

RAPID VISUAL SCREENING OF MASONRY BUILDINGS

by:-

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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. Masonry 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) to 100%

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 geological & geotechnical 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: Masonry load bearing wall buildings

Building Type	Description
A	<ul style="list-style-type: none"> a) Rubble (Field stone) in mud mortar or without mortar usually with sloping wooden roof. b) Uncoursed rubble masonry without adequate 'through stones'. c) Masonry with round stones.
B	Semi-dressed, rubble, brought to courses, with <i>through</i> stones and long <i>corner</i> stones; unreinforced brick walls with country type wooden roofs; unreinforced CC block walls constructed in mud mortar or weak lime mortar.
B+	<ul style="list-style-type: none"> a) Unreinforced brick masonry in mud mortar with vertical wood posts or horizontal wood elements or seismic band (IS: 13828) b) Unreinforced brick masonry in lime mortar.
C	<ul style="list-style-type: none"> a) Unreinforced masonry walls built from fully dressed (Ashler) stone masonry or CC block or burnt brick using good cement mortar, either having RC floor/roof or sloping roof having eave level horizontal bracing system or seismic band. b) As at B with horizontal seismic bands (IS: 13828)
C+	Like C(a) type but having horizontal seismic bands at lintel level of doors & windows (IS: 4326)
D	Masonry construction as at C(a) but reinforced with bands & vertical reinforcement, etc (IS: 4326), or <i>confined</i> masonry using horizontal & vertical reinforcing of walls.

Table A.2: Grades of Damageability of Masonry Buildings

Classification of damage to masonry buildings	
Grade 1: Negligible to slight damage (no structural damage, slight non-structural damage)	
<i>Structural:</i>	Hair-line cracks in very few walls.
<i>Non-structural:</i>	Fall of small pieces of plaster only. Fall of loose stones from upper parts of buildings in very few cases.
Grade 2: Moderate damage (Slight structural damage, moderate non-structural damage)	
<i>Structural:</i>	Cracks in many walls, thin cracks in RC* slabs and A.C.* sheets.
<i>Non-structural:</i>	Fall of fairly large pieces of plaster, partial collapse of smoke chimneys on roofs. Damage to parapets, chajjas. Roof tiles disturbed in about 10% of the area. Minor damage in under structure of sloping roofs.
Grade 3: Substantial to heavy damage (moderate structural damage, heavy non-structural damage)	
<i>Structural:</i>	Large and extensive cracks in most walls. Wide spread cracking of columns and piers.
<i>Non-structural:</i>	Roof tiles detach. Chimneys fracture at the roof line; failure of individual non-structural elements (partitions, gable walls).
Grade 4: Very heavy damage (heavy structural damage, very heavy non-structural damage)	
<i>Structural:</i>	Serious failure of walls (gaps in walls), inner walls collapse; partial structural failure of roofs and floors.
Grade 5: Destruction (very heavy structural damage)	
Total or near total collapse of the building.	

* RC = Reinforced Concrete; AC = Asbestos Cement

Table A.3: Damageability Grades of Masonry Buildings

M A S O N R Y B U I L D I N G S	Type of Building	Zone II MSK VI or less	Zone III MSK VII	Zone IV MSK VIII	Zone V MSK IX or More
	A	<i>Many</i> of grade 1 <i>Few</i> of grade 2 (rest no damage)	<i>Most</i> of grade 3 <i>Few</i> of grade 4 (rest of grade 2 or 1)	<i>Most</i> of grade 4 <i>Few</i> of grade 5 (rest of grade 3, 2)	<i>Many</i> of grade 5 (rest of grade 4 & 3)
	B and B+	<i>Many</i> of grade 1 <i>Few</i> of grade 2 (rest no damage)	<i>Many</i> of grade 2 <i>Few</i> of grade 3 (rest of grade 1)	<i>Most</i> of grade 3 <i>Few</i> of grade 4 (rest of grade 2)	<i>Many</i> of grade 4 <i>Few</i> of grade 5 (rest of grade 3)
	C and C+	<i>Few</i> of grade 1 (rest no damage)	<i>Many</i> of grade 1 <i>Few</i> of grade 2 (rest of grade 1, 0)	<i>Most</i> of grade 2 <i>Few</i> of grade 3 (rest of grade 1)	<i>Many</i> of grade 3 <i>Few</i> of grade 4 (rest of grade 2)
	D		<i>Few</i> of grade 1	<i>Few</i> of grade 2	<i>Many</i> of grade 2 <i>Few</i> of grade 3 (rest of grade 1)

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 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 surveyor may recommend re-evaluation.

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 10.8 %
 IV 17.5 %
 III 30.8 %

TOTAL DAMAGEABLE AREA

~ 59 %

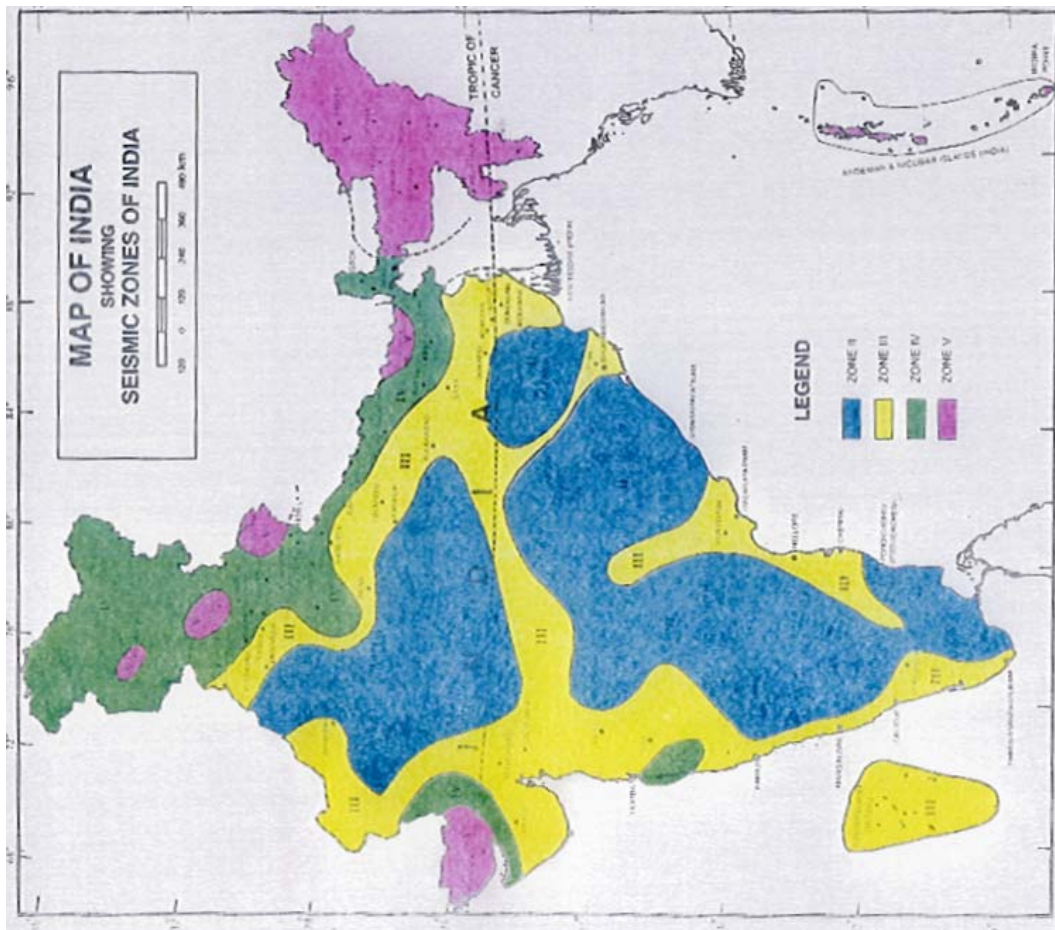
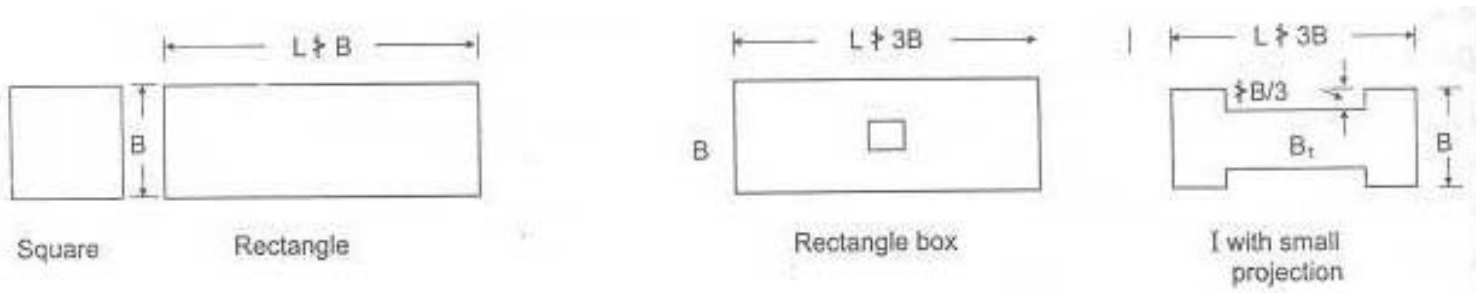


Fig. A.1 EARTHQUAKE HAZARD ZONES 2002



(a) Symmetrical desirable plans

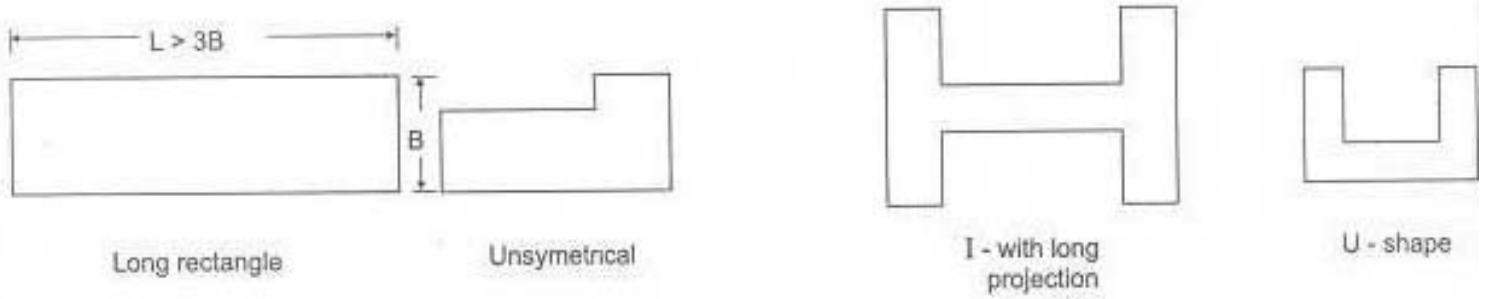


FIG. A.2:- HORIZONTAL IRREGULARITIES

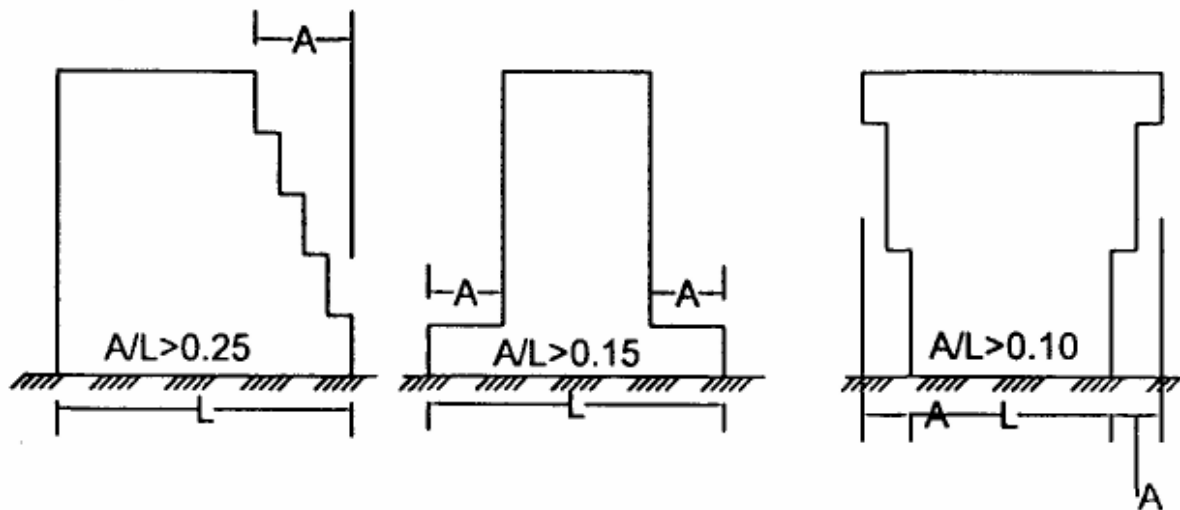


FIG. A.3:- VERTICAL IRREGULARITIES

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