

भारतीय मानक
Indian Standard

IS 16231 (Part 4) : 2014

भवनों में काँच के प्रयोग — रीति संहिता

भाग 4 मानव प्रभाव से संबंधित सुरक्षा

Use of Glass in Buildings — Code of Practice

Part 4 Safety Related to Human Impact

ICS 81.040.20



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FOREWORD

This Indian Standard (Part 4) was adopted by the Bureau of Indian Standards, after the draft finalized by the Building Construction Practices Sectional Committee had been approved by the Civil Engineering Division Council.

Glazing is an important item in building construction and glass, the primary glazing element has to be selected to cater to several requirements. Fixing of glass a specialized operation, when properly done, shall 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 is published in four parts. The other parts in the series are:

- | | |
|--------|-----------------------------------|
| Part 1 | General methodology for selection |
| Part 2 | Energy and light |
| Part 3 | Fire and loading |

This standard (Part 4) is intended to provide guidance with respect to human impact safety while using glazing in buildings.

Standard specifications of various types of glass are not covered in this standard, for which respective Indian Standards as mentioned/available may be referred to.

Correct selection of materials to be used in glazing for buildings depends on many factors. Therefore, provisions in this standard should be used in conjunction with those in other parts. This standard does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application. Attention may be drawn to SP 7 : 2005 'National Building Code of India, 2005' and the applicable statutory regulations in states/ U.T.s including their development control rules and general building requirements that are in force.

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

This standard (along with the other parts) proposes to withdraw the existing standard, IS 3548 : 1988 'Code of Practice for glazing in buildings (*first revision*)', in view of the comprehensive provisions, proposed herein. However, the contents of the same are included as an informative annex in IS 16231 (Part 1). In the formulation of this standard, inputs were derived from the Confederation of Construction Products and Services, New Delhi's publication, 'Guidelines for Use of Glass in Buildings-Human Safety'.

The composition of the Committee responsible for the formulation of this standard is given at Annex A.

For the purpose of deciding whether a particular requirement of this standard 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 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

USE OF GLASS IN BUILDINGS — CODE OF PRACTICE

PART 4 SAFETY RELATED TO HUMAN IMPACT

1 SCOPE

This standard covers provisions for the selection, 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 REFERENCES

The following standards contain provision which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subjected to revision and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated herein.

IS No.	Title
2553 (Part 1) : 1990	Specification for safety glass: Part 1 Architectural, building and railway uses (<i>third revision</i>)
14900 : 2000	Specification for transparent float glass

3 APPLICATION

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

- a) Glazing thickness calculation subjected to wind load is calculated in accordance to IS 16231 (Part 3).
- b) For a given application, the type and thickness of glass selected shall be in accordance with the requirements of IS 16231 (Part 3).

4 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 14900 and IS 2553 (Part 1) and the following shall apply.

4.1 Annealed Glass (*see* Glass) — It is also known as normal glass, most commonly used for flat glass, that is glass not subjected to toughening, lamination and heat strengthening.

4.2 Aspect Ratio — The ratio of a longer side of glass pane to its shorter side.

4.3 Balustrade — A low wall forming a parapet to a stair, ramp, balcony, raised level or a change in level.

4.4 Chair Rail — A fixed glazing bar or rigid push bar that provides protection from human impact.

4.5 Clear Glass — A transparent glass with neutral/near colourless appearance.

4.6 Corridor — A common passage or circulation space including a common hall.

4.7 Curtain Wall — The non-load bearing structure/partition of glass attached to the building frame, usually on the exterior face.

4.8 Double Glazing — The glazing that incorporates two panels of glass, separated with an air or inert gas space, for the purpose of sound and/or thermal insulation.

4.9 Facade — A front or face of the building which is part of framed or frameless system.

4.10 Faceted Glazing — A type of glazing where flat panes of glass are installed vertically at an angle to each other to form a faceted curve.

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

4.12 Flat Glass — A general term covering sheet glass, float glass and various forms of rolled and plate glass in which shape of the glass is flat.

4.13 Float Glass — A type of flat glass produced by floating molten glass on a bath of molten tin to form continuous ribbon of glass.

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

4.15 Frameless Glazing — An unframed glazing which maintains the integrity through pointed support structures.

4.16 Fully Framed Glazing — The glazing in which panels that have all four edges framed.

- 4.17 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.
- 4.18 Glazing** — The (act of) securing of glass into a building in prepared openings in windows, door panels, partitions.
- 4.19 Guarding** — A physical barricade used to prevent people falling wherever there is a change in floor level by means of a permanent barrier such as guard rail.
- 4.20 Heat Soaking** — A treatment 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 minimized by heat soaking process by forcing such glasses to break during the test itself.
- 4.21 Heat Strengthened Glass** — A glass which has been heated past its softening point and chilled at intermittent speed of annealing and tempering to increase its strength and make it thermally safe, but which breaks like annealed glass.
- 4.22 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.
- 4.23 High Activity Area** — An area where multiple and major human activity takes place.
- 4.24 High Risk Area** — An area prone to human injury and causality.
- 4.25 Infill Balustrades** — The balustrades in which the supported glass resists an infill pressure and/or point load applied to the glass panel.
- 4.26 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.
- 4.27 Interlayer** — The transparent damping material used in laminated glass, usually PVB.
- 4.28 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.
- 4.29 Laminated Safety Glass** — It is a glass made of two or more pieces of glass which are held together by an interleaving layer or layers of plastic materials.
- 4.30 Manifestation** — Any technique for enhancing a person's awareness of the presence of transparent glass.
- 4.31 Maximum Thickness** — The thickness of a panel of glass at the maximum thickness tolerance.
- 4.32 Minimum Thickness** — The thickness of a panel of glass at the minimum thickness tolerance.
- 4.33 Monolithic Glass** — A single sheet of flat glass which could be either annealed, toughened or heat strengthened.
- 4.34 Nominal Thickness** — A numeric designation used for reference purposes that indicates the approximate thickness of glass.
- 4.35 Pane** — A single piece of glass or plastic glazing sheet material in a finished size ready for glazing.
- 4.36 Panel** — An assembly containing one or more panes of glass.
- 4.37 Partition** — It means an interior non-load bearing divider, one storey in height or part.
- 4.38 Partly Framed or Unframed Glazing** — The panels that have one or more edges unframed.
- 4.39 Residual Protection** — It is the protection provided to avoid the human impact to 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.
- 4.40 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 vertical fenestration.
- 4.41 Sloped Overhead Glazing** — A glazing that is inclined at less than 75° to the horizontal and located, wholly or partially, directly above an area that may be used by people.
- 4.42 Spandrel** — A non-vision portion of the exterior wall of a building.
- 4.43 Toughened Safety (Tempered) 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.
- 4.44 Vertical Fenestration** — All fenestration other than skylights. Trombe wall assemblies, where glazing is installed within 300 mm (12 inch) of a mass wall, are considered walls and not fenestration.

5 CRITERIA FOR HUMAN IMPACT SAFETY

5.1 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 standard.

This standard does not assume that the glass used in accordance to this standard will not be broken under all human impact conditions, rather,

- it will not be broken under most likely forms of human impact; and
- 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 by the fracture characteristics of the glass.

Further, this standard does not deal with the safety and security of people or goods in relation to risks of,

- vandalism, riots, burglary or break in protection;
- fire arm protection;
- protection from explosion (terrorist attack);
- natural disasters like earthquakes, cyclone, fire, etc; and
- plastic glazing material, safety and security glazing, etc.

In circumstances wherein the requirements of any referred standard(s) exceeds the requirements of this standard, in such cases the higher requirement shall become applicable.

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

5.2 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 standard that may be used in safety glazing provided they meet the conformity requirements in IS 2553 (Part 1) to them. Safety glass according to this standard shall be of following two types:

- Toughened safety (Tempered) glass (TS), and
- Laminated safety glass (LS).
- Toughened Float Safety Glass (TF)
- Laminated Float Safety Glass (LF)

5.2.1 Precautions

All heat-treated/heat strengthened glasses, laminated, toughened, coated glasses, and annealed glasses are not classified as safety glasses unless laminated to meet the requirement of tests specified in IS 2553 (Part 1) for safety glass.

5.3 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,

- where there is danger of falling infill glass material(s) from overhead glazing;
- the danger of falling due to a change in floor level; and
- in case of balustrades, stairs and floors.

Based on typical accidents in glazed buildings, certain locations are found to be more vulnerable to human impact than others. Some of such critical locations are shown in Fig. 1, where necessary precautions as below have to be followed:

- In-and-around doors, low windows;
- Door side panels;
- Panels mistaken for a doorway or opening;
- Panels at low levels in walls and partitions;
- Bathrooms;
- Building associated with special activities, for example, gymnasias, enclosed swimming pools, etc;
- Schools and child care facilities; and
- 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,

- selecting glass of a suitable type, thickness and size;
- enhancing a person's awareness of presence of glass by making glass visible (manifestation of glass); and
- minimizing manual handling of large pieces of glass during installation.

Based on the above, a comprehensive Table 1 is provided for information and use.

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,

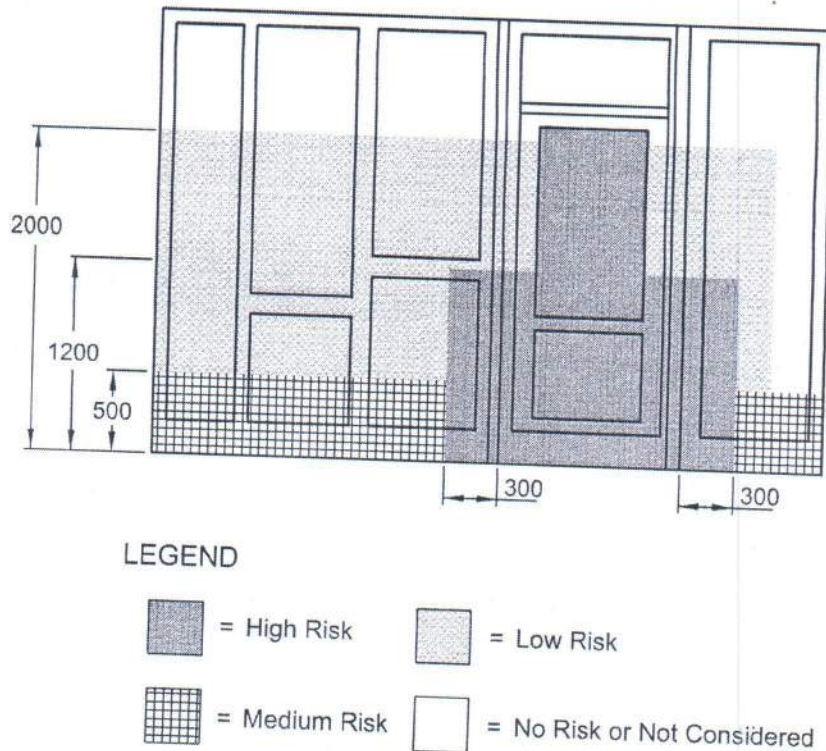


FIG. 1 CRITICAL LOCATIONS

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.

5.4.2 Marking shall be in the form of an opaque band not less than 20 mm in height and located so that the vertical distance from the floor level to the position of manifestation is,

- not less than 700 mm from the upper edge of the band; and
- not more than 1 200 mm to the lower edge of the band.

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

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

- Height of the glass is not greater than 1 000 mm at any part from floor level.
- 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).
- Within 750 mm of the floor there is no glass.
- 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 1 000 mm above the floor level. The glazing bar shall have a face width not less than 40 ± 3 mm; and
- Alternatively patterns may be used as an acceptable form of marking provided it meets the other criteria in this standard.

5.5 Identification

All safety glasses shall be procured from certified manufacturers and the product shall conform to relevant

Table 1 Type of Glass Suggested For Use at Different Critical Locations/Cases in Buildings

(Clause 5.3)

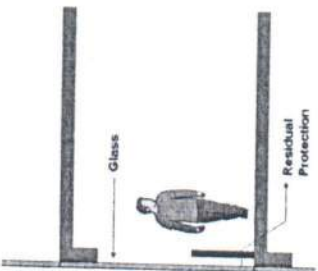
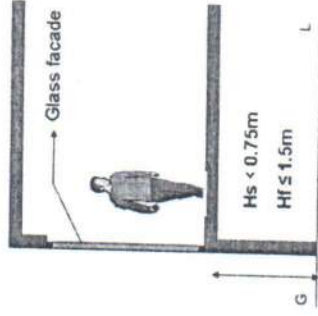
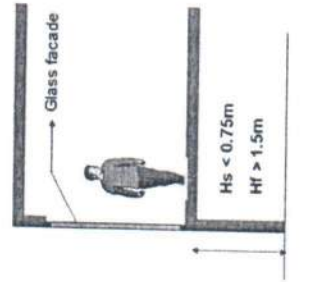


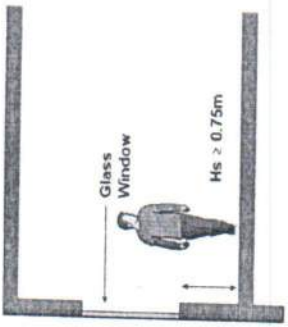
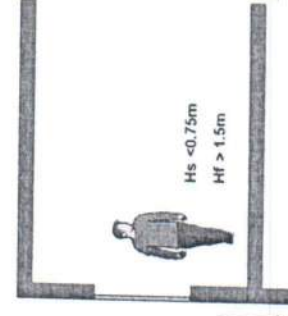


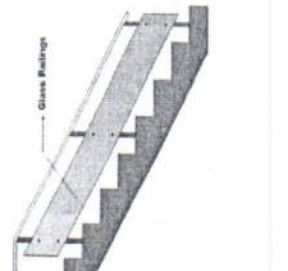
SI No.	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
(1)	Vertical Walls with Residual Protection or $H_s \geq 0.75$ m (not Likely to be Subjected to Human Impact)	Vertical Walls $H_s < 0.75$ m and $H_f \leq 1.5$ m (Human Impact but no Risk of Fall)	Vertical Walls $H_s < 0.75$ m and $H_f \geq 1.5$ m (Human Impact and Risk of Fall)	Horizontal or Sloped Glazing Glass (Risk of Fall)	Glass Acting as a Balustrade/Railing (Human Impact and Risk of Fall)
(2)					
(3)					
Type of glass	Any glass ^{b)}	Safety glass	Safety glass ^{a)}	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	a) Doors b) Side panels c) Curtain walls d) Glazed area e) Doors in Bathroom	a) Curtain walls b) Façade c) Spandrels d) High activity area	a) Roof (Skylights) b) Ceilings c) Bus Shelters d) Floors	a) Balustrades b) Parapets c) Railings

Table 1 — (Concluded)

achieved by providing protection in the form of a sill structure or transom, chair rail or grill work inside	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.	e) High risk area f) To avoid risk	e) Stairs f) Sloped Façade
1) Safety glass is not mandatory.			
2) Laminated float safety glass is preferred.			
NOTES			
1	'H _i ' corresponds to height of fall of human being or glass in case of change in level and 'H _s ' corresponds to the sill height with reference to floor level.		
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:		
	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 from overhead glazing 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 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.		
	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.		
7	In case of external laminated glass façades, 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.		
8	If insulating glass unit (IGU) is used in situations mentioned in this standard, 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 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.		
9	Enhance person's awareness of presence of glass by making visible manifestation.		

standards. Either a label that cannot be removed and reused or a permanent (indelible) mark on the glass surface shall be marked on all the panes of safety glass.

NOTE — Preferably, safety glass certified by BIS with ISI mark, bearing CM/L number and other requirements of BIS certification, may be used. Manufacturers name, registered trade-mark 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, further details of which can be had from IS 2553 (Part 1).

5.6 Test Requirements

5.6.1 Safety glass shall confirm to all the test methods mentioned in the relevant Indian Standards or as listed in Table 2.

5.6.2 Mechanical Strength

The required mechanical strength values (*see* Table 3) 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 3, these materials can be classified as safety glass.

Table 2 Test Requirement
(Clause 5.6.1)

Sl No.	Requirement Against	Laminated Safety Glass	Toughened Safety Glass	Test Requirement as per
(1)	(2)	(3)	(4)	(5)
i)	Impact / Resistance to shock	—	YES	IS 2553 Part 1
ii)	Fragmentation test	—	YES	
iii)	Warp test	—	YES	
iv)	Boil test	YES	—	
v)	Fracture and Adhesion test	YES	—	
vi)	Light stability test	YES	—	

Table 3 Minimum Mechanical Strength Required for Fully Toughened Flat Glass
(Clause 5.6.2)

Sl No.	Type of Glass	Mechanical Strength N/mm ²
(1)	(2)	(3)
i)	Flat (Clear/Tinted/Coated/Mirror)	120
ii)	Enameled flat (Based on enameled surface in tension)	75
iii)	Patterned glass	90

ANNEX A

(Foreword)

COMMITTEE COMPOSITION

Building Construction Practices Sectional Committee, CED 13

Organization	Representative(s)
In personal capacity (Flat No 2061, Engineers Apts, Plot 11, Sector 18A, Dwarka, New Delhi 110 078)	SHRI D. S. SACHDEV (<i>Chairman</i>)
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Central Public Works Department CDO Unit, New Delhi	SHRI A. K. GARG SUPERINTENDING ENGINEER (D) II (<i>Alternate</i>)
Central Public Works Department CSQ Unit, New Delhi	SHRI A. K. SHARMA SHRI S. P. CHOUDHARY (<i>Alternate</i>)
Confederation of Construction Products and Services, New Delhi	SHRI DEEPAK GAHLWT SHRI SHASHI KANT (<i>Alternate</i>)
Delhi Development Authority, New Delhi	CHIEF ENGINEER (SWZ) SUPERINTENDING ENGINEER (P) (SWZ) (<i>Alternate</i>)
Engineers India Limited, New Delhi	SHRI SUDHIR CHATURVEDI SHRI RAVINDRA KUMAR (<i>Alternate</i>)
Fly Ash Unit, Department of Science and Technology, New Delhi	SCIENTIST 'G'
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Public Works Department, Govt of NCT of Delhi, New Delhi	SHRI A.K. SINHA SHRI PUNEET KUMAR VATS (<i>Alternate</i>)
Research, Designs and Standards Organization, (Ministry of Railways), Lucknow	DIRECTOR (Works) SHRI ASHUTOSH KUMAR (<i>Alternate</i>)

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Scientist 'C' (Civil Engg), BIS

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Central Public Works Department, New Delhi
Confederation of Construction Products and Services,
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