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**Use of glass in building —
Part 5: Safety related to human impact**

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Contents	Page
Foreword	iv
1 Scope	1
2 Normative references.....	1
3 Terms and definitions	1
4 Application	1
5 Criteria for human impact safety	2
5.1 General	2
5.2 Safety glass.....	2
5.3 Critical location.....	3
5.4 Manifestation (making glass visible).....	6
5.5 Identification of safety glass	7
5.6 Test requirements	7
5.6.1 Fragmentation test	7
5.6.2 Mechanical strength.....	7
6 Safety related to glass handling, transportation and storage.....	8
6.1 Glass handling and transportation safety considerations.....	8
6.2 Glass storage safety considerations.....	9

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Foreword

Rwanda Standards are prepared by Technical Committees and approved by Rwanda Standards Board (RSB) Board of Directors in accordance with the procedures of RSB, in compliance with Annex 3 of the WTO/TBT agreement on the preparation, adoption and application of standards.

The main task of technical committees is to prepare national standards. Final Draft Rwanda Standards adopted by Technical committees are ratified by members of RSB Board of Directors for publication and gazettment as Rwanda Standards.

DRS 397-5 was prepared by Technical Committee RSB/TC 009, *Civil engineering and building materials*.

In the preparation of this standard, reference was made to the following standards:

- 1) AS 1288, *Glass in buildings – Selection and installation*
- 2) BS 6262-4: 2018, *Code of practice for glazing for buildings*
- 3) IS 3548, *Code of practice for glazing in building*
- 4) IS 16232-4:2019, *Use of glass in buildings — Code of practice — Part 4: Safety related to human impact*

The assistance derived from the above source is hereby acknowledged with thanks.

DRS 397 consists of the following parts, under the general title *Use of glass in building*

- *Part 1: Terminology*
- *Part 2: General methodology for selection*
- *Part 3: Energy and light*
- *Part 4: Fire and loading*
- *Part 5: Safety related to human impact*

Committee membership

The following organizations were represented on the Technical Committee on *Civil engineering and building materials* (RSB/TC 009) in the preparation of this standard.

Advanced Construction Technology Services (ACTS) Rwanda

AFRIPRECAST

Bridge to Prosperity

City of Kigali

Greenpact Africa

Ministry of Health

Mass Design Group

Rwanda Housing Authority (RHA)

Rwanda Transport Development Agency (RTDA)

Standards for Sustainability (SfS)

University of Rwanda – College of Science and Technology (UR-CST)

Rwanda Standards Board (RSB) – Secretariat

Introduction

Glazing is an important item in building construction and glass, the primary glazing element has to be selected to cater for several requirements. Fixing of glass is 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.

This standard on *Code of practice for use of glass in buildings* is envisaged to address the above concerns and their engineering aspects, and is brought out in various parts as listed in the foreword.

DRS397-5 is intended to provide guidance with respect to human impact safety while using glazing in buildings.

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Use of glass in building— Part 5: Safety related to human impact

1 Scope

This Draft Rwanda Standard covers selection, handling, installation and manifestation of glass in buildings, subject to safety with respect to human impact of the occupants.

This standard does not cover the following:

- a) glazing system including frameless glazing system; and
- b) patent glazing.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

RS 397-1, *Use of glass in building — Part 1: Terminology*

RS 397-2, *Use of glass in building — Part 2: General methodology for selection*

DRS 397-4, *Use of glass in building — Code of practice — Part 4: Fire and loading*

RS ISO 12543-4, *Glass in building — Laminated glass and laminated safety glass — Part 4: Test methods for durability*

3 Terms and definitions

For the purposes of this standard, the terms and definitions given in RS 397-1 apply.

4 Application

While selecting the glass for application, the structural performance and required glass thickness shall satisfy the following criteria:

- c) glazing thickness calculation subjected to wind load is calculated in accordance DRS 397-4; and
- d) for a given application, the type and thickness of glass selected shall be in accordance with RS 397-2.

5 Criteria for human impact safety

5.1 General

5.1.1 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 this clause.

5.1.2 This standard does not assume that the glass used in accordance with this standard is not to 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 minimized by virtue of the protection given to the glass, or by the limited size or increased thickness, or by the fracture characteristics of the glass.

5.1.3 Further, this standard 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) fire arm protection,
- c) protection from explosion (terrorist attack),
- d) natural disasters like earthquakes, cyclone, fire, etc,
- e) plastic glazing material, safety and security glazing, etc.

5.1.4 In circumstances wherein the requirements of any referenced standard(s) exceed the requirements of this standard, in such case(s) the higher requirement shall become applicable.

5.1.5 The use of this standard shall also be in conformity with all other relevant standards in force including those on fire safety, structural stability, natural disasters, safety and security.

5.2 Safety glass

5.2.1 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.

5.2.2 The following products may be used in safety glazing provided that they meet the conformity requirements in RS 397-2:

- a) Toughened Safety (Tempered) Glass (TS);
- b) Toughened Float Safety Glass (TF);
- c) Laminated Safety Glass (LS); and

- d) Laminated Float Safety Glass (LF).

NOTE All heat-treated glasses are not safety glasses and all laminated, toughened, coated glasses are not safety glasses. Heat-strengthened glasses and annealed glasses are not classified as safety glasses unless laminated to meet the requirements of tests specified for safety glass.

5.3 Critical location

5.3.1 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.

5.3.2 When the glazing is required to remain in position on impact and be unbroken, or when the glazing is not fully framed on all edges, the designer or specifier should seek advice from the manufacturer.

5.3.3 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 Figure 1, where necessary precautions have to be followed:

- a) in-and-around doors, low windows;
- b) door side panels;
- c) panels mistaken for a doorway or opening;
- d) panels at low levels in walls and partitions;
- e) bathrooms;
- f) building associated with special activities, e.g., gymnasias, enclosed swimming pools, etc;
- g) schools and child care facilities; and
- h) nursing homes and care facilities for the aged and infirmed.

5.3.4 Suitable precautions should be taken to reduce the injuries that can result from glass breakage by:

- a) selecting glass of a suitable type, thickness and size;

- b) enhancing a person’s awareness of presence of glass by making glass visible (manifestation of glass); and
- c) minimizing manual handling of large pieces of glass during installation.



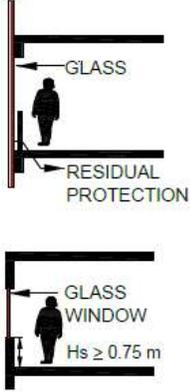
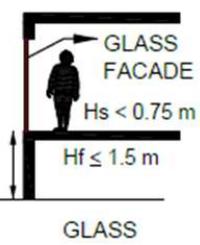
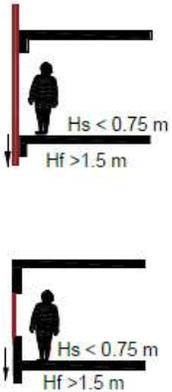
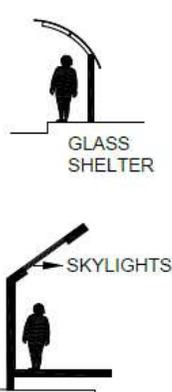
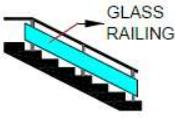
Key

- 1) Doors (high risk)
- 2) Door side panels (medium risk)
- 3) Low-level glazed areas (low risk)

Figure 1 —Critical locations in vertical glazing

Table 1 — Type of glass suggested for use at different critical locations/cases in buildings

CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
Vertical walls with residual protection or $H_s \geq 0.75 m$ (not likely to be subjected to human impact)	Vertical walls $H_s < 0.75 m$ and $H_f \leq 1.5 m$ (Human impact but not risk of fall)	Vertical walls $H_s < 0.75 m$ and $H_f > 1.5 m$ (Human impact and risk of fall)	Horizontal or sloped glazing glass (risk of fall)	Glass acting as a balustrade/ railing (Human impact and risk of fall)

	 <p>GLASS RESIDUAL PROTECTION GLASS WINDOW $H_s \geq 0.75 \text{ m}$</p>	 <p>GLASS FACADE $H_s < 0.75 \text{ m}$ $H_f \leq 1.5 \text{ m}$ GLASS</p>	 <p>$H_s < 0.75 \text{ m}$ $H_f > 1.5 \text{ m}$ $H_s < 0.75 \text{ m}$ $H_f > 1.5 \text{ m}$</p>	 <p>GLASS SHELTER SKYLIGHTS</p>	 <p>GLASS RAILING</p>
<p>Types of glass</p>	<p>Any Glass^{a)}</p>	<p>Safety Glass</p>	<p>Safety Glass^{b)}</p>	<p>Laminated Safety Glass</p>	<p>Laminated safety glass</p>
<p>Examples</p>	<p>Please refer to note 4; 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 or chair rail or grill work inside</p>	<p>a) Doors b) Side panels c) Glazed area d) Doors in bathroom: Fully framed, partially framed, frameless) e) Façade f) Windows g) Internal partitions and doors h) External façade and doors on ground floor, above floors with terrace outside</p>	<p>a) Curtain walls b) Façade c) Spandrels d) High activity area e) High risk area f) To avoid risk</p>	<p>a) Roof (Skylights) b) Ceilings c) Bus shelters d) Floors (not structural floors) e) Stairs f) Sloped façade</p>	<p>a) Balustrades b) Balcony c) Railings</p>
<p>^{a)} Safety glass is not mandatory</p> <p>^{b)} Laminated float glass is preferred</p> <p>NOTE 1 'Hf' 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.</p> <p>NOTE 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.</p> <p>NOTE 3 In case 2 and 3, if the smaller dimension of the pane is 250 mm or less and its area is 0.5 m² or less, glass other than safety glass may be used, provided that its nominal thickness is not less than 6mm. (applicable to vertical glazing).</p> <p>NOTE 4 Toughened or laminated safety glass should meet respective test requirements as given in Table 3.</p>					

5.3.5 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).

5.3.6 Precautions against chances of injuries due to broken glass falling on people include the following:

- 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 sheet 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 sheet safety glass will generally not fall out of fixing. However, where laminated glass with both glasses toughened, used for horizontal or sloped glazing is used, 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;
- d) any broken glass in any glazing should be removed immediately on breakage; and
- 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.

5.3.7 In case of external laminated glass facades, openable portions have to be left at regular distances for firefighting and smoke exhaust.

5.3.8 If Insulating Glass Unit (IGU) is used in situations mentioned in this standard, then one of the following will 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 standard.
- b) In situations where access is restricted to one side of the unit, then only the accessible side should meet the requirements of this standard.

5.4 Manifestation (making glass visible)

5.4.1 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 or other decorative treatment, including being opaque or patterned, the glass should be marked to make it visible.

5.4.2 The manifestation employed should be of a sufficient size to make it immediately obvious. The manifestation should preferably be permanent e.g., etching of the glazing; alternatively, if applied materials are used, they should be durable and not easily removed.

5.4.3 Marking shall be in the form an opaque band not less than 20 mm in height and located so that the vertical distance from the floor level is not less than 700 mm from the upper edge of the band and not more than 1200 mm to the lower edge of the band.

5.4.4 The band shall be such that it is readily apparent and it can be achieved by contrasting the band with background or by increasing height of band. Safety glazing cannot be substituted by making the glass visible by marking.

5.4.5 A band or marking is not required where any one of the following applies:

- a) height of the glass is not greater than 1000 mm at any part;
- b) the 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);
- c) within 750 mm of the floor there is no glass; and
- d) the 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 1000 mm above the floor level. The glazing bar shall have a face width not less than 40 mm \pm 3 mm.

5.5.6 Alternatively, patterns may be used as an acceptable form of marking provided it meets the other criteria in this standard.

5.5 Identification of safety glass

5.5.1 All Safety glasses shall be procured from certified manufacturers and the product shall conform to the requirements of relevant standards. Either a label that cannot be removed and reused or a permanent (indelible) mark on the glass surface shall mark all the panels of safety glass.

NOTE Preferably, safety glass certified by an accredited certification body may be used. Manufacturer's name, registered trademark or code of the manufacturer or supplier, type of safety glass, the standard number against which the safety glass has been tested and the grade of test classification are other commonly marked information.

5.6 Test requirements

5.6.1 Fragmentation test

The fragmentation test shall be done in accordance with RS ISO 12543-2.

5.6.2 Mechanical strength

The required mechanical strength values (see Table 2) apply to quasi-static loading over a short time like wind loading relate to 5% probability of breakage at the lower limit and 95% confidence intervals.

Table 2— Minimum mechanical strength required for fully toughened flat glass

Type of glass	Mechanical strength N/Sq mm
Flat(Clear / Tinted / Coated / Mirror)	120
Enameled flat (Based on enameled surface in tension)	75
Patterned glass	90

If the glass satisfies 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 3 below, these materials can be classified as safety glass.

TABLE 3— Test requirements

Requirements against	Laminated Safety glass	Toughened Safety glass	Test requirement as per
Impact/Resistance to shock	-	Yes	RS ISO 12543-4
Fragmentation Test	-	Yes	
Warp test	-	Yes	
Boil Test	YES	-	
Fracture and Adhesion test	YES	-	
Light stability test	YES	-	

6 Safety related to glass handling, transportation and storage

6.1 Glass handling and transportation safety considerations

6.1.1 Workmen handling or moving glass pieces and waste glass pieces should be provided personal protective equipment including cut/slip resistant gloves and footwear (safety boots) when handling and transporting glass sheets and safety glasses with side shields for eye protection when cutting.

6.1.2 Glass should be inspected before moving it to assure there is no any damage that may cause spontaneous glass breakage to avoid injuries.

6.1.3 Proper and safe lifting and moving techniques including holding the glass firmly in hands and not to carry glass over head or under arms should be used.

6.1.4 When setting glass on the floor, or other any other surface, it should be gently placed down on the long edge and should not be placed directly on hard surfaces, instead, padding, or another type of cushioning agent can be used.

6.2 Glass storage safety considerations

6.2.1 Glass edges shall be covered or otherwise protection provided to prevent hand injuries to workers passing by.

6.2.2 Waste glass pieces should be stored or disposed off in such a manner as to avoid injuries to workmen.

6.2.3 Further glass sheets and plates should not be stacked horizontally nor one upon the other. These should be kept upright slightly slanting.

6.2.4 The following are the safety considerations to avoid injuries/accidents:

- a) all storage areas should be free from slip/trip hazards;
- b) when storing glass on trolleys in a 'static position', ensure trolley braking devices are engaged and restraining bars are used;
- c) glass stored on frames should be evenly loaded on both sides of the frame; and

glass should not be stacked against walls.

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- [3] RS ISO 12543-1: 2011 Glass in building — Laminated glass and laminated safety glass — Part 1: Definitions and description of component parts
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