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Indian Standard

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भूकंप के पश्चात् भवनों का सुरक्षा आकलन — दिशानिर्देश

Post-Earthquake Safety Assessment of Buildings — Guidelines

ICS 91.120.25

भारतीय मानक ब्यूरो
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FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Earthquake Engineering Sectional Committee had been approved by the Civil Engineering Division Council.

About 80 percent of India's housing stock is located in a landmass that is likely to sustain moderate to severe earthquake ground shaking. Also, a significant part of the existing stock of buildings in India is an outcome of unregulated construction. Losses of life and damage in buildings have been significant during past earthquakes in India. The above facts suggest that large losses are likely in buildings in future also. In the aftermath of an earthquake, it is necessary to undertake a damage assessment to help:

a) Determine whether a building that has sustained earthquake shaking can be continued to be used for the function it has been intended; and
b) Learn the deficiencies in the current building stock to eventually make a critical change in the building bye laws.

The nuances are many behind assessment of buildings in the Indian context, where the number of typologies is large and the variation within the typologies is significant. This standard can be used to meet the above needs. This standard recognizes that the damage assessment can be performed at four levels, namely:

a) Level 1: Simplified qualitative assessment;
b) Level 2: Detailed qualitative assessment;
c) Level 3: Simplified quantitative assessment; and
d) Level 4: Detailed quantitative assessment.

The standard uses the Level 1 method of assessment as the basis for post-earthquake damage assessment of buildings through life-threatening factors, which are specific to each building typology.

The standard is expected to be used only by competent Safety Assessment Inspectors (SAIs), who are formally trained to undertake field surveys in earthquake-affected areas. Competent authorities of the Government of India, State Governments or UT Administrations should commission the SAIs to:

a) Undertake field surveys immediately after the emergency period is over and capture the information needed towards the safety assessment of buildings; and
b) Tag (as per colour code) the buildings using the forms given in this standard.

The intended outcome of the safety assessment survey is a decision on whether or not the building is occupiable and the recommendation for further level(s) of technical evaluation.

In the formulation of this standard due weightage has been given to international coordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country. This has been met by deriving assistance from the following publications:

a) A Primer on Rapid Visual Screening (RVS), consolidating earthquake safety assessment efforts in India, National Disaster Management Authority, New Delhi, 2020.

b) Earthquake Disaster Risk Index (EDRI) report, 50 towns and 1 district in seismic zones III, IV and V, National Disaster Management Authority, New Delhi, 2018.

c) FEMA 178, NEHRP Handbook for the seismic evaluation of existing buildings, Federal Emergency Management Agency, Washington DC, USA.

d) FEMA 310, (1998), Handbook for the seismic evaluation of buildings, Federal Emergency Management Agency, Washington DC, USA.

(*Continued on third cover*)

Indian Standard

POST-EARTHQUAKE SAFETY ASSESSMENT OF BUILDINGS — GUIDELINES

1 SCOPE

1.1 The provisions of this standard are applicable to ascertain whether or not a building affected during an earthquake can be occupied immediately after the earthquake.

1.2 This standard provides guidance only for the two common building typologies, namely:

a) Unreinforced masonry load-bearing buildings; and
b) RC moment frame buildings with unreinforced masonry infill walls.

1.3 Provisions of this standard shall be applicable to buildings hosting the following:

a) Residential buildings;
b) Educational namely schools, colleges, institutes, and university buildings;
c) Hospitals and healthcare facilities;
d) Police headquarters buildings and police stations;
e) Fire stations and fire brigade facilities;
f) Food and civil supplies facilities;
g) Transportation facilities;
h) Power generation and distribution facilities;
j) Communication facilities;
k) Disaster management facilities;
m) Business and mercantile buildings; and
n) Governance facilities.

The competent authorities may identify additional facilities that need to be examined after the earthquake.

1.4 The provisions of this standard seek filling of forms based on visual inspection of the building, and do not require any calculations to be performed using geometric dimensions of buildings or current properties of materials used in the construction of the building.

1.5 The provisions of this standard exclude the loss estimation, and correlation between the damage and loss. However, the standard provides clear recommendation as to which level of technical assessment is needed if the building is not green tagged (*see* **5.3** for colour coded tagging of buildings).

1.6 The provisions of the standard may be suitably used to evaluate/assess the buildings damaged by any other disaster by the agencies/authorities concerned.

2 REFERENCES

The standard given below contains provisions, which, through reference in this text, constitute provisions of this standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of these standards:

IS No.	*Title*
IS 13935 : 2009	Seismic evaluation, repair and strengthening of masonry buildings — Guidelines (*first revision*)
IS 15988 : 2013	Seismic evaluation and strengthening of existing reinforced concrete buildings — Guidelines

3 TERMINOLOGY

For the purpose of this standard, the following definitions shall be applicable:

3.1 Architectural Elements and Utilities — Three sets of finishes of buildings that need to be supported by the structural elements, namely:

a) *Contents of buildings* — Items required for functionally enabling the use of spaces, such as:

1) furniture and other items, for example, storage shelves;
2) facilities and equipment, for example, refrigerators, multi-level material stacks, false ceilings; and
3) door and window panels and frames, or plyboard or aluminium partitions.

b) *Appendages to buildings* — Items projecting out from buildings, either horizontally or vertically, such as chimneys, exterior glass or stone cladding (pasted on the building surface as façades), parapets, small water tanks rested on top of buildings, sunshades, advertisement hoardings and communication antennas atop buildings.

c) *Services and utilities* — Items required for facilitating essential activities in the buildings, such as water mains, electricity cables, air-conditioning ducts, rainwater drainpipes, firefighting, gas pipes, instrumentation cables and elevators.

3.2 Architectural Form — The three features, namely:

a) Overall geometry [shape of geometry (convex or concave), absolute dimensions (too tall, too long and too wide, relative dimensions (plan and elevation aspect ratios)];

b) Choice of structural configuration (regularity of the load paths, regularity of mass, stiffness and strength in plan and elevation); and

c) Choice of non-structural elements and their configuration (interference of the non-structural elements with structural elements during the lateral earthquake shaking).

3.3 Damage Assessment — The process of measuring qualitatively or quantitatively the extent of damage, which the structure has sustained. During the aftermath of the earthquake, damage assessment is done to verify whether the building is: (a) occupiable, (b) not occupiable, or (c) needs further examination.

3.4 Fissure — An opening or crack in the surface of ground.

3.5 Hybrid Building — A building in which the loads on the reinforced masonry (RC) slab are carried by unreinforced masonry walls made primarily of burnt or unburnt clay bricks, adobe or concrete blocks.

3.6 Liquefaction — A process during which granular soils lose their shear strength (and thereby the bearing capacity) under saturated condition when shaken by earthquake ground motion, which occurs primarily in loose saturated cohesionless soils.

3.7 Masonry Building — A building in which the loads on the RC slab are carried primarily by unreinforced masonry walls made primarily of burnt or unburnt clay bricks, adobe or concrete blocks.

3.8 Material — The construction materials used for the structural elements of the building.

3.9 MSK Intensity Scale — Scale used to define the severity of earthquake shaking manifested at a site, evaluated based on three aspects, namely:

a) Behaviour of human beings during the earthquake,
b) Performance of buildings during the earthquake, and
c) Changes induced in the natural surroundings by the earthquake.

NOTE — The scale was proposed by three Russian scientists, namely *Medvedev*, *Sponheur* and *Karnik*, in 1964.

3.10 Non-Structural Elements — The elements which imposes loads and not resist the building loads. Examples include equipment, services such as fire water system, ventilation system, drainage systems and masonry infill walls. These are supported necessarily by structural elements.

3.11 Occupancy — The intended use of the building, for example, residential, business, educational, institutional use, etc.

3.12 RC Moment Frame Building — A building in which the loads on the RC slab are carried by monolithically casted RC frames made of beams, and columns and resting on an RC foundation.

3.13 Safety Assessment — The process of measuring qualitatively or quantitatively the extent of departures in the structure as compared to ideal house of the same typology. Safety assessment is done to verify whether the building needs to be retrofitted or not. The same is done to ensure the safety of the people and services and process systems to avoid life threats.

3.13.1 *Level 1: Simplified Qualitative Assessment* — This level of assessment is based on a rapid visual survey of critical aspects of buildings, after earthquakes, involving limited aspects of details of the building along the five facets, namely site conditions, architectural form, structural system, material condition, and construction details.

3.13.2 *Level 2: Detailed Qualitative Assessment* — This level of assessment is based on a detailed visual survey of conceptual aspects of buildings, after earthquakes, involving all details of the building along the five facets, namely site conditions, architectural form, structural system, material condition, and construction details, without the use of any engineering equipment and without necessarily examining the interiors of the building.

3.13.3 *Level 3: Simplified Quantitative Assessment* **—** This level of assessment is based on a simplified estimation of lateral safety of buildings, involving the estimation of horizontal shear capacity along two principal plan directions of buildings to determine the overall horizontal safety of buildings.

3.13.4 *Level 4: Detailed Quantitative Assessment* **—** This level of assessment is based on the detailed structural safety of buildings, involving complete structural safety evaluation of buildings to determine the deficiencies at the component and overall building levels.

3.14 Site Conditions — The topographical features (for example, flat or sloping ground, and ground with cracks/fissures), and soil behavioural features (for example, potential of liquefaction and lateral spreading, possibility of landslide, or rolling debris) at the location where the building is resting.

3.15 Sliding — A condition in which the earthquake-induced horizontal force is more than the frictional resistance at the base of the object.

3.16 Structural Elements — Members (for example, slabs, beams, columns, foundation(s) and joints between them) of a building that carry inertia forces from mass points to the ground underneath.

3.17 Structural System — Structural system of a building defines the primary load path along the horizontal and vertical elements connected to each other from the mass points where inertia force is induced to the ground underneath.

3.18 Tagged Buildings — Buildings inspected post an earthquake by Safety Assessment Inspectors and identified using colour coded tags.

3.18.1 *Green Tag Buildings* **—** Green tag buildings have no life-threatening or economic loss-inducing feature present in them.

3.18.2 *Red Tag Buildings* **—** Red tag buildings have at least one life-threatening feature present in them.

3.18.3 *Yellow Tag Buildings* **—** Yellow tag buildings have no life-threatening features present in them but have economic loss-inducing features present in them.

3.18.4 *Black Tag Buildings* **—** Black tag buildings have severely damaged vertical load-carrying elements and severely damaged life-threatening features.

3.19 Tilt — The out of the vertical plumb state of the building after earthquake shaking, which can happen when any of the following three happen: (a) soil underneath liquefies, (b) soil underneath settles, or (c) the structural element in the foundation fails.

3.20 Toppling — A condition in which the overturning force generated during earthquake shaking is more than restoring force.

3.21 Visual Inspection — The act of examining visually the condition of the building along five aspects, namely:

a) site conditions,
b) architectural form,
c) structural system,
d) material condition, and
e) construction details, without the use of any engineering equipment and without necessarily examining the interiors of the building.

3.22 Wythe — A single vertical layer of the masonry wall, which behaves independently, during earthquake shaking.

3.23 Safety Assessment Inspector (SAI) — A qualified person with a bachelor's degree in civil engineering or architecture; in addition to the above having competence as mentioned in **7.1.1**.

4 SYMBOLS

The symbols and notations used in this standard are given as under:

AEUs	Architectural Elements and Utilities
DDMA	District Disaster Management Authority
NDMA	National Disaster Management Authority
SAIs	Safety Assessment Inspectors
SAPR	Safety Assessment and Performance Rating
SDMA	State Disaster Management Authority

5 GENERAL PRINCIPLES

5.1 Evaluation Criteria

Criteria for post-earthquake evaluation of buildings considered in this standard include:

a) Loss of vertical load-carrying capacity after the earthquake, and

b) Loss of overall integrity of the building.

5.2 Safety Assessment Inspection

The procedures described in this standard assume that local authorities have the authority to inspect buildings, even apparently undamaged structures, in the post event period. Also, the local authorities can authorize Safety Assessment Inspectors (SAIs) to inspect the building.

5.3 Tagging of Buildings

After the inspection, it is necessary to post the building's safety rating. This is done to let the owner, occupants, and public know whether the building is safe for occupancy and general use. Three different safety posting categories for buildings are as follows:

a) Red tag (unsafe): This indicates that the building shall not be occupied.
   1) Buildings categorized as the red tag may be examined in detail for structural safety by a competent structural engineer.
   2) Based on the examination by a competent structural engineer a building may undergo repair or retrofit as may be required and subsequently re-categorized as a green tag building for occupancy.

b) Yellow tag (requires further evaluation): This indicates that the building shall be evaluated further using a higher-level method (level 2~4).

c) Green tag (safe): Indicates that the building can be occupied.

5.4 Barricading of Buildings

All buildings, which are yellow tagged or red tagged, shall be barricaded compulsorily with clear signage indicating:

a) Yellow and red tags, and
b) Type of entry.

6 EARTHQUAKE SAFETY ASSESSMENT

6.1 Assessment Strategy

Damage assessment of buildings can be performed at four levels specified in IS 13935, namely:

a) Level 1: Simplified qualitative assessment,
b) Level 2: Detailed qualitative assessment,
c) Level 3: Simplified quantitative assessment, and
d) Level 4: Detailed quantitative assessment.

This standard uses level 1 as the basis for post-earthquake safety assessment of buildings. In this step, building safety shall be examined for the purpose of immediate occupancy of buildings through life-threatening factors.

6.1.1 *Life-Threatening Factors* **—** These shall be examined in each of the following aspects:

a) Structural Elements:
   1) Site/ground conditions,
   2) Architectural form and elements,
   3) Structural system and components,
   4) Material condition, and
   5) Construction details.

b) Non-Structural Elements:
   1) Toppling or falling AEUs, and
   2) Sliding or breaking AEUS.

7 FIELD SURVEY

Field surveys shall be performed to undertake earthquake safety assessments after an earthquake. The following forms shall be used for the said assessments of the two typologies of buildings considered in this standard:

a) *Unreinforced masonry load-bearing buildings:*
   Use Form 1A for post-earthquake building safety assessment.
b) *RC moment frame buildings with unreinforced masonry infill walls:*
   Use Form 2A for post-earthquake building safety assessment.

7.1 Field Survey Team

The field survey team consists of Safety Assessment Inspectors (SAIs). They shall undertake the earthquake safety assessment of buildings. They shall be performed only by a formally trained team of three assessors consisting of at least one architect, and at least one structural engineer, who has a good understanding of the earthquake behaviour of buildings and experience in handling the design and construction of buildings.

7.1.1 *Competence*

The SAIs shall be selected only if they have the following qualities:

a) Positive attitude (for example, proactive and willing) to assist the government and the people in a fair and objective post-earthquake damage assessment,
b) Sufficient technical skills are required to identify the structural and non-structural damages in buildings during field surveys, and

c) Sound technical knowledge of the behaviour of buildings during strong earthquake ground shaking.

7.1.1.1 The competent authority shall lay down academic qualifications for the SAI (team lead shall have the qualification not less than a Bachelor's degree in Civil Engineering or Architecture).

7.1.1.2 The competent authority shall arrange to train such persons as provided in **7.1.2**.

7.1.2 *Training*

Making SAIs technically competent requires formal training well before the earthquake. The competent authorities shall arrange for such training of pre-identified eligible civil engineers, structural engineers and architects. This training shall have at least the following three components embedded in them:

a) Performance of buildings in the past earthquake in India and worldwide,
b) Detailed discussion on the field survey forms, and
c) Pilot field exercises to undertake the safety assessment and performance rating first assisted and next unassisted.

After the training, the SDMAs can issue certificates to SAIs, upon successful completion of the training.

7.2 Safety Assessment Inspection

7.2.1 *Main Shock and Aftershocks*

Safety assessment inspection shall be undertaken after an earthquake or an aftershock of MSK intensity VI or higher. A building inspected after an earthquake and tagged red and yellow shall be re-inspected after the said aftershock.

7.2.2 *Managing Human Behaviour after Disaster*

The post-earthquake scenario involving severe damages and collapses is demanding on the Safety Assessment Inspectors. Utmost care shall be taken to ensure the aspects listed hereunder.

a) General public — During inspections, the SAIs shall ensure the following:

   1) The negative features of any building shall not be discussed aloud even amongst the group of SAIs.
   2) The SAIs shall keep reiterating that the assessment is in progress and interested persons may approach the Competent Authorities regarding the final assessment or rating.

b) Owners and tenants — The SAIs shall:

   1) Examine any building only in the presence of a person duly appointed by the Competent Authority to assist in the process.
   2) Not convey to the owner or tenant that their building is safe or unsafe.
   3) Remain empathetic to the owner or tenant throughout the process of inspection.

c) Self — Post-earthquake, the building damage evaluation can be grueling work for the SAI. Hence, the SAI shall:

   1) Have requisite field survey forms customized for the said even and the location of inspection before beginning the survey to eliminate repetitive work at the site.
   2) Keep engaging with fellow Safety Assessment Inspectors to share notes and support each other.

7.2.3 *Judgement*

The decision on any building shall be conveyed only to the competent authorities and not to the owner, tenant or a representative of the society.

a) Objective decision making

This standard provides only typical damages commonly observed in buildings, and not an exhaustive list of all potential damages likely in buildings. When new types of damages are observed (for which guidance has not been provided in this standard, or guidance provided in this standard does not match the field condition), the Safety Assessment Inspectors shall use their experience and judgment, and document the same carefully. At all times, the Safety Assessment Inspectors shall provide the most objective decision irrespective of the consequences and without fear or favour.

b) Building demolition

When a building is black tagged and requires demolition, the competent authorities shall take due precautions to ensure that the adjoining buildings, structures, and facilities do not sustain any detrimental effects during or after demolition. In addition, the aspect of environmental pollution (dust), disposal of garbage has to be managed by competent authorities.

8 EARTHQUAKE SAFETY ASSESSMENT FORMS

For the post-earthquake safety assessment of buildings, the following forms should be used:

a) *Unreinforced masonry load-bearing buildings:*

Use Form 1A for post-earthquake building safety assessment as given in Table 1.

b) *RC moment frame buildings with unreinforced masonry infill walls:*

Use Form 2A for post-earthquake building safety assessment as given in Table 2

Table 1 Form 1A for Level 1 Post-Earthquake Safety Assessment of Masonry Buildings
[*Clauses* 7(a) *and* 8(a)]

L1: M	*Post-Earthquake* **Safety Assessment Masonry Buildings**			
Inspection	Identification	Date		Time
	Inspector 1	*Inspector 2*		*Inspector 3*
Building Description	Building Name	Address		Coordinates
				*N*__________ º
				*E*__________ º
Structural System	Load-bearing Masonry with			
	( ) *Igneous rocks*	( ) *Sedimentary rocks*		( ) *Slate blocks*
	( ) *Others (please specify)* ______________________________			
Structural Components	**Floor System**	( ) *RC slab* ( ) *Timber planks and beams* ( ) *Others (please state)* ________________		
	Roof System	Material	Geometry	
		( ) *RC slab*	( ) *Flat*	
		( ) *Wooden truss with Clay tiles*	( ) *Pitched*	
		( ) *Corrugated sheets*	( ) *Hipped*	
		( ) *Wood planks*	( ) *Others (please state)* __________	
		( ) *Steel truss with corrugated sheeting*		
		( ) *Others (please specify)* _____________		
	Wall Masonry Mortar	( ) *Cement*	( ) *Mud*	
		( ) *Lime*	( ) *Others (please state)* __________	
Occupancy	**Residential**	( ) *Individual house*	( ) *Apartment*	
	Educational	( ) *School*	( ) *College*	
		( ) *Institute or university*		
	Lifeline	( ) *Hospital*	( ) *Police station*	
		( ) *Fire station*	( ) *Power station*	
		( ) *Water plant*	( ) *Sewage plant*	
	Commercial	( ) *Hotel*	( ) *Shopping*	
		( ) *Recreational*		
	Office	( ) *Government*	( ) *Private*	
	Mixed Use	( ) *Residential-Commercial*	( ) *Residential-Industrial*	
	Others	( ) *Please state* ______________		

Sl No.	*Feature*	*Parameters*	*Tag*
i)	**Siting/Ground Issues**	Building has the following *Siting Issues*:	
		1) Ground that has failed due to landslide or fissure.	**Red**
		2) Resting on cracked river terraces during the EQ.	**Red**

		3) Resting on hill slopes or adjacent to hill slopes, and has damaged or/& tilted adjoining or uphill building.	**Red**
		4) Resting on hill slopes that has loose boulders.	**Red**
		5) Vulnerable to falling debris from uphill.	**Yellow**
ii)	**Soil and Foundation Conditions**	Building has the following *Soil & Foundation Conditions*:	
		1) Has uneven settlement of foundation.	**Red**
		2) Soil underneath liquefied.	**Red**
iii)	**Architecture Features and Elements**	Building has the following *Architecture Features*:	
		1) Outer dimensions of building at plinth level less than those at the top in any of the two plan directions.	**Yellow**
		2) Cracks in large unanchored projections and overhangs.	**Red**
		3) Plan aspect ratio of the building is more than 5.	**Yellow**
		4) Building has heavier upper storeys which are damaged.	**Red**
		5) Building is located adjacent to damaged building.	**Red**
iv)	**Structural Aspects and Components**	Building has the following *Structural Aspects*:	
		1) Visible damage due to pounding from adjoining building.	**Red**
		2) Tilted during earthquake.	**Red**
		3) Collapsed/damaged staircase or stair cabin.	**Red**
		4) Plinth masonry severely damaged.	**Red**
		5) Sliding shear failure in the walls in any storey.	**Red**
		6) Separation of walls at corners.	**Red**
		7) Diagonal shear cracks in wall panels and/or spandrels.	**Red**
		8) Floor-wall junction separated with walls out-of-plumb.	**Red**
		9) Gable collapse.	**Red**
		10) Walls separated into wythes.	**Red**
		11) Collapsed cantilevers balconies, chimneys and parapets.	**Red**
		12) Uneven settlement of adjacent building.	**Red**
		13) Damage to large unanchored projections or overhangs.	**Red**
		14) Sliding of roof visible over walls.	**Red**
		15) Crushed masonry at wall base or at any level.	**Red**
		16) Openings in masonry walls are cracked at corners.	**Yellow**
v)	**Material and Construction Details**	Building has the following *Material and Construction Details*:	
		1) Walls made with mud mortar and deteriorated significantly.	**Yellow**
		2) Walls are made with no mortar.	**Yellow**
		3) Poor quality materials.	**Yellow**
		4) Poor quality construction.	**Yellow**
vi)	**All**	None of the above	**Green**

RATING		
If GREEN (with no Red or Yellow flag) *Usable*	**If YELLOW (with no Red flag)** *Assess further as recommended below*	**If at least one RED flag** *Unusable*
Suggested interventions:		

Actions
Building to be sealed ( ) *YES* ( ) *NO*
Building to be demolished ( ) *YES* ( ) *NO*

Table 2 Form 2A for Level 1 Post-Earthquake Safety Assessment of RC MRF Buildings
[*Clauses* 7(b) *and* 8(b)]

L1: RC	*Post-Earthquake* **Safety Assessment Reinforced Concrete Building**			
Inspection	Identification	Date		Time
	Inspector 1	*Inspector 2*		*Inspector 3*
Building Description	Building Name	Address		Coordinates
				*N*__________ º
				*E*__________ º
Structural System	( ) *Moment Frame*		( ) *Moment Frame with Structural Walls*	
	( ) *Moment Frame with Braces*		( ) *Others (Please state)* __________	
Structural Components	**Floor System**	( ) *In-situ*	( ) *Precast Planks with In-situ screed*	
		( ) *Precast*	( ) *Others (Please state)* __________	
	Roof System	( ) *Flat*	( ) *Hipped*	
		( ) *Pitched*	( ) *Others (Please state)* __________	
Occupancy	**Residential**	( ) *Individual House*	( ) *Apartment*	
	Educational	( ) *School*	( ) *College*	
		( ) *Institute or University*		
	Lifeline	( ) *Hospital*	( ) *Police Station*	
		( ) *Fire Station*	( ) *Power Station*	
		( ) *Water Plant*	( ) *Sewage Plant*	
	Commercial	( ) *Hotel*	( ) *Shopping*	
		( ) *Recreational*		
	Office	( ) *Government*	( ) *Private*	
	Mixed Use	( ) *Residential-Commercial*	( ) *Residential-Industrial*	
	Others	( ) *Please state* ______________		

Sl No.	*Feature*	*Parameters*	*Tag*
i)	**Siting Issues**	Building has the following *Siting Issues*:	
		1) Ground that has failed due to landslide or fissure.	**Red**
		2) Resting on cracked river terraces.	**Red**
		3) Resting on hill slopes or adjacent to hill slopes, and has damaged and tilted adjoining or uphill building.	**Red**
		4) Resting on hill slopes that has loose.	**Red**
		5) Vulnerable to falling debris from uphill.	**Yellow**
ii)	**Soil and Foundation Conditions**	Building has the following *Soil and Foundation Conditions*:	
		1) Has uneven settlement of foundation.	**Red**
		2) Soil underneath liquefied.	**Red**
		3) Punching shear failure of foundation.	**Red**
iii)	**Architecture Features and Elements**	Building has the following *Architecture Features*:	
		1) Outer dimensions of building at plinth level less than those at the top in any of the two plan directions.	**Yellow**
		2) Cracks in large, unanchored projections and overhangs.	**Red**
		3) Openings in infill masonry walls are cracked at corners.	**Yellow**
		4) Plan aspect ratio of the building is more than 5.	**Yellow**
		5) Building has heavier upper storeys.	**Yellow**
		6) Building has more than 3 storeys.	**Yellow**
		7) The minimum transverse dimension of columns is 200 mm.	**Yellow**
iv)	**Structural Aspects and Components**	Building has the following *Structural Aspects*:	
		1) Pounding from adjoining building.	**Red**
		2) Tilted during earthquake.	**Red**
		3) Collapsed/damaged staircase or stair cabin.	**Red**

		4) *Open storey* at ground /other level with *shear cracks in columns*.	**Red**
		5) Floating columns with cracked supporting beams.	**Red**
		6) Main load resisting columns and walls have shear cracks.	**Red**
		7) Main load resisting short columns have shear cracks.	**Red**
		8) Flat slab with *1-way punching* shear cracks initiated at column.	**Red**
		9) Flat slab with *2-way punching* shear cracks initiated at column.	**Red**
		10) Spalling of cover concrete in main load resisting columns.	**Red**
		11) Extensive cracking or out-of-plane collapse of infills.	**Red**
		12) Collapsed cantilevers, balconies, chimneys and parapets.	**Yellow**
		13) Plastic water tanks on roof displaced from their supports.	**Yellow**
		14) Separation of infill wall - frame, with no damage in columns.	**Yellow**
v)	**Material and Construction Details**	Building has the following *Material and Construction Details*:	
		1) Poor maintenance of the building.	**Yellow**
		2) Concrete grade is less than M15.	**Yellow**
		3) Corrosion of reinforcing bars visible at some places.	**Red**
		4) Poor quality materials.	**Yellow**
		5) Poor quality construction.	**Yellow**
vi)	**All**	None of the above	**Green**

RATING		
If GREEN (with no Red or Yellow flag) *Usable*	**If YELLOW (with no Red flag)** *Assess further as recommended below*	**If at least one RED flag** *Unusable*
Suggested interventions:		
Actions *Building to be sealed ( ) YES ( ) NO* *Building to be demolished ( ) YES ( ) NO*		

ANNEX B

(*Foreword*)

COMMITTEE COMPOSITION

Earthquake Engineering Sectional Committee, CED 39

Organization	*Representative(s)*
Indian Institute of Technology Madras, Chennai	PROF C. V. R. MURTY **(*Chairperson*)**
Atomic Energy Regulatory Board, Mumbai	DR ROSHAN A. D.
Bharat Heavy Electricals Limited, New Delhi	SHRI RAVI KUMAR
Building Materials and Technology Promotion Council, New Delhi	DR SHAILESH KUMAR AGRAWAL SHRI SHARAD GUPTA (*Alternate*)
Central Public Works Department, New Delhi	CHIEF ENGINEER (D&DM) SUPERINTENDING ENGINEER (*Alternate*)
Central Water Commission, New Delhi	DIRECTOR CMDD (E & NE) DIRECTOR EMBANKMENT (NW&S) (*Alternate*)
Central Soils and Materials Research Station, New Delhi	DR N. P. HONKANDAVAR DR MANISH GUPTA (*Alternate*)
Creative Design Consultants Private Limited, Ghaziabad	SHRI AMANDEEP GARG SHRI BARJINDER SINGH (*Alternate*)
CSIR - Central Building Research Institute, Roorkee	DR NAVJEEV SAXENA DR AJAY CHOURASIA (*Alternate*)
CSIR - National Geophysical Research Institute, Hyderabad	DR PRANTIK MANDAL DR SANDEEP KUMAR GUPTA (*Alternate*)
CSIR - Structural Engineering Research Centre, Chennai	SHRIMATI R. SREEKALA DR K. SATISH KUMAR (*Alternate*)
DDF Consultants Private Limited, New Delhi	DR PRATIMA R. BOSE SHRI SADANAND OJHA (*Alternate*)
Engineers India Limited, New Delhi	DR G. G. SRINIVAS ACHARY DR SUDIP PAUL (*Alternate*)
Geological Survey of India, Lucknow	SHRI L. H. MOIRANGCHA SHRI SNEHASIS BHATTACHARYA (*Alternate*)
Indian Association of Structural Engineers, New Delhi	SHRI MANOJ MITTAL SHRI RAJIV AHUJA (*Alternate*)
Indian Concrete Institute, Chennai	DR K. P. JAYA DR DEBASHISH BANDOPADHYAY (*Alternate*)
Indian Institute of Technology Bhubaneswar, Bhubaneswar	DR SURESH RANJAN DASH
Indian Institute of Technology Bombay, Mumbai	DR RAVI SINHA DR ALOK GOYAL (*Alternate*)
Indian Institute of Technology Delhi, New Delhi	DR DIPTI RANJAN SAHOO DR VASANT MATSAGAR (*Alternate*)

Organization	*Representative(s)*
Indian Institute of Technology Gandhinagar, Palaj	DR AMIT PRASHANT DR MANISH KUMAR (*Alternate*)
Indian Institute of Technology Guwahati, Guwahati	DR HEMANT B. KAUSHIK
Indian Institute of Technology Kanpur, Kanpur	DR DURGESH C. RAI
Indian Institute of Technology Madras, Chennai	DR A. MEHER PRASAD DR RUPEN GOSWAMI (*Alternate* I) DR ARUN MENON (*Alternate* II)
Indian Institute of Technology Roorkee, Roorkee	DR YOGENDRA SINGH DR MANISH SHRIKHANDE (*Alternate* I) DR B. K. MAHESHWARI (*Alternate* II) DR P. C. ASHWIN KUMAR (*Alternate* III)
Indian Society of Earthquake Technology, Roorkee	PRESIDENT VICE PRESIDENT (*Alternate*)
International Institute of Information Technology, Hyderabad	DR PRADEEP KUMAR RAMANCHARLA
Ministry of Earth Sciences, National Centre for Seismology, New Delhi	DR O. P. MISHRA DR H. S. MANDAL (*Alternate*)
National Council for Cement and Building Materials, Ballabgarh	SHRI P. N. OJHA SHRI BRIJESH SINGH (*Alternate* I) SHRI ANUP GHATAK (*Alternate* II)
National Disaster Management Authority, New Delhi	JOINT ADVISOR (MP & P) DR SUSANTA KUMAR JENA (*Alternate* I) SHRI MOHAMMAD JAVED IQBAL (*Alternate* II)
NTPC Limited, New Delhi	DR PRAVEEN KHANDELWAL SHRI SAURABH GUPTA (*Alternate*)
Nuclear Power Corporation India Limited, Mumbai	SHRI ARVIND SHRIVASTAVA SHRI RAGHUPATI ROY (*Alternate*)
Power Grid Corporation of India, Gurugram	SHRI P. N. V. M. PRAKASH SHRI AKASH SHRIVASTAVA (*Alternate*)
SD Engineering Consultants LLP, New Delhi	MS SANGEETA WIJ
Tandon Consultants Private Limited, New Delhi	PROF MAHESH TANDON SHRI VINAY K. GUPTA (*Alternate*)
Tata Consulting Engineers, Mumbai	SHRI ARJUN C. R.
Vakil Mehta Sheth Consulting Engineers, Mumbai	MS ALPA R. SHETH SHRI R. D. CHAUDHARI (*Alternate*)
Visvesvaraya National Institute of Technology, Nagpur	DR O. R. JAISWAL DR R. K. INGLE (*Alternate*)
In Personal Capacity (*Row House 4, Sun City Housing Society, Vadgaon Budruk, Pune*)	DR I. D. GUPTA
In Personal Capacity (*36, Old Sneh Nagar, Wardha Road, Nagpur*)	SHRI L. K. JAIN

Organization	*Representative(s)*
In Personal Capacity (H-102, *VVIP Addresses, Rajnagar Extn, Ghaziabad*)	DR A. K. MITTAL
In Personal Capacity (*174/2 F, Solanipuram, Roorkee*)	DR S. K. THAKKAR
BIS Directorate General	SHRI ARUN KUMAR S., SCIENTIST 'E'/DIRECTOR AND HEAD (CIVIL ENGINEERING) [REPRESENTING DIRECTOR GENERAL (*Ex-officio*)]

Member Secretary
SHRI JITENDRA KUMAR CHAUDHARY
SCIENTIST 'B'/ASSISTANT DIRECTOR
(CIVIL ENGINEERING), BIS

Composition of the Working Group under CED 39, WG 52

Organization	*Representative(s)*
International Institute of Information Technology Hyderabad, Hyderabad	DR PRADEEP KUMAR RAMANCHARLA ***(Convener)***
CSIR - Central Building Research Institute, Roorkee	DR AJAY P. CHOURASIA
Indian Institute of Technology Madras, Chennai	PROF C. V. R. MURTY DR ARUN MENON DR RUPEN GOSWAMI
Indian Institute of Technology Bombay, Mumbai	DR RAVI SINHA
Indian Institute of Technology Guwahati	DR HEMANT B. KAUSHIK
Indian Institute of Technology Roorkee, Roorkee	DR YOGENDRA SINGH
R S Mandrekar & Associates, Mumbai	SHRI JASWANT ARLEKAR
Vakil Mehta Sheth Consultants Private Limited, Mumbai	MS ALPA SHETH
Visvesvaraya National Institute Of Technology, Nagpur	DR O. R. JAISWAL
In Personal Capacity (16-9-831/7/1, Sarojini Nagar *Colony, Old Market, Hyderabad 500036*)	DR D. SRINAGESH

(*Continued from second cover*)

e) FEMA 154, (2002), Rapid visual screening of buildings for potential seismic hazards, Federal Emergency Management Agency, Washington DC.

f) FEMA P154, (2015), Rapid visual screening of buildings for potential seismic hazards: A Handbook, Federal Emergency Management Agency, Washington DC, USA.

g) FEMA P-2055, (2019), Post-disaster building safety evaluation guidance, Federal Emergency Management Agency, Washington DC, USA.

h) METU, (2003), Metropolitan municipality of Istanbul — Earthquake master plan for Istanbul, Middle East Technical University, Istanbul, Turkey.

j) NRCC, (1993), Manual for screening of buildings for seismic investigation, National Research Council of Canada, Ottawa.

k) JBDPA, (2001), Standard for seismic capacity evaluation of existing reinforced concrete buildings, Japan Build Disaster Prevention Association, Tokyo.

m) NZSEE, (2006), Assessment and improvement of the structural performance of buildings in earthquakes, New Zealand Society for Earthquake Engineering, Wellington, New Zealand.

n) NZSEE Provisions, 'The seismic assessment of existing buildings', Technical guidelines for engineering assessments, Assessment objectives and Principles, Part A, July 2017.

In addition to the above, the relevant ISO standards on the theme are formulated by the ISO TC 292 on security and resilience. Some of them have already been adopted by the Risk Management, Security and Resilience Sectional Committee of the Bureau of Indian Standards, namely:

a) IS/ISO 22320 : 2018 Security and resilience emergency management guidelines for incident management;
b) IS/ISO 22395 : 2018 Security and resilience community resilience guidelines for supporting vulnerable persons in an emergency; and
c) IS/ISO TR 22370 : 2020 Security and resilience urban resilience framework and principles.

This standard contributes to the following United Nations Sustainable Development Goal 9, 'Industry, Innovation and Infrastructure' towards building resilient infrastructure, promoting inclusive and sustainable industrialization and fostering innovation; and Goal 11, 'Sustainable cities and communities towards making cities and human settlements inclusive, safe, resilient and sustainable.

The composition of the Committee responsible for the formulation of this standard is given in 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 : 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 standard.

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Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the website-www.bis.gov.in or www.standardsbis.in.

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Amendments Issued Since Publication

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