Rapid Structural and Non-structural Assessment of School and Hospital Buildings in SAARC Countries

Repaired and Retrofitted Hospital after the 2005 Muzzafarabad Earthquake (M 7.6)
Under guidance of Professor A. S. Arya

SAARC Disaster Mangement Centre, New Delhi
2011

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SAARC

SAARC Disaster Management Centre

New Delhi

Preface

South Asia is one of the most earthquake prone regions in the world. Six out of the eight countries of South Asia - Afghanistan, Pakistan, India, Nepal, Bhutan and Bangladesh - are located within most seismically active Himalayan - Hindukush belt which has faced some of the worst earthquakes recorded in history. Sri Lanka, Maldives and large parts of the coastal areas of Bangladesh, India and Pakistan are vulnerable to tsunamigenic earthquake in the Indian Ocean.

Earthquakes have caused heavy damages in terms of deaths, injuries, destruction of habitat and disruption of economic activity. Realising the potentially catastrophic consequences of largely unpredictable earthquakes, particularly in growing urban areas in different seismic zones of South Asia, it has become imperative that countries of the region pool their resources, expertise and strengths and share their experiences with each other in managing the risks of earthquake. In order to discuss various issues of earthquake risk management in the region, a Regional Workshop on Earthquake Risk Management was organized in Islamabad on 8-9 October 2009 by the SAARC Disaster Management Centre, New Delhi in collaboration with the National Disaster Management Authority of Pakistan.

The workshop adopted a Roadmap for Regional Cooperation for Earthquake Risk Management in the region, which prescribed inter alia that the SAARC Disaster Management Centre (SDMC) may develop of a Regional Plan for School and Hospital Safety in consultation with the Member States for implementation by the Member States.

The Governing Board of the SDMC decided that in order to implement this road map a template shall be developed by the SDMC in consultation with the experts of the Member States for rapid structural and non-structural assessment of school and hospital buildings. The template shall be circulated to the Member States for compiling necessary information on the current status of safety of school and hospital buildings, based on which respective Member States shall develop National Plans of Action for School and Hospital Safety which would include inter alia the strategies for implementation of the plans. The National Action Plans shall be compiled in the shape of a Regional Plan of Action for School and Hospital Safety by the SDMC.

SDMC requested Dr. A.S.Arya, Professor Emeritus, Earthquake Engineering, IIT Roorkee who is an internationally reputed expert to develop the template. The template developed by Dr.Arya was circulated to the experts from the region for review and further placed before the Governing Board. Based on the comments received the template has been finalized.

SDMC feels happy to release the print version of the template.

P.G.Dhar Chakrabarti
Director
SAARC Disaster Management Centre
New Delhi

Content

Rapid Visual Screening of School and Hospital Buildings in SAARC Countries

1. Introduction

1.1 Need for Seismic Evaluation

An existing building may not comply with requirements of the earthquake building codes for various reasons, such as the following:

- The buildings may not have been designed initially to resist earthquake loads, as it may have been constructed before such a code was adopted, or even if adopted it may not have been mandatory.
- Even if the building was initially built to the earthquake code provisions, the seismic resistance requirements may have been revised upwards in the later revisions of the code.
- The use of building may have changed requiring higher level of safety.
- The condition of the buildings may have deteriorated over the years, in the absence of proper maintenance.

1.2 Steps in Evaluation

There are a few steps involved in the evaluation of the seismic resistance of an existing building.

First, A quick assessment may be carried out by a procedure called Rapid Visual Screening (RVS). This procedure involves a rapid visual inspection and information gathering about the building from the municipal building department records, the owner and the maintenance personnel to identify the vulnerable elements in the buildings.

When a building is identified as vulnerable, the next step will be to have detailed evaluation by acquiring relevant data so as to carry out the detailed assessment of the deficiencies which would need treatment by retrofitting.

1.3 Objective of the Guideline

The objective of this guideline is to formulate the procedure to carry out the Rapid Visual Screening of large number of various school and health buildings in all the SAARC region countries by which an initial appraisal could be obtained about the collapse potential or the damageability grades to which they may be subjected in the Seismic Intensity occurrence postulated in the Seismic Zone they are situated in. This information will help in developing damage potential of such important community buildings in future earthquake occurrences so that countries may prepare suitable disaster management plans accordingly.

The RVS Procedure Outline

2.1 Purpose of RVS

The RVS procedure has been formulated to *identify, inventories*, and to *rank* buildings that may be potentially hazardous under Maximum Considered Earthquake (MCE) at the site of the building. The RVS procedure is designed to be implemented without performing structural analysis calculations. It utilizes a procedure that requires the Assessor to (1) identify the primary structural lateral-load-resisting system of the building; and (2) identify building attributes that will modify the seismic performance expected of this lateral-load-resisting system.

2.2 Data Collection Forms for RVS

The inspection, data collection, and decision-making process will occur mostly at the building site with access to its exterior as well as the interior. Results are recorded on one of RVS Forums (Data Collection Forms), prepared separately according to the seismicity of the region being surveyed. The RVS procedure can be implemented relatively quickly and inexpensively to develop a list of potentially hazardous buildings without the high cost of a detailed seismic analysis of individual buildings. Some times buildings may be reviewed from the sidewalk without the benefit of building entry, structural drawings, or structural calculations. But the reliability and confidence in building attribute determination are increased, however, if the structural framing system can be verified during interior inspection, or on the basis of a review of constructions documents. The RVS procedure may be applicable throughout a country only, for all conventional building types. But it may not be applicable to bridges, large towers, and other non-building structure.

2.3 RVS Result

If a building receives a *high score* or indicative of *minimum structural damage Grade* (i.e., above a specified cut-off score), the building is considered to have adequate seismic resistance. If a building receives a *lower safety score*, high damageability Grade it is recommend to be evaluated by a professional engineer having experience or training in seismic design.

On the basis of a detailed inspection, engineering analysis, and other detailed procedures, a final determination of the seismic adequacy and need for retrofitting can be finalized. If the RVS authority decides that a low score automatically requires that further study be performed by a professional engineer, then some *acceptable level* of qualification held by the Assessor performing the screening will be necessary.

2.4 Use of RVS Result

RVS projects have a wide range of goals and they have constraints on budget, completion date and accuracy, which must be considered by the RVS authority as it selects qualification requirements of the screening personnel. Under most circumstances, a well planned and thorough RVS project will require *engineers* to perform the inspections. In any case, the program should be overseen by a design professional knowledgeable in seismic design for quality assurance purposes.

Seismic Hazard Intensities in SAARC Countries

3.0 The seismic hazard status of the SAARC Countries has been searched through internet as well as available published literature. The Hazard Intensity is part of the RVS forms since the vulnerability of existing school and hospital buildings, or infact any other building, is related to the intensity of the earthquake hazard, higher the intensity higher the damage the building will sustain and higher will be its vulnerability. Hence each level of seismic intensity forms the basis of one RVS Form and *the number of such forms will be equal to the number of seismic intensity zones*. Effort has been made here to collect the seismic hazard data for each country to correlate with one of the following three intensities:

- ***High** hazard intensity*
- ***Moderate** hazard intensity*
- ***Low** hazard intensity*

3.1 Determination of seismic hazard intensity

3.1.1 FEMA 154 method for RVS'

For use with FEMA 154 RVS procedure and Arya procedure, the Seismic Hazard Intensity may be determined as explained below:

According to FEMA 154, the level of hazard intensity will be determined in the following manner. From the seismic hazard map of the country, find the design Spectral Accelerations (SA) for the time Period of 0.2 second and 1.0 second, then multiply the value by a factor of 2/3 and check the calculated values as below:

Table 3.1 Definition of Hazard Intensities in FEMA 154 RVS Handbook

Level of Seismic hazard intensity	Calculated 2/3 SA for period of 0.2 second	Calculated 2/3 SA for period of 1.0 second
High Hazard	Greater than or equal to 0.50 g	Greater than or equal to 0.20 g
Moderate Hazard	Between 0.167 g and 0.5 g	Between 0.067 g and 0.20 g
Low Hazard	Less than 0.167 g	Less than 0.067 g

It is proposed to use the same criteria for specifying the hazard intensities in the seismic zones of SAARC countries when using FEMA 154 for RVS.

3.1.2 Arya method for RVS

This method uses MSK intensities for preparing RVS form. An equivalence with FEMA 154 hazard intensities is studied below:

The spectral Acceleration curves adopted in IS:1893-2002 are shown in Fig. 3.1. Using these curves with Peak Ground Acceleration values specified for the zones, namely 0.36g in Zone V (MSK IX), 0.24g in Zone IV (MSK VIII) and 0.16g in Zone III (MSK VII), the value of 2/3 SA are obtained as given in Table 3.2.

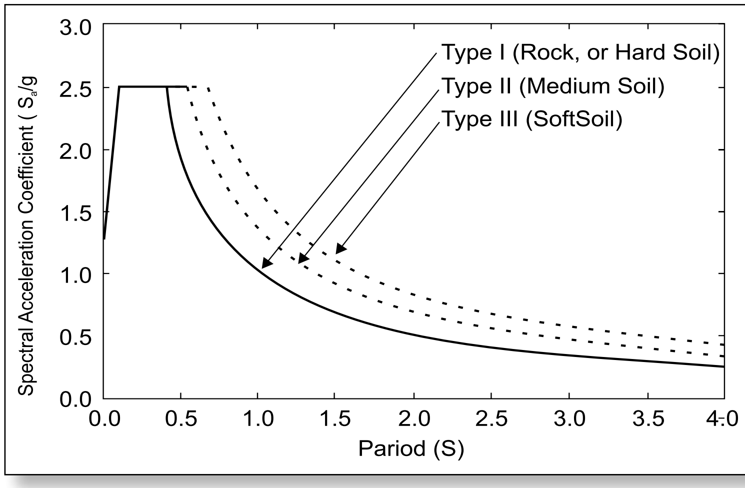


Fig. 3.1: Response Spectra for Rock and Soil Sites for 5 percent Damping

Table 3.2: Definition of MSK Intensities in Arya's RVS.

2/3 SA for T= 0.20 sec		**2/3 SA for T=1.0 sec**		
Intensity PGA	**All Soil**	**Soft Soil**	**Medium Soil**	**Hard Soil**
MSK IX = 0.36g	0.60 g	0.40 g	0.33 g	0.24 g
MSK VIII = 0.24 g	0.40g	0.27 g	0.22 g	0.16 g
MSK VII = 0.16 g	0.27g	0.18 g	0.15 g	0.11 g

For Comparing the values of FEMA 154 criteria with the spectral Acceleration result of IS: 1893-2002 (the India Standard Design Criteria), the values obtained are shown in the Table 3.2. Only values for Hard Soil are compared since FEMA 154 has Score Modifiers for softer soils.

- MSK IX has 0.2 sec value of 0.6g which is >0.50 g, and 1.0 sec value of 0.24g>0.20g. Hence MSK IX may be taken as **High** Hazard Intensity.
- MSK VIII has 0.2 sec value as 0.4g for all soils which lies between 0.167 and 0.5 g hence may be taken as **Moderate** Hazard Intensity. Also the 1.0 sec value is 0.16g for hard soil which satisfies Moderate Hazard Intensity criteria of FEMA 154.
- MSK VII has 0.2 sec value as 0.27g which is considerably higher than 0.167g. Also the 1.0 sec value is 0.11g for hard soil which is considerably higher than .067g of FEMA 154. Therefore MSK VII is more conservative than the **Low** Hazard definition of FEMA 154.

Therefore for all purposes, MSK IX, VIII and VII may be considered as **High, Moderate** and **Low** hazard intensities for RVS procedure.

Hence for SAARC Countries, the hazard intensity criteria can be suitably defined based on Paras 3.1.1 and 3.1.2.

3.2 Afghanistan

The seismic zoning map of Afganistan is shown in figure 3.2. It shows seismic zones of MSK 'IX and higher'

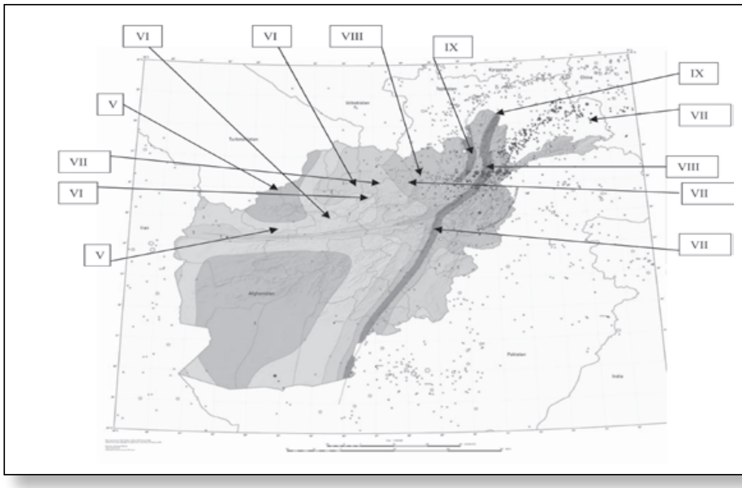


Fig. 3.2 : Map of Afghanistan

representing High Hazard Zone, MSK VIII Zone of Moderate Hazard, and MSK VII Zone of Low Hazard. It also shows MSK 'VI and lower Zones representing Very Low Hazard.

3.3 Bangladesh

"Based on the frequency, intensity and geologic condition, Bangladesh has been divided into three generalized seismic zones which has been shown in Figure 3.3 and the zones are zone-I, zone-II and zone-III.

"Zone-I comprising the northern and eastern regions of Bangladesh with the presence of the Dauki Fault system of eastern Sylhet and the deep seated Sylhet Fault, and proximity to the highly disturbed southeastern Assam region with the Haflong thrust, Naga thrust and Disang thrust, is a zone of high seismic risk with a basic seismic co-efficient of 0.08. Northern Bangladesh comprising greater Rangpur and Dinajpur districts is also a region of high seismicity because of the presence of the Jamuna Fault and the proximity to the active east-west running fault and the Main Boundary Fault to the north in India. The Chittagong-Tripura Folded Belt experiences frequent earthquakes, as just to its east is the Burmese Arc where a large number of shallow depth earthquakes originate. Zone-II comprising the central part of Bangladesh represents the regions of recent uplifted Pleistocene blocks of the Barind and Madhupur Tracts, and the western extension of the folded belt. The Zone-III comprising the southwestern part of Bangladesh

Fig. 3.3 : Seismic Zone Map of Bangladesh

is seismically quiet, with an estimated basic seismic co-efficient of 0.04".

For purpose of RVS, Zone I may be taken to present **High** Hazard, Zone II as **Moderate** Hazard and Zone III as **Low** Hazard Zone.

3.4 Bhutan

Seismic zoning map of Bhutan could not be found and apparently not prepared as yet. Bhutan is surround on the east-south and west by the India states of Assam and Sikkim and Tibet on the north side. According to the definitions of **High** and **Moderate** seismic hazards defined in Para 3.1.2, Assam will be under **high** seismic hazard and Sikkim under **moderate** seismic hazard. Also looking at the earthquake occurrences in the territory of Bhutan and in it close vicinity around it, it may be concluded that the RVS Forms of **High** and **Moderate** hazards will be applicable in Bhutan. The country can determine based on the seismic zoning map to be developed in future as to which hazard intensity will be most relevant at any place and the RVS forms may be chosen accordingly.

3.5 India

Four seismic zones are specified in the seismic zoning map of India shown in Fig. 3.4 namely Seismic Zone V, IV, III and II based on MSK Intensities 'IX and more', MSK VIII, MSK VII and MSK 'VI or lower' respectively. As stated earlier under Para 3.1.2, Seismic Zone V may be taken as **high** hazard intensity, Zone IV be considered as **moderate** hazard intensity and Zone III may be considered as **low** hazard intensity area for purposes of carrying out RVS survey of school and hospital buildings.

3.6 Maldives

The earthquake study carried out for Maldives by RMSI under UNDP assisted project has proposed the seismic zoning map shown in Fig. 3.5 according to which the whole area has been divided into five seismic zones as follows:

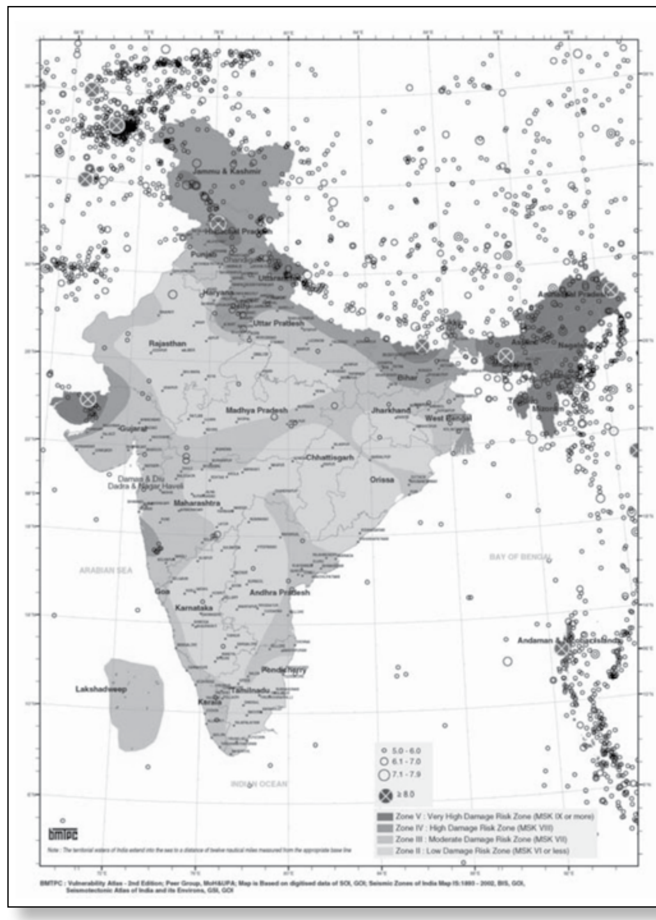


Fig. 3.4 : Seismic Zone Map of India

Table 3.3 : Probable Maximum PGA values in each Hazard Zone

Seismic Hazard Zones	PGA values for 475 yrs return period	Equivalent Intensity of MSK Scale
1	Less than 0.04	IV
2	0.04 to 0.05	V
3	0.05 to 0.07	VI
4	0.07 to 0.18	VII
5	0.18 to 0.32	VIII

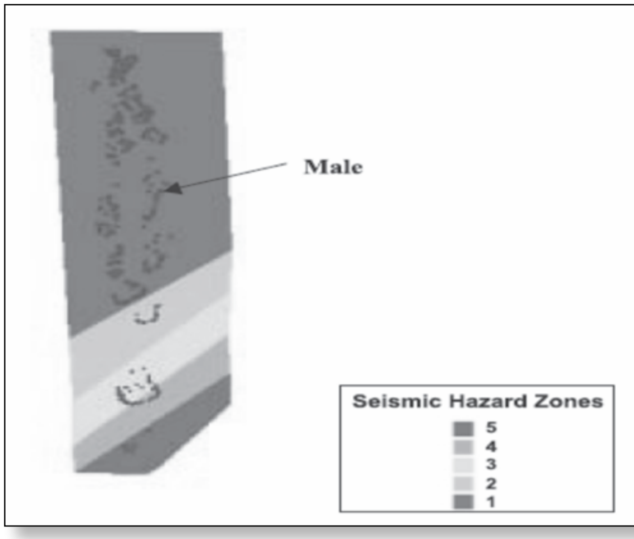


Fig. 3.5 Seismic Hazard Zones of Maldives

According to this classification Zone 5 is equivalent to MSK intensity VIII and Zone 4 equivalent to MSK intensity VII area. As explained in Para 3.1.2, these could be considered as **moderate** hazard intensity and **low** hazard intensity areas for carrying out RVS studies on school and hospital buildings.

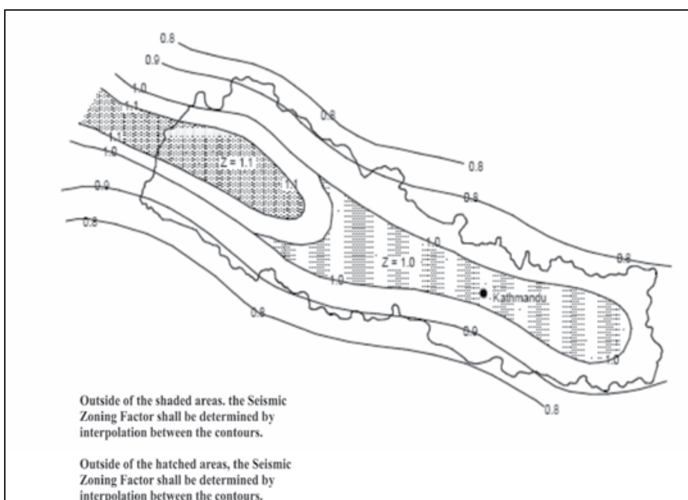


Fig. 3.6 : Seismic Hazard Zone of Nepal

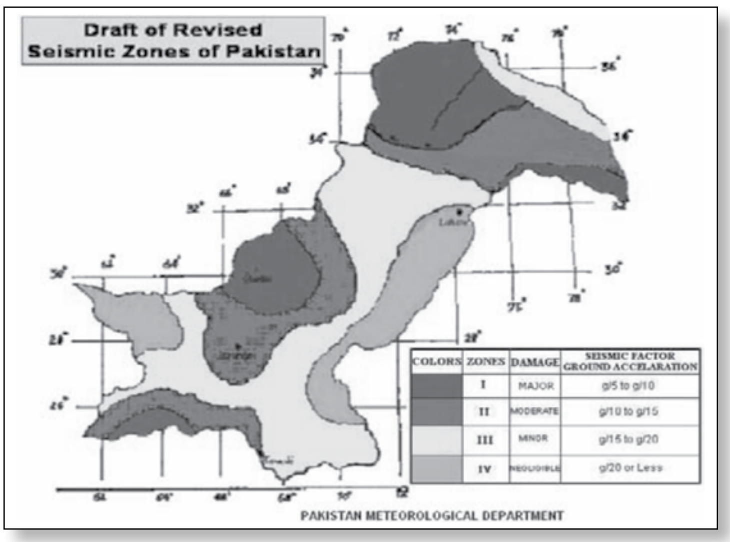
3.7 Nepal

The seismicity map of Nepal is given as a part of the National Building Code of Nepal as shown is fig. 3.6.

The intensity variation in the map is shown in terms of zone factor contours namely 1.1, 1.0, 0.9 and 0.8 which means that the intensity from one zone factor to the next changes by about 10%. This is a much lower rate of change of the intensity as compared with the MSK intensities IX, VIII and VII where rate of change is taken as 33% in the Indian Standard code IS:1893. Therefore to got the intensity levels an exercise was carried out to compare the seismic design co-efficient of rigid masonry buildings having time period 0.2 sec and ordinary reinforce concrete building of time period 1.0 sec as recommended in FEMA 154. The design factors so worked out indicate that the zone factors of 1.1, 1.0 and 0.9 together may be taken equivalent to **high** hazard intensity and seismic zone factor 0.8 may be taken equivalent to **moderate** hazard intensity.

3.8 Pakistan

"The Pakistan region comprises diverse nature of geological features as it lies at the junction of Indian, Eurasian and Arabian plate boundaries. Seismic zoning map of Pakistan have been developed by Pakistan Meteorological Department in 1998 by earthquake data collected from United States Geological Survey (USGS), International Seismological Centre (ISC) and PMD for the period from 1905 to 1998. For this purpose the magnitude range for Seismicity map was taken as greater than 4.5 on Richter scale. Figure 3.7 shows, the Seismic Zoning Map of Pakistan. The region of Pakistan is divided into four main Seismic zones in term of major, moderate, minor and negligible seismicity zones with respect to ground acceleration values as shown in the figure 3.7 where g is the ground acceleration.



Zones	Damage	Seismic Factor Ground Acceleration
I	Major	g/5 to g/10
II	Moderate	g/10 to g/15
III	Minor	g/15 to g/20
IV	Negligible	g/20 or less

Fig. 3.7 : Seismic Zoning Map of Pakistan

Accordingly zone I (Major) should be considered **High** Hazard, zone II (Moderate) should be take as **Moderate** Hazard and Zone III (Minor) should be considered **Low** Hazard zone for RVS purposes.

3.9 Sri Lanka

It appears that a seismic zoning map has not yet been prepared for Sri Lanka. The seismicity has been studied in 2005 by Seneviratne, H.N.; Ratnaweera, H.G.P.A.; Bandara, R.M.S. and published in Geotechnical Engineering for Disaster Mitigation and Rehabilitation. It is mentioned that during the last 400 years ten earthquakes have occurred within Sri Lanka out of which seven had epicenters close to the city of Colombo. It is also stated that the first documented earthquake in Sri Lanka occurred in the year 1615 with an estimated Richter Magnitude of 6.5 which killed thousands of people and destroyed hundreds of homes.

In view of these statements it may be assumed that parts of Sri Lanka close to Colombo may be considered having **moderate** hazard intensity and the other areas having **low** hazard intensities. The demarcation of the exact zones may be done when the seismic zoning map of Sri Lanka is prepared.

Building Typologies in SAARC Countries

The building typologies used in school and health buildings in SAARC countries could not be obtained from available literature or from internet. Considering that there will be varying typologies in rural and urban areas, somewhat similar to residential building technologies, a detailed list of building types is prepared here out of which the SAARC countries should be able to identify those used therein.

The nomenclature used for various buildings as used in FEMA 154 and Arya's method were identified for each building, except some building types used in USA whose similar buildings are not apparently used in SAARC countries and their RVS has to be used where necessary using FEMA 154 procedures.

Table 4.1 : Building Typologies – Clay, Stone and Wood buildings

S.No.	Wall Material	Description of construction	Roof Type	Floor if any	Designation in Fema 154	Designation in Arya's RVS
1	**Clay (Cl1)**	Walls constructed on ground or shallow foundation	Pitched &Flexible	Flat & Flexible	Nil	A
			Flat & Flexible			
			Flat & rigid			
	Adobe & Unburnt brick(Cl2)	Walls constructed on ground or shallow foundation	Pitched & Flexible	Flat & Flexible	Nil	A+
			Flat & Flexible			
2	**Stone (ST1)**	Random Rubble, dry construction or with mud mortar	Pitched & Flexible	Flat & Flexible	Nil	A+
			Flat & Flexible			
	Stone (ST2)	As above with horizontal wooden dovels	Pitched & Flexible	Flat & Flexible	Nil	B
			Flat & Flexible			
			Flat & Rigid			
	Stone (ST3)	Dressed stone laid in good lime mortar/ cement mortar	Pitched & Flexible	Flat & Rigid	Nil	B+
			Flat & Rigid			
	Stone (ST4)	As ST2 with horizontal wood runners used as bands or RC bands	Pitched & Flexible	Flat & Rigid	Nil	C
			Flat & Rigid			
3	**Wood (WD1)**	Wattle & daub	Pitched & Flexible		Nil	B
	Wood (WD2)	Assam Type Stud wall with Ikra wall panels	Pitched & Flexible		W1/W2	D
	Wood (WD3)	Wood frame with brick nogging (Dhajji Diwari)	Pitched & Flexible	Flat & Flexible	Nil	C+
	Wood (WD4)	wood stud wall with wood or metal siding	Pitched & Flexible	Flat & Flexible	W1/W2	D

Table 4.2 : Building Typologies – Burnt Brick & Cement Concrete Block buildings

S.No.	Wall Material	Description of construction	Roof Type	Floor if any	Designation in Fema 154	Designation in Arya's RVS
1	**Burnt brick walls in mud mortar**	Burnt brick walls in mud mortar	Pitched & Flexible	Flat & Flexible	Nil	B
			Flat & Flexible	Flat & Rigid		
			Flat & Rigid			
	Burnt brick (BB2)	Burnt brick walls in ordinary lime mortar	Pitched & Flexible	Flat & Rigid	URM	B+
			Flat & Flexible			
			Flat & Rigid			
	Burnt brick (BB3)	Burnt brick walls in good cement mortar	Pitched & Flexible	Flat & Rigid	URM	C
			Flat & Rigid			
	Burnt brick (BB4)	Similar to BB3 with RC Seismic Bands	Pitched & Flexible	Flat & Rigid	URM	C+
			Pitched & Rigid			
			Flat & Rigid			
	Burnt brick (BB5)	Similar to BB3 but with seismic bands & vertical reinforcements at corners and jambs of openings or confined masonry	Pitched & Rigid	Flat & Rigid	RM1	D
			Flat & Rigid		RM2	
	Burnt brick (BB6)	Reinforced masonry walls	Pitched & Rigid	Flat & Rigid	Nil	D+
			Flat & Rigid		RM2	
2	**Cement Concrete block (CC1) (Solid/ hollow)**	CC blocks with cement mortar	Pitched & Flexible Pitched & Rigid Flat & Rigid	Flat & Rigid	URM	C
	CC block (CC2) (Solid/ hollow)	As CC1 but with seismic bands	Pitched & Flexible Pitched & Rigid Flat & Rigid	Flat & Rigid	URM	C+
	CC block (CC3) (Solid/ hollow)	As CC2 with vertical steel at corners	Pitched & Flexible Pitched & Rigid Flat & Rigid	Flat & Rigid	RM1	D
			Flat & Rigid		RM2	

Table 4.3 : Building Typologies – Reinforced Concrete and Steel Frame buildings

S.No.	Wall Material	Description of construction	Roof Type	Floor if any	Designation in FEMA 154	Designation in Arya's RVS
1	**Reinforced Concrete (RC1)**	Non-engineered beam post construction with unreinforced brick infill walls	Flat & Rigid	Flat & Rigid	C3	C
	Reinforced Concrete (RC2)	Prefabricated reinforced concrete building	Flat & Rigid	Flat & Rigid	Nil	C+
	Reinforced Concrete (RC3)	Moment Resistant Reinforced Concrete frame of ordinary design with unreinforced masonry infill	Flat & Rigid	Flat & Rigid	Nil	C+
	Reinforced Concrete (RC4)	Moment resistant RC frame with ordinary earthquake resistant design without ductility details with unreinforced masonry infill	Flat & Rigid	Flat & Rigid	Nil	D
	Reinforced Concrete (RC5)	Moment resistant RC frame with earthquake resistant design and special ductility details with unreinforced masonry infill	Flat & Rigid	Flat & Rigid	Nil	E
	Reinforced Concrete (RC6)	Same as RC5 but with well designed infill walls	Flat & Rigid	Flat & Rigid	Nil	E+
	Reinforced Concrete (RC7)	Moment resistant RC frame with earthquake resistant design with special ductility details and shear walls	Flat & Rigid	Flat & Rigid	C2	F
2	**Steel Frame (SF1)**	Steel frame without bracings having hinged joints	Pitched & Flexible	Flat & Flexible	Nil	C
	Steel Frame (SF2)	Steel frame of ordinary design with unreinforced masonry infill	Pitched & Flexible Flat & Flexible Flat & Rigid	Flat & Flexible Flat & Rigid	S5	C+
	Steel Frame (SF3)	Moment resistant steel frame without bracings & without plastic design details	Flat & Rigid	Flat & Rigid	Nil	C+
	Steel Frame (SF4)	Moment resistant steel frame with ordinary ERD without special details	Flat & Rigid	Flat & Rigid	Nil	D
	Steel Frame (SF5)	Moment resistant steel frame with high level earthquake resistant design and special plastic design details/steel braces	Flat & Rigid	Flat & Rigid	Nil	E

S.No.	Wall Material	Description of construction	Roof Type	Floor if any	Designation in FEMA 154	Designation in Arya's RVS
	Steel Frame (SF6)	Ordinary steel frame with braces	Flat & Rigid	Flat & Rigid	S2	E+
	Steel Frame (SF7)	Steel frames with cast in place shear walls	Flat & Rigid	Flat & Rigid	S4	F
Notes						
Pitched & Flexible	Sloping roofs with tiles, slates or shingle corrugated iron. Corrugated galavanised iron sheets or asbestos cement sheets or thatch, grass, leaves, bamboo etc.					
Pitched & Rigid	Reinforced Cement Concrete sloping slabs					
Flat & Flexible	Wooden logs or joists with reeds & bushes covered with earth /wooden joist with bricks & stone slabs					
Flat & Rigid	Reinforced brick concrete/Reinforced Cement Concrete/Jack Arch floor/roof					

Table 4.4: Building Typology in FEMA 154 not used in SAARC countries

S. No.	Wall Material	Description of construction	Roof Type	Floor if any	Designation in Fema 154	Designation in Arya's RVS
1	Reinforced Concrete	Tilt-ups are typically one or two stories high and are basically rectangular in plan.			PC1	
		Exterior walls are traditionally formes and cast on ground adjacent to their final position, and then "titled-up" and attached to the floor slab				
		Precast concrete frames are, in essence, post and beam construction in concrete.			PC2	
		Structures often employ concrete or reinforced masonry (brick and block) shear walls				
	Reinforced Concrete	All exposed concrete frames are reinforced concrete (not steel frames encased in concrete)			C1	

S. No.	Wall Material	Description of construction	Roof Type	Floor if any	Designation in Fema 154	Designation in Arya's RVS
		A fundamental factor governing the performance of concrete moment resisting frames is the level of ductile detailing.				
2	Steel Frame	The structural system usually consists of moment frames in the transverse direction and braced frames in the longitudinal direction, with corrugated sheet-metal siding. In some regions, light metal buildings may have partial height masonry walls.			S3	

Available RVS Procedures

5.0 There are two procedures for carrying out Rapid Visual Screening of Buildings: One, which has been used in California USA and the other, which has been used in a number of state in India. The first one was prepared by Federal Emergency Management Agency (FEMA) as a handbook in 1988. This was used to evaluate more than 70,000 buildings. Also it was tested during damaging earthquakes which occurred in California, and was revised after new data on the performance of the buildings in earthquakes became available.

RVS procedures in India was developed by Professor Arya in the year 2004 while working as the National Seismic Advisor to the Ministry of Home Affairs, Govt. of India under GoI-UNDP Disaster Risk Management Programme during 2003-2006. This procedure was made available to the various states and some training programmes organized for the Public Works Department (PWD) Engineers. Effort has been made to make it widely applicable to various types of buildings in India including school and hospital buildings.

The two procedures are briefly outlined in the following paragraphs.

5.1 The RVS Procedure of FEMA 154

5.1.1 Basically the FEMA 154 procedure is based on *Seicmicity zone classification, building typology and soil classification* used in USA and analysis for performance of buildings carried out during the earthquake occurrences in California.

5.1.2 Parameters considered in RVS

The FEMA 154 Procedure uses a system of numerical scores for various parameters of the building to be assessed. The following parameters are considered in the RVS Data Form for determining the total numerical score of the building:

A. Basic Score

1. Seismic Hazard Intensity
2. Building Type, its lateral load resisting structure

B. Score Modifiers

1. Height of the building
2. Soil Type in the foundation
3. Plan irregularity of the building
4. Vertical Irregularity of the building
5. Conformity to the seismic building code in the design or otherwise.

Among the above parameters, each Hazard Intensity has a separate Form and the building type is assigned a Basic Score which is infact related to its lateral load resisting structural system and earthquake performance observed. The other five parameters are used as Modifiers to the Basic Score which are positive or negative in value to the Basic Score, that is increasing or decreasing the seismic safety index. The final score S is the total sum of the Basic Score and the Modifiers.

5.1.3 Building Types

The building types considered are given below (with more details in Table 6.2 along with the basic score assigned to them in the three Hazard Intensity areas). It may be seen that these types are as seen in USA in general and California in particular. It will be only rare to find exactly similar buildings in SAARC countries.

W1	Light wood frame, residential or commercial, < 5000 square feet
W2	Wood frame buildings, > 5000 square feet
S1	Steel moment-resisting frame
S2	Steel braced frame
S3	Light metal frame
S4	Steel frame with cast-in-place concrete shear walls
S5	Steel frame with unreinforced masonry infill
C1	Concrete moment-resisting frame
C2	Concrete shear wall
C3	Concrete frame with unreinforced masonry infill
PC1	Tilt-up construction
PC2	Precast concrete frame
RM1	Reinforced masonry with flexible floor and roof diaphragms
RM2	Reinforced masonry with rigid diaphragms
URM	Unreinforced masonry bearing-wall buildings

5.1.4 Type of Base Soil

In the USA standards, six soil type are considered
Type A Hard Rock
Type B Average Rock
Type C Soft Rock / Dence Soil
Type D Stiff Soil
Type E Soft Soil
Type F Poor Soil
The Basic Score given in the Data Collection Form is for Rocks, Types A & B. Soil type F if met under a building will be referred to a geotechnical expert for the site evaluation of the building. For the cases for Soil Type C, D and E, there is a negative effect on the Basic Score.

5.1.5 Determination of Cut-Off Score:

Use of the RVS on a community-wide basis enables the RVS authority to divide screened buildings into two categories: those that are expected to have acceptable seismic performance, and those that may be seismically hazardous and should be studied further. This requires that the RVS authority to determine an appropriate "cut-off" score. The S score of 2 is suggested as a "cut-off", based on present seismic design criteria. Using this cut-off level, buildings having an S score of 2 or less should be investigated by a design professional experienced in seismic design, and S>2 may be taken as acceptable seismic safety of the building.

5.2 The RVS Procedure by Arya

5.2.1 Basis of RVS Procedure

The screening procedure is based on Code based Seismic Intensity Zones, Building Types and Damageability Grade as observed in past earthquakes and covered in MSK/European Macro-Intensity Scales.

5.2.2 Seismic Hazards considered in RVS forms

Three levels of seismic hazard intensities are considered as given below:-

- **High** seismic hazard (maximum damage during earthquake may be under MSK Intensity IX or greater).

- **Moderate** seismic hazard (maximum damage during earthquake may be as per MSK Intensity VIII).
- **Low** seismic hazard (maximum damage during earthquake may correspond to MSK Intensity VII).

It is considered that various SAARC countries will be able to choose the applicable Hazard Intensity equivalent to one of these (See Chapter-3) and select the RVS form accordingly.

When a particular hazard Intensity occurs, different building types experience different levels of damage depending on their inherent characteristics.

5.2.3 Building Types Considered in RVS Procedure

A wide variety of construction types and building materials are used in urban and rural areas of SAARC countries (See Chapter-4). These include local materials such as mud, bamboo and wood, semi-engineered materials such as burnt brick and stone with different dressings, 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 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 resistant 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.

The RVS procedure has considered different building types: Masonry buildings as presented in Table 7.1 and framed RC and steel buildings in Table 7.2. The likely damages to buildings have been categorized in different Grades depending on the seismic intensity impact on the strength of the building.

5.2.4 Grades of Damageability

Five grades of damageability from G1 to G5 are specified in MSK and European Intensity Scales as described in Tables 7.3 and 7.4 for Masonry and RCF/SF buildings respectively.

5.2.5 Relationship of Seismic Intensity, Building Type & Damage Grades

Tables 7.5 and 7.6 provide guidance regarding likely performance of the masonry and RCF/SF buildings respectively in the event of occurrence of the earthquake intensity postulated in the seismic hazard zones.

5.2.6 RVS Survey Forms – Special Points

The RVS survey forms are developed here for the seismic hazard intensity zones, the building types A to F and damageability grades G1 to G5 as described here above. Some special cases included therein are:

- Liquefiable condition:
- Land Slide Prone Area:
- Irregular Buildings:
  - Vertical Irregularities; and
  - Plan Irregularities
- Falling Hazard; and
- Type of Foundation Soil

RVS Procedure of Fema 154

6.1 Background

6.1.1. Rapid visual screening of buildings for potential seismic hazards, as described here, originated in 1988 with the publication of the FEMA 154 Report, Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook. Written for a broad audience ranging from engineers and building officials to appropriately trained non-professionals, the Handbook provided a "sidewalk survey" approach that enabled users to classify surveyed buildings into two categories: those acceptable as to risk to life safety or those that may be seismically hazardous and should be evaluated in more detail by a design professional experienced in seismic design.

6.1.2. During the decade following publication of the first edition of the FEMA 154 Handbook, the rapid visual screening (RVS) procedure was used by private-sector organizations and government agencies to evaluate more than 70,000 buildings nationwide. This widespread application provided important information about the purposes for which the document was used, the ease-of-use of the document, and perspectives on the accuracy of the scoring system upon which the procedure was based. Concurrent with the widespread use of the document, damaging earthquakes occurred in California and elsewhere, and extensive research and development efforts were carried out under the National Earthquake Hazards Reduction Program (NEHRP). These efforts yielded important new data on the performance of buildings in earthquakes, and on the expected distribution, severity, and occurrence of earthquake-induced ground shaking.

6.1.3. Basically the FEMA 154 procedure is based on Seicmicity zone classification, building typology and soil classification used in USA and analysis for performance of buildings obtained during the earthquake occurrences in California.

6.2 Parameters considered in RVS

The following parameters are considered in the RVS Data Form for determing the total numerical score of building (See Fig. 6.1)

- Seismic Hazard Intensity
- Building Type
- Height of the building
- Soil Type in the foundation
- Plan irregularity of the building
- Vertical Irregularity of the building
- Conformity to the seismic building code in the design or not

Among the above parameters, each Hazard Intensity has a separate Form and the building type is assigned a Basic Score which is infact related to its lateral load resisting structural system and earthquake performance observed. The other five parameters are used as Modifiers to the Basic Score. The final score is the total sum of the Basic Score and the Modifiers.

The other information on the data collection form is the following:

- Address of the building and other relevant data, name of the Screener (Assessor)
- Building Occupancy (use and maximum number of occupants).
- Soil Type
- Falling hazards

Rapid Visual Screening of Buildings for Potential Seismic Hazards **LOW Seismicity**

FEMA-154 Data Collection Form

Address: ______________________________

______________________________ Zip __________

Other Identifiers ______________________________

No. Stories ____________________ Year Built ________

Screener ______________________ Date __________

Tota Floor Area (sq.ft.) ______________________

Building Name ______________________________

Use ______________________________

PHOTOGRAPH

Scale:

OCCUPANCY			SOIL	TYPE						FALLING HAZARDS			
Assembly	Govt	Office	Number of Persons	A	B	C	D	E	F	☐	☐	☐	☐
Commercial	Historic	Residential	0-10 11-100	Hard	Avg.	Dense	Stiff	Soft	Poor	Unreinforced	Parapets	Cladding	Other:
Emer. Services	Industrial	School	101-1000 1000+	R°ck	Rock	Soil	Soil	Soil	Soil	Chimneys	----------------		

BASIC SCORE, MODIFIERS, AND FINAL SCORE, S

BUILDING TYPE	W1	W2	S1 (MRF)	S2 (BR)	S3 (LM)	S4 (RCSW)	S5 (URM INF)	C1 (MRF)	C2 (SW)	C3 (URM INF)	PC1 (TU)	PC2	RM1 (FD)	RM2 (RD)	URM
Basic Score	7.4	6.0	4.6	4.8	4.6	4.8	5.0	4.4	4.8	4.4	4.4	4.6	4.8	4.6	4.6
Mid Rise (4 to 7 stories)	N/A	N/A	+0.2	+0.4	N/A	+0.2	-0.2	+0.4	-0.2	-0.4	N/A	-0.2	-0.4	-0.2	-0.6
High Rise (>7 stories)	N/A	N/A	+1.0	+1.0	N/A	+1.0	+1.2	+1.0	0.0	-0.4	N/A	-0.2	N/A	0.0	N/A
Vertical Irregularity	-4.0	-3.0	-2.0	-2.0	N/A	-2.0	-2.0	-1.5	-2.0	-2.0	N/A	-1.5	-2.0	-1.5	-1.5
Plan Irregularity	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8
Pre-Code	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Post-Benchmark	0.0	+0.2	+0.4	+0.6	N/A	+0.6	N/A	+0.6	+0.4	N/A	+0.2	N/A	+0.2	+0.4	+0.4
Soil Type C	-0.4	-0.4	-0.8	-0.4	-0.4	-0.4	-0.4	-0.6	-0.4	-0.4	-0.4	-0.2	-0.4	-0.2	-0.4
Soil Type D	-1.0	-0.8	-1.4	-1.2	-1.0	-1.4	-0.8	-1.4	-0.8	-0.8	-0.8	-1.0	-0.8	-0.8	-0.8
Soil Type E	-1.8	-2.0	-2.0	-2.0	-2.0	-2.2	-2.0	-2.0	-2.0	-2.0	-1.8	-2.0	-1.4	-1.6	-1.4
FINAL SCORE, S															
COMMENTS															Detailed Evaluation Required YES NO

* = Estimated, subjective, or unreliable data	BR = Braced frame	MRF = Moment-resisting frame	SW = Shear wall
DNK ■ Do Not Know	FD = Flexible diaphragm	RC = Reinforced concrete	TU = Tilt up
	LM = Light metal	RD = Rigid diaphragm	URM INF = Unreinforced masonry infill

Fig. 6.1 : RVS Format (FEMA 154)

Space is provided for the Screener (Assessor) for making a sketch of the building, and attaching a photograph thereof. Beside giving the result 'Detailed evaluation required or not, space is provided for comments by the Assessor.

The building parameters forming part of the date collection form are explained below in brief.

6.3 Seismic Hazard Intensities

According to FEMA 154, the level of hazard intensity will be determined in the following manner. From the seismic hazard map of the country, find the design Spectral Accelerations (SA) for the time Period of 0.2 second and 1.0 second, then multiply the value by a factor of 2/3 and check the calculated values as below:

Table 6.1 : Definition of Hazard Intensities in FEMA 154 RVS Handbook

Level of Seismic hazard intensity	Calculated 2/3 SA for period of 0.2 second	Calculated 2/3 SA for period of 1.0 second
High Hazard	Greater than or equal to 0.50 g	Greater than or equal to 0.20 g
Moderate Hazard	Between 0.167 g and 0.5 g	Between 0.067 g and 0.20 g
Low Hazard	Less than 0.167 g	Less than 0.067 g

It is proposed to use the same criteria for specifying the hazard intensities in the seismic zones of SAARC countries when using FEMA 154 for RVS.

6.4 Building Types

The building types considered are given in Table 6.2 along with the basic score assigned to them in the three Hazard Intensities area. It may be seen that these types are as seen in USA in general and California in particular. It will be only rare to find exactly similar buildings in SAARC countries. Very rough equivalence has been proposed in Chapter 4 of this document for the purpose of using FEMA 154 for RVS purposes if one opts to use it for RVS of School and Hospital buildings.

6.5 Height of Building

Two height ranges are considered: (i) Mid-Rise (4 to 7 storeys) and ii) High Rise (more than 7 storeys).

The height of a storey will generally be in the range 2.8 to 4 m. The storey may be counted from where the building is considered fixed near its base. In a stepped building, the face having the maximum number of storeys may be considered.

Some building types namely, URM, PCI, S3, W2 and W1 are generally low height, hence modification score for height are not applicable (N/A).

In this RVS procedure, the score modifiers for greater than 3 storeys are seen to be positive, that is, such buildings are considered safer against seismic hazard, possibly because of use of better quality material like concrete & masonry, better design proficiency and higher skills in construction.

6.6 Plan irregularity

Plan irregularity (see Fig. 6.3) also lowers the performance of a building under earthquake motions, hence the score modifier has a negative value.

6.7 Vertical Irregularity

Vertical irregularity (see Fig. 6.4) particularly in stiffness is considered a serious weakness and the corresponding score modifier is negative for all building types.

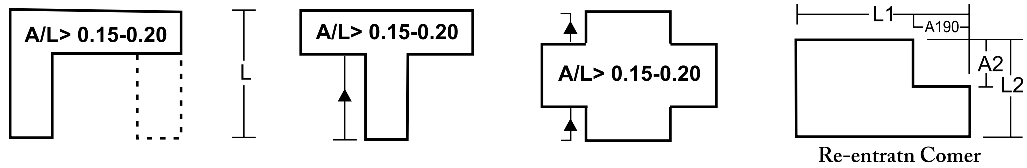


Fig. 6.3 : Plan Irregularities

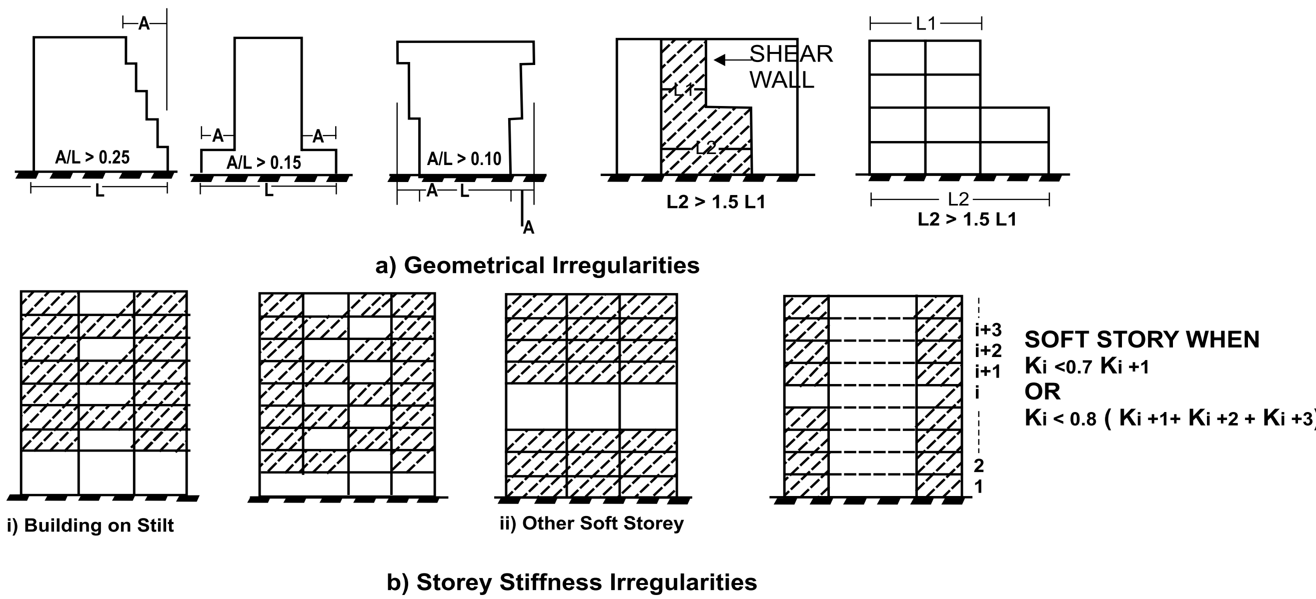


Fig. 6.4 : Vertical Irregularities

6.8 Conformity with earthquake Resistant Building Code:

Here a number of situations will arise:

(i) Pre Code construction. The design and construction of the building was done before the seismic building code was adopted. For example in India the earthquake codes were published as follows:

IS: 1893-1962, "Criteria for Earthquake Resistance Design of Structure".

IS: 4326-1967, "Earthquake Resistance Design and Construction of Buildings----Code of Practice".

All framed construction before 1963 and all masonry buildings before 1968 may be considered without Earthquake Resistant Design, that is, (without ERD).

(ii) Code Revised and made more stringent

The building may have been designed as per the then Earthquake Code but may be deficient in terms of the revised Code.

(iii) Building not designed for the Earthquake Code

This situation may be commonly found in SAARC Countries since the use of Code may not be mandatory in the Municipal Building Bylaws.

In the score modifiers, Pre Code and Post Benchmark are stated which will infact mean 'No ERD' and 'Code Compliant'. Obviously Pre Code (No ERD) will indicate decrease of seismic safety and will have *negative score modifier.* And Post Benchmark (Code Compliant) will *increase seismic safety*, *hence positive score modifier.*

6.9 Type of Base Soil

In the USA standard, six soil type are considered

Type A Hard Rock

Type B Average Rock

Type C Soft Rock / Dance Soil

Type D Stiff Soil

Type E Soft Soil

Type F Poor Soil

For definition of these types, see Ch. 9, Para 9.8. The Basic Score given in the Data Collection Form is for Rocks, Types A & B. Soil type F if met under a building will be referred to a geotechnical expert for the site evaluation of the building. For the cases for Soil Type C, D and E, there is a negative effect on seismic safety, the negative effect being more as the soil becomes softer. Thus the score modifiers are negative, become more negative for soil type E and least for soil type C.

6.10 Falling Hazard

They include unreinforced smoke chimneys, parapets, infill and cladding walls. If present, the comments will have to specify the need for their stabilization using appropriate means.

6.11 The Basic Score, the Score Modifiers and the Final Score

6.11.1

The structural scoring system consists of a matrix of Basic Structural Hazard Scores (one for each building type and its associated seismic lateral force-resisting system) and Score Modifiers to seismic performance. The Basic Structural Hazard Scores and Score Modifiers are based on (1) design and construction practices in the California region of USA, (2) attributes known to decrease or increase seismic resistance capacity, and (3) maximum considered ground motions for the seismicity region under consideration. The Basic Structural Hazard Score, Score Modifiers, and Final Structural Score, S, all relate to the probability of building collapse, should the maximum ground motions considered by the RVS procedure occur at the site. Final S scores typically range from 0 to 7, with higher S scores corresponding to better seismic performance.

The maximum ground motions considered in the scoring system of the RVS procedure are consistent with those specified for detailed building seismic evaluation in the FEMA 310 Report, Handbook for the Seismic Evaluation of Buildings—A Pre standard. Such ground motions generally have a 2% chance of being exceeded in 50 years, and are multiplied by a 2/3 factor in the FEMA 310 evaluation procedures and in the design requirements for new buildings in FEMA 302, Recommended Provisions for Seismic Regulations for New Buildings and Other Structures. (Ground motions having a 2% probability of being exceeded in 50 years are commonly referred to as the maximum considered earthquake (MCE) ground motions).

Note: The Peak Ground Acceleration (PGA) values specified for MCE in each seismic zone (IS:1893-2002) are based on same definition.

6.11.2 Determination of Cut-Off Score:

Use of the RVS on a community-wide basis enables the RVS authority to divide screened buildings into two categories: those that are expected to have acceptable seismic performance, and those that may be seismically hazardous and should be studied further. This requires that the RVS authority todetermine, preferably as part of the pre-planning process, an appropriate “cut-off” score. The S score of 2 is suggested as a “cut-off”, based on present seismic design criteria. Using this cut-off level, buildings having an S score of 2 or less should be investigated by a design professional experienced in seismic design, and S>2 may be taken as acceptable seismic safety of the building.

6.12 The Data Collection Forms

There is one form for each Hazard Intensity, namely **High** Seismicity, **Moderate** Seismicity & **Low** Seismicity. Also quick Reference Guide is provided. These are given in the Template Chap. 8 Para 8.2.

Table 6.2 : Building Types in RVS of FEMA 154

Buildings Identifier	**Description**	**Basic Structural Hazard Score**		
		High	**Mod.**	**Low**
W1 Light wood frame residential and commercial buildings equal to or smaller than 5,000 sq ft (465 m^2)	Wood stud walls are typically constructed of 2-inch by 4-inch vertical wood members set about 16 inches apart (2-inch by 6-inch for multiple stories). Most common exterior finish materials are wood siding, metal siding, or stucco.	2.8	5.2	7.4
W2 Light wood frame buildings greater than 5,000 sq ft (465 m^2)	These are large apartment buildings, commercial buildings or industrial structures usually of one to three stories, and rarely, as tall as six stories.	3.8	4.8	6.0
S1 Steel moment resisting frame	Typical steel moment-resisting frame structures usually have similar bay widths in both the transverse and longitudinal directions, around 20-30 ft. The floor diaphragms are usually concrete, sometimes over steel decking. This structural type is used for commercial, institutional and public buildings.	2.8	3.6	4.6
S2 Braced steel frame	These buildings are braced with diagonal members, which usually cannot be detected from the building exterior. Braced frames are sometimes used for long and narrow buildings because of their stiffness.	3.0	3.6	4.8
S3 Light metal building	The structural system usually consists of moment frames in the transverse direction and braced frames in the longitudinal direction, with corrugated sheet-metal siding. In some regions, light metal buildings may have partial height masonry walls.	3.2	3.8	4.6
S4 Steel frames with cast-in-place concrete shear walls	Lateral loads are resisted by shear walls, which usually surround elevator crores and stairwells, and are covered by finish materials.	2.8	3.6	4.8
S5 Steel frames with unreinforeced masonry infill walls	Steel columns are relatively thin and may be hidden in walls. Usually masonry is exposed on exterior with narrow piers (less than 4 ft wide) between windows.	2.0	3.6	5.0
C1 Concrete moment resisting frames	All exposed concrete frames are reinforced concrete (not steel frames encased in concrete). A fundamental factor governing the performance of concrete moment resisting frames is the level of ductile detailing.	2.5	3.0	4.4

Buildings Identifier	Description	Basic Structural Hazard Score		
		High	Mod.	Low
C2 Concrete shear wall buildings	Concrete shear- wall buildings are usually cast in place, and show typical signs of cast-in-place concrete. Shear-wall thickness ranges from 6 to 10 inches (150-250 mm).	2.8	3.6	4.8
C3 Concrete frames with unreinforced masonry infill walls	Concrete columns and beams may be full wall thickness and may be exposed for viewing on the sides and rear of the building. Usually masonry is exposed on the exterior with narrow piers (less than 4 ft, 1.2 m wide) between windows.	1.6	3.2	4.4
PC1 Tilt –up buildings	Tilt-ups are typically one or tow stories high and are basically rectangular in plan. Exterior walls were traditionally formed and cast on the ground adjacent to their final position, and then “tilted-up” and attached to the floor slab.	2.6	3.2	4.4
PC2 Precast concrete frame buildings	Precast concrete frames are, in essence, post and beam construction in concrete. Structures often employ concrete or reinforced masonry (brick and block) shear walls.	2.4	3.2	4.6
RM1 Reinforced masonry buildings with flexible diaphragms	Walls are either brick or concrete block. Wall thickness is usually 8 inches to 12 inches (300 mm). Interior inspection is required to determine if diaphragms are flexible or rigid.	2.8	3.6	4.8
RM2 Reinforced masonry buildings with rigid diaphragms	Walls are either brick or concrete block. Wall thickness is usually 8 inches to 12 inches (200-300 mm). Interior inspection is required to determine if diaphragms are flexible of rigid.	2.8	3.4	4.6
URM Unreinforced masonry buildings	These buildings often used weak lime mortar to bond the masonry units together. Arches are often an architectural of older brick bearing wall buildings.	1.8	3.4	4.6

Rapid Visual Screening Procedure Developed by Arya

7.1 Basis of RVS Procedure

The screening procedure is based on Code based Seismic Intensity Zones, Building Types and Damageability Grade as observed in past earthquakes and covered in MSK/European Macro-Intensity Scales.

7.2 Uses of RVS Results

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

- To identify if a particular building requires further evaluation for assessment of its seismic vulnerability.
- To assess the seismic damageability (structural vulnerability) of the buildings if and when the design seismic intensity may occur.
- To assess the damageability of non-structural building elements requiring stabilization.

7.3 Seismic Hazards considered in RVS forms

Three levels of seismic hazard intensities are considered as given below:-

- **High** seismic hazard (maximum damage during earthquake may be under MSK Intensity IX or greater).
- **Moderate** seismic hazard (maximum damage during earthquake may be as per MSK Intensity VIII).
- **Low** seismic hazard (maximum damage during earthquake may correspond to MSK Intensity VII).
- Very Low seismic hazard (corresponding to MSK Intensity VI or lower) is considered negligible.

It is considered that various SAARC countries will be able to choose the applicable Hazard Intensity equivalent to one of these (See Chapter-3) and select the RVS form accordingly.

When a particular hazard Intensity occurs, different building types experience different levels of damage depending on their inherent characteristics.

7.4 Building Types Considered in RVS Procedure

A wide variety of construction types and building materials are used in urban and rural areas of SAARC countries (See Chapter-4). These include local materials such as mud, bamboo and wood, semi-engineered materials such as burnt brick and stone with different dressings, 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 professional 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 resistant 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 by the author as **A, A+, B, B+** etc.

The RVS procedure presented here has considered different building types, based on the build ing materials and construction types that are most commonly found in SAARC countries. Masonry buildings are presented in Table 7.1 and framed RC and steel buildings in Table 7.2. The likely damages to buildings have been categorized in different Grades depending on the seismic intensity impact on the strength of the building.

7.5 Grades of Damageability

Five grades of damageability from **G1** to **G5** are specified in MSK and European Intensity Scales as described in Tables 7.3 and 7.4 for Masonry and RCF/SF buildings respectively.

7.6 Relationship of Seismic Intensity, Building Type & Damage Grade

Tables 7.5 and 7.6 provide guidance regarding likely performance of the masonry and RCF/SF buildings respectively in the event of occurrence of the earthquake intensity postulated in the seismic hazard zones.

This information has been used in developing the RVS forms to arrive at Grade of Damage likely to occur in the building surveyed and 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 considered economically 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

About single, Few: 5% *Many*: *about* 50% *Most*: about 75%

Tables 7.5 & 7.6 are generally based on MSK descriptions.

Note:- MSK VII to X Intensities related to building performance are described in Appendix-I for ready reference.

7.7 RVS Survey Forms – Special Points

The RVS survey forms are developed here for the seismic hazard intensity zones, the building types **A** to **F** and damageability grades G1 to G5 as described here above. Some special cases included therein are described below:

7.7.1 Importance of Building/Structure

In most earthquake building codes an importance factor I is defined which require enhancement of the seismic strength of buildings & structures. School and hospital buildings fall in structures included in the category of important buildings. Other Important buildings include: Monumental buildings; *emergency communication buildings like telephone exchange, television, radio stations, lifeline buildings like railway stations, fire stations, large community halls like cinemas, assembly halls and subway stations, power stations, VIP residences & Residences of Important Emergency persons. Any building having more than 1000 Occupants at any time of the day or night may be treated as Important for purpose of RVS.*

For these important buildings the value of I is specified differently in various Codes. IS:1893 (Part-1) – 2002 specifies I as 1.5, by which the design seismic force is increased by a factor of 1.5.

Now the seismic zone factors for MCE for zone II to V in the Indian Standard IS:1893-2002 are as follows.

Seismic Intensity Zone	MSKVI	MSKVII	MSKVIII	MSKIX & More
Zone Factor	0.10	0.16	0.24	0.36
(Peak ground acceleration)				

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

Hence it may be argued that to deal with the damageability of important buildings in any Hazard Intensity zone, they should be checked for one *unit higher Intensity*. However as shown in Chapter 3, Para 3.1. MSK IX, VIII and VII intensities as such qualify to be taken for **High, Moderate and Low** hazard intensities for RVS purposes.

7.8 Building Attributes enhancing Earthquake Risk

There are some special hazardous conditions to be considered:

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

7.8.2 *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 for the building will be needed.

7.8.3 *Irregular Buildings:* Irregularities in buildings are defined in the building codes under the following sub-heads:

- *Plan Irregularities:*

  These are generally defined as follows:
  - Torsion Irregularity
  - Re-entrant Corners
  - Diaphragm Discontinuity
  - Out of Plane Offsets
  - Non – Parallel Systems

  The Geometric Irregularities in building plans which can be easily identified are shown in Fig.7.1

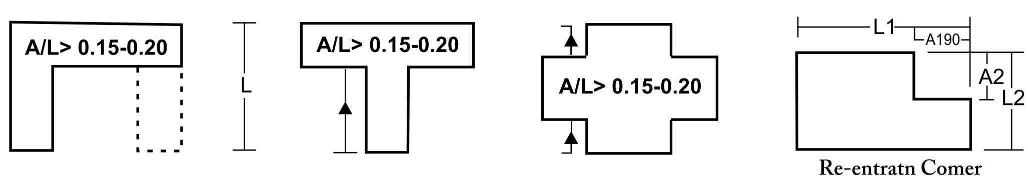


Fig. 7.1:Plan Irregularities

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

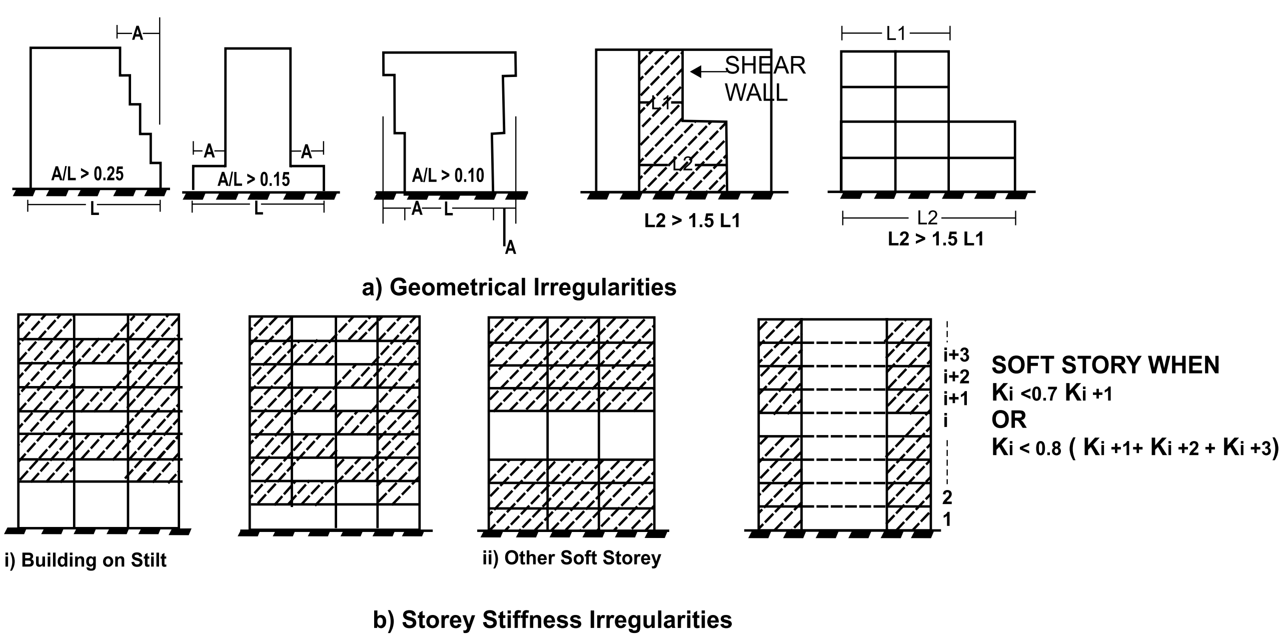


Fig. 7.2: Vertical Irregularities

- *Vertical Irregularities:*

  The following vertical irregularities may be seen in masonry buildings (see Fig. 7.2).
  - Mass Irregularity
  - Vertical Geometric Irregularity
  - In-Plane Discontinuity in vertical Elements Resisting Lateral Forces.

If any of these irregularities are noticed, the building may undergo much more severe damage even upto Grade 4 or 5 and should be recommended for detailed evaluation or a Grade of damage by two units highers may be specified.

7.8.4 *Falling Hazard***:** Where such hazards are present, particularly in High Intensity Zones, recommendations should make reference to these in the survey report as indicated.

7.9 *Type of Foundation Soil:* Normally earthquake resistant building codes define three soil types hard/stiff, medium & soft.

No effect of these is seen in the design spectra of short period buildings, i.e. having T< 0.4 second, covering practically *all* masonry buildings, hence the soil effect may be considered not so significant in masonry buildings, but it will be prudent to specify one unit higher Grade of damage for Soft Soil condition.

Table 7.1: Masonry load bearing wall buildings

Building Type	Description
A	a) Walls constructed using clay on ground with shallow foundation b) Rubble (Field stone) in mud mortar or without mortar usually with sloping wooden roof. c) Uncoursed rubble masonry without adequate 'through stones'. d) Masonry with round stones. e) Unburnt brick wall in mud mortar
A+	
B	Semi-dressed, rubble, brought to courses, with through stones and long corner stones; unreinforced brick walls with country type wooden roofs; unreinforced CC block walls constructed in mud mortar or weak lime mortar.
B+	a) Unreinforced brick masonry in mud mortar with vertical wood posts or horizontal wood elements or wooden seismic band (IS: 13828)* b) Unreinforced brick masonry in lime mortar.
C	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 confined masonry using horizontal & vertical reinforcing elements of reinforced concrete.
D+	Reinforced burnt brick masonry walls

S:13828-1993, "Improving Earthquake Resistance of Low Strength Masonry Buildings --- Guidelines".
IS:4326-1993, "Earthquake Resistant Design and Construction of Buildings – Code of Practice BIS 2005

Table 7.2: 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.

IS:13920-1993, "Ductile Detailing of Reinforced concrete structures subjected to seismic forces-Code of Practice" ,BIS.2002".
**IS:1893(Part-I) 2002, "Criteria for Earthquake Resistant Design of Structures", BIS 2007.*
SP:6(6)-1972, "Plastic Design of Steel Structures—Handbook", BIS.1972.
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 7.3: Grades of Damageability of Masonry Buildings

Grade 1: Negligible to slight damage (no structural damage, slight non-structural damage) Structural: Hair-line cracks in very few walls. Non-structural: 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) Structural: Cracks in many walls, thin cracks in RC* slabs and A.C.* sheets. Non-structural: 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) Structural: Large and extensive cracks in most walls. Wide spread cracking of columns and piers. Non-structural: 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) Structural: 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 7.4: Grades of Damageability of RCC Buildings

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 above Table 7.4). 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 7.5: Damageability Grades of Masonry Buildings

Type of Building	Low Intensity MSK VII	Moderate Intensity MSK VIII	High Intensity (MSK IX or More)
A and A$^+$	Most of grade 3 Few of grade 4 (rest of grade2or1)	Most of grade 4 Few of grade 5 (rest of grade 3,2)	Many of grade 5 (rest of grade 4&3)
B and B$^+$	Many of grade 2 Few of grade 3 (rest of grade 1)	Most of grade 3 Few of grade 4 (rest of grade 2)	Many of grade 4 Few of grade 5 (rest of grade 3)
C and C$^+$	Many of grade 1 Few of grade 2 (rest of grade 1,0)	Most of grade 2 Few of grade 3 (rest of grade 1)	Many of grade 3 Few of grade 4 (rest of grade 2)
D and D$^+$	Few of grade 1	Few of grade 2	Many of grade 2 Few of grade 3 (rest of grade 1)

NOTE:

- *As per MSK scale, Few, Many and Most may be taken as: Few: 15%, Many: 50% and Most: 75%.*
- *While selecting the damageability grade for ordinary residential building, the grade may be taken as indicated for Many, for Schools and Hospital building the highest grade may be chosen even if indicated for Few.*
- *Buildings having vertical irregularity may undergo severe damage in seismic Moderate & High Intensity zones MSK (VIII and 'IX or more)' 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.*
- *Buildings having plan irregularity may undergo a damage of one grade higher in the Low, Moderate and High Intensity zones MSK VII, VIII& IX and higher. The surveyor may recommend re-evaluation if damageability grade G4 or more is indicated.*
- *Masonry buildings of three storey height may have a damage grade one unit higher, as also buildings founded on Soft Soil.*

Table 7.6: Damageability Grades of RCC Buildings

Type of Building	Low Intensity MSK VII	Moderate Intensity MSK VIII	High Intensity (MSK IX or More)
C and C$^+$	Few of grade 2 (rest of grade 1 or 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 and 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:

- *As per MSK scale, Few, Many and Most may be taken as: Few: 15%, Many: 50% and Most: 75%.*
- *While selecting the damageability grade for ordinary residential building, the grade may be taken as indicated for Many, for Schools and Hospital building the highest grade may be chosen even if indicated for Few.*
- *Buildings having vertical irregularity may undergo severe damage in seismic Moderate & High Intensity zones MSK (VIII and 'IX or more)' 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.*
- *Buildings having plan irregularity may undergo a damage of one grade higher in the Low, Moderate and High*

Intensity zones MSK VII, VIII& IX and higher. The surveyor may recommend re-evaluation if damageability grade G4 or more is indicated.

- *Frame buildings of more than four storayes founded on Soft Soil may have a Damage Grade one unit higher.*

7.10 RVS Forms for School and Hospital Buildings

The RVS Forms (Arya's Procedure) for Load Bearing Masonry Building as well as for Reinforced Concrete or Steel Frame buildings for each Hazard Intensity are given in the template Chapter 8, Para 8.3. One form is taken here for explanation.

7.10.1 Masonry Building in Moderates Hazard Area

The form as shown in Fig. 7.3 will be used for this case. The following items may be identified in this form:

1.0 General Information: It deals with the seismic zone building name and address use of the building, its ground coverage and the soil type, etc.

2.1 Foundation Type

2.3.1 Wall Type: Various types of wall types are included for identification.

2.3.2 Mortar Type.

2.3.3 Vertical Reinforcing Bars Provided in the Building.

2.3.4 Seismic Bands Provided in the Building at various levels.

2.3.5 Special Observations in regard to the building.

Every item has been assigned a digital number by which the data could be entered in digitized data base of each building.

Besides the above, other information is also to be verified as follows:

4.0 Special hazard including Water Table in the ground, landslide proneness of the area and vertical and plan irregularities of the building.

Information is also required about the non-structural components including Falling hazards, equipment and furnishing and basic installation and services. These will not have influence on the damageable of the building as whole but will require taking care to prevent their own damage.

Under the item 6.0 the probable damageability of the building is to be identified after the building category has been identified between **A** and **D+.** Under item 6^o the damageability grade is to be en circled along with the building classification.

The recommended action to be specified by the Assessor is next given in the form.

At the top of the form space is provided where a sketch of the building plan and/or elevation may be drawn, or one or two photographs could be pasted illustrating the most important views of the building.

Note that all items on the form are assigned a digital number which will simplify preparing the data base about the building components.

7.10.2 Quick Reference Guide for Ready Reference

It has been prepared on one sheet (see Fig. 7.4). This sheet is to be taken by the Assessor along with the forms while going out for RVS exercise for a building.

This Guide shows the relationship between the building type **A** to **D** and the digital numbers allotted to various types of building components on which the information has been collected in the survey form.

The items of equipment to be taken by the Assessor in the field for survey work is given for ready reference, Explanatory notes are provided for understanding the items such as *plan* and *vertical irregularities*.

This guide will be found handy by the Assessors so that he may not have to refer to the whole guide at the time of field survey.

2 Arya's Method of RVS of School & Hospital Masonry Buildings Moderate Hazard MSK VIII

Photograph/ Sketch Plan with Length & Breadth

4.0 Special Hazard

4.1 High Water Table (within 3m below ground level) & if sandy soil, then liquefiable site indicated. Yes □ No □

4.2 Land Slide Prone Site Yes □ No □

4.3 Severe Vertical Irregularity Yes □ No □ (Increase damageability grade by 2 units)

4.4 Severe Plan Irregularity Yes □ No □ (Increase damageability grade by 1 unit)

5.0 Non-structural Components*:- Whether the following non-structural elements has been properly anchored/fastened keeping into consideration the potential damages from earthquake

5.1 Falling Hazards (Brick wall/wooden partitions, Façade elements, False Ceilings, Parapets, Chimneys, Signs, display boards etc.) Yes □ No □

4.2 Equipments & Furnishings [Medical equipment/lab equipments, Industrial equipment (generators/machines etc.), Office Equipments (Almirah, Computer, Photocopy Machine, Printer, Fax, Shelving (Library books/pharmaceuticals etc.)] Yes □ No □

4.3 Basic Installation & Services [Telecommunications (Roof top antennas, Satellite Dishes) Vacuum network, Drinking water (Roof top water tanks, Water coolers), Air conditioning plants/ducts] Yes □ No □

Assessment of 5.0 does not modify the damageability grade of the building.

6.0 Probable Damageability in Few/Many Buildings

Building Type	**6.1 Masonry Building**				
Damageability in Intensity VIII	A/A+	B/B+	C/C+	D	D+
	G5	G4/G3	G3/G2	G2	Nil

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.

RECOMMENDED ACTION:-

- If in the evaluation the damageability grades are G1/G2 the building may be considered seismically safe.
- If the damageability grade obtained is G3 the building will not be likely to collapse but subject to heavy damage. In such a case the building may be recommended for evaluation.
- If the damageability grade obtained are G4/G5 it indicates that the building is unsafe and will need retrofitting after re-evaluation.
- If any Special Hazard 4.0 found , re-evaluate for possible retrofitting.
- If any of the falling hazard (5.1) is present, either remove it or strengthen against falling. Items under 5.2 & 5.3 will generally need stabilization.
- Special observation (2.3.5) if not compliant may lead to more severe damage and will call for retrofitting.

Surveyor's sign:____________ Name:___________________ Date: __________

1.0 General Information

1.1 Seismic Zone ____________________________

1.2 Building Name__________________________

1.3 Use___________________________________

1.4 Address:_______________________________

1.5 Other Identifiers_________________________

1.6 No. of Stories___________________________

1.7 Year Built ______________________________

1.8 Total Covd. Area; all floors (sq.m) ____________

1.9 Ground Coverage (Sq.m):__________________

1.10 Soil Type: _____________________________

2.1 Foundation Type

2.1.1 Strip footing Yes □ No □

2.1.2 Isolated pier footing Yes □ No □

2.3 Structural Components:

2.3.1 Wall Type

2.3.1.1 Earthen/claymud/Adobe Yes □ No □

2.3.1.2 Bamboo Yes □ No □

2.3.1.3 Wooden Yes □ No □

2.3.1.4 UCR Masonr Yes □ No □

2.3.1.5 Dressed stone masonry Yes □ No □

2.3.1.6 Burnt Brick Yes □ No □

2.3.1.7 Cement Concrete Blocks Yes □ No □

2.3.1.8 Reinforce masonry wall Yes □ No □

2.3.1.9 Thickness of wall _________________________

2.3.2 Mortar Type:

2.3.2.1 Mud mortar Yes □ No □

2.3.2.2 Lime Mortar Yes □ No □

2.3.2.3 Cement Mortar Yes □ No □

2.3.3 Vert. R/F bars provided (at corners, T-junctions & Jambs)

2.3.3.1 Using Wood Yes □ No □

2.3.3.2 Using RC Yes □ No □

2.3.4 Seismic bands in all internal & ext. walls (at plinth, lintel, eaves of pitched & gable wall top)

2.3.4.1 Using wood Yes □ No □

2.3.4.2 Using RC Yes □ No □

2.3.5 Special Observation

2.3.5.1 Length of wall between two cross walls are as per the national standards*. Yes □ No □

2.3.5.2 Percentage of openings in walls are as per the national standard*. Yes □ No □

2.3.5.3 Ratio of height & width of wall is as per the national standard*. Yes □ No □

2.3.5.4 Whether through stones and corner stones provided. Yes □ No □

*For example Indian Standards IS:4326 & IS:13828 have specific provisions

Fig. 7.3 : Masonry Buildings in Moderate Hazard Intensity Zone

Quick Reference Guide for Ready Reference Building Types

Building Types

Masonry load bearing wall buildings ***Reinforced Concrete Frame Buildings (RCF)***

Fig. 7.3 : Eample of VRS Form (Masonry Building in Moderate Hazard)

Building Type	Description*
A	2.3.1.1 ,
A+	2.3.1.1 / 2.3.1.2 / 2.3.1.4 + 2.3.2.1
B	2.3.1.4 / 2.3.1.6 / 2.3.1.7 + 2.3.2.1 + 2.3.5.4
B+	2.3.1.4 / 2.3.1.6 / 2.3.1.7 + 2.3.2.2 + 2.3.5.4
C	2.3.1.5 / 2.3.1.6/ 2.3.1.7 + 2.3.2.3
C+	2.3.1.5 / 2.3.1.6 / 2.3.1.7 + 2.3.2.3 + 2.3.4.1/2.3.4.2
D	2.3.1.6 / 2.3.1.7 + 2.3.2.3 + 2.3.4.2 + 2.3.3.2

** See the reference numbers on the forms 1,2,3.*

Frame Type	Description*
C	3.3.1
C+	3.3.2
D	3.3.3
E	3.3.4
E+	3.3.5
F	3.3.6

** See the reference numbers on the forms 4,5,6.*

Equipments to be carried by the Surveyor:-

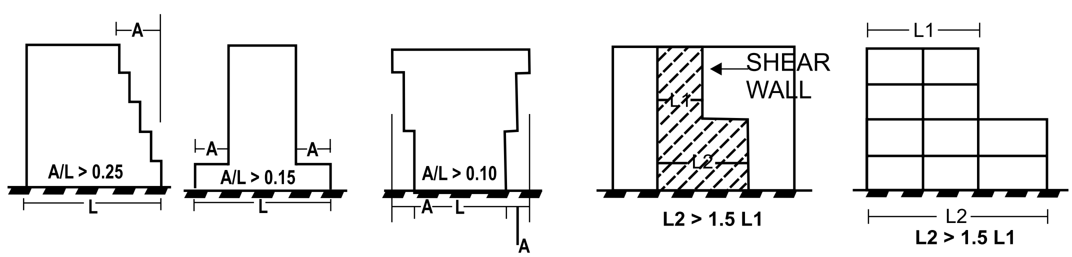
- Camera, preferably digital.
- Hard board with clip.
- Adequate no. of survey sheets.
- One copy of RVS guidelines.
- One copy of Quick Reference Guide (Laminated for Repeated Use)
- Pencil & eraser/ ball pen (black), foot scale, measuring tape as found suitable

Expalantory Note:-

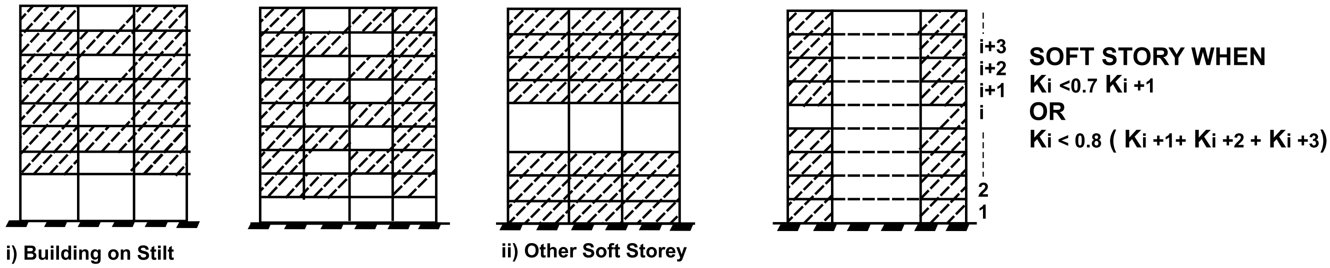
1.3 Use:- Residential, school, hospital, office etc.

1.8 Total Covered area:- Covered area on all floors.

4.3 Vertical Irregularity: As explained in diagram below



a) Geometrical Irregularities



b) Storey Stiffness Irregularities

4.4 Plan Irregularity: As explained in diagram below

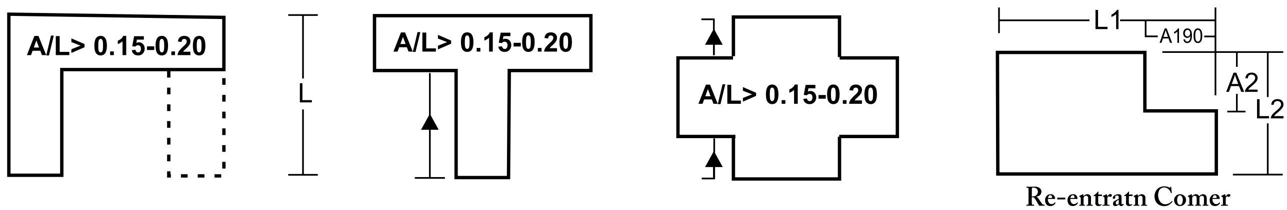


Fig. 7.4 : Quick Reference Guide (Arya Procedure)

Template for RVS of School and Hospital Buildings in SAARC Countries

8.0 The total template is in three parts given in main sections 8.1, 8.2 and 8.3 covering the following aspects.

Section 8.1 gives questionnaire through witch all the data about the school and hospital buildings may be collected by countries. The data points are digitally number so that the whole data could be entered in the computer data base dealing with school buildings and hospital buildings. In the cases where all data has been obtained, rapid assessment of the seismic safety of the building could be carried out while sitting in office and site visit will be useful to verified and authenticate the data.

Section 8.2 deals with the RVS procedures adopted by FEMA 154 giving the RVS forms along with a quick reference guide to assist the surveyors/ assessors in filling the form and making recommendations. The whole process of FEMA 154 is explained in Chapter 6 and only the working forms are given in this sections.

Section 8.3 deals with the RVS forms and quick reference guide of the Arya's procedures which was fully explained in Chapter 7 and only the RVS forms and quick reference guide are presented in this section.

The Assessors will have to make a choice between the two RVS procedures depending upon the building type. If the building type is similar to describe in FEMA 154 it will be appropriate to use that RVS procedures. However, if the actual building is similar to at described in Arya's procedures, it will be better to use this procedure.

8.1 Questionaire for Collection of Building Data

1.0 General Information

1.1 Seismic Zone ______________________________

1.2 Building Name______________________________

1.3 Use______________________________

1.4 Address:______________________________

______________________________Pin ____________

1.5 Other Identifiers______________________________

1.6 No. of Stories______________________________

1.7 Year Built ______________________________

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

1.9 Ground Coverage (Sq.m):______________________________

1.10 Soil Type: ______________________________

2.0 Masonry Building Typology

2.1 Foundation Type

2.1.1 Strip footing Yes ☐ No ☐

2.1.2 Isolated pier footing Yes ☐ No ☐

2.1.3 Any other ______________________________

2.2 Roof whether flat or pitched with material

2.2.1 Flat Roof or Floor

2.2.1.1 wooden joist with earth fill Yes ☐ No ☐

2.2.1.2 Steel joist with stone slabs Yes ☐ No ☐
2.2.1.3 Jach arch roof/ floor Yes ☐ No ☐
2.2.1.4 Reinforced cement concrete/reinforced brick oncrete Yes ☐ No ☐
2.2.1.5 Any other (please describe) ____________________
2.2.1.6 Thickness of slab Yes ☐ No ☐

2.2.2 Pitched roof Understructure
2.2.2.1 Bamboo truss/rafter/purlin Yes ☐ No ☐
2.2.2.2 Wooden truss/rafter/purlin Yes ☐ No ☐
2.2.2.3 Steel truss/purlin Yes ☐ No ☐
2.2.2.4 Any other (please describe)____________________

2.2.3 Pitched Roof Covering
2.2.3.1 Stone slates Yes ☐ No ☐
2.2.3.2 Burnt Clay Tiles Yes ☐ No ☐
2.2.3.3 Corrugated Galvanised Iron (CGI)Sheets Yes ☐ No ☐
2.2.3.4 Asbestos Cement (A.C.) Sheets Yes ☐ No ☐
2.2.3.5 Fibre sheets Yes ☐ No ☐
2.2.3.6 Any other ____________________

2.3 Structural Components:
2.3.1 Wall Type
2.3.1.1 Earthen / clay mud / Adobe Yes ☐ No ☐
2.3.1.2 Bamboo Yes ☐ No ☐
2.3.1.3 Wooden Yes ☐ No ☐
2.3.1.4 Uncoursed Random Rubble Masonry Yes ☐ No ☐
2.3.1.5 Dressed stone masonry Yes ☐ No ☐
2.3.1.6 Burnt Brick Yes ☐ No ☐
2.3.1.7 Cement Concrete Blocks Yes ☐ No ☐
2.3.1.8 Any other (please state) ____________________
2.3.1.9 Thickness of wall ____________________

2.3.2 Mortar Type:
2.3.2.1 Mud mortar Yes ☐ No ☐
2.3.2.2 Lime Mortar Yes ☐ No ☐
2.3.2.3 Cement Mortar Yes ☐ No ☐

2.3.3 Vert. R/F bars provided
2.3.3.1 At Corners Yes ☐ No ☐
2.3.3.2 At T-junctions Yes ☐ No ☐
2.3.3.3 At Jambs Yes ☐ No ☐

2. 3.4 Seismic bands in all external and internal walls
2.3.4.1 Plinth level Yes ☐ No ☐
2.3.4.2 Lintel level of doors and windows Yes ☐ No ☐
2.3.4.3 Eaves level of pitched roofs Yes ☐ No ☐
2. 3.4.4 Gable wall top Yes ☐ No ☐

2.3.5 Special Observation

2.3.5.1 Length of wall between two cross walls are as per the national standards*. Yes □ No □

2.3.5.2 Percentage of openings in wall are as per the national standard*. Yes □ No □

2.3.5.3 Ratio of height & width of wall is as per the national standard*. Yes □ No □

**For example Indian Standards IS:4326 & IS:13828 have specific provisions*

3.0 Reinforced Concrete/Steel Frame Building Typology

3.1 Foundation Type

3.1.1 Individual footing Yes □ No □

3.1.2 As in 3.1.1 with interconnecting beams Yes □ No □

3.1.3 Beam raft footing Yes □ No □

3.1.4 Full Solid Raft Yes □ No □

3.1.5 Pile foundation Yes □ No □

3.1.6 Any other ______________________________

3.2 Roof whether flat or pitched with material

3.2.1 Flat Roof and Floor

3.2.1.1 Reinforced concrete flat slab on T beam Yes □ No □

3.2.1.2 Steel beam and steel plate deck Yes □ No □

3.2.1.3 Overall thickness of floor/roof______________________________

3.2.2 Pitched roof Understructure

3.2.2.1 Reinfoced Cement Concrete Yes □ No □

3.2.2.2 Steel truss/purlin Yes □ No □

3.2.2.3 Any other (please describe)______________________________

3.2.3 Pitch Roof Covering

3.2.3.1 Corrugated Galvanised Iron (CGI)Sheets Yes □ No □

3.2.3.2 Asbestos Cement (A.C.) Sheets Yes □ No □

3.3.2.3 Fibre Sheets Yes □ No □

3.2.3.4 Any other ______________________________

3.3 Structural Components:

3.3.1 **'**R.C. beam-post' buildings without Earthquake Resistant Design, (built in Non-engineered way). Yes □ No □

3.3.2 Reinforced Concrete Frame (RCF) of ordinary design for gravity loads without Earthquake Resistant Design. Yes □ No □

3.3.3 Moment Resistant - RCF/SF (steel Frame) of ordinary design without Earthquake Resistant Design. Yes □ No □

3.3.4 Moment Resistant – RCF/SF with ordinary Earthquake Resistant Design and with ordinary infill walls. Yes □ No □

3.3.5 Moment Resistant – RCF/SF with high level of Earthquake Resistant Design and special details as per plastic hand book. Yes □ No □

3.3.5 Moment Resistant – RCF/SF with high level of Earthquake Resistant Design and special details as per plastic hand book and with well designed infill walls/braces. Yes □ No □

3.3.5 Moment Resistant – RCF/SF with high level of Earthquake Resistant Design, special details as per plastic hand book and with detailed RC shear walls/detailed steel braces & cladding. Yes □ No □

4.0 Special Hazard

4.1 High Water Table (within 3m below ground level) & if sandy soil, then liquefiable site indicated. Yes ☐ No ☐

4.2 Land Slide Prone Site Yes ☐ No ☐

4.3 Severe Vertical Irregularity in the building Yes ☐ No ☐

4.4 Severe Plan Irregularity in the building Yes ☐ No ☐

5.0 Non-structural Components

Whether the following non-structural elements have been properly anchored/fastened keeping into consideration the potential damages from earthquake?

5.1 Architectural

5.1.1 Divisions and partitions (brick wall/wooden partitions etc.) Yes ☐ No ☐

5.1.2 Façade elements (cladding materials/decorative elements) Yes ☐ No ☐

5.1.3 False Ceilings Yes ☐ No ☐

5.1.4 Parapets (brick wall/pillars/planters etc.) Yes ☐ No ☐

5.1.5 Chimneys Yes ☐ No ☐

5.1.6 Glass (large size used in windows/doors) Yes ☐ No ☐

5.1.7 Attachments (Signs, display boards etc.) Yes ☐ No ☐

5.2 Equipments & Furnishings

5.2.1 Medical equipment/lab equipments Yes ☐ No ☐

5.2.2 Industrial equipment (generators/machines etc.) Yes ☐ No ☐

5.2.3 Office Equipments

5.2.3.1 Almirahs Yes ☐ No ☐

5.2.3.2 Computer Yes ☐ No ☐

5.2.3.3 Photocopy Machine Yes ☐ No ☐

5.2.3.4 Printer Yes ☐ No ☐

5.2.3.5 Fax Yes ☐ No ☐

5.2.4 Shelving (Library books/pharmaceuticals etc.) Yes ☐ No ☐

5.3 Basic Installation & Services *(the pipes used for supply of services should have flexible joints)*

5.3.1 Medical gases (Oxygen etc.) Yes ☐ No ☐

5.3.2 Industrial fuel (Diesel/ L.P.G./C.N.G. etc.) Yes ☐ No ☐

5.3.3 Electricity (Poles/fixtures etc.) Yes ☐ No ☐

5.3.4 Telecommunications

5.3.4.1 Roof top antennas Yes ☐ No ☐

5.3.4.2 Satellite Dishes Yes ☐ No ☐

5.3.5 Vacuum network Yes ☐ No ☐

5.3.6 Drinking water

5.3.6.1 Roof top water tanks Yes ☐ No ☐

5.3.6.2Water coolers Yes ☐ No ☐

5.3.7 Air conditioning plants/Air conditioners/ducts Yes ☐ No ☐

5.3.8 Piping Yes ☐ No ☐

5.3.9 Waste disposal Yes ☐ No ☐

8.2 RVS forms of FEMA 154

Rapid Visual Screening of Buildings for Potential Seismic Hazards **LOW Seismicity**
FEMA-154 Data Collection Form

Address: ____
________________________________ Zip __________
Other Identifiers ________________________________
No. Stories ______________________ Year Built ________
Screener _________________________ Date ___________
Tota Floor Area (sq.ft.) ___________________________
Building Name ___________________________________
Use ____

PHOTOGRAPH

Scale:

OCCUPANCY			**SOIL**	**TYPE**						**FALLING HAZARDS**			
Assembly	Govt	Office	Number of Persons	A	B	C	D	E	F	☐	☐	☐	☐
Commercial	Historic	Residential	0-10 11-100	Hard	Avg.	Dense	Stiff	Soft	Poor	Unreinforced	Parapets	Cladding	Other:
Emer. Services	Industrial	School	101-1000 1000+	R°ck	Rock	Soil	Soil	Soil	Soil	Chimneys	----------------		

BASIC SCORE, MODIFIERS, AND FINAL SCORE, S

BUILDING TYPE	**W1**	**W2**	**S1 (MRF)**	**S2 (BR)**	**S3 (LM)**	**S4 (RCSW)**	**S5 (URM INF)**	**C1 (MRF)**	**C2 (SW)**	**C3 (URM INF)**	**PC1 (TU)**	**PC2**	**RM1 (FD)**	**RM2 (RD)**	**URM**
Basic Score	7.4	6.0	4.6	4.8	4.6	4.8	5.0	4.4	4.8	4.4	4.4	4.6	4.8	4.6	4.6
Mid Rise (4 to 7 stories)	N/A	N/A	+0.2	+0.4	N/A	+0.2	-0.2	+0.4	-0.2	-0.4	N/A	-0.2	-0.4	-0.2	-0.6
High Rise (>7 stories)	N/A	N/A	+1.0	+1.0	N/A	+1.0	+1.2	+1.0	0.0	-0.4	N/A	-0.2	N/A	0.0	N/A
Vertical Irregularity	-4.0	-3.0	-2.0	-2.0	N/A	-2.0	-2.0	-1.5	-2.0	-2.0	N/A	-1.5	-2.0	-1.5	-1.5
Plan Irregularity	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8
Pre-Code	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Post-Benchmark	0.0	+0.2	+0.4	+0.6	N/A	+0.6	N/A	+0.6	+0.4	N/A	+0.2	N/A	+0.2	+0.4	+0.4
Soil Type C	-0.4	-0.4	-0.8	-0.4	-0.4	-0.4	-0.4	-0.6	-0.4	-0.4	-0.4	-0.2	-0.4	-0.2	-0.4
Soil Type D	-1.0	-0.8	-1.4	-1.2	-1.0	-1.4	-0.8	-1.4	-0.8	-0.8	-0.8	-1.0	-0.8	-0.8	-0.8
Soil Type E	-1.8	-2.0	-2.0	-2.0	-2.0	-2.2	-2.0	-2.0	-2.0	-2.0	-1.8	-2.0	-1.4	-1.6	-1.4
FINAL SCORE, S															

COMMENTS	Detailed Evaluation Required YES NO

* = Estimated, subjective, or unreliable data	BR = Braced frame	MRF = Moment-resisting frame	SW = Shear wall
DNK ■ Do Not Know	FD = Flexible diaphragm	RC = Reinforced concrete	TU = Tilt up
	LM = Light metal	RD = Rigid diaphragm	URM INF = Unreinforced masonry infill

Rapid Visual Screening of Buildings for Potential Seismic Hazards
FEMA-154 Data Collection Form

MODERATE Seismicity

Address: ____
____________________________________ Zip __________
Other Identifiers ____________________________________
No. Stories _______________________ Year Built________
Screener _________________________ Date ___________
Tota Floor Area (sq.ft.) __________________________
Building Name ______________________________________
Use ____

PHOTOGRAPH

Scale:

OCCUPANCY			**SOIL**	**TYPE**						**FALLING HAZARDS**			
Assembly	Govt	Office	Number of Persons	A	B	C	D	E	F	☐	☐	☐	☐
Commercial	Historic	Residential	0-10 11-100	Hard	Avg.	Dense	Stiff	Soft	Poor	Unreinforced	Parapets	Cladding	Other:
Emer. Services	Industrial	School	101-1000 1000+	R°ck	Rock	Soil	Soil	Soil	Soil	Chimneys	----------------		

BASIC SCORE, MODIFIERS, AND FINAL SCORE, S

BUILDING TYPE	**W1**	**W2**	**S1 (MRF)**	**S2 (BR)**	**S3 (LM)**	**S4 (RCSW)**	**S5 (URM INF)**	**C1 (MRF)**	**C2 (SW)**	**C3 (URM INF)**	**PC1 (TU)**	**PC2**	**RM1 (FD)**	**RM2 (RD)**	**URM**
Basic Score	5.2	4.8	3.6	3.6	3.8	3.6	3.6	3.0	3.6	3.2	3.2	3.2	3.6	3.4	3.4
Mid Rise (4 to 7 stories)	N/A	N/A	+0.4	+0.4	N/A	+0.4	+0.4	+0.2	+0.4	+0.2	N/A	+0.4	+0.4	+0.4	-0.4
High Rise (>7 stories)	N/A	N/A	+1.4	+1.4	N/A	+1.4	+0.8	+0.5	+0.8	+0.4	N/A	+0.6	N/A	+0.6	N/A
Vertical Irregularity	-3.5	-3.0	-2.0	-2.0	N/A	-2.0	-2.0	-2.0	-2.0	-2.0	N/A	-1.5	-2.0	-1.5	-1.5
Plan Irregularity	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-05	-0.5	-0.5	-0.5	-0.5	-05
Pre-Code	0.0	-0.2	-0.4	-0.4	-0.4	-0.4	-0.2	-1.0	-0.4	-1.0	-0.2	-0.4	-0.4	-0.4	-0.4
Post-Benchmark	+1.6	+1.6	+1.4	+1.4	N/A	+1.2	N/A	+1.2	+1.6	N/A	+1.8	N/A	20	+1.8	N/A
Soil Type C	-0.2	-0.8	-0.6	-0.8	-0.6	-0.8	-0.8	-0.6	-0.8	-0.6	-0.6	-0.6	-0.8	-0.6	-0.4
Soil Type D	-0.6	-1.2	-1.0	-12	-1.0	-1.2	-1.2	-1.0	-12	-1.0	-1.0	-1.2	-1.2	-1.2	-0.8
Soil Type E	-1.2	-1.8	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6	-1.6
FINAL SCORE, S															

COMMENTS	Detailed Evaluation Required YES NO

* = Estimated, subjective, or unreliable data
DNK = Do Not Know
BR = Braced frame
FD = Flexible diaphragm
LM = Light metal
MRF = Moment-resisting frame
RC = Reinforced concrete
RD = Rigid diaphragm
SW = Shear wall
TU = Tilt up
URM INF = Unreinforced masonry infill

Rapid Visual Screening of Buildings for Potential Seismic Hazards **HIGH Seismicity**
FEMA-154 Data Collection Form

Address: ____
____________________________________ Zip ___________
Other Identifiers ____________________________________
No. Stories _______________________Year Built________
Screener _________________________ Date ____________
Tota Floor Area (sq.ft.) _____________________________
Building Name ______________________________________
Use ____

PHOTOGRAPH

Scale:

OCCUPANCY			SOIL	TYPE						FALLING HAZARDS			
Assembly	Govt	Office	Number of Persons	A	B	C	D	E	F	☐	☐	☐	☐
Commercial	Historic	Residential	0-10 11-100	Hard	Avg.	Dense	Stiff	Soft	Poor	Unreinforced	Parapets	Cladding	Other:
Emer. Services	Industrial	School	101-1000 1000+	R°ck	Rock	Soil	Soil	Soil	Soil	Chimneys	----------------		

BASIC SCORE, MODIFIERS, AND FINAL SCORE, S

BUILDING TYPE	W1	W2	S1 (MRF)	S2 (BR)	S3 (LM)	S4 (RCSW)	S5 (URM INF)	C1 (MRF)	C2 (SW)	C3 (URM INF)	PC1 (TU)	PC2	RM1 (FD)	RM2 (RD)	URM
Basic Score	4.4	3.8	2.8	3.0	3.2	2.8	2.0	2.5	2.8	1.6	2.6	2.4	2.8	2.8	1.8
Mid Rise (4 to 7 stories)	N/A	N/A	+0.2	+0.4	N/A	+0.4	+0.4	+0.4	+0.4	+0.2	N/A	+0.2	+0.4	+0.4	-0.4
High Rise (> 7 stories)	N/A	N/A	+0.6	+0.8	N/A	+0.8	+0.8	+0.6	+0.8	+0.3	N/A	+0.4	N/A	+0.6	N/A
Vertical Irregularity	-2.5	-2.0	-1.0	-1.5	N/A	-1.0	-1.0	-1.5	-1.0	-1.0	N/A	-1.0	-1.0	-1.0	-1.0
Plan irregularity	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
Pre-Code	0.0	-1.0	-1.0	-08	-0.6	-0.8	-0.2	-1.2	-1.0	-0.2	-0.8	-0.8	-1.0	-0.8	-0.2
Post-Benchmark	+2.4	+2.4	+1.4	+1.4	N/A	+1.6	N/A	+1.4	+2.4	N/A	+2.4	N/A	+2.8	+2.6	N/A
	-0.2	-0.8	-0.6	-0.8	-0.6	-0.8	-0.8	-0.6	-0.8	-0.6	-0.6	-0.6	-0.8	-0.6	-0.4
Soil Type C	0.0	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
Soil Type D	0.0	-0.8	0.6	-0.6	-0.6	-0.6	-0.4	-0.6	-0.6	-0.4	-0.6	-0.6	-0.6	-0.6	-0.6
Soil Type E	0.0	-0.8	-1.2	-1.2	-1.0	-1.2	-0.8	-1.2	-0.8	-0.8	-0.4	-1.2	-0.4	-0.6	-0.8

COMMENTS

Detailed Evaluation Required
YES NO

* = Estimated, subjective, or unreliable data	BR = Braced frame	MRF = Moment-resisting frame	SW = Shear wall
DNK ■ Do Not Know	FD = Flexible diaphragm	RC = Reinforced concrete	TU = Tilt up
	LM = Light metal	RD = Rigid diaphragm	URM INF = Unreinforced masonry infill

Rapid Visual Screening of Buildings for Potential Seismic Hazards (FEMA154)

Quick Reference Guide (for use with Data Collection Form)

1 Model Building Types and Critical Code Adoption and Enforcement Dates		**Year Seismic Codes Initially Adopted and Enforced***	**Benchmark Year when Codes Improved**
Structural Types			
W1	Light wood frame, residential or commercial, < 5000 square feet	---------------------	---------------------
W2	Wood frame buildings, > 5000 square feet.	---------------------	---------------------
51	Steel moment-resisting frame	---------------------	---------------------
52	Steel braced frame	---------------------	---------------------
53	Light metal frame	---------------------	---------------------
54	Steel frame with cast-in-place concrete shear walls	---------------------	---------------------
55	Steel frame with unreinforced masonry infill	---------------------	---------------------
C1	Concrete moment-resisting frame	---------------------	---------------------
C2	Concrete shear wall	---------------------	---------------------
C3	Concrete frame with unreinforced masonry infill	---------------------	---------------------
PC1	Tilt-up construction	---------------------	---------------------
PC2	Precast concrete frame	---------------------	---------------------
RM1	Reinforced masonry with flexible floor and roof diaphragms	---------------------	---------------------
RM2	Reinforced masonry with rigid diaphragms	---------------------	---------------------
URM	Unreinforced masonry bearing-wall buildings	---------------------	---------------------

*Not applicable in regions of low seismicity

2. Anchorage of Heavy Cladding

Year in which seismic anchorage requirements were adopted: ---------------------

3. Occupancy Loads

Use	Square Feet, Per Person	Use	Square Feet, Per Person
Assembly	varies, 10 minimum	Industrial	200-500
Commercial	50-200	Office	100-200
Emergency Services	100	Residential	100-300
Government	100-200	School	50-100

4. Score Modifier Definitions

Mid-Rise:	4 to 7 stories
High-Rise:	8 or more stories
Vertical Irregularity:	Steps in elevation view; inclined walls; building on hill; soft story (e.g., house over garage); building with short columns; unbraced cripple walls.
Plan Irregularity	Buildings with re-entrant corners (L, T, U, E, + or other irregular building plan); buildings with good lateral resistance in one direction but not in the other direction; eccentric stiffness in plan, (e.g. corner building, or wedge-shaped building, with one or two solid walls and all other walls open).
Pre-Code:	Building designed and constructed prior to the year in which seismic codes were first adopted and enforced in the jurisdiction; use years specified above in Item 1; default is 1941, except for PC1, which is 1973.
Post-Benchmark:	Building designed and constructed after significant improvements in seismic code requirements (e.g., ductile detailing) were adopted and enforced; the benchmark year when codes improved may be different for each building type and jurisdiction; use years specified above in Item 1 (see Table 2-2 of FEMA 154 Handbook for additional information).
Soil Type C:	Soft rock or very dense soil; S-wave velocity: 1200 - 2500 ft/s; blow count > 50; or undrained shear strength > 2000 psf.
Soil Type D:	Stiff soil; S-wave velocity: 600 - 1200 ft/s; blow count: 15-50; or undrained shear strength: 1000-2000 psf.
Soil Type E:	Soft soil; S-wave velocity < 600 ft/s; or more than 100 ft of soil with plasticity index > 20, water content > 40%, and undrained shear strength < 500 psf.

2. Arya's Method of RVS of School & Hospital Masonry Buildings Moderate Hazard MSK VIII

Photograph/ Sketch Plan with Length & Breadth

4.0 Special Hazard

4.1 High Water Table (within 3m below ground level) & if sandy soil, then liquefiable site indicated. Yes □ No □

4.2 Land Slide Prone Site Yes □ No □

4.3 Severe Vertical Irregularity Yes □ No □ (Increase damageability grade by 2 units)

4.4 Severe Plan Irregularity Yes □ No □ (Increase damageability grade by 1 unit)

6.0 Non-structural Components*:- Whether the following non-structural elements has been properly anchored/fastened keeping into consideration the potential damages from earthquake

5.1 Falling Hazards (Brick wall/wooden partitions, Façade elements, False Ceilings, Parapets, Chimneys, Signs, display boards etc.) Yes □ No □

6.2 Equipments & Furnishings [Medical equipment/lab equipments, Industrial equipment (generators/machines etc.), Office Equipments (Almirah, Computer, Photocopy Machine, Printer, Fax, Shelving (Library books/pharmaceuticals etc.)] Yes □ No □

6.3 Basic Installation & Services [Telecommunications (Roof top antennas, Satellite Dishes) Vacuum network, Drinking water (Roof top water tanks, Water coolers), Air conditioning plants/ducts] Yes □ No □

Assessment of 5.0 does not modify the damageability grade of the building.

6.0 Probable Damageability in Few/Many Buildings					
Building Type	**6.1 Masonry Building**				
Damageability	A/A+	B/B+	C/C+	D	D+
in Intensity VIII	G5	G4/G3	G3/G2	G2	Nil

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.

RECOMMENDED ACTION:-

- If in the evaluation the damageability grades are G1/G2 the building may be considered seismically safe.
- If the damageability grade obtained is G3 the building will not be likely to collapse but subject to heavy damage. In such a case the building may be recommended for evaluation.
- If the damageability grade obtained are G4/G5 it indicates that the building is unsafe and will need retrofitting after re-evaluation.
- If any Special Hazard 4.0 found , re-evaluate for possible retrofitting.
- If any of the falling hazard (5.1) is present, either remove it or strengthen against falling. Items under 5.2 & 5.3 will generally need stabilization.
- Special observation (2.3.5) if not compliant may lead to more severe damage and will call for retrofitting.

Surveyor's sign:____________ Name:____________________ Date: __________

1.0 General Information

1.1 Seismic Zone ___________________________

1.2 Building Name___________________________

1.3 Use___________________________

1.4 Address:___________________________

1.5 Other Identifiers___________________________

1.6 No. of Stories___________________________

1.7 Year Built ___________________________

1.8 Total Covd. Area; all floors (sq.m) _____________

1.9 Ground Coverage (Sq.m):___________________

1.10 Soil Type: ___________________________

2.1 Foundation Type

2.1.1 Strip footing Yes □ No □

2.1.2 Isolated pier footing Yes □ No □

2.3 Structural Components:

2.3.1 Wall Type

2.3.1.1 Earthen/claymud/Adobe Yes □ No □

2.3.1.2 Bamboo Yes □ No □

2.3.1.3 Wooden Yes □ No □

2.3.1.4 UCR Masonr Yes □ No □

2.3.1.5 Dressed stone masonry Yes □ No □

2.3.1.6 Burnt Brick Yes □ No □

2.3.1.7 Cement Concrete Blocks Yes □ No □

2.3.1.8 Reinforce masonry wall Yes □ No □

2.3.1.9 Thickness of wall ________________________

2.3.2 Mortar Type:

2.3.2.1 Mud mortar Yes □ No □

2.3.2.2 Lime Mortar Yes □ No □

2.3.2.3 Cement Mortar Yes □ No □

2.3.3 Vert. R/F bars provided (at corners, T-junctions & Jambs)

2.3.3.1 Using Wood Yes □ No □

2.3.3.2 Using RC Yes □ No □

2.3.4 Seismic bands in all internal & ext. walls (at plinth, lintel, eaves of pitched & gable wall top)

2.3.4.1 Using wood Yes □ No □

2.3.4.2 Using RC Yes □ No □

2.3.5 Special Observation

2.3.5.1 Length of wall between two cross walls are as per the national standards*. Yes □ No □

2.3.5.2 Percentage of openings in walls are as per the national standard*. Yes □ No □

2.3.5.3 Ratio of height & width of wall is as per the national standard*. Yes □ No □

2.3.5.4 Whether through stones and corner stones provided. Yes □ No □

*For example Indian Standards IS:4326 & IS:13828 have specific provisions

3 Arya's Method of RVS of School & Hospital Masonry Buildings
High Hazard MSK IX or Higher

Photograph/ Sketch Plan with Length & Breadth

4.0 Special Hazard

4.1 High Water Table (within 3m below ground level) & if sandy soil, then liquefiable site indicated. Yes ☐ No ☐

4.2 Land Slide Prone Site Yes ☐ No ☐

4.3 Severe Vertical Irregularity Yes ☐ No ☐ (Increase damageability grade by 2 units)

4.4 Severe Plan Irregularity Yes ☐ No ☐ (Increase damageability grade by 1 unit)

5.0 Non-structural Components*:- Whether the following non-structural elements has been properly anchored/fastened keeping into consideration the potential damages from earthquake

5.1 Falling Hazards (Brick wall/wooden partitions, Façade elements, False Ceilings, Parapets, Chimneys, Signs, display boards etc.) Yes ☐ No ☐

5.2 Equipments & Furnishings [Medical equipment/lab equipments, Industrial equipment (generators/machines etc.), Office Equipments (Almirah, Computer, Photocopy Machine, Printer, Fax, Shelving (Library books/pharmaceuticals etc.)] Yes ☐ No ☐

5.3 Basic Installation & Services [Telecommunications (Roof top antennas, Satellite Dishes) Vacuum network, Drinking water (Roof top water tanks, Water coolers), Air conditioning plants/ducts] Yes ☐ No ☐

Assessment of 5.0 does not modify the damageability grade of the building.

6.0 Probable Damageability in Few/Many Buildings

Building Type	**6.1 Masonry Building**				
Damageability	A/A+	B/B+	C/C+	D	D+
in Intensity VIII	G5	G4/G3	G3/G2	G2	Nil

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.

RECOMMENDED ACTION:-

- If in the evaluation the damageability grades are G1/G2 the building may be considered seismically safe.
- If the damageability grade obtained is G3 the building will not be likely to collapse but subject to heavy damage. In such a case the building may be recommended for evaluation.
- If the damageability grade obtained are G4/G5 it indicates that the building is unsafe and will need retrofitting after re-evaluation.
- If any Special Hazard 4.0 found , re-evaluate for possible retrofitting.
- If any of the falling hazard (5.1) is present, either remove it or strengthen against falling. Items under 5.2 & 5.3 will generally need stabilization.
- Special observation (2.3.5) if not compliant may lead to more severe damage and will call for retrofitting.

Surveyor's sign:____________ Name:____________________ Date: __________

1.0 General Information

1.1 Seismic Zone ____________________________

1.2 Building Name__________________________

1.3 Use___________________________________

1.4 Address:_______________________________

1.5 Other Identifiers________________________

1.6 No. of Stories___________________________

1.7 Year Built ______________________________

1.8 Total Covd. Area; all floors (sq.m) ____________

1.9 Ground Coverage (Sq.m):__________________

1.10 Soil Type: ______________________________

2.1 Foundation Type

2.1.1 Strip footing Yes ☐ No ☐

2.1.2 Isolated pier footing Yes ☐ No ☐

2.3 Structural Components:

2.3.1 Wall Type

2.3.1.1 Earthen/claymud/Adobe Yes ☐ No ☐

2.3.1.2 Bamboo Yes ☐ No ☐

2.3.1.3 Wooden Yes ☐ No ☐

2.3.1.4 UCR Masonr Yes ☐ No ☐

2.3.1.5 Dressed stone masonry Yes ☐ No ☐

2.3.1.6 Burnt Brick Yes ☐ No ☐

2.3.1.7 Cement Concrete Blocks Yes ☐ No ☐

2.3.1.8 Reinforce masonry wall Yes ☐ No ☐

2.3.1.9 Thickness of wall ________________________

2.3.2 Mortar Type:

2.3.2.1 Mud mortar Yes ☐ No ☐

2.3.2.2 Lime Mortar Yes ☐ No ☐

2.3.2.3 Cement Mortar Yes ☐ No ☐

2.3.3 Vert. R/F bars provided (at corners, T-junctions & Jambs)

2.3.3.1 Using Wood Yes ☐ No ☐

2.3.3.2 Using RC Yes ☐ No ☐

2.3.4 Seismic bands in all internal & ext. walls (at plinth, lintel, eaves of pitched & gable wall top)

2.3.4.1 Using wood Yes ☐ No ☐

2.3.4.2 Using RC Yes ☐ No ☐

2.3.5 Special Observation

2.3.5.1 Length of wall between two cross walls are as per the national standards*. Yes ☐ No ☐

2.3.5.2 Percentage of openings in walls are as per the national standard*. Yes ☐ No ☐

2.3.5.3 Ratio of height & width of wall is as per the national standard*. Yes ☐ No ☐

2.3.5.4 Whether through stones and corner stones provided. Yes ☐ No ☐

*For example Indian Standards IS:4326 & IS:13828 have specific provisions

4 Arya's Method of RVS of School & Hospital RCF/SF Buildings Low Hazard MSK VII

Photograph/ Sketch Plan with Length & Breadth

4.0 Special Hazard

4.1 High Water Table (within 3m below ground level) & if sandy soil, then liquefiable site indicated. Yes □ No □

4.2 Land Slide Prone Site Yes □ No □

4.3 Severe Vertical Irregularity Yes □ No □ (Increase damageability grade by 2 units)

4.4 Severe Plan Irregularity Yes □ No □ (Increase damageability grade by 1 unit)

5.0 Non-structural Components*:- Whether the following non-structural elements has been properly anchored/fastened keeping into consideration the potential damages from earthquake

5.1 Falling Hazards (Brick wall/wooden partitions, Façade elements, False Ceilings, Parapets, Chimneys, Signs, display boards etc.) Yes □ No □

5.2 Equipments & Furnishings [Medical equipment/lab equipments, Industrial equipment (generators/machines etc.), Office Equipments (Almirah, Computer, Photocopy Machine, Printer, Fax, Shelving (Library books/pharmaceuticals etc.)] Yes □ No □

5.3 Basic Installation & Services [Telecommunications (Roof top antennas, Satellite Dishes) Vacuum network, Drinking water (Roof top water tanks, Water coolers), Air conditioning plants/ducts] Yes □ No □

Assessment of 5.0 does not modify the damageability grade of the building.

6.0 Probable Damageability in Few/Many Buildings					
Building Type	**6.1 Masonry Building**				
Damageability	A/A+	B/B+	C/C+	D	D+
in Intensity VIII	G5	G4/G3	G3/G2	G2	Nil

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.

RECOMMENDED ACTION:-

- If in the evaluation the damageability grades are G1/G2 the building may be considered seismically safe.
- If the damageability grade obtained is G3 the building will not be likely to collapse but subject to heavy damage. In such a case the building may be recommended for evaluation.
- If the damageability grade obtained are G4/G5 it indicates that the building is unsafe and will need retrofitting after re-evaluation.
- If any Special Hazard 4.0 found , re-evaluate for possible retrofitting.
- If any of the falling hazard (5.1) is present, either remove it or strengthen against falling. Items under 5.2 & 5.3 will generally need stabilization.
- Special observation (2.3.5) if not compliant may lead to more severe damage and will call for retrofitting.

Surveyor's sign:____________ Name:____________________ Date: __________

1.0 General Information

1.1 Seismic Zone ____________________________

1.2 Building Name___________________________

1.3 Use____________________________________

1.4 Address:________________________________

1.5 Other Identifiers__________________________

1.6 No. of Stories____________________________

1.7 Year Built ______________________________

1.8 Total Covd. Area; all floors (sq.m) _____________

1.9 Ground Coverage (Sq.m):___________________

1.10 Soil Type: ______________________________

2.1 Foundation Type

2.1.1 Strip footing Yes □ No □

2.1.2 Isolated pier footing Yes □ No □

2.3 Structural Components:

2.3.1 Wall Type

2.3.1.1 Earthen/claymud/Adobe Yes □ No □

2.3.1.2 Bamboo Yes □ No □

2.3.1.3 Wooden Yes □ No □

2.3.1.4 UCR Masonr Yes □ No □

2.3.1.5 Dressed stone masonry Yes □ No □

2.3.1.6 Burnt Brick Yes □ No □

2.3.1.7 Cement Concrete Blocks Yes □ No □

2.3.1.8 Reinforce masonry wall Yes □ No □

2.3.1.9 Thickness of wall ________________________

2.3.2 Mortar Type:

2.3.2.1 Mud mortar Yes □ No □

2.3.2.2 Lime Mortar Yes □ No □

2.3.2.3 Cement Mortar Yes □ No □

2.3.3 Vert. R/F bars provided (at corners, T-junctions & Jambs)

2.3.3.1 Using Wood Yes □ No □

2.3.3.2 Using RC Yes □ No □

2.3.4 Seismic bands in all internal & ext. walls (at plinth, lintel, eaves of pitched & gable wall top)

2.3.4.1 Using wood Yes □ No □

2.3.4.2 Using RC Yes □ No □

2.3.5 Special Observation

2.3.5.1 Length of wall between two cross walls are as per the national standards*. Yes □ No □

2.3.5.2 Percentage of openings in walls are as per the national standard*. Yes □ No □

2.3.5.3 Ratio of height & width of wall is as per the national standard*. Yes □ No □

2.3.5.4 Whether through stones and corner stones provided. Yes □ No □

*For example Indian Standards IS:4326 & IS:13828 have specific provisions

5 Arya's Method of RVS of School & Hospital RCF/SF Buildings Moderate Hazard MSK VIII

Photograph/ Sketch Plan with Length & Breadth

4.0 Special Hazard

4.1 High Water Table (within 3m below ground level) & if sandy soil, then liquefiable site indicated. Yes □ No □

4.2 Land Slide Prone Site Yes □ No □

4.3 Severe Vertical Irregularity Yes □ No □ (Increase damageability grade by 2 units)

4.4 Severe Plan Irregularity Yes □ No □ (Increase damageability grade by 1 unit)

5.0 Non-structural Components*:- Whether the following non-structural elements has been properly anchored/fastened keeping into consideration the potential damages from earthquake

5.1 Falling Hazards (Brick wall/wooden partitions, Façade elements, False Ceilings, Parapets, Chimneys, Signs, display boards etc.) Yes □ No □

5.2 Equipments & Furnishings [Medical equipment/lab equipments, Industrial equipment (generators/machines etc.), Office Equipments (Almirah, Computer, Photocopy Machine, Printer, Fax, Shelving (Library books/pharmaceuticals etc.)] Yes □ No □

5.3 Basic Installation & Services [Telecommunications (Roof top antennas, Satellite Dishes) Vacuum network, Drinking water (Roof top water tanks, Water coolers), Air conditioning plants/ducts] Yes □ No □

Assessment of 5.0 does not modify the damageability grade of the building.

6.0 Probable Damageability in Few/Many Buildings

Building Type	**6.1 Masonry Building**				
Damageability	A/A+	B/B+	C/C+	D	D+
in Intensity VIII	G5	G4/G3	G3/G2	G2	Nil

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.

RECOMMENDED ACTION:-

- If in the evaluation the damageability grades are G1/G2 the building may be considered seismically safe.
- If the damageability grade obtained is G3 the building will not be likely to collapse but subject to heavy damage. In such a case the building may be recommended for evaluation.
- If the damageability grade obtained are G4/G5 it indicates that the building is unsafe and will need retrofitting after re-evaluation.
- If any Special Hazard 4.0 found , re-evaluate for possible retrofitting.
- If any of the falling hazard (5.1) is present, either remove it or strengthen against falling. Items under 5.2 & 5.3 will generally need stabilization.
- Special observation (2.3.5) if not compliant may lead to more severe damage and will call for retrofitting.

Surveyor's sign:____________ Name:____________________ Date: __________

1.0 General Information

1.1 Seismic Zone ____________________________

1.2 Building Name__________________________

1.3 Use__________________________________

1.4 Address:______________________________

1.5 Other Identifiers________________________

1.6 No. of Stories___________________________

1.7 Year Built ______________________________

1.8 Total Covd. Area; all floors (sq.m) _____________

1.9 Ground Coverage (Sq.m):__________________

1.10 Soil Type: _____________________________

2.1 Foundation Type

2.1.1 Strip footing Yes □ No □

2.1.2 Isolated pier footing Yes □ No □

2.3 Structural Components:

2.3.1 Wall Type

2.3.1.1 Earthen/claymud/Adobe Yes □ No □

2.3.1.2 Bamboo Yes □ No □

2.3.1.3 Wooden Yes □ No □

2.3.1.4 UCR Masonr Yes □ No □

2.3.1.5 Dressed stone masonry Yes □ No □

2.3.1.6 Burnt Brick Yes □ No □

2.3.1.7 Cement Concrete Blocks Yes □ No □

2.3.1.8 Reinforce masonry wall Yes □ No □

2.3.1.9 Thickness of wall _________________________

2.3.2 Mortar Type:

2.3.2.1 Mud mortar Yes □ No □

2.3.2.2 Lime Mortar Yes □ No □

2.3.2.3 Cement Mortar Yes □ No □

2.3.3 Vert. R/F bars provided (at corners, T-junctions & Jambs)

2.3.3.1 Using Wood Yes □ No □

2.3.3.2 Using RC Yes □ No □

2.3.4 Seismic bands in all internal & ext. walls (at plinth, lintel, eaves of pitched & gable wall top)

2.3.4.1 Using wood Yes □ No □

2.3.4.2 Using RC Yes □ No □

2.3.5 Special Observation

2.3.5.1 Length of wall between two cross walls are as per the national standards*. Yes □ No □

2.3.5.2 Percentage of openings in walls are as per the national standard*. Yes □ No □

2.3.5.3 Ratio of height & width of wall is as per the national standard*. Yes □ No □

2.3.5.4 Whether through stones and corner stones provided. Yes □ No □

*For example Indian Standards IS:4326 & IS:13828 have specific provisions

6 Arya's Method of RVS of School & Hospital RCF/SF Buildings High Hazard MSK IX or Higher

Photograph/ Sketch Plan with Length & Breadth

4.0 Special Hazard

4.1 High Water Table (within 3m below ground level) & if sandy soil, then liquefiable site indicated. Yes ☐ No ☐

4.2 Land Slide Prone Site Yes ☐ No ☐

4.3 Severe Vertical Irregularity Yes ☐ No ☐ (Increase damageability grade by 2 units)

4.4 Severe Plan Irregularity Yes ☐ No ☐ (Increase damageability grade by 1 unit)

5.0 Non-structural Components*:- Whether the following non-structural elements has been properly anchored/fastened keeping into consideration the potential damages from earthquake

5.1 Falling Hazards (Brick wall/wooden partitions, Façade elements, False Ceilings, Parapets, Chimneys, Signs, display boards etc.) Yes ☐ No ☐

5.2 Equipments & Furnishings [Medical equipment/lab equipments, Industrial equipment (generators/machines etc.), Office Equipments (Almirah, Computer, Photocopy Machine, Printer, Fax, Shelving (Library books/pharmaceuticals etc.)] Yes ☐ No ☐

5.3 Basic Installation & Services [Telecommunications (Roof top antennas, Satellite Dishes) Vacuum network, Drinking water (Roof top water tanks, Water coolers), Air conditioning plants/ducts] Yes ☐ No ☐

****Assessment of 5.0 does not modify the damageability grade of the building.***

6.0 Probable Damageability in Few/Many Buildings

Building Type	**6.1 Masonry Building**				
Damageability in Intensity VIII	A/A+	B/B+	C/C+	D	D+
	G5	G4/G3	G3/G2	G2	Nil

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.

RECOMMENDED ACTION:-

- If in the evaluation the damageability grades are G1/G2 the building may be considered seismically safe.
- If the damageability grade obtained is G3 the building will not be likely to collapse but subject to heavy damage. In such a case the building may be recommended for evaluation.
- If the damageability grade obtained are G4/G5 it indicates that the building is unsafe and will need retrofitting after re-evaluation.
- If any Special Hazard 4.0 found , re-evaluate for possible retrofitting.
- If any of the falling hazard (5.1) is present, either remove it or strengthen against falling. Items under 5.2 & 5.3 will generally need stabilization.
- Special observation (2.3.5) if not compliant may lead to more severe damage and will call for retrofitting.

Surveyor's sign:____________ Name:____________________ Date: __________

1.0 General Information

1.1 Seismic Zone ______________________________

1.2 Building Name__________________________

1.3 Use____________________________________

1.4 Address:________________________________

1.5 Other Identifiers__________________________

1.6 No. of Stories_____________________________

1.7 Year Built ________________________________

1.8 Total Covd. Area; all floors (sq.m) _____________

1.9 Ground Coverage (Sq.m):__________________

1.10 Soil Type: _______________________________

2.1 Foundation Type

2.1.1 Strip footing Yes ☐ No ☐

2.1.2 Isolated pier footing Yes ☐ No ☐

2.3 Structural Components:

2.3.1 Wall Type

2.3.1.1 Earthen/claymud/Adobe Yes ☐ No ☐

2.3.1.2 Bamboo Yes ☐ No ☐

2.3.1.3 Wooden Yes ☐ No ☐

2.3.1.4 UCR Masonr Yes ☐ No ☐

2.3.1.5 Dressed stone masonry Yes ☐ No ☐

2.3.1.6 Burnt Brick Yes ☐ No ☐

2.3.1.7 Cement Concrete Blocks Yes ☐ No ☐

2.3.1.8 Reinforce masonry wall Yes ☐ No ☐

2.3.1.9 Thickness of wall ________________________

2.3.2 Mortar Type:

2.3.2.1 Mud mortar Yes ☐ No ☐

2.3.2.2 Lime Mortar Yes ☐ No ☐

2.3.2.3 Cement Mortar Yes ☐ No ☐

2.3.3 Vert. R/F bars provided (at corners, T-junctions & Jambs)

2.3.3.1 Using Wood Yes ☐ No ☐

2.3.3.2 Using RC Yes ☐ No ☐

2.3.4 Seismic bands in all internal & ext. walls (at plinth, lintel, eaves of pitched & gable wall top)

2.3.4.1 Using wood Yes ☐ No ☐

2.3.4.2 Using RC Yes ☐ No ☐

2.3.5 Special Observation

2.3.5.1 Length of wall between two cross walls are as per the national standards*. Yes ☐ No ☐

2.3.5.2 Percentage of openings in walls are as per the national standard*. Yes ☐ No ☐

2.3.5.3 Ratio of height & width of wall is as per the national standard*. Yes ☐ No ☐

2.3.5.4 Whether through stones and corner stones provided. Yes ☐ No ☐

*For example Indian Standards IS:4326 & IS:13828 have specific provisions

Quick Reference Guide for Ready Reference Building Types

Masonry load bearing wall buildings

Building Type	Description*
A	2.3.1.1 ,
A+	2.3.1.1 / 2.3.1.2 / 2.3.1.4 + 2.3.2.1
B	2.3.1.4 / 2.3.1.6 / 2.3.1.7 + 2.3.2.1 + 2.3.5.4
B+	2.3.1.4 / 2.3.1.6 / 2.3.1.7 + 2.3.2.2 + 2.3.5.4
C	2.3.1.5 / 2.3.1.6/ 2.3.1.7 + 2.3.2.3
C+	2.3.1.5 / 2.3.1.6 / 2.3.1.7 + 2.3.2.3 + 2.3.4.1/2.3.4.2
D	2.3.1.6 / 2.3.1.7 + 2.3.2.3 + 2.3.4.2 + 2.3.3.2

** See the reference numbers on the forms 1,2,3.*

Reinforced Concrete Frame Buildings (RCF) and Steel Frames (SF)

Frame Type	Description*
C	3.3.1
C+	3.3.2
D	3.3.3
E	3.3.4
E+	3.3.5
F	3.3.6

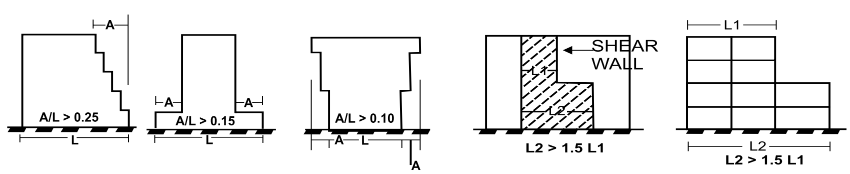
** See the reference numbers on the forms 4,5,6.*

Equipments to be carried by the Surveyor:-

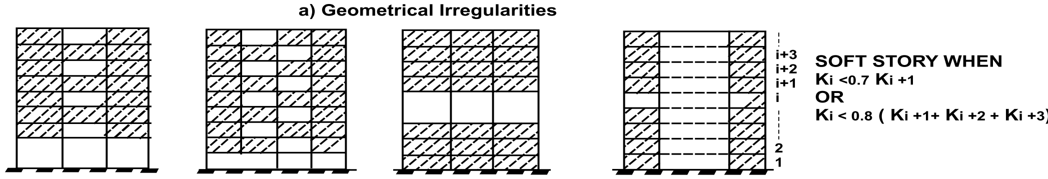
- Camera, preferably digital.
- Hard board with clip.
- Adequate no. of survey sheets.
- One copy of RVS guidelines.
- One copy of Quick Reference Guide (Laminated for Repeated Use)
- Pencil & eraser/ ball pen (black), foot scale, measuring tape as found suitable

Expalantory Note:-

- **Use:-** Residential, school, hospital, office etc.
- **Total Covered area:-** Covered area on all floors.
- **Vertical Irregularity**: As explained in diagram below



a) Geometrical Irregularities

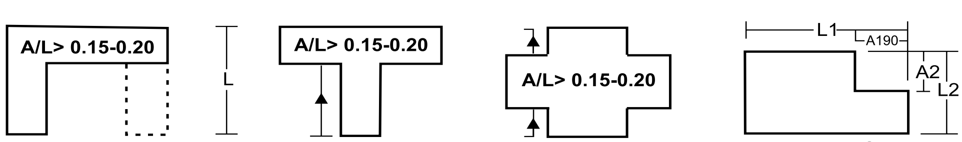


i) Building on Stilt

ii) Other Soft Storey

b) Storey Stiffness Irregularities

4.4 Plan Irregularity: As explained in diagram below



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RVS Implementation Sequence

9.0 There are several steps involved in planning and performing RVS of potentially seismically hazardous buildings. As a *first step*, the building officials should formally approve of the general RVS procedure. *Second*, the School and Hospital authorities and managements should be informed about the purpose of the screening process and how it will be carried out soliciting their cooperation and assistance. There are also other decisions to be made, such as use of the screening results, responsibilities of the building owners and the community, and actions to be taken.

General Sequence of Implementing RVS

The general sequence of implementing the RVS procedure will include the following:

- Budget development and cost estimation, recognizing the expected extent of the screening and further use of the gathered data;
- Pre-planning, including selection of the area to be surveyed, identification of building types to be screened, selection and development of a record-keeping system, and compilation and development of maps that give local seismic hazard information;
- Selection and review of the RVS Data Collection Form;
- Selection and training of Assessors, the screening personnel;
- Acquisition and review of pre-survey data; for example review of existing building files and databases of the survey area to document information identifying buildings to be screened (e.g., address, lot number, number of storeys, design and / or construction date) and identifying soil types
- Review of existing building plans, if available say in municipal files, school or hospital records;
- Visual screening of individual buildings in the field. It will consist of:
  - Verifying and updating building identification information,
  - Walking around the building and sketching a plan and elevation view on the Data Collection Form,
  - Determining occupancy (that is, the building use and number of occupants during day and night),
  - Determining soil type, if not identified during the pre-planning process, by asking questions.
  - Identifying potential nonstructural falling hazards.
  - Identifying the seismic-lateral-load resisting system (entering the building, if possible, to facilitate this process),
  - Identifying the appropriate seismic performance attributes (e.g., number of storeys, design and / or construction date, and soil type),
  - Photographing the building; and
  - Checking the quality of RVS data form, and filing the screening data in the record-keeping system, or database.
- Determining the Final Damageability Score, and deciding if a detailed evaluation is required.

9.2 Cost Estimation and Budget Development

Many decisions about the level of details to be documented during the Rapid Visual Screening may depend upon budget constraints. Although the RVS procedure is designed such that screening of each building should take no more than one hour, the time and funds should also be allocated for pre-survey data collection. This can be extremely useful in reducing the total survey time and in increasing the reliability of data collected in the field. A good example of this is the age, or design and construction date, of a building. This might be readily available from municipality or building department files but is much more difficult to determine otherwise. Another issue to consider is travel time, if the distance between buildings to be screened is large. Other factors in cost estimation are training of personnel and the development and administration of a record keeping system for the screening process.

9.3 Pre-Field Planning

The RVS authority may decide the priorities that should be set for certain sectors within the chosen region on certain building types as for example, educational and health sector buildings that should be surveyed immediately, whereas other areas and buildings can be surveyed at a later time. An area may first be selected because it is older and may have a higher density of potentially seismically hazardous buildings relative to other areas. For example an older part of the region that consists mainly of unreinforced masonry buildings may be of higher priority than a residential section consisting of woodframe single-family dwellings.

Compiling and developing maps for the concerned region is important in the initial planning phase as well as in scheduling of the Assessor. Maps of soil profiles, maps of landslide potential, maps of liquefaction potential and those of active faults will be directly useful in the screening.

Discussions with Local Body Authorities should include the information about the dates when certain aspects of seismic design and detailing were *adopted*, and properly *enforced*.

Planning phase may include deciding how buildings are to be identified such as name of building. Its address, Census identification, lot number, and owner. Consideration should be given to developing a computerized database containing location and other building information to generate forms that incorporate unique information for each building. The advantage of using a computerized record generation and collection system is that graphical data, such as sketches and photographs, are increasingly more easily converted to digital form and stored on the computer, especially if they are collected in digital format in the field. This can be facilitated through the use of *digital cameras*.

9.4 Selection and Review of the Data Collection Form

The RVS Data Collection Forms are developed one for each of the seismicity regions: which may be called Low (L), Moderate (M), High (H), and Very High (VH) intensity seismic zones. Full-sized versions of each form are provided in chapter. Reference Guide that contains definitions and explanations for terms used on the Data Collection Form are also provided with the forms.

Each RVS Data Collection Form provides *space to record the following*:

- the building identification information,
- for drawing a sketch of the building (plan and elevation views),
- attaching a photograph of the building,
- to indicate the occupancy,
- to indicate the soil type,
- documentation of the existence of falling hazards,
- to develop a Final Structural Score and/for Damageability Grade for the building,
- to indicate if a detailed evaluation is required, and
- to provide additional comments.

9.5 Determination of Seismicity of the Region

To select the appropriate RVS Data Collection Form, it is first necessary to determine the seismicity of the region in which the area to be screened is located.

The seismicity region (**H, M,** or **L**) for the screening area can be determined as follows:

The maximum ground motions considered in the scoring system of the RVS procedure should be consistent with those specified for detailed Seismic Structural Design procedure of the Country. Seismic Ground motions having a

2% probability of being exceeded in 50 years are commonly referred to as the Maximum Considered Earthquake (MCE) ground motions. MCE for each seismic zone of any country is specified in zoning Map specifications. Hence the location of the survey-region is to found on the seismicity map of the country or enlarged seismicity map of the state or province where available.

9.6 Qualifications and Training for Assessors

It is considered that a training program will be required to ensure a consistent, high quality of the data and uniformity of decisions among Assessors. The training should include discussion of lateral force-resisting systems and how they behave when subjected to seismic loads, how to use the RVS Data Collection Form, what to look for in the field such as the building attributes, and how to account for uncertainty. In parallel with a professional engineer (a structural engineer) experienced in seismic design, the Assessor trainees should simultaneously consider and score buildings of several different types and compare the results determined by the professional engineer. This will serve as a "calibration" for the Assessors. This process can easily be accomplished in a classroom setting with photographs and / or architectural and structural drawings of actual buildings to use as examples. Prospective Assessors should study the drawings and photographs and perform the RVS procedure as though they were in the field. Upon completion, the class should discusses the results and the trainees can compare how they did in relation to the rest of the class.

9.7 Acquisition and Review of Pre- RVS Data

Information on the structural system, age or occupancy may be available from Local Body Authority sources. These data may be selected from Municipal building department files, Building Census data and previous studies, if any should be reviewed and collated for a given area or building type under study, before commencing the field survey for that area. It is recommended that this supplemental information either be written directly on the RVS Forms as it is retrieved or be entered into a computerized database. The advantage of a database is that selected information can be printed in a report format that can be taken into the field, or printed onto structure labels that can be affixed to the relevant RVS Forms. In addition, RVS survey data can be added to the database and used to generate maps and reports.

9.8 Information about Foundation Soil Strata

Soil type has a major influence on amplitude and duration of shaking, and thus structural damage. Generally speaking, the deeper and softer the soils at a site, the more damaging the earthquake motion will be. Six soil types are considered in the RVS procedure of FEMA 154 as follows

- Hard rock (type A); measured shear wave velocity>1524 m/s (500 ft/s)
- average rock (type B); Shear wave velocity between 762 & 1524 m/s (2500-5000 ft/s)
- dense soil (type C); SPT N>50 or SWV between 366 & 762 m/s (1200-2500 ft/s)
- stiff soil (type D); SPT M from 15:50 or SWV 183-366 m/s (600-1200 ft/s)
- soft soil (type E); more than 30 m (100 ft) soft soil with SWV<183 m/s (600 ft/s)
- poor soil (type F); Soils requiring into specific evaluation, very compassable in nature.

Information on these soil types and how to identify them should be learnt by the Assessor. As per the Indian Seismic Code, IS: 1823 Part-I, there are three soil types as follows;

Type I Rock or Hard Soil: SPT N (corrected)>30

Type II Medium Soil: SPT N (corrected) between 10 and 30

Type III Soft Soils: SPT N (corrected)< 10

Thus Type I Rock or Hard Soil Types partly cover A,B and C of FEMA 154, Type II medium Soil same as parts of type D & E and Type III is roughly between Types E & F. FEMA 154 provides that buildings on Soil Type F (liquefiable or highly compressible) cannot be screened effectively by the RVS procedure. Similarly Soft Soils

(Type III or IS:1893) have to be left out of screening other than to recommend that buildings on this soil type be further evaluated by a geotechnical engineer and design professional experienced in seismic design.

Since soil conditions cannot be readily identified by visual methods in the field, geologic and geotechnical maps and other information should be collected during the planning stage and put into a readily usable map format for use during RVS. During the screening, or the planning stage, this soil type should also be documented on the Data Collection Form by circling the correct soil type, as designated by the letters A through F on the FEMA forms or Type I, II, III of Arya's Form.

Default Values:

If sufficient guidance or data are not available during the planning stage to classify the soil type as A through F, a soil type E should be assumed. However, for one-storey or two-storey buildings with a roof height equal to or less than 7.5 m, a class D soil type or Type III of IS:1893 may be assumed when site conditions are not known.

9.9 Review of Construction Documents

Whenever possible, design and construction documents should be reviewed prior to the conduct of field work to help the Assessor identify the type *of lateral-force- resisting system* for each building. The review of construction documents to identify the building type substantially improves the confidence in RVS which requires that each building be identified as one of model building types considered in developing the RVS methodology.

9.10 Field Screening of Buildings

RVS screening of buildings in the field should be carried out by teams consisting of *two persons* each. Teams of two are recommended to provide an opportunity for them to discuss issues requiring judgment and to facilitate the data collection process. If at all possible, one of the team members should be a design professional who can identify lateral-force resisting systems. Relatively few tools or equipment are needed. The following list provides a checklist of items that may be needed in performing an RVS as described in this *document.*

- Binoculars, if high-rise buildings are to be evaluated
- Camera, preferably digital
- Clipboard for holding Data Collection Forms
- Copy of the RVS document
- Laminated version of the Quick Reference Guide defining terms used on the Data Collection Form
- Pen or pencil
- Straight edge (optional for drawing sketches)
- Tape or stapler, for affixing photo, as required
- Adequate number of RVS Data Forms relevant to the Seismicity Zone

9.11 Checking the Quality and Filing the Field Data in the Record- Keeping System

The last step in the implementation of Rapid Visual Screening is checking the quality and filing the RVS data in the record-keeping system established for this purpose. If the data are to be stored in file folders or envelopes containing data for each building that was screened, the process is straightforward, and requires careful organization. If the data are to be stored in *digital form*, it is important that the data input and verification process include either *double entry* of all data, or systematic *in-depth* checking of print outs (item by item review) of all entered data. It is also recommended that the quality review be performed under the supervision of a design professional with significant experience in seismic design.

9.12 Completing Data Collection Form

RVS Form has to be selected, based on the seismicity level of the area to be screened. The Data Collection Form is completed for each building screened through the following steps:

- Verifying and updating the building identification information;
- Walking *around* and *in* the building to identify its size and shape, and sketching a plan and elevation view on the Data Collection Form;
- Determining and documenting occupancy;
- Determining soil type, if not identified during the pre-planning process;
- Identifying potential nonstructural falling hazards, if any, and indicating their existence on the Data Collection Form;
- Identifying the seismic lateral-load resisting system on the form.
- Identifying and circling the appropriate seismic performance attributes (number of storeys, design date, and soil type)
- Determining the Final Score, and deciding if a detailed evaluation is required; and
- Photographing the building and attaching the photo to the form or indicating a photo reference number on the form if a digital camera is used.

9.13 Sketching the Plan and Elevation Views

As a minimum, a sketch plan of the building should be drawn on the Data Collection Form. An elevation may also be useful in indicating significant features. The sketches are especially important, as they reveal many of the building's attributes to the Assessor as the sketch is made. In other words, it forces the Assessor to systematically view all aspects of the building. The plan sketch should include the location of the building on the site and distance to adjacent buildings. The sketch should note and emphasize special features such as existing significant *cracks* or *configuration* problems.

Building Attributes Affecting Seismic Performance of Buildings

Potential Nonstructural Falling Hazards

Nonstructural falling hazards such as chimneys, parapets, cornices, veneers, overhangs and heavy cladding can pose life-safety hazards if not adequately anchored to the building. Although these hazards may be present, the basic lateral load system for the building may be adequate and require no further review. The falling hazards of major concern are:

- *Unreinforced Chimneys.* Unreinforced masonry chimneys are common in older masonry and wood-frame buildings. They are often inadequately tied to the building structure and fall when strongly shaken. If in doubt as to whether a chimney is reinforced or unreinforced, *assume it is unreinforced*.
- *Parapets*. Unbraced parapets are difficult to identify from the street as it is sometimes difficult to tell if a facade projects above the roofline. Parapets often exist on all sides of the building, their height may not be visible from any side of the structure. Climbing to the roof will indicate the situation correctly.
- *Heavy Cladding*. Large heavy cladding elements, usually precast concrete panels or cut figures should be entered in the Data Collection Form for documenting nonstructural falling hazards. If improperly anchored, the loss of panels may also create major changes to the building stiffness (the elements are considered nonstructural but often contribute substantial stiffness to a building), thus setting up plan irregularities or torsion when only some panels fall.

The existence of heavy cladding is of concern if the connections were designed and installed before the building code adopted seismic anchorage requirements which are normally twice that for gravity loads in the planning stages of the RVS process.

If any of the above nonstructural falling hazards exist, the appropriate box should be checked in the RVS form.

If there are any other falling hazards, the “Other” box should be checked, and the type of hazard indicated the comments section. The RVS authority may later use this information as a basis for notifying the owner of potential problems.

Note: Glass curtain walls are not considered as heavy cladding in the RVS procedure.

10.2 Identifying the Lateral-Load-Resisting System and Distinguishing Between Frame and Bearing Wall Building Systems.

A frame structure (for example, S1, S2, S3, S4, C1, PC2 in FEMA 154) is made up of beams and columns throughout the entire structure, resisting both vertical and lateral loads. A bearing wall structure (for example, PC1 and URM in FEMA 154) uses vertical-load-bearing walls, which are more or less solid, to resist the vertical and lateral loads. When a building has large openings on all sides, it is probably a frame structure as opposed to a bearing wall structure. A common characteristic of a frame structure is the rectangular grid patterns of the facade, indicating the location of the columns and girders behind the finish material. This is particularly revealing when windows occupy the entire opening in the frame, and no infill wall is used. A newer multistory commercial building should be assumed to be a frame structure, even though there may exist interior shear walls carrying the lateral loads (this would be a frame structure with shear walls).

Bearing wall systems carry vertical and lateral loads with walls rather than solely with columns. Structural floor members such as slabs, joists, and beams, are supported by load-bearing walls. A bearing wall system is thus characterized by more or less solid walls and, as a rule of thumb, a load-bearing wall will have more solid areas than openings. It also will have no wide openings, unless a structural lintel is used.

Some bearing-wall structures incorporate structural columns, or are partly frame structures. This is especially popular in multistory commercial buildings in urban lots where girders and columns are used in the ground floor of a bearing wall structure to provide larger openings for retail spaces. Another example is where the loads are carried by both interior columns and a perimeter wall. Both of these examples should be considered as bearing wall structures, because lateral loads are resisted by the bearing walls. Bearing wall structures sometimes utilize only two walls for load bearing. The other walls are non-load-bearing and thus may have large openings as for example shops open only or the front. Therefore, the openness of the front elevation should not be used to determine the structure type. The Assessor should also look at the side and rear facades. If at least two of the four exterior walls appear to be solid then it is likely that it is a bearing wall structure. Window openings in older frame structures can sometimes be misleading. Since wide windows were excessively costly and fragile until relatively recently, several narrow windows separated by thin mullions are often seen in older buildings. These thin mullions are usually not load bearing. When the narrow windows are close together, they constitute a large opening typical of a frame structure, or a window in a bearing wall structure with steel lintels. Whereas open facades on all sides clearly indicate a frame structure, solid walls may be indicative of a bearing wall structure or a frame structure with solid infill walls. Bearing walls are usually much thicker than infill walls, and increase in thickness in the lower storey of multi-storey buildings. This increase in wall thickness can be detected by comparing the wall thickness at windows on different floors. Thus, solid walls can be identified as bearing or non-bearing walls according to their thickness, if the structural material is known. A bearing wall system is sometimes called a box system. It is then useful to know that:

- unreinforced masonry and tilt-up buildings are usually bearing-wall type,
- steel buildings and pre-cast concrete buildings are usually frame type, and
- concrete and reinforced masonry buildings may be either type. A careful review of Table 3-1 and the information provided in Appendices D and E, along with training by knowledgeable building design professionals, should assist the screener in the determination of lateral-force-resisting systems. There will be some buildings for which the lateral-force-resisting system cannot be identified because of their facade treatment. In this case, the screener should liminate those lateral-force-resisting systems that are not possible and assume that any of the others are possible.

10.2 Interior Inspection

Ideally, whenever possible, the Assessor should seek access to the interior of the building to identify, or verify, the lateral-force-resisting system for the building. In the case of reinforced masonry buildings, entry is particularly important so that the Assessor can distinguish between RM1 buildings, which have flexible floor and roof diaphragms, and RM2 buildings, which have rigid floor and roof diaphragms.

10.3 Vertical Irregularity

This performance attribute applies to all building types. Examples of vertical irregularity include buildings with setbacks, hillside buildings, and buildings with soft storey (see illustrations of example vertical irregularities in Figure 6.3 in Section 6). If the building is irregularly shaped in elevation, or if some walls are not vertical, then we have to apply the modifier. If the building is on a steep hill so that over the up-slope dimension of the building, the hill rises at least one story height, a problem may exist because the horizontal stiffness along the lower side may be different from the uphill side. In addition, in the up-slope direction, the stiff short columns attract the seismic shear forces and may fail. In this case the performance modifier will be applicable. A soft story exists if the stiffness of one story is dramatically less than that of most of the others. Examples are shear walls or infill walls not continuous to the foundation. Soft storey are difficult to verify without knowledge of how the building was designed and how the lateral forces are to be transferred from storey to storey. In other words, there may be shear walls in the building that are not visible from the outside. However, if there is doubt, it is best to be conservative and indicate the existence of a soft storey by circling the Vertical Irregularity Score Modifier. Use an asterisk and the comment section to explain the source of uncertainty. In many commercial buildings, the first story is soft due to large window openings for display purposes. If one story is particularly tall or has windows on all sides, and if the stories above have fewer windows, then it is probably a soft story. A building may be adequate in one direction but be "soft" in the perpendicular direction. For example, the front and back walls may be open but the side walls may be solid. Another common example of soft story is "stilt floor" parking commonly found in apartment buildings. Several past earthquakes in California, New Zenland and India have shown the vulnerability of this type of construction. Vertical Irregularity is a difficult characteristic to define, and considerable judgment and experience are required for identification purposes.

10.3 Plan Irregularity

If a building has a plan irregularity, as described below, this modifier will apply. Plan irregularity can affect all building types. Examples of plan irregularity include buildings with re-entrant corners, where damage is likely to occur; buildings with good lateral-load resistance in one direction but not in the other; and buildings with major stiffness eccentricities in the lateral force- resisting system, which may cause twisting (torsion) around a vertical axis.

Buildings with re-entrant corners include those with long wings that are E, L, T, U, or + shaped (see Figures 6.4. Plan irregularities causing torsion are especially prevalent among corner buildings, in which the two adjacent street sides of the building are largely windowed and open, whereas the other two sides are generally solid. Wedge-shaped buildings, triangular in plan, on corners of streets not meeting at 90°, are similarly susceptible. Although plan irregularity can occur in all building types, primary concern lies with wood, tilt-up, pre-cast frame, reinforced masonry and unreinforced masonry construction. Damage at connections may significantly reduce the capacity of a vertical-load-carrying element, leading to partial or total collapse.

SAARC

SAARC DISASTER MANAGEMENT CENTRE

Ground Floor, NIDM Building, IIPA Campus
IP Estate, Ring Road, New Delhi-110002
Phone : 91-11-23702445
Fax : 91-11-23702446
E-mail : director.sdmc@gmail.com
Website : www.saarc-sdmc.nic.in