to frame of the glass system.

J-5.5 Category E – Formation of splinters from the glass system or the frame within a distance of 3m.

J-5.6 Category F – Total collapse of the glass or frame of the glass system or both.

J-6 REPORT GENERATION

J-6.1 Upon completion of the testing, the test director assigns a test number and record the test measurement and observations obtained from all test specimen(s) for preparation of test report.

J-6.2 The trial officer and the test director signs the test report and gets it approved from competent authority.

ANNEX K
(*Foreword*)

CONFORMITY ASSESMENT SHEET FOR GLASS AND GLAZING SYSTEM

K-1 For the purpose of conformity assessment by building regulator for glass and glazing aspects, following sheet shall be used.

Sl. No.	**Parameters**	**Details**
(1)	(2)	(3)
	1. GENERAL	
1.1	Building Typology	
1.2	Location (City, State)	
1.3	Orientation	
1.4	Climate Zone	
1.5	WWR	
	2. GLASS	
2.1	Component of Building (Glass on Roof/ Floor / wall / Railing / Glass Fin)	
2.2	**Type of Glass**	
	Combination (if needed)	
2.3	**Tinted / Clear / Coated:**	
	if yes, Side (Outer / Inner)	
	Description	
2.4	**Patterned / Non- patterned:**	
	if yes, Side (Outer / Inner)	
	Dimension of Glass (L X B) (mm)	
2.5	**Thickness & Deflection:**	
	Calculated Deflection as per NBC	
	Calculated Thickness (mm) as per NBC	
	Actual Thickness (mm)	
	Glass specifications as per NBC	**Yes / No**
2.6	**Safety**	
	Glass Height from Ground	
	Presence of Residual Protection ? (Yes / No)	
	Presence of Window Restrictor for children	
	Anti Fall out norms followed? (Yes / No)	
	Safety Glass Norms followed as per NBC	**Yes / No**
2.7	**Energy Performance:**	
	U value	
	SHGC / Solar Factor	
	Visible Light Transmittance (VLT)	
	Shading Co-efficient	

Sl. No.	**Parameters**	**Details**
(1)	(2)	(3)
	3. FRAME	
3.1	Thickness	
3.2	Dimension	
3.3	Frame Material	
3.4	Frame supported sides (Glass inside structures can also be considered as framed)	
3.5	Deflection of Frames	
3.6	Face Width	
3.7	U value of Frame	
3.8	Depth of the Profile	
	Frame specifications as per NBC	**Yes / No**
	4. GLAZING SYSTEM	
4.1	**Thickness and Dimension**	
	Dimension	
	Thickness	
4.2	**Energy**	
	U factor	
	Solar Factor / SHGC	
	Visible Light Tranmittance (VLT)	
	Energy Efficiency specifications as per NBC	**Yes / No**
4.3	**Structural Parameters**	
	Design Load and Wind Load	
	Other Loads	
	Air Permeability	
	Deflection	
	Seismic Parameters	
	Water tightness (classification)	
	Structural aspects as per NBC	**Yes / No**
4.4	**Glazing Material**	
	Front and Back Clearance	
	Edge Clearance	
	Edge Cover	
	Rebate Depth	
4.5	**Fire Resistant Glazing system:**	
	If Fire Resistant, Category (E / EW / EI)	
	Duration of Resistance to Fire (in mins)	

Sl. No.	**Parameters**	**Details**
(1)	(2)	(3)
	Thickness of Glazing system	
4.6	**Acoustics**	
	Airborne Sound Insulation	
	Impact Sound Insulation	
5. THIRD PARTY TEST CERTIFICATES (FOR ALL PRESCRIBED PROPERTIES)		
5.1	Glass	Yes / No
5.2	Frames	Yes / No
5.3	Glazing Systems - Energy Performance	Yes / No
5.4	Glazing Systems - Structural Aspects	Yes / No
5.5	Glazing Systems - Fire Resistance (if applicable)	Yes / No
5.6	Glazing Systems - Acoustics	Yes / No

LIST OF STANDARDS

The following list records those standards which are acceptable as 'good practice' and 'accepted standards' in the fulfillment of the requirements of the code. The latest version of a standard shall be adopted at the time of enforcement of the code. The standards listed may be used by the Authority for conformance with the requirements of the referred clauses in the Code.

In the following list, the number appearing in the first column within parentheses indicates the number of the reference in this section:

	IS No.	*Title*
(1)	14900 : 2018	Specification for transparent float glass (first revision)
	2553 (Part 1) : 2018	Safety glass - Specification: Part 1 architectural, building and general uses (Fourth Revision)
(2)	3808 : 1979	Method of test for non-combustibility of building materials (*first revision*)
(3)	2835 : 1987	Specification for flat transparent sheet glass (*third revision*)
(4)	14900 : 2018	Specification for Transparent float glass (first revision)
(5)	2553 (Part 1) : 2018	Safety glass - Specification: Part 1 architectural, building and general uses (Fourth Revision)
(6)	5437 : 2024	Rolled Glass - Patterned, Extra Clear Patterned, Wired and Wired-Patterned Glass – Specification
(7)	875 (Part 3) : 2015	Code of Practice for design loads (other than earthquake) for buildings and structures: Part 3 Wind Loads (*third revision*)
(8)	1893 (Part 1) : 2016	Criteria for earthquake resistant design of structures: Part 1 General provisions and buildings
(9)	875 (Part 2) : 1987	Code of Practice for design loads (other than earthquake) for buildings and structures: Part 2 Imposed loads *(second revision)*
(10)	IS/ISO 834-1 : 1999	Fire-resistance tests — Elements of building construction Part 1 General requirements
	IS/ISO 834-4 : 2000	Fire-resistance tests — Elements of building construction Part 4 Specific requirements for load bearing vertical separating elements

	IS/ISO 834-5 : 2000	Fire-resistance tests — Elements of building construction Part 5 Specific requirements for load bearing horizontal separating elements
	IS/ISO 834-6 : 2000	Fire-resistance tests — Elements of building construction Part 6 Specific requirements for beams
	IS/ISO 834-7 : 2000	Fire-resistance tests — Elements of building construction Part 7 Specific requirements for columns
	IS/ISO 834-8 : 2002	Fire-resistance tests — Elements of building construction Part 8 Specific requirements for non-load bearing vertical separating elements
	IS/ISO 834-9 : 2003	Fire-resistance tests — Elements of building construction Part 9 Specific requirements for non-load bearing ceiling elements
	IS 17518 (Part 1) : 2022	Fire resistance tests — Door and shutter assemblies Part 1 General requirements
	ISO 3008-1 : 2019	
	IS/ISO 3009 : 2003	Fire-Resistance Tests — Elements of Building Construction — Glazed Elements
	IS 16945 : 2018	Fire resistance test for glass walls
	IS 16947 : 2018	Fire resistance tests for doors with glass panes, openable glass windows and sliding glass doors
(11)	875	Code of Practice for design loads (other than earthquake) for buildings and structures
	(Part 1) : 1987	Dead loads- Unit weights of building material and stored materials
	(Part 2) : 1987	Imposed loads
	(Part 3) : 2015	Wind loads (*Third revision*)
	(Part 5) : 1987	Special loads and load combinations
(12)	733 : 1983	Specification for wrought aluminium and aluminium alloy bars, rods and sections (for general engineering purposes) (*third revision*)
	738 : 1994	Specification for wrought aluminium alloys, drawn tube for general engineering purposes (*third revision*)
(13)	6911 : 2017	Specification for stainless steel plate, sheet and strip (*second revision*)
(14)	16982 : 2018	Heat strengthened glass — Specification

(15)	IS ---- : 20XX	Fire resistant glass — Specification
(16)	IS 16978 (Part 1) : 2022 ISO 16936-1 : 2020	Glass in building — Forced-Entry security glazing Part 1 Test and classification by repetitive ball drop (*first revision*)
	IS 16978 (Part 2) : 2018 ISO 16936-2 : 2005	Glass in building — Forced-Entry security glazing Part 2 Test and classification by repetitive impact of a hammer and axe at room temperature
	IS 16978 (Part 3) : 2018 ISO 16936-3 : 2005	Glass in building — Forced-Entry security glazing Part 3 Test and classification by manual attack
	IS 16978 (Part 4) : 2018 ISO 16936-4 : 2005	Glass in building — Forced-Entry security glazing Part 4 Test and classification by pendulum impact under thermally and fire stressed conditions
(17)	IS 18518 : 2023	Bullet resistant security glass — Quality and performance requirements
(18)	IS 18648 : 2024	Classification and performance requirements for doors, windows and sliders — Specification
(19)	IS 18472 : 2024	Air permeability for curtain walls, windows, sliders, doors and skylights — Method of test
(20)	IS 18434 : 2023	Field measurement of air permeability and water penetration through installed curtain wall, windows, doors, sliders and skylights under static air pressure difference — Method of test
(21)	IS 18459 : 2024	Water penetration of curtain walls, windows, sliders, doors and skylights by uniform static air pressure difference — Method of test
(22)	IS 18647 : 2024	Water penetration of curtain walls, windows, sliders and doors by dynamic air pressure — Method of test
(23)	IS 18268 : 2023 ISO 9379 : 2005	Operating forces — Test methods — Doors
(24)	IS 17909 : 2022 ISO 8274 : 2005	Windows and doors — Resistance to repeated opening and closing — Test method
(25)	IS 17004 : 2018	Testing Methods for Processed Glass
(26)	IS 1948 : 2024	Aluminium framed doors, windows and sliders — Specification *(first revision)*
(27)	IS 1946(Part 2) : 20XX	Design of post-installed anchorage to concrete — Code of practice
(28)	875	Code of Practice for design loads (other than earthquake) for buildings and structures

	(Part 1) : 1987	Dead loads- Unit weights of building material and stored materials
	(Part 2) : 1987	Imposed loads
	(Part 3) : 2015	Wind loads (*Third revision*)
	(Part 4) : 2021	Snow loads (*third revision*)
	(Part 5) : 1987	Special loads and load combinations
	1893 (Part 1) : 2016	Criteria for earthquake resistant design of structures: Part 1 General provisions and buildings
	IS 16700 : 2023	Criteria for structural safety of tall concrete buildings *(first revision)*
(29)	IS 16231 (Part 3) : 2019	Use of glass in buildings — Code of practice Part 3 Fire and loading *(first revision)*
	875	Code of Practice for design loads (other than earthquake) for buildings and structures
	(Part 1) : 1987	Dead loads - Unit weights of building material and stored materials
	(Part 2) : 1987	Imposed loads
(30)	IS 16231 (Part 3) : 2019	Use of glass in buildings — Code of practice Part 3 Fire and loading *(first revision)*
(31)	IS 17953 : 2023	uPVC profiles for windows and doors — Specification
(32)	IS 1038 : 1983	Specification for steel doors, windows and ventilators *(third revision)*
(33)	IS 11050 (Part 1) : 2023 ISO 717-1 : 2020	Rating of sound insulation in buildings and of building elements Part 1 Airborne sound insulation *(first revision)*
(34)	IS 11050 (Part 2) : 2023 ISO 717-2 : 2020	Rating of sound insulation in buildings and of building elements Part 2 Impact sound insulation *(first revision)*
(35)	IS 18473 : 2024	Wind resistance for curtain walls, windows, sliders, doors and skylights — Method of test
(36)	IS 17911 : 2022 ISO 15099 : 2003	Thermal performance of windows, doors and shading devices — Detailed calculations
(37)	IS 17920 : 2022 ISO 10077-2 : 2017	Thermal performance of windows, doors and shutters — Calculation of thermal transmittance — Numerical method for frames

(38)	IS 19006 : 2023 ISO 8248 : 1985	Windows and door height windows — Mechanical tests
(39)	IS 17518 (Part 1) : 2022 ISO 3008-1 : 2019	Fire resistance tests — Door and shutter assemblies Part 1 General requirements
(40)	IS 16945 : 2018	Fire resistance test for glass walls
(41)	IS 16947 : 2018	Fire resistance tests for doors with glass panes, openable glass windows and sliding glass doors
(42)	SP 32 : 1986	Handbook on functional requirements of industrial buildings (lighting and ventilation)
	SP 41 : 1987	Handbook on functional requirements of buildings (other than industrial buildings)
(43)	IS 18190 : 2023	Fire resistance of perimeter fire barrier joint system — Method of tests
(44)	IS 1946 (Part 5) : 20XX	Code of practice for Installation and On-Site Testing of Post–Installed Anchorage to Concrete
(45)	IS 16978 (Part 1) : 2022 ISO 16936-1 : 2020	Glass in building — Forced-Entry security glazing Part 1 Test and classification by repetitive ball drop (*first revision*)
	IS 16978 (Part 2) : 2018 ISO 16936-2 : 2005	Glass in building — Forced-Entry security glazing Part 2 Test and classification by repetitive impact of a hammer and axe at room temperature

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