Design & Analysis of Earthquake Resistant Structure: A Critical Review

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[a]Abhishek Kumar Singh, [a]Dr. Rakesh Kumar Pandey
Amity University Chhattisgarh, Raipur 492001
Department of Civil Engineering

Abstract

The turf of seismic activity Engineering has existed in our nation for over 35 years now. Indian Earthquake Engineers have made momentous hand-outs to the seismic safety of a number of important structures in the country. However, as the recent earthquakes have shown, the performance of normal structures during past Indian earthquakes has been less satisfactory. This is mainly due to the lack of awareness amongst most practicing engineers of the special provisions that need to be followed in earthquake resistant design and thereafter in construction.

Earthquakes compose one of the supreme hazards of living and assets on the earth. Due to abruptness of their happening, they are least understood and most dreaded. The earthquake resistant construction is considered to be very important to mitigate their effects. This paper presents the concise prerequisites of earthquake resistant construction and a few techniques to improve the resistance of building and building materials to earthquake forces, economically.

Keywords:-Earthquake, Structure, Resistant Design, Economically.

I. INTRODUCTION

Our earth is prone to much natural debacle, occurring frequently for example – floods, tornado, tsunami, volcanic eruption, earthquake, storms etc. It causes enormous damage to living being as well as nature. It is uneven and capricious. One of the precarious disasters is Earthquake also known as quake or tremor. The severe damage occurs where the places are highly populated.

Our earth is unevenly colonized. Earth's lithosphere consists of different plates termed as tectonic plates. Tectonic plates are pieces of earth's crust and outermost mantle. It has to part oceanic crust (dominating with SIMA {silicon and magnesium}) and continental crust (dominating with SIAL {silicon and aluminum}). Geologist agrees that the tectonic plate exist with roughly defined boundaries. Further study shows that the earth lithosphere can be studied by 8 major plates – Pacific plate, north American plate, Eurasian plate, African plate , Antarctic plate, Australian plate, Indian Plate, south American plate. (ref. fig.1) & few minor plates – Caribbean plate, cocos plate, Arabian plate, Philippine plate, Nazca plate, Juan de Fuca plate etc.

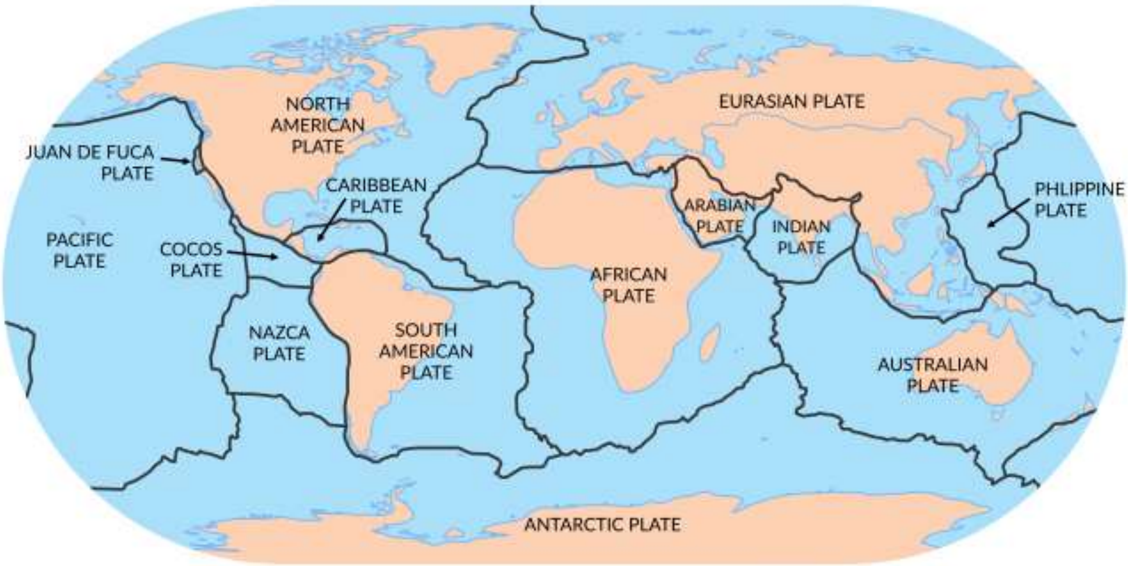

Fig. 1: Earth's Tectonic plates

Tectonic plate are like riddle stretch all over the earth and it always keep on stirring slowly and descending & bumping into each other. The edges of these plates are termed as Plate boundaries. The plate boundaries consist of many faults. At times the faults get stuck to each other and the rest of the plate keeps moving resulting in the storing of the energy at the faults. When the force overcome the friction of the jagged fault a sudden release of the energy radiates outward from the fault in all direction in the form of seismic wave like a ripple in pond . These waves shake the surface and move anything on it. This shaking of the earth surface is termed as Earthquake.

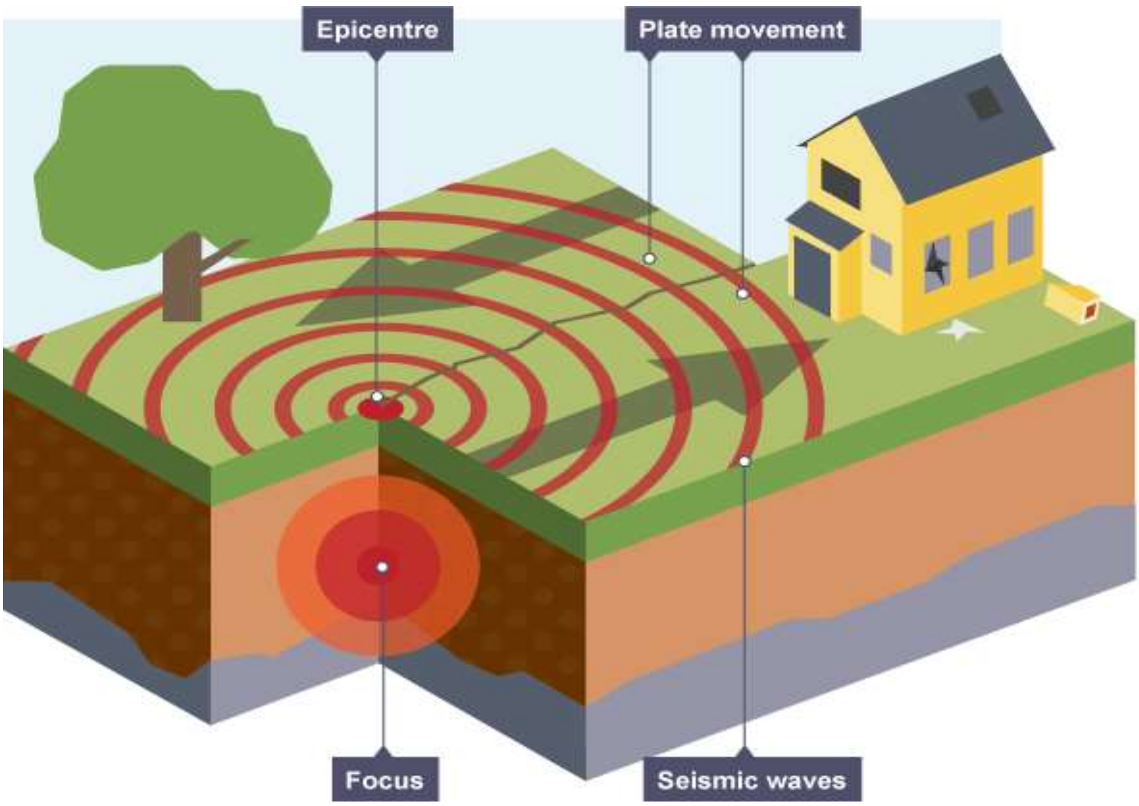

Fig.2: Origin of an earthquake

The place in the crust where the movement starts is called Earthquake hypocenter (Focus). The place on the surface above the focus is called epicenter. Vibration travel outwards from the epicenter as waves. Greatest damage is usually closest to the epicenter and the strength of the earthquake decreases away from the center.

There is currently no way to forecast about the earthquake, its concentration, span and strength. The earthquake may vary magnitude and can last for few seconds to minutes. The earthquake can be recorded at the time of occurrence. It is measured on Richter scale. Richter scale measure the magnitude of the earthquake (how powerful it is).it is recorded in an instrument – seismometer.(fig.3) It produces a graph known as seismograph. The Richter scale is normally between 1-10, though there is no upper limit. For example- earthquake measuring 1-2 on the scale is so small that people cannot feel anything. Earthquake measuring upward to 7 are very powerful (not frequently occurring) and causes lot of destruction. The largest earthquake ever recorded was in Chile in 1960, which measured 9.5 on the Richter scale.

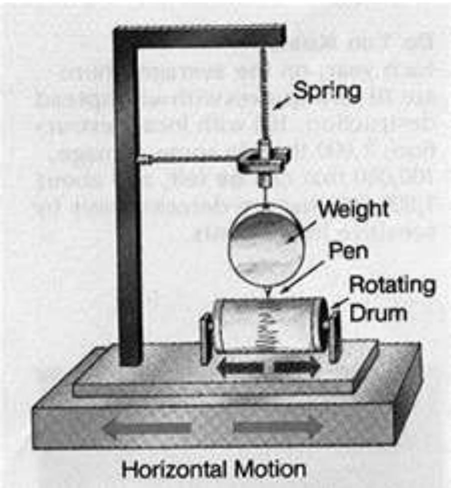

Fig. 3: Seismograph

It is estimated that round 500,000 earthquakes occur each year, detectable with current instrumentation. About 100,000 of these can be felt. Minor earthquake occur nearly constantly around the world in places like California and Alaska in the U.S as well as in El Salvador, Mexico, Guatemala, Chile, Peru, Indonesia, Philippines, Iran, Pakistan, Turkey, New Zealand, Italy, India, Nepal and Japan.

Most of the world's earthquakes (90%, and 81% of the largest) take place in the 40,000-kilometre-long (25,000 mi), horseshoe-shaped zone called the circum-Pacific seismic belt, known as the Pacific Ring of fire, which for the most part bounds the Pacific Plate. Massive earthquakes tend to occur along other plate boundaries too, such as along the Himalayan Mountains.

II. Problem Identification

India is very prone to earthquakes as well. The major reason for the high frequency and intensity of the earthquakes is that the Indian plate is driving into Asia at a rate of approximately 47 mm/year. As per the Geographical statistics, almost 54% of the land in India is vulnerable to earthquakes.

According to the estimates shown by a World Bank and United Nations report; around 200 million city dwellers in India will be exposed to storms and earthquakes by 2050.

The latest version of the seismic zoning map of India assigns four levels of seismicity for India in terms of zone factors, which means India is divided into 4 seismic zones:

Zone 2
Zone 3
Zone 4
Zone 5

Zone 5 is highly prone to the earthquake with the highest level of seismicity whereas Zone 2 is associated with the lowest level of seismicity. So, the Zones - marked two to five -indicate areas most likely to experience tremors with five being the most vulnerable.

Indian cities, ranging from the metros to the smaller cities - all at least once have been shaken up due to earthquakes which usually range from medium to high intensity on the Richter scale. As shown in the figure 4.

After the 2001 earthquake, the Indian middle class witnessed for the first time, multi-storey buildings fall like a pack of cards, and realized that these housing types are similar to the ones in which they are living or have plans to retire into. The Central and State governments announced numerous plans and activities. It was hoped that India would now have an effective programmer for earthquake safety, and that most (if not all) new constructions would now comply with seismic codes

The country is going through a major development phase wherein infrastructure is being added at an unprecedented pace. It is a great opportunity to ensure that all new infrastructures comply with seismic requirements. Unfortunately, this is not happening. For instance:

- About 6000 school building were constructed across the state of Gujarat during April 1999 to December 2000 by pre-cast construction technology that was deficient in seismic aspects. About three-quarters of these schools either collapsed or were seriously damaged during the 2001 Bhuj earthquake.

- The Austin Creek Bridge connecting the North Andaman with the Middle Andaman was inaugurated in 2002 and did not have seismic features, even though Andaman’s are a high seismic zone. The deficiencies were pointed out and yet no corrective actions could be undertaken, and the bridge went out of function after the 2004 Sumatra earthquake.

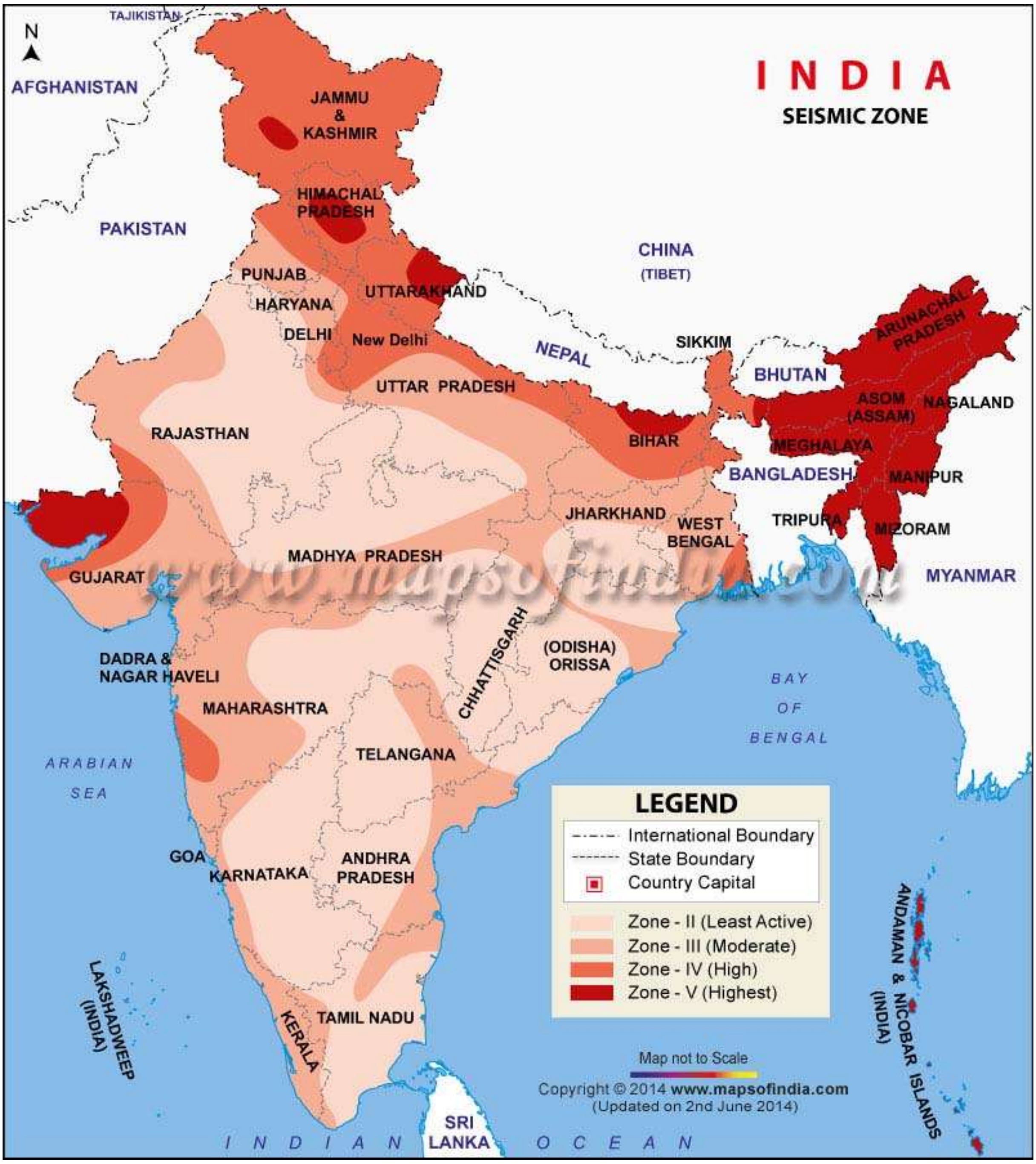

Fig. 4: Seismic zoning map of India

Top 10 Indian cities which are observed as high earthquake prone zones are-

1. Guwahati - Assam

Guwahati falls in zone five of the seismic zones in India which is highly prone to earthquakes. The place has seen some of the deadliest earthquakes and even today small tremors are a common situation. Guwahati receives earthquake predictions on a daily basis; resulting which many adjoining areas in the North-East get affected.

2. Srinagar - Jammu and Kashmir

This capital city of Jammu and Kashmir also comes under Seismic Zone 5. Most parts of the Kashmir Valley, which is around 11% of the area of the state covering the Districts of Srinagar, Gander bal, Baramulla, Kupwara, Bandipora, Budgam, Anantnag, Pulwama, Doda, Ramban, Kishtwar, come under Seismic Zone 5, where around 50% of the population of the state lives. The rest of the state, including the whole of the Ladakh region and Jammu Division (90% of the total area of the state), are under the Seismic Zone 4.

Being very close to the Himalayas, Srinagar faces heavy risk of earthquakes, high as well as moderate. The friction between the Indian and the Eurasian plane causes earthquakes to occur on the areas close to the Himalayas.

3. Delhi

Delhi is categorized under Seismic Zone 4. Delhi has been hit by five devastating earthquakes measuring higher than magnitude of 5 since 1720. The most prone to earthquake neighborhoods in Delhi lie about two miles on either side of the Yamuna river, the southwestern outskirts of the city known as the Chhattarpur basin, as well as an area popularly known as The Ridge in Delhi

4. Mumbai - Maharashtra

Mumbai falls in the Zone 4 of the seismic zone divisions which makes it quite vulnerable to damage. We all know Mumbai is located on the coastal line, which increases the risk of facing tsunami-like disasters. Mild to strong earthquakes are very common in parts of Mumbai. Mild earthquakes are often faced by people living there and parts of the adjoining regions of Gujarat. It should be noted that for the last 20 years, almost all of the buildings in Mumbai have been designed and built keeping in mind that the city falls in seismic zone 4.

5. Chennai - Tamil Nadu

The city, formerly in the comfort Zone 2, has now shifted to Zone 3 - indicating higher seismic activity. According to the seismic mapping, districts in the western part along the border with Kerala are also in Zone 3, along with districts along the border of Andhra Pradesh and a section of the border with Karnataka.

The status of Chennai along with major towns on the eastern coast in terms of vulnerability has increased especially after Chennai experienced tremors in September 2001 following a quake measuring 5.6 on the Richter scale off the Pondicherry coast.

Tamil Nadu had faced the wrath of the deadly 2004 tsunami when the Marina beach was affected.

Recently, in the year 2012, Chennai shook terribly due to a rather high intensity earthquake (having its epicenter in the Indian Ocean).

6. Pune - Maharashtra

7. Kochi - Kerala

8. Kolkata - West Bengal

9. Thiruvananthapuram - Kerala

10. Patna – Bihar

In this section we will specifically designing a resident building for the zone III areas in India. Using STAAD PRO - checking the safety of the building. During earthquake unpredicted consequences need to be faced - Loss of many human and cattle lives, Damage and destruction of many human constructions, namely buildings, roads or highways, bridges, temples, UNESCO world heritage sites, towns and villages. It creates landslides which may block the highways, river channels, etc. Earthquake crates different types of avalanches which may kill hundreds of climbers, trekkers. Earthquakes and continuous aftershocks destroyed the civil structures killing thousands of people.

Earthquakes: Nature's most unpredictable and one of her most devastating natural disasters. When high intensity earthquakes strike they can cause thousands of deaths and billions of dollars in damaged property. For decades, experts have studied major earthquakes; most have focused on fatalities and destruction in terms of the primary effects, the shaking unleashed

Since 1900, 2.3 million people have died in 2,233 earthquakes, yet it is important to understand that 93 percent of the fatalities that occurred as a result of violent earthquakes happened in only 1 percent of key earthquakes. In other words, the worst devastation tends to happen in only a very few quakes and generally as a result of dire secondary effects. Indeed fully 40 percent of economic losses and deaths result from secondary effects rather than the shaking itself. Several key earthquakes have changed our knowledge of secondary effects and serve as models to understand and need in planning communities, homes and buildings, highways, and infrastructure such as nuclear power plants.

In 2004 the Indian Ocean earthquake unleashed tsunamis that killed a total of 227,300 people in Indonesia, Sri Lanka, India, and Thailand, plus more than $10 billion in damages. In 2011, the Tohoku earthquake created a series of huge tsunami waves, which damaged coastal communities killing more than 17,900 people, forcing more than 50,000 households to relocate, and caused the Fukushima nuclear power plant failure, a nuclear disaster second only to Chernobyl in Russia in 1986, but which spread radiation across the Pacific Ocean. Studying the Indian Ocean and Tohoku earthquakes gives us information to create maximum tsunami height models for these high risk areas to better predict how populations, property, and gross domestic product might be impacted in the future by similar events.

. Fig.5 One side of the street dropped

Fig 6 . Building falling after earthquake

Buildings can also be damaged by strong surface waves making the ground heave and lurch. Any buildings in the path of these surface waves can lean or tip over from all the movement. The ground shaking may also cause landslides, mudslides, and avalanches on steeper hills or mountains, all of which can damage buildings and hurt people.

Ground Displacement

The second main earthquake hazard is ground displacement (ground movement) along a fault. If a structure (a building, road, etc.) is built across a fault, the ground displacement during an earthquake could seriously damage or rip apart that structure.

Fig. 7: Ground displacement

Flooding

The third main hazard is flooding. An earthquake can rupture (break) dams or levees along a river. The water from the river or the reservoir would then flood the area, damaging buildings and maybe sweeping away or drowning people.

Fire

The main earthquake hazard is fire. These fires can be started by broken gas lines and power lines, or tipped over wood or coal stoves. They can be a serious problem, especially if the water lines that feed the fire hydrants are broken. Most of the hazards to people come from man-made structures themselves and the shaking they receive from the earthquake. The real dangers to people are being crushed in a collapsing building, drowning in a flood caused by a broken dam or levee, getting buried under a landslide, or being burned in a fire.

Ground Rupture

Ground rupture is another important effect of earthquakes which occurs when the earthquake movement along a fault actually breaks the Earth's surface. While active ground rupture is comparatively rare, there have been cases of it in California -- for example, during the 1906 earthquake, fences near Pt. Reyes were offset by as much as 7 meters. And in the Owens Valley earthquake in 1872, a fault scarp as much as 8 meters high broke the ground near Lone Pine. Rupture causes problems for humans by, well, rupturing things; pipelines, tunnels, aqueducts, railway lines, roads, and airport runways which cross an area of active rupture can easily be destroyed or severely damaged.

Ground Shaking

Ground shaking is the most familiar effect of earthquakes. It is a result of the passage of seismic waves through the ground, and ranges from quite gentle in small earthquakes to incredibly violent in large earthquakes. In the 27 March 1964 Alaskan earthquake, for example, strong ground shaking lasted for as much as 7 minutes. Buildings can be damaged or destroyed, people and animals have trouble standing up or moving around, and objects can be tossed around due to strong ground shaking in earthquakes. However, it should be note that, while many people are killed in earthquakes, none are actually killed directly by the shaking -- if people were out in an open field during a magnitude 9 earthquake, it would be extremely scared, but your chance of dying would be zero or damn near it.

Tsunamis

Tsunamis, which are popularly -- and incorrectly -- known as ``tidal waves,'' are a grave hazard to many parts of the world, particularly around the Pacific Ocean basin. Tsunamis are a series of water waves caused when the seafloor moves vertically in an earthquake and which can travel vast distances in a short period of time. Tsunami speeds in the deep ocean have been measured at more than 700 km/hr, comparable to some jet planes, and when tsunamis reach shallow water near the coast, they can reach heights of more than 27 meters (90 feet) Remember that tsunamis are a series of waves, and may start with a gentle withdrawal of water, followed by a very abrupt arriving wave, followed by another withdrawal, etc. The safest thing to do if you hear a tsunami is coming is to move to higher ground away from the beach as quickly as possible.

Liquefaction, Subsidence, and Related Effects

Liquefaction and subsidence of the ground are important effects which often are the cause of much destruction in earthquakes, particularly in unconsolidated ground. Liquefaction is when sediment grains are literally made to float in groundwater, which causes the soil to lose all its solidity. Subsidence can then follow as the soil recompacts. Sand blows, or sand volcanoes, form when pressurized jets of groundwater break through the surface. They can spray mud and sand over an area a few meters across. All of these effects pose a grave danger to buildings, roads, train lines, airport runways, gas lines, etc. Buildings have actually tipped over and sunk partway into liquefied soils, as in the 1964 Niigata earthquake in Japan. Underground gas tanks and septic tanks have been known to float to the surface through liquefied soils.

III. Experiment and Result

Seismic performance

Seismic performance is an execution of a building structure's ability to sustain its due functions, such as safety and serviceability, at and after a particular earthquake. A structure is, normally, considered safe if it does not endanger the lives and wellbeing of those in or around it by partially or completely collapsing. A structure may be considered serviceable if it is able to fulfill its operational functions for which it was designed.

Improving earthquake resistance of minor building –

1. Size of building –

Small Buildings:

Small buildings are more affected, or shaken, by high frequency waves (short and frequent). For example, a small boat sailing in the ocean will not be greatly affected by a large swell. On the other hand several small waves in quick succession can overturn, or capsize, the boat. In the same way, a small building experiences more shaking by high frequency earthquake waves.

Tall High Rises:

Large structures or high rise buildings are more affected by long period, or slow shaking. For instance, an ocean liner will experience little disturbance by short waves in quick succession. However, a large swell will significantly affect the ship. Similarly, a skyscraper will sustain greater shaking by long period earthquake waves, than by the shorter waves.

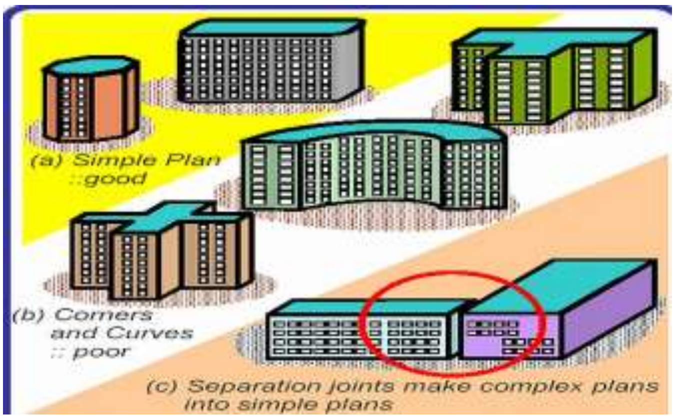

Fig 8 - simple plan shape building

2. Construction Material –

Use Reinforced cement concrete over plain cement concrete. Buildings consisting primarily of steel or other metals are much better at resisting earthquakes. Steel is much lighter than concrete, but it still brings a great deal of durability to construction projects. More flexible than concrete and other building materials, steel is more likely to bend instead of break when experiencing seismic force. Because of these attributes, buildings constructed primarily from steel require less earthquake proofing than those made from other materials. This means that it's easier to pass seismic tests and meet building codes in earthquake-prone communities when your construction projects involve steel. Additionally, steel buildings require fewer repairs after earthquakes, lowering maintenance and insurance costs for your project.

3. Structure-

Strong column weak beam design

The beams should fail (or form plastic hinges) prior to the columns. To avoid progressive collapse of a structure due to cascade effect created by column failure in the lower levels, the columns and beams are to be designed as per Strong- Column Weak Beam Design. This helps the structure to dissipate seismic energy better, without total collapse i.e. these plastic hinges formed in the beams, increases the ductility of the structure and hence the structure would be able to undergo large lateral displacements. As per the Indian code, IS: 13920, to ensure Strong Column-Weak Beam Design, the moment capacity of the columns have to be greater than the beam moment capacity, to ensure the beams fail first.

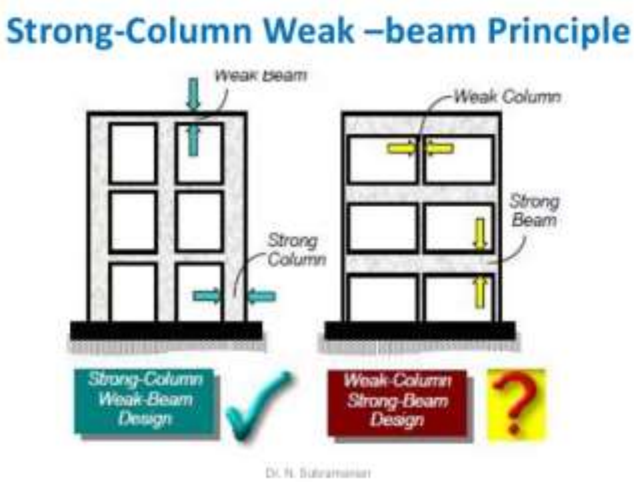

fig : 9 Strong-column weak-beam

Soft storey effect -

A soft storey, also known as a weak story, is defined as a storey in a building that has substantially less resistance, or stiffness, than the stories above or below it. In essence, a soft story has inadequate shear resistance or inadequate ductility (energy absorption capacity) to resist the earthquake-induced building stresses.

Soft storey buildings are characterized by having a storey which has a lot of open space. Parking garages, for example, are often soft stories, as are large retail spaces or floors with a lot of windows. While the unobstructed space of the soft story might be aesthetically or commercially desirable, it also means that there are fewer opportunities to install shear walls, specialized walls which are designed to distribute lateral forces so that a building can cope with the swaying characteristic of an earthquake.

As **per IS 1893:2002** “A soft storey is one in which the lateral stiffness is less than 70 percent of that in the storey above or less than 80 percent of the average lateral stiffness of the three storey’s above.

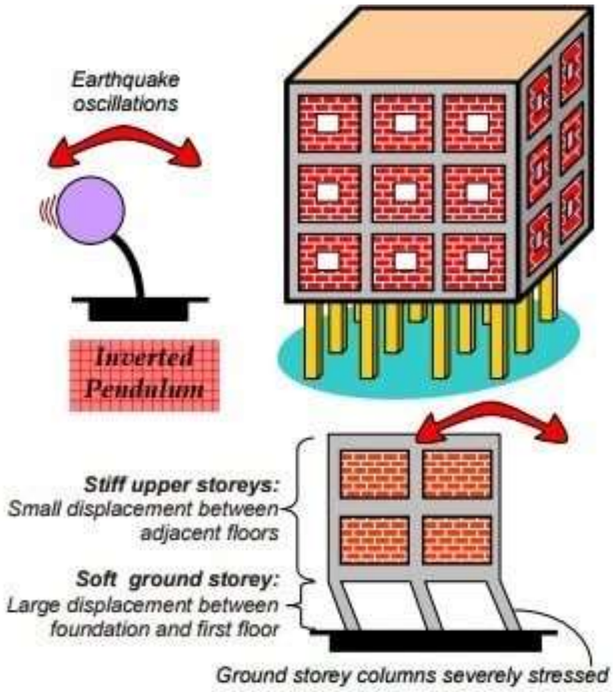

fig :10 – Soft storey in building

Shear wall -

Shear wall is a structural member used to resist lateral forces i.e. parallel to the plane of the wall. For slender walls where the bending deformation is more, Shear wall resists the loads due to Cantilever Action. In other words, Shear walls are vertical elements of the horizontal force resisting system. Shear walls are especially important in high-rise buildings subject to lateral wind and seismic forces. Generally, shear walls are either plane or flanged in section, while core walls consist of channel sections. They also provide adequate strength and stiffness to control lateral displacements. The shape and plan position of the shear wall influences the behavior of the structure considerably. Structurally, the best position for the shear walls is in the center of each half of the building.

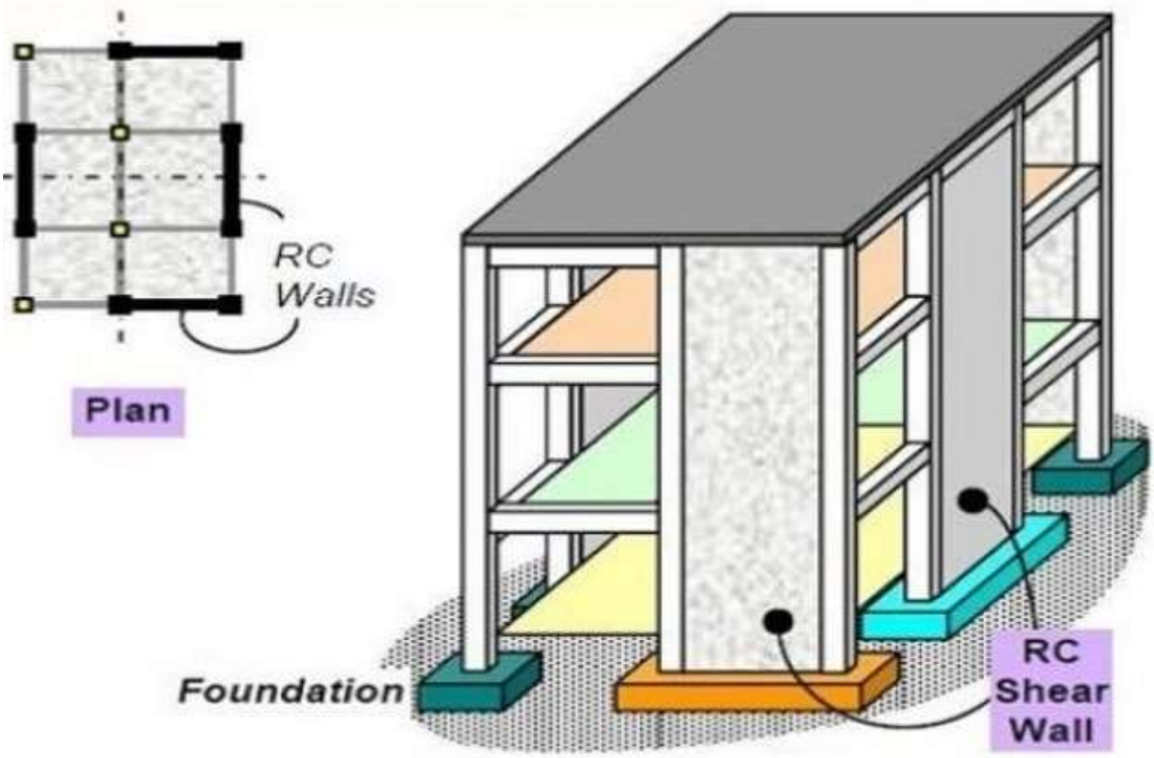

Fig- 11 Shear wall

Provide large strength and stiffness to building. Thickness varies from 150 mm to 400 mm in high rise building. Effective when located exterior perimeter of building, helps in minimizing the effect on non-structural elements. E.g. – glass, windows.

Base Isolation

Base isolation is a state-of-the-art method in which the structure (superstructure) is separated from the base (foundation or substructure) by introducing a suspension system between the base and the main structure.

The basic principle behind base isolation is that the response of the structure or a building is modified such that the ground below is capable of moving without transmitting minimal or no motion to the structure above. A complete separation is possible only in an ideal system. In a real world scenario, it is necessary to have a vertical support to transfer the vertical loads to the base.

Types of base isolation are -

- Elastomeric Rubber Bearings
- Roller and Ball Bearings
- Springs
- Sliding Bearing

fig -12 Base Isolation

Advantages of Base isolation-

- Reduced the seismic demand of structure, thereby reducing the cost of structure.
- Lesser displacements during an earthquake. Improves safety of Structures Reduced the damages caused during an earthquake.
- This helps in maintaining the performance of structure after event.
- Enhances the performance of structure under seismic loads.
- Preservation of property.

Keeping building upright –

A new-technology discovered in Japan, when a quake strikes, the new system dissipates energy through steel frames in the building's core and exterior. These frames are free to rock up and down within fittings fixed at their bases. Steel tendons made from twisted steel cables run the length of each frame, keeping the frames from moving so much that the building could shear. When the quake stops, these tensile tendons pull the frames back down into the "shoes" at their bases, returning the building to its plumb, upright position.

At the base of each frame is flexible steel "fuse" that takes the brunt of the force, keeping the frame and constituent tendons from shouldering the entire load. The fuses are easily replaceable when they blow -- just like an electrical fuse -- so after a quake, the building can be refitted with fresh fuses for its next bout with Earth's occasional tectonic fits. Perhaps the most promising aspect of the system is that it can be retrofitted to existing buildings using readily available materials. It has been found to be survived even in extreme earthquake.

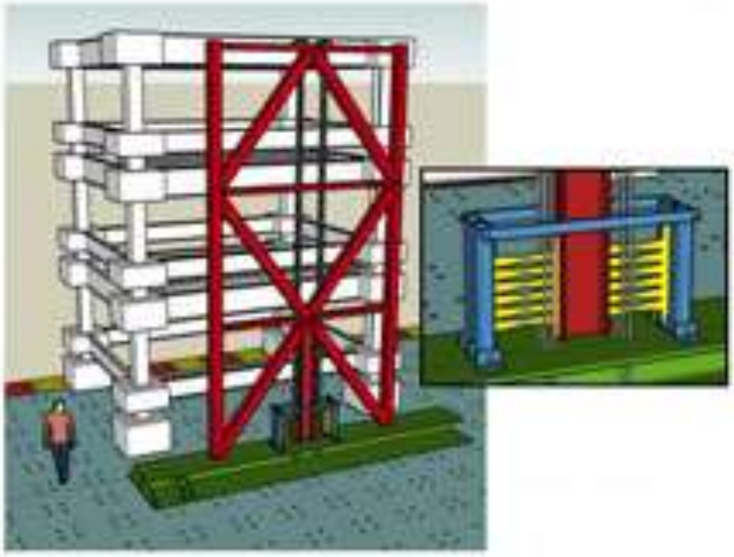

fig- 13 Keeping Building upright

IV. RESULT AND DISCUSSION

In this section we will specifically designing a resident building for the zone III areas in India. Using STAAD PRO - checking the safety of the building. During earthquake unpredicted consequences need to be faced - Loss of many human and cattle lives, Damage and destruction of many human constructions, namely buildings, roads or highways, bridges, temples, UNESCO world heritage sites, towns and villages. It creates landslides which may block the highways, river channels, etc. Earthquake crates different types of avalanches which may kill hundreds of climbers, trekkers. Earthquakes and continuous aftershocks destroyed the civil structures killing thousands of people.

List of Indian Standards on Earthquake Engineering

1**. IS 1893 (Part I), 2002**: Indian Standard Criteria for Earthquake Resistant Design of Structures

2**. IS 4326, 1993:** Indian Standard Code of Practice for Earthquake Resistant Design & Construction of Buildings.

3**. IS 13827, 1993**: Indian Standard Guidelines for improving Earthquake Resistance of Earthen Buildings

4**. IS 13828, 1993**: Indian Standard Guidelines for Improving Earthquake Resistance of Low Strength Masonry Buildings

5**. IS 13920, 1993** Indian Standard Code of Practice for Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces.

6**. IS 13935, 1993**: Indian Standard Guidelines for Repair and Seismic Strengthening of Buildings

FOLLOWING RESULT S ARE OBTAIN FROM THE DESIGNING OF G+10 RCC BUILDING –

Software licensed to	Job No	Sheet No 1
	Part	
Job Title EARTHQUAKEDESIGN OF RCC BUILDING(G+10)	Ref	
	By	Date 21-Apr-20
Client	File amity project.std	Date/Time 2

Job Information

	Engineer	Checked	Approved
Name:			
Date:	21-Apr-20		

Structure Type	SPACE FRAME

Number of Nodes	696	Highest Node	722
Number of Elements	2117	Highest Beam	2154
Number of Plates	33	Highest Plate	2187

Number of Basic Load Cases	3
Number of Combination Load Cases	0

Included in this printout are data for:

All	The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	4	X
Primary	5	Z
Primary	1	DEAD LOAD

Fig 14 – Observation I

Software licensed to	Job No	Sheet No 2	Rev
	Part		
Job Title EARTHQUAKEDESIGN OF RCC BUILDING(G+10)	Ref		
	By	Date 21-Apr-20	Chd
Client	File amity project.std	Date/Time 21-Apr-2020 15:03	

Beams

Beam	Node A	Node B	Length (m)	Property	β (degrees)
3	3	27	0.900	2	0
4	4	5	3.330	2	0
5	5	6	3.350	2	0
6	6	7	3.330	2	0
7	7	29	2.530	2	0
9	9	10	2.000	2	0
12	10	13	3.400	2	0
13	13	14	3.400	2	0
14	12	15	2.000	2	0
15	14	16	2.000	2	0
16	15	17	1.770	2	0
17	16	18	1.770	2	0
18	17	33	0.900	2	0
19	19	20	3.330	2	0
20	20	21	3.350	2	0
21	21	22	3.330	2	0
22	22	31	2.530	2	0
29	4	65	2.770	2	0
31	7	80	2.770	2	0
33	27	4	2.530	2	0
36	29	8	0.900	2	0
37	31	18	0.900	2	0
38	33	19	2.530	2	0
41	32	16	0.900	2	0
42	32	31	1.770	2	0
57	3	49	1.770	2	0
58	49	51	2.000	2	0
59	51	52	3.400	2	0
60	52	12	3.400	2	0
61	8	9	1.770	2	0

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Fig 15 – Observation II

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Beams Cont...

Beam	Node A	Node B	Length (m)	Property	β (degrees)
62	29	57	1.770	2	0
63	54	70	1.200	2	0
64	27	55	1.770	2	0
65	53	58	1.200	2	0
66	52	53	2.900	2	0
67	55	59	2.200	2	0
68	56	33	1.770	2	0
69	57	69	2.200	2	0
70	49	55	0.900	2	0
71	15	56	0.900	2	0
72	57	9	0.900	2	0
74	58	56	2.200	2	0
75	59	53	1.200	2	0
76	59	61	1.200	2	0
77	61	62	1.200	2	0
78	62	60	1.200	2	0
79	60	58	1.200	2	0
80	65	68	1.200	2	0
81	66	19	2.770	2	0
82	67	66	1.200	2	0
84	63	65	1.330	2	0
85	65	68	1.200	2	0
86	63	61	1.200	2	0
87	61	68	1.330	2	0
88	60	67	1.330	2	0
89	60	64	1.200	2	0
90	64	66	1.330	2	0
91	68	72	1.200	2	0
92	53	62	1.200	2	0
93	69	54	1.200	2	0

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Fig 16 – Observation III

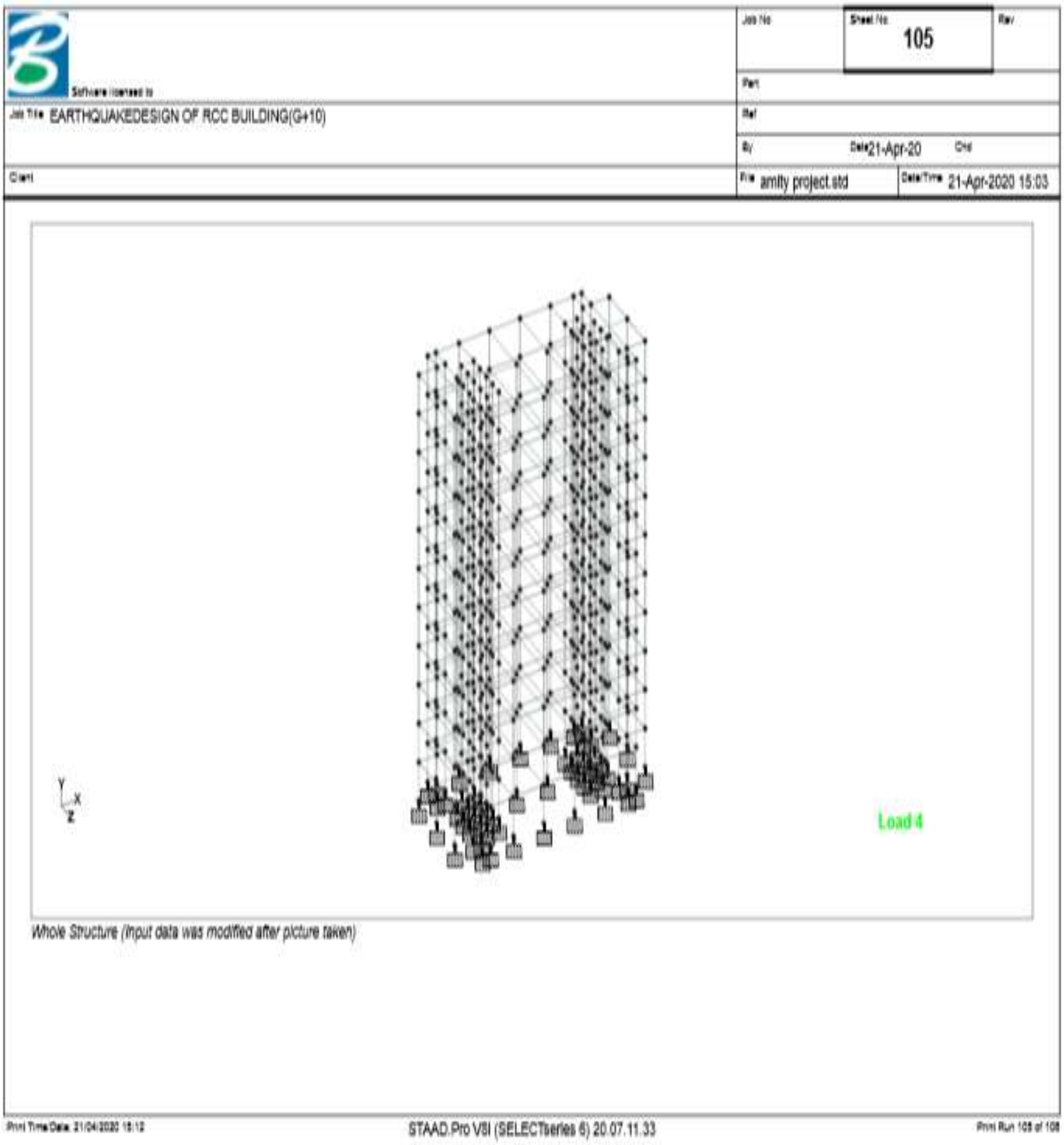

Fig 17 – Observation IV

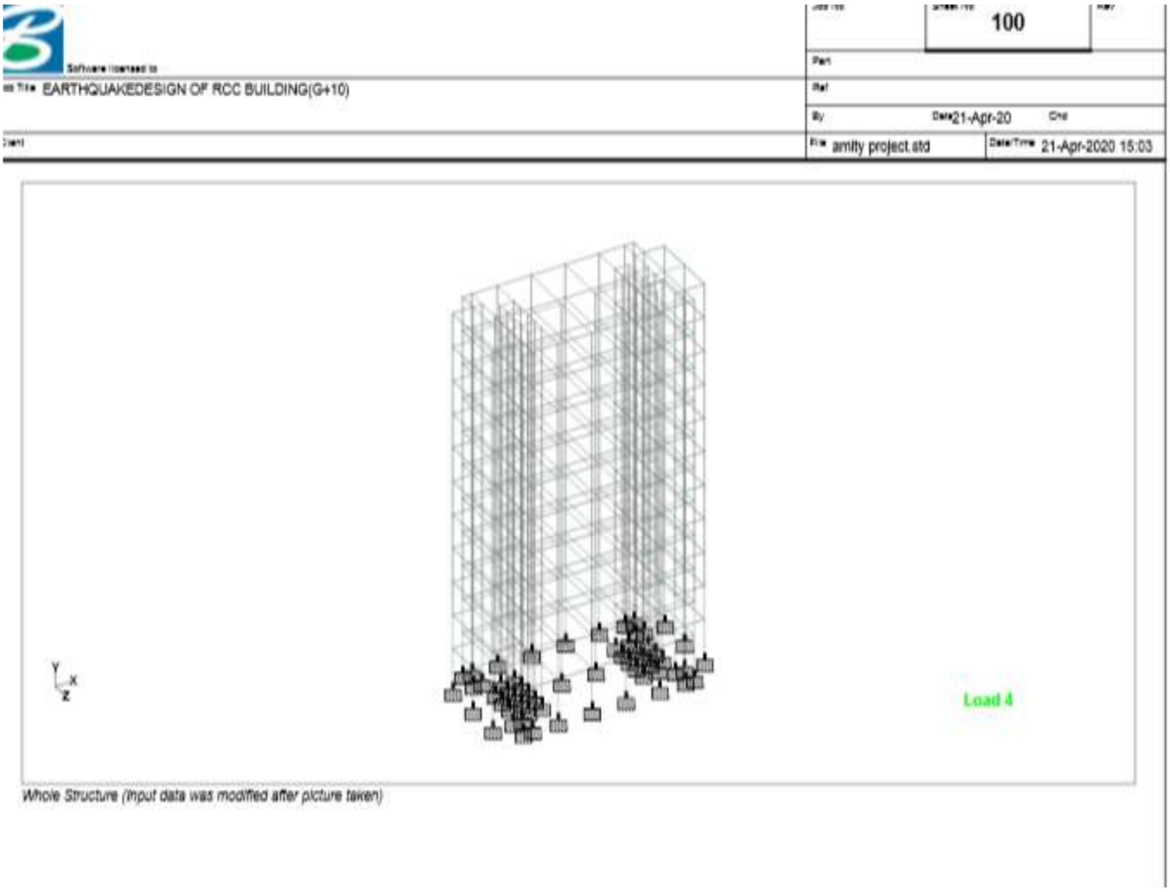

Fig 18 – Observation V

V. Conclusion & Scope of further work

The tasks of providing full seismic safety for the residents inhabiting the most earthquake prone regions are far from being solved. However in present time we have new regulations in place for construction that greatly contribute to earthquake disaster mitigation and are being in applied in accordance with world practice.

In the regulations adopted for implementation in India the following factors have been found to be critically important in the design and construction of seismic resistant buildings:

- Sites selection for construction that are the most favorable in terms of the frequency of occurrence and the likely severity of ground shaking and ground failure;
- High quality of construction to be provided conforming to related IS codes such as IS 1893 , IS 13920 to ensure good performance during future earthquakes.
- To implement the design of building elements and joints between them in accordance with analysis .i.e. ductility design should be done. Structural-spatial solutions should be applied that provide symmetry and regularity in the distribution of mass and stiffness in plan and in elevation.
- Whereas such the situations demands irregularity maximum effort should be given to done away with the harmful effects like that of " SHORT COLUMN EFFECT"

Researchers indicate that compliance with the above-mentioned requirements will contribute significantly to disaster mitigation, regardless of the intensity of the seismic loads and specific features of the earthquakes. These modifications in construction and design can be introduced which as a result has increase seismic reliability of the buildings and seismic safety for human life.

The best approach to earthquake problem is to work on all the fronts simultaneously: engineering, science and instrumentation, public awareness, public policy, etc. The author does not underestimate the contribution science can make to reducing earthquake disasters.

While we have made some progress in terms of public awareness, legal framework and capacity building of engineers, we have done pathetically little towards improving professional ambience in the building industry and towards enforcement.

- We need technological solutions wherein the common man can construct an ordinary earthquake-resistant house with locally available resources. Examples of traditional constructions having excellent earthquake resistance include the Assam-type housing in the northeastern states and Dhajji-Dwari constructions in Kashmir. Research is needed to develop contemporary versions of these and other types of constructions.

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