RAPID VISUAL SCREENING OF RCC BUILDINGS

by:-

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Rapid Visual Screening of Reinforce Concrete Buildings

A.1 RVS Procedure, Objectives and Scope

The Rapid Visual Screening method is designed to be implemented without performing any structural calculations. The procedure utilises a *damageability grading system* that requires the evaluator to (1) identify the primary structural lateral load-resisting system, and (2) identify building attributes that modify the seismic performance expected for this lateral load-resisting system along with non-structural components. The inspection, data collection and decision-making process typically occurs at the building site, and is expected to take couple of hours for a building, depending on its size.

The screening is based on Code based Seismic Intensity, Building Type and Damageability Grade as observed in past earthquake and covered in MSK/European macro-intensity

A.2 Uses of RVS Results

The main uses of this procedure in relation to seismic upgrading of existing buildings are:

i. To identify if a particular building requires further evaluation for assessment of its seismic vulnerability.
ii. To assess the seismic damageability (structural vulnerability) of the building and seismic rehabilitation needs.
iii. To identify simplified retrofitting requirements for the building (to collapse prevention level) where further evaluations are not considered necessary or not found feasible.

A.3 Seismic Hazard in India

As per IS 1893:2002 (Part 1), India has been divided into 4 seismic hazard zones (*see* Fig.A.1). The details of different seismic zones are given below:

Zone II Low seismic hazard (damage during earthquake may be of MSK Intensity VI or lower)
Zone III Moderate seismic hazard (maximum damage during earthquake may be upto MSK Intensity VII)
Zone IV High seismic hazard (maximum damage during earthquake may be upto MSK Intensity VIII)
Zone V Very high seismic hazard (maximum damage during earthquake may be of MSK Intensity IX or greater)

When a particular damage Intensity occurs, different building types experience different levels of damage depending on their inherent characteristics. For carrying out the Rapid Visual Screening, all four hazard zones have been considered.

A.4 Building Types Considered in RVS Procedure

A wide variety of construction types and building materials are used in urban and rural areas of India. These include local materials such as mud, straw and wood, semi-engineered materials such as burnt brick and stone masonry and engineered materials such as concrete and steel. The seismic vulnerability of the different building types depends on the choice of building materials and construction technology adopted. The building vulnerability is generally highest with the use of local materials without engineering inputs and lowest with the use of engineered materials and skills.

The basic vulnerability class of a building type is based on the average expected seismic performance for that building type. All buildings have been divided into type A to type F based on the European Macroseismic Scale (EMS-98) recommendations. The buildings in type A have the highest seismic vulnerability while the buildings in type F have the lowest seismic vulnerability. A building of a given type, however, may have its vulnerability different from the basic class defined for that type depending on the condition of the building, presence of earthquake resistance features, architectural features, number of storeys etc. It is therefore possible to have a damageability range for each building type considering the different factors affecting its likely performance. Some variations in building type are therefore defined as A, B, B+ etc.

The RVS procedure presented here has considered different building types, based on the building materials and construction types that are most commonly found in India. RCC buildings are presented in Tables A.1. The likely damages to buildings have been categorized in different Grades depending on the seismic impact on the strength of the building.

A.5 Grades of Damageability

`Five grades of damageability from G1 to G5 are specified in MSK and European Intensity Scale as described in Table A.2:

A.6 Relationship of Seismic Intensity, Building Type & Damage Grades

Table A.3 provides guidance regarding likely performance of the building in the event of design-level earthquake intensity postulated in the seismic zone. This information has been used in the survey forms to decide if there is necessity of further evaluation of the building using higher level procedures. It can also be used to identify need for retrofitting, and to recommend simple retrofitting techniques for ordinary buildings where more detailed evaluation is not feasible.

The Indicative quantities ***Few, Many*** and ***Most*** as defined in European Intensity Scales are as follows:

Few: Less than (15±5) %; *Many*: Between (15±5) to (55±5) %;

Most: Between (55±5) to100%

As per MSK Intensity scale the average values of these terms may be taken as
Few: 5-15% *Many*: 50% *Most*: 75%
Table A.3 is generally based on MSK descriptions.

A.7 RVS Survey Forms – Special Points

The RVS survey forms are developed here for all the seismic zones II to V based on the probable earthquake Intensities, building types and damageability grades as described above. Some special cases included therein are described below:

1) Importance of Building/Structure

As per IS: 1893-2002, an important factor I is defined for enhancing the seismic strength of buildings & structures, as follows:

***Important buildings**:** Hospitals, Schools, monumental structures; emergency buildings like telephone exchange, television, radio stations, railway stations, fire stations, large community halls like cinemas, assembly halls and subway stations, power stations, Important Industrial establishments, VIP residences & Residences of Important Emergency person.

**Any building having more than 100 Occupants may be treated as Important for purpose of RVS.*

For these important buildings the value of I is specified as 1.5, by which the design seismic force is increased by a factor of 1.5. Now the seismic zone factors for zone II to V are as follows.

Zone	***II***	***III***	***IV***	***V***
Zone Factor	0.10	0.16	0.24	0.36

It is seen that one Unit change in Seismic Zone Intensity increases the Zone Factor 1.5 times.

Hence to deal with the damageability of Important buildings in any zone, they should be checked for one Unit higher zone. The assessment forms are designed accordingly.

2) Special Hazards

There are some special hazardous conditions to be considered:

I. *Liquefiable condition:* Normal loose sands submerged under high water table are susceptible to liquefaction under moderate to high ground accelerations; building founded on such soils will require special evaluation and treatment.

II. *Land Slide Prone Area:* If the building is situated on a hill slope which is prone to land slide/ land slip or rock-fall under monsoon and/or earthquake, special evaluation of the site and treatment of the building will be needed.

III. Irregular Buildings:

Irregularities in buildings are defined in **Cl.7.1 of IS: 1893 – 2002** under the following sub- heads:

i. Plan Irregularities: These are defined in Table 4 of the Code as follows:

a) Torsion Irregularity

b) Re-entrant Corners

c) Diaphragm Discontinuity

d) Out of Plane Offsets

e) Non – Parallel Systems

The Geometric Irregularities in building plans which can be easily identified are shown in Fig.A.2

These irregularities enhance the overall damage (increased grade of damage e.g. at re-entrant corners). Such a building may be recommended for detailed evaluation.

ii. *Vertical Irregularities:* The following vertical irregularities may be seen in masonry buildings (*see* Fig. A.3).

a) Mass Irregularity

b) Vertical Geometric Irregularity

c) In-Plane Discontinuity in vertical Elements Resisting Lateral Forces.

If any of these irregularities are noticed, the building should be recommended for detailed evaluation.

IV. Falling Hazard: Where such hazards are present, particularly in Zones IV & V, recommendations should make reference to these in the survey report as indicated.

V. Type of Foundation Soil: IS 1893-2002 defines three soil types hard/stiff, medium & soft. No effect of these is seen in the design spectra of short period buildings, T< 0.4 second, covering all masonry buildings, hence the effect may be considered not so significant.

Table A.1: Reinforced Concrete Frame Buildings (RCF) and Steel Frames (SF)

Frame Type	Description
C	a) RC Beam Post buildings without ERD or WRD, built in non-engineered way. b) SF without bracings having hinge joints;. c) RCF of ordinary design for gravity loads without ERD or WRD. d) SF of ordinary design without ERD or WRD
C+	a) MR-RCF/MR-SF of ordinary design without ERD or WRD. b) Do, with unreinforced masonry infill. c) Flat slab framed structure. d) Prefabricated framed structure.
D	a) MR-RCF with ordinary ERD without special details as per IS: 13920, with ordinary infill walls (such walls may fail earlier similar to C in masonry buildings. b) MR-SF with ordinary ERD without special details as per Plastic Design Hand Book SP:6(6)-1972.
E	a) MR-RCF with high level of ERD as per IS: 1893-2002 & special details as per IS: 13920. b) MR-SF with high level of ERD as per IS: 1893-2002 & special details as per Plastic Design Hand Book, SP:6(6)-1972
E+	a) MR-RCF as at E with well designed infills walls. b) MR-SF as at E with well designed braces
F	a) MR-RCF as at E with well designed & detailed RC shear walls. b) MR-SF as at E with well designed & detailed steel braces & cladding. c) MR-RCF/MR-SF with well designed base isolation.

Notes: RCF = Reinforced concrete column- beam frame system
SF = Steel column- beam frame system
ERD = Earthquake Resistant Design
WRD = Wind Resistant Design
MR = Moment Resistant jointed frame

IMPORTANT NOTE:

Buildings having severe vertical irregularity e.g. open plinth, stilt floor called soft storey & those having floating columns resting on horizontal cantilever beams are not covered in the above table & will require special evaluation.

Table A.2: ***Grades of Damageability of RCC Buildings***

Classification of damage to buildings of reinforced concrete
Grade 1: Negligible to slight damage (no structural damage, slight non-structural damage) Fine cracks in plaster over frame members or in walls at the base. Fine cracks in partitions & infills.
Grade 2: Moderate damage (Slight structural damage, moderate non-structural damage) Cracks in columns & beams of frames & in structural walls. Cracks in partition & infill walls; fall of brittle cladding & plaster. Falling mortar from the joints of wall panels.
Grade 3: Substantial to heavy damage (moderate structural damage, heavy non-structural damage) Cracks in columns & beam column joints of frames at the base & at joints of coupled walls. Spalling of concrete cover, buckling of reinforced rods. Large cracks in partition & infill walls, failure of individual infill panels.
Grade 4: Very heavy damage (heavy structural damage, very heavy non-structural damage) Large cracks in structural elements with compression failure of concrete & fracture of rebar's; bond failure of beam reinforcing bars; tilting of columns. Collapse of a few columns or of a single upper floor.
Grade 5: Destruction (very heavy structural damage) Collapse of ground floor parts (e.g. Wings) of the building.

*** The grades of damage in steel and wood buildings will also be based on non-structural and structural damage classification (shown in bold print in Table 4). Non-structural damage to infills would be the same as indicated for masonry building in the above table. Structural damage grade in steel & wooden elements still needs to be defined.**

Table A.3: ***Damageability Grades of RCC Buildings***

RCF/SF/BUILDING	**Type of Building**	**Zone II MSK VI or less**	**Zone III MSK VII**	**Zone IV MSK VIII**	**Zone V MSK IX or More**
	C and C+	*Few* of grade 1 (rest no damage)	*Few* of grade 2 (rest of grade 1,0)	*Many* of grade 2 *Few* of grade 3 (rest of grade 1)	*Many* of grade 3 *Few* of grade 4 (rest of grade 2)
	D	-	*Few* of grade 1	*Few* of grade 2	*Many* of grade 2 *Few* of grade 3 (rest of grade 1)
	E and E+	-	-	-	*Few* of grade 2 (rest of grade 1 or 0)
	F	-	-	-	*Few* of grade 1

NOTE:

NOTE:

1. **As per MSK scale, few, Many and Most may be taken as: Few: 15%, Many: 50% and Most: 75%.**
2. **Buildings having vertical irregularity (see note under table 3) may under go severe damage in seismic zones III, IV & V if not specifically designed. Hence they will require special evaluation. Also buildings sited in liquefiable or landslide prone areas will require special evaluation for seismic safety.**
3. **Buildings having plan irregularity may under go a damage of one grade higher in zones III, IV & V. The sur veyor may recommend re-evakuation.**

ZONE V MM IX OR MORE
ZONE IV MM VIII
ZONE III MM VII
ZONE II MM VI OR LESS

AREAS UNDER THE ZONES

V	10.9 %
IV	17.3 %
III	30.4 %

TOTAL DAMAGEABLE AREA
~ 58.6 %

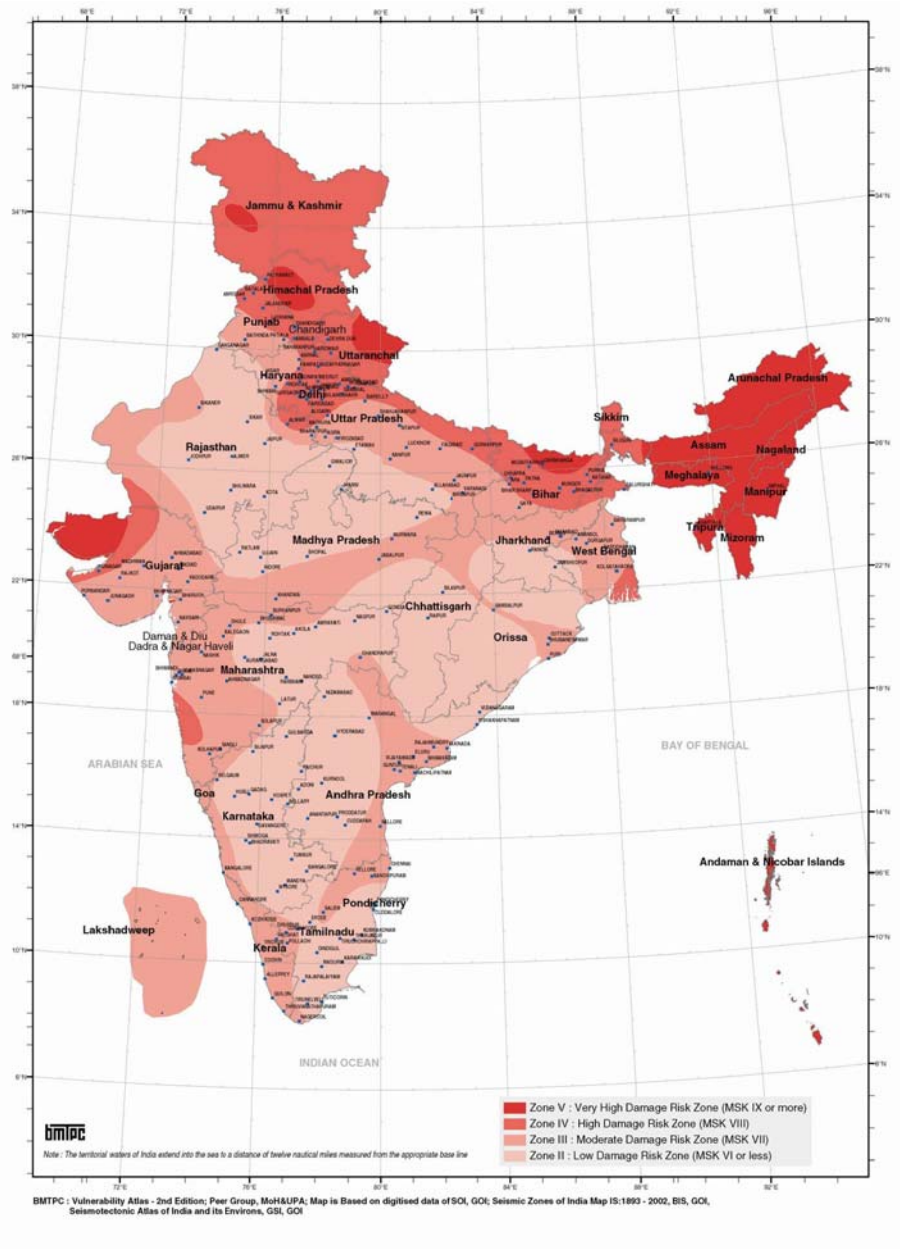


Fig. A.1 EARTHQUAKE HAZARD ZONES 2002

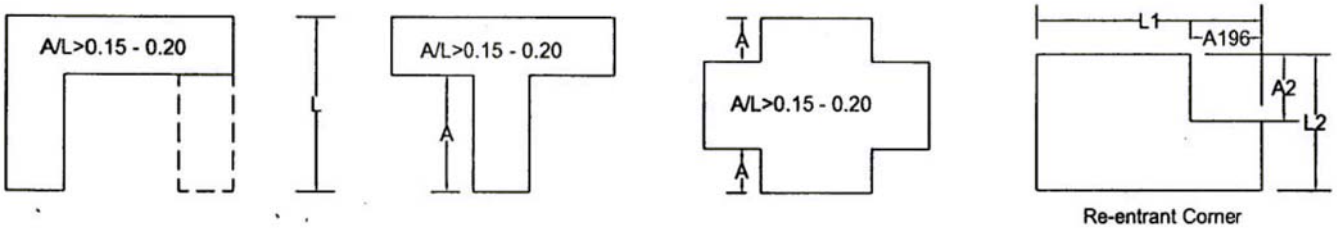
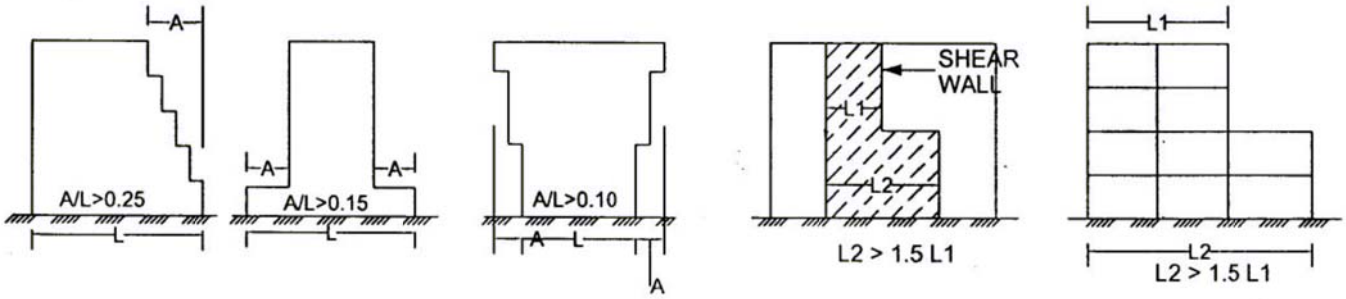
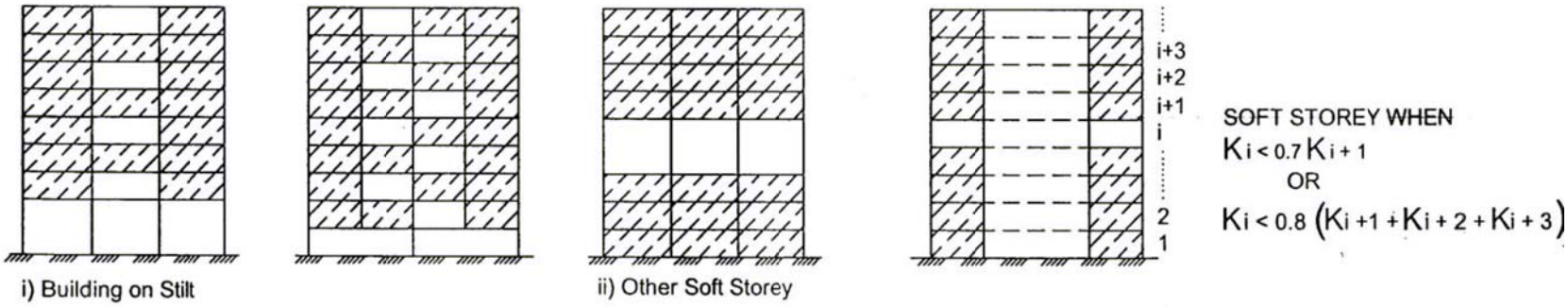


FIG. 2 PLAN IRREGULARITIES



a) Geometrical Irregularities



b) Storey Stiffness Irregularities

FIG.3 VERTICAL IRREGULARITIES

1 Rapid Visual Screening of RC/Steel Buildings for Seismic Hazards

Seismic Zone II Ordinary Building

Photograph

Sketch Plan with Length & Breadth

1.1 Building Name_____

1.2 Use_____

1.3 Address:_____

_____Pin _____

1.4 Other Identifiers_____

1.5 No. of Stories_____ **1.6** Year of Const._____

1.7 Storey Ht: 1st _____, 2nd _____, 3rd_____ etc.

1.8 Total Covered Area; all floors (sq.m) _____

1.9 Ground Coverage (Sq.m):_____

1.10 Soil Type:_____**1.11** Foundation Type:_____

1.12 Depth of Ground water table: _____

1.13 Bldg. Type: Frame ☐ Pre-cast ☐ Frame - Shear Wall ☐ Flat Slab Frame ☐

1.14 Thickness of infill wall: Exterior _____ Interior _____

1.15 Struct. Dwg./Calculations available: Yes / No (If yes,attach)

1.16 Extn. to the original bldg. Yes/ No (If.yes pl. indicate)

1.17 Location of Shear walls (if any)

1.18 Special Confining R/F in Beam/Column/joints:

1.19 Stair case: Separated ☐ Connected ☐ Enclosed ☐

2.0 OCCUPANCY	**3.0 SPECIAL HAZARD**	**4.0 FALLING HAZARD**
2.1 Important buildings*:** Hospitals, Schools, monumental structures; emergency buildings like telephone exchange, television, radio stations, railway stations, fire stations, large community halls like cinemas, assembly halls and subway stations, power stations, Important Industrial establishments, VIP residences & Residences of Important Emergency person. **Any building having more than 100 Occupants may be treated as **Important**.* ***2.2 Ordinary buildings:- Other buildings having occupants <100	**3.1** High Water Table (within 1m) & if sandy soil, then liquefiable site indicated. ☐ Yes ☐ No **3.2** Land Slide Prone Site ☐ Yes ☐ No **3.3** Severe Vertical Irregularity ☐ Yes ☐ No **3.4** Severe Plan Irregularity ☐ Yes ☐ No	**4.1** Chimneys ☐ **4.2** Parapets ☐ **4.3** Cladding ☐ **4.4** Others ☐

RECOMMENDED ACTION:-

☐ Ensure adequate maintenance.

☐ If any Special Hazard 3.0 found , re-evaluate for possible retrofitting.

5.0 Probable Damageability in Few/Many Buildings

Building Type	**5.1 RC or Steel Frame/ wooden Buildings**				**5.2 URM Infill**
Damage-ability in Zone II	**C / C+**	**D**	**E,E+**	**F**	
	G1 / G1	-	-	-	**G1**

Note: +sign indicates higher strength hence somewhat lower damage expected as stated. Also average damage in one building type in the area may be lower by one grade point than the probable damageability indicated.

Surveyor will identify the Building Type; encircle it, also the corresponding damage grade.

Surveyor's sign:_____

Name:_____

Executive Engineer's Sign:_____

Date of Survey:_____

2 Rapid Visual Screening of RC/Steel Buildings for Seismic Hazards

Seismic Zone III Ordinary Building

(Also for Zone II Important Building)

Photograph

Sketch Plan with Length & Breadth

1.1 Building Name_____

1.2 Use_____

1.3 Address:_____

_____Pin _____

1.4 Other Identifiers_____

1.5 No. of Stories_____ **1.6** Year of Const._____

1.7 Storey Ht.: 1st _____, 2nd _____, 3rd_____ .etc.

1.8 Total Covered Area; all floors (sq.m) _____

1.9 Ground Coverage (Sq.m):_____

1.10 Soil Type:_____**1.11** Foundation Type:_____

1.12 Depth of Ground water table: _____

1.13 Bldg. Type: Frame ☐ Pre-cast ☐ Frame - Shear Wall ☐ Flat Slab Frame ☐

1.14 Thickness of infill wall: Exterior _____ Interior _____

1.15 Struct. Dwg./Calculations available: Yes / No (If yes,attach)

1.16 Extn. to the original bldg. Yes/ No (If.yes pl. indicate)

1.17 Location of Shear walls (if any)

1.18 Special Confining R/F in Beam/Column/joints:

1.19 Stair case: Separated ☐ Connected ☐ Enclosed ☐

2.0 OCCUPANCY	**3.0 SPECIAL HAZARD**	**4.0 FALLING HAZARD**
2.1 Important buildings*:** Hospitals, Schools, monumental structures; emergency buildings like telephone exchange, television, radio stations, railway stations, fire stations, large community halls like cinemas, assembly halls and subway stations, power stations, Important Industrial establishments, VIP residences & Residences of Important Emergency person. **Any building having more than 100 Occupants may be treated as **Important**.* ***2.2 Ordinary buildings:- Other buildings having occupants <100	**3.1** High Water Table (within 3m) & if sandy soil, then liquefiable site indicated. ☐ Yes ☐ No **3.2** Land Slide Prone Site ☐ Yes ☐ No **3.3** Severe Vertical Irregularity ☐ Yes ☐ No **3.4** Severe Plan Irregularity ☐ Yes ☐ No	**4.1** Chimneys ☐ **4.2** Parapets ☐ **4.3** Cladding ☐ **4.4** Others ☐

RECOMMENDED ACTION:-

☐ Ensure adequate maintenance.

☐ If any Special Hazard 3.0 found , re-evaluate for possible prevention/retrofitting.

☐ If any of the falling hazard is present, either remove it or strengthen against falling.

Surveyor's Sign :_____

Name:_____

Executive Engineer's Sign:_____

Date of Survey:_____

5.0 Probable Damageability in Few/Many Buildings

Building Type	**5.1 RC or Steel Frame/ wooden Buildings**				**5.2 URM Infill**
Damage- ability in Zone III	**C / C+**	**D**	**E,E+**	**F**	
	G2 / G1	**G1**	**-**	**-**	**G2**

Note: +sign indicates higher strength hence somewhat lower damage expected as stated. Also average damage in one building type in the area may be lower by one grade point than the probable damageability indicated.

Surveyor will identify the Building Type; encircle it, also the corresponding damage grade.

3 Rapid Visual Screening of RC/Steel Buildings for Seismic Hazards

Seismic Zone IV Ordinary Building

(Also for Zone III Important Building)

Photograph

Sketch Plan with Length & Breadth

1.1 Building Name_____

1.2 Use_____

1.3 Address:_____

_____Pin _____

1.4 Other Identifiers_____

1.5 No. of Stories_____ **1.6** Year of Const._____

1.7 Storey Ht.: 1st _____, 2nd _____, 3rd_____ .etc.

1.8 Total Covered Area; all floors (sq.m) _____

1.9 Ground Coverage (Sq.m):_____

1.10 Soil Type:_____**1.11** Foundation Type:_____

1.12 Depth of Ground water table: _____

1.13 Bldg. Type: Frame ☐ Pre-cast ☐ Frame - Shear Wall ☐ Flat Slab Frame ☐

1.14 Thickness of infill wall: Exterior _____ Interior _____

1.15 Struct. Dwg./Calculations available: Yes / No (If yes,attach)

1.16 Extn. to the original bldg. Yes/ No (If.yes pl. indicate)

1.17 Location of Shear walls (if any)

1.18 Special Confining R/F in Beam/Column/joints:

1.19 Stair case: Separated ☐ Connected ☐ Enclosed ☐

2.0 OCCUPANCY	3.0 SPECIAL HAZARD	4.0 FALLING HAZARD
2.1 Important buildings*:** Hospitals, Schools, monumental structures; emergency buildings like telephone exchange, television, radio stations, railway stations, fire stations, large community halls like cinemas, assembly halls and subway stations, power stations, Important Industrial establishments, VIP residences & Residences of Important Emergency person. **Any building having more than 100 Occupants may be treated as **Important**.* ***2.2 Ordinary buildings:- Other buildings having occupants <100	**3.1** High Water Table (within 5m) & if sandy soil, then liquefiable site indicated. ☐ Yes ☐ No **3.2** Land Slide Prone Site ☐ Yes ☐ No **3.3** Severe Vertical Irregularity ☐ Yes ☐ No **3.4** Severe Plan Irregularity ☐ Yes ☐ No	**4.1** Chimneys ☐ **4.2** Parapets ☐ **4.3** Cladding ☐ **4.4** Others ☐

RECOMMENDED ACTION:-

- ☐ C: evaluate in detail for need for retrofitting
- ☐ If any Special Hazard 3.0 found , re-evaluate for possible prevention/retrofitting.
- ☐ If any of the falling hazard is present, either remove it or strengthen against falling.
- ☐ URM infill : evaluate in detail for need of retrofitting

Surveyor's Sign :_____
Name:_____

Executive Engineer's Sign:_____

Date of Survey:_____

5.0 Probable Damageability in Few/Many Buildings

Building Type	5.1 RC or Steel Frame/ wooden Buildings				5.2 URM Infill
Damage-ability in Zone IV	C / C+	D	E,E+	F	
	G3 / G2	G2	-	-	G3

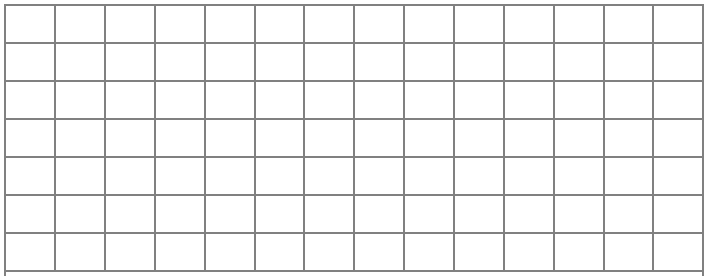
Note: +sign indicates higher strength hence somewhat lower damage expected as stated. Also average damage in one building type in the area may be lower by one grade point than the probable damageability indicated.

Surveyor will identify the Building Type; encircle it, also the corresponding damage grade.

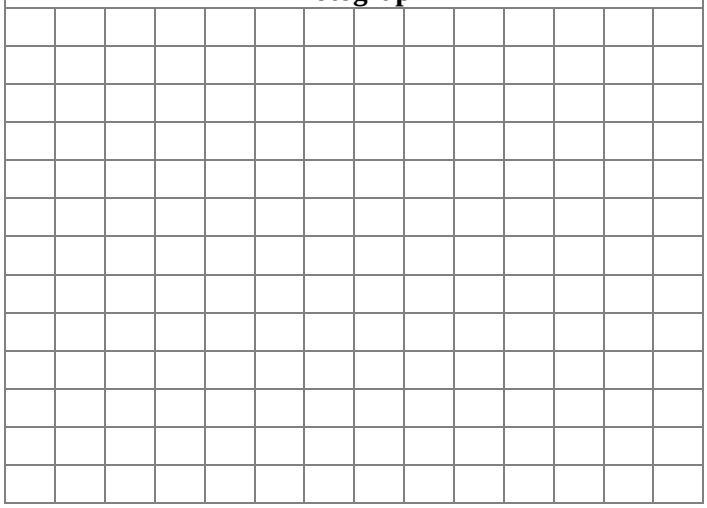
4 Rapid Visual Screening of RC/Steel Buildings for Seismic Hazards

Seismic Zone V All Buildings

(Also for Zone IV Important Building)



Photograph



Sketch Plan with Length & Breadth

1.1 Building Name_____

1.2 Use_____

1.3 Address:_____

_____Pin _____

1.4 Other Identifiers_____

1.5 No. of Stories_____ **1.6** Year of Const._____

1.7 Storey Ht.: 1st _____, 2nd _____, 3rd_____ .etc.

1.8 Total Covered Area; all floors (sq.m) _____

1.9 Ground Coverage (Sq.m):_____

1.10 Soil Type:_____**1.11** Foundation Type:_____

1.12 Depth of Ground water table: _____

1.13 Bldg. Type: Frame ☐ Pre-cast ☐

Frame - Shear Wall ☐ Flat Slab Frame ☐

1.14 Thickness of infill wall: Exterior _____ Interior _____

1.15 Struct. Dwg./Calculations available: Yes / No (If yes,attach)

1.16 Extn. to the original bldg. Yes/ No (If.yes pl. indicate)

1.17 Location of Shear walls (if any)

1.18 Special Confining R/F in Beam/Column/joints:

1.19 Stair case: Separated ☐ Connected ☐ Enclosed ☐

2.0 OCCUPANCY	**3.0 SPECIAL HAZARD**	**4.0 FALLING HAZARD**
2.1 Important buildings*:** Hospitals, Schools, monumental structures; emergency buildings like telephone exchange, television, radio stations, railway stations, fire stations, large community halls like cinemas, assembly halls and subway stations, power stations, Important Industrial establishments, VIP residences & Residences of Important Emergency person. **Any building having more than 100 Occupants may be treated as **Important**.* ***2.2 Ordinary buildings:- Other buildings having occupants <100	**3.1** High Water Table (within 3m) & if sandy soil, then liquefiable site indicated. ☐ Yes ☐ No **3.2** Land Slide Prone Site ☐ Yes ☐ No **3.3** Severe Vertical Irregularity ☐ Yes ☐ No **3.4** Severe Plan Irregularity ☐ Yes ☐ No	**4.1** Chimneys ☐ **4.2** Parapets ☐ **4.3** Cladding ☐ **4.4** Others ☐

RECOMMENDED ACTION:-

- ☐ C: evaluate in detail for need for retrofitting to achieve type E, E+.
- ☐ If any Special Hazard 3.0 found , re-evaluate for possible prevention/ retrofitting.
- ☐ If any of the falling hazard is present, either remove it or strengthen against fall.
- ☐ URM infill : evaluate for need of reconstruction or possible retrofitting to level D.

5.0 Probable Damageability in Few/Many Buildings

Building Type	**5.1 RC or Steel Frame/ wooden Buildings**				**5.2 URM Infill**
Damage-ability in Zone V	**C / C+**	**D**	**E,E+**	**F**	
	G4 / G3	**G3**	**G2/G1**	**G1**	**G4**

Note: +sign indicates higher strength hence somewhat lower damage expected as stated. Also average damage in one building type in the area may be lower by one grade point than the probable damageability indicated.

Surveyor will identify the Building Type; encircle it, also the corresponding damage grade.

Surveyor's Sign :_____

Name:_____

Executive Engineer's Sign:_____

Date of Survey:_____

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