"Rapid Visual Screening of Buildings"

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF REQUIREMENTS FOR THE AWARD OF THE DEGREE

OF

MASTER OF TECHNOLOGY IN STRUCTURAL ENGINEERING

Submitted by

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CANDIDATE'S DECLARATION

I, Ankit Gumber, Roll No. 2K16/STE/03 Student of M.Tech. (Structural Engineering), hereby declare that the project Dissertation titled " Rapid Visual Screening of Buildings" which is submitted by me/us to the Department of Civil Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other similar title or recognition.

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CERTIFICATE

I hereby certify that the Project Dissertation titled "**Rapid Visual Screening of Buildings** " which is submitted by **Ankit Gumber**, Roll No **2K16/STE/03** [Department of Civil Engineering], Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is a record of the project work carried out by the students under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere

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ABSTRACT

The seismic history of India displays a worrisome number of earthquakes and subsequent large scale losses of life and. A few notable examples being the Bhuj Earthquake of 2001, the Indo-Nepal quake of 2015, Kashmir quake of 2005, Great Assam quake of 1897. These events resulted in large scale destruction of life and property and hence call for a risk mitigation and assessment approach. Seismic design however has rapidly evolved over the years but so have the complexities, particularly in design and construction. The structural depreciation is unavoidable in the long run irrespective of the maintenance techniques used. Rapid population increase coupled with a strain on the land for rapid urban development have led to subpar construction quality control being prevalent in the country. Hence the need for a rapid, economical and reliable method of performance evaluation of any structure comes into play and one such viable approach is the Rapid Visual Assessment, called the RVA in short.

By the means of this project, multiple aspects and guidelines for Rapid Visual Assessment (RVA) have been considered. The main guidelines for the process are laid down by FEMA 154 in the USA and no detailed guidelines exist in India. During the course of this project an attempt will be made to model a prototype more suited to the Indian Scenario. A separate sheet that is specified by the Bureau of Indian Standards will be used to screen a number of structures followed by the inferences derived, utility and the suitability of the system thus generated will be discussed in detail.

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Last but not least, I specially thank all the people who are active in this field. Reference material (pictures, tables and forms) from various national and internal reports and journals are included in this report as per requirement and all these are quoted under the reference section at the last of this report.

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

There has been a rapid population explosion all over the world over the past decade, especially in the developing nations. This has led to a sudden rise in the level of infrastructure required to support the increased populace, be it commercial, residential or other services like power and transportation. The existing infrastructural facilities face an increased stress level due to this and a rapid rate of construction has been adopted to keep up with the exponentially growing demands.

With the advent of the era of rapid construction techniques quality has become an even more vital and paramount feature of these techniques with more stringent methods being implemented especially for the seismic evaluation and design. However it is seen that there is also an equally large moral grey zone in the industry that consists of improper construction practices, underhanded methods and non-provision of codal requirements. All of these when coupled with substandard material and increased workload on the structure lead to its rapid deterioration, increasing the vulnerability, and as such call for an improved method of evaluation.

Thus, in case of a developing country such as India, we need a rapid, economical and reliable method of risk assessment of a structure from seismic viewpoints and that's when Rapid Visual Assessment comes in. It is a process developed exclusively along these parameters and has proven its utility in multiple projects all over the world.

However, in case of the Indian subcontinent, this process is still in the stage of infancy and is not widely accepted or used. The major reason behind this would be the differences in the scenario when it comes to India as compared to say USA. A method of overcoming this issue is discussed in this project and that is to alter FEMA 154P scoring system to include factors more pertinent to our Indian scenario. Moreover another drawback of using a manual method can be overcome by creating a program to handle the basic score keeping and calculations, thus reducing the workload on the surveyor. This will not only simplify the process but would also expedite it along with an improved book keeping method.

1.2 OBJECTIVE OF PRESENT STUDY

- 1. An **in-depth study based approach towards RVA (Rapid Visual Assessment) systems proposed** by various Indian researchers and to incorporate their methodologies into a unified RVA system with modification to existing FEMA scores.
- 2. Modifying the factors to be studied for the evaluation of a structure by incorporating factors more useful to our subcontinent and thus enhancing the scoring system.
- 3. **Developing a computer aided approach** to the scoring system to expedite and make the project more convenient.
- 4. Using this methodology to **survey a number of structures** for which data would be gathered and scores generated.
- 5. Using the said data to **draw useful inferences and to propose future scope** for studies while generating conclusions.

1.3 SCOPE OF PRESENT STUDY

This project will aim at developing a prototype system for Rapid Visual Assessment which can serve as a prerequisite to a more precise model tailor made for the Indian scenario which might prove to be better than the vague methods currently in use.

This would lead to a more economic, quicker and more precise method for seismic evaluation and assessment of structures which would aim to be simpler than the obscure methods prevalent.

With proper development and follow up research along with field studies this could lead to creation of a method which can find its way as an Integrated Assessment Tool which can be further expanded to account for vulnerabilities for a wider spectrum of disasters; not only limited to seismic activities.

The computer based model/program so developed can easily be altered for any changes based on the study or the basic guidelines with an ease of adding or editing current parameters along with a mechanization of the whole process. This could further be used to create a municipal database easily accessed while planning disaster mitigation programmes suited to a particular locality or a niche study.

1.4 BASIC METHODOLOGY

The methodology adopted for this project can be easily subdivided under 5 stages, namely:-

- 1. Studying a few basic methodologies and procedures normally adopted for the RVA in India.
- 2. Developing a model more suited for our purpose and refining the weights and factors considered.
- 3. Developing a program to handle the basic data and generate scores while drawing comparisons with score sheets used under FEMA and IS guidelines.
- 4. Using the modified method to rate a number of structures via field inspection and studies.
- 5. Observations, inferences and concluding remarks with a discussion for further scope and developments.

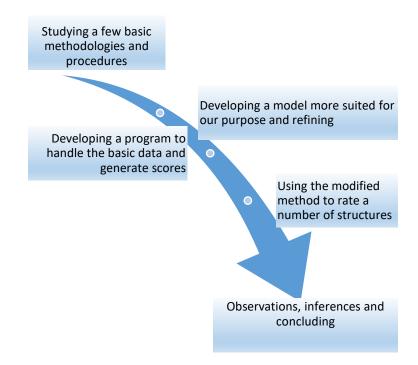


Fig 1.1 Basic RVA Methodology

CHAPTER 2

LITERATURE REVIEW

2.1 BASIC PROCEDURES NECESSITATED

3 levels of risk management techniques need to be used:

- 1. Level 1- RVS (Rapid Visual Screening) requiring only visual evaluation and limited additional information (Level 1 procedure), a procedure recommended for all buildings.
- 2. Level 2-SVA (Simplified vulnerability assessment) which requires limited engineering analysis. It is based on information from visual observations and/or structural drawings aided by on-site measurements. It is recommended for buildings housing a large number of people.
- 3. Level 3- DVA (Detailed vulnerability assessment) which requires detailed computer analysis. It is similar or could be more complex than the design of a new building (procedure). It is required for all important and lifeline structures.

2.2 RVA: BASIC DEFINITION

"Rapid Visual Screening or **Sidewalk Survey** is a procedure of **visual inspection** of a particular building or a group or cluster of buildings of same type so as to identify the presence of basic structural anomalies and environmental damage which that building has faced during the years, recording these observations and thus commenting on the **seismic and overall safety** of the building or group of buildings"

It is to be noted that RVA is only a method for visual assessment and no form of testing procedure can be involved in the process, also it must always be rapid and quick. Thus on the whole it is a process that uses visual inspection techniques and pertinent data for rapid assessment of structures.

2.3 NEED FOR RAPID VISUAL ASSESSMENT

As mentioned previously, RVA methodology comes under the level 1 assessment techniques and is vital in case of high risk zones.

If the building shows a poor score in this preliminary analysis it necessitates the need for further detailed assessments, namely level 2 and level 3 to evaluate the seismic vulnerability.

RVA also provides us a basic tool for the preliminary estimation of the retrofitting techniques and the work involved if the structure is found to have subpar performance characteristics.

For low risk to medium risk structures it gives a reliable and cheap method of analysis without going into detailed work which would potentially increase the cost of investigation. It also helps us identify potential construction or maintenance hazards and apply suitable rectification methods for damage mitigation.

2.4 RESEARCH AND DEVELOPMENT

RVA has been in practice since time immemorial and is not a modern day tool. Since ancient times, those that were involved in the construction of structures were frequently called upon for their advice about the condition or construction of any new building. This, in essence, is the RVA methodology and those technical experts filled in the roles of the screeners.

The modern day variation of this method however is far more sophisticated than those in the old days. It was initially developed by Federal Emergency Management Agency or FEMA in short. It is an agency functioning under the department of homeland security of USA. It came into print in 1988 in the form of FEMA 154, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook* which was used to instruct both engineers and other trained personnel about the basic procedure and guidelines involved in the process.

Over the next decade there was a rapid rise in the use of RVA procedure among the private as well as government organizations to evaluate structures. The ease of use prompted many countries to develop methodologies of their own.

This was later on followed up by *FEMA 154* 2^{nd} edition in 2002. The basic guidelines and the framework was same as that of the previous edition but there were improved score modifiers based on ground motion criteria as given by FEMA 310 Report, *Handbook for Seismic Evaluation of Building*.

After that "*Rapid Visual Screening of Buildings for Potential Seismic Hazards*" Supporting *Documentation* **FEMA 155, Edition 2** was released to further improve the FEMA RVS procedure. It explained how the scores for structure type and modifiers were decided based on Hazus vulnerability analysis.

The latest edition being *FEMA 154 3rd edition published in 2014*, this is also referred to as FEMA P-154. The major enhancements being:

- An optional Level 2 Data Collection Form has been added.
- The number of seismicity regions has been expanded from three to five to increase accuracy of screening in higher seismicity regions. The Third Edition seismicity regions are based on MCER ground motions (rather than the two-thirds of MCE ground motions that were used in the Second Edition).
- Large multi-unit, multi-story wood frame residential and manufactured housing building types have been added.

This is supported by FEMA P-155, which includes the following enhancements:

- Update of the Data Collection Form, and the addition of an optional more detailed page to the form.
- Update of the Basic Scores and Score Modifiers.
- Inclusion of additional building types that are prevalent.
- Inclusion of additional considerations, such as non-structural hazards, existing retrofits, building additions, and adjacency.

Another major development following this was the IRVS, Integrated Rapid Visual Screening process developed under BIPS, Buildings and Infrastructure Protection Series, September 2007 developed by the Department of Homeland Security, USA. This was used to improve the basic RVA method by integrating it with Google Earth with the help of a computer to assess building vulnerability to resist a wider variety of disasters like fires, terrorist attacks, cyclone etc. in addition to the seismic risk.

2.5 FEMA NORMS

2.5.1 OVERVIEW:

The FEMA methodology for Rapid Visual Screening is based on a structural score method

In this approach each structure is assigned a *basic score* based on the type of structure. FEMA 154 P classifies 17 basic types of structures and the screener has to identify the structure out of these 17 available types. This provides the screener with the basic score for the structural system.

After this FEMA 154 provides some parameters known as <u>score modifiers</u>. These are the additional factors which have an affect on the seismic performance of a structure like stiffness or mass irregularities, soil type, etc. Each factor is provided a score which is used to modify the basic structure score.

The screener records this basic score and the score modifiers by means of visual inspection of the building. This is recorded on the <u>RVS forms</u> provided in FEMA 154 P. This is recorded with other details of the structure like photographs, location, occupancy, sketches, structure use etc. The algebraic sum of this basic score and the score modifiers gives the <u>overall structural</u> <u>score</u>. If the overall structural score obtained is less than the specified <u>cut off score</u>, then the

structure is considered unsafe and detailed structural analysis of the building for seismic vulnerability needs to be undertaken. If the score is found higher the structure is considered safe.

The determination of the Cut Off score is the most important part of this methodology. Generally, 2 or 3 is the specified score adopted; it depends on severity, frequency and intensity of earthquakes, but the screener can choose any value according to his experience and on the importance of building. A lower cut off score results in a higher safety criteria and alternatively a higher score results in a greater economy in analysis.

2.5.2 FEMA DOCUMENTS FOR RVA:

1) FEMA P-154:

FEMA P-154 is the basic document that details the procedure for Rapid Visual Assessment of any structure. This is the latest edition that was revised in 2014 which was an improvement over the second edition published in 2002. This is a handbook that outlines the procedure in detail along with the extent of damage any portion of the structure or a structural system is assumed to undergo in the event of any seismic activity. The method is also illustrated in detail by means of a few solved examples.

2) FEMA P-155:

"FEMA P-155 Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation (third edition) is a companion volume to FEMA 154 report, which documents the technical basis for the RVS procedure described in FEMA 154 Handbook, including the method for calculating the Basic Structural Scores and Score Modifiers. The FEMA 155 report (ATC, 2002) also summarizes other information considered during development of this FEMA 154 handbook including the efforts to solicit user feedback and a FEMA 154 Users Workshop held in September 2000."

3) Other FEMA documents related to RVS include-

FEMA 178 NEHRP Handbook for the Seismic Evaluation of Existing Buildings [BSSC, 1992]) FEMA 310, Handbook for Seismic Evaluation of Buildings (ASCE, 1998) FEMA 356, Prestandard and Commentary for the Seismic Rehabilitation of Buildings (ASCE, 2000).

FEMA 273 NEHRP Guidelines for the Seismic Rehabilitation of Buildings (ATC, 1997) FEMA 274 Commentary on the NEHRP Guidelines for the Seismic Rehabilitation of Buildings (ATC, 1997b).

2.5.3 RVA PROCEDURE BASIC FLOWCHART: [1]

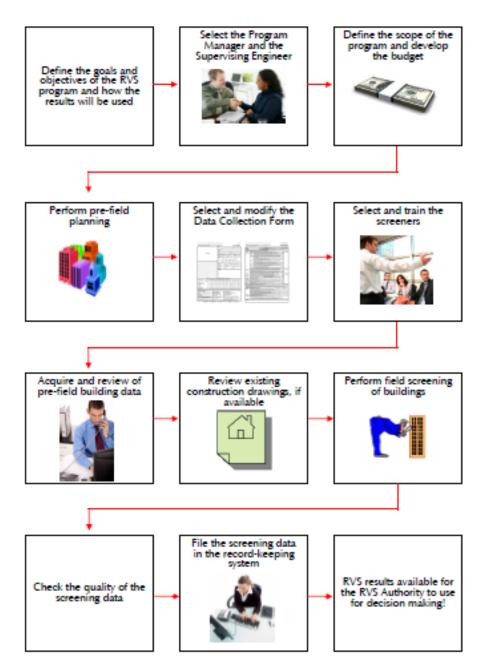


Fig 2.1[1] Steps involved in RVA procedure

The basic process as per this flowchart involves the following steps:

- *Defining the goals and objectives* of the RVS program and how the results will be used
- Selecting the Program Manager and the Supervising Engineer
- *Defining the scope* of the program and develop the budget

- *Performing pre-field planning*, to identify the area to be surveyed, dividing it into a grid pattern and assigning teams to each area, collection of suitable local data about soil types etc.
- Selection and modification of the *Data Collection Form*, to suit the needs of the current survey
- *Selection and training of the screeners*, making them aware of the methods of collecting and reporting data and the proper protocol to be followed.
- Acquisition and review of pre-field building data
- Reviewing existing construction drawings, if available from the local municipal corporation or the builder that performed the construction.
- Performing field screening of buildings.
- *Filing the screening data* in the record-keeping system.
- *Quality check* of the collected data and reviewing it to draw suitable conclusions about the survey quality.

2.5.4 BASIC STRUCTURAL FORMS AND THEIR SCORES [1]

Following are the 17 FEMA Building Types considered in the FEMA P-154 RVS procedure.

- 1. Light wood frame single- or multiple-family dwellings of one or more stories in height (W1)
- 2. Light wood frame multi-unit, multi-story residential buildings with plan areas on each floor of greater than 3,000 square feet (W1A)
- 3. Wood frame commercial and industrial buildings with a floor area larger than 5,000 square feet (W2)
- 4. Steel moment-resisting frame buildings (S1)
- 5. Braced steel frame buildings (S2)
- 6. Light metal buildings (S3)
- 7. Steel frame buildings with cast-in-place concrete shear walls (S4)
- 8. Steel frame buildings with unreinforced masonry infill walls (S5)
- 9. Concrete moment-resisting frame buildings (C1)
- 10. Concrete shear-wall buildings (C2)
- 11. Concrete frame buildings with unreinforced masonry infill walls (C3)
- 12. Tilt-up buildings (PC1)
- 13. Precast concrete frame buildings (PC2)
- 14. Reinforced masonry buildings with flexible floor and roof diaphragms (RM1)
- 15. Reinforced masonry buildings with rigid floor and roof diaphragms (RM2)
- 16. Unreinforced masonry bearing-wall buildings (URM)
- 17. Manufactured housing (MH)

			1
Building	Dhata and h	Basic Structural	Characteristics and Defenses
W1 Light wood frame resi- dential and commercial buildings equal to or smaller than 5,000 square feet	Photograph	Hazard Score H = 2.8 M = 5.2 L = 7.4	 Characteristics and Performance 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. Buildings of this type performed very well in past earthquakes due to inherent qualities of the structural system and because they are lightweight and low rise. Earthquake-induced cracks in the plaster and stucco (if any) may appear, but are classified as non-structural damage. The most common type of structural damage in older buildings results from a lack of connection between the superstructure and the foundation, and inadequate chimney support.
W2 Light wood frame build- ings greater than 5,000 square feet		H = 3.8 M = 4.8 L = 6.0	 These are large apartment buildings, commercial build- ings or industrial structures usually of one to three stories, and, rarely, as tall as six sto- ries.

Fig 2.2 [1] FEMA structural types, scores and characteristics

Building Identifier	Photograph	Basic Structural Hazard Score	Characteristics and Performance
S1 Steel moment- resisting frame		H = 2.8 M = 3.6 L = 4.6	 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. The 1994 Northridge and 1995 Kobe earthquakes showed that the welds in steel moment- frame buildings were vulnerable to severe damage. The damage took the form of broken connections between the beams and columns.
S2 Braced steel frame	Com-in of upper photo	H = 3.0 M = 3.6 L = 4.8	 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. From the building exterior, it is difficult to tell the difference between steel moment frames, steel braced frames, and steel frames with interior concrete shear walls. In recent earthquakes, braced frames were found to have damage to brace connections, especially at the lower levels.

Fig 2.2 [1] Continued

Building Identifier	Photograph	Basic Structural Hazard Score	Characteristics and Performance
S5 Steel frames with unrein- forced masonry infill walls		H = 2.0 M = 3.6 L = 5.0	 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. Portions of solid walls will align vertically. Infill walls are usually two to three wythes thick. Veneer masonry around columns or beams is usually poorly anchored and detaches easily.
C1 Concrete moment- resisting frames		H = 2.5 M = 3.0 L = 4.4	 All exposed concrete frames are reinforced concrete (not steel frames encased in con- crete). A fundamental factor govern- ing the performance of con- crete moment-resisting frames is the level of ductile detailing. Large spacing of ties in col- umns can lead to a lack of concrete confinement and shear failure. Lack of continuous beam rein- forcement can result in hinge formation during load rever- sal. The relatively low stiffness of the frame can lead to substan- tial nonstructural damage. Column damage due to pounding with adjacent build- ings can occur.

Fig 2.2 [1] Continued

Building Identifier	Photograph	Basic Structural Hazard Score	Characteristics and Performance
	al roof collapse due to failed dia- gm-to-wall connection	H = 2.6 M = 3.2 L = 4.4	 Tilt-ups are typically one or two stories high and are basi- cally rectangular in plan. Exterior walls were tradition- ally formed and cast on the ground adjacent to their final position, and then "tilted-up" and attached to the floor slab. The roof can be a plywood diaphragm carried on wood purlins and glulam beams or a light steel deck and joist sys- tem, supported in the interior of the building on steel pipe columns. Weak diaphragm-to-wall anchorage results in the wall panels falling and the collapse of the supported diaphragm (or roof).

Fig 2.2 [1] Continued

Building Identifier	Photograph	Basic Structural Hazard Score	Characteristics and Performance
C2 Concrete shear wall buildings		H = 2.8 M = 3.6 L = 4.8	 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. These buildings generally per- form better than concrete frame buildings. They are heavier than steel- frame buildings but more rigid due to the shear walls. Damage commonly observed in taller buildings is caused by vertical discontinuities, pounding, and irregular con- figuration.
C3 Concrete frames with unreinforced masonry infill walls		H =1.6 M = 3.2 L = 4.4	 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 wide) between windows. Portions of solid walls will align vertically. This type of construction was generally built before 1940 in high-seismicity regions but continues to be built in other regions. Infill walls tend to buckle and fall out-of-plane when sub- jected to strong lateral out-of- plane forces. Veneer masonry around col- umns or beams is usually poorly anchored and detaches easily.

Fig 2.2 [1] Continued

Building Identifier	Photograph	Basic Structural Hazard Score	Characteristics and Performance
PC2 Precast con- crete frame buildings	<image/> <image/>	H = 2.4 M = 3.2 L = 4.6	 Precast concrete frames are, in essence, post and beam construction in concrete. Structures often employ con- crete or reinforced masonry (brick or block) shear walls. The performance varies widely and is sometimes poor. They experience the same types of damage as shear wall buildings (C2). Poorly designed connections between prefabricated ele- ments can fail. Loss of vertical support can occur due to inadequate bear- ing area and insufficient con- nection between floor elements and columns. Corrosion of metal connectors between prefabricated ele- ments can occur.

Fig 2.2 [1] Continued

Identifier	Photograph	Basic Structural Hazard Score	Characteristics and Performance
RM1 Reinforced masonry buildings with flexible dia- phragms	<image/> <image/> <image/> <image/>	H = 2.8 M = 3.6 L = 4.8	 Characteristics and Performance Walls are either brick or concrete block. Wall thickness is usually 8 inches to 12 inches. Interior inspection is required to determine if diaphragms are flexible or rigid. The most common floor and roof systems are wood, light steel, or precast concrete. These buildings can perform well in moderate earthquakes if they are adequately reinforced and grouted, with sufficient diaphragm anchorage. Poor construction practice can result in ungrouted and unreinforced walls, which will fail easily.

Fig 2.2 [1] Continued

Building Identifier	Photograph	Basic Structural Hazard Score	Characteristics and Performance
RM2 Reinforced masonry buildings with rigid dia- phrams		H = 2.8 M = 3.4 L = 4.6	 Walls are either brick or concrete block. Wall thickness is usually 8 inches to 12 inches. Interior inspection is required to determine if diaphragms are flexible or rigid. The most common floor and roof systems are wood, light steel, or precast concrete. These buildings can perform well in moderate earthquakes if they are adequately reinforced and grouted, with sufficient diaphragm anchorage. Poor construction practice can result in ungrouted and unreinforced walls, which will fail easily.
URM Unreinforced masonry buildings		H = 1.8 M = 3.4 L = 4.6	 These buildings often used weak lime mortar to bond the masonry units together. Arches are often an architec- tural characteristic of older brick bearing wall buildings. Other methods of spanning are also used, including steel and stone lintels. Unreinforced masonry usu- ally shows header bricks in the wall surface. The performance of this type of construction is poor due to lack of anchorage of walls to floors and roof, soft mortar, and narrow piers between window openings.

Fig 2.2 [1] Continued

2.5.5 DATA COLLECTION FORMS [1]

Rapid Visual Screening of Buildings for Potential Seismic Hazards

FEMA-154 Data Collection Form

Address: Zip Other Identifiers No. Stories Year Built Screener Date Total Floor Area (sq. ft.) Building Name Use PHOTOGRAPH Scale: OCCUPANCY SOIL TYPE FALLING HAZARDS В D С F A E Assembly Govt Office Number of Persons \square Hard Dense Stiff Soft Poor Avg. Rock Commercial Historic Residential 0 - 10 11 - 10 101-1000 1000+ 11 - 100 Unreinforced Parapets Cladding Other: Emer. Services Industrial Rock Soil Soil Soil Soil School Chimneys BASIC SCORE, MODIFIERS, AND FINAL SCORE, S BUILDING TYPE PC1 (TU) W1 W2 S1 (MRF) S2 (BR) S3 (LM) S4 (RC SW) S5 (URM INF) C1 (MRF) C2 (SW) C3 (URM INF) PC2 RM1 RM2 URM (FD) (RD) 4.8 Basic Score 7.4 6.0 4.6 4.8 4.6 4.8 5.0 4.4 4.4 4.4 4.6 4.8 4.6 4.6 Mid Rise (4 to 7 stories) N/A N/A +0.2+0.4N/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 -2.0 -2.0 -2.0 -2.0 N/A -2.0 N/A -1.5 -1.5 -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 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 -2.2 -2.0 -2.0 -2.0 -2.0 -1.8 -1.4 -1.4 -2.0 -2.0 -2.0 -1.6 FINAL SCORE, S COMMENTS Detailed Evaluation Required YES NO BR = Braced frame FD = Flexible diaphragm * = Estimated, subjective, or unreliable data

LM = Light metal

MRF = Moment-resisting frame RC = Reinforced concrete RD = Rigid diaphragm

SW = Shear wall TU = Tilt up URM INF = Unreinforced masonry infill

LOW Seismicity

Rapid Visual Screening of Buildings for Potential Seismic Hazards

FEMA-154 Data Collection Form

MODERATE Seismicity

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Commercial Histo	Off ric Re:	ice sidential	Numbe 0 – 10 101-100 B/ S1	er of Per 11 - 0 100 ASIC \$ \$2	- 100 00+ SCORE S3	Hard Av Rock Ro , MODIFIE S4	B C g. Dense ick Soil ERS, AND S5	D Stiff Soil FINAL C1	Soft Poo Soil Soi SCORE	or 1 (5, S C3	Inreinforced Chimneys		ts Cla	dding (Dther:
Commercial Histo Emer. Services Indus	Off ric Re trial Sch W1	ice sidential nool W2	Numbo 0 – 10 101-100 B S1 (MRF)	er of Per 11 - 0 100 ASIC \$ 82 (BR)	– 100 00+ SCORE S3 (LM)	Hard Av Rock Ro , MODIFIE S4 (RC SW)	B C g. Dense ck Soil ERS, AND S5 (URM INF)	D Stiff Soil FINAL C1 (MRF)	Soft Poo Soil Soi SCORE C2 (sw)	or U () () () () () () () () () () () () ()	Inreinforced Chimneys PC1 IF) (TU)	Parapet	ts Cla RM1 (FD)	dding (RM2 (RD)	URM
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Commercial Histo Emer. Services Indus BUILDING TYPE Basic Score Mid Rise (4 to 7 stories) High Rise (>7 stories)	Off ric Re: trial Sch W1 5.2 N/A N/A	ice sidential nool W2 4.8 N/A N/A	Numbe 0 - 10 101-100 B S1 (MRF) 3.6 +0.4 +1.4	er of Per 11 - 0 100 ASIC S (BR) 3.6 +0.4 +1.4	– 100 00+ SCORE S3 (LM) 3.8 N/A N/A	Hard Av Rock Rc , MODIFIE S4 (RC sw) 3.6 +0.4 +1.4	B C g. Dense Soil ERS, AND S5 (URM INF) 3.6 +0.4 +0.4	D Stiff Soil FINAL (MRF) 3.0 +0.2 +0.5	Soft Poo Soil Soi SCORE (sw) 3.6 +0.4 +0.8	or , S C3 (URM IM +0.2 +0.4	Inreinforced Chimneys IF) PC1 (TU) 3.2 N/A N/A	Parapet PC2 3.2 +0.4 +0.6	(FD) RM1 (FD) 3.6 +0.4 N/A	RM2 (RD) 3.4 +0.4 +0.6	URM 3.4 -0.4 N/A
Commercial Histo Emer. Services Indus BUILDING TYPE Basic Score Mid Rise (4 to 7 stories) High Rise (>7 stories) Vertical Irregularity	Off ric Re: trial Sch W1 5.2 N/A N/A -3.5	w2 4.8 N/A N/A -3.0	Numbe 0 - 10 101-100 B S1 (MRF) 3.6 +0.4 +1.4 -2.0	er of Per 11 - 0 100 ASIC S (BR) 3.6 +0.4 +1.4 -2.0	– 100 00+ SCORE S3 (LM) 3.8 N/A N/A N/A	Hard Av Rock Rc , MODIFIE 3.6 +0.4 +1.4 -2.0	3 C g. Dense Soil ERS, AND S5 (URM INF) 3.6 +0.4 +0.8 -2.0	D Stiff Soil FINAL (MRF) 3.0 +0.2 +0.5 -2.0	Soft Poo Soil Soi SCORE (sw) 3.6 +0.4 +0.8 -2.0	ог , S СЗ (URM IN +0.2 +0.4 -2.0	PC1 (TU) (TU) (TU) (TU) (TU) (TU) (TU) (TU)	Parapet PC2 3.2 +0.4 +0.6 -1.5	Es Cla RM1 (FD) 3.6 +0.4 N/A -2.0	dding RM2 (RD) 3.4 +0.4 +0.6 -1.5	URM -0.4 N/A -1.5
Commercial Histo Emer. Services Indus BUILDING TYPE Basic Score Mid Rise (4 to 7 stories) High Rise (>7 stories)	Off ric Re: trial Sch W1 5.2 N/A N/A	ice sidential nool W2 4.8 N/A N/A -3.0 -0.5	Numbe 0 - 10 101-100 B S1 (MRF) 3.6 +0.4 +1.4	er of Per 11 - 0 100 ASIC S (BR) 3.6 +0.4 +1.4	– 100 00+ SCORE S3 (LM) 3.8 N/A N/A	Hard Av Rock Rc , MODIFIE S4 (RC sw) 3.6 +0.4 +1.4	B C g. Dense Soil ERS, AND S5 (URM INF) 3.6 +0.4 +0.4	D Stiff Soil FINAL (MRF) 3.0 +0.2 +0.5	Soft Poo Soil Soi SCORE (sw) 3.6 +0.4 +0.8	or , S C3 (URM IM +0.2 +0.4	PC1 (TU) (TU) (TU) (TU) (TU) (TU) (TU) (TU)	Parapet PC2 3.2 +0.4 +0.6	(FD) RM1 (FD) 3.6 +0.4 N/A	RM2 (RD) 3.4 +0.4 +0.6	URM 3.4 -0.4 N/A
Commercial Histo Emer. Services Indus BUILDING TYPE Basic Score Mid Rise (4 to 7 stories) High Rise (>7 stories) Vertical Irregularity Plan Irregularity	Offric Re- trial Sch W1 5.2 N/A N/A -3.5 -0.5	ice sidential nool W2 4.8 N/A N/A -3.0 -0.5 -0.2	Numbd 0 - 10 101-100 B , S1 (MRF) 3.6 +0.4 +1.4 -2.0 -0.5	er of Per 11 - 0 100 ASIC S (BR) 3.6 +0.4 +1.4 -2.0 -0.5	– 100 00+ SCORE 33 (LM) 3.8 N/A N/A N/A N/A -0.5	Hard Av Rock Rc , MODIFIE 3.6 +0.4 +1.4 -2.0 -0.5	B C g. Dense Soil Soil ERS, AND S5 (URM INF) 3.6 +0.4 +0.8 -2.0 -0.5	D Stiff Soil FINAL (MRF) +0.2 +0.5 -2.0 -0.5	Soft Soil Soil Soil Soil Soil Soil Soil Soil	or , S C3 (URM IN 3.2 +0.2 +0.4 -2.0 -0.5	PC1 (TF) PC1 (TU) 3.2 N/A N/A N/A N/A N/A -0.5 -0.2	Parapet PC2 +0.4 +0.6 -1.5 -0.5	Es Cla RM1 (FD) 3.6 +0.4 N/A -2.0 -0.5	RM2 (RD) 3.4 +0.4 +0.6 -1.5 -0.5	URM -0.4 N/A -1.5 -0.5
Commercial Histo Emer. Services Indus BUILDING TYPE Basic Score Mid Rise (4 to 7 stories) High Rise (>7 stories) Vertical Irregularity Plan Irregularity Plan Irregularity Pre-Code Post-Benchmark Soil Type C	W1 5.2 N/A N/A -3.5 -0.5 0.0 +1.6 -0.2	ice sidential nool W2 4.8 N/A N/A -3.0 -0.5 -0.2 +1.6 -0.8	Numbe 0 - 10 101-100 B 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.4 -0.6	er of Per 11- 0 100 ASIC S (BR) 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.4 -0.8	- 100 00+ SCORE 3.8 N/A N/A N/A N/A -0.5 -0.4 N/A -0.6	Hard Av Rock Rc , MODIFIE 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.2 -0.8	3 C g. Dense ck Soil RS, AND S5 (URM INF) 3.6 +0.4 +0.8 -2.0 -0.5 -0.2 N/A -0.8	D Stiff Soil FINAL C1 (MRF) 3.0 +0.2 +0.5 -2.0 -0.5 -1.0 +1.2 -0.6	Soft Poc Soil Soi Socretary Soil 3.6 +0.4 +0.8 -2.0 -0.5 -0.4 +1.6 -0.8	or J C3 URM IN +0.2 +0.4 -2.0 -0.5 -1.0 N/A -0.6	PC1 (Tru) (Tru) 3.2 N/A N/A N/A N/A N/A -0.5 -0.2 +1.8 -0.6	Parapet PC2 3.2 +0.4 +0.6 -1.5 -0.5 -0.4 N/A -0.6	Ex Cla RM1 (FD) 3.6 +0.4 N/A -2.0 -0.5 -0.4 2.0 -0.8	RM2 (RD) 3.4 +0.4 +0.6 -1.5 -0.5 -0.4 +1.8 -0.6	URM 3.4 -0.4 N/A -1.5 -0.5 -0.4 N/A -0.4
Commercial Histo Emer. Services Indus BUILDING TYPE Basic Score Mid Rise (4 to 7 stories) High Rise (>7 stories) Vertical Irregularity Plan Irregularity Plan Irregularity Pre-Code Post-Benchmark Soil Type C Soil Type D	V1 V1 V2 V2 V2 V4 V4 V2 V4 V4 V4 V4 V4 V4 V4 V4 V4 V4	ice sidential nool W2 4.8 N/A N/A -3.0 -0.5 -0.2 +1.6 -0.8 -1.2	Numbe 0 - 10 101-100 B 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.4 -0.5 -0.4 +1.4 -0.6 -1.0	er of Per 11- 0 100 ASIC S (BR) 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.4 -0.8 -1.2	- 100 00+ SCORE S3 (LM) 3.8 N/A N/A -0.5 -0.4 N/A -0.6 -1.0	Hard Av Rock Rc , MODIFIE 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.2 -0.8 -1.2	B C g. Dense Soil Soil RS, AND S5 (URM INF) 3.6 +0.4 +0.8 -2.0 -0.5 -0.2 N/A -0.8 -1.2	D Stiff Soil FINAL C1 (MRF) 3.0 +0.2 +0.5 -2.0 -0.5 -1.0 +1.2 -0.6 -1.0	Soft Poc Soil Soi Socret Soi . Score 	or J C3 URM IN +0.2 +0.4 -2.0 -0.5 -1.0 N/A -0.6 -1.0	PC1 (Tru) (Tru) 3.2 N/A N/A N/A N/A -0.5 -0.2 +1.8 -0.6 -1.0	Parapet PC2 3.2 +0.4 +0.6 -1.5 -0.5 -0.4 N/A -0.6 -1.2	RM1 (FD) 3.6 +0.4 N/A -2.0 -0.5 -0.4 2.0 -0.8 -1.2	RM2 (RD) 3.4 +0.4 +0.6 -1.5 -0.5 -0.4 +1.8 -0.6 -1.2	URM 3.4 -0.4 N/A -1.5 -0.5 -0.4 N/A -0.4 -0.8
Commercial Histo Emer. Services Indus BUILDING TYPE Basic Score Mid Rise (4 to 7 stories) High Rise (>7 stories) Vertical Irregularity Plan Irregularity Plan Irregularity Pre-Code Post-Benchmark Soil Type C Soil Type E	W1 5.2 N/A N/A -3.5 -0.5 0.0 +1.6 -0.2	ice sidential nool W2 4.8 N/A N/A -3.0 -0.5 -0.2 +1.6 -0.8	Numbe 0 - 10 101-100 B 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.4 -0.6	er of Per 11- 0 100 ASIC S (BR) 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.4 -0.8	- 100 00+ SCORE 3.8 N/A N/A N/A N/A -0.5 -0.4 N/A -0.6	Hard Av Rock Rc , MODIFIE 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.2 -0.8	3 C g. Dense ck Soil RS, AND S5 (URM INF) 3.6 +0.4 +0.8 -2.0 -0.5 -0.2 N/A -0.8	D Stiff Soil FINAL C1 (MRF) 3.0 +0.2 +0.5 -2.0 -0.5 -1.0 +1.2 -0.6	Soft Poc Soil Soi Socretary Soil 3.6 +0.4 +0.8 -2.0 -0.5 -0.4 +1.6 -0.8	or J C3 URM IN +0.2 +0.4 -2.0 -0.5 -1.0 N/A -0.6	PC1 (Tru) (Tru) 3.2 N/A N/A N/A N/A -0.5 -0.2 +1.8 -0.6 -1.0	Parapet PC2 3.2 +0.4 +0.6 -1.5 -0.5 -0.4 N/A -0.6	Ex Cla RM1 (FD) 3.6 +0.4 N/A -2.0 -0.5 -0.4 2.0 -0.8	RM2 (RD) 3.4 +0.4 +0.6 -1.5 -0.5 -0.4 +1.8 -0.6	URM 3.4 -0.4 N/A -1.5 -0.5 -0.5 -0.4 N/A -0.4
Commercial Histo Emer. Services Indus BUILDING TYPE Basic Score Mid Rise (4 to 7 stories) High Rise (>7 stories) Vertical Irregularity Plan Irregularity Pre-Code Post-Benchmark Soil Type C Soil Type D Soil Type E FINAL SCORE S	V1 V1 V1 V2 V2 V4 V4 V2 V4 V4 V4 V4 V4 V4 V4 V4 V4 V4	ice sidential nool W2 4.8 N/A N/A -3.0 -0.5 -0.2 +1.6 -0.8 -1.2	Numbe 0 - 10 101-100 B 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.4 -0.5 -0.4 +1.4 -0.6 -1.0	er of Per 11- 0 100 ASIC S (BR) 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.4 -0.8 -1.2	- 100 00+ SCORE S3 (LM) 3.8 N/A N/A -0.5 -0.4 N/A -0.6 -1.0	Hard Av Rock Rc , MODIFIE 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.2 -0.8 -1.2	B C g. Dense Soil Soil RS, AND S5 (URM INF) 3.6 +0.4 +0.8 -2.0 -0.5 -0.2 N/A -0.8 -1.2	D Stiff Soil FINAL C1 (MRF) 3.0 +0.2 +0.5 -2.0 -0.5 -1.0 +1.2 -0.6 -1.0	Soft Poc Soil Soi Socret Soi . Score 	or J C3 URM IN +0.2 +0.4 -2.0 -0.5 -1.0 N/A -0.6 -1.0	PC1 (Tru) (Tru) 3.2 N/A N/A N/A N/A -0.5 -0.2 +1.8 -0.6 -1.0	Parapet PC2 3.2 +0.4 +0.6 -1.5 -0.5 -0.4 N/A -0.6 -1.2	RM1 (FD) 3.6 +0.4 N/A -2.0 -0.5 -0.4 2.0 -0.8 -1.2	RM2 (RD) 3.4 +0.4 +0.6 -1.5 -0.5 -0.4 +1.8 -0.6 -1.2	URM 3.4 -0.4 N/A -1.5 -0.5 -0.4 N/A -0.4 -0.8
Commercial Histo Emer. Services Indus BUILDING TYPE Basic Score Mid Rise (4 to 7 stories) High Rise (>7 stories) Vertical Irregularity Plan Irregularity Plan Irregularity Pre-Code Post-Benchmark Soil Type C Soil Type D Soil Type E	V1 V1 V1 V2 V2 V4 V4 V2 V4 V4 V4 V4 V4 V4 V4 V4 V4 V4	ice sidential nool W2 4.8 N/A N/A -3.0 -0.5 -0.2 +1.6 -0.8 -1.2	Numbe 0 - 10 101-100 B 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.4 -0.5 -0.4 +1.4 -0.6 -1.0	er of Per 11- 0 100 ASIC S (BR) 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.4 -0.8 -1.2	- 100 00+ SCORE S3 (LM) 3.8 N/A N/A -0.5 -0.4 N/A -0.6 -1.0	Hard Av Rock Rc , MODIFIE 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.2 -0.8 -1.2	B C g. Dense Soil Soil RS, AND S5 (URM INF) 3.6 +0.4 +0.8 -2.0 -0.5 -0.2 N/A -0.8 -1.2	D Stiff Soil FINAL C1 (MRF) 3.0 +0.2 +0.5 -2.0 -0.5 -1.0 +1.2 -0.6 -1.0	Soft Poc Soil Soi Socret Soi . Score 	or J C3 URM IN +0.2 +0.4 -2.0 -0.5 -1.0 N/A -0.6 -1.0	PC1 (Tru) (Tru) 3.2 N/A N/A N/A N/A -0.5 -0.2 +1.8 -0.6 -1.0	Parapet PC2 3.2 +0.4 +0.6 -1.5 -0.5 -0.4 N/A -0.6 -1.2	RM1 (FD) 3.6 +0.4 N/A -2.0 -0.5 -0.4 2.0 -0.8 -1.2	dding RM2 (RD) 3.4 +0.4 +0.6 -1.5 -0.5 -0.4 +1.8 -0.6 -1.2 -1.6	URM 3.4 -0.4 N/A -1.5 -0.5 -0.4 N/A -0.4 -0.8
Commercial Histo Emer. Services Indus BUILDING TYPE Basic Score Mid Rise (4 to 7 stories) High Rise (>7 stories) Vertical Irregularity Plan Irregularity Pre-Code Post-Benchmark Soil Type C Soil Type D Soil Type E FINAL SCORE S	V1 V1 V1 V2 V2 V4 V4 V2 V4 V4 V4 V4 V4 V4 V4 V4 V4 V4	ice sidential nool W2 4.8 N/A N/A -3.0 -0.5 -0.2 +1.6 -0.8 -1.2	Numbe 0 - 10 101-100 B 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.4 -0.5 -0.4 +1.4 -0.6 -1.0	er of Per 11- 0 100 ASIC S (BR) 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.4 -0.8 -1.2	- 100 00+ SCORE S3 (LM) 3.8 N/A N/A -0.5 -0.4 N/A -0.6 -1.0	Hard Av Rock Rc , MODIFIE 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.2 -0.8 -1.2	B C g. Dense Soil Soil RS, AND S5 (URM INF) 3.6 +0.4 +0.8 -2.0 -0.5 -0.2 N/A -0.8 -1.2	D Stiff Soil FINAL C1 (MRF) 3.0 +0.2 +0.5 -2.0 -0.5 -1.0 +1.2 -0.6 -1.0	Soft Poc Soil Soi Socret Soi . Score 	or J C3 URM IN +0.2 +0.4 -2.0 -0.5 -1.0 N/A -0.6 -1.0	PC1 (Tru) (Tru) 3.2 N/A N/A N/A N/A -0.5 -0.2 +1.8 -0.6 -1.0	Parapet PC2 3.2 +0.4 +0.6 -1.5 -0.5 -0.4 N/A -0.6 -1.2	RM1 (FD) 3.6 +0.4 N/A -2.0 -0.5 -0.4 2.0 -0.8 -1.2	dding RM2 (RD) 3.4 +0.4 +0.6 -1.5 -0.5 -0.4 +1.8 -0.6 -1.2 -1.6 Deta Evalu	URM 3.4 -0.4 N/A -1.5 -0.5 -0.4 N/A -0.4 -0.8 -1.6 ailed uation
Commercial Histo Emer. Services Indus BUILDING TYPE Basic Score Mid Rise (4 to 7 stories) High Rise (>7 stories) Vertical Irregularity Plan Irregularity Pre-Code Post-Benchmark Soil Type C Soil Type D Soil Type E FINAL SCORE S	V1 V1 V1 V2 V2 V4 V4 V2 V4 V4 V4 V4 V4 V4 V4 V4 V4 V4	ice sidential nool W2 4.8 N/A N/A -3.0 -0.5 -0.2 +1.6 -0.8 -1.2	Numbe 0 - 10 101-100 B 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.4 -0.5 -0.4 +1.4 -0.6 -1.0	er of Per 11- 0 100 ASIC S (BR) 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.4 -0.8 -1.2	- 100 00+ SCORE S3 (LM) 3.8 N/A N/A -0.5 -0.4 N/A -0.6 -1.0	Hard Av Rock Rc , MODIFIE 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.2 -0.8 -1.2	B C g. Dense Soil Soil RS, AND S5 (URM INF) 3.6 +0.4 +0.8 -2.0 -0.5 -0.2 N/A -0.8 -1.2	D Stiff Soil FINAL C1 (MRF) 3.0 +0.2 +0.5 -2.0 -0.5 -1.0 +1.2 -0.6 -1.0	Soft Poc Soil Soi Socret Soi . Score 	or J C3 URM IN +0.2 +0.4 -2.0 -0.5 -1.0 N/A -0.6 -1.0	PC1 (Tru) (Tru) 3.2 N/A N/A N/A N/A -0.5 -0.2 +1.8 -0.6 -1.0	Parapet PC2 3.2 +0.4 +0.6 -1.5 -0.5 -0.4 N/A -0.6 -1.2	RM1 (FD) 3.6 +0.4 N/A -2.0 -0.5 -0.4 2.0 -0.8 -1.2	dding RM2 (RD) 3.4 +0.4 +0.6 -1.5 -0.5 -0.4 +1.8 -0.6 -1.2 -1.6 Deta Evalu	URM 3.4 -0.4 N/A -1.5 -0.5 -0.4 N/A -0.4 -0.8 -1.6 ailed
Commercial Histo Emer. Services Indus BUILDING TYPE Basic Score Mid Rise (4 to 7 stories) High Rise (>7 stories) Vertical Irregularity Plan Irregularity Pre-Code Post-Benchmark Soil Type C Soil Type D Soil Type E FINAL SCORE S	V1 V1 V1 V2 V2 V4 V4 V2 V4 V4 V4 V4 V4 V4 V4 V4 V4 V4	ice sidential nool W2 4.8 N/A N/A -3.0 -0.5 -0.2 +1.6 -0.8 -1.2	Numbe 0 - 10 101-100 B 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.4 -0.5 -0.4 +1.4 -0.6 -1.0	er of Per 11- 0 100 ASIC S (BR) 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.4 -0.8 -1.2	- 100 00+ SCORE S3 (LM) 3.8 N/A N/A -0.5 -0.4 N/A -0.6 -1.0	Hard Av Rock Rc , MODIFIE 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.2 -0.8 -1.2	B C g. Dense Soil Soil RS, AND S5 (URM INF) 3.6 +0.4 +0.8 -2.0 -0.5 -0.2 N/A -0.8 -1.2	D Stiff Soil FINAL C1 (MRF) 3.0 +0.2 +0.5 -2.0 -0.5 -1.0 +1.2 -0.6 -1.0	Soft Poc Soil Soi Socret Soi . Score 	or J C3 URM IN +0.2 +0.4 -2.0 -0.5 -1.0 N/A -0.6 -1.0	PC1 (Tru) (Tru) 3.2 N/A N/A N/A N/A -0.5 -0.2 +1.8 -0.6 -1.0	Parapet PC2 3.2 +0.4 +0.6 -1.5 -0.5 -0.4 N/A -0.6 -1.2	RM1 (FD) 3.6 +0.4 N/A -2.0 -0.5 -0.4 2.0 -0.8 -1.2	dding RM2 (RD) 3.4 +0.4 +0.6 -1.5 -0.5 -0.4 +1.8 -0.6 -1.2 -1.6 Deta Evalu Requ	URM 3.4 -0.4 N/A -1.5 -0.5 -0.4 N/A -0.4 -0.8 -1.6 ailed uation uired
Commercial Histo Emer. Services Indus BUILDING TYPE Basic Score Mid Rise (4 to 7 stories) High Rise (>7 stories) Vertical Irregularity Plan Irregularity Pre-Code Post-Benchmark Soil Type C Soil Type D Soil Type E FINAL SCORE S	Offric Re: trial Sch W1 5.2 N/A N/A -3.5 -0.5 -0.5 -0.5 -0.0 +1.6 -0.2 -0.6 -1.2	ice sidential tool W2 4.8 N/A N/A -3.0 -0.5 -0.2 +1.6 -0.8 -1.2 -1.8	Numbe 0 - 10 101-100 B 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.4 -1.0 -1.6	er of Per 11 0 100 ASIC 5 82 (BR) 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.4 -1.6	- 100 00+ SCORE S3 (LM) 3.8 N/A N/A -0.5 -0.4 N/A -0.6 -1.0	Hard Av Rock Rc , MODIFIE 3.6 +0.4 +1.4 -2.0 -0.5 -0.4 +1.2 -0.8 -1.2 -1.6	B C g. Dense Soil Soil RS, AND S5 (URM INF) 3.6 +0.4 +0.8 -2.0 -0.5 -0.2 N/A -0.8 -1.2	D Stiff Soil FINAL C1 (MRF) +0.2 +0.5 -2.0 -0.5 -1.0 -1.6 -1.0 -1.6	Soft Poc Soil Soi Soil Soil Score Soil 3.6 +0.4 +0.8 -2.0 -0.5 -0.4 +1.6 -0.8 -1.2 -1.6	л г ц с с с с с с с с с с с с с	PC1 (Tru) (Tru) 3.2 N/A N/A N/A N/A -0.5 -0.2 +1.8 -0.6 -1.0	Parapet PC2 3.2 +0.4 +0.6 -1.5 -0.5 -0.4 N/A -0.6 -1.2	RM1 (FD) 3.6 +0.4 N/A -2.0 -0.5 -0.4 2.0 -0.8 -1.2	dding RM2 (RD) 3.4 +0.4 +0.6 -1.5 -0.5 -0.4 +1.8 -0.6 -1.2 -1.6 Deta Evalu Requ	URM 3.4 -0.4 N/A -1.5 -0.5 -0.4 N/A -0.4 -0.8 -1.6 ailed uation

Rapid Visual Screening of Buildings for Potential Seismic Hazards

FEMA-154 Data Collection Form

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Con Eme Basie Mid I High Verti Plan Pre-	BUILDI c Score Rise (4 Rise (4 cal Irregula Code	ices ING TY to 7 st > 7 sto gularity arity	Govt Historic Industria (PE tories) rries)	Off Re: al Sch W1 4.4 N/A -2.5 -0.5 0.0	ice sidential hool W2 3.8 N/A -2.0 -0.5 -1.0	I I <thi< th=""> <thi< th=""> <thi< th=""> <thi< th=""></thi<></thi<></thi<></thi<>	Number - 10 11-1000 BAS 11 RF) .8 0.2 0.6 0.0 0.5 .0	r of Per 11 - 100 SIC S 82 (BR) 3.0 +0.4 +0.4 +0.8 -1.5 -0.5 -0.8	- 100)0+ CORE, S3 (LM) 3.2 N/A N/A N/A N/A -0.5 -0.6	Hard Rock MODI S (RC : 2. +0 +0 -1. -0. -0.	Avg Roo IFIEF 4 sw) 8 .4 .8 .0 .5 .8	C Dense Soil Soil C(URM INF) 2.0 +0.4 +0.8 -1.0 -0.5 -0.2	D Stiff Soil FINAL (MRF) 2.5 +0.4 +0.6 -1.5 -0.5 -1.2	Soft Poo Soil Soi SCORE, (sw) 2.8 +0.4 +0.8 -1.0 -0.5 -1.0	S (URN 1. +() +() -1 -0 -0 -0	Unreinforced Chimneys 3 PC1 (TU) 6 2.6 0.2 N/A 0.3 N/A 0.0 N/A 0.5 -0.5 0.2 -0.8	Parapets PC2 2.4 +0.2 +0.4 -1.0 -0.5 -0.8	RM1 (FD) 2.8 +0.4 N/A -1.0 -0.5 -1.0	RM2 (RD) 2.8 +0.4 +0.6 -1.0 -0.5 -0.8	URM 1.8 0.0 N/A -1.0 -0.5 -0.2
Con Eme Basi Mid I High Verti Plan Pre- Post	BUILDI BUILDI c Score Rise (4 Rise (4 Rise (2 cal Irregula Code -Benchr	to 7 sto y arity mark	Govt Historic Industria (PE tories) rries)	0ff Re: 3d Sch W1 4.4 N/A N/A -2.5 -0.5 0.0 +2.4	ice sidential nool 3.8 N// -2.0 -0.5 -1.0 +2.0	I I <thi< th=""> <thi< th=""> <thi< th=""> <thi< th=""></thi<></thi<></thi<></thi<>	Number - 10 11-1000 BAS 11 RF) .8 0.2 0.6 0.2 0.6 1.0 1.4	of Per 11- 100 SIC S S2 (BR) 3.0 +0.4 +0.4 +0.8 -1.5 -0.5 -0.8 +1.4	- 100)0+ CORE, S3 (LM) 3.2 N/A N/A N/A -0.5 -0.6 N/A	Hard Rock MODI S (RC 2. +0 +0 -1. -0. -1. -0. +1	Avg Roo IFIEF 4 sw) 8 .4 .8 .0 .5 .8 .6	С . Dense x Soil 25, AND F 20 +0.4 +0.8 -1.0 -0.5 -0.2 N/A	D Stiff Soil FINAL C1 (MRF) 2.5 +0.4 +0.6 -1.5 -0.5 -1.2 +1.4	Soft Poo Soil Soi SCORE, C2 (sw) 2.8 +0.4 +0.8 -1.0 -0.5 -1.0 +2.4	I S C(URN 11 +(C +(C -1 -0 -0 N	Unreinforced Chimneys 3 PC1 INF) (TU) 6 2.6 0.2 N/A 0.3 N/A 0.0 N/A 0.5 -0.5 0.2 -0.8 (A +2.4	Parapets Parapets PC2 2.4 +0.2 +0.4 -1.0 -0.5 -0.8 N/A	RM1 (FD) 2.8 +0.4 N/A -1.0 -0.5 -1.0 +2.8	RM2 (RD) 2.8 +0.4 +0.6 -1.0 -0.5 -0.8 +2.6	URM 1.8 0.0 N/A -1.0 -0.5 -0.2 N/A
Con Eme Basid Mid I High Verti Plan Pre-0 Post Soil	BUILDI BUILDI C Score Rise (4 Rise (2 cal Irregula Code Benchr Type C	to 7 sto y arity mark	Govt Historic Industria (PE tories) rries)	0ff Res al Sch W1 4.4 N/A -2.5 -0.5 0.0 +2.4 0.0	ice sidential nool 3.8 N/A -2.0 -0.5 -1.0 +2 -0.4	I 0 - 1 22 \$\$ 33 22 (M) 34 +(1 35 -20 36 -11 37 -12 36 -11 37 -12 36 -11 37 -12 38 -11 38 -11 38 -11 39 -11 39 -11 39 -11 30 -11 30 -11 30 -11 30 -11 30 -11 30 -11 30 -11 30 -11 30 -11 30 -11 30 -11 30 -11 30 -11 30 -11 30 -11 30 -11 30 </td <td>Number - 10 11-1000 BAS 11 RF) .8 0.2 0.6 0.0 0.5 0.0 1.4</td> <td>of Per 11- 100 SIC S (BR) 3.0 +0.4 +0.8 -1.5 -0.5 -0.8 +1.4 -0.4</td> <td>- 100)0+ CORE, S3 (LM) 3.2 N/A N/A N/A -0.5 -0.6 N/A -0.4</td> <td>Hard Rock MODI S (RC 2. +0 +0 -1 -0. -0. -0. -0. -0.</td> <td>Avg Roo IFIEF 4 sw) 8 .4 .8 .0 .5 .8 .6 .4</td> <td>С . Dense % Soil 25, AND F 20 +0.4 +0.8 -1.0 -0.5 -0.2 N/A -0.4</td> <td>D Stiff Soil FINAL C1 (MRF) 2.5 +0.4 +0.6 -1.5 -0.5 -1.2 +1.4 -0.4</td> <td>Soft Poo Soil Soi Score Soi score Soi cc (sw) csoi -0.4</td> <td>S C(URN (URN +() -1 -0 -0 -0 N -0 -0</td> <td>Unreinforced Chimneys 3 PC1 INF) (TU) 6 2.6 0.2 N/A 0.3 N/A 0.0 N/A 0.5 -0.5 0.2 -0.8 (A +2.4 0.4 -0.4</td> <td>Parapets Parapets PC2 2.4 +0.2 +0.4 -1.0 -0.5 -0.8 N/A -0.4</td> <td>RM1 (FD) 2.8 +0.4 N/A -1.0 -0.5 -1.0 +2.8 -0.4</td> <td>RM2 (RD) 2.8 +0.4 +0.6 -1.0 -0.5 -0.8 +2.6 -0.4</td> <td>URM 1.8 0.0 N/A -1.0 -0.5 -0.2 N/A -0.4</td>	Number - 10 11-1000 BAS 11 RF) .8 0.2 0.6 0.0 0.5 0.0 1.4	of Per 11- 100 SIC S (BR) 3.0 +0.4 +0.8 -1.5 -0.5 -0.8 +1.4 -0.4	- 100)0+ CORE, S3 (LM) 3.2 N/A N/A N/A -0.5 -0.6 N/A -0.4	Hard Rock MODI S (RC 2. +0 +0 -1 -0. -0. -0. -0. -0.	Avg Roo IFIEF 4 sw) 8 .4 .8 .0 .5 .8 .6 .4	С . Dense % Soil 25, AND F 20 +0.4 +0.8 -1.0 -0.5 -0.2 N/A -0.4	D Stiff Soil FINAL C1 (MRF) 2.5 +0.4 +0.6 -1.5 -0.5 -1.2 +1.4 -0.4	Soft Poo Soil Soi Score Soi score Soi cc (sw) csoi -0.4	S C(URN (URN +() -1 -0 -0 -0 N -0 -0	Unreinforced Chimneys 3 PC1 INF) (TU) 6 2.6 0.2 N/A 0.3 N/A 0.0 N/A 0.5 -0.5 0.2 -0.8 (A +2.4 0.4 -0.4	Parapets Parapets PC2 2.4 +0.2 +0.4 -1.0 -0.5 -0.8 N/A -0.4	RM1 (FD) 2.8 +0.4 N/A -1.0 -0.5 -1.0 +2.8 -0.4	RM2 (RD) 2.8 +0.4 +0.6 -1.0 -0.5 -0.8 +2.6 -0.4	URM 1.8 0.0 N/A -1.0 -0.5 -0.2 N/A -0.4
Con Ema Basid Mid I High Verti Plan Pre-t Post Soil	BUILDI C Score Rise (4 Rise (4 Rise (2 cal Irregula Code Benchr Type C Type D	to 7 sto gularity mark	Govt Historic Industria (PE tories) rries)	Offf Re: Sch W1 4.4 N/A N/A -2.5 -0.5 0.0 +2.4 0.0 0.0	ice sidential hool 3.8 N// -2.0 -0.5 -1.0 +2 -0.4 -0.8	I 0 - 1 22 \$\$ 33 22 (M) \$\$ 34 +(1) 45 -00 44 -00 44 -00 44 -00	Number - 10 11-1000 BAS 11 RF) .8 0.2 0.6 0.0 0.5 0.0 1.4 0.4 0.6	r of Per 11 100 SIC S (BR) 3.0 +0.4 +0.4 +0.8 -1.5 -0.5 -0.8 +1.4 -0.4 -0.4 -0.6	- 100)0+ CORE, S3 (LM) 3.2 N/A N/A N/A N/A -0.5 -0.6 N/A -0.4 -0.6	Hard Rock MODI S (RC 2. +0 +0 -1. -0. -0. -1. -0. -0. -0. -0. -0. -0. -0. -0.	Avç Rod IFIEF 4 .4 .8 .0 .5 .8 .6 .6 .4 .6	С . Dense % Soil 25, AND F 20 +0.4 +0.8 -1.0 -0.5 -0.2 N/A -0.4 -0.4 -0.4	D Stiff Soil FINAL C1 (MRF) 2.5 +0.4 +0.6 -1.5 -0.5 -1.2 +1.4 -0.4 -0.6	Soft Poo Soil Soi SCORE, Soi (sw) 2.8 +0.4 +0.8 -1.0 -0.5 -1.0 +2.4 -0.4 -0.6	S C(URN +(URN +() -1 -0 -0 -0 N -0 -0	Unreinforced Chimneys 3 PC1 (TU) 6 2.6 0.2 N/A 0.3 N/A 0.0 N/A 0.5 -0.5 0.2 -0.8 (A +2.4 0.4 -0.4 0.4 -0.6	Parapets PC2 2.4 +0.2 +0.4 -1.0 -0.5 -0.8 N/A -0.4 -0.6	RM1 (FD) 2.8 +0.4 N/A -1.0 -0.5 -1.0 +2.8 -0.4 -0.6	RM2 (RD) 2.8 +0.4 +0.6 -1.0 -0.5 -0.8 +2.6 -0.4 -0.6	URM 1.8 0.0 N/A -1.0 -0.5 -0.2 N/A -0.4 -0.6
Con Ema Basi Mid I High Verti Plan Pre-(Post Soil ' Soil '	BUILDI c Score Rise (4 Rise (4 Rise (3 cal Irregula Code Benchr Type C Type D Type E	to 7 sto y arity mark	Govt Historic Industria (PE tories) (0ff Res al Sch W1 4.4 N/A -2.5 -0.5 0.0 +2.4 0.0	ice sidential nool 3.8 N/A -2.0 -0.5 -1.0 +2 -0.4	I 0 - 1 22 \$\$ 33 22 (M) \$\$ 34 +(1) 45 -00 44 -00 44 -00 44 -00	Number - 10 11-1000 BAS 11 RF) .8 0.2 0.6 0.0 0.5 0.0 1.4 0.4 0.6	of Per 11- 100 SIC S (BR) 3.0 +0.4 +0.8 -1.5 -0.5 -0.8 +1.4 -0.4	- 100)0+ CORE, S3 (LM) 3.2 N/A N/A N/A -0.5 -0.6 N/A -0.4	Hard Rock MODI S (RC 2. +0 +0 -1 -0. -0. -0. -0. -0.	Avç Rod IFIEF 4 .4 .8 .0 .5 .8 .6 .6 .4 .6	С . Dense % Soil 25, AND F 20 +0.4 +0.8 -1.0 -0.5 -0.2 N/A -0.4	D Stiff Soil FINAL C1 (MRF) 2.5 +0.4 +0.6 -1.5 -0.5 -1.2 +1.4 -0.4	Soft Poo Soil Soi Score Soi score Soi cc (sw) csoi -0.4	S C(URN +(URN +() -1 -0 -0 -0 N -0 -0	Unreinforced Chimneys 3 PC1 INF) (TU) 6 2.6 0.2 N/A 0.3 N/A 0.0 N/A 0.5 -0.5 0.2 -0.8 (A +2.4 0.4 -0.4	Parapets Parapets PC2 2.4 +0.2 +0.4 -1.0 -0.5 -0.8 N/A -0.4	RM1 (FD) 2.8 +0.4 N/A -1.0 -0.5 -1.0 +2.8 -0.4	RM2 (RD) 2.8 +0.4 +0.6 -1.0 -0.5 -0.8 +2.6 -0.4	URM 1.8 0.0 N/A -1.0 -0.5 -0.2 N/A -0.4
Con Ema Basid Mid I High Verti Plan Pre-t Post Soil ¹ Soil ¹ Soil ¹	BUILDI c Score Rise (4 Rise (2 cal Irregula Code Benchr Type C Type D Type E IAL Si	ices ING TY to 7 sto gularity mark	Govt Historic Industria (PE tories) (Offf Re: Sch W1 4.4 N/A N/A -2.5 -0.5 0.0 +2.4 0.0 0.0	ice sidential hool 3.8 N// -2.0 -0.5 -1.0 +2 -0.4 -0.8	I 0 - 1 22 \$\$ 33 22 (M) \$\$ 34 +(1) 45 -00 44 -00 44 -00 44 -00	Number - 10 11-1000 BAS 11 RF) .8 0.2 0.6 0.0 0.5 0.0 1.4 0.4 0.6	r of Per 11 100 SIC S (BR) 3.0 +0.4 +0.4 +0.8 -1.5 -0.5 -0.8 +1.4 -0.4 -0.4 -0.6	- 100)0+ CORE, S3 (LM) 3.2 N/A N/A N/A N/A -0.5 -0.6 N/A -0.4 -0.6	Hard Rock MODI S (RC 2. +0 +0 -1. -0. -0. -1. -0. -0. -0. -0. -0. -0. -0. -0.	Avç Rod IFIEF 4 .4 .8 .0 .5 .8 .6 .6 .4 .6	С . Dense % Soil 25, AND F 20 +0.4 +0.8 -1.0 -0.5 -0.2 N/A -0.4 -0.4 -0.4	D Stiff Soil FINAL C1 (MRF) 2.5 +0.4 +0.6 -1.5 -0.5 -1.2 +1.4 -0.4 -0.6	Soft Poo Soil Soi SCORE, Soi (sw) 2.8 +0.4 +0.8 -1.0 -0.5 -1.0 +2.4 -0.4 -0.6	S C(URN +(URN +() -1 -0 -0 -0 N -0 -0	Unreinforced Chimneys 3 PC1 (TU) 6 2.6 0.2 N/A 0.3 N/A 0.0 N/A 0.5 -0.5 0.2 -0.8 (A +2.4 0.4 -0.4 0.4 -0.6	Parapets PC2 2.4 +0.2 +0.4 -1.0 -0.5 -0.8 N/A -0.4 -0.6	RM1 (FD) 2.8 +0.4 N/A -1.0 -0.5 -1.0 +2.8 -0.4 -0.6	RM2 (RD) 2.8 +0.4 +0.6 -1.0 -0.5 -0.8 +2.6 -0.4 -0.6	URM 1.8 0.0 N/A -1.0 -0.5 -0.2 N/A -0.4 -0.6
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Con Ema Basid Mid I High Verti Plan Pre-t Post Soil ¹ Soil ¹ Soil ¹	BUILDI c Score Rise (4 Rise (2 cal Irregula Code Benchr Type C Type D Type E IAL Si	ices ING TY to 7 sto gularity mark	Govt Historic Industria (PE tories) (Offf Re: Sch W1 4.4 N/A N/A -2.5 -0.5 0.0 +2.4 0.0 0.0	ice sidential hool 3.8 N// -2.0 -0.5 -1.0 +2 -0.4 -0.8	I 0 - 1 22 \$\$ 33 22 (M) \$\$ 34 +(1) 45 -00 44 -00 44 -00 44 -00	Number - 10 11-1000 BAS 11 RF) .8 0.2 0.6 0.0 0.5 0.0 1.4 0.4 0.6	r of Per 11 100 SIC S (BR) 3.0 +0.4 +0.4 +0.8 -1.5 -0.5 -0.8 +1.4 -0.4 -0.4 -0.6	- 100)0+ CORE, S3 (LM) 3.2 N/A N/A N/A N/A -0.5 -0.6 N/A -0.4 -0.6	Hard Rock MODI S (RC 2. +0 +0 -1. -0. -0. -1. -0. -0. -0. -0. -0. -0. -0. -0.	Avç Rod IFIEF 4 .4 .8 .0 .5 .8 .6 .6 .4 .6	С . Dense % Soil 25, AND F 20 +0.4 +0.8 -1.0 -0.5 -0.2 N/A -0.4 -0.4 -0.4	D Stiff Soil FINAL C1 (MRF) 2.5 +0.4 +0.6 -1.5 -0.5 -1.2 +1.4 -0.4 -0.6	Soft Poo Soil Soi SCORE, Soi (sw) 2.8 +0.4 +0.8 -1.0 -0.5 -1.0 +2.4 -0.4 -0.6	S C(URN +(URN +() -1 -0 -0 -0 N -0 -0	Unreinforced Chimneys 3 PC1 (TU) 6 2.6 0.2 N/A 0.3 N/A 0.0 N/A 0.5 -0.5 0.2 -0.8 (A +2.4 0.4 -0.4 0.4 -0.6	Parapets PC2 2.4 +0.2 +0.4 -1.0 -0.5 -0.8 N/A -0.4 -0.6	RM1 (FD) 2.8 +0.4 N/A -1.0 -0.5 -1.0 +2.8 -0.4 -0.6	RM2 (RD) 2.8 +0.4 +0.6 -1.0 -0.5 -0.8 +2.6 -0.4 -0.6 -0.6 Det Evalue	URM 1.8 0.0 N/A -1.0 -0.5 -0.2 N/A -0.4 -0.6 -0.8 ailed uation
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Con Ema Basid Mid I High Verti Plan Pre-t Post Soil 1 Soil 1 Soil 1 FIN CO	BUILDI c Score Rise (4 Rise (- cal Irrec cal Irrec irregula Code Bencht Type C Type D Type E IAL S MME	to 7 sto yularity mark COR	Govt Historic Industria (PE tories) vries) (E, S	0ff Re: Sch 4.4 N/A N/A -2.5 -0.5 0.0 0.0 0.0 0.0	ice sidential 3.8.8 N/A -2.0 -0.1 -1.0 -0.1 -0.0 -0.0	I 0 - 1 2 \$\$ (M 3 2 (M 4 +1 5 -0 -15 -0 -14 +1 4 -0 8 -0 8 -1	Number - 10 11-1000 BAS 0.2 0.6 0.0 0.5 0.0 0.5 0.0 0.5 0.0 0.5 0.0 0.4 0.6 0.2 0.6 0.2 0.6 0.0 0.5 0.0 0.5 0.0 0.5 0.0 0.5 0.0 0.5 0.0 0.5 0.0 0.5 0.0 0.5 0.0 0.5 0.0 0.5 0.0 0.5 0.0 0.5 0.0 0.5 0.5	r of Per 11 - 1000 SIC S S2 (BR) 3.0 +0.4 +0.8 -1.5 -0.5 -0.5 -0.5 +1.4 -0.6 -1.2 R = Brain	- 100)0+ CORE, S3 (LM) 3.2 N/A N/A N/A N/A -0.5 -0.6 N/A -0.4 -0.6	Hard Rock MODD S (RC +0 +0 +0 -1. -0 -0 -0 -1. -0 -0 -1. -0 -0 -1. -0 -0 -0 -1. -0 -0 -0 -0 -0 -0 -0 -0 -0 -0	Avg Rod FIEF 4 swy) 8 4 8 0 5 5 8 6 4 6 4 6 4 6 4 6 4 6 4 	С . Dense % Soil 25, AND F 20 +0.4 +0.8 -1.0 -0.5 -0.2 N/A -0.4 -0.4 -0.4	D Stiff Soil FINAL C1 (MRF) 2.5 +0.4 +0.6 -1.5 -0.5 -1.2 +1.4 -0.6 -1.2	Soft Poo Soil Soi Score, Soi c2 (sw) 2.8 +0.4 +0.8 -1.0 -0.5 -1.0 +2.4 -0.6 -0.4 -0.6 -0.8 -0.4	SW =	Unreinforced Chimneys 3 PC1 (TU) 6 2.6 0.2 N/A 0.3 N/A 0.0 N/A 0.5 -0.5 0.2 -0.8 (A +2.4 0.4 -0.4 0.4 -0.6	Parapets PC2 2.4 +0.2 +0.4 -1.0 -0.5 -0.8 N/A -0.4 -0.6	RM1 (FD) 2.8 +0.4 N/A -1.0 -0.5 -1.0 +2.8 -0.4 -0.6	RM2 (RD) 2.8 +0.4 +0.6 -1.0 -0.5 -0.8 +2.6 -0.4 -0.6 -0.6 Det Eval Req	URM 1.8 0.0 N/A -1.0 -0.5 -0.2 N/A -0.4 -0.6 -0.8 ailed uation wired

HIGH Seismicity

2.5.6 ADDITIONAL FORM DETAILS AND THE SCORE MODIFIERS

Rapid Visual Screening of Buildings for Potential Seismic Hazards (FEMA 154)

Quick Reference Guide (for use with Data Collection Form)

	el Building Types and Critical Code Adoption	Veen Osiensia Osela	Development
and	Enforcement Dates	Year Seismic Codes Initially Adopted	Benchmark Year when
Structura	al Types	and Enforced*	Codes Improved
W1	Light wood frame, residential or commercial, \leq 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		
*Not applie	cable in regions of low seismicity		

2. Anchorage of Heavy Cladding

Year in which seismic anchorage requirements were adopted:

3. Occupancy Loads			
<u>Use</u>	<u>Square Feet, Per Person</u>	<u>Use</u>	<u>Square Feet, Per Person</u>
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 Defir			

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.	4. Score Modifier D	ennitions
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 IrregularityBuildings 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 E:Soft soil; S-wave velocity: 600 – 1200 ft/s; blow count: 15 – 50; or undrained shear strength: 1000 – 2000 psf.	Mid-Rise:	4 to 7 stories
Plan Irregularitybuilding with short columns; unbraced cripple walls.Plan IrregularityBuildings 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,	High-Rise:	8 or more stories
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,	Vertical Irregularity:	
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,	Plan Irregularity	plan, (e.g. corner building, or wedge-shaped building, with one or two solid walls and all
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,	Pre-Code:	adopted and enforced in the jurisdiction; use years specified above in Item 1; default is
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,	Post-Benchmark:	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
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,	Soil Type C:	
	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:	

2.5.7 DETERMINING THE STRUCTURAL SCORE AND ADDITIONAL SCORE MODIFIERS

The scoring system in FEMA P-154 follows a probabilistic estimation approach. It is defined as the negative logarithm to the base 10 of the probability of collapse occurring from suspected or designed ground motions, this is taken as maximum considered earthquake or MCE_R. The MCE values considered in edition 2 were modified with a more precise approach by the USGS and the value taken was 2/3 of the MCE characterized in that area. The basic relation as given by FEMA P-155 is

Si = -log10(P[Collapse|MCE_R ground motions])

where Si= Structural Score, MCE = Maximum Considered Earthquake

Earlier in the first edition of FEMA 154 (1984) P was defined as probability of 60% or greater damage which was improved in second edition in 2002 where P was considered as the Probability of Collapse, collapse is more clearly defined in the third edition as; building collapse means that any part of the gravity system experiences dynamic instability leading to the loss of load bearing capacity. The dynamic instability leads to severe structural deformation of a potentially life-threatening nature, especially falling of all or portions of a structure. Partial building collapse means that the dynamic instability occurs only in a portion of the building. The probability of at least partial building collapse refers to the expected value of the chance that partial collapse or collapse will occur, given some specified conditions. The conditions used here are knowledge of building features observed during the screening and occurrence of MCE_R shaking.

Si is a basic score for a class or type of building. Score Modifiers (SMs) need to be added to it that are specific to that system, to get the final Structural Score, S.

i.e. *S* = Si +/- SMs

The final score so obtained is an indicator of the collapse probability of the structure i.e. say for a factor obtained as 2 or 3 the probability of collapse would be taken as as of the order of 0.01 or 0.001 respectively, that is 1 in 100 or 1 in 1000.

The 1st edition FEMA 154(1984) contained BSH Scores based on the expert-opinion Damage Probability Matrices (DPMs) provided in the ATC- 13 report, Earthquake Damage Evaluation Data for California (ATC, 1985). However with the coming of 2nd edition FEMA 154 (2002) the basic structural scores for each structure type and score modifiers were decided based on Hazus Fragility curves and capacity curves specified in the 1999 SR2 edition of the *HAZUS Technical Manual* (NIBS, 1999). For the *Third Edition*, the probability of collapse is calculated using a modified version of the OSHPD HAZUS methodology (which is itself a modified version of the HAZUS methodology that was used to develop the *Second Edition* scores).

"The **building capacity curve (also known as the push-over curve)** is a plot of a building's lateral-load resistance as a function of some characteristic lateral displacement. This is derived usually from static push-over analysis that defines the relationship between static equivalent base shear versus a building's roof displacement. **Standard building fragility curves** in HAZUS99 are used to estimate the probability of being in, or exceeding various damages states of buildings - slight, moderate, extensive, and complete - for a given demand parameter, that is, spectral displacement response."

The details of how these curves are used to determine BSHs and SMs are specified in HAZUS Technical Manual (NIBS, 1999) and FEMA 155.

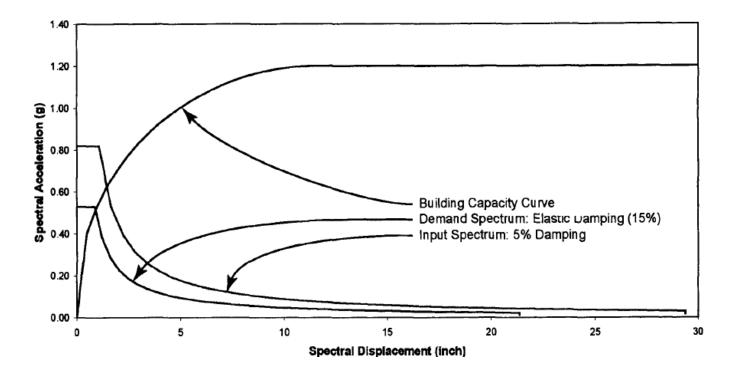


Fig 2.3 Input demand spectrum, demand spectrum with 15% elastic damping, and a typical capacity curve (from NIBS, 1999).

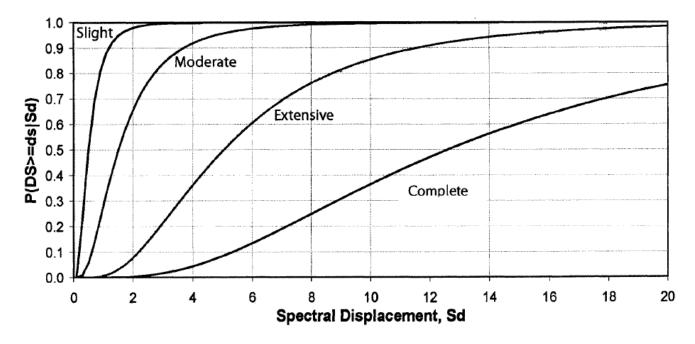
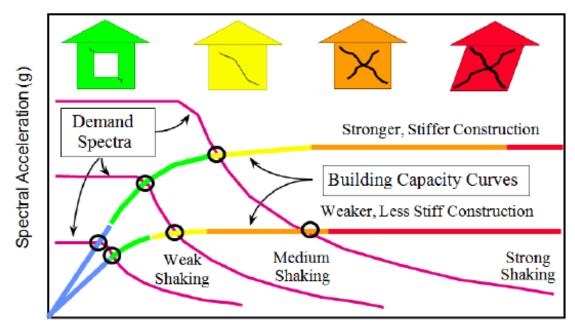


Fig 2.4 Typical HAZUS99 fragility curves (in this case for high-code W1 wood frame-buildings) showing the probability of a damage state being exceeded for a given level of ground shaking (NIBS, 1999).



Spectral Displacement (inches)

Fig. 2.5 [2] Construction types according to FEMA

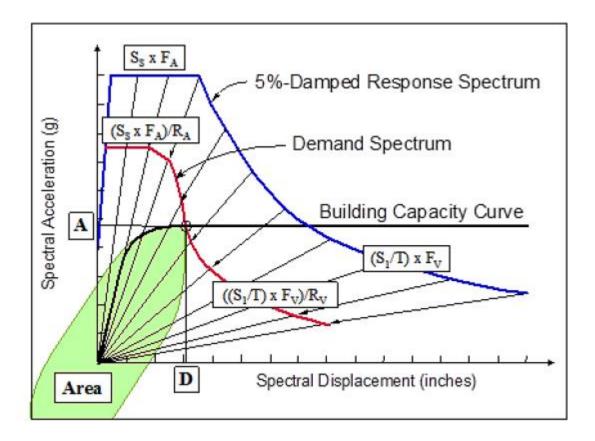


Fig. 2.6 [2] Example calculation of demand spectrum by reduction of 5% damped response spectrum of ground motions

2.5.8 DETERMINING THE CUT OFF SCORE:

"The Rapid Visual Screening (RVS) Cut off Score is decided on the basis of "Costs of Safety" versus "Benefits" analysis.

The cost of safety includes:

• The cost incurred during review and investigation, in detail, of hundreds of buildings to identify some of those that might actually sustain severe structural damage during an earthquake; and

• The cost incurred during rehabilitation of the buildings that are finally determined as being unacceptably weak.

The most significant **benefit** is the life-saving aspect and injury prevention due to reduction in damage for the buildings that will be rehabilitated. This damage reduction not only includes less material damage, but reduces the major disruptions in day to day lives of people and local businesses.

Every community or authority, therefore, has freedom in choosing its own cut-off scores on the basis of the relative importance of cost of safety versus benefits.

National Bureau of Standards (NBC) of U.S. (1980) and SAC (2000) suggest a value of **Cut-off Score S as 3 being appropriate for normal day-to-day loads, and about 2, or somewhat less as appropriate for earthquake loadings**.

Unless a community considers by itself the cost / benefit aspect of seismic safety, an estimated *S* value of around 2.0 can be reasonably assumed as a preliminary value for use with RVS to differentiate and determine adequate buildings from potentially inadequate ones. Using a higher cut-off *score* value results in a greater benchmark for safety but consequently increases costs for evaluations and, if needed, rehabilitation; using a lower value of *cut-off score* results in increased seismic risk, lower short-term costs for evaluating and, if needed, rehabilitating of the structures.

Further guidance for cost and societal implications of rehabilitation of vulnerable buildings is available in other FEMA published report series on existing buildings; FEMA-156 and FEMA-157, *Typical Costs for Seismic Rehabilitation of Buildings*, 2nd Edition, Volumes 1 and 2, FEMA-255 and FEMA-256, *Seismic Rehabilitation of Federal Buildings – A Benefit/Cost Model*, Volumes 1 and 2 (VSP, 1994).

2.6 RAPID VISUAL ASSESSMENT (RVA) FOR INDIAN CONDITIONS

2.6.1 OVERVIEW:

The *FEMA methodology* prescribed in FEMA P-154 *isn't exactly ideal for Indian conditions in the raw form.* The reason being the highly diverse Indian scenario where construction practices range from modular steel and Reinforced Cement Concrete structures in urban areas to basic thatch, brick masonry or earthen houses in villages. As such only some but not all structure types as per FEMA P-154 can be found among Indian structures. Moreover, the variation in size, occupancy, and construction practices for these structures has its own influence. The variation in seismicity in India cannot either be overlooked. This necessitates a somewhat different method for RVA in Indian.

With regard to this the contributions and suggestions by *Prof. Ravi Sinha and Prof. Alok Goyal* (IIT Bombay) and *Dr. Anand S. Arya* (Professor Emeritus, Dept. of Eq. Engineering, IIT Roorkee, Chairman, BIS Committee CED 39) are invaluable as they contributed to developing of the basic philosophies of RVS for evaluating Indian Structures (steel frame, RCC, and Masonry) based on the research conducted with reference to seismic code IS 1893:2002. Prof. Sinha and Prof. Goyal using the score system given by FEMA 154 made the use of structural score method to classify various damageability grades as per EMS-98 (European Macro seismic Scale).Later on, the same EMS-98 recommendations were used by Dr. Arya for classification of Indian structures and damageability that any particular structure could undergo. Data collection forms using this, were prepared and suitable procedures proposed. Later on, the same methodology was further incorporated in *IS 13935:2009 "Indian Standard Seismic Evaluation, Repair and Strengthening of Masonry Buildings- Guidelines (First Revision)"*

Rapid Visual Screening (RVS) as specified by IS 13935:2099 is a "*Logical system*" rather than being a "structural score system" as per FEMA 154.

In this system there are 6 building types (A to F) among which some types (C and D) exist commonly among both masonry and RCC or steel frames. + Sign is used to denote more seismic strength (slight) or lower seismic vulnerability. 5 Damageability Grades (G1 to G5) are specified along with these for masonry and RCC or Steel frames. Using the type of structure and the location in any particular seismic zone *i.e.* from zone 2 to zone 5, the probable damage it can undergo is listed in a table. Moreover, there are also some other parameters such as URM infill, falling hazards, special hazards, etc. are specified.

In accordance with these parameters and also the type of structure with the seismic zone the screener can identify the potential damage that the structure could undergo (given by damageability grade G) and possible Remedial measures. All this has been recorded in the *Data Collection Forms; 1 for each seismic zone; a total of 8 forms, (4 being for masonry structures and 4 are for RCC or Steel frames).*

2.6.2 SEISMIC ZONES OF INDIA: [14]

IS 1893:2002 (Part 1) divides India into 4 seismic hazard zones. Their details are as follows:

Zone II - Low seismic hazard with damage of MSK Intensity VI or lower. **Zone III-** Moderate seismic hazard with maximum damage of and till MSK Intensity VII. **Zone IV-** High seismic hazard with maximum damage of and till MSK Intensity VIII. **Zone V-** Very high seismic hazard with maximum damage of MSK Intensity IX or more.

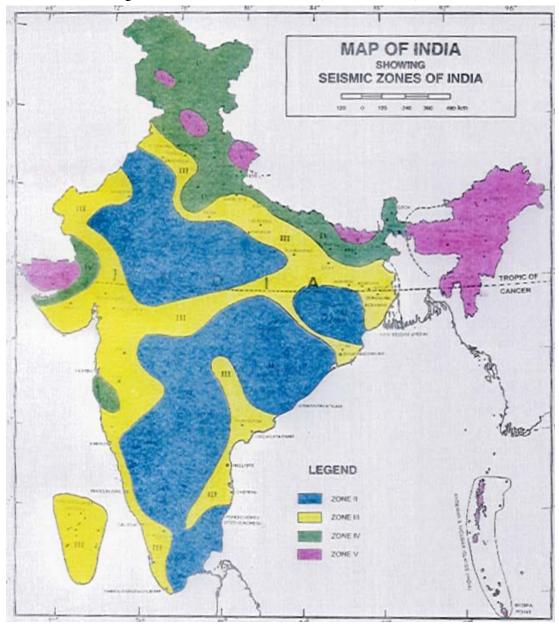


Fig. 2.7: Seismic zones in India (IS: 1893-2002)

2.6.3 STRUCTURE TYPES ACCORDING TO INDIAN CONDITIONS:

We see a variety of construction materials and structural forms being used in urban and semiurban areas in India. These usually include a variety of locally available materials for example mud, straw, wood and semi-engineered materials i.e. brick and stone masonry and engineering materials like concrete or steel.

The seismic vulnerability of any structure type depends on the building materials and construction method adopted. The vulnerability is generally greatest with use of local materials of the un-engineered types and lowest for engineered materials and practices. The vulnerability class of any building type depends on the average expected seismic response for that structure type.

A building may have its vulnerability class different from basic class defined for that form depending on condition of building, architectural features, earthquake resistance features, height etc. Therefore, it is possible to obtain a damageability range of each building type considering the various factors that are likely to affect its performance. Some variations are therefore defined alphabetically as A, B, B+ etc.

Building Type	Description
A	 Rubble (Field stone) in mud mortar or without mortar usually with sloping wooden roof.
	b) Uncoursed rubble masonry without adequate 'through stones'.
	c) Masonry with round stones.
В	Semi-dressed, rubble, brought to courses, with <i>through</i> stones and long <i>corner</i> stones; unreinforced brick walls with country type wooden roofs; unreinforced CC block walls constructed in mud mortar or weak lime mortar.
B+	 a) Unreinforced brick masonry in mud mortar with vertical wood posts or horizontal wood elements or seismic band (IS: 13828) b) Unreinforced brick masonry in lime mortar.
С	 a) Unreinforced masonry walls built from fully dressed (Ashler) stone masonry or CC block or burnt brick using good cement mortar, either having RC floor/roof or sloping roof having eave level horizontal bracing system or seismic band.
	b) As at B with horizontal seismic bands (IS: 13828)
C+	Like C(a) type but having horizontal seismic bands at lintel level of doors & windows (IS: 4326)
D	Masonry construction as at C(a) but reinforced with bands & vertical reinforcement, etc (IS: 4326), or <i>confined</i> masonry using horizontal & vertical reinforcing of walls.

Table 2.1 [6]: Masonry Structure Classes for RVS

Table 2.2 [5]: RCC/Steel Frame classification for RVS

Frame	Description
Type	
С	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.
Е	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.

2.6.4 DAMAGE CLASSIFICATION (AS PER BIS METHOD):

Classification of	of damage to masonry buildings					
Grade 1: Neglig damage)	gible to slight damage (no structural damage, slight non-structural					
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: Mode	rate 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: Subst structural dam	antial to heavy damage (moderate structural damage, heavy non- age)					
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: Destr	uction (very heavy structural damage)					
	Total or near total collapse of the building.					

Table 2.3 [6] Classification of Damage to Masonry Buildings

* RC = Reinforced Concrete; AC = Asbestos Cement

Table 2.4 [5] Classification of damage to buildings of Reinforced Concrete

Classification of damage to buildings of reinforced concrete

Grade 1: Negligible to slight damage (no structural damage, slight non-structural damage)

Fine cracks in plaster over frame members or in walls at the base.

Fine cracks in partitions & infills.

Grade 2: Moderate damage (Slight structural damage, moderate non-structural damage)

Cracks in columns & beams of frames & in structural walls.

Cracks in partition & infill walls; fall of brittle cladding & plaster. Falling mortar from the joints of wall panels.

Grade 3: Substantial to heavy damage (moderate structural damage, heavy non-structural damage)

Cracks in columns & beam column joints of frames at the base & at joints of coupled walls. Spalling of concrete cover, buckling of reinforced rods.

Large cracks in partition & infill walls, failure of individual infill panels.

Grade 4: Very heavy damage (heavy structural damage, very heavy non-structural damage)

Large cracks in structural elements with compression failure of concrete & fracture of rebar's; bond failure of beam reinforcing bars; tilting of columns. Collapse of a few columns or of a single upper floor.

Grade 5: Destruction (very heavy structural damage)

Collapse of ground floor parts (e.g. Wings) of the building.

*The grades of damage in steel and wood buildings will also be based on non-structural and structural damage classification. 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.

2.6.5 DAMAGE CORRELATION AND BUILDING TYPE

MASONRY BUILDINGS	Type of Building	Zone II MSK VI or less	Zone III MSK VII	Zone IV MSK VIII	Zone V MSK IX or More
	A	Many of grade 1 Few of grade 2 (rest no damage)	Most of grade 3 Few of grade 4 (rest of grade2or1)	Most of grade 4 Few of grade 5 (rest of grade 3,2)	<i>Many</i> of grade 5 (rest of grade 4&3)
	B and B+	Many of grade 1 Few of grade 2 (rest no damage)	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+	Few of grade 1 (rest no damage)	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		Few of grade 1	Few of grade 2	Many of grade 2 Few of grade 3 (rest of grade 1)

 Table 2.5 [6]: Structure type and Damageability correlation for Masonry Buildings

NOTE:

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

R	Type of	Zone II	Zone III	Zone IV	Zone V
С	Building	MSK VI or less	MSK VII	MSK VIII	MSK IX or
F					More
1	С	Few of grade 1	Few of grade 2	Many of grade 2	Many of grade 3
S	and	(rest no damage)	(rest of grade 1,0)	Few of grade 3	Few of grade 4
F	C+			(rest of grade 1)	(rest of grade 2)
1	D		Few of grade 1	Few of grade 2	Many of grade 2
В		-			Few of grade 3
U					(rest of grade 1)
Ι	Е				Few of grade 2
L	and	-	-	-	(rest of grade 1 or
D	E+				0)
Ι					
Ν	F	_	-	-	Few of grade 1
G					č

Table 2.6 [5]: Structure type and Damageability Correlation for RCC/Steel Frame Buildings

-

- . .

NOTE:

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

2.6.6 SPECIAL PARAMETERS FOR DATA COLLECTION FORMS [5],[6],[14]

1) Importance of Building/Structure:

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

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

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

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

Zone II III IV V

Zone Factor 0.10 0.16 0.24 0.36

It is seen that one Unit change in Seismic Zone Intensity increases the Zone Factor 1.5 times. *Hence to deal with the damageability of important buildings in any zone, they should be checked for one Unit higher zone.* The assessment forms are designed accordingly.

2) Special Hazards:

There are some special hazardous conditions to be considered:

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

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

III. Irregular Buildings:

Irregularities in buildings are defined in Cl.7.1 of IS: 1893 - 2002 under the following subheads:

<u>i. Plan Irregularities</u>: These are defined in Table 4 of the Code as follows: a) Torsion Irregularity b) Re-entrant Corners c) Diaphragm Discontinuity d) Out of Plane Offsets e) Non – Parallel Systems The Geometric Irregularities in building plans which can be easily identified in Figure 5 These irregularities enhance the overall damage (increased grade of damage e.g. at re-entrant corners). Such a building may be recommended for detailed evaluation.

<u>ii. Vertical Irregularities</u>: The following vertical irregularities may be seen in masonry buildings (see Fig.5).
a) Mass Irregularity
b) Vertical Geometric Irregularity
c) In-Plane Discontinuity in vertical Elements Resisting Lateral Forces.
If any of these irregularities are noticed, the building should be recommended for detailed evaluation.

3) Falling Hazards:

Falling hazards include chimneys, parapets, cladding etc. Where such hazards are present, particularly in Zones IV & V, recommendations should make reference to these in the survey report as indicated.

4) Type of Foundation Soil:

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

5) Special Observations:

These observations are applicable only for masonry buildings. They specify certain parameters which determine whether the structural components are in correct proportion or not as per IS 4326:1993 "Indian Standard Code of practice for Earthquake Resistant Design and Construction of Buildings" and IS 13828:1993 "Indian Standard Guidelines for Improving Earthquake Resistance of Low Strength Masonry Buildings" There absence may call for retrofitting or revaluation.

6) URM Infills:

Presence of Unreinforced Masonry (URM) infills also determine whether the structure needs to be further evaluated for seismic vulnerability or not. They are applicable on for RCC and Steel Frame structures

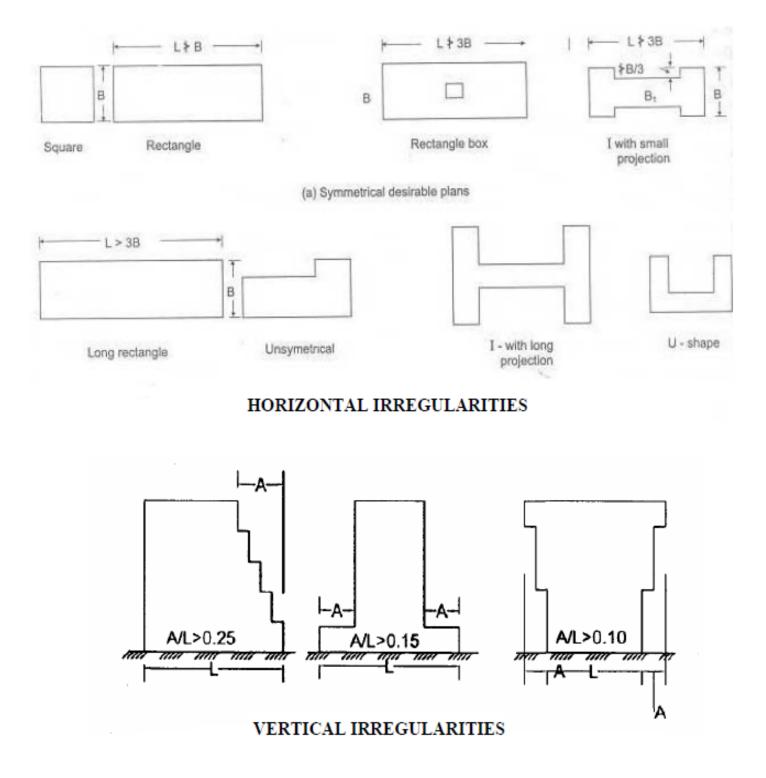


Fig 2.8 [5],[6]: Irregularities in structures (RCC and Masonry)

37

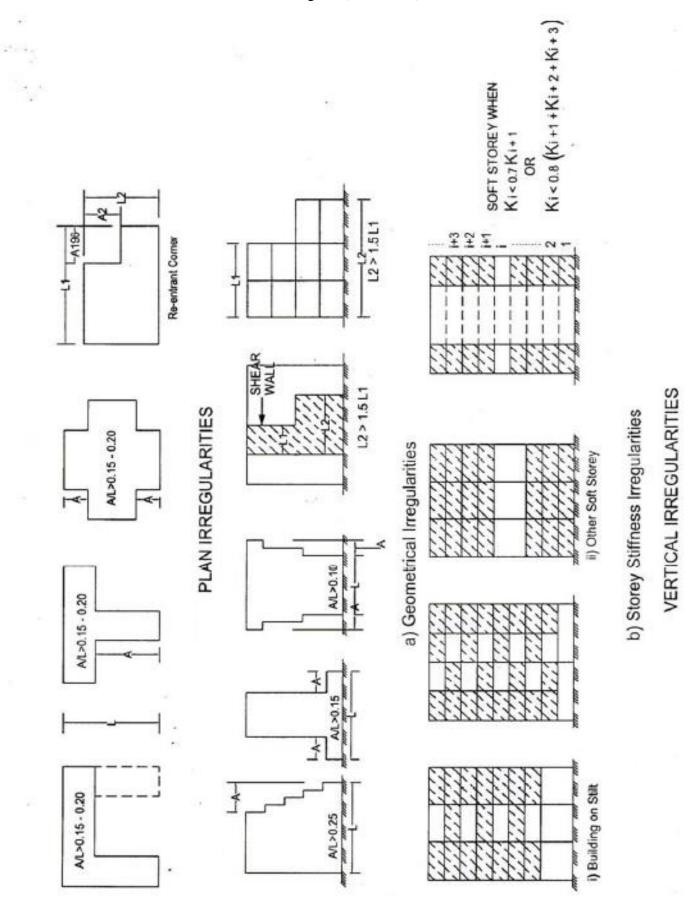


Fig 2.8 (Continued)

2.6.7 DATA COLLECTION FORMS FOR MASONRY STRUCTURES [6]:

1 Rapid Visual Screening of Masonry Buildings for Seismic Hazards

_	Sei	ismic Zone II Ordinary Building
	Image: state stat	Pin Pin
		, *UCR - Uncoursed Random Rubble
Shatah Plan ari	*CCB: Cement Co	
2.0 OCCUPANCY 2.1 Important buildin Hospitals, Schools, menunes structures; emergency build like telephone excha television, radio stations, rail stations, fire stations, rail stations, fire stations, Inpor assembly halls like cines assembly halls and sub stations, power stations, Impor Industrial establishments, residences & Residences Important Emergency person. *Any building having m than 100 Occupants may treated as Important. 2.2 Ordinary buildings:- O buildings having occupants <1	1 then liquefiable site indicated. Yes No 4.1 Chimme 3.2 Land Slide Prone Site Yes No 4.2 Parapet 3.3 Severe Vertical Irregularity Yes No 4.3 Claddin 3.4 Severe Plan Irregularity Yes No 4.4 Others 5.0 SPECIAL OBSERVATION 5.1 Length of wall between two cross walls are as per IS: IS:13828. Yes No 6 5.2 Percentage of openings in walls is as per IS:4326 or IS:13828 Yes No S:13828 7 5.3 Ratio of height & width of wall is as per IS:4326 or IS:13828 Yes No S:13828	All Cookies in the control of the formation of the f
5.0 Probable Dama	ability in Few/Many Buildings	

Building Type	Building Type 5.1 Masonry Building							
Damage- ability in	A	A B / B+ C / C+ D						
Zone II	G2	G2 / G1	G1 / G1	-				
Note: +sign indicates higher strength hence somewhat lower damage expected as stated. Also average damage in one building type in the area may be lower by one grade point than the probable damageability indicated.								
Surveyor will identify the Building Type; encircle it, also the corresponding damage grade.								

Surveyor's sign:_ Name: Executive Engineer's Sign:_

Date of Survey:_

2 Rapid Visual Screening of Masonry Buildings for Seismic Hazards

Seismic Zone III Ordinary Building (Also for Zone II Important Building)

				\vdash			<u> </u>	<u> </u>		$\left \right $	- 1.1 Building Name
							<u> </u>	⊢			1.2 Use
								<u> </u>			
											1.3 Address:
											Pin
											1.4 Other Identifiers
											1.5 No. of Stories 1.6 Year Built
				Pl	hoto	graj	ph				1.7 Total Covered Area; all floors (sq.m)
											1.8 Ground Coverage (Sq.m):
											1.9 Soil Type:1.10 Foundation Type:
											1.11 Roof Type: 1.12 Floor Type
											1.12 Structural Components:
											1.12.1 Wall Type: BB* Earthen UCR* CCB*
											1.12.2 Thickness of wall: 1.12.3 Slab Thickness:
											1.12.4 Mortar Type: Mud Lime Cement
											1.12.5 Vert. R/F bars: Corners T-junctions Jambs
											1.12.6 Seismic bands: Plinth Lintel Eaves Gable
											1.12.0 Seismic oands: Pinnin [] Lintel Eaves Gaole
											*BB - Burnt Brick, *UCR - Uncoursed Random Rubble
	Ske	tch	Plan	ı wit	h L	engt	h &	Bre	adth		*CCB: Cement Concrete Block

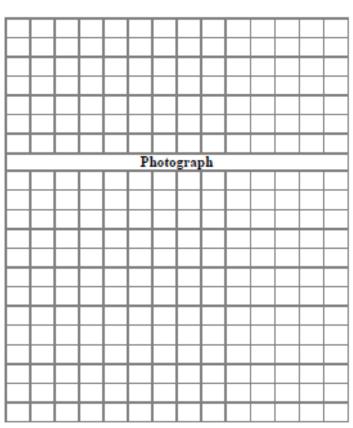
4.0 FALLING RECOMMENDED ACTION:-2.0 OCCUPANCY 3.0 SPECIAL HAZARD HAZARD Ensure adequate maintenance. 3.1 High Water Table (within 3m) & if sandy soil, 21 Important buildings: Detailed evaluation of B type 4.1 Chimneys Hospitals, Schools, monumental then liquefiable site indicated. Yes 🗌 No 🗌 for need for retrofitting. structures; emergency buildings 4.2 Parapets Detailed evaluation of A types Yes No like telephone exchange, 3.2 Land Slide Prone Site television, radio stations, railway for need for reconstruction or 4.3 Cladding 3.3 Severe Vertical Irregularity Yes 🗌 No 🗌 stations, fire stations, large possible retrofitting. community halls like cinemas, assembly halls and subway 4.4 Others Yes 🗌 No 🗌 3.4 Severe Plan Irregularity □ If any Special Hazard 3.0 found re-evaluate for possible stations, power stations, Important Industrial establishments, VIP residences & Residences of prevention/retrofitting. 5.0 SPECIAL OBSERVATION □ If any of the falling hazard is 5.1 Length of wall between two cross walls are as per IS:4326 or Important Emergency person. present, either remove it or IS:13828. Yes 🗆 No 🗆 *Any building having more strengthen against falling. 5.2 Percentage of openings in walls is as per IS:4326 or IS:13828 than 100 Occupants may be Special observation if not compliant Yes 🗆 No 🗆 treated as Important. may lead to more severe damage 5.4 Ratio of height & width of wall is as per IS:4326 or IS:13828 and will call for retrofitting. 2.2 Ordinary buildings :- Other buildings having occupants <100 Yes 🗆 No 🗆 5.0 Probable Damageability in Few/Many Buildings Surveyor's

Building Type		5.1 Maso	Sign :			
Damage- ability in	A	B / B+	C / C+	D		Name:
Zone III	64	G3 / G2	G2 / G1	G1		Executive
Note: +sign indic	Engineer's					
stated. Also avera	Sign:					
grade point than	Date of Survey:					
Surveyor will iden	Date of Survey.					



3 Rapid Visual Screening of Masonry Buildings for Seismic Hazards

1.1 Building Name



Sketch Plan with Length & Breadth

1.3 Address:	
1.0 Augess.	Pin
1.4 Other Identifiers	
1.5 No. of Stories	1.6 Year Built
1.7 Total Covered Area; a	all floors (sq.m)
1.8 Ground Coverage (Sq	1.m):
1.9 Soil Type:	_1.10 Foundation Type:
1.11 Roof Type:	1.12 Floor Type
1.12 Structural Compone	nts:
1.12.1 Wall Type: BB*	Earthen UCR* CCB*
1.12.2 Thickness of wall;	1.12.3 Slab Thickness:
1.12.4 Mortar Type: Mud	l Lime Cement
1.12.5 Vert. R/F bars: Co	mers T-junctions I Jambs I
1.12.6 Seismic bands: Pli	inth 🗌 Lintel 🗌 Eaves 🔲 Gable 🗌

Seismic Zone IV Ordinary Building

(Also for Zone III Important Building)

*CCB: Cement Concrete Block

2.0 OCCUPANCY	3.0 SPECIAL HAZARD	4.0 FALLING HAZARD	RECOMMENDED ACTION:-
2.1 Important buildings: Hospitals, Schools, monumental structures; emergency buildings like telephone exchange,	 3.1 High Water Table (within 3m) & if sandy soil, then liquefiable site indicated. Yes No 3.2 Land Slide Prone Site Yes No 	4.1 Chimneys 🗌 4.2 Parapets 🔲	reconstructions or possible retrofitting to achieve type C or D B+, C: evaluate in detail for need for retrofitting
television, radio stations, railway stations, fire stations, large community halls like cinemas, assembly halls and subway	3.3 Severe Vertical Irregularity Yes No 3.4 Severe Plan Irregularity Yes No	4.3 Cladding 4.4 Others	 If any Special Hazard 3.0 found , re- evaluate for possible prevention/retrofitting. If any of the falling hazard is present.
stations, power stations, Important Industrial establishments, VIP residences & Residences of Important Emergency person.	5.0 SPECIAL OBSERVATION 5.1 Length of wall between two cross walls ar IS:13828. Yes No	either remove it or strengthen against falling.	
*Any building having more than 100 Occupants may be treated as Important.	5.2 Percentage of openings in walls is as per IS:432 Yes D No D		may lead to more severe damage and will call for retrofitting.
2.2 Ordinary buildings:- Other buildings having occupants <100	5.5 Ratio of height & width of wall is as per IS:432 Yes 🛛 No 🗆	26 or IS:13828	

5.0 Probable Damageability in Few/Many Buildings

5.0 Probable D	Surveyor's							
Building Type		5.1 Mas	Sign :					
Damage- ability in								
Zone IV						Name:		
	G5	G4 / G3	G3 / G2	G2		Executive		
Note: +sign indica stated. Also averag grade point than th	Engineer's Sign:							
Surveyor will identi	Date of Survey:							

4 Rapid Visual Screening of Masonry Buildings for Seismic Hazards

Seismic Zone V All Buildings

(Also for Zone IV Important Building)

			1.1 Building Name						
			1.3 Address:						
	+ $+$ $+$ $+$		Pin						
	+ $+$ $+$ $+$		1.4 Other Identifiers						
	+ $+$ $+$ $+$		1.5 No. of Stories1.6 Year Built						
Phot	ograph			ll floors (sq.m)					
				m):					
				_1.10 Foundation Type:					
				1.12 Floor Type					
			1.12 Structural Componen						
				Earthen UCR* CCB*					
	+ $+$ $+$ $+$		1.12.2 Thickness of wall:	1.12.3 Slab Thickness:					
	+ $+$ $+$ $+$		1.12.4 Mortar Type: Mud	Lime Cement					
	+ $+$ $+$ $+$		1.12.5 Vert. R/F bars: Cor	ners 🗌 T-junctions 🔲 Jambs 🗖					
			1.12.6 Seismic bands: Plir	th 🗌 Lintel 🗌 Eaves 🗌 Gable 🗌					
			*BB – Burnt Brick, *UCR *CCB: Cement Concrete I	– Uncoursed Random Rubble					
Sketch Plan with	Length & Brea	dth	CCB. Cement Concrete I	SIOCE					
2.0 OCCUPANCY	3.0 SPE	CIAL HAZARD	4.0 FALLING HAZARD	RECOMMENDED ACTION:-					
2.0 OCCUPANCY		CIAL HAZARD	HAZARD	A or B, B+ : evaluate in detail for					
2.1 Important buildings: Hospitals, Schools, monumental	3.1 High Water Tab	CIAL HAZARD le (within 3m) & if sa ite indicated. Yes 🗌	HAZARD ndy soil,	A or B, B ⁺ : evaluate in detail for need of reconstructions or possible retrofitting to achieve type C ⁺ or D					
2.1 Important buildings: Hospitals, Schools, monumental structures; emergency buildings like telephone exchange,	3.1 High Water Tab then liquefiable si	le (within 3m) & if sa	HAZARD ndy soil, No 4.1 Chimneys	A or B, B+ : evaluate in detail for need of reconstructions or possible					
2.1 Important buildings: Hospitals, Schools, monumental structures; emergency buildings like telephone exchange, television, radio stations, railway	3.1 High Water Tabl then liquefiable si 3.2 Land Slide Prop	le (within 3m) & if sa ite indicated. Yes 🗌	HAZARD ndy soil, No 4.1 Chimneys No 4.2 Parapets	 A or B, B⁺: evaluate in detail for need of reconstructions or possible retrofitting to achieve type C⁺ or D C: evaluate in detail for need for retrofitting to achieve type C⁺, D. Wood : evaluate in detail for 					
2.1 Important buildings: Hospitals, Schools, monumental structures; emergency buildings like telephone exchange, television, radio stations, railway stations, fire stations, large community halls like cinemas,	 3.1 High Water Table then liquefiable si 3.2 Land Slide Prom 3.3 Severe Vertical 	le (within 3m) & if sa ite indicated. Yes e Site Yes 	HAZARD ndy soil,	 A or B, B⁺: evaluate in detail for need of reconstructions or possible retrofitting to achieve type C⁺ or D C: evaluate in detail for need for retrofitting to achieve type C⁺, D. Wood : evaluate in detail for Retrofitting 					
2.1 Important buildings: Hospitals, Schools, monumental structures; emergency buildings like telephone exchange, television, radio stations, railway stations, fire stations, large community halls like cinemas, assembly halls and subway stations, power stations, Important	 3.1 High Water Table then liquefiable si 3.2 Land Slide Promi 3.3 Severe Vertical 3.4 Severe Plan Irre 	le (within 3m) & if sa ite indicated. Yes e Site Yes Irregularity Yes gularity Yes	HAZARD ndy soil, 4.1 Chimneys No 4.2 Parapets No 4.3 Cladding No 4.4 Others	 A or B, B⁺: evaluate in detail for need of reconstructions or possible retrofitting to achieve type C⁺ or D C: evaluate in detail for need for retrofitting to achieve type C⁺, D. Wood: evaluate in detail for Retrofitting If any Special Hazard 3.0 found, re-evaluate for possible prevention/ 					
2.1 Important buildings: Hospitals, Schools, monumental structures; emergency buildings like telephone exchange, television, radio stations, railway stations, fire stations, large community halls like cinemas, assembly halls and subway stations, power stations, Important Industrial establishments, VIP residences & Residences of	 3.1 High Water Table then liquefiable si 3.2 Land Slide Proni 3.3 Severe Vertical 3.4 Severe Plan Irre 	le (within 3m) & if sa te indicated. Yes e Site Yes Irregularity Yes gularity Yes 5.0 SPECIAL OBSE	HAZARD ndy soil, No 4.1 Chimneys No 4.2 Parapets No 4.3 Cladding No 4.4 Others	 A or B, B⁺: evaluate in detail for need of reconstructions or possible retrofitting to achieve type C⁺ or D C: evaluate in detail for need for retrofitting to achieve type C⁺, D. Wood : evaluate in detail for Retrofitting If any Special Hazard 3.0 found , re- 					
2.1 Important buildings: Hospitals, Schools, monumental structures; emergency buildings like telephone exchange, television, radio stations, railway stations, fire stations, large community halls like cinemas, assembly halls and subway stations, power stations, Important Industrial establishments, VIP residences & Residences of Important Emergency person.	 3.1 High Water Tabi then liquefiable ti 3.2 Land Slide Prom 3.3 Severe Vertical 3.4 Severe Plan Irre 5.1 Length of wal 	le (within 3m) & if sa te indicated. Yes e Site Yes Irregularity Yes gularity Yes 5.0 SPECIAL OBSE	HAZARD ndy soil, 4.1 Chimneys No 4.2 Parapets No 4.3 Cladding No 4.4 Others	 A or B, B⁺: evaluate in detail for need of reconstructions or possible retrofitting to achieve type C⁺ or D C: evaluate in detail for need for retrofitting to achieve type C⁺, D. Wood: evaluate in detail for Retrofitting If any Special Hazard 3.0 found , reevaluate for possible prevention/ retrofitting. If any of the falling hazard is present, either remove it or 					
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2.1 Important buildings: Hospitals, Schools, monumental structures; emergency buildings like telephone exchange, television, radio stations, railway stations, fire stations, large community halls like cinemas, assembly halls and subway stations, power stations, Important Industrial establishments, VIP residences & Residences of Important Emergency person. *Any building having more than 100 Occupants may be treated as Important. 2.2 Ordinary buildings:- Other buildings having occupants <100	3.1 High Water Tabi then liquefiable si 3.2 Land Slide Prom 3.3 Severe Vertical 3.4 Severe Plan Irre 5.1 Length of wal IS:13828. 5 5.2 Percentage of op 5.6 Ratio of height 5.6 Ratio of height 5.1 Ma: B / B+ G5 / G4	le (within 3m) & if sa te indicated. Yes e Site Yes gularity Yes 5.0 SPECIAL OBSEI Il between two cross Yes No penings in walls is as Yes No t & width of wall is as Yes No Many Building sonry Building C / C+ G4 / G3 mewhat lower dat	HAZARD ndy soil, No 4.1 Chimneys No 4.2 Parapets No 4.3 Cladding No 4.3 Cladding No 4.4 Others RVATION walls are as per IS:4326 or per IS:4326 or IS:13828 per IS:4326 or IS:13828 gs G3 mage expected as	 A or B, B⁺: evaluate in detail for need of reconstructions or possible retrofitting to achieve type C⁺ or D C: evaluate in detail for need for retrofitting to achieve type C⁺, D. Wood : evaluate in detail for Retrofitting If any Special Hazard 3.0 found , re- evaluate for possible prevention/ retrofitting. If any of the falling hazard is present, either remove it or strengthen against fall. Special observation if not compliant may lead to more severe damage and will call for retrofitting. Surveyor's Sign :					
2.1 Important buildings: Hospitals, Schools, monumental structures; emergency buildings like telephone exchange, television, radio stations, railway stations, fire stations, large community halls like cinemas, assembly halls and subway stations, power stations, Important Industrial establishments, VIP residences & Residences of Important Emergency person. *Any building having more than 100 Occupants may be treated as Important. 2.2 Ordinary buildings:- Other buildings having occupants <100	3.1 High Water Tabi then liquefiable si 3.2 Land Slide Prom 3.3 Severe Vertical 3.4 Severe Plan Irre 5.1 Length of wal IS:13828. 7 5.2 Percentage of of 5.6 Ratio of height 5.6 Ratio of height 5.6 Ratio of height 5.1 May 5.1 May 5.1 May 6.1 May 6.1 May 6.1 May	le (within 3m) & if sa te indicated. Yes e Site Yes gularity Yes 5.0 SPECIAL OBSE Il between two cross Yes No penings in walls is as Yes No t & width of wall is as Yes No Many Building c / C+ G4 / G3 mewhat lower data ype in the area me	HAZARD ndy soil, No 4.1 Chimneys No 4.2 Parapets No 4.3 Cladding No 4.3 Cladding No 4.4 Others RVATION walls are as per IS:4326 or per IS:4326 or IS:13828 per IS:4326 or IS:13828 gs G3 mage expected as	 A or B, B⁺: evaluate in detail for need of reconstructions or possible retrofitting to achieve type C⁺ or D C: evaluate in detail for need for retrofitting to achieve type C⁺, D. Wood : evaluate in detail for Retrofitting If any Special Hazard 3.0 found , re-evaluate for possible prevention/ retrofitting. If any of the falling hazard is present, either remove it or strengthen against fall. Special observation if not compliant may lead to more severe damage and will call for retrofitting. Surveyor's Sign :					

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

2.6.8 DATA COLLECTION FORMS FOR RCC/ SF STRUCTURES [5]:

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

Seismic Zone II Ordinary Building

_	_			_		_									
														1.1	Building Name
														1.2	Use
														1.3	Address:
															Pin
														14	Other Identifiers
														1	
														1	No. of Stories1.6 Year of Const
		_			P	hoto	grap	bh						1.7	Storey Ht: 1 st , 2 nd , 3 rd etc.
														1.8	Total Covered Area; all floors (sq.m)
														1.9	Ground Coverage (Sq.m):
														1.1	0 Soil Type:1.11 Foundation Type:
														1.1	2 Depth of Ground water table:
														1.1	3 Bldg. Type: Frame Pre-cast
	4														Frame - Shear Wall Flat Slab Frame
															Frame - Shear Wall 🗀 Flat Slab Frame
														1.1	4 Thickness of infill wall: Exterior Interior
	1													1.1	5 Struct. Dwg./Calculations available: Yes / No (If yes,attach)
														1.1	6 Extn. to the original bldg. Yes/ No (If.yes pl. indicate)
														1.1	7 Location of Shear walls (if any)
														1	8 Special Confining R/F in Beam/Column/joints:
														1	9 Stair case: Separated Connected Enclosed
		Ske	tch	Pla	n wit	th L	engti	h &	Bre	adtl	1			1.1	y Stair case: Separated 🗀 Connected 🗀 Enclosed 🗀
		 									•				
		2	0 0	ccu	PAN	CY			3	.0 SF	ECL	ALB	AZAF	D	4.0 FALLING HAZARD RECOMMENDED ACTION:-
F									-				(within		Ensure adequate maintenance.
	2.1 Sch				ilding		Hospi emerge			-			en liquet		☐ If any Special Hazard 3.0 found
							televis					оц, ше 2	•	10016	4.1 Chimneys , re-evaluate for possible

radio stations, railway stations, fire stations, large community halls like cinemas, assembly	Yes No		retrofitting.
halls and subway stations, power stations, Important Industrial establishments, VIP residences & Residences of Important	3.2 Land Slide Prone Site	4.2 Parapets	
Emergency person. *Any building having more than 100	3.3 Severe Vertical Irregularity Yes No	4.3 Cladding	
Occupants may be treated as Important. 2.2 Ordinary buildings:- Other buildings having occupants <100	3.4 Severe Plan Irregularity	4.4 Others	
			1

5.0 Probable Damageability in Few/Many Buildings

Building Type	5.1 R	5.2 URM	Surveyor'									
Damage-	C / C+	Infill	sign:									
ability in Zone II	G1 / G1	-	-	-	G1	Name: Executive						
stated. Also a	average damage in	ndicates higher strength hence somewhat lower damage expected as werage damage in one building type in the area may be lower by one han the probable damageability indicated.										
Surveyor will	identify the Buildin	ig Type; encircle it, al	lso the correspon	ding damage gr	ade.	Date of Sur						

)ate	of	Sur	ver	r.

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

Seismic Zone III Ordinary Building (Also for Zone II Important Building)

												1.1 Building Name
												1.2 Use
												1.3 Address:
												Pin
<u> </u>	<u> </u>		<u> </u>			<u> </u>		<u> </u>			-+	1.4 Other Identifiers
<u> </u>								-			\rightarrow	1.5 No. of Stories 1.6 Year of Const
<u> </u>					PI	hoto	σrat	հ				1.7 Storey Ht.: 1 st , 2 nd , 3 nd etc.
<u> </u>							51.01	<u> </u>				1.8 Total Covered Area; all floors (sq.m)
												1.9 Ground Coverage (Sq.m):
												1.10 Soil Type: 1.11 Foundation Type:
												1.12 Depth of Ground water table:
												1.13 Bldg. Type: Frame Pre-cast
											$ \rightarrow$	Frame - Shear Wall Flat Slab Frame
	<u> </u>							<u> </u>			-	1.14 Thickness of infill wall: Exterior Interior
<u> </u>								-			\rightarrow	1.15 Struct. Dwg/Calculations available: Yes / No (If yes,attach)
<u> </u>	-		-			-		-			\rightarrow	1.16 Extn. to the original bldg. Yes/ No (If yes pl. indicate)
<u> </u>	<u> </u>		<u> </u>			<u> </u>		<u> </u>			\rightarrow	
											\rightarrow	1.17 Location of Shear walls (if any)
											\rightarrow	 1.18 Special Confining R/F in Beam/Column/joints:
												1.19 Stair case: Separated Connected Enclosed
		Ske	tch	Plar	ı wit	th La	engt	հ &	Bre	adth		

2.0 OCCUPANCY	3.0 SPECIAL HAZARD	4.0 FALLING HAZARD	RECOMMENDED ACTION:- Ensure adequate maintenance.
 2.1 Important buildings: Hospitals, Schools, monumental structures; emergency buildings like telephone exchange, television, radio stations, railway stations, fire stations, large community halls like cinemas, assembly halls and subway stations, power stations, Important Industrial establishments, VIP residences & Residences of Important Emergency person. *Any building having more than 100 Occupants may be treated as Important. 2.2 Ordinary buildings:- Other buildings having occupants <100 	 3.1 High Water Table (within 3m) & if sandy soil, then liquefiable site indicated. Yes No 3.2 Land Slide Prone Site Yes No 3.3 Severe Vertical Irregularity Yes No 3.4 Severe Plan Irregularity Yes No 	4.1 Chimneys 4.2 Parapets 4.3 Cladding 4.4 Others	 If any Special Hazard 3.0 found , re-evaluate for possible prevention/retrofitting. If any of the falling hazard is present, either remove it or strengthen against falling.
5 0 Deckella Decembra 1/11/cm/m	T		

5.0 Probable Damageability in Few/Many Buildings

Building Type	5.1 RC or Steel Frame/ wooden Buildings 5.2 URM												
Damage- ability in Zone III	C / C+	C / C+ D E,E+ F Infill											
	G2 / G1	GI	-	-	G2								
stated. Also ave	licates higher stree rage damage in or in the probable da	ne building type in	the area may b										
Surveyor will id	entify the Building	Type; encircle it, a	lso the correspon	iding damage g	rade.								

Surveyor's

Sign :____ Name:____

Executive

Engineer's

Sign:____

Date of Survey:

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

Г

<u>Seismic Zone IV Ordinary Building</u> (Also for Zone III Important Building)

														 1.1 Building Nat 	me	
					-					\rightarrow	_			_		Pin
					+				\vdash	+	_			1.4 Other Identif	iers	
					+	-			\vdash	+	_			1.5 No. of Storie	5	1.6 Year of Const
					hoto	gra	 ph							1.7 Storey Ht.: 1	st	_, 2 nd , 3 nd etc.
					T									1.8 Total Covere	d Area; all	l floors (sq.m)
					\square					\neg				1.9 Ground Cove	erage (Sq.r	n):
														1.10 Soil Type:_		1.11 Foundation Type:
														1.12 Depth of G	round wate	er table:
					-				\vdash	\rightarrow	_			1.13 Bldg. Type:	:	Frame Pre-cast
	-				\vdash	-			\vdash	\rightarrow	_				Frame - S	Shear Wall 🗌 Flat Slab Frame 🗌
	-				+	-			\vdash	+	-			1.14 Thickness o	of infill wal	ll: Exterior Interior
					+					+				1.15 Struct. Dwg	g./Calculati	ions available: Yes / No (If yes,attach)
					\vdash					\neg				1.16 Extn. to the	original bl	ldg. Yes/ No (If.yes pl. indicate)
														1.17 Location of	Shear wal	ls (if any)
					\perp					\rightarrow	_			1.18 Special Cor	ufining R/F	in Beam/Column/joints:
														1.19 Stair case: S	Separated	Connected Enclosed
		Sk	etch	Plan v	vith l	Lenş	gth 8	è Br	eadtl	h						
		2.	0 00	CUPAN	NCY			3.	0 SPE	ECIA	LH	IAZA	RD	4.0 FALLI HAZARD	NG	RECOMMENDED ACTION:-
2	1 h			CUPAN buildin		Hosp	itals,		.0 SPE High W					HAZARD	NG	RECOMMENDED ACTION:- C: evaluate in detail for need for retrofitting
Sc	hools,	npor mon	tant ument	<i>buildin</i> tal struct	gs: ures;	emerg	ency	3.11 8	High W k if sand	later T dy soi	Fable il, the	(with	in Su	n)		 C: evaluate in detail for need for retrofitting If any Special Hazard 3.0 found ,
Sc bu rat	hools, iilding dio st	mpor mon s like	<i>tant</i> ument telepl railw	<i>buildin</i> tal struct hone excl vay statio	igs: ures; hange, ns, fir	emerg televi e stat	ency sion, ions,	3.11 8	High W k if sand ite indic	later T dy soi cated.	Fable il, the	(with en liqu	in Su	n) ele 4.1 Chinney:	⁵	C: evaluate in detail for need for retrofitting
Sc bu rat lat ha	thools, iilding dio str rge cor ills an	mpor mon s like ations, mmun ad sui	<i>tant</i> ument telepl railw ity ha bway	<i>buildin</i> tal struct hone excl vay statio lls like ci stations,	igs: ures; nange, ns, fir nemas, powe	emerg televi e stat , asser r stat	ency sion, ions, nbly ions,	3.11 8 5	High W k if sand ite india Ye	later T dy soi cated. ²⁵	Table il, the	(with en liqu No	in Su	n)	⁵	 C: evaluate in detail for need for retrofitting If any Special Hazard 3.0 found , re-evaluate for possible prevention/retrofitting. If any of the falling hazard is
Sc bu rat lau ha In	thools, iilding dio str rge cor lls an iportar	mpor mon s like ations, mmun ad sui at Ir	<i>tant</i> telepl railw ity ha bway dustri	buildin tal struct hone excl vay statio lls like ci stations, al estab	gs: ures; nange, ns, fir nemas, powe lishme	emerg televi e stat , assei r stat mts,	ency sion, ions, nbly ions, VIP	3.11 8 5 3.21	High W k if sand ite indid Ye Land Sl	Vater T dy soi cated. ²⁵ [lide Pt	Table il, the	(with en liqu No Site	in Su	n) ele 4.1 Chinney:	⁵	 C: evaluate in detail for need for retrofitting If any Special Hazard 3.0 found , re-evaluate for possible prevention/retrofitting. If any of the falling hazard is present, either remove it or strengthen against falling.
Sc bu rat lau ha In res	thools, iilding dio str rge cor lls an iportar	mpor mon s like ations, mmun id sui it Ir es &	tant telepl railw ity ha bway idustri k Re	<i>buildin</i> tal struct hone excl vay statio lls like ci stations,	gs: ures; nange, ns, fir nemas, powe lishme	emerg televi e stat , assei r stat mts,	ency sion, ions, nbly ions, VIP	3.11 8 3.21 3.3	High W t if sand ite india Ve Land Sl Ve Severe	Vater T dy soi cated. ²⁵ [lide Pi ^{es} [Verti	Table il, the rone	(with en liqu No Site No rreguli	in Su lefiab	HAZARD n) le 4.1 Chimney: 4.2 Parapets	¹	 C: evaluate in detail for need for retrofitting If any Special Hazard 3.0 found , re-evaluate for possible prevention/retrofitting. If any of the falling hazard is present, either remove it or strengthen against falling. URM infill : evaluate in detail for
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4 Rapid Visual Screening of RC/Steel Buildings for Seismic Hazards

Seismic Zone V All Buildings

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(Also for Zone IV Important Building)

2.7 ANALOGOUS POINTS IN VARIOUS METHODOLOGIES (FEMA P-154 AND BIS METHOD)

2.7.1 STRUCTURE TYPES (ANALOGIES):

S.No.	Structure type	As denoted in FEMA P-154 (Ref. No. 1)	As per Ref. No. 12	As per Ref. No. 5 and Ref. No. 6
1.	Wooden (Light wooden frame with buildings less than 5000 sq. ft.)	W1	Wood	A, B (partially)
2.	Wooden (Light wooden frame with buildings greater than 5000 sq. ft.)	W2		
3.	Moment resistant Steel Frame (FRAME)	S1	S1	*C+,* D, E, E+, F (with varying degree of earthquake resistant design)
4.	Braced steel Frame (BR)	S2		E+, F (with varying degree of earthquake resistant design)
5.	Light Metal (LM) steel structure	S3	S2	*C
6.	Steel Frame with concrete shear wall (RC SW)	S4		 (specified in concrete only)
7.	Steel frame with Un reinforced masonry infill wall (URM INF)	S5		 (specified in concrete only)
8.	Concrete Moment Resisting Frame (MRF)	C1	C1	*C+,* D, E, E+, F (with varying degree of earthquake resistant design)
9.	Concrete Shear Wall Buildings (SW)	C2	C2	F

Table 2.7: Comparative structure types

10.	Concrete frame with Burnt Brick Masonry (URM) Infill Wall (INF)	C3	C3	E+
11.	Tilt Up buildings (TU)	PC1		
12.	Precast Concrete Frame buildings	PC2		*C+
13.	Un reinforced or reinforced Masonry Building with Seismic Band + Rigid Diaphragm (BAND+RD)	RM2	URM1	C, C+, D
14.	Unreinforced or Reinforced Masonry building with Seismic Band + Flexible Diaphragm (BAND+ FD)	RM1	URM2	B+
15.	Unreinforced (URM) Burnt Brick or Stone Masonry (Cement mortar)	URM	URM3	B+, C,C+
16.	Unreinforced Masonry (URM) (Lime mortar)		URM4	В

FEMA 154 specifies 15 structure types as shown above out of which 10 structure types have been used in the report of Prof. Sinha and Prof. Goyal (IIT Bombay) (Ref. No.12) for Indian conditions. However the report of BIS Committee (Dr. Anand S. Arya – IIT Roorkee) (Ref. No. 5 and 6) and IS 13935-2009 uses 6 structure types with altogether different symbols (A-F) based on European macro seismic scale (EMS-98) recommendations . Here the prefix symbol * is used to specify concrete and steel and to differentiate between masonry and concrete/steel structures since type C, C+ and D are used to denote both masonry and concrete structures (although this symbol * is not specified in the original literature)

In the above table an analogy or similarity has been shown in the representation of different structure types mentioned in different reports. For the current project work, representations given in Ref. No.12 (which is nearly similar to FEMA 154) are used.

2.7.2 ANALOGY OF SOIL TYPES AND SOIL INFORMATION [1]:

"Soil type information in FEMA is given in FEMA 302 in detail. FEMA 302 classifies six soil types from A to F as-

Soil Type Definitions and Related Parameters

The six soil types, with measurable parameters that define each type, are:

Type A (hard rock): measured shear wave velocity, *vs.* > 5000 ft/sec.

Type B (rock): *vs.* between 2500 and 5000 ft/sec.

Type C (soft rock and very dense soil): *vs.* between 1200 and 2500 ft/sec, or standard blow count N > 50, or undrained shear strength su > 2000 psf.

Type D (stiff soil): *vs.* between 600 and 1200 ft/sec, or standard blow count *N* between 15 and 50, or undrained shear strength, *su* between 1000 and 2000 psf.

Type E (soft soil): More than 100 feet of soft soil with plasticity index PI > 20, water content w > 40%, and *su* < 500 psf; or a soil with *vs*. ≤ 600 ft/sec.

Type F (poor soil): Soils requiring site-specific evaluations:"

• Soils vulnerable to potential failure or collapse under seismic loading, such as liquefiable soils, quick and highly-sensitive clays, collapsible weakly-cemented soils.

 \bullet Peats or highly organic clays (H > 10 feet of peat or highly organic clay, where H = thickness of

soil)

• Very high plasticity clays (H > 25 feet with PI > 75).

• More than 120 ft of soft or medium stiff clays. The parameters vs, N, and su are,

respectively, the average values (often shown with a bar above) of shear wave velocity, Standard Penetration Test (SPT) blow count and undrained shear strength of the upper 100 feet of soils at the site.

Out of these FEMA 154 makes use of 3 types that is Soil type C, D and E. It specifies that if the soil type is unknown at a particular location, we will assume type E (soft soil). However, for one-story or two-story buildings with a roof height equal to or less than 25 feet, a class D soil type may be assumed when site conditions are not known.

The analogy for soil type in IS Classification and FEMA 154 is-

FEMA 154 soil c	lassification	IS soi	l classification	soil nature
Soil type C	→	Soil type 1	→	Hard soil
Soil type D	→	Soil type 2	→	Medium soil
Soil type E	>	Soil type 3	→	Soft soil

CHAPTER 3

DEVELOPMENT OF A NEW AND MODIFIED RVA METHODOLOGY

3.1 OVERVIEW

The RVA method in the Indian condition that has been adopted by BIS (Bureau of Indian Standards) and included in IS 13935:2009 is a very simple and quick method based on logic. This method gives a very detailed and comprehensive classification of structural types which can be commonly found all over India.

But, even though it's a very rapid and simple procedure, it lacks in incorporating the amount of detail and consequently, accuracy that FEMA method provides for RVA. The FEMA method is based on a structural score technique and gives a clear-cut indication of the seismic safety of a building by comparing the calculated structural score with the pre-decided cut off score. It gives a reliable demarcation between seismically safe and unsafe buildings. On the other hand, the BIS method, even though relatively simple and easy, doesn't provide that clear a line demarcating the two. Instead, it provides a logical basis to judge the safety and buildings just lying on the threshold margin between the seismically safe or unsafe structures can easily be misjudged. Thus in the Indian methodology for RVA, the wisdom and experience of the screener plays a pivotal role.

If, on the other hand we try to apply the FEMA methodology for RVA without modification for Indian conditions it shows some areas of limitations. There are certain factors in FEMA methodology that even though are recorded during RVA process, do not actively participate in having a large effect the overall structural score. Some of those are occupancy, age, soft storey presence, condition of building at the time of survey, etc. On the other hand there are some factors which are not yet included by FEMA but play an active role in affecting the overall seismic score of the building. These factors are can be summarised as the characteristic features of the surrounding environment and can have a major influence in countries like India where construction trends are non-uniform and haphazard in nature.

Thus there is a need for a method based on scoring that's similar to FEMA P-154 but can also include some of these other factors that might affect the overall vulnerability of the structure being screened when it comes to seismic forces.

In order to create such a system, during the course of this project, the FEMA P-154 method is adopted directly as a reference base with a handful of structures. To this are added some more modifiers to enhance the suitability and accuracy for the standard method as per Indian conditions. After this a Microsoft Excel program has been created to get a more, accurate, speedy and refined score in accordance with RVA system for Indian conditions.

3.2 FEATURES OF THE NEW MODIFIED RVA SYSTEM

The **factors already mentioned** for RVA procedure specified by FEMA P-154 and by Ref. No. 12 and also by IS 13935-2009 (similar to Ref. No. 5 and 6) that affect the seismic strength of any building being considered are-

1) Structure Type

2) Height of building (low, medium or high)

3) Soil type

4) Code Detailing (noted as Pre code or Post bench-mark by FEMA P-154 and a simple code detail by IS 13935)

5) Plan Irregularity

6) Vertical irregularity

7) Special Hazards like liquefiable soil, land slide prone areas, are also mentioned

In the new RVA prototype method that is being proposed for <u>greater accuracy</u>, the basis would be the structural score system as adopted by FEMA P-154. The factors mentioned bfore are considered directly in accordance with the handbook guidelines. In addition to these some additional factors are introduced to modify the determined structural score. A few of these factors have already been touched upon by a few reports but have not been included in the score calculation. For this project they are also assigned some scores as well as a few additional factors are added. All of these together are referred to as <u>"additional score modifiers"</u>. These factors are:-

8) Last recorded maintenance from the day of construction till the day of screening

9) Condition of building (cracks, presence of vegetation, falling plaster and facades, exposed reinforcement with or without rust, warped members etc.)

10) Occupancy (to determine the importance of building)

11) Falling Hazards (unsupported parapets, chimneys etc.)

12) Bottom Soft storey presence

13) Collateral Damage Probability (It is used to gauge the risk entailed by the surroundings of the building such as a tall tower or a closely spaced structure that can cause pounding etc.)

14) Emergency services availability (proximity to services such as fire stations, hospitals, etc)

15) Ease of Evacuation (Additional emergency exits etc)

Each of the additional score modifiers is assigned a value from 1 to 10 (other than occupancy). This signifies the degree of dominance or presence (denoted by D) in the particular structure being screened. The algebraic nature of D is taken + or - by considering the effect the parameter has on the safety of the structure (+ refers to an improvement in safety or a reduction in risk and - refers to a decrease in overall safety or an increase in risk).

Since each modifier has a variable extent to which it affects the overall seismic vulnerability, **Sensitivity factor (denoted by W) is applied to every modifier**. The sensitivity factor is analogous to weight factor applied to various readings and is selected according to personal discretion such that the final modifier score (S*W) is restricted in the same range as modifier score obtained by default factors.

The final score due to every additional modifier in the overall score obtained as a product of D and W

i.e. <u>ADDITIONAL MODIFIER SCORE</u> = (D) * (W) (+ or – according to nature)

The Final Score (S) is to be calculated as mentioned by FEMA P-154 by summing up of basic score (factor 1 to 7) and the additional modifier values as obtained from the calculation above (factor 8 to 15)

As a result of including additional score modifiers the **final cut off values also need to be modified**. The modified cut off is mentioned later on in the report.

3.3 SENSITIVITY/WEIGHTS FOR ADDITIONAL FACTORS TAKEN

Not all the additional modifiers considered have the same amount or intensity of influence or effect. A few of these modifiers such as "soft storey presence" have a large impact on the seismic behaviour of the structure while other ones like "emergency services availability" and "ease of evacuation" have a relatively low effect on the seismic vulnerability. To account for this variability in the extent of influence we need to take every factor with a particular weight instead of a simple algebraic addition and hence W factors have been assigned to every modifier.

The additional modifiers according to order of importance (most important to least important) are mentioned with their Sensitivity/Weightage factors (W) in the following table:

S.No.	Additional Score Modifiers	Nature	Order of Importance	Sensitivity/Weightage Factor (W)
8.	Bottom soft storey presence	-	Most important	0.1
9.	Occupancy	-	\land	0.001
10.	Condition of building	-		0.05
11.	Maintenance History	-		0.05
12.	Collateral Damage Vulnerability	-		0.025
13.	Falling Hazards	-		0.025
14.	Ease of Evacuation	+		0.01
15.	Emergency Services Availability	+	Least important	0.01

Table 3.1: Weightage factors for additional score modifier parameters

3.4 DECIDING THE CUT OFF SCORES

With the inclusion of additional modifiers the final cut off score is also modified. The value of cut of score can be on a safer side by choosing higher presence (i.e. max D) for each additional modifier and adding Σ (+/-DXW) to the original cut off score. Similarly for economy a lower value of D can be chosen. It must be noted while calculating Σ (+/-DXW) for getting the modified cut off score, value of D should be chosen same for all additional modifiers.

In this project work, in order to decide the cut off score, a **medium degree of presence or dominance** has been taken i.e. the **value of D is taken as 5 (for all except for occupancy for which it is taken as 500)** for additional score modifier parameters. Accordingly the final modifier score for each additional modifier parameter is calculated by multiplying 5 or 500 (whichever is applicable) by each additional modifier's weightage factor. Finally summation of all final modifier scores gives the value by which we have to change the cut off score. The calculations are shown by the following table:

S.No.	Additional Score Modifiers	Degree of Dominance or Presence (D)	Nature of D	Sensitivity/Weightage Factor (W)	Final additional modifier score =[(+/-D) * (W)]
8.	Bottom soft storey presence	5	-	0.1	-0.5
9.	Occupancy	500	-	0.001	-0.5
10.	Condition of building	5	-	0.05	-0.25
11.	Maintenance History	5	-	0.05	-0.25
12.	Collateral Damage Vulnerability	5	-	0.025	-0.125
13.	Falling Hazards	5	-	0.025	-0.125
14.	Ease of Evacuation	5	+	0.01	+0.05
15.	Emergency Services Availability	5	+	0.01	+0.05
FINAI	CUT OFF MODIFY	ING VALUE : Σ	[(D) * (W)]	= -1.65

Table 3.2: Weightage factors and Final additional Modifier cut off scores

Hence we deduct 1.65 (or add -1.65) to each value of Final Structural Score S range (for various damageability grades as specified in report of Prof. Sinha and Prof. Goyal (IIT Bombay)) to get new ranges of S for same Damageability grades and also new value of S required to be used as a check whether the building requires further evaluation or not. The results obtained are shown below:

Table 3.3: Final Cut Off scores and score ranges

ORIGINAL CUT OFF SCORES AND SCORE RANGES	MODIFIED CUT OFF SCORES AND SCORE RANGES
DAMAGE PROBABILITY BASED ON FINA	AL STRUCTURAL SCORE S RANGE
S<0.3 → Grade 5 (High), Grade 4 (Very High)	S<-1.35 → Grade 5 (High), Grade 4 (Very High)
$0.3 < S < 0.7 \rightarrow$ Grade 4 (High), Grade 3 (Very High)	-1.35 <s<-0.95 <math="">\rightarrow Grade 4 (High), Grade 3 (Very High)</s<-0.95>
0.7 <s<2 (high),="" (very="" 2="" 3="" grade="" high)<="" td="" →=""><td>-0.95<s<0.35 <math="">\rightarrow Grade 3 (High), Grade 2 (Very High)</s<0.35></td></s<2>	-0.95 <s<0.35 <math="">\rightarrow Grade 3 (High), Grade 2 (Very High)</s<0.35>
2 <s<3 (high),="" (very="" 1="" 2="" grade="" high)<="" td="" →=""><td>$0.35 < S < 1.35 \rightarrow$ Grade 2 (High), Grade 1 (Very High)</td></s<3>	$0.35 < S < 1.35 \rightarrow$ Grade 2 (High), Grade 1 (Very High)
S>3 → Grade 1 (High)	S>1.35 → Grade 1 (High)
NEED OF FURTHER EVALUATION	
YES if S < 2	YES if S <0.35
(2 is the cut off score)	(2-1.65=0.35 is the cut off score)

3.5 NEW MODIFIED RVS DATA COLLECTION FORMS

Following Data collection forms are developed for different seismic zones/seismicity regions:

MODIFIED DATA COLLECTION FORM FOR RAPID VISUAL SCREENING OF BUILDINGS

(based on FEMA 154 and IIT Bombay report)

(INDIAN STANDARDS SEISMIC ZONE 2 / FEMA (U.S.A.) LOW SEISMICITY ZONE)

(FRONT)

	ILDING DETAILS:											
Bu	lding Name:			Addr	ess:							
	code:						ngitude)		Othe	r identifiers:		
	r Built: No of S											
Co	struction drawings av	ailable()	Yes/No):	s	urveyor's	name:			Surv	ey date:		
Ad	ditional Comments:											
BU	ILDING TYPE->	Wood	S1(FRAME)	52(LM)	C1(MRF)	C2(SW)	C3(INF)	URM1(BAND+RD)	URM2(BAND+	FD) URM3	URM4
BA	SIC SCORE MODIFIER	RS:									-	
1	Basic structural score	6.0	4.0	4.0	4.4	4.8	4.4	4.0	,	4.8	4.0	3.0
2	Low rise (<4 stories)	N/A	N/A	N/A	N/A	N/A	N/A	N/	A	N/A	N/A	N/A
	Mid rise (4-7 stories)	N/A	+0.2	N/A	+0.4	-0.2	-0.4	-0.2	2	-0.4	-0.6	-0.6
	High rise (>7 stories)	N/A	+1.0	N/A	+1.0	+0.0	-0.4	N//	A.	N/A	N/A	N/A
3	Vertical Irregularity	-3.0	-2.0	N/A	-1.5	-2.0	-2.0	-1.	5	-2.0	-1.5	-1.5
4	Plan Irregularity	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0	.8	-0.8	-0.8	-0.8
5	Code Detailing	N/A	+0.4	N/A	+0.6	+0.4	N/A	N/	A A	N/A	N/A	N/A
6	Soil type 1/C (Hard so	il) N/A	N/A	N/A	N/A	N/A	N/A	N,	/A	N/A	N/A	N/A
	Soil type 2/D(*med. s	1	-0.8	-0.4	-0.6	-0.4	-0.4	-0.3	2	-0.4	-0.4	-0.4
	Soil type 3/E (soft soi	8.0- (-1.4	-1.0	-1.4	-0.8	-0.8	-0	.8	-0.8	-0.8	-0.8
7	Special hazards like	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-1	.6	-1.4	-1.4	-1.4
	liquefiable soil, land											
	slide prone area etc							1				
								1				1
AI	DITIONAL SCORE M	ODIFIE	RS: (SAME F	OR ALL ST	RUCTURE	YPES)	med. Der	notes medi	um			
AI	DDITIONAL SCORE M	ODIFIE	RS: (SAME F	OR ALL ST		YPES) *	med. Der	iotes medi	um		 	
AI	DDITIONAL SCORE M	ODIFIE	RS: (SAME F	OR ALL ST		YPES) •	med. Der	notes medi	um	÷	+	
		ODIFIÉ	÷	¥	ł	¥	¥		,	÷	 	↓ ↓ •
AD	DITIONAL	ODIFIE	+	DEGREE (DF PRESEN	¥	¥	NATURE	WEIGHTA	GE/SENSTIVITY		
AD	DITIONAL	ŧ	+		DF PRESEN	↓ ICE	+	NATURE (+/-)	WEIGHTA FACTOR	(w)	FINAL SC [= (+/-D)	
AD M(DITIONAL DDIFIER Bottom soft storey pre	ŧ	(GOOD	DEGREE (DOMINA	DF PRESEN	+ ICE10 (8		NATURE (+/-) 	WEIGHTA FACTOR	(w)		
AD M(8. 9.	DITIONAL IDIFIER Bottom soft storey pro Occupancy	• esence	(GODI	DEGREE (DOMINA 0) 0 D) 0	DF PRESEN	ICE 10 (8 1000 (IAD) (BAD)	NATURE (+/-) 	WEIGHTA FACTOR 0.	(w) .1 .001		
AD M(8. 9.	DITIONAL DIFIER Bottom soft storey pro Occupancy Condition of building	• esence	(GODI (GOD (GOD)	DEGREE (DOMINA 0) 0 D) 0 D) 0	DF PRESEN NCE (D) 	ICE 10 (E 1000 ((AD) (BAD) (BAD)	NATURE (+/-) 	WEIGHTA FACTOR 0. 0. 0. 0.	(w) 1 .001		
AD M(8. 9. 10.	DITIONAL DIFIER Bottom soft storey pro Occupancy Condition of building Maintenance	esence	(GODI (GODI (GODI (GODI	DEGREE (DOMINA b) 0 D) 0 D) 0 D) 0 D) 0	DF PRESEN	ICE 10 (E 1000 (1000 (10 (I 10 (I	AD) (BAD) (BAD) (BAD)	NATURE (+/-) 	WEIGHTA FACTOR 0. 0	(W) .1 .001 .05 0.05		
AD 8. 9. 10.	DITIONAL DIFIER Bottom soft storey pro Occupancy Condition of building Maintenance Collateral damage Vu	esence	(GOOD (GOOD (GOOD (GOOD (GOOD	DEGREE (DOMINA 0) 0 D) 0 D) 0 D) 0 D) 0	DF PRESEN	ICE 10 (8 1000 (10 (1 10 (1 10 (1	IAD) (BAD) (BAD) (BAD) (BAD)	NATURE (+/-) 	WEIGHTA FACTOR 0. 0 0 0 0	(w) .1 .001 .05 0.05		
AD 8. 9. 10. 11. 12.	DITIONAL DIFIER Bottom soft storey pre Occupancy Condition of building Maintenance Collateral damage Vu Falling hazards	esence	(GOOD (GOOD (GOOD (GOOD (GOOD (GOOD	DEGREE (DOMINA 0) 0 D) 0 D) 0 0) 0 0) 0 0) 0	DF PRESEN NCE (D) 	ICE 10 (8 10 00 (10 (8 10 (8 10 (8 10 (8	(AD) (BAD) (BAD) (BAD) (BAD) (BAD)	NATURE (+/-) 	WEIGHTA FACTOR 0. 0 0 0 0 0 0 0 0 0	(w) .1 .001 .05 .05 .025		
AD 8. 9. 10. 11. 12. 13.	DITIONAL DDIFIER Bottom soft storey pro Occupancy Condition of building Maintenance Collateral damage Vu Falling hazards Ease of Evacuation	esence	(GODD (GODD (GODD (GODD (GODD (BAD	DEGREE (DOMINA D) 0 D) 0 D) 0 D) 0 D) 0 D) 0 D) 0	DF PRESEN NCE (D) 3	ICE 10 (E 1000 (1000 (10 (E 10 (E 10 (E 10 (C	IAD) (BAD) (BAD) (BAD) (AD) (AD) (GOOD)	NATURE (+/-) 	WEIGHTA FACTOR 0. 0. 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	(w) 11 0001 0.05 0.025 0.025 0.01		
AD 8. 9. 10. 11. 12. 13.	DITIONAL DIFIER Bottom soft storey pre Occupancy Condition of building Maintenance Collateral damage Vu Falling hazards	esence	(GODD (GODD (GODD (GODD (GODD (BAD	DEGREE (DOMINA D) 0 D) 0 D) 0 D) 0 D) 0 D) 0 D) 0	DF PRESEN NCE (D) 	ICE 10 (E 1000 (1000 (10 (E 10 (E 10 (E 10 (C	IAD) (BAD) (BAD) (BAD) (AD) (AD) (GOOD)	NATURE (+/-) 	WEIGHTA FACTOR 0. 0. 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	(w) .1 .001 .05 .05 .025		
AD 8. 9. 10. 11. 12. 13. 14.	DITIONAL DDIFIER Bottom soft storey pro Occupancy Condition of building Maintenance Collateral damage Vu Falling hazards Ease of Evacuation	esence : uInerabi	(GODD (GODD (GODD (GODD (GODD (GODD (BAD (BAD	DEGREE (DOMINA D) 0 D) 0 D) 0 D) 0 D) 0 D) 0 D) 0 D) 0	DF PRESEN NCE (D) 333333	ICE 1000 (1000 (10 () 10 () 10 () 10 () 10 () 10 () 10 ()	(AD) (BAD) (NATURE (+/-) 	WEIGHTA FACTOR 0. 0. 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	(w) 11 0001 0.05 0.025 0.025 0.01	[= (+/-D)	
AD 8. 9. 10. 11. 12. 13. 14. 15.	DITIONAL DIFIER Bottom soft storey pro Occupancy Condition of building Maintenance Collateral damage Vu Falling hazards Ease of Evacuation Emergency services a	esence Inerabi	(GODD (GODD (GODD (GODD (GODD (GODD (BAD (BAD S=summation	DEGREE (DOMINA 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0	DF PRESEN NCE (D) 333333	ICE 1000 (1000 (10 () 10 () 10 () 10 () 10 () 10 () 10 ()	(AD) (BAD) (NATURE (+/-) 	WEIGHTA FACTOR 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	(w) 1 1 1 1 1 1 1 1 1 1 1 1 1	[= (+/-D] 	
AD 8. 9. 10. 11. 13. 14. 15. FIN	DITIONAL DDIFIER Bottom soft storey pro Occupancy Condition of building Maintenance Collateral damage Vu Falling hazards Ease of Evacuation Emergency services a IAL STRUCTURAL SCO PECTED DAMAGE (LI	esence invailabil ORE S (kely but	(GODD (GODD (GODD (GODD (GODD (GODD (BAD (BAD (BAD S=summation Iding perform	DEGREE (DOMINA 0) 0 0) 0 0 0	DF PRESEN NCE (D) 3	ICE 10 (E 1000 (10 () 10	(AD) (BAD) (NATURE (+/-) + + +	WEIGHTA FACTOR 0. 0. 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	(w) 1 1 1 1 1 1 1 1 1 1 1 1 1	[= (+/-D]) × (W)]
AD 8. 9. 10. 11. 13. 14. 15. FIN EX	DITIONAL DDIFIER Bottom soft storey pro Occupancy Condition of building Maintenance Collateral damage Vu Falling hazards Ease of Evacuation Emergency services a IAL STRUCTURAL SCO PECTED DAMAGE (LI	esence invailabil ORE S (kely but	(GODD (GODD (GODD (GODD (GODD (GODD (BAD (BAD (BAD (BAD (BAD (BAD (BAD (B	DEGREE (DOMINA 0) 0 0) 0 0] 0 0] 0 0] 0 0] 0 0] 0 0] 0 0] 0	DF PRESEN NCE (D) 3	ICE 10 (8 1000 (10 (8 10 (8 10 (8 10 (8 10 (6 10 (6 10)	(AD) (BAD) (BAD) (AD) (AD) (CO	NATURE (+/-) + + + +	WEIGHTA FACTOR (0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	(w) .1 .001 .005 .005 .025 .01 .01 S=	[= (+/-D]) × (W)]
AD 8. 9. 10. 11. 13. 14. 15. FIN EX S>: SE	DITIONAL DDIFIER Bottom soft storey pro Occupancy Condition of building Maintenance Collateral damage Vu Falling hazards Ease of Evacuation Emergency services a IAL STRUCTURAL SCO PECTED DAMAGE (LII 1.35 High prob	esence invailabil ORE S (kely but bability ability ((GOOD (GOOD (GOOD (GOOD (GOOD (BAD (BAD (BAD (BAD (BAD (BAD (BAD (BA	DEGREE (DOMINA 0) 0 0) 0	DF PRESEN NCE (D) 3	ICE 10 (8 1000 (10 () 10 (8 10 (8) (8 10 (8) (8) (8) (8) (8) (8) (8) (8) (8) (8)	(AD) (BAD) (BAD) (AD) (AD) (CO	NATURE (+/-) + + + e 4 damae e 3 damae	WEIGHTA FACTOR (0. 0. 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	(w) 1 1 1 1 1 1 1 1 1 1 1 1 1	[= (+/-D]) × (W)]
AD 8. 9. 10. 11. 13. 14. 15. FII EX SSE	DITIONAL DDIFIER Bottom soft storey pro Occupancy Condition of building Maintenance Collateral damage Vu Falling hazards Ease of Evacuation Emergency services a IAL STRUCTURAL SCO PECTED DAMAGE (UI 1.35 High prob -1.35,-0.95) High prob	esence invailabil ORE S (kely but bability (ability ((GOOD (GOOD (GOOD (GOOD (GOOD (GOOD (BAD (BAD (BAD (BAD (BAD (BAD (BAD (BA	DEGREE (DOMINA 0) 0 0) 0	DF PRESEN NCE (D) 3	ICE 10 (8 1000 (10 () 10 () 10 (8 10 (8 10 (0 10 (0)) 10 (0 10 (0)) 10 (0 10 (0)) 10 (0)) 10 (0) (0)) 10 (0) (0)) 10 (0) (0)) 10 (0) (0)) 10 (0)) 10 (0)	(AD) (BAD) (BAD) (AD) (AD) (CO	NATURE (+/-) + + + e 4 dama e 3 damage e 2 damage	WEIGHTA FACTOR (0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	(w) 1 1 1 1 1 1 1 1 1 1 1 1 1	[= (+/-D]) × (W)]
AD 8. 9. 10. 11. 12. 13. 14. 15. FIN EX SSE SSE	DITIONAL DDIFIER Bottom soft storey pro Occupancy Condition of building Maintenance Collateral damage Vu Falling hazards Ease of Evacuation Emergency services a IAL STRUCTURAL SCI PECTED DAMAGE (UI 1.35 High prob -1.35,-0.95) High prob -0.95,+0.35) High prob	esence inerabi ovailabil ORE S (kely but bability bability bability	(GOOD (GOOD (GOOD (GOOD (GOOD (GOOD (BAD (BAD (BAD (BAD (BAD (BAD (BAD (BA	DEGREE (DOMINA 0) 0 0) 0 0 0) 0	DF PRESEN NCE (D) 3	ICE 10 (8 1000 (10 () 10 () 10 (8 10 (8 10 (0 10 (0)) 10 (0 10 (0)) 10 (0 10 (0)) 10 (0)) 10 (0) (0)) 10 (0) (0)) 10 (0) (0)) 10 (0) (0)) 10 (0)) 10 (0)	(AD) (BAD) (BAD) (AD) (AD) (CO	NATURE (+/-) + + + e 4 dama e 3 damage e 2 damage	WEIGHTA FACTOR (0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	(w) 1 1 1 1 1 1 1 1 1 1 1 1 1	[= (+/-D]) × (W)]

MODIFIED DATA COLLECTION FORM FOR RAPID VISUAL SCREENING OF BUILDINGS

(based on FEMA 154 and IIT Bombay report)

(INDIAN STANDARDS SEISMIC ZONE 3 / FEMA (U.S.A.) MODERATE SEISMICITY ZONE)

(FRONT)

	ILDING DETAILS:												
Bul	lding Name:			Addr	ess:								
Pin	code:	GPS	5 Coordinate:	s: (latitud	e)	(lo	ngitude)		Othe	r identifiers	:		
Yea	r Built: No of S	stories:_	/	Approxim	ate total f	loor area	(sq. ft./	sq. m.):		Use:			
Cor	struction drawings av	ailable()	Yes/No):	5	urveyor's i	name:			Surv	ey date:			
Ado	ditional Comments:												
BU	ILDING TYPE->	Wood	S1(FRAME)	S2(LM)	C1(MRF)	C2(SW)	C3(INF)	URM1(B	AND+RD)	URM2(BAN	ND+FD)	URM3	URM4
BA	SIC SCORE MODIFIE	RS:											
			2.6										
1	Basic structural score		3.6	3.8	3.0	3.6	3.2	3.4		3.6		3.0	2.4
2	Low rise (<4 stories)	N/A	N/A	N/A	N/A	N/A	N/A	N/4		N/A		N/A	N/A
•	Mid rise (4-7 stories)		+0.4	N/A	+0.2	+0.4	+0.2	+0.4		+0.4		-0.4	-0.4
-	High rise (>7 stories)		+0.8	N/A	+0.5	+0.8	+0.4	N//		N/A		N/A	N/A
3	Vertical Irregularity	-3.0	-2.0	N/A	-2.0	-2.0	-2.0	-2.0		-2.0		-1.5	-1.5
4	Plan Irregularity	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.	-	-0.5		-0.5	-0.5
5	Code Detailing	N/A	+1.4	N/A	+1.2	+1.6	+1.2	+2.0		+2.0		N/A	N/A
6	Soil type 1/C (Hard so	·		N/A	N/A	N/A	N/A	N//		N/A		N/A	N/A
•	Soil type 2/D(*med. s	1		-0.6	-0.6	-0.8	-0.6	-0.		-0.8		-0.4	-0.4
•	Soil type 3/E (soft soi	r i	-1.2	-1.0	-1.0	-1.2	-1.0	-1.		-1.2		-0.8	-0.8
7	Special hazards like	-1.2	-1.6	-1.6	-1.6	-1.6	-1.6	-1.	6	-1.6		-1.6	-1.0
	liquefiable soil, land												
- 1	slide prone area etc												
- 1		1 1											
AD	DITIONAL SCORE M	IODIFIE	RS: (SAME F	OR ALL ST	RUCTURE T	YPES)		*me	ed. Denotes	5			
AD	DITIONAL SCORE M	iodifië	RS: (SAME F	OR ALL ST		YPES)	+	*me	ed. Denotes	•		÷	
AD	DITIONAL SCORE M	iodifië	RS : (SAME F ↓	OR ALL ST	RUCTURE T	YPES)	+	-me	ed. Denote:	•		+	
	DITIONAL SCORE M		¥	¥		ţ	+	•		s JGE/SENSTIN	VITY F	INAL SCO	
AD		iodifié	+	¥	F PRESEN	ţ		•		GE/SENSTIN		INAL SC(= (+/-D)	
ADI	DITIONAL	Ł	+	DEGREE (F PRESEN	↓ ICE		NATURE	WEIGHTA	GE/SENSTIN			
ADI MC 8. 1	DITIONAL	Ł	(GOOD	DEGREE (DOMINA	DF PRESEN	+ ICE10 (8	AD)	NATURE (+/-)	WEIGHTA FACTOR (0	GE/SENSTIN			
ADI MC 8. 1 9. (DITIONAL IDIFIER Bottom soft storey pro	esence	(GOOD (GOOD	DEGREE (DOMINA)) 0 D) 0	DF PRESEN	ICE 10 (8 1000 (AD) (BAD)	NATURE (+/-) 	WEIGHTA FACTOR 0 0	GE/SENSTIN			
ADI MC 8. 1 9. (DITIONAL IDIFIER Bottom soft storey pro Occupancy	esence	(GOOD (GOOD (GOOD	DEGREE (DOMINA 0) 0 0) 0 0) 0	DF PRESEN NCE (D) 5 500	ICE 10 (8 1000 (AD) (BAD) BAD)	NATURE (+/-) 	WEIGHTA FACTOR 0 0	GE/SENSTIN			
ADI MC 8. 1 9. 1 10.	DITIONAL DIFIER Bottom soft storey pro Occupancy Condition of building	esence	(GOOD (GOOD (GOOD (GOOD	DEGREE (DOMINA 0) 0 D) 0 D) 0 0) 0	DF PRESEN NCE (D) 	ICE 10 (8 1000 (10 (8	AD) (BAD) BAD) BAD)	NATURE (+/-) 	WEIGHTA FACTOR 0 0 0	GE/SENSTIN (W) .001 .05			
ADI MC 8. 1 9. 0 10. 11. 12.	DITIONAL DIFIER Bottom soft storey pro Occupancy Condition of building Maintenance	esence	(GOOD (GOOD (GOOD (GOOD (GOOD	DEGREE (DOMINA 0) 0 D) 0 D) 0 D) 0 D) 0	DF PRESEN NCE (D) 	ICE 10 (8 10 (8 10 (8 10 (8 10 (10	IAD) BAD) BAD) BAD) BAD)	NATURE (+/-) 	WEIGHTA FACTOR 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	GE/SENSTIN (W) .001 .005 0.05			
AD MC 8. 1 10. 11. 12. 13.	DITIONAL DIFIER Bottom soft storey pro Occupancy Condition of building Maintenance Collateral damage Vu	esence	(GOOD (GOOD (GOOD (GOOD (GOOD (GOOD		DF PRESEN NCE (D) 	ICE 10 (8 1000 (1000 (10 (8 10 (8 10 (8 10 (8	AD) BAD) BAD) BAD) BAD) BAD)	NATURE (+/-) 	WEIGHTA FACTOR I 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	GE/SENSTIN (W) .1 .001 .05 0.05 0.05			
ADI 8. 1 9. 0 10. 11. 12. 13. 14.	DITIONAL DIFIER Bottom soft storey pro Occupancy Condition of building Maintenance Collateral damage Vu Falling hazards	esence : ulnerabi	(GOOD (GOOD (GOOD (GOOD (GOOD (BAD	DEGREE (DOMINA 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0	DF PRESEN NCE (D) 	ICE 10 (8 1000 (10 (8 10 (8 10 (8 10 (8 10 (8 10 (0	(AD) (BAD) (BAD) (BAD) (BAD) (AD) (GOOD)	NATURE (+/-) 	WEIGHTA FACTOR 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	GE/SENSTIV (W) .1 .001 .05 0.05 0.025			
ADI MC 8. 1 10. 11. 12. 13. 14. 15.	DITIONAL DIFIER Bottom soft storey pro Occupancy Condition of building Maintenance Collateral damage Vu Falling hazards Ease of Evacuation	esence : ulnerabi	(GODD (GODD (GODD (GODD (GODD (GODD (BAD (BAD	DEGREE (DOMINA 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0	DF PRESEN NCE (D) 	ICE 1000 (1 1000 (1 10 (1 10 (1 10 (1 10 (1 10 (0 10 (0 10 (0	IAD) BAD) BAD) BAD) BAD) BAD) BOD) BOOD)	NATURE (+/-) 	WEIGHTA FACTOR 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	GE/SENSTIV (W) .1 .001 .03 0.05 0.025 0.025 0.01			
ADI 8. (9. (10. 11. 12. 13. 14. 15. FIN	DITIONAL DIFIER Bottom soft storey pro Occupancy Condition of building Maintenance Collateral damage Vu Falling hazards Ease of Evacuation Emergency services a	esence : uInerabi availabil	(GOOD (GOOD (GOOD (GOOD (GOOD (BAD (BAD S=summation	DEGREE (DOMINA 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0 0 0	DF PRESEN NCE (D) 	ICE 1000 (1 1000 (1 10 (1 10 (1 10 (1 10 (1 10 (0 10 (0 10 (0	IAD) BAD) BAD) BAD) BAD) BAD) BOD) BOOD)	NATURE (+/-) 	WEIGHTA FACTOR I 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	GE/SENSTIV (W) .1 .001 .05 0.025 0.025 0.01 0.01	[= (+/-D)	
ADI 8. 1 9. (10. 11. 13. 14. 15. FIN	DITIONAL DIFIER Bottom soft storey pro Occupancy Condition of building Maintenance Collateral damage Vu Falling hazards Ease of Evacuation Emergency services a	esence : uInerabi availabil	(GOOD (GOOD (GOOD (GOOD (GOOD (BAD (BAD S=summation	DEGREE (DOMINA 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0 0 0	DF PRESEN NCE (D) 	ICE 1000 (1 1000 (1 10 (1 10 (1 10 (1 10 (1 10 (0 10 (0 10 (0	IAD) BAD) BAD) BAD) BAD) BAD) BOD) BOOD)	NATURE (+/-) 	WEIGHTA FACTOR I 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	GE/SENSTIV (W) .1 .001 .03 0.05 0.025 0.025 0.01	[= (+/-D)	
ADI MC 8. 1 9. 0 10. 11. 12. 13. 14. 15. FIN EXI S>-	DITIONAL DIFIER Bottom soft storey pro Occupancy Condition of building Maintenance Collateral damage VC Falling hazards Ease of Evacuation Emergency services a IAL STRUCTURAL SCO PECTED DAMAGE (LI) 1.35 High prob	esence : uInerabi oRE S (kely but	(GODD (GODD (GODD (GODD (GODD (GODD (BAD (BAD (BAD (BAD (BAD (BAD (BAD (B	DEGREE (DOMINA 0) 0 0) 0	OF PRESEN NCE (D)	ICE 10 (8 10 (9 10 (9) (9) (9) (9) (9) (9) (9) (9) (9) (9)	AD) BAD) BAD) AAD) AAD) AAD) GOOD) GOOD) 15)	NATURE (+/-) + + + +	WEIGHTA FACTOR 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	GE/SENSTIV (W) .1 .001 .05 0.025 0.025 0.01 0.01	S=	= (+/-D)	× (W)]
ADI MC 8. 1 9. 0 10. 11. 12. 13. 14. 15. FIN EXI S>-(DITIONAL DIFIER Bottom soft storey pro Occupancy Condition of building Maintenance Collateral damage VC Falling hazards Ease of Evacuation Emergency services a IAL STRUCTURAL SCO PECTED DAMAGE (LI 1.35 High prob	esence : ulnerabi oRE S (kely but bability sability o	(GOOD (GOOD (GOOD (GOOD (GOOD (GOOD (BAD (BAD (BAD (BAD (BAD (BAD (BAD (BA	DEGREE (DOMINA 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0 0 of all mode nance) amage, va	DF PRESEN NCE (D) 3	ICE 10 (8 10 (9 10 (9))))))))))))))))))))))))))))))))))))	AD) BAD) BAD) AAD) AAD) AAD) GOOD) 15) of Grad of Grad	NATURE (+/-) + + + e 4 damage e 3 damag	WEIGHTA FACTOR 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	GE/SENSTIV (W) .1 .001 .03 0.025 0.025 0.01 0.025 0.01 0.01 ((HER EVALU	S=	= (+/-D)	× (w)]
ADI 8. 1 9. 0 10. 11. 12. 13. 14. 15. FIN EXI SS=(SSE(DITIONAL DIFIER Bottom soft storey pro Occupancy Condition of building Maintenance Collateral damage VC Falling hazards Ease of Evacuation Emergency services a IAL STRUCTURAL SCO PECTED DAMAGE (LI 1.35 High prob -0.95,+0.35) High prob	esence : ulnerabi ore S (kely but bability sability o	(GOOD (GOOD (GOOD (GOOD (GOOD (GOOD (BAD (BAD (BAD (BAD (BAD (BAD (BAD (BA	DEGREE (DOMINA 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0 0) 0 0 0 0) 0	DF PRESEN NCE (D) 3	ICE 10 (8 10 (9 10 (9 	AD) BAD) BAD) AAD) AAD) AAD) BAD) BAD) B	NATURE (+/-) + + + e 4 damage e 3 damage 2 damage	WEIGHTA FACTOR 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	GE/SENSTIV (W) .1 .001 .05 0.025 0.025 0.01 0.01 HER EVALU	S=	= (+/-D)	× (W)]
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MODIFIED DATA COLLECTION FORM FOR RAPID VISUAL SCREENING OF BUILDINGS

(based on FEMA 154 and IIT Bombay report)

(INDIAN STANDARDS SEISMIC ZONE 4 AND 5 / FEMA (U.S.A.) HIGH SEISMICITY ZONE)

(FRONT)

BU	ILDING DETAILS:													
Bu	Ilding Name:			Addr	ess:									
Pin	code:	GP:	5 Coordinate	s: (latitud	e)	(lo	ngitude)		Othe	r Identifiers:				
	ar Built: No of S													
	nstruction drawings av													
Ad	ditional Comments:													
BU	BUILDING TYPE-> Wood S1(FRAME) S2(LM) C1(MRF) C2(SW) C3(INF) URM1(BAND+RD) URM2(BAND+FD) URM3 URM													
BA	SIC SCORE MODIFIEI	RS:												
1	Basic structural score	3.8	2.8	3.2	2.5	2.8	2.6	2.8		2.8	1.8	1.4		
2	Low rise (<4 stories)	N/A	N/A	N/A	N/A	N/A	N/A	N//	4	N/A	N/A	N/A		
	Mid rise (4-7 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		
3	Vertical Irregularity	-2.0	-1.0	N/A	-1.5	-1.0	-1.0	-1.0)	-1.0	-1.0	-1.0		
4	Plan Irregularity	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.	5	-0.5	-0.5	-0.5		
5	Code Detailing	N/A	+0.4	N/A	+0.2	+1.4	+0.2	N//	Ą	N/A	N/A	N/A		
6	Soil type 1/C (Hard so	il) N/A	N/A	N/A	N/A	N/A	N/A	N//	Ą	N/A	N/A	N/A		
	Soil type 2/D(*med. s		-0.4	-0.4	-0.4	-0.4	-0.4	-0.	4	-0.4	-0.4	-0.4		
	Soil type 3/E (soft soi	0 -0.8	-0.6	-0.6	-0.6	-0.6	-0.4	-0.	6	-0.6	-0.6	-0.6		
7	Special hazards like	-0.8	-1.2	-1.0	-1.2	-0.8	-0.8			-0.6	-0.8	-0.8		
	liquefiable soil, land													
	slide prone area etc													
A	DDITIONAL SCORE M	ODIFIE	RS: (SAME F	OR ALL ST	RUCTURE T	YPES)		•"	ned. Denot	es medium				
		¥	÷	¥	¥	¥	¥		,	¥	÷	Ŧ		
AD	DITIONAL			DEGREE	OF PRESEN	CE		NATURE	WEIGHTA	GE/SENSTIVITY	FINAL SCO	DRE		
						ICE .			FACTOR		[= (+/-D)			
	DDIFIER Bottom soft storey pre			DOMINA	NCE (D)	10.0	ADI	(+/-)		.1	(-(+/-0)	× (w)1		
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	. Condition of building				500					.001				
	. Condition of building Maintenance				3					0.05				
	. Collateral damage Vu	Inerahi								0.05				
	. Collateral damage Vu . Falling hazards	incrab												
										0.025				
	Ease of Evacuation) 0			(000	+		0.01				
	Emergency services a		IEV I (BAD	J 0		10 (0	1000)	+		0.01				
					lifier values	from 1 to	15)			S=				
FIN		ORE S (S=summation	of all mod	lifier values	from 1 to	15)		FURT	S=	N			
FIN	VAL STRUCTURAL SC	ORE S (S=summation	of all moo				e 4 damar						
FIN EX	PECTED DAMAGE (LI	ORE S (kely but	S=summation Iding perform	of all moo nance) amage, v	ery high p	robability	of Grad		pe (REC	Ľ				
FIN EX S>- SE	PECTED DAMAGE (LI -1.35 High prot (-1.35,-0.95) High prot	ORE S (kely but bability	S=summation Iding perform of Grade 5 d	of all moo nance) amage, v	ery high pr	robability	of Grad	e 3 damag	e (REC	COMMENDED IF	i < +0.35)			
FIN EX S> SE SE	PECTED DAMAGE (LI -1.35 High prob (-1.35,-0.95) High prob (-0.95,+0.35) High prob	ORE S (kely but bability bability (bability (S=summation Iding perform of Grade 5 d of Grade 4 da	of all mod nance) amage, vo amage, vo	ery high pi ery high pr ery high pr	robability obability	of Grad of Grad of Grad	e 3 damag e 2 damag	e (REC					
FIN EX S>- SE SE SE	PECTED DAMAGE (LI -1.35 High prob (-1.35,-0.95) High prob (-0.95,+0.35) High prob (+0.35,+1.35) High prob	ORE S (kely bui bability bability (bability bability	S=summation Iding perform of Grade 5 d of Grade 4 da	of all moo nance) amage, v amage, v amage, v amage, v	ery high pi ery high pr ery high pr	robability obability	of Grad of Grad of Grad	e 3 damag e 2 damag	e (REC	COMMENDED IF	i < +0.35)			

SK	ET	HC	HE	S (DF	LA	Y	วบ	T	(P	LA	N	AN	1D	EL	EV	ΆΤ	10	N)																						
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(ВАСК)

CHAPTER 4

SALIENT FEATURES OF MS EXCEL PROGRAM DEVELOPED (RVS)

4.1 OVERVIEW

In accordance with RVS methodologies mentioned by IS 13935:2009 and by FEMA P-154 (3rd edition) 2 MS Excel Spreadsheets have been created separately. The first Excel program is based on the RVS method mentioned by IS 13935:2009 and hence provides results in accordance with this. (This program is used mainly for comparative purposes later on). The second Excel program is based on the new modified RVS system as explained previously. This one however is also set to provide results in accordance with FEMA guidelines and gives a comparative analysis result and provides results side by side with both methods.

The need for manual entering of data has been completely eradicated as the sheet is programmed to accept binary inputs only i.e. 1 or 0 to generate a true or false logic statement. This provides a speedier approach. Moreover, there is no need to carry operation manual along by the screener while conducting the survey as the first page in the sheet is dedicated to theory and basic instructions regarding the working and operating procedures of the RVS software. This leads to an even shorter execution time as the surveyor can accomplish the task on a handheld tablet or a sufficiently advanced smartphone or PDA. The program, also, automatically saves the data in the spreadsheet itself which can be easily read and retrieved later on.

The programs is designed on the basis of a *user friendly* GUI. Every tab of import is colour coded along with comments and instructions entered at suitable locations. These are aimed towards user comfort and ease of operations. The results generated are in simple English text or numerical values which are easy to understand as compared to the archaic manual forms. The logical operators in the formula are simple statements formed along basic functions such as IF clause, ELSE, nested IF ELSE, AND, OR, and text based output operators which are easy

to comprehend and alter as per need. The results also include a generated comment based on the structural score obtained by the building, extent of possible damage, need for evaluation or basic performance.

4.2 MS EXCEL PROGRAM IN ACCORDANCE WITH BIS (BEUREAU OF INDIAN STANDARDS)

This excel program is based on the BIS committee reports and IS code IS 13935:2009

The Excel program includes 5 worksheets

Sheet 1: This sheet is an instruction manual for the screener to follow while conducting the RVS. It also contains the basic references and alphanumeric codes used to refer to various types of structures, namely, RCC, masonry or steel and the estimated damage which the structure could undergo during seismic activity. The sheet also lists the various abbreviations used throughout the excel spreadsheet and the basic gauging criteria.

Sheet 2- Sheet5: These sheets are created specifically for the zones as per IS 1893:2002 (zone 2, 3, 4, and 5). The sheets are have colour coded segments in the form of green and red cells. The green cells are used to Input general data such as basic details, structure type, special hazards, codal provisions etc. The red cells display the alphanumeric output comments.

To begin the survey the screener is advised to carefully read the first sheet and select the requisite seismic zone from among the bottom tabs. This should be followed by the basic data entry in the green cells. The data entered such should be entered carefully. This data can include alphanumeric values and is purely for record keeping purposes only. The rest of the cells take an binary data form where 0 indicates the absence of the parameter being entered while 1 signifies the presence of the same in the structure. The first sheet may be used as a reference guide in filling up this data.

After the completion of the data entry process, the program will analyse the inputs and display the outputs in the red zone of the sheet. The output is of alphanumeric form and represents the damageability grade of the structure under scrutiny and the recommendations for the same. The specific values are present in a tabular form in sheet number 1 and hence must be referred to from there.

A B	С	D	E	F	G	н	1	J	К	L	M	N	0	Р	Q	R	S	Т	U	V	V	×	Y	Z	AA	AB
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											10115												(DNLY		
BUILDING DETAILS	(MASON	KY):															BUILDING	DETAILS	S (RCC ANI	D SF) :						
BUILDING NAME:																	BUILDING	NAME .								
USE:																	USE :	INPAIVIE .								
ADDRESS:																	ADDRESS :									
OTHER IDENTIFIERS:																	OTHER IDE	NTIFIERS								
NO OF STOREYS:																	NO OF STO									
EAR BUILT:																	YEAR BUIL									
TOTAL COVERED ARE	A, ALL FLOO	RS(sqm):															TOTAL COV	ERED ARE	A, ALL FLOO	DRS (sqm)	:					
GROUND COVERAGE	(sqm):																GROUND	OVERAGE	(sqm):							
SOIL TYPE:																	SOIL TYPE									
FOUNDATION TYPE:																	FOUNDATI	ON TYPE :								
ROOF TYPE:																	DEPTH OF	GROUND	WATER TAB	LE (m) :						
FLOOR TYPE:																	BUILDING									
WALL TYPE (BB, EART		CCB):															FRAMETYP):				
THICKNESS OF WALL	:																THICKNES									
SLAB THICKNESS :																	THICKNES									
MORTAR TYPE (MUD,																	STRUCTUR					E (YES/NO) :				
VERTICAL R/F BARS (C																			INAL BUILD		10):					
SEISMIC BANDS (PLIN	ITH, LINTEL	, EAVES, GAE	BLE) :														LOCATION									
OCCUPANCY :																	SPECIAL CO									
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STRUCTURE TYPE	DRESENCE											SPECIAL		DRESENC	F/ABSEN	CE										
STRUCTURE TITE	FRESERVE	ADJENCE										SPECIAL	IALAND	FRESERVE	LINDSLIV		Sel	ectio	on of	' bas	IC ZO	one				
A	0			HIG	GH WAT	ER TABLE	WITHIN 3	m) AND I	SANDY SC	DI THEN LI	OUFFIARI	SITE INDIC	ATED													
	0											DE PRONE S		0	\sim	/	and	l ins	truct	tion	s					
6)		and				-					

Fig. 4.1: MS Excel program screenshots (RVA)

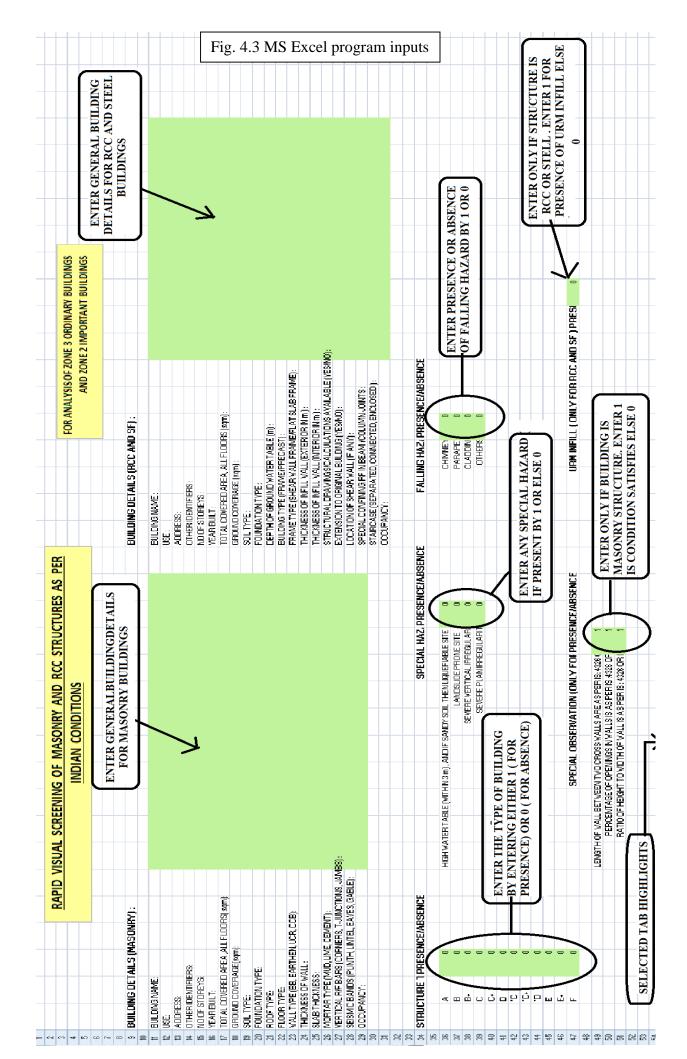
B C D	E	F G	н	J K	L	M	N	0	P	Q	R	S	т	U	
	RAPIE	VISUAL	SCREENIN	G OF MAS	ONRY	AND	RCC S	TRUC	TURES	AS	PER				
				INDIAN (CONDIT	<u>rions</u>									
INSTRUCTIONS:												REFEREN	NCES:		
 Select the seismic zone f If the building is importation 	nt select a zon	higher than th		hich it is originally			IC ZONES		India has	have due	1 d a d 1 a t a	A antonia base			
2. If the building is importa located eg for important bu Importance of 3. Use REFERENCES for Ide 4. Enter Alphanumeric Dat 5 Enter only 0 or 1 for othe special observations and U Enter 1 for Pro	Int select a zone uilding of zone f building is det entifying the str a for Building (er parameters I RM infills. esence of the p isence of the p (ES)	higher than th 2 select zone 3 t cermined referr ucture and Dam Details ike Structure typ arameter	tab i ng to the referenc nage Grade and Abl	e section breviations		As per l Zone II Zone III Zone IV	S 1893:200 Low seism Moderate High seisr Very high	02 (Part 1), ic hazard (seismic h nic hazard	damage d azard (max (maximur	uring ear timum da n damage	thquake r amage du e during e	4 seismic hazz nay be of MSł ring earthqual earthquake ma ing earthquak	K Intensit ike may b ay be upt	ty VI or lo be upto M to MSK li	VISK nten
2. If the building is importa located eg for important build Importance of 3. Use REFERENCES for Ide 4. Enter Alphanumeric Dat 5 Enter only 0 or 1 for othe special observations and U Enter 1 for Pm Enter 0 for Ab 6. Enter only in GREEN BO	nt select a zone iliding of zone f building is det entifying the str a for Building I er parameters I RM infills. esence of the p sence of the p (KES	higher than th 2 select zone 3 t cermined referr ucture and Dam Details ike Structure typ arameter	tab ing to the reference nage Grade and Abl pe, Other hazard, F	e section breviations		As per l Zone II Zone III Zone IV Zone V greater	S 1893:200 Low seism Moderate High seisr Very high :)	D2 (Part 1), ic hazard (e seismic h nic hazard seismic ha	damage di azard (max (maximur zard (maxi	uring ear ámum da n damag mum dai	thquake r amage du e during e mage duri	may be of MSM ring earthqua earthquake ma	K Intensit ske may b ay be upt ce may be	ty VI or lo be upto M to MSK In e of MSH	MSK nten (Int

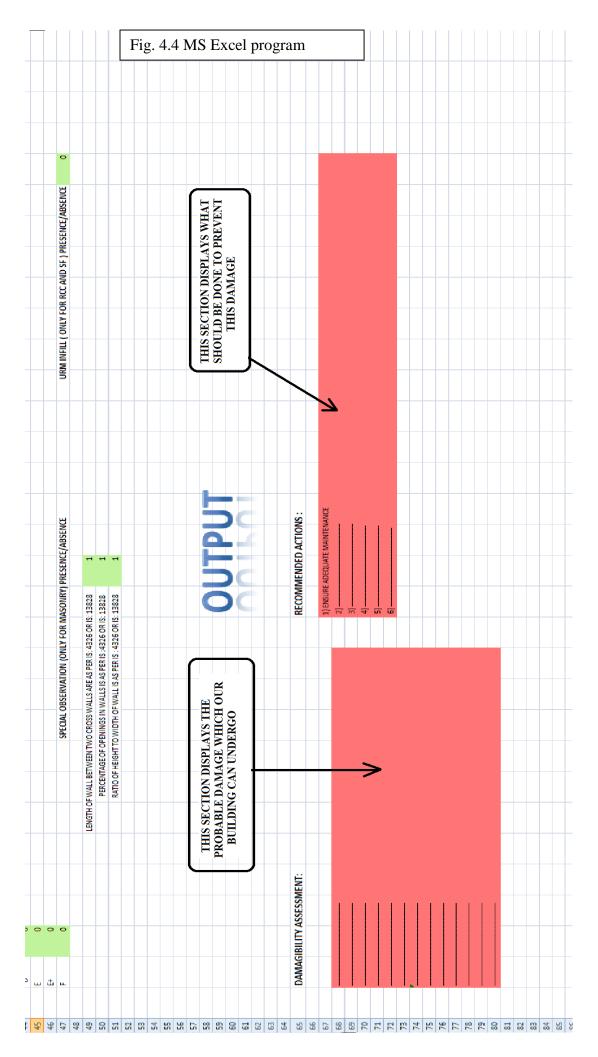
F50	\bullet : $\times \checkmark f_x$	Y
В	C D E F G H I J K	L M N O P Q R S T U V
28 Type 29 A 30 31 32	Description a) Rubble (Field stone) in mud mortar or without mortar usually with sloping wooden roof. b) Uncoursed rubble masonry without adequate 'through stones'. c) Masonry with round stones.	Frame 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
33 34 35 36 37	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.	*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.
38 B+ 39 40 41	 a) Unreinforced brick masonry in mud mortar with vertical wood posts or horizontal wood elements or seismic band (IS: 13828) b) Unreinforced brick masonry in lime mortar. 	 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.
42 43 44 45	 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) 	E a) MR-RCF with high level of ERD as per IS: 1893-2002 & special details as per IS: 1392 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
46 47 48	Like C(a) type but having horizontal seismic bands at lintel level of doors & windows (IS: 4326)	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.
49 50 51 52	Masonry construction as at C(a) but reinforced with bands & vertical reinforcement, etc (IS: 4326), or <i>confined masonry using horizontal & vertical</i> reinforcing of walls.	b) MR-SF as at E with well designed & detailed steel braces & cladding. c) MR-RCF/MR-SF with well designed base isolation.
52 53 54 55		* differenciates between masonry and rcc structures denoted by same alphabet MR stands for moment resistent
	INSTRUCTIONS AND REFERENCES ZONE 2 ONLY ZONE 3 +ZONE 2 IMP ZONE 4 +	ZONE 3 IMP 💮 🗄 🖣 👘
READY		

Fig. 4.2: Reference section MS Excel Program

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	В	С	D	E	F	G	Н	1	J	К	L	М	Ν	0	Р	Q	R	S	Т	U	V
5																					
7		CLASS	IFICATIO	N OF DA	MAGE TO	D MASO	NRY BUI	LDINGS				C	LASSIFIC	ATION O	F DAMA	GE TO F	REINFORG	ED CON	CRETE BU	UILDING	5
8	~ ~ 1											*01.0									>
	G1 Grad damage)		gible to slig	nt damage	e (no structi	ural dama	ge, slight n	ion-structu	ral								ictural dam alls at the b		non-struct	urai damaį	ge)
1	Structura	nl: Hair-lin	e cracks in v										ks in partit								
			l of small pi		<i>ster only.</i> puildings in	very few c	2505					*G2 Gra	de 2. Mode	erate dama	age (Slight	structura	l damage, r	noderate n	on-structu	ral damag	-1
-		ose stone.	s nom uppe		Junion igo ini	very levv c	ases.						columns &					insucrate in	ion structu	a a a a a a a a a a a a a a a a a a a	-,
					tructural d				al damage))		Cracks in	partition 8	k infill walls	s; fall of br	ittle cladd	ing & plaste	er. Falling n	nortar from	n the joints	of wal
					cks in RC* s of plaster, p				ws on			*G3 Gra	de 3: Subst	tantial to h	eavy dam	age (mode	erate struct	ural dama	ge, heavy r	non-structu	ıral da
					tiles distur				<i>yo on</i>			Cracks in	columns &	beam colu	umn joints		at the base				
	area. Mir	nor damag	ge in under	structure o	of sloping ro	ofs.							ckling of re				1				
	G3 Grad	le 3: Subsi	antial to he	avy dama	ge (modera	te structu	ral damag	e. heavy no	nstructura	al		Large cra	cks in parti	ition & intil	i walis, tai	lure of Ind	ividual infil	i paneis.			
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	Structura and piers	-	nd extensiv	e cracks in	most walls.	Wide spre	ad crackin	g of columi	75								on failure o of a few co				bond f
			of tiles deta	ch. Chimne	eys fracture	at the roo	f line; failu	re of individ	dual nonstr	ructural		beamrei	moreing be	ins, circing c	n columns	. conapse	01 8 12 10 00	iunnis or o	r a single a	pper noor.	
5	elements	s (partitio	ns, gable wa	ills).									de 5: Destr								
-	G4 Grad	le 4: Verv	heavy dam	age (heavy	structural	damage. v	erv heavv	non-struct	ural			Collapse	of ground f	noor parts	(e.g. Wing	s) of the b	ullaing.				
	damage)		,	-8- (,			,,														
-		al: Serious f roofs and		alls (gaps i	in walls), ini	ner walls c	ollapse; pa	rtial struct	ıral												
-	railure of	roors and	noors.									-									
					ructural dar	nage)															
	Total or r	near total	collapse of	the buildin	ig.																

Fig. 4.2 (Continued)





4.3 MODIFIED MS EXCEL SHEET FOR RVS SYSTEM (BASED ON FEMA METHODOLOGY)

The Excel program consists of 4 worksheets

Sheet 1: This sheet includes the instructions for the screener to follow while using RVS with the aid of this program. It contains the references as well as the abbreviations used for various structural forms and the type of damageability for every form This sheet is to be used as a reference while conducting the procedure.

In the addition to the reference material and instructions this sheet also contains links to various documents which can be studied by the screener if he/she wishes to acquire in-depth knowledge of the scoring system and the additional modifiers being used.

Sheet 2-4: These are sheets specific to the four seismic zones of India (Zone 2-5). Seismic zone 4 and 5 are considered collectively under the high seismicity zone that is specified in FEMA manuals. The sheets are colour coded with green being for basic input cells. These include data like building details, basic score modifiers and presence of additional modifiers and their degree of effect. Yellow and pink cells represent the output cells that show data such as score modifiers and the final scores.

The first step to be taken by the screener is a careful study of the basic instructions as laid down in sheet 1 and then select the suitable tab for the seismic zone. The input data in the green boxes should be entered carefully with a unique building number being used every time. The data to be entered can be alphanumeric and the building details are needed just for accurate book keeping. These will have no impact on the score. However, the data to be entered in the scoring portion must be of numeric form only as explained in the instruction sheet.

Basic score modifiers require data to be entered in binary form only i.e. 0 or 1 with 0 denoting the absence of the recorded factor and 1 being the presence.

The data entry cells for additional score modifiers must be filled with numerical values ranging from 0 to 10 (except for occupancy). This multiplied by their weight factor will show the score modifier value for that particular feature under consideration.

Once the data entry step is complete the program will automatically calculate and display the scores, modifiers and the values according to FEMA and the modified system. The output includes score, damageability values and the assessment/evaluation needed.

The final step of the method is to hit the next building tab present on the sheet which will reset the input cells and hence allow input of a new data value and continuation of the survey.

Fig. 4.5: MS Excel screenshots of modified RVS system

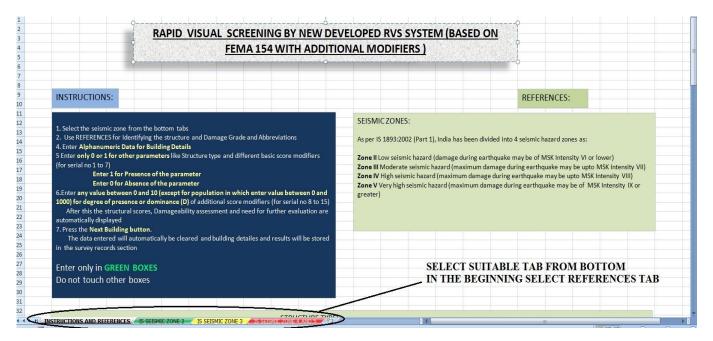
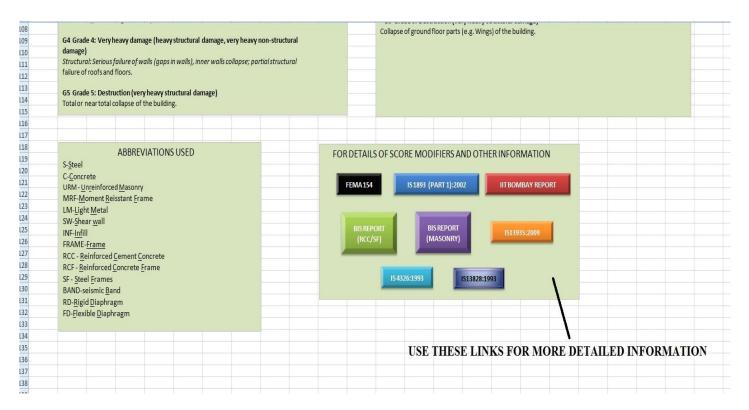


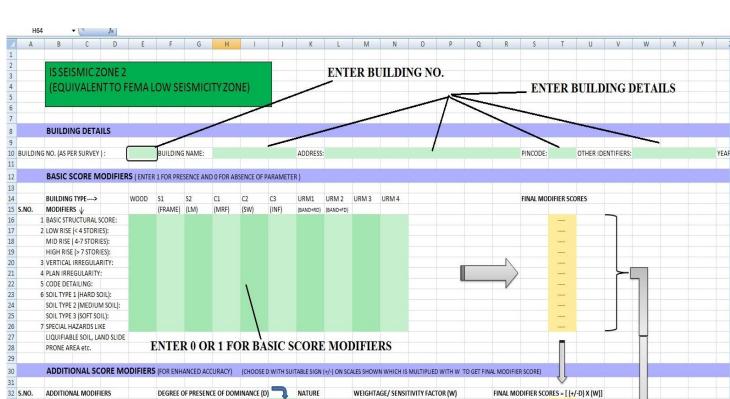
Fig. 4.6: Reference section in MS excel for modified RVS System

31				
32				
33 34 35 36 37			STRUCTURE TYPES	
34				
35	Туре	Description	Features and performance	
36	Wood	Light wooden frame buildings	Wooden Buildings of any type	
	wood	Light wooden frame buildings	wooden Buildings of any type	
38 39 40 41 42	S1 (FRAME)	Moment Resistant Steel frame	• Typical steel moment-resisting frame structures usually have similar bay widths in both the transverse and longitudinal directions, around 20-30 ft.	
39	(/		• The floor diaphragms are usually concrete, sometimes over steel decking. This structural type is used for commercial, institutional and public buildings.	
40			The 1994 Northridge and 1995 Kobe earthquakes showed that the welds in steel moment- frame buildings were vulnerable to severe damage. The damage	
41			took the form of broken connections between the beams and columns	=
42				
43	S2(LM)	Light Metal Steel structure	 The structural system usually consists of moment frames in the transverse direction and braced frames in the longitudinal direction, with corrugated sheet 	
44			metal siding. In some regions, light metal buildings may have partialheight masonry walls.	
45 46			 The interiors of most of these buildings do not have interior finishes and their structural skeleton can be seen easily. Insufficient capacity of tension braces can lead to their elongation and consequent building damage during earthquakes. 	
46			Insurient conception of a sab foundation can allow the building columns to side on the slab.	
47 48			Isosofte clading can occur	
48				
49	C1(MRF)	Concrete Moment Resistant Frame	All exposed concrete frames are reinforced concrete (not steel frames encased in concrete).	
50			A fundamental factor governing the performance of concrete moment-resisting frames is the level of ductile detailing.	
51			Large spacing of ties in columns can lead to a lack of concrete confinement and shear failure.	
52			Lack of continuous beam reinforcement can result in hinge formation during load reversal.	
53			The relatively low stiffness of the frame can lead to substantial nonstructural damage.	
51 52 53 54 55 56 57			Column damage due to pounding with adjacent buildings can occur.	
55	C2(SW)	Concrete Shear Wall buildings	Concrete shear-wall buildings are usually cast in place, and show typical signs of cast-inplace concrete.	
56	02(011)	condicte offen fran banango	 Shear-wall thickness ranges from 6 to 10 inches. 	
57			These buildings generally perform better than concrete buildings.	
58			They are heavier than steelframe buildings but more rigid due to the shear walls.	
58 59 60			Damage commonly observed in taller buildings is caused by vertical discontinuities, pounding, and irregular configuration	
60				
61	C3(INF)	Concrete frame with burnt brick masonry	Concrete columns and beams may be full wall thickness and may be exposed for viewing on the sides and rear of the building.	
62		Infill walls	Usually masonry is exposed on the exterior with narrow piers (less than 4 ft wide) between windows.	-
			Portions of solid walls will align vertically.	

85 86 87 88	URM 4 Unreinforced (URM) Burnt Brick or Stone (Features and behaviour is same as a Masonry (Lime mortar)	bove except bondage is of lime mortar in place of cement mortar)
89		
90 91	CLASSIFICATION OF DAMAGE TO MASONRY/WOOODEN BUILDINGS	CLASSIFICATION OF DAMAGE TO R.C.C./STEEL BUILDINGS
92	G1 Grade 1: Negligible to slight damage (no structural damage, slight non-structural	*G1 Grade 1: Negligible to slight damage (no structural damage, slight non-structural damage)
93	damage) Structural: Hair-line cracks in very few walls.	Fine cracks in plaster over frame members or in walls at the base.
94	Non-structural: Fall of small pieces of plaster only.	Fine cracks in partitions & infills.
95	Fall of loose stones from upper parts of buildings in very few cases.	*G2 Grade 2: Moderate damage (Slight structural damage, moderate non-structural damage)
96		Cracks in columns & beams of frames & in structural walls.
97	G2 Grade 2: Moderate damage (Slight structural damage, moderate non-structural damage)	Cracks in partition & infill walls; fall of brittle cladding & plaster. Falling mortar from the joints of wall panels.
98	Structural: Cracks in many walls, thin cracks in RC* slabs and A.C.* sheets.	
99	Non-structural: Fall of fairly large pieces of plaster, partial collapse of smoke chimneys on	*G3 Grade 3: Substantial to heavy damage (moderate structural damage, heavy non-structural damage)
100	roofs. Damage to parapets, chajjas. Roof tiles disturbed in about 10% of the	Cracks in columns & beam column joints of frames at the base & at joints of coupled walls. Spalling of concrete
101	area. Minor damage in under structure of sloping roofs.	cover, buckling of reinforced rods.
102		Large cracks in partition & infill walls, failure of individual infill panels.
103	G3 Grade 3: Substantial to heavy damage (moderate structural damage, heavy nonstructural damage)	
.04	Structural: Large and extensive cracks in most walls. Wide spread cracking of columns	*G4 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
.05	and piers.	beam reinforcing bars; tilting of columns. Collapse of a few columns or of a single upper floor.
.06	Non-structural: Roof tiles detach. Chimneys fracture at the roof line; failure of individual nonstructural	beam emotion goals, during of columns, compactor a rew columns of or a single upper noor.
.07	elements (partitions, gable walls).	*G5 Grade 5: Destruction (very heavy structural damage)
08		Collapse of ground floor parts (e.g. Wings) of the building.
.09	G4 Grade 4: Very heavy damage (heavy structural damage, very heavy non-structural	
10	damage)	
111	Structural: Serious failure of walls (gaps in walls), inner walls collapse; partial structural	
12	failure of roofs and floors.	
13	G5 Grade 5: Destruction (very heavy structural damage)	
14	Total or near total collapse of the building.	
.15	,	
16		

Fig. 4.7: Important document links in Excel sheet (modified RVS system)





8 BOTTOM SOFT STOREY PRESENCE:

(GOOD) 0

5

10 (BAD)

(-)

> X

 \rightarrow 0.1

33

Fig. 4.8: Input section (MS Excel) of modified RVS system

	PRONE AREA etc.		ENTER	SUITABL	E VA	LUE	FOR	R ADDITIONAL SC	ORE MOI	DIFIER			
	ADDITIONAL SCORE MODIFIE	ERS (FOR ENHAM	NCED ACCURAC	(CHOOSE D V		BLE SIGN (+	+/-) ON S	CALES SHOWN WHICH IS MULTIPLIED	WITH W TO GET FI	NAL MODIFIER SCORE)	ļ		
NO.	ADDITIONAL MODIFIERS	DEGREE OF	PRESENCE OF D	OMINANCE (D)		NATURE		WEIGHTAGE/ SENSITIVITY FACT	OR (W)	FINAL MODIFIER SC	ORES = [(+/-D) X (W	1	
	8 BOTTOM SOFT STOREY PRESENCE:	(GOOD) 0	5	10 (BAD)	1	-)	→ x			\longrightarrow	0		
	9 OCCUPANCY:	(GOOD) 0	500	1000 (BAD)	1	-)	→ x	→ 0.001		\rightarrow	0		OUTPUT
	10 CONDITION OF BUILDING:	(GOOD) 0	5	10 (BAD)	(-)	→ x	→ 0.05 —	→ =	\rightarrow	0		
	11 AGE OF BUILDING:	(GOOD) 0	5	10 (BAD)	(-)	→ x	→ 0.05		\longrightarrow	0		///
	12 COLLATERAL DAMAGE VULNERABILIT	Y: (GOOD)0	5	10 (BAD)	(-) —	→ x	→ 0.025		\rightarrow	0	///	//
	13 FALLING HAZARDS:	(GOOD) 0	5	10 (BAD)	(-)	→ x	→ 0.025		\longrightarrow	0		//
	14 EASE OF EVACUATION:	(BAD) 0	5	10 (GOOD)	(+) —	→ x	→ 0.01 →	> =	\longrightarrow	/		/
	15 EMERGENCY SERVICES AVAILABILITY:	(BAD) 0	5	10 (GOOD)	(+)	→ x	→ 0.01 —		\rightarrow		11	1
	FINAL STRUCTURAL SCORE "	S" (SUMMATIO	N OF FINAL MOI	DIFIER SCORES OF	SCORE MO	ODIFIERS F	PARAME		FINAL STRUCT	MAL SCORE =	#VALUE!	-	.UE!
	FINAL STRUCTURAL SCORE "	UCTURAL SCORE	FOR NEW DEVE	ELOPED RVS SYSTE	M (INCLU	JDING ADI			FINAL STRUCT	HAL SCORE =	#VALUE!		UEI
	YELLOW BOX DISPLAYS THE FINAL STR	UCTURAL SCORE	FOR NEW DEVE S OF SCORE MO	ELOPED RVS SYSTE	M (INCLU	JDING ADI I 1 TO 15)	DITIONA	L MODIFIERS)	FINAL STRUCT	HAL SCORE =	#VALUE!		VEI
	YELLOW BOX DISPLAYS THE FINAL STR (SUMMATIUON OF FINAL P	UCTURAL SCORE MODIFIER SCORE FURAL SCORE FO	FOR NEW DEVE S OF SCORE MO R TRADITIONAL	ELOPED RVS SYSTE DIFIER PARAMETI FEMA 154 RVS SY	IM (INCLL ERS FROM STEM (W	JDING ADI I 1 TO 15) /ITHOUT II	DITIONA	L MODIFIERS)	FINAL STRUCT	HAL SCORE =	#VALUE!		
	YELLOW BOX DISPLAYS THE FINAL STR (SUMMATIUON OF FINAL M PINK BOX DISPLAYS THE FINAL STRUC	UCTURAL SCORE MODIFIER SCORE FURAL SCORE FO	FOR NEW DEVE S OF SCORE MO R TRADITIONAL	ELOPED RVS SYSTE DIFIER PARAMETI FEMA 154 RVS SY	IM (INCLL ERS FROM STEM (W	JDING ADI I 1 TO 15) /ITHOUT II	DITIONA	L MODIFIERS)	FINAL STRUCT	HAL SCORE =	walue!		
	YELLOW BOX DISPLAYS THE FINAL STR (SUMMATIUON OF FINAL M PINK BOX DISPLAYS THE FINAL STRUC	UCTURAL SCORE MODIFIER SCORE TURAL SCORE FO MODIFIER SCORE	FOR NEW DEVE S OF SCORE MO R TRADITIONAL S OF SCORE MO	ELOPED RVS SYSTE DIFIER PARAMETI FEMA 154 RVS SY DIFIER PARAMETI	ERS FROM STEM (W ERS FROM	JDING ADI I 1 TO 15) /ITHOUT II I 1 TO 7 ON	DITIONA NCLUDIN NLY)	L MODIFIERS)	FINAL STRUCT	HAL SCORE =	"#VALUE!		UE
	YELLOW BOX DISPLAYS THE FINAL STR (SUMMATIUON OF FINAL PINK BOX DISPLAYS THE FINAL STRUC (SUMMATIUON OF FINAL N	UCTURAL SCORE MODIFIER SCORE FURAL SCORE FOI MODIFIER SCORE T AND RECO	FOR NEW DEVE S OF SCORE MO R TRADITIONAL S OF SCORE MO MMENDATI	ELOPED RVS SYSTE DIFIER PARAMETI FEMA 154 RVS SY DIFIER PARAMETI ON (FOR FUTI	M (INCLL ERS FROM STEM (W ERS FROM HER EVA	JDING ADI 1 TO 15) /ITHOUT II 1 TO 7 ON ALUATIC	DITIONA NCLUDIN NLY) DN)	L MODIFIERS)	/				DDITIONAL MODIFIERS)
	YELLOW BOX DISPLAYS THE FINAL STR (SUMMATIUON OF FINAL PINK BOX DISPLAYS THE FINAL STRUC (SUMMATIUON OF FINAL DAMAGABILITY ASSESSMEN	UCTURAL SCORE MODIFIER SCORE FURAL SCORE FOI MODIFIER SCORE T AND RECO	FOR NEW DEVE S OF SCORE MO R TRADITIONAL S OF SCORE MO MMENDATI	ELOPED RVS SYSTE DIFIER PARAMETI FEMA 154 RVS SY DIFIER PARAMETI ON (FOR FUTI	M (INCLL ERS FROM STEM (W ERS FROM HER EVA	JDING ADI 1 TO 15) /ITHOUT II 1 TO 7 ON ALUATIC	DITIONA NCLUDIN NLY) DN)	L MODIFIERS)	/				
	YELLOW BOX DISPLAYS THE FINAL STR (SUMMATIUON OF FINAL 1 PINK BOX DISPLAYS THE FINAL STRUC (SUMMATIUON OF FINAL 1 DAMAGABILITY ASSESSMEN DAMAGIBILITY ASSESSMENT AS PER	UCTURAL SCORE MODIFIER SCORE FURAL SCORE FOI MODIFIER SCORE T AND RECO	FOR NEW DEVE S OF SCORE MO R TRADITIONAL S OF SCORE MO MMENDATI	ELOPED RVS SYSTE DIFIER PARAMETI FEMA 154 RVS SY DIFIER PARAMETI ON (FOR FUTI	M (INCLL ERS FROM STEM (W ERS FROM HER EVA	JDING ADI 1 TO 15) /ITHOUT II 1 TO 7 ON ALUATIC	DITIONA NCLUDIN NLY) DN)	L MODIFIERS)	/				
	YELLOW BOX DISPLAYS THE FINAL STR (SUMMATIUON OF FINAL M PINK BOX DISPLAYS THE FINAL STRUC (SUMMATIUON OF FINAL M DAMAGABILITY ASSESSMENT DAMAGIBILITY ASSESSMENT AS PER	UCTURAL SCORE MODIFIER SCORE FURAL SCORE FOI MODIFIER SCORE T AND RECO	FOR NEW DEVE S OF SCORE MO R TRADITIONAL S OF SCORE MO MMENDATI	ELOPED RVS SYSTE DIFIER PARAMETI FEMA 154 RVS SY DIFIER PARAMETI ON (FOR FUTI	M (INCLL ERS FROM STEM (W ERS FROM HER EVA	JDING ADI 1 TO 15) /ITHOUT II 1 TO 7 ON ALUATIC	DITIONA NCLUDIN NLY) DN)	L MODIFIERS) NG ADDITIONAL MODIFIERAT DAMAGIBILITY ASSES	/				
	YELLOW BOX DISPLAYS THE FINAL STR (SUMMATIUON OF FINAL M PINK BOX DISPLAYS THE FINAL STRUC (SUMMATIUON OF FINAL M DAMAGABILITY ASSESSMENT DAMAGIBILITY ASSESSMENT AS PER	UCTURAL SCORE MODIFIER SCORE FURAL SCORE FO MODIFIER SCORE T AND RECOI NEW DEVELOPED	FOR NEW DEVE S OF SCORE MO R TRADITIONAL S OF SCORE MO MMENDATI D RVS SYSTEM (ELOPED RVS SYSTE DIFIER PARAMETI FEMA 154 RVS SY DIFIER PARAMETI ON (FOR FUTI	M (INCLL ERS FROM STEM (W ERS FROM HER EVA	JDING ADI 1 TO 15) /ITHOUT II 1 TO 7 ON ALUATIC	DITIONA NCLUDIN NLY) DN)	L MODIFIERS)	SSMENT AS PER TR.				

Fig. 4.9: Program outputs, results section (MS Excel) of modified RVS system

48	(SUMMATIUON OF FINAL MODIFIER SCORES OF SCORE MODIFIER PARAMETERS FRO	OM 1 TO 7 ONLY)				
49						
50	DAMAGABILITY ASSESSMENT AND RECOMMENDATION (FOR FUTHER E	VALUATION)				
51						
52	DAMAGIBILITY ASSESSMENT AS PER NEW DEVELOPED RVS SYSTEM (INCLUDING ADDITIONAL	MODIFIERS)	DAMAGIBILITY ASSESSMENT	AS PER TRADITIONAL FEMA 154 RVS	SYSTEM (WITHOUT INCLU	DING ADDITIONAL MODIFIERS)
54	#VALUE!	1	#VALUE!			
53 54 55 56 57		65	THE COLL			
56						
57	DETAILED FURTHER EVATUATION RECOMMENDED				#VALUE!	
58 59	(CUT OFF SCORE TAKEN AS 0.35)		(CUT OFF	SCORE TAKEN AS 2)		
59 60		NEXT BUILDING				
61		-				TON
62 63				PRESS NEXT B	UILDING BUI	ION
63	SURVEY DATA IS STORED HERE					
64 65						
66	SURVEY RECORD					
67	SURVET RECORD					
68 BUILDI	DING NO. BUILDING NAME ADDRESS		PINCODE	OTHER IDENTIFIERS	YEAR BUILT	NO OF STORIES APPROXIMATE
70	/					
71	/					
72						
73						
75						
76						
77						
78						
69 70 71 72 73 74 75 76 77 77 78 80						
80						

CHAPTER 5

SURVEY AND STUDY

5.1 OVERVIEW

In order to determine the viability of the method developed and to derive scores according to the process formulated above, Rapid Visual Screening of a number of structures was carried out in the city of Ludhiana, Punjab. The buildings selected provide a representative sample of vulnerable localities in the area including old town sections as well as commercial buildings.

The above mentioned structures were also scored by the traditional FEMA guidelines to provide a comparative sample data to draw inferences from. Since most of the structures surveyed were of masonry type the method specified by BIS was also used and a comparison between the three methods was made.

Photographs for each structure are attached along with their index number in the report. A representative photograph for the general construction form is otherwise mentioned for the areas where singular construction forms were prevalent such as in government colonies. In certain structures photography or entry was prohibited to the general public and hence the surveyor has used his own discretion to score those buildings.

5.2 SOIL TYPE

The nature and type of soil along with the liquefaction risk has been compiled from various regional reports as well as government databases. In certain cases direct consultation from the engineer in charge of the area has been carried out. Detailed soil investigation techniques are not permitted in RVS since it is a level 0 investigation technique.

South-western Punjab is mainly dominated by calcareous soil which includes desert soil and sierozem soil. The pH value in this zone ranges from 7.8 to 8.5 and also have grey and red desert soil, calsisol soil, regosol soil and alluvial soil. The soil of central Punjab ranges from sandy loam to clayey with pH value from 7.8 to 8.5 making alkalinity and salinity problematic

for this place. The alluvial soil of this zone can be widely described as arid and brown soil or tropical arid brown soil. The soil in Eastern Punjab is loamy to clayey. Ludhiana falls in central Punjab.

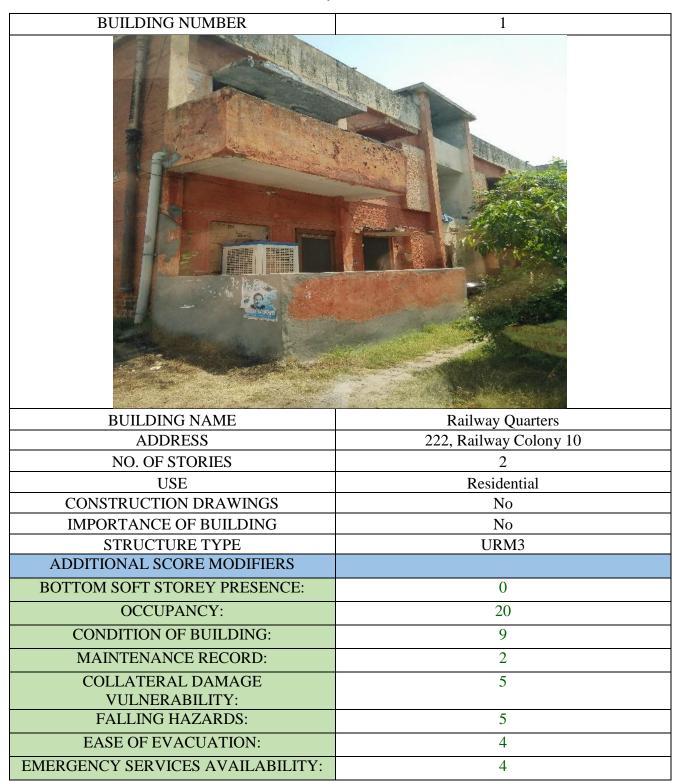
Liquefaction risk is most commonly associated with loose sands submerged under a high water table resulting in liquefaction under seismic forces. Since the soil in Ludhiana is basically alluvium which has a very low liquefaction risk the relevant parameter was taken as 0 in the report for every zone. This is further supported by the site engineer for certain structures as well as a lack of investigative techniques permitted

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5.3 SURVEY OBSERVATIONS

5.3.1 STRUCTURAL SURVEY OBSERVATIONS MADE:

Table 5.1: Survey data for structure 1



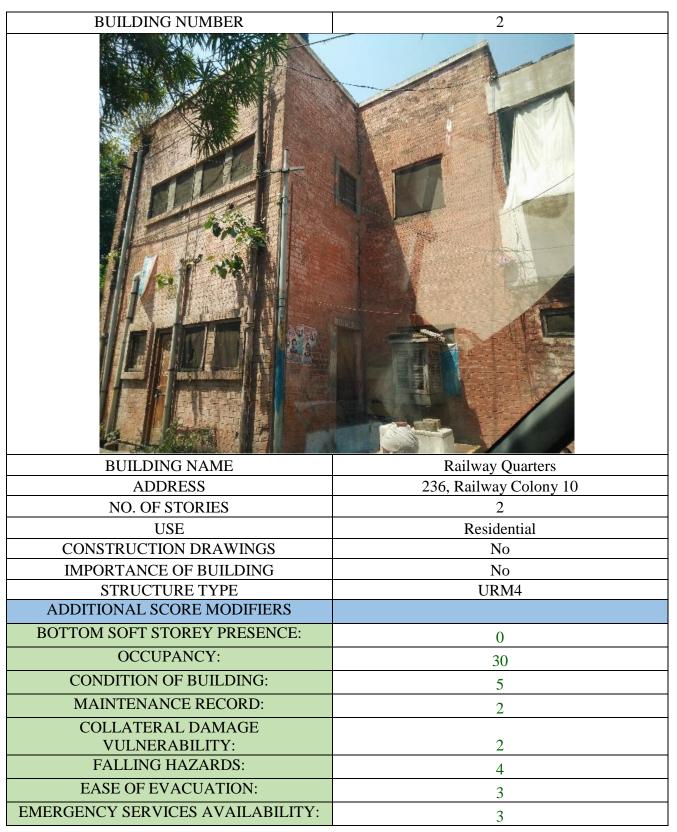


Table 5.2: Survey data for structure 2

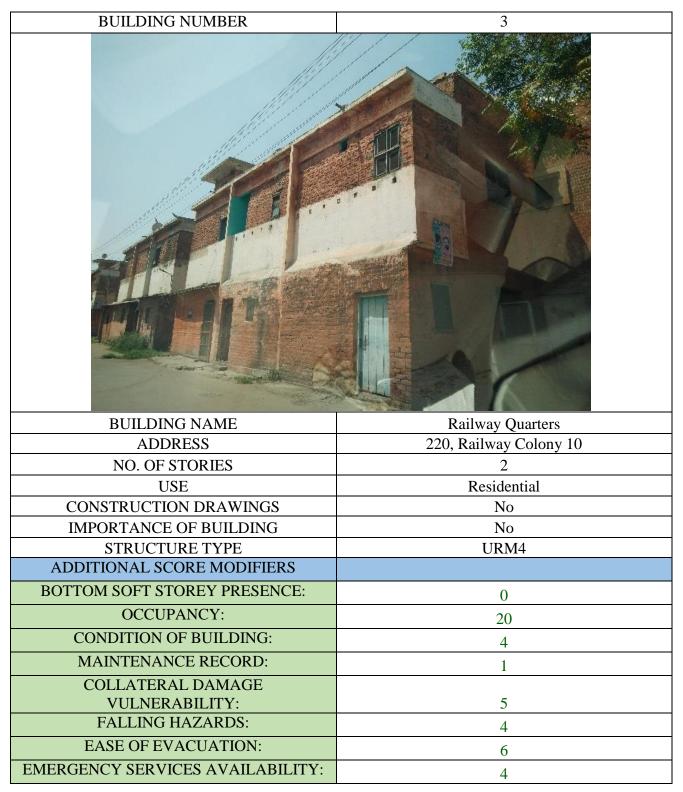


Table 5.3: Survey data for structure 3

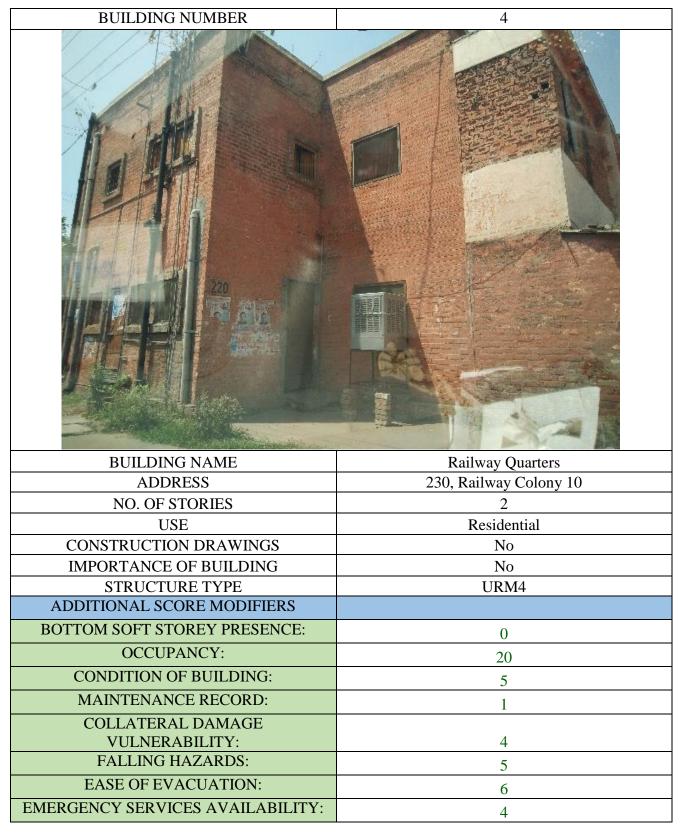


Table 5.4: Survey data for structure 4

Table 5.5: Survey	data for structure 5
BUILDING NUMBER	5
BUILDING NAME	Railway Bungalow
ADDRESS	L-5/A, Railway Colony 9
NO. OF STORIES	1
USE	Residential
CONSTRUCTION DRAWINGS	No
IMPORTANCE OF BUILDING	No
STRUCTURE TYPE	URM4
ADDITIONAL SCORE MODIFIERS	
BOTTOM SOFT STOREY PRESENCE:	0
OCCUPANCY:	9
CONDITION OF BUILDING:	3
MAINTENANCE RECORD:	0
COLLATERAL DAMAGE	
VULNERABILITY:	0
FALLING HAZARDS:	1
EASE OF EVACUATION:	5
EMERGENCY SERVICES AVAILABILITY:	

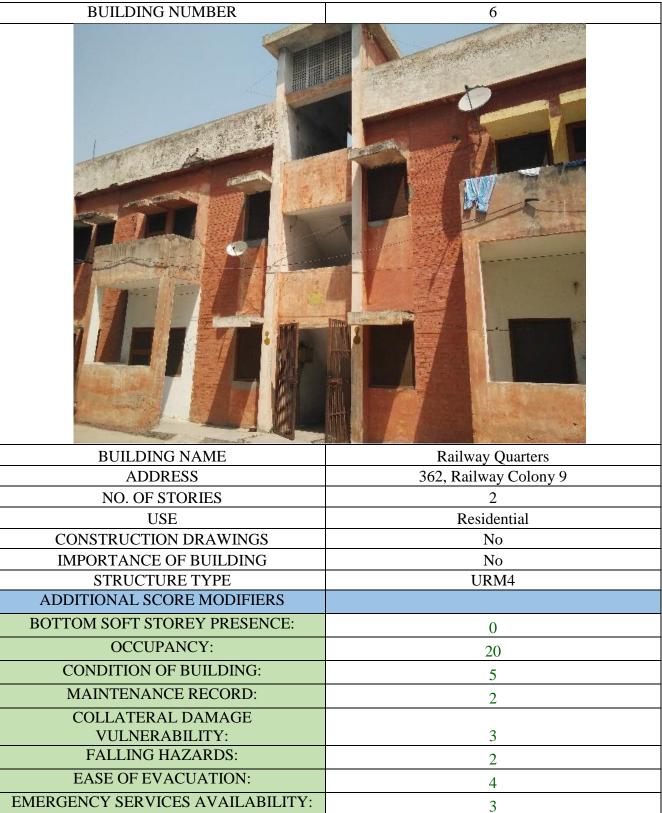
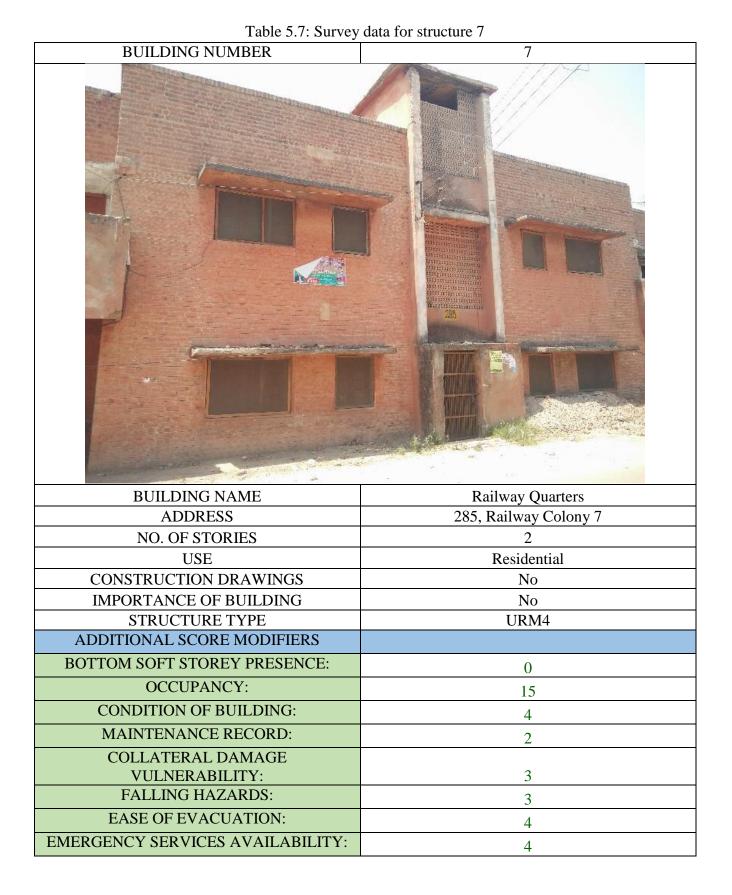


 Table 5.6: Survey data for structure 6



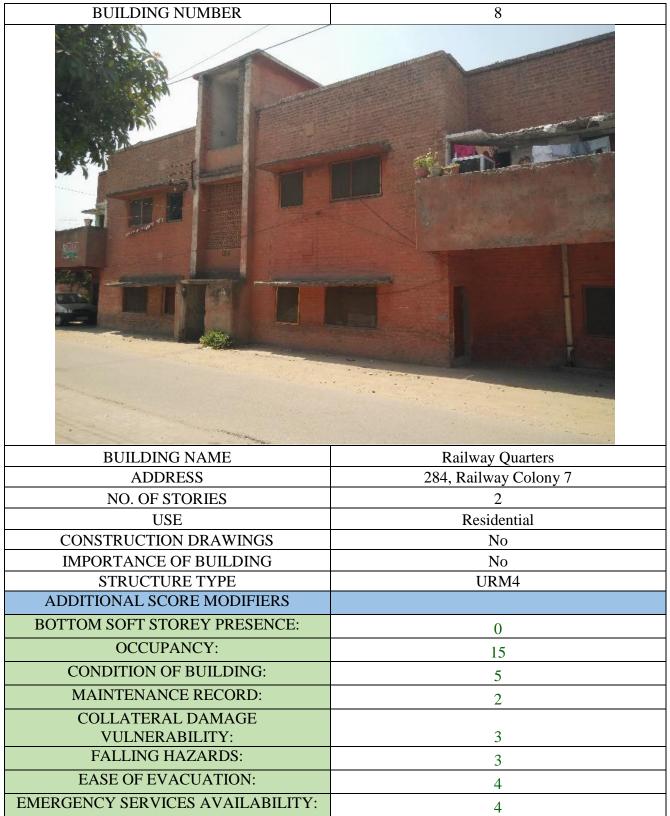


Table 5.8: Survey data for structure 8

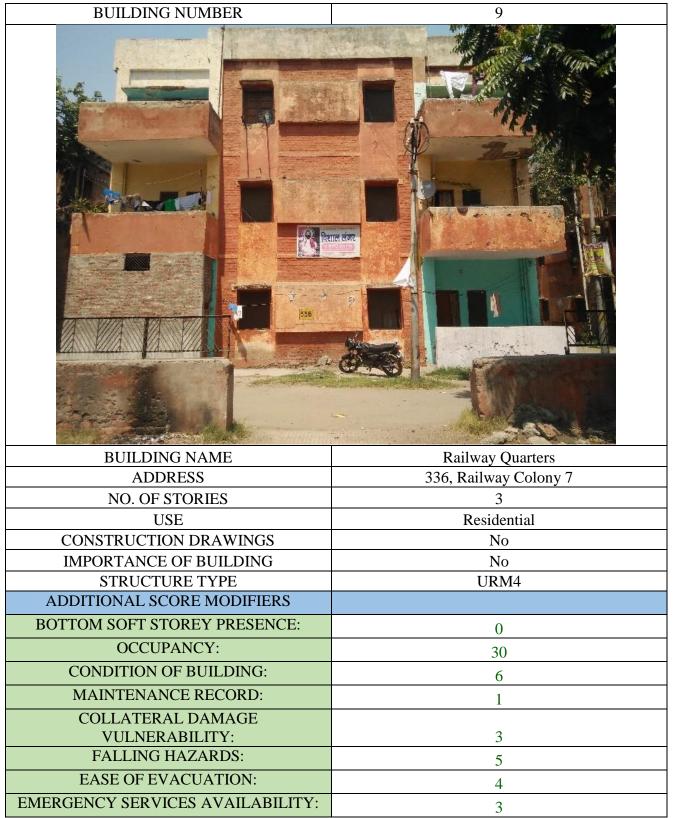


Table 5.9: Survey data for structure 9

BUILDING NUMBER	10
BUILDING NAME	Railway Quarters
ADDRESS	361, Railway Colony 7
NO. OF STORIES	3
USE	Residential
CONSTRUCTION DRAWINGS	No
IMPORTANCE OF BUILDING	No
STRUCTURE TYPE	URM4
ADDITIONAL SCORE MODIFIERS	
BOTTOM SOFT STOREY PRESENCE:	0
OCCUPANCY:	30
CONDITION OF BUILDING:	6
MAINTENANCE RECORD:	1
COLLATERAL DAMAGE	
VULNERABILITY:	3
FALLING HAZARDS:	3
EASE OF EVACUATION:	3
EMERGENCY SERVICES AVAILABILITY:	3

Table 5.10: Survey data for structure 10

BUILDING NUMBER	11
BUILDING NAME	Railway Quarters
BUILDING NAME ADDRESS	Railway Quarters 283. Railway Colony 7
ADDRESS	Railway Quarters 283, Railway Colony 7 2
ADDRESS NO. OF STORIES	283, Railway Colony 7 2
ADDRESS	283, Railway Colony 7
ADDRESS NO. OF STORIES USE	283, Railway Colony 7 2 Residential
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS	283, Railway Colony 7 2 Residential No
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING	283, Railway Colony 7 2 Residential No No
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE	283, Railway Colony 7 2 Residential No No
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS	283, Railway Colony 7 2 Residential No URM4 0
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE:	283, Railway Colony 7 2 Residential No URM4 0 20
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE: OCCUPANCY:	283, Railway Colony 7 2 Residential No URM4 0 20 7
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE: OCCUPANCY: CONDITION OF BUILDING:	283, Railway Colony 7 2 Residential No URM4 0 20
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE: OCCUPANCY: CONDITION OF BUILDING: MAINTENANCE RECORD:	283, Railway Colony 7 2 Residential No URM4 0 20 7
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE: OCCUPANCY: CONDITION OF BUILDING: MAINTENANCE RECORD: COLLATERAL DAMAGE	283, Railway Colony 7 2 Residential No No URM4 0 20 7 3
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE: OCCUPANCY: CONDITION OF BUILDING: MAINTENANCE RECORD: COLLATERAL DAMAGE VULNERABILITY:	283, Railway Colony 7 2 Residential No No URM4 0 20 7 3 4

Table 5.11: Survey data for structure 11

BUILDING NUMBER	12
BUILDING NAME	Railway Quarters
ADDRESS	270, Railway Colony 8
NO. OF STORIES	2
USE	Residential
CONSTRUCTION DRAWINGS	
	No
IMPORTANCE OF BUILDING	No No
STRUCTURE TYPE	
STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS	No
STRUCTURE TYPE	No
STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS	No URM4
STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE:	No URM4 0
STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE: OCCUPANCY: CONDITION OF BUILDING: MAINTENANCE RECORD:	No URM4 0 15
STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE: OCCUPANCY: CONDITION OF BUILDING: MAINTENANCE RECORD: COLLATERAL DAMAGE	No URM4 0 15 8 0
STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE: OCCUPANCY: CONDITION OF BUILDING: MAINTENANCE RECORD:	No URM4 0 15 8 0 4
STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE: OCCUPANCY: CONDITION OF BUILDING: MAINTENANCE RECORD: COLLATERAL DAMAGE VULNERABILITY:	No URM4 0 15 8 0

Table 5.12: Survey data for structure 12

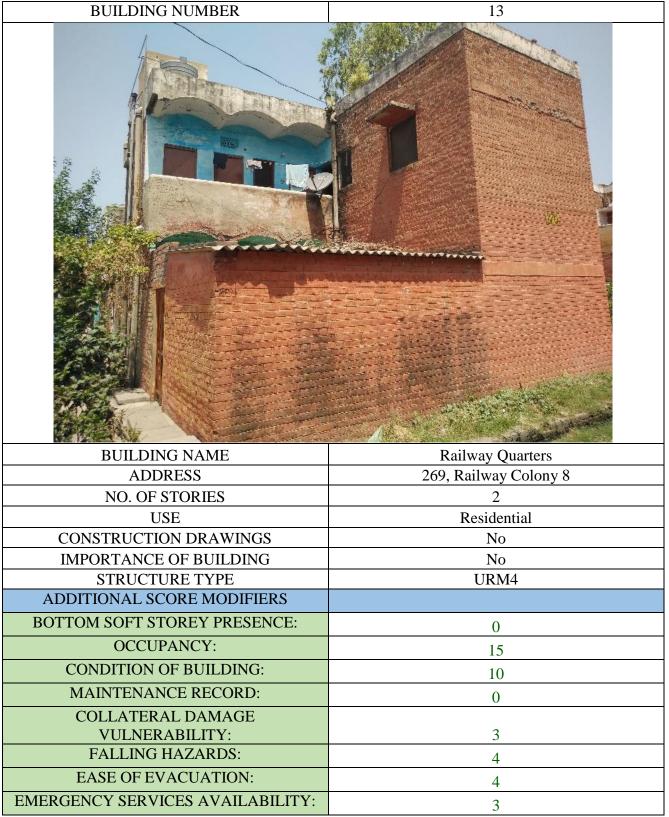


Table 5.13: Survey data for structure 13

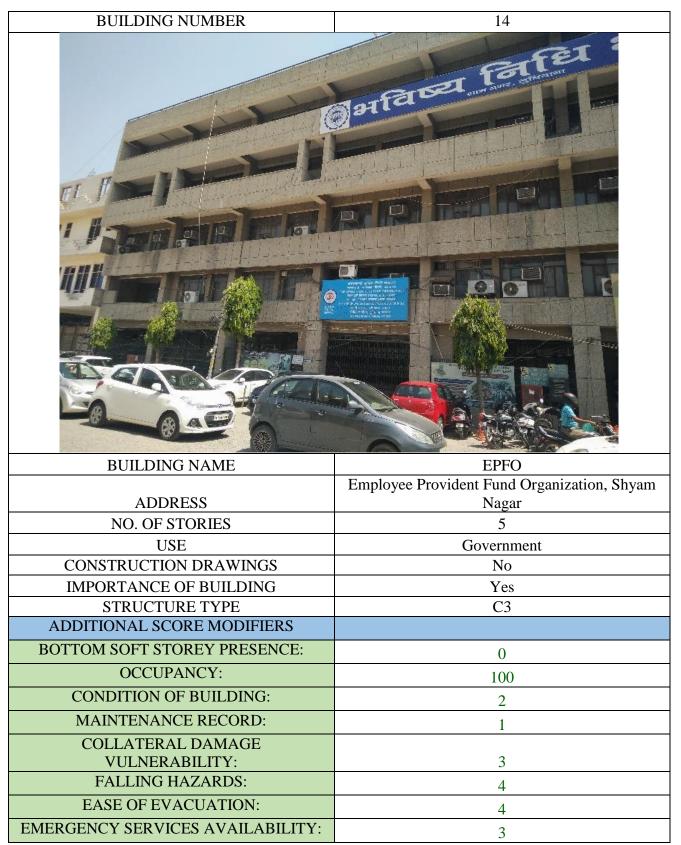


Table 5.14: Survey data for structure 14

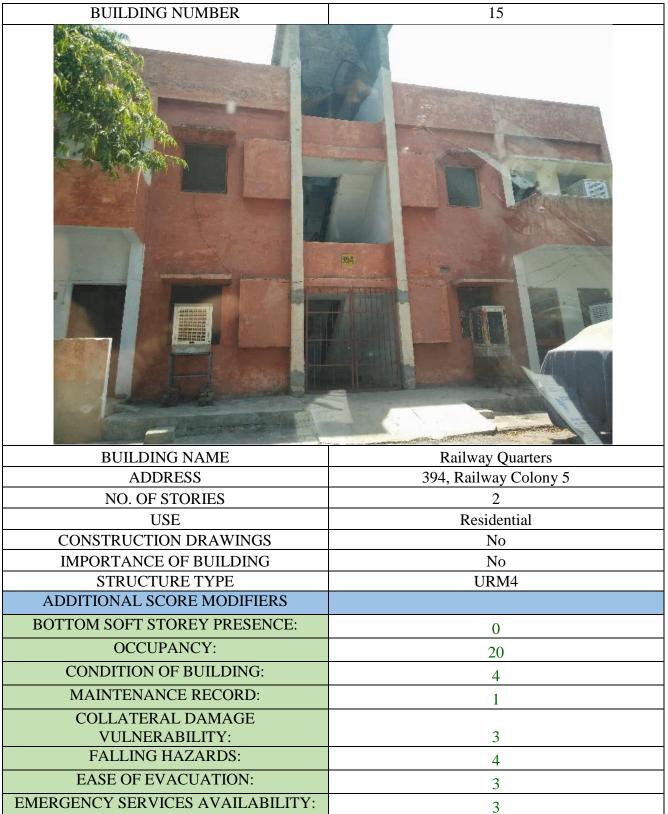


Table 5.15: Survey data for structure 15

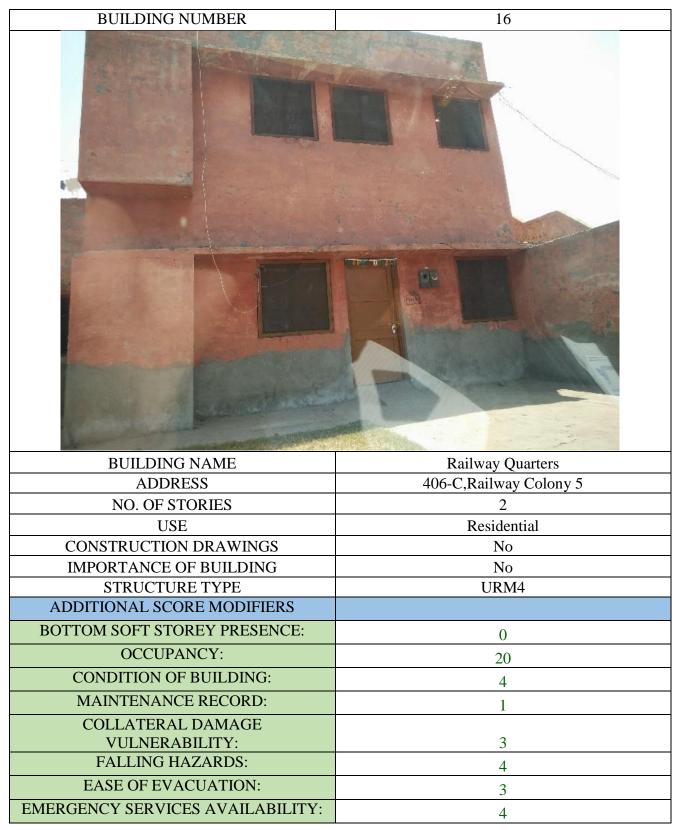


Table 5.16: Survey data for structure 16

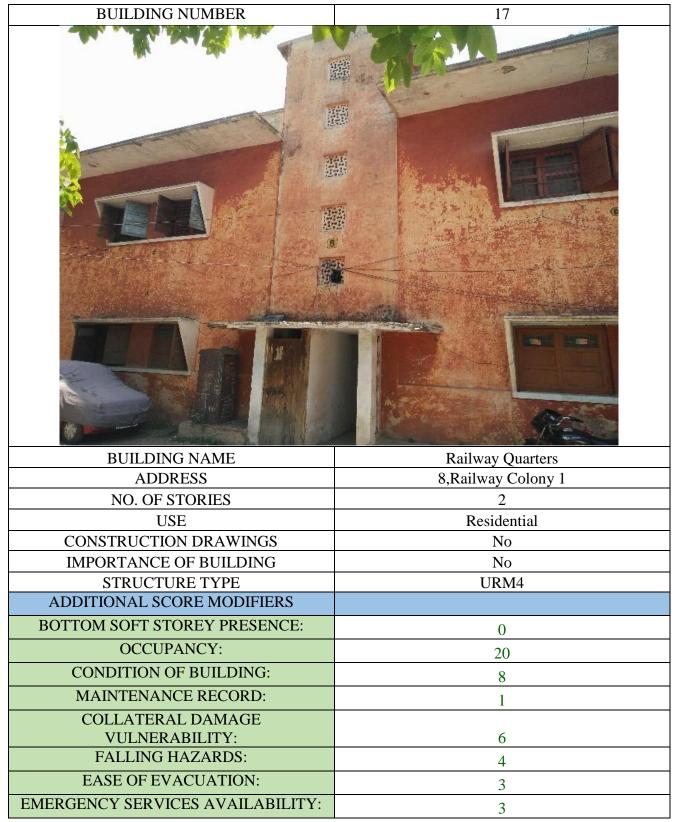


Table 5.17: Survey data for structure 17

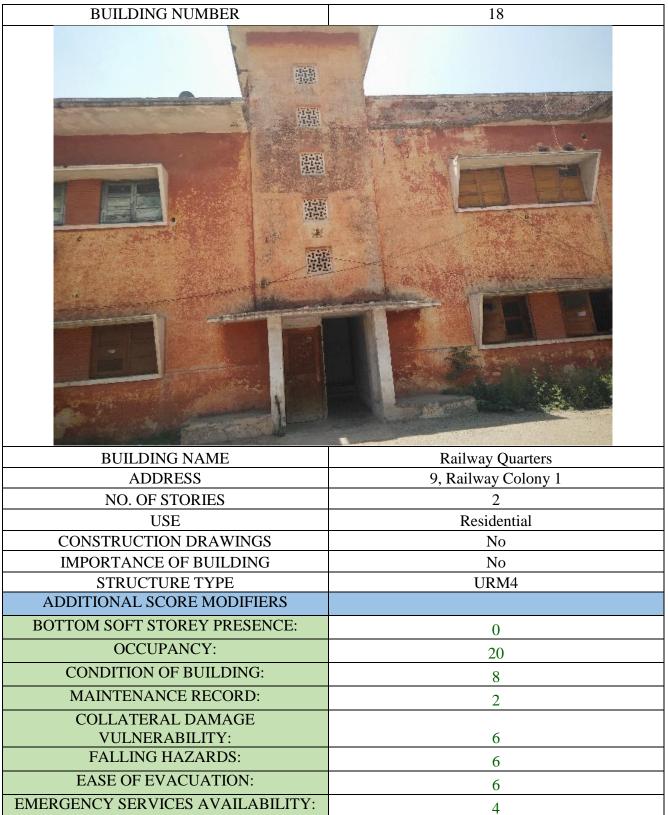


Table 5.18: Survey data for structure 18

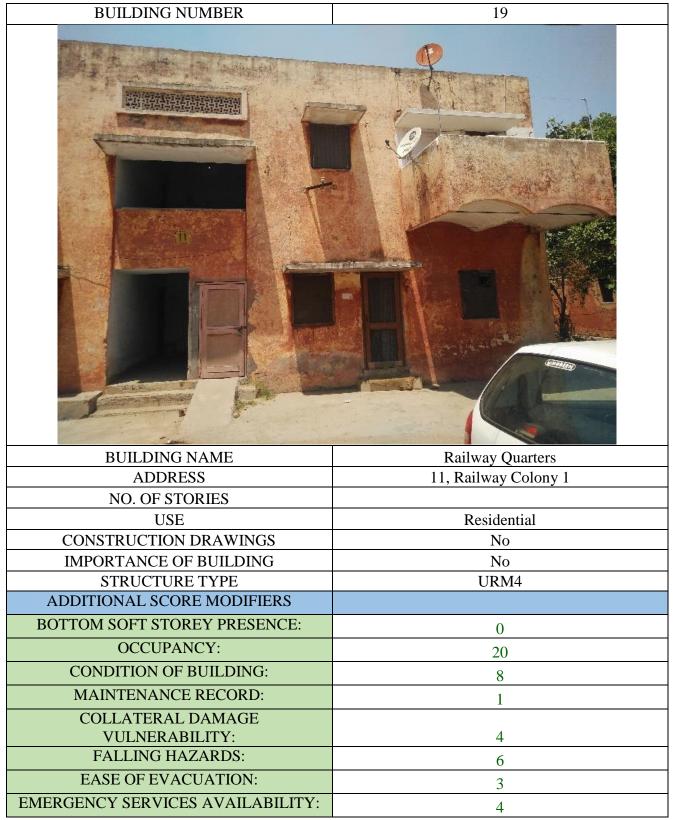


Table 5.19: Survey data for structure 19

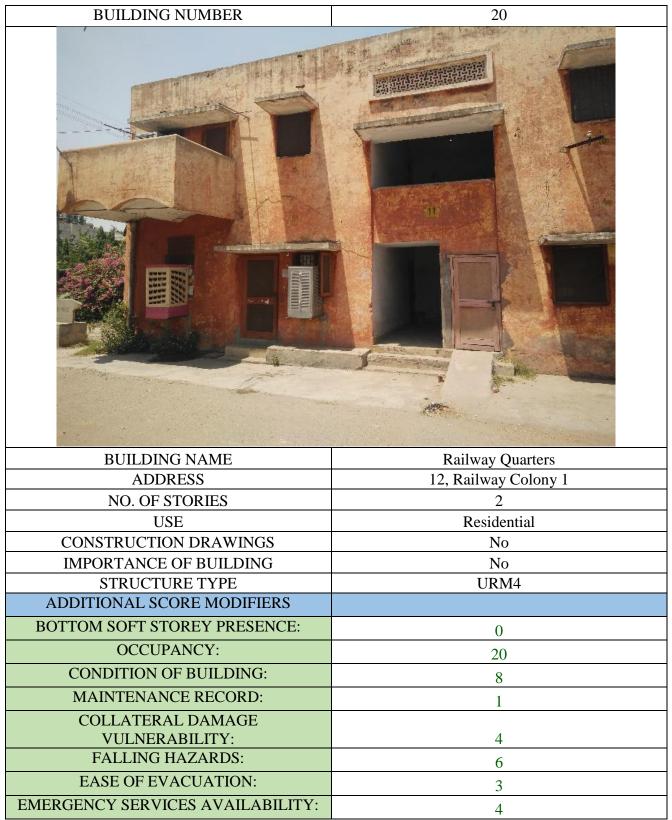


Table 5.20: Survey data for structure 20

BUILDING NUMBER	21
BUILDING NUMBER 21	
BUILDING NAME	Railway Quarters
ADDRESS	13, Railway Colony 1
ADDRESS NO. OF STORIES	13, Railway Colony 1 2
ADDRESS NO. OF STORIES USE	13, Railway Colony 1 2 Residential
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS	13, Railway Colony 1 2 Residential No
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING	13, Railway Colony 1 2 Residential No No
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE	13, Railway Colony 1 2 Residential No
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING	13, Railway Colony 1 2 Residential No URM4
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS	13, Railway Colony 1 2 Residential No URM4 0
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE:	13, Railway Colony 1 2 Residential No URM4 0 20
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE: OCCUPANCY:	13, Railway Colony 1 2 Residential No No URM4 0 20 8
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE: OCCUPANCY: CONDITION OF BUILDING:	13, Railway Colony 1 2 Residential No URM4 0 20
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE: OCCUPANCY: CONDITION OF BUILDING: MAINTENANCE RECORD: COLLATERAL DAMAGE VULNERABILITY:	13, Railway Colony 1 2 Residential No No URM4 0 20 8
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE: OCCUPANCY: CONDITION OF BUILDING: MAINTENANCE RECORD: COLLATERAL DAMAGE	13, Railway Colony 1 2 Residential No No URM4 0 20 8 1
ADDRESS NO. OF STORIES USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE: OCCUPANCY: CONDITION OF BUILDING: MAINTENANCE RECORD: COLLATERAL DAMAGE VULNERABILITY:	13, Railway Colony 1 2 Residential No No URM4 0 20 8 1 4

Table 5.21: Survey data for structure 21

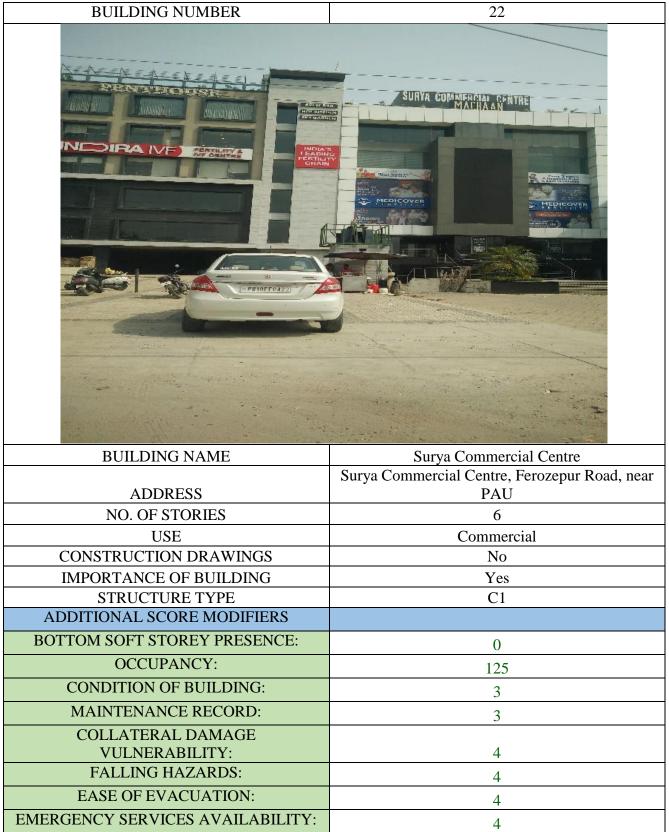


Table 5.22: Survey data for structure 22

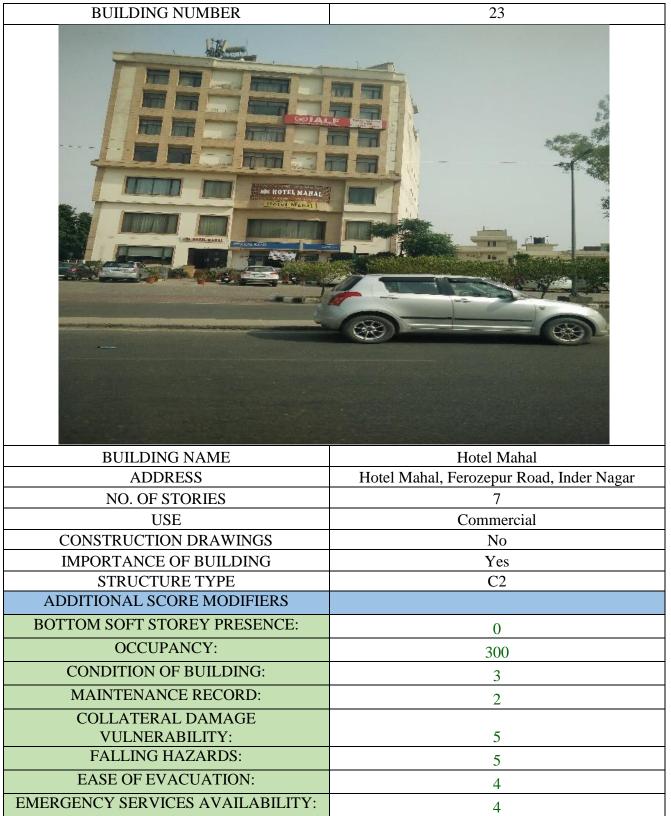


Table 5.23: Survey data for structure 23



BUILDING NUMBER	25
BUILDING NAME	Waves Mall
ADDRESS	Waves Mall, Ferozepur Road
NO. OF STORIES	7
USE	Commercial
CONSTRUCTION DRAWINGS	No
IMPORTANCE OF BUILDING	Yes
STRUCTURE TYPE	C2
ADDITIONAL SCORE MODIFIERS	
BOTTOM SOFT STOREY PRESENCE:	5
OCCUPANCY:	250
CONDITION OF BUILDING:	1
MAINTENANCE RECORD:	1
COLLATERAL DAMAGE	-
VULNERABILITY:	3
FALLING HAZARDS:	5
EASE OF EVACUATION:	6
EMERGENCY SERVICES AVAILABILITY:	4

Table 5.25: Survey data for structure 25

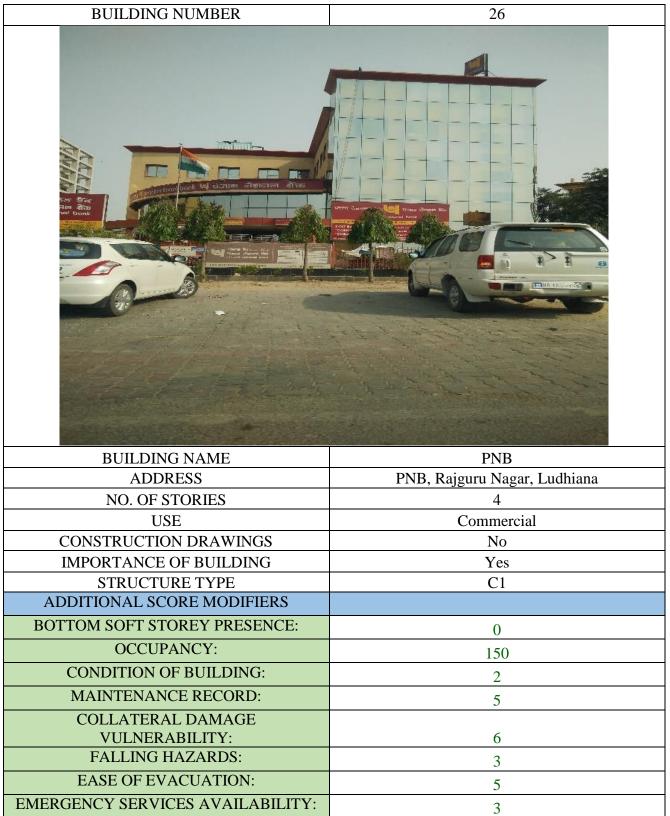


Table 5.26: Survey data for structure 26

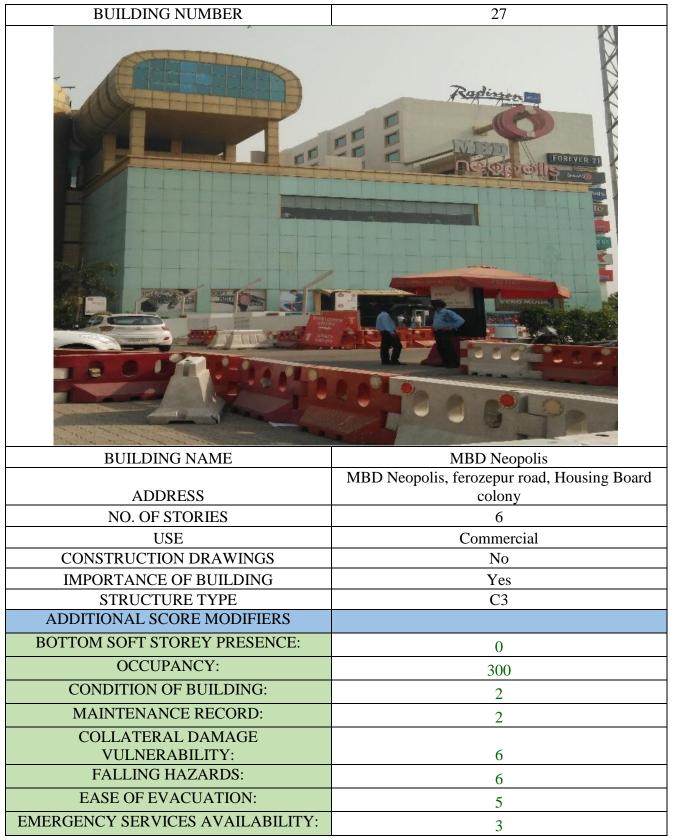


Table 5.27: Survey data for structure 27



Table 5.28: Survey data for structure 28

BUILDING NUMBER	29			
BUILDING NUMBER				
BUILDING NAME	AXEN Construction Office			
	AXEN Construction Office, near Ludhiana			
ADDRESS	Station			
NO. OF STORIES	2			
USE	Government			
CONSTRUCTION DRAWINGS	No			
IMPORTANCE OF BUILDING	Yes			
STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS	C3			
BOTTOM SOFT STOREY PRESENCE:				
OCCUPANCY:	0			
CONDITION OF BUILDING:	30			
MAINTENANCE RECORD:	1			
COLLATERAL DAMAGE	0			
VULNERABILITY:	2			
FALLING HAZARDS:	0			
EASE OF EVACUATION:	5			
EMERGENCY SERVICES AVAILABILITY:	5			

Table 5.29: Survey data for structure 29

BUILDING NUMBER	30
BUILDING NAME	Silver Arc Mall
ADDRESS	Silver Arc mall, Gurdev Nagar, Ludhiana
NO. OF STORIES	6
USE NO. OF STORIES	
	6
USE	6 Commercial
USE CONSTRUCTION DRAWINGS	6 Commercial No
USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING	6 Commercial No Yes
USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE	6 Commercial No Yes
USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS	6 Commercial No Yes C2
USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE:	6 Commercial No Yes C2 0 300
USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE: OCCUPANCY: CONDITION OF BUILDING: MAINTENANCE RECORD:	6 Commercial No Yes C2 0
USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE: OCCUPANCY: CONDITION OF BUILDING: MAINTENANCE RECORD: COLLATERAL DAMAGE	6 Commercial No Yes C2 0 300 1 0
USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE: OCCUPANCY: CONDITION OF BUILDING: MAINTENANCE RECORD: COLLATERAL DAMAGE VULNERABILITY:	6 Commercial No Yes C2 0 300 1 0 2
USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE: OCCUPANCY: CONDITION OF BUILDING: MAINTENANCE RECORD: COLLATERAL DAMAGE VULNERABILITY: FALLING HAZARDS:	6 Commercial No Yes C2 0 300 1 0
USE CONSTRUCTION DRAWINGS IMPORTANCE OF BUILDING STRUCTURE TYPE ADDITIONAL SCORE MODIFIERS BOTTOM SOFT STOREY PRESENCE: OCCUPANCY: CONDITION OF BUILDING: MAINTENANCE RECORD: COLLATERAL DAMAGE VULNERABILITY:	6 Commercial No Yes C2 0 300 1 0 2

Table 5.30: Survey data for structure 30



Table 5.31: Survey data for structure 31

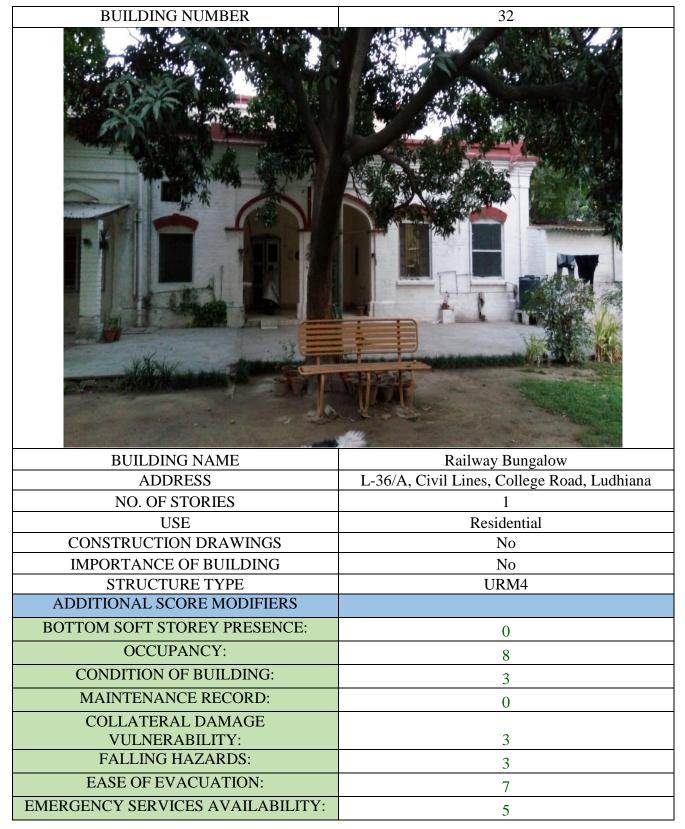


Table 5.32: Survey data for structure 32

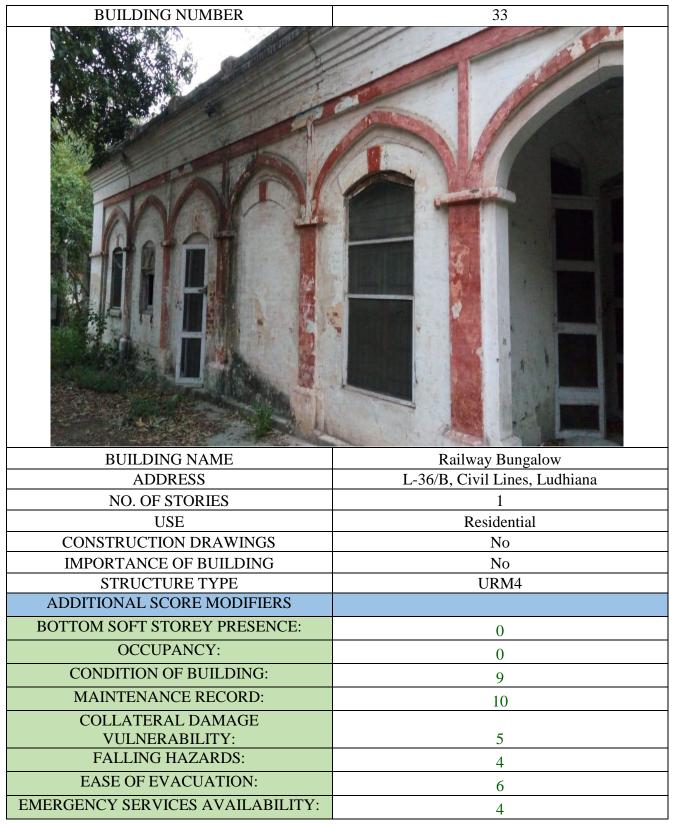


Table 5.33: Survey data for structure 33

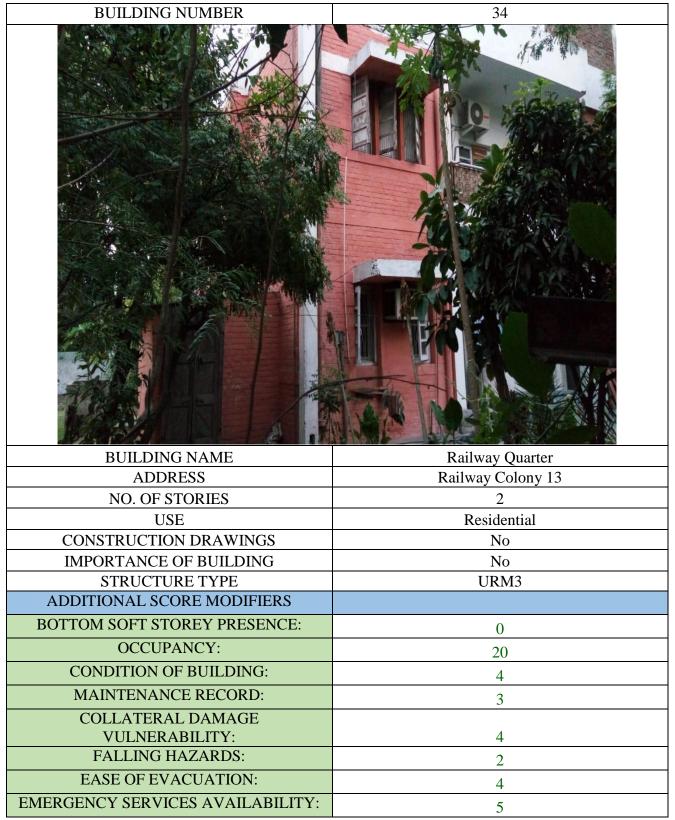
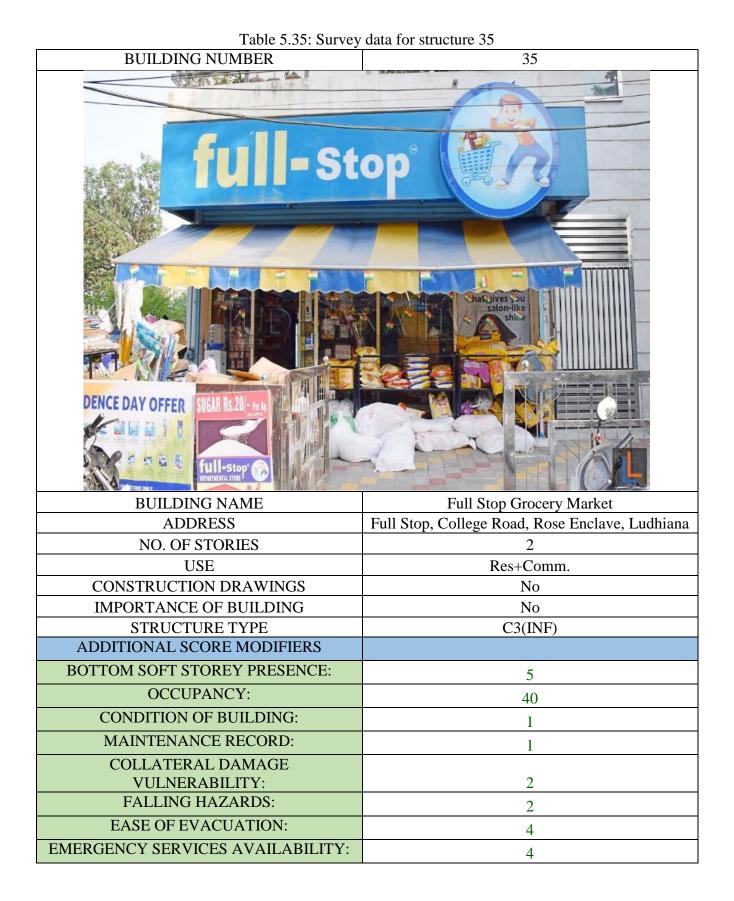


Table 5.34: Survey data for structure 34



5.3.2 EXCEL SHEET INPUTS:

BASIC PARAMETERS							
BUILDING NUMBER	1	2	3	4	5	6	7
BUILDING NAME	Railway Quarters	Railway Quarters	Railway Quarters	Railway Quarters	Railway Bungalow	Railway Quarters	Railway Quarters
ADDRESS	222, railway colony 10	236, Railway Color	220, Railway Color	230, Railway Colo	L-5/A, Railway Cold	362, Railway Colo	285, Railway Colon
NO. OF STORIES	2	2	2	2	1	2	2
USE	Residential	Residential	Residential	Residential	Residential	Residential	Residential
CONSTRUCTION DRAWINGS	No	No	No	No	No	No	No
IMPORTANCE OF BUILDING	No	No	No	No	No	No	No
Basic Score Modifiers							
STRUCTURE TYPE	URM3	URM4	URM4	URM4	URM4	URM4	URM4
LOW RISE (<4 STORIES):	1	1	1	1	1	1	1
MID RISE (4-7 STORIES):	0	0	0	0	0	0	0
HIGH RISE (> 7 STORIES):	0	0	0	0	0	0	0
VERTICAL IRREGULARITY:	0	0	0	0	0	0	0
PLAN IRREGULARITY:	0	1	0	1	0	0	0
CODE DETAILING:	0	0	0	0	0	0	0
SOIL TYPE 1 (HARD SOIL):	0	0	0	0	0	0	0
SOIL TYPE 2 (MEDIUM SOIL):	0	0	0	0	0	0	0
SOIL TYPE 3 (SOFT SOIL):	1	1	1	1	1	1	1
SPECIAL HAZARDS LIKE	0	0	0	0	0	0	0
LIQUIFIABLE SOIL, LAND SLIDE	6 (C) 1		9. 2.		2 1		
PRONE AREA etc.							
ADDITIONAL SCORE MODIFIERS							
BOTTOM SOFT STOREY PRESENCE:	0	0	0	0	0	0	0
OCCUPANCY:	20	30	20	20	9	20	15
CONDITION OF BUILDING:	9	5	4	5	3	5	4
MAINTENANCE RECORD:	2	2	1	1	0	2	2
COLLATERAL DAMAGE VULNERABILITY:	5	2	5	4	0	3	3
FALLING HAZARDS:	5	4	4	5	1	2	3
EASE OF EVACUATION:	4	3	6	6	5	4	
EMERGENCY SERVICES AVAILABILITY:	4	3	4	4	4	3	4

Table 5.36: Survey inputs

Table 5.36 (continued)

8	9	10	11	12	13	14	15
Railway Quarters	Railway Quarters	Railway Quarters	Railway Quarters	Railway Quarters	Railway Quarters	EPFO	Railway Quarters
284, Railway Colo	336, Railway Color	361, Railway Colo	283, Railway Colo	270, Railway Colo	269, Railway Colo	Employee Provident I	394, Railway Colon
2	3	3	2	2	2	5	2
Residential	Residential	Residential	Residential	Residential	Residential	Government	Residential
No	No	No	No	No	No	No	No
No	No	No	No	No	No	Yes	No
LIDAAA	LIDAA	UDAAA	LIDAAA	1100.04	LIDAAA	<u></u>	LIDAAA
URM4	URM4	URM4	URM4	URM4	URM4	C3	URM4
1	1	1	1	1	1	0	1
0	0	0	0	0	0	1	0
0	1	0	1	1	1	1	0
0	1	0	1	1	1	1	0
0	0	0	0	0	- 0	1	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0
1	1	1	1	1	1	0	1
0	0	0	0	0	0	0	C
0	0	0	0	0	0	0	0
15	30	30	20	15	15	100	20
5	6	6	7	8	10	2	4
2	1	1	3	0	0	1	1
3	- 3	3	4	4	3	3	3
3	5	3	5	5	4	4	4
4	4	3	4	4	4	4	3
4	3	3	3	3	3	3	3

Table 5.36 (continued)

16	17	18	19	20	21	22	23	24
Railway Quarters	Railway Quarters	Railway Quarters	Railway Quarters	Railway Quarters	Railway Quarters	Surya Commercial Centre	Hotel Mahal	Grand Walk Mall
406-C,Railway Colo	8,Railway Colony 1	9, Railway Colony 1	11, Railway Colony	12, Railway Colon	13, Railway Colon	Surya Commercial Centre	Hotel <mark>M</mark> ahal, F	Grand Walk Mall, I
2	2	2		2	2	6	7	6
Residential	Residential	Residential	Residential	Residential	Residential	Commercial	Commercial	Commercial
No	No	No	No	No	No	No	No	No
No	No	No	No	No	No	Yes	Yes	Yes
URM4	URM4	URM4	URM4	URM4	URM4	C1	C2	C2
1	1	1	1	1	1	0	0	0
0	0	0	0	0	0	1	1	1
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	1	0
0	0	0	0	0	0	0	0	C
0	0	0	0	0	0	1	1	1
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	1	1
1	1	1	1	1	1	0	0	C
0	0	0	0	0	0	0	0	C
						2) 6		
0	0	0	0	0	0	0	0	C
20	20	20	20	20	20	125	300	300
4	8	8	8	8	8	3	3	3
1	1	2	1	1	1	3	2	2
3	6	6	4	4	4	4	5	5
4	4	6	6	6	6	4	5	3
3	3	6	3	3	4	4	4	6
4	3	4	4	4	4	4	4	5

Table 5.36 (continued)

25	26	27	28	29	30	31
Waves Mall	PNB	MBD Neopolis	Dainik Bhaskar Office	AXEN Construction Office	Silver Arc Mall	Pavilion Mall
Waves Mall, Fero	PNB, Rajguru Nagar,	MBD Neopolis, fer	Dainik Bhaskar Office	AXEN Construction Office,	Silver Arc mall,	Pavilion Mall, Fo
7	4	6	6	2	6	7
Commercial	Commercial	Commercial	Commercial	Government	Commercial	Commercial
No	No	No	No	No	No	No
Yes	Yes	Yes	No	Yes	Yes	Yes
C2	C1	C3	C3	C3	C2	C2(SW)
0	0	0	0	1	0	1
1	1	1	1	0	1	0
0	0	0	0	0	0	0
1	1	1	1	0	0	1
0	1	1	1	0	0	1
1	1	1	1	1	1	1
0	0	0	0	0	0	0
1	1	1	0	0	1	1
0	0	0	1	1	0	0
0	0	0	0	0	0	0
5	0	0	5	0	0	0
250	150	300	45	30	300	400
1	2	2	4	1	1	1
1	5	2	10	0	0	0
3	6	6	1	2	2	3
5	3	6	2	0	2	2
6	5	5	4	5	5	5
4	3	3	5	5	4	5

32	33	34	35	
Railway Bungalow	Railway Bungalow	Railway Quarter	Full Stop Grocery Mar	ket
L-36/A, Civil Lines,	L-36/B, Civil Lines,	Railway Colony 1	Full Stop, College Roa	d, Rose Enclave, Ludhiana
1	1	2	2	A11 6.7
Residential	Residential	Residential	Res+Comm.	
No	No	No	No	
No	No	No	No	
URM4	URM4	URM3	C3(INF)	
1	1	1	1	
0	0	0	0	
0	0	0	0	
0	0	0	1	
0	0	0	0	
0	0	1	1	
0	0	0	0	
0	0	0	0	
1	1	1	1	
0	0	0	0	
	0	0	-5	
8	0	20	40	
3	9	4	1	
0	10	3	1	
3	5	4	2	
3	4	2	2	
7	6	4	4	
5	4	5	4	

Table 5.36 (continued)

CHAPTER 6

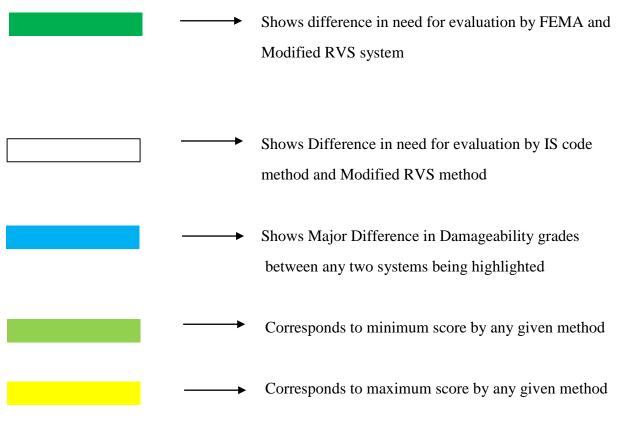
RESULTS, COMPARISONS, AND CONCLUSIONS

6.1 SURVEY RESULTS

BUILDING DAMAGEABILI		DAMAGEABILITY GRADE		STRUCTUR	STRUCTURAL SCORES		NEED FOR FURTHER EVALUATION		
NO.									
	RVS AS PER IS	NEW DEVELOPED RVS	RVS AS PER FEMA 154	RVS AS PER IS	NEW DEVELOPED RVS	RVS AS PER FEMA 154	RVS AS PER IS	NEW DEVELOPED RVS	RVS AS PER FEMA 15
1	G3	G2,G1	G3,G2	N/A	0.46	1.2	YES	NO	YES
2	G3	G3,G2	G4,G3	N/A	-0.17	0.3	YES	YES	YES
3	G3	G2,G1	G3,G2	N/A	0.405	0.8	YES	NO	YES
4	G3	G3,G2	G4,G3	N/A	-0.145	0.3	YES	YES	YES
5	G3	G2,G1	G2,G3	N/A	0.706	0.8	YES	NO	YES
6	G3	G2,G1	G2,G3	N/A	0.375	0.8	YES	NO	YES
7	G3	G2,G1	G2,G3	N/A	0.415	0.8	YES	NO	YES
8	G3	G2,G1	G2,G3	N/A	0.365	0.8	YES	NO	YES
9	G3	G2,G3	G5,G4	N/A	-0.71	-0.2	YES	YES	YES
10	G3	G2,G3	G3,G2	N/A	0.32	0.8	YES	YES	YES
11	G3	G5,G4	G5,G4	N/A	-1.375	-0.7	YES	YES	YES
12	G3	G4.G3	G5,G4	N/A	-1.27	-0.7	YES	YES	YES
13	G3	G4.G3	G5,G4	N/A	-1.32	-0.7	YES	YES	YES
14	G3	G2,G1	G3,G2	N/A	1.245	1.6	YES	NO	YES
15	G3	G2,G1	G3,G2	N/A	0.415	0.8	YES	NO	YES
16	G3	G2,G1	G3,G2	N/A	0.425	0.8	YES	NO	YES
17	G3	G2,G3	G3,G2	N/A	0.14	0.8	YES	YES	YES
18	G3	G2,G3	G3,G2	N/A	0.08	0.8	YES	YES	YES
19	G3	G2,G3	G3,G2	N/A	0.15	0.8	YES	YES	YES
20	G3	G2,G3	G3,G2	N/A	0.15	0.8	YES	YES	YES
21	G3	G2,G3	G3,G2	N/A	0.16	0.8	YES	YES	YES
22	G3	G2,G1	G3,G2	N/A	0.655	1.2	YES	NO	YES
23	G1	G1	G1	N/A	2.48	3.2	NO	NO	NO
24	G1	G1	G1	N/A	3.56	4.2	NO	NO	NO
25	G1	G1	G1	N/A	2.25	3.2	NO	NO	NO
26	G3	G2,G3	G2,G3	N/A	0.055	0.7	YES	YES	YES
27	G1	G1	G2,G1	N/A	1.8	2.7	NO	NO	NO
28	no damage	G2,G3	G2,G3	N/A	-0.13	1.1	YES	YES	YES
29	G3	G1	G2,G1	N/A	2.37	2.4	NO	NO	NO
30	G1	G1	G1	N/A	3.84	4.2	NO	NO	NO
31	G1	G1	G1	N/A	2.625	3.1	NO	NO	NO
32	G3	G2,G1	G2,G3	N/A	0.612	0.8	YES	NO	YES
33	G3	G2,G3	G2,G3	N/A	-0.275	0.8	YES	YES	YES
34	G3	G2,G1	G2,G3	N/A	0.77	1.2	YES	NO	YES
35	G2	G2,G1	G2,G3	N/A	0.74	1.4	YES	NO	YES

Table 6.1: Survey Results

Where:



6.2 OBSERVATIONS

• DAMAGEABILITY GRADE:

 Of the 35 structures that were surveyed in this project
 1 structure i.e. 28 is observed to have no damage according to IS method of RVS while 6 Structures are found to have negligible damage scale of G1: 23, 24, 25, 27, 30, 31.

7 Structures were found to have negligible damage, damage grade G1 in accordance with the new **developed RVS** methodology namely 23, 24, 25, 27, 29, 30, 31

5 Structures were found to have negligible damage, damage grade G1 in accordance with traditional **FEMA methodology** namely 23, 24, 25, 30, 31

- 2. For the structures with negligible damage scales in the standard BIS method we see a range of damageability grades in the other two methods varying from grade G1 to grade G3.
- 3. There is only 1 structure, 9 for which we see a large variation in damageability grades between the FEMA method and the Developed RVS method. FEMA method denotes it as G4, G5 whereas the developed method denotes it as G2, G3. The rest of the structure grades do not vary too widely with a maximum of +/- 1 Grade with the average being the same.
- 4. This overall variation can be summarised as follows. For the older URM structures the estimates made by FEMA and BIS almost coincide with BIS value being a bit conservative and equal to the higher damageability grade given by FEMA. In those structures we see that our developed method lags behind a bit and estimates a slightly lower grade owing to the variation that is included due to the presence of additional modifiers and certain ones of those end up giving a higher estimate of grade. For the more modern constructions the estimates made by the developed system and FEMA can be taken as almost the same values. In those structures the BIS method was found to give similar results to FEMA estimates, most probably due to them being high grades of construction.
- **5.** This experiment was limited to 35 structures only and a larger sample pool might be necessary to draw any certain conclusions.

• STRUCTURAL SCORE:

- 1. The final structural score by FEMA method results in the same values for a large number of structures, example being structure 15-21 which have the same basic features and result in the same score of 0.8. This occurs because FEMA works on binary logic i.e. the presence of a factor or not and has a fixed value for each case.
- 2. However, the final score in case of the modified RVS method has a larger variation since it takes into account various score modifiers which occur on a spectrum rather than simple binary logic. For example, the condition of the structure.
- **3.** This helps us see the variation among similarly scored structures which would have otherwise been grouped together and improves the quality of the results obtained and is a distinct advantage over the standard Quantitative FEMA system.
- **4.** The highest score obtained by the RVS method was 3.84 for structure 30. The same structure when analysed by FEMA method gave a score of 4.2. This discrepancy occurred due to factors such as falling hazards, ease of evacuation, occupancy classes etc which combine to give a better picture of the real risk that the structure entails. FEMA method gave it a higher score due to the recent construction along with proper and symmetric design.
- 5. Likewise the lowest score in FEMA method is -0.7 which has a corresponding score of -1.375 in RVS system for structure 11. This clearly shows the difference in the classical method and the new developed method since we have been able to incorporate the real condition of the structure. This structure had multiple structural cracks, loose lintels, exposed reinforcement, unauthorized extensions etc which cannot be account for in the FEMA method.
- 6. This, however does not give any concrete conclusions about the applicability of the method in field. However even if the damageability grades of the structures obtained are comparable the modified method provides a qualitative improvement to the simple FEMA method. It successfully points out certain weaknesses such as evacuation measures or ease with which emergency services can reach a location , falling hazards etc to name a few so the relevant authorities know which things have a dominant effect in the risk assessment.

• FURTHER EVALUATION

- Of the survey sample containing 35 structures the need for further evaluation as prescribed by various methods is as follows,
 28 structures need further evaluation according to BIS method
 15 structures need further evaluation according to modified RVS method
 28 structures need further evaluation according to FEMA method
- 2. Thus it can be seen that the BIS method gives more weightage to higher level analysis than the modified RVS system for vulnerability assessment of seismic risk.
- **3.** Out of the surveyed 35 structures we see 13 instances where the modified RVS system and the BIS system differ in their suggestions for further evaluation of structures. In all these structures BIS suggests further analysis whereas RVS system denies the need. The possible reason being that the additional score modifiers have imparted a highly positive impact on the total score and hence this method considers that there is no need for further evaluation.
- **4.** Of these 13 instances, all of them agree with the standard FEMA suggestions for further evaluation. The possible reason being the age and construction of the structures coupled with the high seismic zone suggests that further evaluation is necessary for the continued safety of these structures.
- 5. To summarize the inferences, the BIS method is more prone to suggesting reevaluation since it gauges its necessity based on the presence or absence of a handful of features only such as asymmetry or irregularities. The modified RVS system and the FEMA system on the other hand are more conservative when making those estimates. These two tend to disagree only in the cases where the positive modifiers have a high impact on the total score such as in case of wellmaintained but old structures or with structures having a low degree of occupancy. In case of newer constructions the results are in agreement with FEMA method.

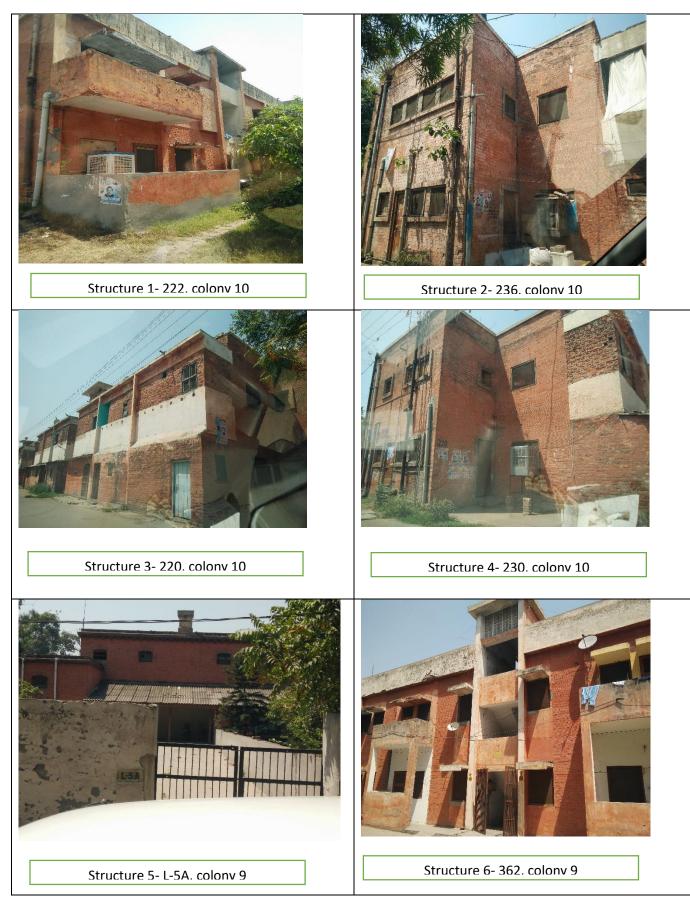
6.3 CONCLUSIONS

- In the project consisting of RVS of 35 structures in various localities of Ludhiana 7 structures came in the category of no damage, namely 23,24,25,27,29,30,31.
- Modified RVS method shows that 15 structures, i.e. 43 % of the total sample require further evaluation. The same as per BIS and FEMA methods is 27, i.e. 77% of the total sample.
- Some results are supported by both FEMA and BIS methods. For example Structure 30 was found to be the strongest in terms of both damageability estimates, G1 and final score, 3.84 whereas structure 11 was found to be the weakest in the same, G4, G5 and -1.375.
- The BIS method was found to give damageability estimates of a higher degree out of all 3 methods. The modified RVS method usually gave estimates close to or slightly lower than those by FEMA standards. This could be due to the positive modifier scores influencing the proposed damageability grades such as in case of old and well maintained structures. Thus it can be stated that the modified system gives a more qualitative result than the other two methods.
- A further variation in structures which obtained the same FEMA scores shows a more detailed estimate of their seismic vulnerabilities. This improves our results since otherwise they would have been impossible to differentiate.
- Thus the modified RVS system provides a better method for older structural forms as compared to FEMA method since it provides a more accurate picture of their current condition.
- Considering the availability of computers and other electronic gadgets RVS procedure may be efficiently and economically applied for condition assessment of structures on a large scale.
- RVS procedure may be applied in difficult situations such as in post-earthquake surveys for condition assessment of structures for the sake of award of compensation.

6.4 FUTURE SCOPE

- Firstly, the additional modifier factors and weights can be further improved to improve the accuracy of the system. Along with this further research can be conducted by using test buildings to obtain practical data and checking if it was consistent with the data obtained during RVS or not.
- Secondly, a more mechanized approach involving neural networks or fuzzy logic or any such spectrum based logic function could be utilized to further improve the results of RVS. Along with this suitable devices with built in optical analysis software can be used to more accurately gauge any structure with only a handful of input parameters requires. This will thus eliminate the human subjective errors.
- Thirdly, more research can be carried out to develop a scoring method that is entirely separate from the FEMA method as is used in this project.
- Fourthly, a slight amount of testing apparatus could be used during the course of the survey for better assessment of the structure since not all damages can be visually inspected.

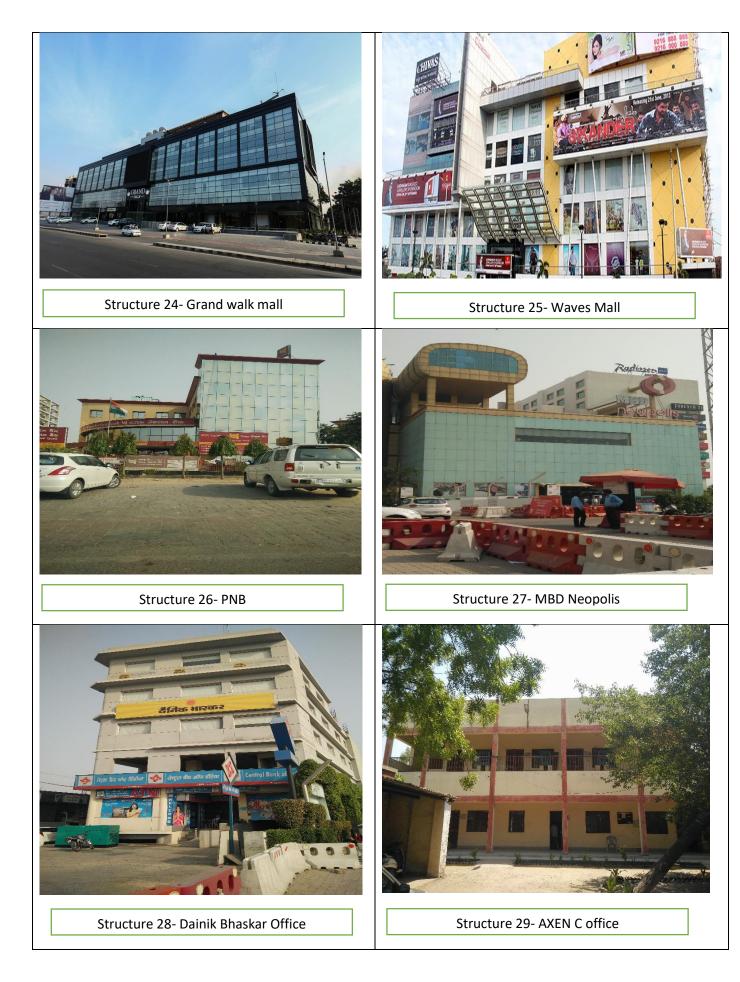
ANNEXURE A – PHOTOGRAPHS













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