Seismic Vulnerability Assessment of Existing Buildings: It's Importance

Th. Kiranbala Devi, Nganthoi Naorem

Abstract: Earthquake induced damage has been increased over the few years. Gujarat (2001), Sumatra (2004), Pakistan (2005) and Haiti (2010) are the examples of devastating damage due to earthquake. Collapse of non – engineered and engineered buildings and structures is the chief contributor to the loss of lives and injuries to people. Vulnerability Atlas of India states that there are about 11 million seismically vulnerable houses in Seismic Zone- V , while the corresponding figure for Seismic Zone – IV is 50 million. In all, there are about 80 million building units in India, which are vulnerable, and pose unprecedented risk, if earthquake strikes. However, severe damage was observed in a relatively small percentage of existing buildings even after damaging earthquakes in the World. Identifying such vulnerable buildings to future earthquake is important. To identify such buildings, three levels of seismic vulnerability assessment methods starting from simple to sophisticated procedure, (a) Rapid Visual Screening (RVS) , (b) Simplified Vulnerability Assessment (SVA) and (c) Detailed Vulnerability Assessment (DVA) can be carried out according to the problems detected in the building.

***Keywords:** Collapse, damage, seismic zone, structures, vulnerable*

I. INTRODUCTION

Most building codes in the world explicitly or implicitly accept structural damage to occur in a building during strong earthquakes as long as the hazard to life is prevented. Indeed many earthquakes caused such damage in the past. Seismic design codes were improved after such earthquake disasters, but old constructions were left unprotected by the new technology. Most of the loss of lives and casualties in earthquake are caused due to the collapse of structures and buildings . Therefore, rapid growth of cities with unabated construction of buildings and structures in the recent past co- related with high degree of population density is really a big challenge in high seismic zone , i.e. Zone –IV and V (IS : 1893 - 2002). Since standard codes of building constructions are improved and upgraded , vulnerability assessment of buildings both new and old are becoming necessitated . In fact, assessment of seismic vulnerability status of existing buildings and strengthening of it for seismic resistance is very important and it should be in co-operated in the planning of seismic hazard mitigation.

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Recognising the importance of improving seismic resistance of existing buildings, after the 1995 Hyogo – Ken Nanbu earthquake, Japanese Diet (Congress) even enforced a law on December 25, 1995, requiring numbers of un- identified people and owner of buildings must make effort to perform vulnerability assessment of the structures and must make efforts to strengthen the structures, if needed.

II. VULNERABILITY ASSESSMENT

Assessment of an existing structure for safety is much more difficult task than evaluation of a design on paper. The basic objective of the exercise is to assess the hazard safety of existing buildings and to demonstrate and encourage owners for retrofitting methods of unsafe buildings, particularly those where safety of large number of people is involved.
Seismic evaluations of the buildings systematically performed in three levels 1. Rapid Visual Screening, 2. Simplified Vulnerability Assessment and3. Detailed Vulnerability Assessment

I. Rapid Visual Screening (RVS) : This prequiring only visual evaluation and limited additional information. The important feature of this procedure is that it permits vulnerability assessment based on walk – around of the building by a trained evaluator. This is recommended for all buildings.

***II. Simplified Vulnerability Assessment (SVA)*:** This method is more complex than RVS procedure. The procedure requires limited engineering analysis based on information from visual observations and structural drawings or on site measurements and hence more accurate. For this method, a qualified experienced structural engineered is required. This procedure is recommended for all buildings with high concentration of people.

III. Detailed Vulnerability Assessment (DVA) :The procedure requires detailed computer analysis, similar to or more complex than that required for design of a new building. The detailed vulnerability assessment procedure is highly specialised and recommended for all important and life line buildings. Detailed seismic vulnerability evaluation is a technically complex and expensive procedure and can only be performed on a limited number of buildings. Therefore, it is very important to use simpler method (RVS) that can help readily evaluate the vulnerability profile of different types of buildings, so that the more complex evaluation procedures can be limited to the most critical buildings.

III. DAMAGE STATISTIC FROM MAJOR EARTHQUAKES

After major earthquakes in Japan as well as in the world, the Architectural Institute of Japan (AIJ) investigated and assessed damage level of other buildings. In the assessment, a heavily damaged area was first identified, and the damage level of all

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buildings in the area was assessed by structural engineers and researchers.

Table. 1. Damage Statistics of Buildings From Major Earthquakes:

Earthquake, year	Magnitude	Operational Damage	Heavy Damage	Collapse	Total
Mexico City, 1985	8.1	4,251 (93.8%)	194 (4.3%)	87 (1.9%)	4,532
Lazaro Cardenas, Mexico, 1985	8.0	137 (83.5%)	25 (15.2%)	2 (1.2%)	164
Baguio City, Philippines, 1990	7.7	138 (76.2%)	34 (18.8%)	9 (5.0%)	181
Erzincan City, Turkey, 1992	6.8	328 (77.4%)	68 (16.8%)	28 (6.6%)	424
Kobe (pre-1981construction),1995	6.9	1,186 (79.4%)	149 (10.0%)	158(10.6%)	1,493
Kobe (post -1982 construction), 1995	6.9	1,733 (94.0%)	73 (4.0%)	38 (2.1%)	1,844

The damage statistics show that 75 to 95 percent of buildings in severely damaged areas remained operational after the strong earthquakes in Mexico City, Erzincan City, and Kobe City. Wide difference in percentage of damaged buildings in Kobe in respect of pre and post 1981 constructions indicate the essential of performing seismic vulnerability assessment of buildings periodically as these buildings had shown different seismic resistance, as built using new construction materials and adopting different building construction codes (changed codes).

Table. 2. Seismic Vulnerability Classification for Different Structural Types:

All buildings can be divided in to the following primary categories: (1) masonry buildings, (2) RCCbuildings, (3) steelbuildings, and (4) timberbuildings. These can be further divided into various sub-categories. Based on their seismicresistance the following vulnerability classification has been proposed based on the European Macroseismic Scale (EMS-98) and modified during development of World Housing Encyclopaedia.

<table>
<tr><th rowspan="2">Mate-rial</th><th rowspan="2">TypeofLoad-BearingStructure</th><th rowspan="2">Sub-Types</th><th colspan="6">VulnerabilityClass</th></tr>
<tr><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th></tr>
<tr><td rowspan="16">Masonry</td><td rowspan="2">Stone Masonry Walls</td><td>Rubble stone(fieldstone)inmud/lime mortarorwithoutmortar(usuallywithtimberroof)</td><td>O</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Massivestonemasonry(inlime/cement mortar)</td><td>|-</td><td>-</td><td>O</td><td>-|</td><td></td><td></td></tr>
<tr><td rowspan="4">Earthen/Mud/ Adobe/Rammed EarthenWalls</td><td>Mud walls</td><td>O</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Mudwallswithhorizontalwood elements</td><td>|-</td><td>O</td><td>-|</td><td></td><td></td><td></td></tr>
<tr><td>Adobe block walls</td><td>O</td><td>-|</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Rammedearth/Piseconstruction</td><td>O</td><td>-|</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="6">Burnt clay brick/block masonrywalls</td><td>Unreinforcedbrickmasonryinmudmortar</td><td>|-</td><td>O</td><td>-|</td><td></td><td></td><td></td></tr>
<tr><td>Unreinforcedbrick masonryinmud mortarwith verticalposts</td><td>|-</td><td>O</td><td>-</td><td>-|</td><td></td><td></td></tr>
<tr><td>Unreinforced brickmasonryinlime mortar</td><td>|-</td><td>O</td><td>-</td><td>-|</td><td></td><td></td></tr>
<tr><td>Unreinforced brickmasonryincement mortarwith reinforcedconcretefloor/roofslabs</td><td></td><td>|-</td><td>O</td><td>-|</td><td></td><td></td></tr>
<tr><td>Unreinforced brickmasonryincement mortarwith lintelbands(variousfloor/roofsystems)</td><td></td><td>|-</td><td>O</td><td>-|</td><td></td><td></td></tr>
<tr><td>Confined brick/blockmasonrywithconcrete posts/tiecolumns and beams</td><td></td><td></td><td>|-</td><td>O</td><td>-|</td><td></td></tr>
<tr><td rowspan="2">Concreteblock masonry</td><td>Unreinforced,inlime/cement mortar(variousfloor/roofsystems)</td><td></td><td>|-</td><td>O</td><td>-|</td><td></td><td></td></tr>
<tr><td>Reinforced,incementmortar(variousfloor/roofsystems)</td><td></td><td></td><td>|-</td><td>O</td><td>-|</td><td></td></tr>
<tr><td rowspan="8">Structuralconcrete</td><td rowspan="6">Moment resisting frame</td><td>Designedforgravityloadsonly(predating seismic codes i.e.noseismic features)</td><td>|-</td><td>-</td><td>O</td><td>-|</td><td></td><td></td></tr>
<tr><td>Designedwithseismic features(various ages)</td><td></td><td></td><td>|-</td><td>-</td><td>O</td><td>-|</td></tr>
<tr><td>Frame withunreinforced masonryinfillwalls</td><td></td><td>|-</td><td>O</td><td>-</td><td>-|</td><td></td></tr>
<tr><td>Flat slab structure</td><td></td><td>|-</td><td>O</td><td>-</td><td>-|</td><td></td></tr>
<tr><td>Precast frame structure</td><td></td><td>|-</td><td>O</td><td>-|</td><td></td><td></td></tr>
<tr><td>Frame withconcreteshearwalls(dual system)</td><td></td><td></td><td>|-</td><td>-</td><td>O</td><td>-|</td></tr>
<tr><td rowspan="2">Shearwallstructure</td><td>Walls cast in-situ</td><td></td><td></td><td></td><td>|-</td><td>O</td><td>-|</td></tr>
<tr><td>Precast wallpanelstructure</td><td></td><td>|-</td><td>O</td><td>-|</td><td></td><td></td></tr>
<tr><td rowspan="5">Steel</td><td rowspan="3">Moment-resisting frame</td><td>With brickmasonrypartitions</td><td></td><td></td><td>|-</td><td>O</td><td>-</td><td>-|</td></tr>
<tr><td>With cast in-situ concretewalls</td><td></td><td></td><td>|-</td><td>-</td><td>O</td><td>-|</td></tr>
<tr><td>With lightweightpartitions</td><td></td><td></td><td></td><td>|-</td><td>O</td><td>-|</td></tr>
<tr><td>Bracedframe</td><td>With variousfloor/roofsystems</td><td></td><td></td><td></td><td>|-</td><td>O</td><td>-|</td></tr>
<tr><td>Lightmetalframe</td><td>Single storeyLMframe structure</td><td></td><td></td><td>|-</td><td>-</td><td>O</td><td>-|</td></tr>
<tr><td rowspan="3">Woodenstructures</td><td rowspan="3">Load-bearing</td><td>Thatchroof</td><td>|-</td><td>-</td><td>O</td><td>-|</td><td></td><td></td></tr>
<tr><td>Post andbeamframe</td><td></td><td></td><td>|-</td><td>O</td><td>-|</td><td></td></tr>
<tr><td>Wallswithbamboo/reedmesh andpost (Wattle and Daub)</td><td></td><td>|-</td><td>O</td><td>-|</td><td></td><td></td></tr>
</table>

	timberframe	Frame with(stone/brick)masonryinfill	|-	-	O	-|		
		Frame with plywood/gypsumboardsheathing		|-	O	-|		
		Frame withstudwalls				|-	O	-|

O Most likely vulnerability class
|- Most likely lower range
-| Most likely upper range

Table. 3. Classification of Damage to Buildings:

The damage classifications based on the European Macroseismic Scale(EMS-98)define building damage to be in Grade1to Grade5.The damage classifications help in evaluation of earthquake intensity following an earthquake. They are used in RVS to predict potential damage of a building during code-level earthquake.

Classification of damage to masonry buildings	Classification of damage to reinforced concrete buildings
Grade1:Negligibletoslightdamage (No structural damage ,slight non-structural damage) Hair-line cracks in very few walls. Fall of small pieces of plaster only. Fall of loose stones from upper parts of buildings in very few cases.	**Grade1:Negligibletoslightdamage (No structural damage, slight non-structural damage)** Fine cracks in plaster over frame members or in walls at the base. Fine cracks in partitions and in fills.
Grade2:Moderatedamage (Slight structural damage ,moderate non-structural damage) Cracks in many walls. Fall of fairly large pieces of plaster. Partial collapse of chimneys and mumptys.	**Grade2:Moderatedamage (Slight structural damage, moderate non-structural damage)** Cracks in columns and beams of frames and in structural walls. Cracks in partition and infill walls; fall of brittle cladding and plaster. Falling mortar from the joints of wall panels.
Grade3:Substantialtoheavydamage(moderatestructuraldamage,heavynon-structuraldamage) Large and extensive cracks inmost walls. Roof tiles detach. Chimneys fracture at the roof line; failure of individual non-structural elements (partitions ,gable walls etc.).	**Grade3:Substantialtoheavydamage(moderatestructuraldamage,heavynon-structuraldamage)** Cracks in columns and beam-column joints of frames at the base and at joints of coupled walls. Spalling of concrete cover, buckling of reinforced bars. Large cracks in partition and infill walls, failure of individual infill panels.
Grade4:Veryheavydamage(heavystructuraldamage,veryheavynon-structuraldamage) Serious failure of walls (gaps in walls); partial structural failure of roofs and floors.	**Grade4:Veryheavydamage(heavystructuraldamage,veryheavynon-structuraldamage)** Large cracks in structural elements with compression failure of concrete and fracture of rebars; bond failure of beam reinforcing bars; tilting of columns. Collapse of a few columns or of a single upper floor.
Grade5:Destruction(very heavy structural damage) Total or near total collapse of the building.	**Grade5:Destruction(very heavy structural damage)** Collapse of ground floor parts (e.g.wings) of the building.

Table. 4. Expected Damage Level as Function of RVS score:

The probable damage can be estimated based on the RVS score and is given below. However, it should be realised that the actual damage will depend on a number of factors that are not included in the RVS procedure. As a result, this table should only be used as indicative to determine the necessity of carrying out simplified vulnerability assessment of the buildings. These results can also be used to determine the necessity of retrofitting buildings where more comprehensive vulnerability assessment may not be feasible.

RVSScore	Damage Potential
S< 0.3	High probability of Grade 5 damage; Very high probability of Grade 4 damage
0.3 <S< 0.7	High probability of Grade 4 damage; Very high probability of Grade 3 damage
0.7 <S< 2.0	High probability of Grade 3 damage; Very high probability of Grade 2 damage
2.0 <S< 3.0	High probability of Grade 2 damage; Very high probability of Grade 1 damage
S> 3.0	Probability of Grade 1 damage

IV. SEISMICITY IN INDIA

India has been divided in to four seismic zones, (Fig. 1), (IS: 1893-2002).Details of different seismic zones are given in table 5.

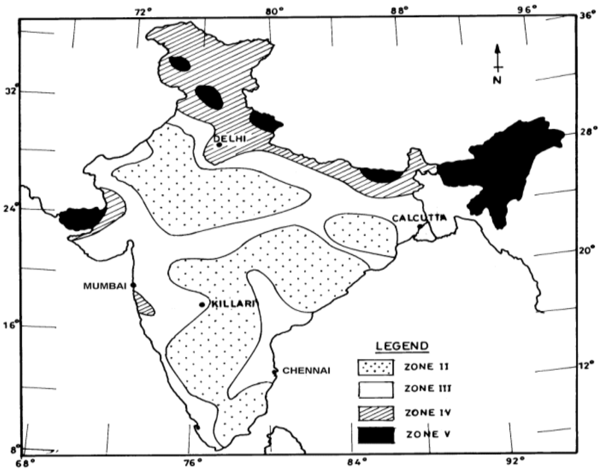

Fig. 1. Seismic zoning map of India (IS: 1893-2002, part 1)

Table 5. Seismic hazards related to seismic zones:

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

Rapid Visual Screening of Buildings for Potential Seismic Vulnerability

FEMA – 154/ATC – 21 Based Data Collection Form **(Seismic Zones II)**

Address: ______________________________
______________________ Pin ______________________
Other Identifiers ______________________
GPS Coordinates (if available) ______________________
No. Stories ______________ Year Built ______________
Surveyor ______________ Date ______________
Total Floor Area (sq.ft./ sq. m) ______________________
Building Name ______________________
Use ______________________
Current Visual Condition : Excellent ☐ / Good ☐ /Damaged ☐ / Distressed ☐
Building on Stilts / Open Ground Floor : Yes ☐ / No ☐
Construction Drawing Available : Yes ☐ / No ☐

PHOTOGRAPH
(OR SPECIFY PHOTOGRAPH NUMBERS)

Plan and Elevation Scale:	

OCCUPANCY		SOIL TYPE (IS 1893:2002)	FALLING HAZARDS
Assembly Govt. Office Commercial Historic Residential Emer.Service Industrial School	Max. No. of persons 0 – 10 11 – 100 101 – 1000 1000+	Type I Type II Type III Hard Soil Medium Soil Soft Soil	☐ Chimneys ☐ Parapets ☐ Catching ☐ Other

BASIC SCORE, MODIFIERS, AND FINAL SCORE, S

Building Type	Wood	S1 (FRAME)	S2 (LM)	C1 (MRF)	C2 (SW)	C3 (INF)	URM1 (BAND+RD)	URM2 (BAND+FD)	URM3	URM4
Basic Score	6.0	4.6	4.6	4.4	4.8	4.4	4.6	4.8	4.6	3.6
Mid.Rise (4 to7 stories)	N/A	+0.2	N/A	+0.4	- 0.2	- 0.4	- 0.2	- 0.4	- 0.6	- 0.6
High Rise (>7 stories)	N/A	+1.0	N/A	+1.0	+0.8	0.0	- 0.4	N/A	N/A	N/A
Vertical Irregularity	-3.0	- 2.0	N/A	- 1.5	-2.0	-2.0	-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
Code Detailing	N/A	+0.4	N/A	+0.6	+0.4	N/A	N/A	N/A	N/A	N/A
Soil Type II	- 0.4	- 0.8	- 0.4	- 0.6	- 0.4	- 0.4	- 0.2	- 0.4	- 0.4	- 0.4
Soil Type III	- 0.8	- 1.4	- 1.0	- 1.4	- 0.8	- 0.8	- 0.8	- 0.8	- 0.8	- 0.8
Liquifiable Soil	- 2.0	- 2.0	- 2.0	- 2.0	- 2.0	- 2.0	- 1.6	- 1.4	- 1.4	- 1.4

FINAL SCORE, S

Result Interpretation (*Likely building performance*)	Further Evaluation Recommended
S < 0.3 High probability of Grade 5 damage, Very high probability of Grade 4 damage 0.3 < S < 0.7 High probability of Grade 4 damage, Very high probability of Grade 3 damage 0.7 < S < 2.0 High probability of Grade 3 damage, Very high probability of Grade 2 damage 2.0 < S < 3.0 High probability of Grade 2 damage, Very high probability of Grade 1 damage S > 3.0 Probability of Grade 1 damage	YES NO

* = Estimated, subjective, or unreliable data FRAME = Steel Frame SW = Sheer Wall URM3 =Unreinforced burnt brick or stone masonry (cem mortar)
DNK = Do Not Know INF= Burnt Brick Masonry Infill Wall LM = Light Metal
MRF = Moment – Resisting Frame BAND = Seismic Band RD = Rigid Diaphragm
FD = Flexible Diaphragm URM4 = Unreinforced masonry (lime mortar)

Rapid Visual Screening of Buildings for Potential Seismic Vulnerability
FEMA – 154/ATC – 21 Based Data Collection Form **(Seismic Zones III)**

Address: ____

______________________Pin ______________________

Other Identifiers ____

GPS Coordinates (if available) ______________________________

No. Stories _______________ Year Built _____________________

Surveyor ________________ Date ___________________________

Total Floor Area (sq.ft./ sq. m) ____________________________

Building Name ____

Use ____

Current Visual Condition : Excellent ☐ / Good ☐ /Damaged ☐ / Distressed ☐

Building on Stilts / Open Ground Floor : Yes ☐ / No ☐

Construction Drawing Available : Yes ☐ / No ☐

PHOTOGRAPH
(OR SPECIFY PHOTOGRAPH NUMBERS)

Plan and Elevation Scale:

OCCUPANCY		SOIL TYPE (IS 1893:2002)	FALLING HAZARDS
Assembly Govt. Office Commercial Historic Residential Emer.Service Industrial School	Max. No. of persons 0 – 10 11 – 100 101 – 1000 1000+	Type I Type II Type III Hard Soil Medium Soil Soft Soil	☐ Chimneys ☐ Parapets ☐ Catching ☐ Other

BASIC SCORE, MODIFIERS, AND FINAL SCORE, S

Building Type	Wood	S1 (FRAME)	S2 (LM)	C1 (MRF)	C2 (SW)	C3 (INF)	URM1 (BAND+RD)	URM2 (BAND+FD)	URM3	URM4
Basic Score	4.4	3.6	3.8	3.0	3.6	3.2	3.4	3.6	3.0	2.4
Mid Rise (4 to7 stories)	N/A	+0.4	N/A	+0.2	+0.4	+0.2	+0.4	+0.4	- 0.4	- 0.4
High Rise (>7 stories)	N/A	+0.8	N/A	+0.5	+0.8	+0.4	N/A	N/A	N/A	N/A
Vertical Irregularity	-3.0	- 2.0	N/A	- 2.0	-2.0	-2.0	-2.0	-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 - 0.5
Code Detailing	N/A	+1.4	N/A	+1.2	+1.6	+1.2	+ 2.0	+ 2.0	N/A	N/A
Soil Type II	- 0.2	- 0.6	- 0.6	- 0.6	- 0.8	- 0.6	- 0.8	- 0.8	- 0.4	- 0.4
Soil Type III	- 0.6	- 1.2	- 1.0	- 1.0	- 1.2	- 1.0	-1.2	- 1.2	- 0.8	- 0.8
Liquifiable Soil	- 1.2	- 1.6	- 1.6	- 1.6	- 1.6	- 1.6	- 1.6	-1.6	- 1.6	- 1.6

FINAL SCORE, S

Result Interpretation (*Likely building performance*)

S	Interpretation
S < 0.3	High probability of Grade 5 damage, Very high probability of Grade 4 damage
0.3 < S < 0.7	High probability of Grade 4 damage, Very high probability of Grade 3 damage
0.7 < S < 2.0	High probability of Grade 3 damage, Very high probability of Grade 2 damage
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S > 3.0	Probability of Grade 1 damage

Further Evaluation Recommended

YES NO

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* = Estimated, subjective, or unreliable data   FRAME = Steel Frame   SW = Sheer Wall   URM3 =Unreinforced burnt brick or stone masonry (cem mortar)
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MRF = Moment – Resisting Frame   BAND = Seismic Band   RD = Rigid Diaphragm
FD = Flexible Diaphragm   URM4 = Unreinforced masonry (lime mortar)

Rapid Visual Screening of Buildings for Potential Seismic Vulnerability
FEMA – 154/ATC – 21 Based Data Collection Form **(Seismic Zones IV & V)**

Address: ______________________________
______________Pin ______________
Other Identifiers ______________________
GPS Coordinates (if available) ______________
No. Stories __________ Year Built __________
Surveyor __________ Date __________
Total Floor Area (sq.ft./ sq. m) ______________
Building Name ______________________
Use ______________________
Current Visual Condition : Excellent ☐ / Good ☐ /Damaged ☐ / Distressed ☐
Building on Stilts / Open Ground Floor : Yes ☐ / No ☐
Construction Drawing Available : Yes ☐ / No ☐

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BASIC SCORE, MODIFIERS, AND FINAL SCORE, S

Building Type	Wood	S1 (FRAME)	S2 (LM)	C1 (MRF)	C2 (SW)	C3 (INF)	URM1 (BAND+RD)	URM2 (BAND+FD)	URM3	URM4
Basic Score	3.8	2.8	3.2	2.5	2.8	2.6	2.8	2.8	1.8	1.4
Mid.Rise (4 to7 stories)	N/A	+0.2	N/A	+0.4	+0.4	+0.2	+0.4	+0.4	- 0.2	- 0.4
High Rise (>7 stories)	N/A	+0.6	N/A	+0.6	+0.8	+0.3	N/A	N/A	N/A	N/A
Vertical Irregularity	-2.0	- 1.0	N/A	- 1.5	-1.0	-1.0	-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
Code Detailing	N/A	+0.4	N/A	+0.2	+1.4	+0.2	N/A	N/A	N/A	N/A
Soil Type II	- 0.4	- 0.4	- 0.4	- 0.4	- 0.4	- 0.4	- 0.4	- 0.4	- 0.4	- 0.4
Soil Type III	- 0.8	- 0.6	- 0.6	- 0.6	- 0.6	- 0.4	- 0.6	- 0.6	- 0.6	- 0.6
Liquifiable Soil	- 0.8	- 1.2	- 1.0	- 1.2	- 0.8	- 0.8	- 0.6	- 0.6	- 0.8	- 0.8

FINAL SCORE, S	
Result Interpretation (*Likely building performance*) S < 0.3 High probability of Grade 5 damage, Very high probability of Grade 4 damage 0.3 < S < 0.7 High probability of Grade 4 damage, Very high probability of Grade 3 damage 0.7 < S < 2.0 High probability of Grade 3 damage, Very high probability of Grade 2 damage 2.0 < S < 3.0 High probability of Grade 2 damage, Very high probability of Grade 1 damage S > 3.0 Probability of Grade 1 damage	Further Evaluation Recommended YES NO

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FD = Flexible Diaphragm URM4 = Unreinforced masonry (lime mortar)

V. CONCLUSION

With the development of new technology and employing of new construction materials many buildings though constructed by adopting standard seismic resistance building construction codes are considered no longer sufficient for seismic resistance of structure and expose to hazard in future earthquakes, mainly the old buildings remained unprotected. However small is the destruction and collapse of buildings in percentage, loss of lives and injuries are caused due to poor earthquake resistance of buildings. To identify these small numbers of seismically vulnerable buildings, assessment of the buildings and structures periodically and in systematic manner is very important. For the safety and mitigation of disastrous effects of earthquake hazard, performing seismic vulnerability assessment of all buildings in high seismic zone regions at least by RVS method and strengthening of the structures, if needed is highly recommended.

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