Develop Database on Code Compliant & Non-Compliant RC Structures

FINAL YEAR PROJECT – UG BATCH 2018

NUST Institute of Civil Engineering (NICE)

School of Civil and Environmental Engineering (SCEE)

National University of Sciences and Technology Islamabad, Pakistan

(2022)

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Final Year Project Titled

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has been accepted towards requirements for the undergraduate degree in CIVIL ENGINEERING

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Our efforts towards a seismic field are also due to the 80,000 people that lost their lives in the deadly Earthquake of 05th-Oct-2005. Their lives have changed our views and enabled us to understand the importance of Seismic safety of our structures. These efforts will remain continued and we have tried to play our part at our level in it.

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ABSTRACT

With every passing year, our buildings are getting older and we should know which buildings no longer can withstand the seismic activities so are in a need of our attention and which are safe to use. To know this, we can do a detailed structural analysis on each building but it will require a lot of time and resources per building. So, there should be a way of eliminating some fraction of buildings which are safe and highlight some fraction of buildings which are need of detailed structural analysis so that a lot of time and valuable resources do not go into waste.

In other countries there is an empirical technique of RAPID VISUAL SCREENING in practice. By performing this technique on a region's buildings, they are being able to develop a database which helps them in identifying the buildings which are in a need of detailed analysis. This technique saves a lot of time and valuable resources. We have also performed the same technique on the 225 commercial buildings of G-sectors and have developed a database on code compliant and non-compliant RC structures. This report will help in eliminating the buildings which are safe and do not need the detailed analysis and vice versa. This report will also help in making of 3 representative building models of these 225 buildings and 3 representative building models for each G sector, which can act as input data for analytical analysis.

Chapter 1: Introduction

1.1 Background and Motivation

Unlike gravitational force, Earthquake is a very strange force that behaves in a very different way as far as structural behavior is concerned. It is also frequently mentioned that "Earthquake in itself is not responsible for the death of people, it is due to poor design of the buildings". From recent earthquakes, it is clear and evident when poor design and low-quality construction combines with earthquake force; the result is disastrous causing loss of lives and a blow to economy. Kashmir Earthquake (2006) was the wakeup call for designers and engineers, that building construction in Pakistan must be improved to follow a certain level of standards so that lives can be saved. Moreover, destruction caused by recent earthquakes in Pakistan, demands for an urgent seismic vulnerability assessment of all the buildings especially the significant buildings located in highly seismic prone areas such as the commercial buildings in Islamabad which we focused on. But there is a drawback to these seismic hazard assessment for high seismic zones – they are very expensive, time taking and complex, thus requiring some modified vulnerability assessment methods. One such method which is less expensive and very fast is Rapid visual screening (RVS). It is a very useful technique to narrow down the buildings that need simplified vulnerability assessment procedures and helps in determining critical structures which need detailed vulnerability assessment. It will be handy to identify seismic vulnerable buildings so that these buildings can be retrofitted timely before they collapse in the event of an earthquake.

1.2 Seismic Hazard Assessment

Seismic Risk Assessment is performed to predict the probability of economic losses and infrastructure damage according to potential earthquake scenarios.

1.2.1 Types of Seismic Assessments

1. **Seismic Hazard Assessment:**
   Seismic hazard assessment is an struggle by earth scientists to quantify seismic hazard. It is also an effort to quantify its associated uncertainty in time and space. The ultimate purpose is to provide seismic hazard estimates for seismic risk assessment and other applications.

2. **Seismic Vulnerability Assessment:**
   In the case of earthquakes of given intensity, the seismic vulnerability of a structure is a quantity associated with its weakness. The value of this quantity and the knowledge of seismic hazard enables us to evaluate the expected damage from future earthquakes

We will be performing **Seismic Vulnerability Assessment** in our project.

which can be subdivided into

1. Empirical Techniques
2. Analytical Techniques

We will be using a well-known and most used empirical technique which is **Rapid Visual Screening.**

Figure 1: Types of Seismic Risk Assessment

1.3 Rapid Visual Screening

In 1988 in the United States of America, the need for a fast, reliable and easy method for seismic vulnerability was first identified. It was proposed by the Federal Emergency Management Agency (FEMA) as "Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook".

RVS is carried out by a visual inspection of structures during a street survey without the need of accessing any structure. Approximately 15-20 minutes is required for each building. The important thing is to collect the structural and nonstructural features of the building. A structural score is calculated based on the data that is collected. This score is used to compute the damage which will be caused if an earthquake occurs and if the structure needs further analyzing.

1.4 Problem statement

Islamabad lies in an area of high to moderate seismicity and no large-scale seismic vulnerability assessment using empirical techniques has been performed before. There are many builds which are non-code complaint hence it is imperative to find out whether the commercial buildings are at a risk of seismic hazard.

1.5 Following are the objectives of this project:

- Complete a data base on code complaint and non-complaint commercial buildings in G-sector, Islamabad.
- Get the Fema P-154 scores for the commercial buildings and find out which ones are in need of structural seismic vulnerability assessment

Chapter 2: Literature Review

2.1 Seismicity in Pakistan

Pakistan is one of the most seismically active regions in the world. There is continuous subduction of the Indian plate beneath the Eurasian plate.

It is reported by Meteorological Department (PMD), 58 earthquakes in the past fifty years of considerable magnitude struck Pakistan causing serious damage to lives and economy. However, the top six most dangerous earthquakes to have struck Pakistan are

1. The famous Kangra earthquake 1905
2. Quetta earthquake 1935
3. Makran earthquake 1945
4. Kashmir earthquake 2005
5. Southern Pakistan earthquake 2011
6. Awaran earthquake 2013

On average, Every 10 years, Pakistan may experience an earthquake which can cause social and economic losses. The 2005 Kashmir earthquake resulted in around 73,000 casualities, 80,000 wounded or injured and 2.8 mil people were left homeless. Around US$ 5198 million total losses are estimated due to the Kashmir earthquake. The causes of this is a lack of awareness, building codes not being followed. We are just not prepared enough.

It is also further due to ineffective policies and the ineffective implementation of effective policis that these losses occur. It is due to these huge losses of infrastructure and lives in the history of Pakistan, the seismic prone districts require seismic vulnerability assessment.

Usually, Pakistani buildings are constructed without following the building designs and are semi-engineered or non-engineered. Surveys suggest that ninety percent of the buildings in Pakistan are masonry that is non-enginered. And also very less research is being conducted on these non-engineered buildings. These non-engineered buildings perform fine against gravity loads but fail to stand against lateral loads. It is therefore necessary to assess the vulnerability of such types of buildings which are in a high-risk earthquake area, so effective measures can be taken in case of an earthquake.

It can be clearly seen in the seismic hazard map, Islamabad lies in an area of moderate to high PGA values hence the seismic assessment of its buildings is important.

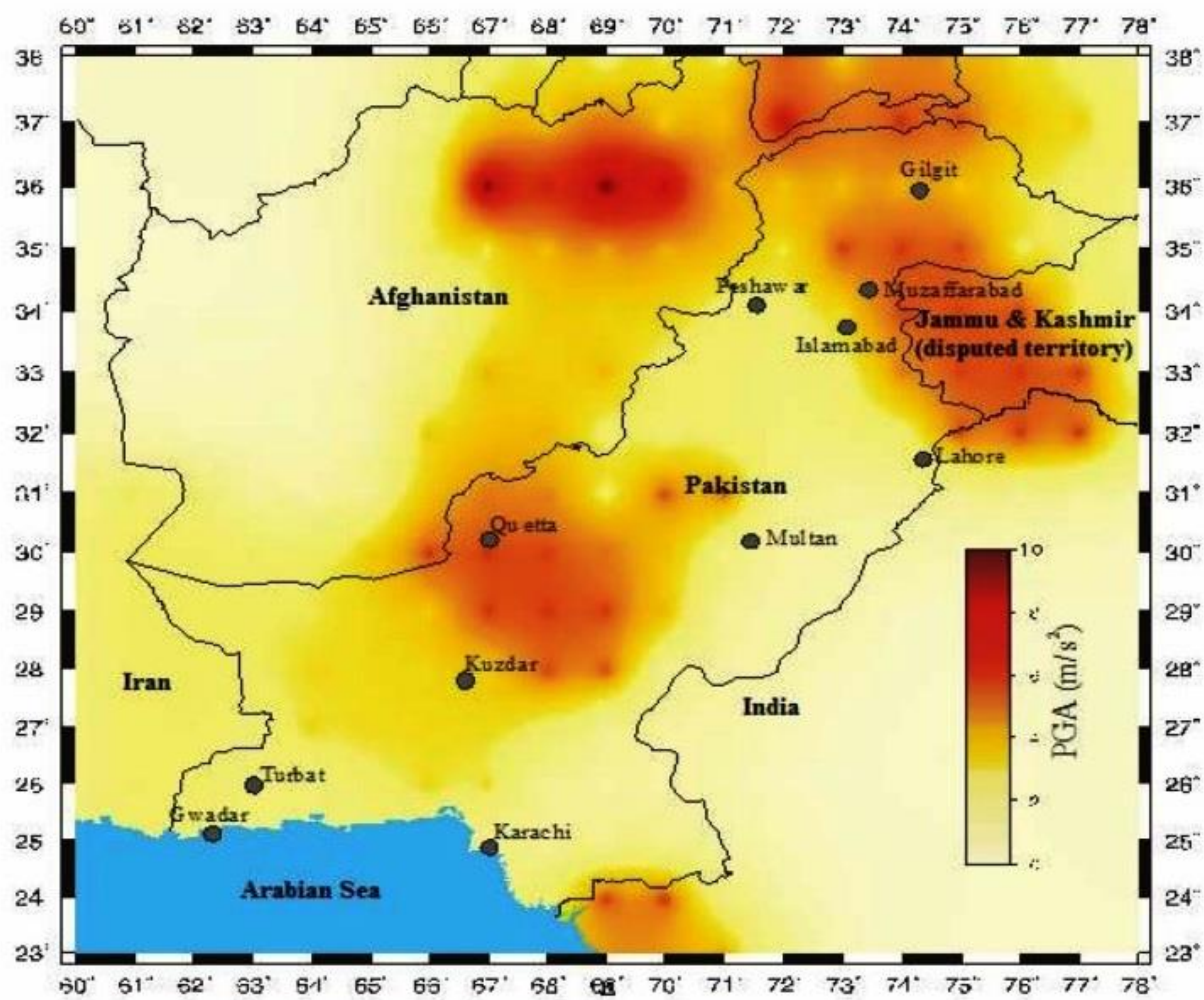


Figure 2: Seismic Hazard Map of Pakistan

2.2 Usage of Fema-154 in Pakistan for seismic vulnerability assessment

FEMA-154 is not as popular in Pakistan. One study has been conducted before in the area of Malakand. In this performed study, vulnerability assessment of different buildings was performed using the latest FEMA methods. The area selected was Malakand district of KPK which is a high Earthquake prone zone. Malakand had been declared a high seismicity zone by the NDMA of Pakistan but no such assessment like this had been performed before. Structural damage assessment suggests that Malakand may suffer a losses if an earthquake was to hit it. It was clearly not possible to replace the vulnerable buildings as it would be too costly and unpractical, so it was imperative to spread awareness among the masses so they would take them measures necessary to protect themselves against earthquake damage. People frequently invest in the decorations of their houses – interior and exterior. But if they were warned they would also invest in the retrofitting of their homes.

Vulnerability assessment of the buildings and then rehabilitation and restoration can reduce the potential damage caused by these earthquakes. The technique was the same one as the one we used, Rapid Visual Screening and using Fema-154.

2.2.1 Results of this study

During the survey, it was observed that unconfined masonry buildings had heavy damages caused by recent earthquakes. Stone masonry, followed by block and brick masonry experienced the maximum damages, respectively. Reinforced concrete buildings were semi-engineered. There were severe vertical irregularities such as

- column
- soft story
- vertical setbacks
- heavy overhangs

The most common type of irregularities found were the L and U shaped. Structural scores obtained showed that almost fifty percent of the buildings needed rehabilitation or they needed to be entirely replaced.

School buildings were further found to be more vulnerable than the residential buildings. On the surveyed buildings, US$ 13.5 million total economical losses are expected. This is less than one percent of the total stock of buildings

2.3 RVS techniques employed across the globe

The common RVS methodologies adopted by various countries across the globe including

1. Rapid Visual Screening by USA (FEMA)
2. Greek method by Earthquake Planning and Protection Organization (OASP)
3. Rapid Evaluation method by New Zealand Society of Earthquake Engineering (NZSEE)
4. Indian approach based on FEMA 154 (developed by IIT Kanpur)
5. Rapid Visual Screening by Canada developed by National Research Council (NRC)
6. Japanese method developed by Japanese Building Disaster Prevention Association (JBDPA)
7. Turkish method developed by the Structural Engineering Research Unit (TERU)
8. The Italian method by the National Earthquake Defense Group (GNDT)

Chapter 3: Methodology

3.1 Introduction to RVS

We will be using the a well-known and most used empirical technique which is **Rapid Visual Screening.**

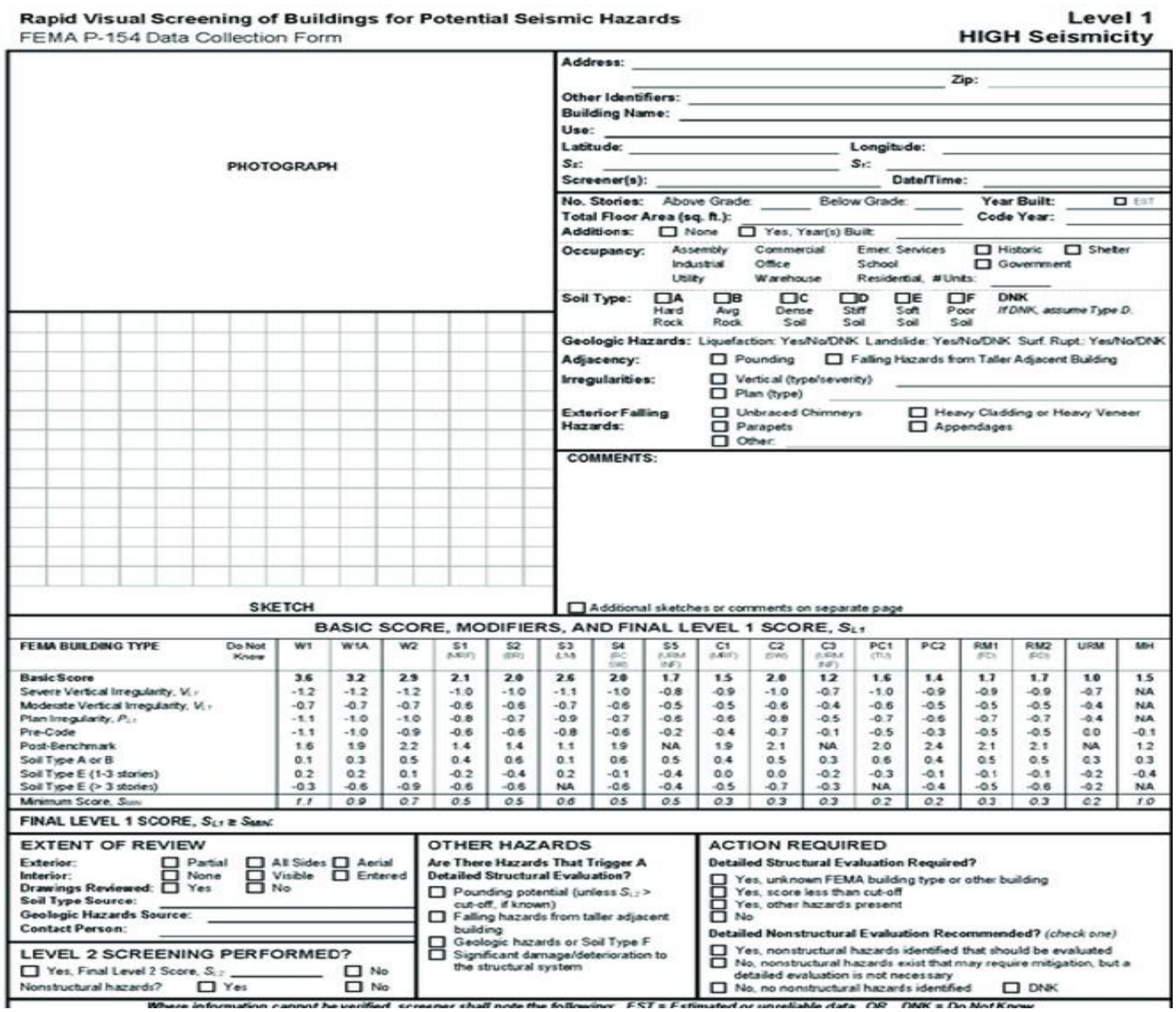
The rapid visual screening (RVS) technique has been advanced to identify, inventory, and display screen homes which might be probably hazardous in the event of a seismic activity. The RVS technique makes use of a method primarily based totally on a sidewalk survey of a construction and a Data Collection Form, which the individual engaging in the survey completes, primarily based totally on visible remarks of the construction from the exterior, and if possible, the interior. There are different methods available for performing of this technique which are as follows:

1. FEMA P-154 *(USA)*
2. EMS (98) *(Europe)*
3. IITK – GGSDMA *(Indian)*
4. EMPI *(Turkish)*

3.2 Fema P-154 Characteristics

We chose FEMA P-154 as our method for our project as it is the most mature and detailed one.

The follow figure shows the characteristics of the fema form.



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

Level 1
HIGH Seismicity

PHOTOGRAPH

Address:
Zip:
Other Identifiers:
Building Name:
Use:
Latitude: **Longitude:**
S_S: **S_1:**
Screener(s): **Date/Time:**

No. Stories: Above Grade: Below Grade: **Year Built:** ☐ EST
Total Floor Area (sq. ft.): **Code Year:**
Additions: ☐ None ☐ Yes, Year(s) Built:
Occupancy: Assembly Commercial Emer. Services ☐ Historic ☐ Shelter Industrial Office School ☐ Government Utility Warehouse Residential, #Units:
Soil Type: ☐A Hard Rock ☐B Avg Rock ☐C Dense Soil ☐D Stiff Soil ☐E Soft Soil ☐F Poor Soil DNK *If DNK, assume Type D.*
Geologic Hazards: Liquefaction: Yes/No/DNK Landslide: Yes/No/DNK Surf. Rupt.: Yes/No/DNK
Adjacency: ☐ Pounding ☐ Falling Hazards from Taller Adjacent Building
Irregularities: ☐ Vertical (type/severity) ☐ Plan (type)
Exterior Falling Hazards: ☐ Unbraced Chimneys ☐ Heavy Cladding or Heavy Veneer ☐ Parapets ☐ Appendages ☐ Other:

COMMENTS:

SKETCH

☐ Additional sketches or comments on separate page

BASIC SCORE, MODIFIERS, AND FINAL LEVEL 1 SCORE, S_{L1}

FEMA BUILDING TYPE	Do Not Know	W1	W1A	W2	S1 (MRF)	S2 (BR)	S3 (LM)	S4 (RC SW)	S5 (URM INF)	C1 (MRF)	C2 (SW)	C3 (URM INF)	PC1 (TU)	PC2	RM1 (FD)	RM2 (RD)	URM	MH
Basic Score		**3.6**	**3.2**	**2.9**	**2.1**	**2.0**	**2.6**	**2.0**	**1.7**	**1.5**	**2.0**	**1.2**	**1.6**	**1.4**	**1.7**	**1.7**	**1.0**	**1.5**
Severe Vertical Irregularity, V_{L1}		-1.2	-1.2	-1.2	-1.0	-1.0	-1.1	-1.0	-0.8	-0.9	-1.0	-0.7	-1.0	-0.9	-0.9	-0.9	-0.7	NA
Moderate Vertical Irregularity, V_{L1}		-0.7	-0.7	-0.7	-0.6	-0.6	-0.7	-0.6	-0.5	-0.5	-0.6	-0.4	-0.6	-0.5	-0.5	-0.5	-0.4	NA
Plan Irregularity, P_{L1}		-1.1	-1.0	-1.0	-0.8	-0.7	-0.9	-0.7	-0.6	-0.6	-0.8	-0.5	-0.7	-0.6	-0.7	-0.7	-0.4	NA
Pre-Code		-1.1	-1.0	-0.9	-0.6	-0.6	-0.8	-0.6	-0.2	-0.4	-0.7	-0.1	-0.5	-0.3	-0.5	-0.5	0.0	-0.1
Post-Benchmark		1.6	1.9	2.2	1.4	1.4	1.1	1.9	NA	1.9	2.1	NA	2.0	2.4	2.1	2.1	NA	1.2
Soil Type A or B		0.1	0.3	0.5	0.4	0.6	0.1	0.6	0.5	0.4	0.5	0.3	0.6	0.4	0.5	0.5	0.3	0.3
Soil Type E (1-3 stories)		0.2	0.2	0.1	-0.2	-0.4	0.2	-0.1	-0.4	0.0	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	-0.2	-0.4
Soil Type E (> 3 stories)		-0.3	-0.6	-0.9	-0.6	-0.6	NA	-0.6	-0.4	-0.5	-0.7	-0.3	NA	-0.4	-0.5	-0.6	-0.2	NA
Minimum Score, S_{MIN}		*1.1*	*0.9*	*0.7*	*0.5*	*0.5*	*0.6*	*0.5*	*0.5*	*0.3*	*0.3*	*0.3*	*0.2*	*0.2*	*0.3*	*0.3*	*0.2*	*1.0*

FINAL LEVEL 1 SCORE, $S_{L1} \geq S_{MIN}$:

EXTENT OF REVIEW
Exterior: ☐ Partial ☐ All Sides ☐ Aerial
Interior: ☐ None ☐ Visible ☐ Entered
Drawings Reviewed: ☐ Yes ☐ No
Soil Type Source:
Geologic Hazards Source:
Contact Person:

LEVEL 2 SCREENING PERFORMED?
☐ Yes, Final Level 2 Score, S_{L2} ☐ No
Nonstructural hazards? ☐ Yes ☐ No

OTHER HAZARDS
Are There Hazards That Trigger A Detailed Structural Evaluation?
☐ Pounding potential (unless S_{L2} > cut-off, if known)
☐ Falling hazards from taller adjacent building
☐ Geologic hazards or Soil Type F
☐ Significant damage/deterioration to the structural system

ACTION REQUIRED
Detailed Structural Evaluation Required?
☐ Yes, unknown FEMA building type or other building
☐ Yes, score less than cut-off
☐ Yes, other hazards present
☐ No
Detailed Nonstructural Evaluation Recommended? *(check one)*
☐ Yes, nonstructural hazards identified that should be evaluated
☐ No, nonstructural hazards exist that may require mitigation, but a detailed evaluation is not necessary
☐ No, no nonstructural hazards identified ☐ DNK

Where information cannot be verified, screener shall note the following: EST = Estimated or unreliable data OR DNK = Do Not Know

Figure 3: FEMA High Seismicity Form

3.3 Site Identification Information:

The follow data is to be filled:

Address: ____________________

____________________ Zip: ________

Other Identifiers: ____________________

Building Name: ____________________

Use: ____________________

Latitude: ________ Longitude: ________

S_S: ________ S_1: ________

Screener(s): ________ Date/Time: ________

Figure 4: Site Identification Information

3.3.1 Site Characteristics:

Space is supplied to report critical site characteristics (see Figure).

No. Stories: Above Grade: ____ Below Grade: ____ Year Built: ____ ☐

Total Floor Area (sq. ft.): ________ Code Year: ____

Additions: ☐ None ☐ Yes, Year(s) Built: ________

Figure 5: Site Characteristics

3.3.2 Number of Stories

The number of stories are counted and filled in the fema form. The variety of stories is an idcator of the peak of a site. We additionally made sure to count the stories below ground.

3.3.3 Year Built and Code Year:

This record isn't normally to be had on the site. If record on “year built” isn't to be had as in our case, a difficult estimate of the constructing’s age may be made on the idea of architectural fashion and site use.

3.3.4 Total Floor Area:

Most possibly be predicted through multiplying the predicted place of 1 story through the whole number of stories withinside the site. Total ground place can be beneficial at a later time for estimating the fee of the constructing or for estimating occupancy load.

3.3.5 Photographing the Site:

Photos of site are placed in the form as shown. We used to take at the least 1 image for every site.

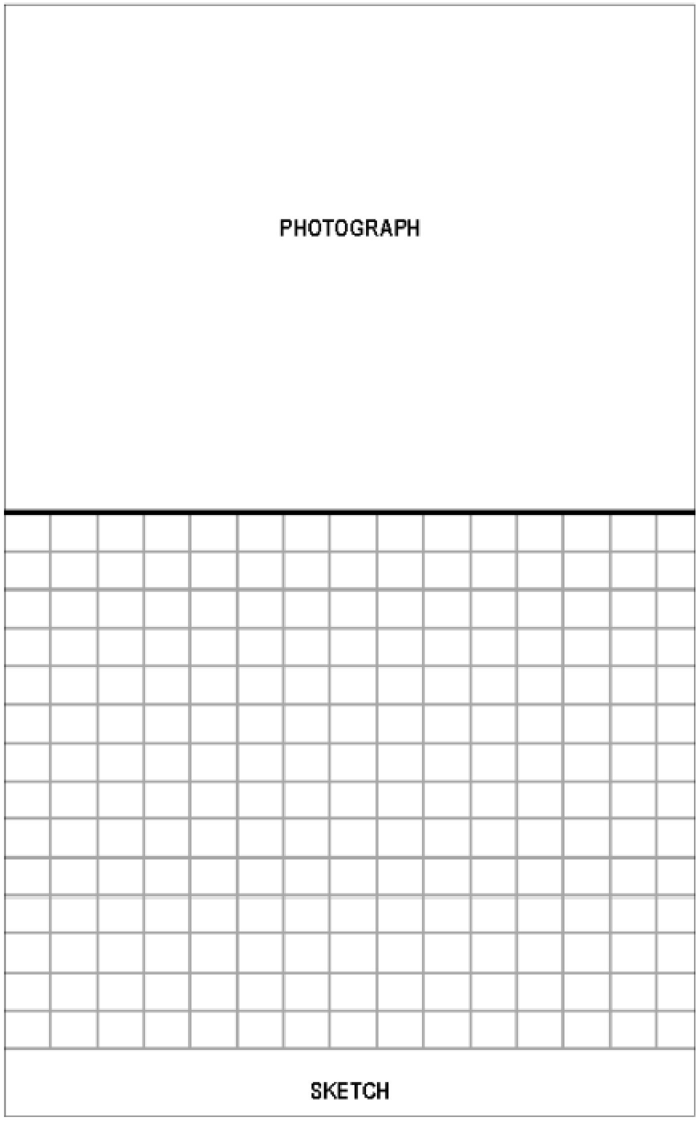


Figure 6: Building Visuals

Sufficient distance is provided for large buildings to accommodate the frame of the camera.

Moreover multiple photos are also taken from different angles.

3.3.6 Sketching the Site:

A place is provided on the Level 1 Data Collection Form to draw a sketch of the site (see Figure). We used to draw a plan sketch. Drawing the sketch is an important part of the screening procedure because many of the site's attributes will be revealed.

3.3.7 Site Occupancy:

The occupancy of a site refers to its use. Although it does now no longer normally endure at once at the structural threat or chance of maintaining foremost damage, the occupancy of a site is of interest and used whilst figuring out priorities for mitigation.

3.3.8 Occupancy Classes:

There are 9 of them as shown in the figure:

Occupancy:	Assembly	Commercial	Emer. Services	☐ Historic	☐ Shelter
	Industrial	Office	School	☐ Government	
	Utility	Warehouse	Residential, # Units:	________	

Figure 7: Occupancy Classes

3.3.9 Soil Type:

The right type of soil type is recognized and then is ticked in the form. If the type is unknown, we opt for the option D.

Soil Type:	☐**A** Hard Rock	☐**B** Avg Rock	☐**C** Dense Soil	☐**D** Stiff Soil	☐**E** Soft Soil	☐**F** Poor Soil	**DNK** *If DNK, assume Type D.*

Figure 8: Soil Type

3.3.10 Geologic Hazards:

A detailed structural analysis is required if any of the following hazards are identified on the site.

Geologic Hazards: Liquefaction: Yes/No/DNK Landslide: Yes/No/DNK Surf. Rupt.: Yes/No/DNK

Figure 9: Geological Hazards

3.3.11 Adjacency:

When there is insufficient distance between sites, they can "pound" together resulting in damage. Another danger is that an adjacent building which is taller can result in fall of hazards to the lower buildings in case of an seismic event.

Adjacency: ☐ Pounding ☐ Falling Hazards from Taller Adjacent Building

Figure 10: Adjacency

3.4 Irregularities:

There are multiple irregularities present in a building due to multiple reasons such as architectural, functional etc.

Irregularities: ☐ Vertical (type/severity) ______
☐ Plan (type) ______

Figure 11: Irregularities

3.4.1 Vertical Irregularities:

Vertical irregularities can have an effect on all site types. There are sixcommon styles of vertical irregularities which can be defined below:

1. Sloping Site
2. Weak Story
3. Out-of-Plane Setback
4. In-Plane Setback
5. Short Column/Pier
6. Split Levels

3.4.2 Plan Irregularities:

There are 5 common forms of plan irregularities which might be defined below:

Torsion

Non-Parallel Systems

Reentrant Corners

Diaphragm Openings

Beams do not align with columns:

If the site being screened has a plan irregularity, we used to test the plan irregularity field within side the Irregularities phase of the shape and word the form of irregularity.

3.5 Exterior Falling Hazards:

Lots of exterior falling hazards are present such as:

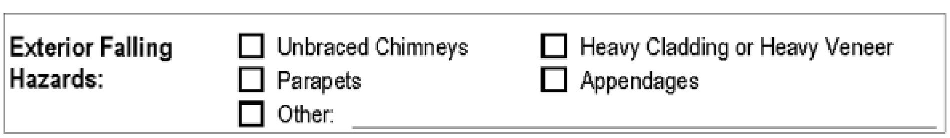

Exterior Falling Hazards:
☐ Unbraced Chimneys
☐ Parapets
☐ Other: ____
☐ Heavy Cladding or Heavy Veneer
☐ Appendages

Figure 12: Exterior Falling Hazards

Falling risks of important concern are:

3.5.1 Unbraced Chimneys:

Unbraced, unreinforced masonry chimneys are common in older masonry and wooden body dwellings. They are regularly inadequately tied to the shape and fall in slight to robust shaking. If unsure as to whether or not a chimney is braced or unbraced, count on that it's far unbraced.

3.5.2 Parapets:

A parapet is the part of the outdoors wall or façade that extends above the roof. The number one challenge is parapets built of unreinforced masonry, together with brick, stone, or concrete block. In an earthquake, those can break and fall onto the roof or out into the street. It is occasionally hard to inform if a façade tasks above the roofline, forming a parapet and, if there's a parapet, it's far regularly hard to inform if it's far braced. Parapets regularly exist on 3 facets of the site, and their height can be seen from the returned of the shape. In a few cases, the presence of bracing can be demonstrated the use of satellite imagery. If unsure as to whether or not an unreinforced masonry parapet is braced or unbraced, count on that it is unbraced.

3.5.3 Heavy Cladding

Large heavy cladding factors, normally precast concrete/reduce stone, may also fall off the site all through an earthquake if it is not anchored properly

3.5.4 Appendages:

Appendages which are anchored on a building may fall off in case of an earthquake if they are not properly anchored.

3.5.5 Other

There may be any other threat that is present for the building whose option is not available on the FEMA form. For this, we can select “other”.

3.6 Identifying the FEMA Site Type:

- **Step 1:**

Identify the gravity system. Is the site commonly timber, steel, concrete, or masonry? Screen out substances that the site obviously isn't always to reach at one or materials.

- **Step 2:**

Identify the form of seismic force-resisting system. Is the seismic force-resisting system a frame, braced frame, or bearing wall?

- **Step 3:**

Based at the material kind from Step 1 and the form of seismic force-resisting system from Step 2, cast off as many FEMA Site Types as feasible. We had been usually capable of narrow down the feasible FEMA Site Types to among one and three.

Of those steps, figuring out the seismic force-resisting device (Step 2) is possibly the maximum challenging. A frame structure (for example, S1, S3, S4, C1, or PC2) is made of beams and columns at some point of the whole shape, resisting each vertical and lateral loads. A braced frame structure (S2) has beams and columns that withstand vertical loads and diagonal braces that withstand lateral hundreds. A bearing wall shape (for example, PC1 and URM) makes use of vertical-load-bearing partitions, which can be greater or much less solid, to face up to the vertical and lateral hundreds.

3.7 Screening Sites with More Than One FEMA Site Type:

Sometimes, a building may satisfy more than one FEMA types then we fill the forms below:

3.7.1 Score Modifiers:

Once we are done with the top half of the level 1 form, we are now able to calculate the final score of the building. Each building has a basic score and then there are score modifiers which change the score of the building. These score modifiers can be positive and negative. There are many score modifiers such as:

BASIC SCORE, MODIFIERS, AND FINAL LEVEL 1 SCORE, S_{L1}

FEMA BUILDING TYPE	Do Not Know	W1	W1A	W2	S1 (MRF)	S2 (BR)	S3 (LM)	S4 (RC SW)	S5 (URM INF)	C1 (MRF)	C2 (SW)	C3 (URM INF)	PC1 (TU)	PC2	RM1 (FD)	RM2 (RD)	URM	MH
Basic Score		**3.6**	**3.2**	**2.9**	**2.1**	**2.0**	**2.6**	**2.0**	**1.7**	**1.5**	**2.0**	**1.2**	**1.6**	**1.4**	**1.7**	**1.7**	**1.0**	**1.5**
Severe Vertical Irregularity, V_{L1}		-1.2	-1.2	-1.2	-1.0	-1.0	-1.1	-1.0	-0.8	-0.9	-1.0	-0.7	-1.0	-0.9	-0.9	-0.9	-0.7	NA
Moderate Vertical Irregularity, V_{L1}		-0.7	-0.7	-0.7	-0.6	-0.6	-0.7	-0.6	-0.5	-0.5	-0.6	-0.4	-0.6	-0.5	-0.5	-0.5	-0.4	NA
Plan Irregularity, P_{L1}		-1.1	-1.0	-1.0	-0.8	-0.7	-0.9	-0.7	-0.6	-0.6	-0.8	-0.5	-0.7	-0.6	-0.7	-0.7	-0.4	NA
Pre-Code		-1.1	-1.0	-0.9	-0.6	-0.6	-0.8	-0.6	-0.2	-0.4	-0.7	-0.1	-0.5	-0.3	-0.5	-0.5	0.0	-0.1
Post-Benchmark		1.6	1.9	2.2	1.4	1.4	1.1	1.9	NA	1.9	2.1	NA	2.0	2.4	2.1	2.1	NA	1.2
Soil Type A or B		0.1	0.3	0.5	0.4	0.6	0.1	0.6	0.5	0.4	0.5	0.3	0.6	0.4	0.5	0.5	0.3	0.3
Soil Type E (1-3 stories)		0.2	0.2	0.1	-0.2	-0.4	0.2	-0.1	-0.4	0.0	0.0	-0.2	-0.3	-0.1	-0.1	-0.1	-0.2	-0.4
Soil Type E (> 3 stories)		-0.3	-0.6	-0.9	-0.6	-0.6	NA	-0.6	-0.4	-0.5	-0.7	-0.3	NA	-0.4	-0.5	-0.6	-0.2	NA
Minimum Score, S_{MIN}		*1.1*	*0.9*	*0.7*	*0.5*	*0.5*	*0.6*	*0.5*	*0.5*	*0.3*	*0.3*	*0.3*	*0.2*	*0.2*	*0.3*	*0.3*	*0.2*	*1.0*

Figure 13: Basic Score Modifiers

3.7.2 Vertical Irregularity:

If one or greater excessive vertical irregularities had been recognized within side the Irregularities phase of the form.

3.7.3 Plan Irregularity:

If one or greater plan irregularities had been recognized within side the Irregularities phase of the form. the Plan Irregularity Score Modifier ought to be circled.

3.7.4 Pre-Code:

This Score Modifier is relevant if the site being screened was designed and built previous to the preliminary adoption and enforcement of seismic codes relevant for that FEMA Site Type.

3.7.5Post-Benchmark:

This Score Modifier is relevant if the site being screened turned into designed and built after notably advanced seismic codes relevant for that FEMA Site Type

3.7.6 Soil Type:

Different score modifiers are present for different soil types.

3.7.7 Minimum Score, SMIN:

Individual Score Modifiers had been evolved through calculating the possibility of disintegrate whilst various a single condition. Summing more than one Score Modifiers can overestimate the blended impact of more than one situations and might bring about a very last rating much less than zero. A bad rating implies a possibility of disintegrate extra than 100%, which isn't always feasible. To deal with this, a Minimum Score, SMIN, is furnished. The Minimum Score turned into evolved through thinking about the worst feasible mixture of soil type, vertical and plan irregularities, and placement age, all at once.

3.8 Determining the Final Level 1 score:

The Final Level 1 score, SL1, is determined for a given site by adding the circled Score Modifiers for that site to the Basic Score for the site.

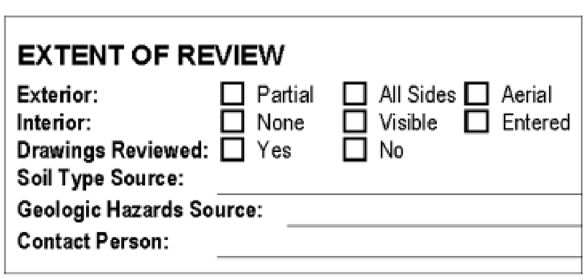
We used to check the sum of Basic Score and Score Modifiers against the Minimum Score, SMIN, and use the Minimum Score if it is larger than the sum. The result is documented on the bottom line of the scoring matrix next to “Final Level 1 score, SL1.”

When we used to be uncertain of the FEMA Site Type, an attempt should be made to eliminate all unlikely FEMA Site Types.

This is a conservative approach, and has the disadvantage that the assigned score may indicate that the site presents a greater risk than it actually does. If we had little or no confidence about any choice for the structural system, as in the case of sites with uncertain façade treatment, we would have circled DNK for “FEMA Site Type,” which indicates that we did not know. In that case, no SL1 score would have been calculated.

3.9 Documenting the Extent of Review:

The “Extent of Review” portion of the form is provided to document the thoroughness of the site screening.


EXTENT OF REVIEW

Exterior: ☐ Partial ☐ All Sides ☐ Aerial
Interior: ☐ None ☐ Visible ☐ Entered
Drawings Reviewed: ☐ Yes ☐ No
Soil Type Source:
Geologic Hazards Source:
Contact Person:

Figure 14: Extent of Review

3.10 Documenting the Level 2 Screening Results:

If we had additionally finished the elective Level 2 part of the form which we did not because of time constraints, the outcomes of the Level 2 screening might had been recorded on this segment of the Level 1 form (see Figure below).

3.11 Documenting Other Hazards:

Level 2 form required if we diagnose any other dangerous situation

LEVEL 2 SCREENING PERFORMED?

☐ Yes, Final Level 2 Score, S_{L2} ___________ ☐ No

Nonstructural hazards? ☐ Yes ☐ No

Figure 15: Level 2 Form

OTHER HAZARDS

Are There Hazards That Trigger A Detailed Structural Evaluation?

☐ Pounding potential (unless S_{L2} > cut-off, if known)

☐ Falling hazards from taller adjacent building

☐ Geologic hazards or Soil Type F

☐ Significant damage/deterioration to the structural system

Figure 16: Miscellaneous Hazards

3.12 Determining the Action Required:

The last step is to indicate the action required according to the form:

ACTION REQUIRED

Detailed Structural Evaluation Required?

- ☐ Yes, unknown FEMA building type or other building
- ☐ Yes, score less than cut-off
- ☐ Yes, other hazards present
- ☐ No

Detailed Nonstructural Evaluation Recommended? *(check one)*

- ☐ Yes, nonstructural hazards identified that should be evaluated
- ☐ No, nonstructural hazards exist that may require mitigation, but a detailed evaluation is not necessary
- ☐ No, no nonstructural hazards identified ☐ DNK

Figure 17: Action Required

3.13 Detailed Structural Evaluation:

We used to suggest whether or not a Detailed Structural Evaluation is needed through checking one of 4 boxes.

• Yes, unknown FEMA Site Type or different site. If we had very little self assurance approximately any desire for the structural system, or if the site does now no longer agree to any of the 17 FEMA Site Types taken into consideration at the form, the screening can't be used to finish that the site isn't probably dangerous. Therefore, a Detailed Structural Evaluation of the site need to be carried out through an skilled design professional.

• Yes, rating much less than cut-off. If the site gets a rating this is much less than the cut-off, it can be seismically dangerous and need to acquire a Detailed Structural Evaluation through an skilled design professional.

• Yes, different dangers present. If different dangers are present, as indicated within side the "Other Hazards" segment of the form, the site can be seismically dangerous and need to acquire a Detailed Structural Evaluation through an skilled design professional.

• No. If the site gets a rating more than the cut-off, and no different dangers are present, then a Detailed Structural Evaluation isn't required.

3.18 Detailed Nonstructural Evaluation:

The very last step of the screening is to suggest whether or not a Detailed Nonstructural Evaluation is suggested.

• Yes, nonstructural dangers recognized that need to be evaluated. This container is checked if a nonstructural chance has been found and in addition nonstructural assessment is suggested to decide whether or not the recognized capability falling chance is in reality a chance. For example, an in depth assessment might be vital to decide whether or not a site’s heavy cladding is well anchored. If the distinct assessment reveals that it is well anchored, the heavy cladding is not taken into consideration a falling chance.

• No, nonstructural dangers exist that can require mitigation, however an in depth assessment isn't vital. This container is checked if a nonstructural chance that could be a known chance has been found. For example, an unreinforced brick chimney. In those cases, extra assessment isn't vital, despite the fact that mitigation might be vital if the chance is to be reduced. The jurisdiction can also additionally determine to make mitigation of those falling dangers mandatory.

• No, no nonstructural dangers recognized. If no outdoors falling dangers were found for the duration of the screening, in addition nonstructural assessment isn't vital.

• DNK. A “do now no longer know” alternative is likewise supplied if have been not able to decide whether or not to advise an in-depth nonstructural assessment. We might have mentioned the motive of our uncertainty within side the remarks container.

Chapter 4: Results and Discussions

4.1 Scores of Total Buildings

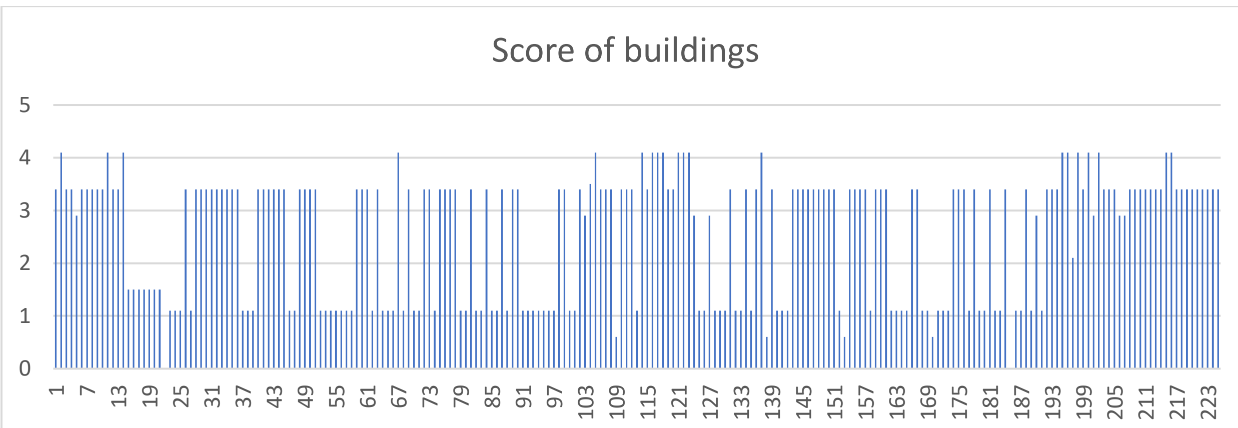


Figure 18:Score wise distribution of the buildings

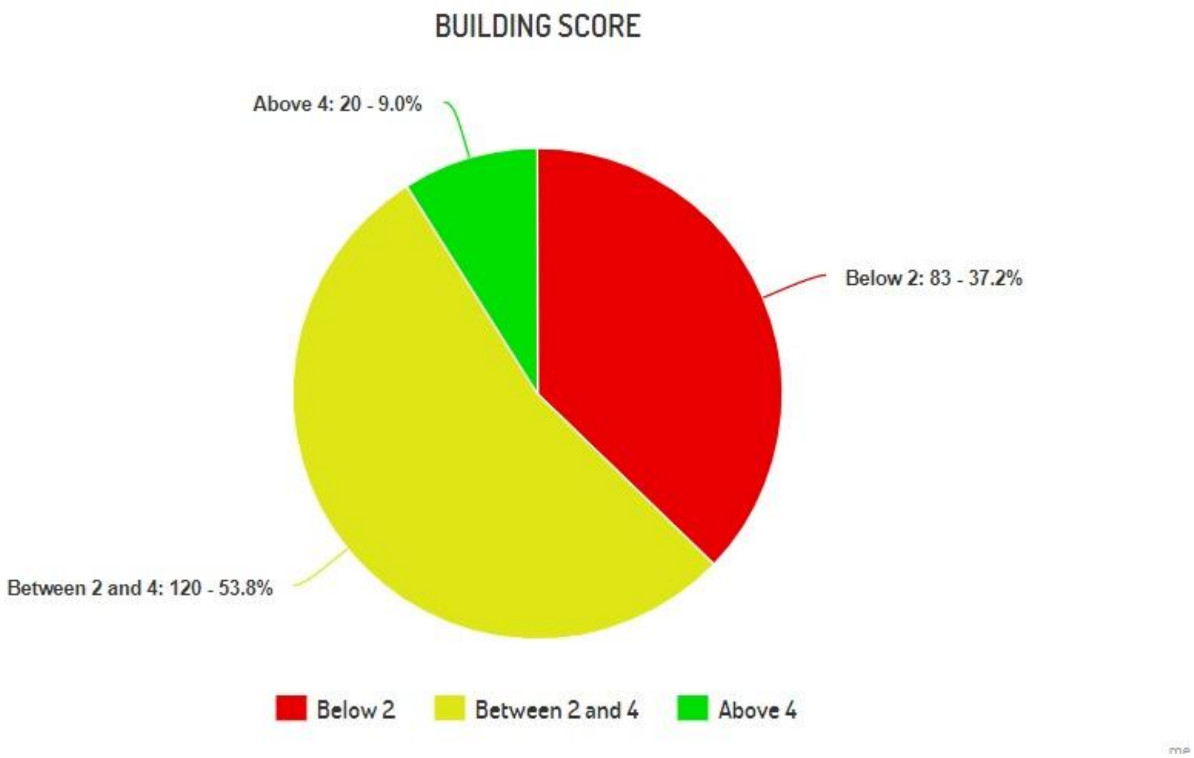


Figure 19: Score wise distribution of the buildings

The above fig shows that buildings that were surveyed had score ranges from 1 to 4.

The first we can deduce from this is out of all the 225 buildings the newly constructed ones would have score greater than 2. All the precode buildings will have a score of less than 2.

2 being the threshold for the competency of the building.

This data will further be classified into different sectors to get a better understanding.

4.2 Sector wise Score of buildings

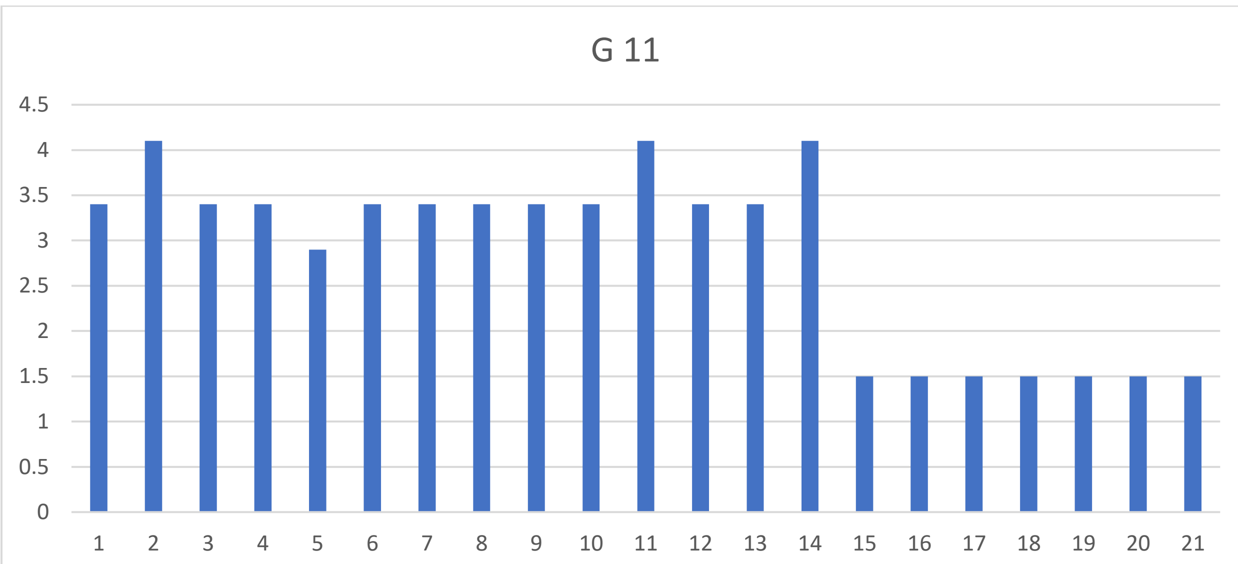


Figure 20:Score wise distribution of the buildings sector G-11

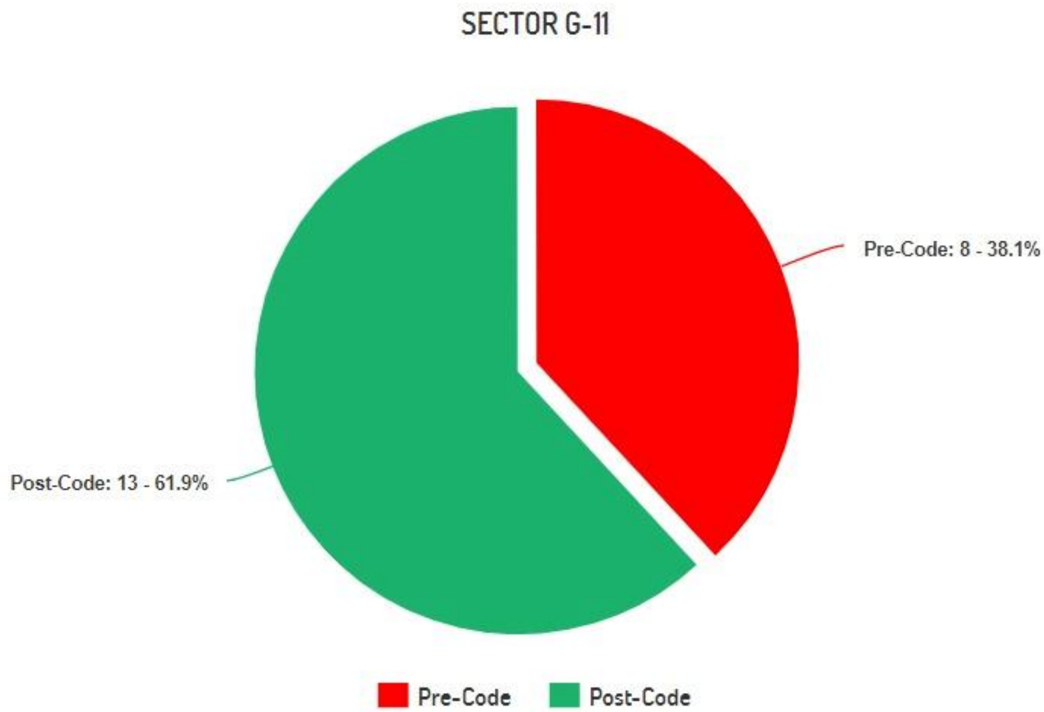


Figure 21: Pre/Post code distribution of buildings in G-11

This graph shows that the G11 sector have score range from 1.5 to 4. Building no 15-21 have low score these buildings were relatively old and are precode. So they have less score than that of newly constructed buildings like 1-14.

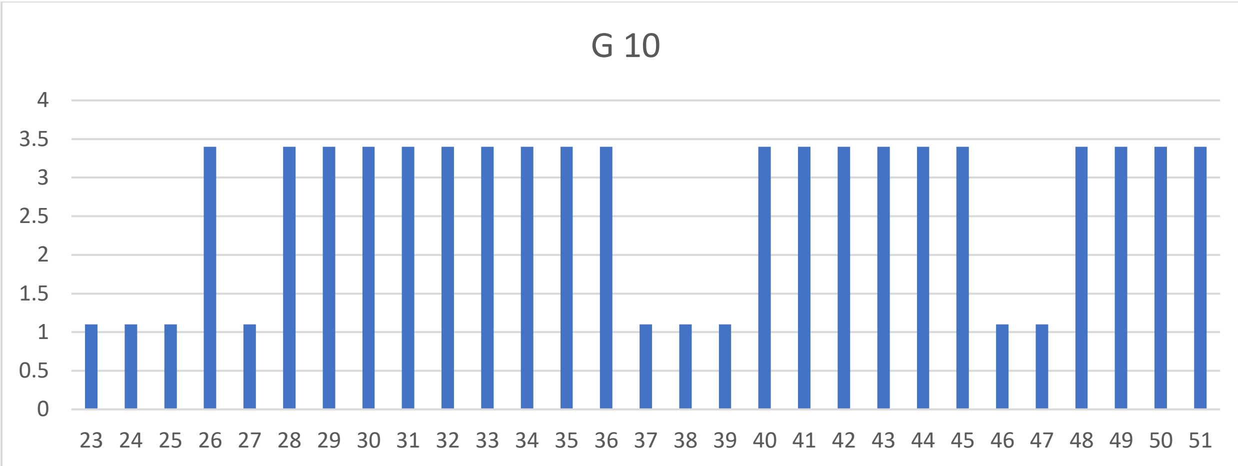


Figure 22:Score wise distribution of the buildings sector G-10

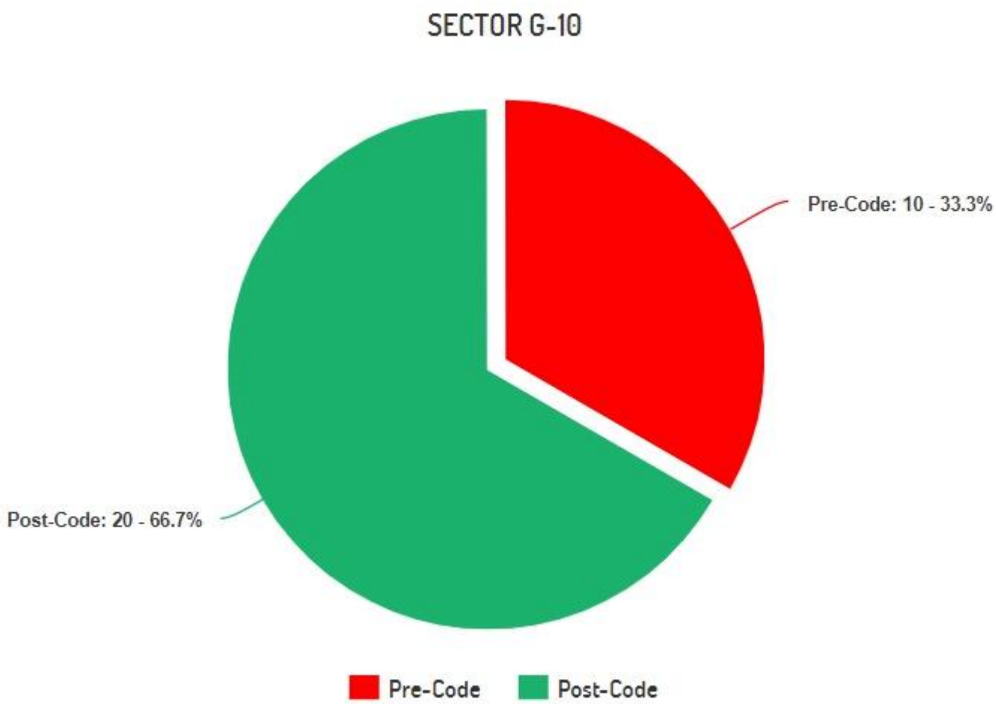


Figure 23: Pre/Post code distribution of buildings in G-10

Similarly the graph ranges from 1.1 to 3.4 . Buildings having score less than 2 are referred to further indepth analysis.

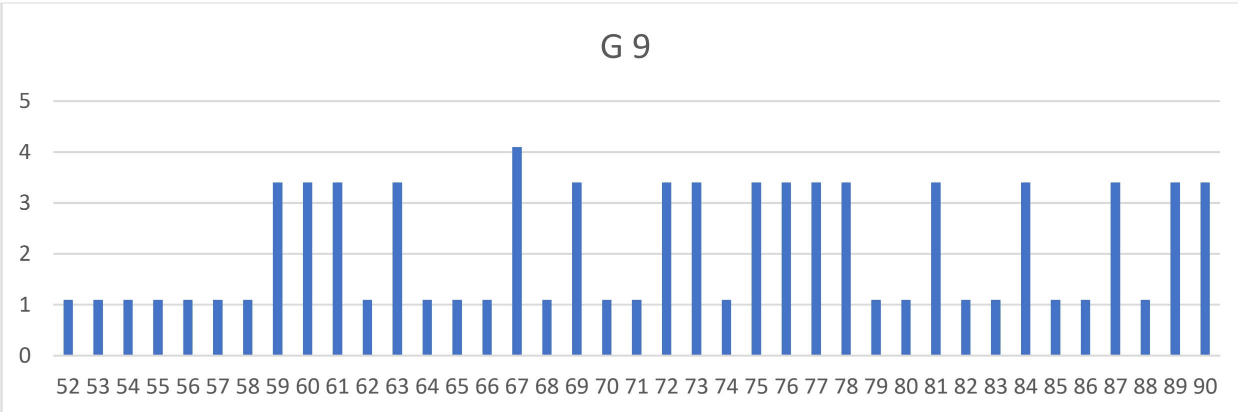


Figure 24:Score wise distribution of the buildings sector G-9

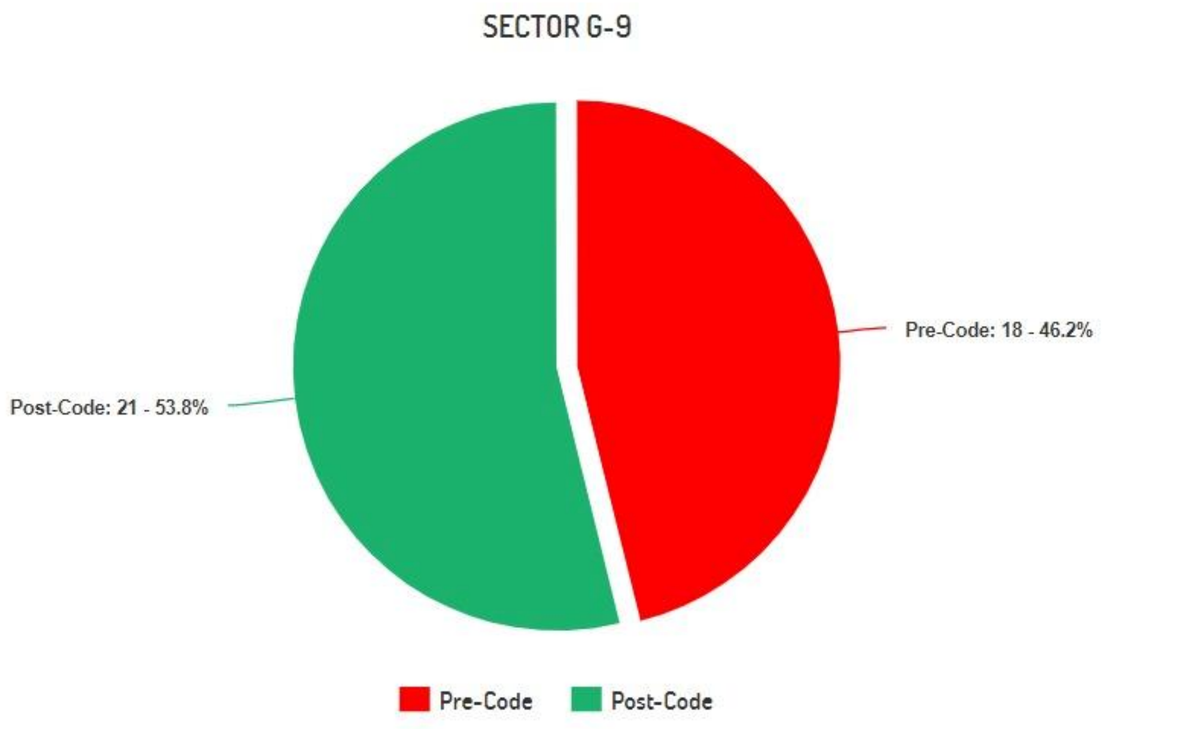


Figure 25: Pre/Post code distribution of buildings in G-9

From this data we can analyze that the G-9 sector have most of the buildings under 2 score and thus they are mostly pre code. They are referred to further indepth analysis. These buildings are either too old or do not have proper maintenance in their life span. Thus they are prone to seismic activity.

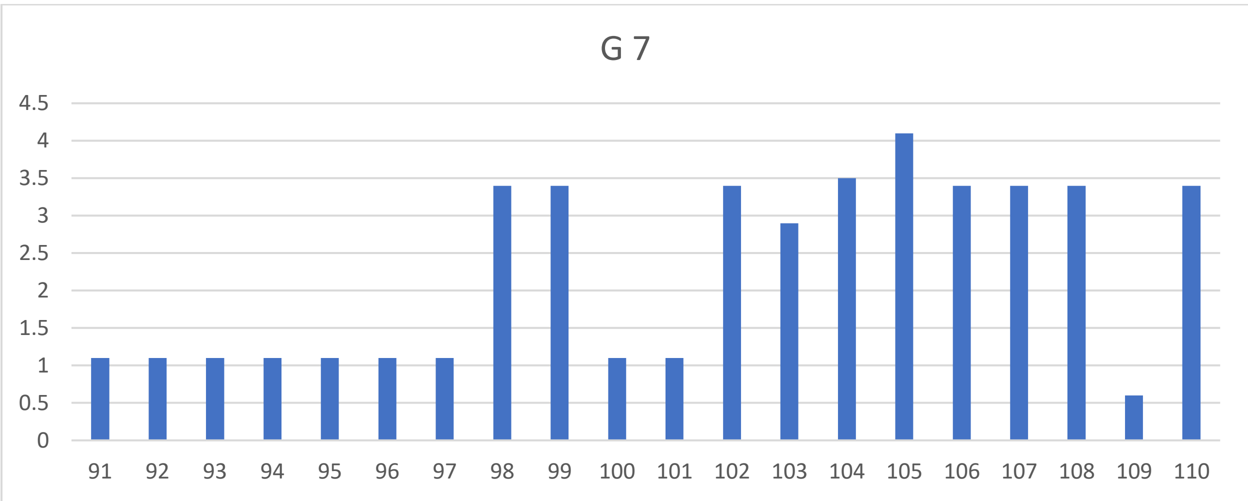


Figure 26:Score wise distribution of the buildings sector G-7

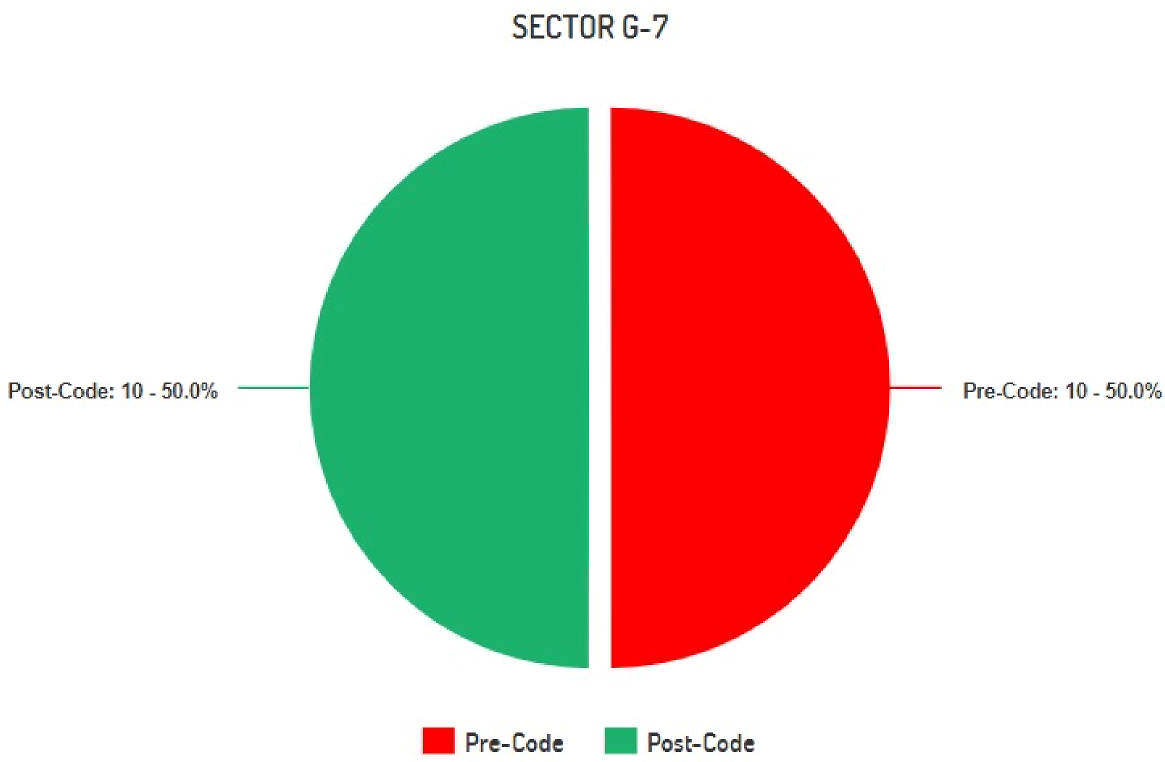


Figure 27: Pre/Post code distribution of buildings in G-7

G-7 sector have equal distribution of precode and postcode buildings it have some buildings below 2 score and some above it.

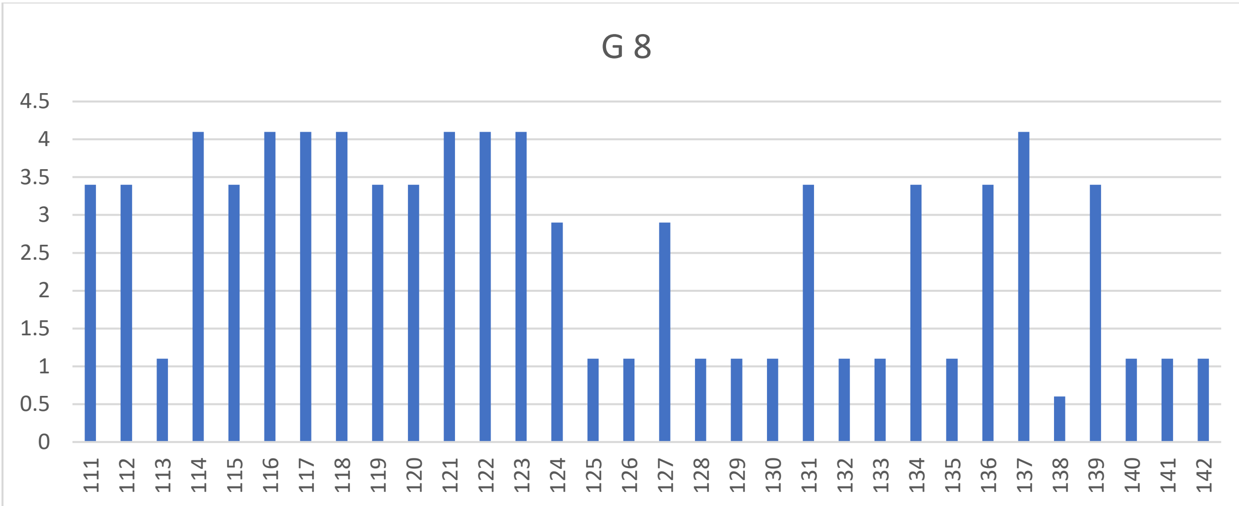


Figure 28:Score wise distribution of the buildings sector G-8

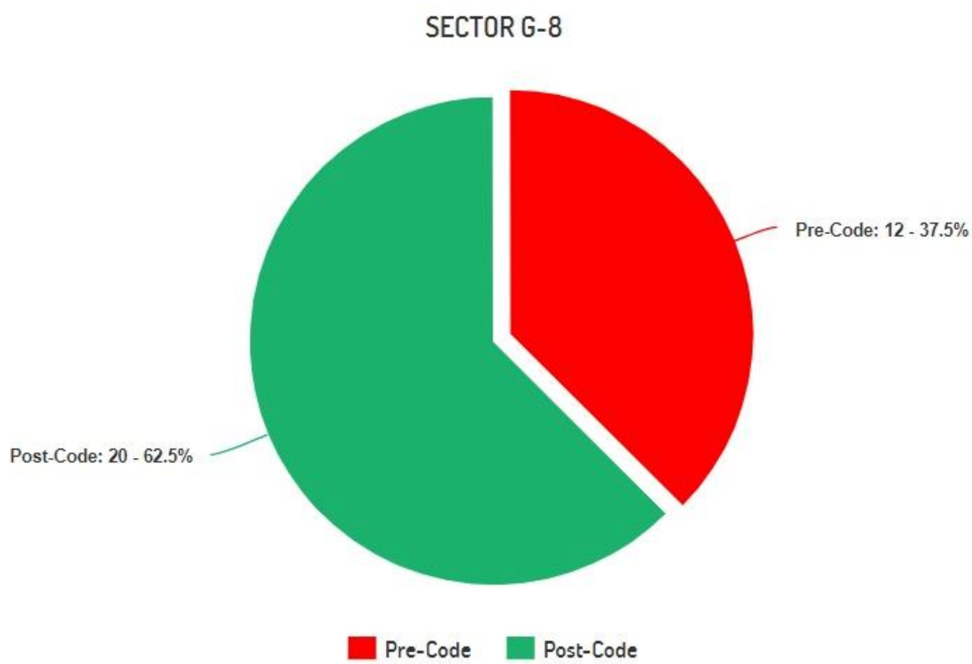


Figure 29: Pre/Post code distribution of buildings in G-8

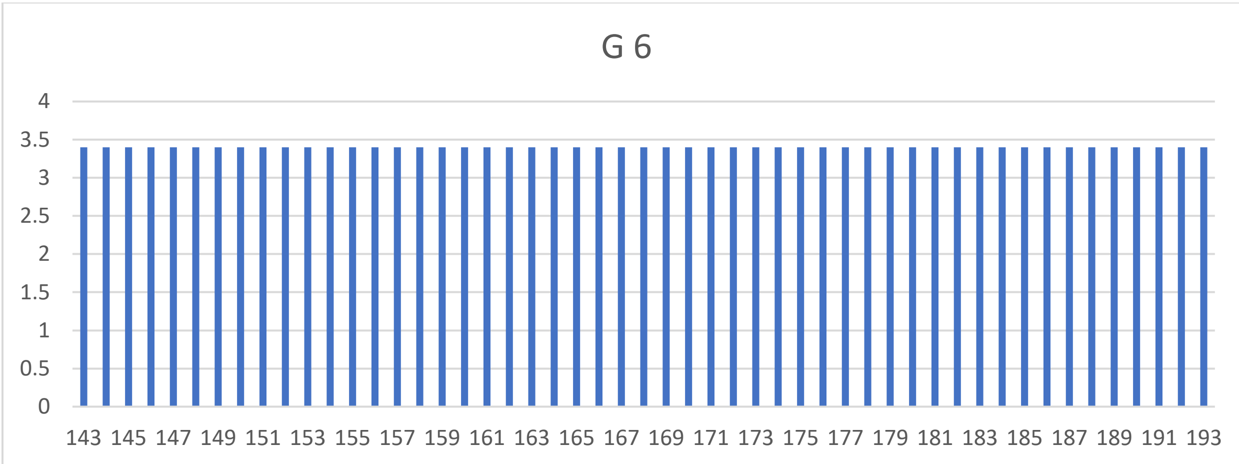


Figure 30:Score wise distribution of the buildings sector G-6

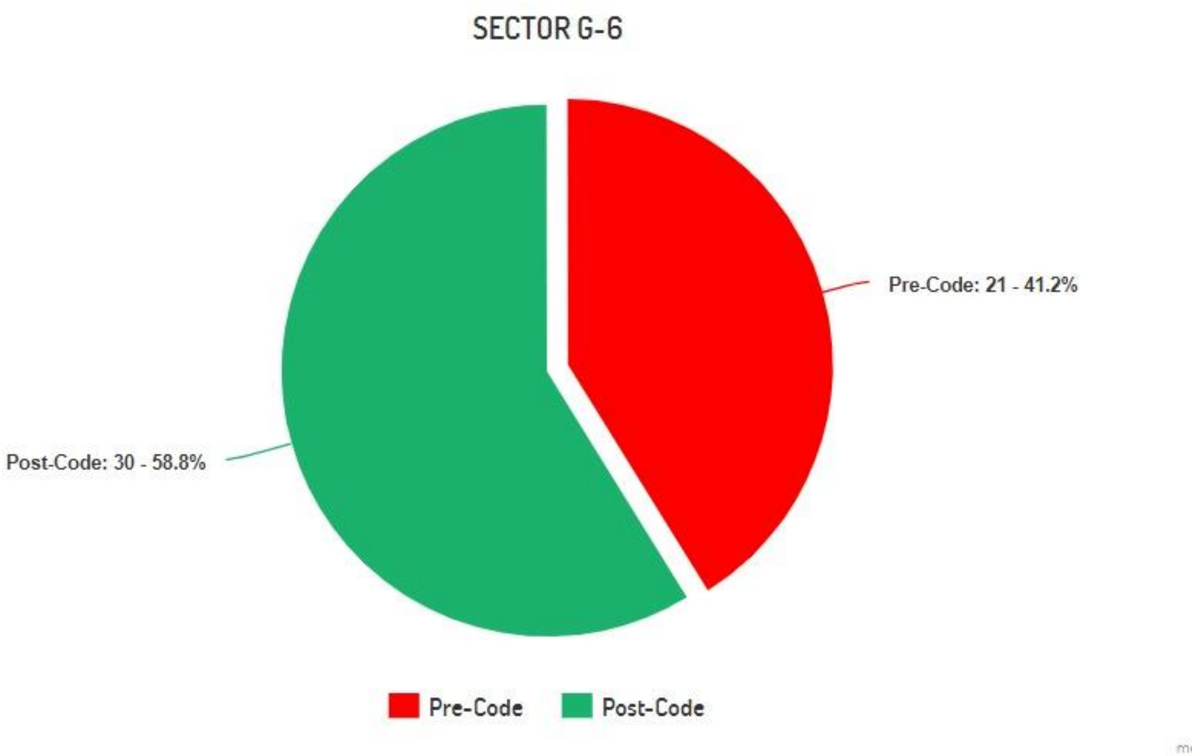


Figure 31: Pre/Post code distribution of buildings in G-6

In this figure we can conclude that all of the buildings in the sector G-6 are postcode and there is no need for further analysis of this sector. This sector is relatively strong in terms of seismic hazard analysis.

The avg score range of this sector is 3.4.

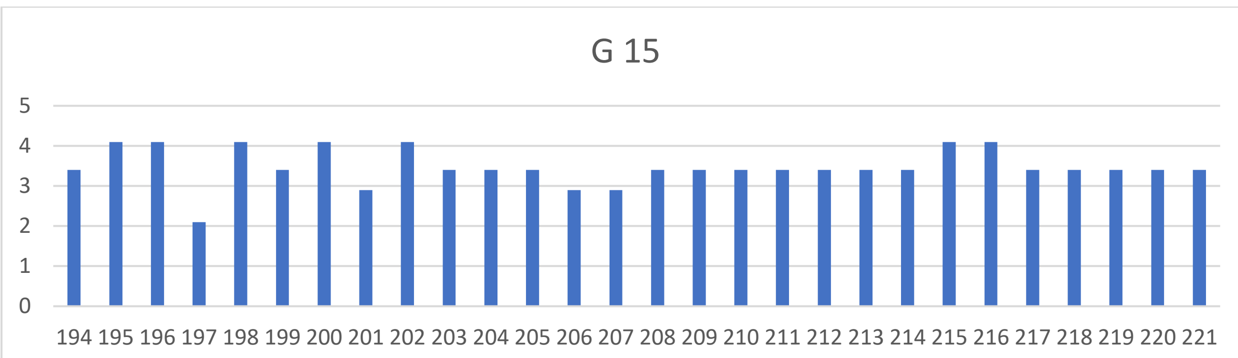


Figure 32:Score wise distribution of the buildings sector G-15

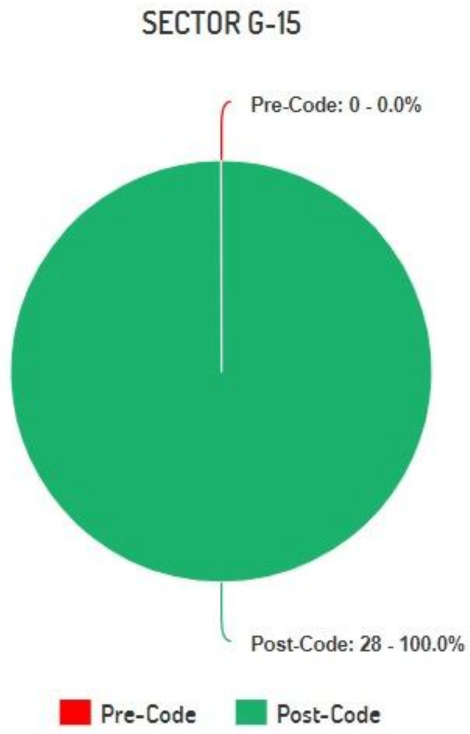


Figure 33:Pre/Post code distribution of buildings in G-15

From the data we can conclude that the G-15 is newly constructed sector which do not have precode buildings in it all of the buildings score above 2 and hence fulfil our criteria.

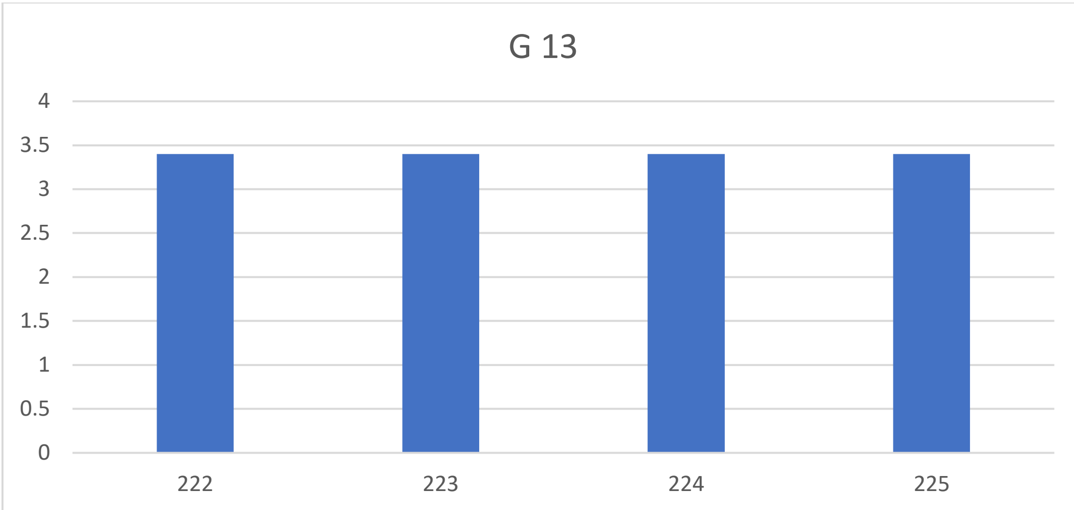
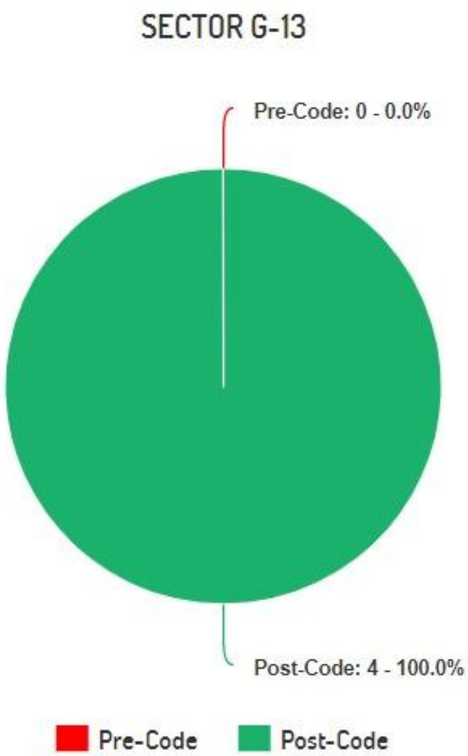


Figure 34:Score wise distribution of the buildings sector G-13



4.3 Score vs No of stories

Figure 35:Score vs Number of stories

Another approach used to sort the data was no of stories and their relative score.

By this we were able to find the trends in no of stories of a building and its health after years.

By collection of data and its analysis it can be seen that there was no link between the building score and the building stories they both are independent of each other.

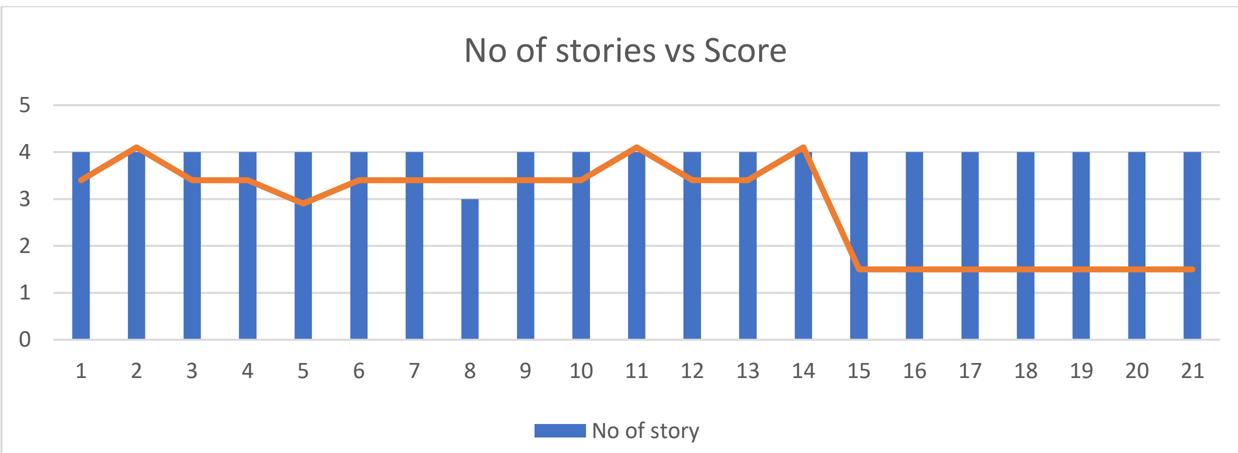


Figure 36: G-11 Stories vs score

The above graph shows the data of buildings in G11 sector. The no of stories in the sector was approximately same but the score varies randomly. It is 1 for some buildings and 4 of some buildings of the same stories.

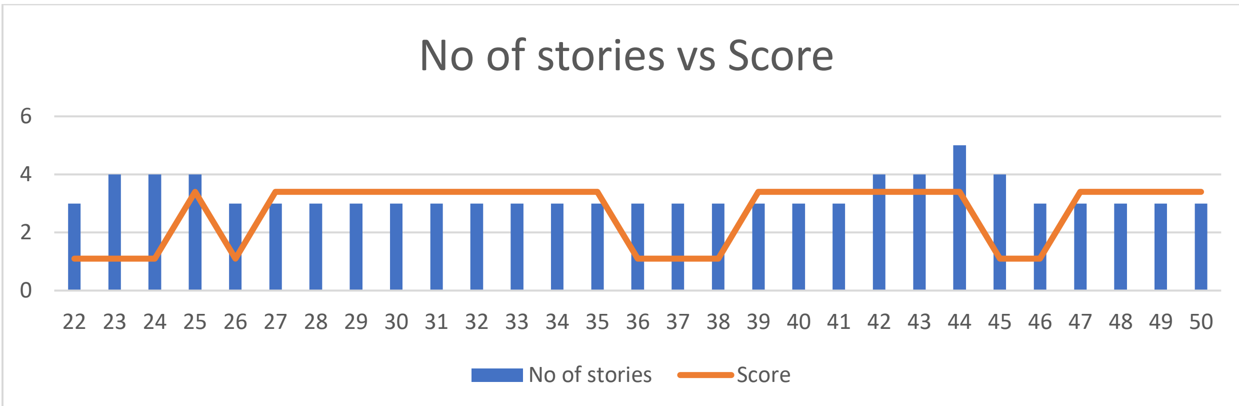


Figure 37: G-10 Stories vs Score

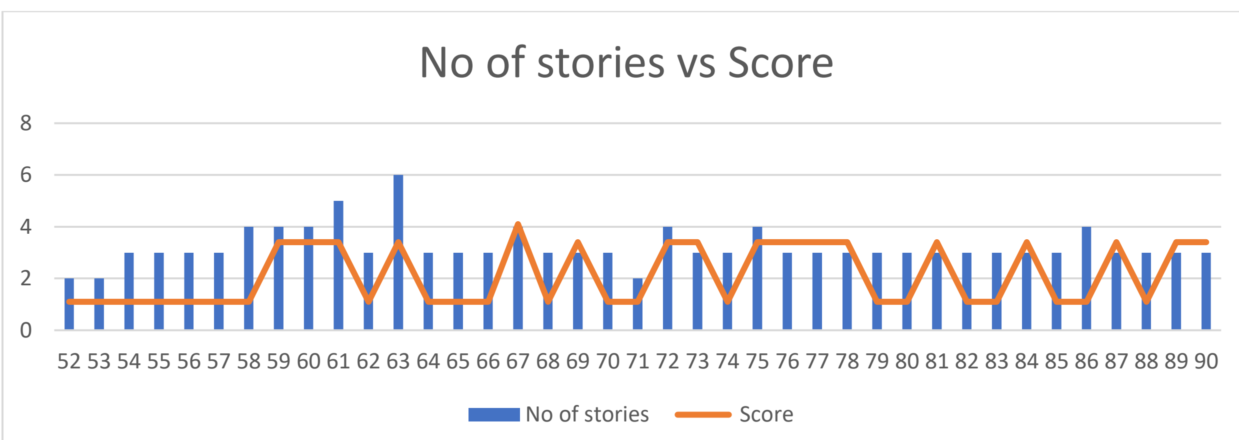


Figure 38: G-9 Stories vs score

This graph clearly shows that the building height or no of stories have no impact on the score the score varies with the physical condition of the building. The condition of the building depends upon when it was built rather than the height of the building.

So the score depend on the age of building.

4.4 LIMITATIONS

Like any other research work, this study also has some limitations.

As it was first of its kind in Islamabad. In this section the prominent limitations of the work are given below.

- Fema 154 was developed for American standards, and it does not directly apply to Pakistan.
- Some sides of building were inaccessible
- Fema 154 do not accurately define the score of the building it is just a approximate representation of building.

Chapter no 5: Conclusions

The rapid visual screening procedure adopted during this work is the basic step in the identification of Earthquake prone buildings. Buildings that have potential hazardous elements must be analyzed by professionals in detail . Rapid visual screening is done on the street, so interior inspection can not be possible in some cases, details won't be visible, and seismically hazardous buildings might not be identified as such. Similarly, buildings that are identified as potentially hazardous by surveyor may be non hazardous. A very critical problem in the usage of FEMA 154 is the cutoff score. Determining the value of S so that below this score the detailed seismic evaluation is required , and therefore the selection of cutoff score is of greater importance as it can change the whole outcome of the result ,below cutoff score the detail assessment is required.

Following are discussions :

1. interpretation and selection of the “cut-off” score
2. prior uses of the FEMA 154 RVS procedure,
3. including decisions regarding the “cut-off” score

5.1 Interpretation of RVS Score

After using the RVS technique and determining the final score of the building , S, which is the basic score of any building depending on its type for example Concrete , Reinforced concrete , Steel structure , Timber , Masonry . Score Modifiers are also given depending on the physical features of the building such as cladding , pounding , appendages. the RVS authority is of course faced with the question of what these S scores mean. The ultimate S score is an estimate of the probability (or chance) that the building will collapse if ground motions occur that equal or exceed the maximum considered earthquake (MCE) ground motions (the current FEMA 310 ground motion specification for detailed seismic evaluation of buildings). These estimates of the score are supported limited observed and analytical data, and therefore the probability of collapse is therefore approximate. for instance , a final score of S = 2 implies there's a chance of 1 in 10^2, or 1 in 100, that the building will collapse if such ground motions occur.

5.2 Selection of RVS “Cut-Off” Score

One of The most difficult question to answer in RVS is the score S “what is save value of S” ?, “What is a suitable S?” This is a question for the community that involves the costs of safety versus the benefits. the prices of safety include:

• the prices of reviewing and investigating in detail hundreds or thousands of buildings in order to identify some fraction of those that would sustain major damage in an earthquake

• the prices associated with rehabilitating those buildings finally determined to be unacceptably weak.

The Final step in this work will be the formation of representative model buildings from the given data. These buildings are often formulated by using the means of the data. It are often sorted for single sector or for whole data.

Table 1: Standard Deviation of G-11

	Mean	Standard Deviation
No of Bays - x (End)	2	0
Bay Sizes (End)	16.38	5.643
No of Bays - x(Rest)	3.38	1.64
Bays Sizes (Rest)	17.09	5.96
No of Bays - y (End)	2	0
Bay Sizes (End)	15.71	5.36
No of Bays - y(Rest)	1.95	0.57
Bays Sizes (Rest)	18.61	3.94

Table 2:Standard Deviation of 225 Buildings

	Mean	Standard Deviation
No of Bays - x (End)	1.955	0.25
Bay Sizes (End)	12.54	4.64
No of Bays - x(Rest)	3.7	3.04
Bays Sizes (Rest)	10.75	5.7
No of Bays - y (End)	1.99	0.133
Bay Sizes (End)	13.35	4.69
No of Bays - y(Rest)	2.42	1.96
Bays Sizes (Rest)	12.24	4.8

The SD of the data is given representative buildings can be formed by using the above values ie, by adding and subtracting the means. So for each sector we can have 3 buildings.

These buildings are then to be used for in-depth seismic hazard assessment.

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