Earthquake vulnerability and Preparedness in Patna: A Community survey Analysis

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1. INTRODUCTION

1.1 INTRODUCTION TO THE TOPIC

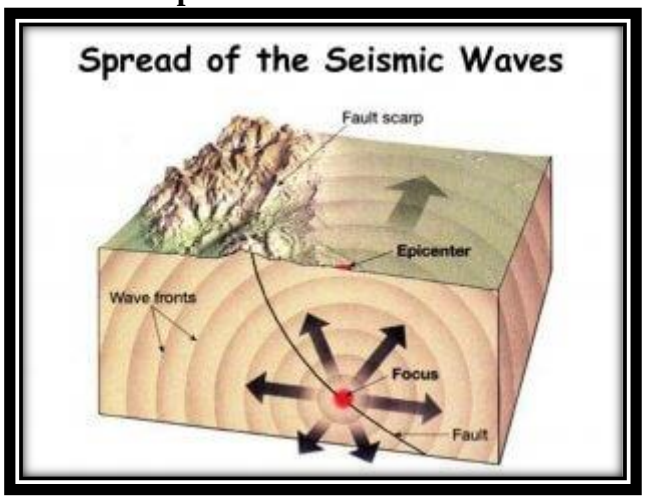
An earthquake is a major demonstration of the power of the tectonic forces caused by endogenetic thermal conditions of the interior of the earth. “An earthquake is a motion of the ground surface, ranging from a faint tremor to a wild motion capable of shaking building apart and causing gaping fissures to open in the ground. The earthquake is a form of energy of wave motion transmitted through the surface layer of the earth in widening circle from a point of sudden energy release, the focus” (A.N. Strahler and A.H. Strahler, 1976)

Earthquake of mild intensity takes place daily. Strong tremors causing large scale destructions are, however, less frequent. Earthquakes are more frequent in the areas of plate boundaries, especially along the convergent boundaries. In India, the region of convergence of the Indian Plate and the Eurasian Plate is more vulnerable to earthquakes. E.g. the Himalayan Region. The peninsular part of India is considered to be a stable block. Occasionally, however, some earthquakes are felt along the margins of minor plates. The Koyna earthquake of 1967 and the Latur earthquake of 1993 are examples of earthquakes in peninsular regions.

The experts of Indian Seismology have divided India into Four seismic zones namely Zone-II, Zone-III, Zone-IV, and Zone-V. It may be observed that the entire Himalayan region, the states of North-East India, Western and Northern Punjab, Haryana, Uttar Pradesh, Delhi, and parts of Bihar and Gujarat belong to the highest and the high-risk categories zone, named as zone V and IV. The remaining parts of the northern plains and western coastal areas fall in moderate risk zone and a large part of the peninsular region lies in the low-risk zone.

The point within Earth where faulting begins is the focus, or hypocenter. The point directly above the focus on the surface is the epicenter. The intensity of the earthquake is highest at the epicenter and decreases with distance from the epicenter.

Fig. no.-1.1
Spread of seismic waves



*source- google image

Richter scale

Richter magnitude scale is the scale to measure the magnitude of energy released by an earthquake. This scale was devised by Charles. F. Richter in the year 1935.The number indicating magnitude ranges between 0 to 9.

Mercalli scale

The Mercalli intensity scale is a seismic scale used for measuring the intensity of an earthquake. It measures the effects of an earthquake .The number indicating intensity ranges between 1 to 12

Seismic Waves

Seismic waves are the waves of energy caused by the sudden breaking of rock within the earth. They are the energy that travels through the earth and is recorded on seismographs. The two main types of waves are body waves and surface waves.

Body waves

- Primary waves (P-waves)
- Secondary waves (S-waves)

Surface Waves

- Love Waves (L-waves)
- Rayleigh waves

Primary waves (longitudinal wave)-

The first kind of body wave is the P wave or primary wave .This is the fastest kind of seismic wave. The P wave can move through gaseous, solid rock and fluids, like water or the liquid layers of the earth. It pushes and pulls the rock, it moves through just like sound waves.

Secondary waves (transverse wave)

- The second type of body wave is the S wave or secondary wave.
- An S wave is slower than P wave and can only move through solid rock.
- This wave moves rock up and down, or side-to-side.
- S-waves arrive at the surface with some time Lag.

Love Waves

The first kind of surface wave is called a Love wave, named after A.E.H. Love, a British. Mathematician. It's the fastest surface wave and moves the ground from side-to-side.

1.2 REVIEW OF LITERATURE

- The study by Anjali Sharma et al.,2017, highlights that architectural considerations necessary for restoration of buildings damaged by earthquake.
- Anbazhagan Panjamani et al.,2015, emphasized the importance of developing seismic hazard maps of Patna district considering the region specific maximum magnitude and ground motion prediction equation (GMPEs).

1.3 OBJECTIVES OF THE STUDY

In the light of the above facts, the present study aims-

- To find out the causes of earthquake in Patna.
- To assess the adverse effect of earthquake.
- To suggest possible risk reduction and mitigation measures.

1.4 METHODOLOGY

The present study is based upon a distinct methodology which include the following steps-

1. Pre-field survey stage
   - Collection of study material, data, and maps
   - Study of relevant literature
   - Visit to concerned websites.
2. Field survey stage
   - Preparation of schedule of collected data
   - Collection of primary data from study area (Patna)

3. Post field survey stage

- Treatment and tabulation of collected data
- Analysis of data with the help of cartographic presentation
- Preparation of project report

1.5 STUDY AREA

Patna, the capital of Bihar, is one of the oldest continuously inhabited places in the world. Ancient Patna, known as Pataliputra, was the capital of the Magadha Empire under Haryanka, Nanda, Mauryan, Sunga, Gupta and Pala. However, "Pataliputra's stars faded after almost a millennium of brilliance" until Sher Shah Suri built a walled fortress at Patna in 1541 of which only the eastern and the western gates are marked at present.Though, a mosque, built to commemorate his reign, still survives. In 1580 the Mughals made Bihar a subah (province), with Patna as headquarters of a long line of governors, many of whom were Mughal princes who built several madrasas, mausoleums, mosques, administrative and shopping centres. The English East India Company set up a factory at Patna as early as 1657 and established Bankipore after the battles of Plassey (1757) and Buxar (1764) comprising the civil station, cantonment and a race course. With the Great Revolt of 1857 the British Crown soon assumed direct control over India and established several public buildings in the city. In 1911, Patna was declared as the capital of Bihar and Orissa and New Patna came up with many more public buildings ,which became diverse when India gained independence in 1947.The Patna district center point having latitude 25.611N and longitude 85.144 E is situated on the southern bank of the Ganges. The city also straddles the rivers Sone, Gandak and Punpun. The study area of Patna belongs to the Seismic zone IV in current Seismic Zonation map of India (IS: 1893 2002), with zone factor of 0.24.

The total 57 samples have been collected from the Patna district of Bihar.

Fig. no.-1.2

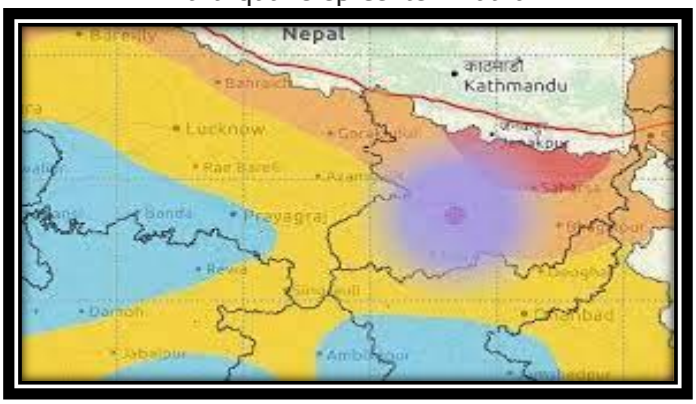
Patna, Bihar

*source- google image

2. EARTHQUAKE IN PATNA

More than 80% buildings in Patna are not earthquake resilient, experts said, and warned that they may not withstand a major tremor in future, causing huge loss of human lives and infrastructure.

Fig. no.-2.1
Earthquake epicenter- Patna



*source- google image

Bihar's capital city is one of the most vulnerable to earthquakes as per the National Centre of Seismology (NCS), India Meteorological Department (IMD). Patna falls under Zone IV, classified as a severe zone by the NCS.

Fig. no.- 2.2
Damaged house

*source- google image

With the latest one reported on February 2021, the city receives aftershocks most times an earthquake shakes up Indo- Nepal border areas. On August 21, 1988, when a 6.9 magnitude quake hit Nepal near the Indian border, the entire north Bihar including Patna shook for 15 seconds and the tremors left behind cracks in thousands of buildings including the old secretariat in the capital.In 2015, an earthquake of 7.8 magnitude on Richter scale hit the capital in April, followed by another earthquake of 7.3 magnitude in May, though their epicentre was in Nepal. These quakes damaged many old structures in the city.

2.1 CAUSES OF EARTHQUAKE

Earthquakes are caused mainly due to dis-equilibrium in any part of the crust of the earth A number of causes have been assigned to caused dis-equilibrium or isostatic imbalance in the earth's crust.

(a). Natural Reasons

- Volcanic eruption
- Faulting and folding
- Upwarping and downwarping
- Gaseous expansion and contraction inside the earth.
- Plate Movement
- Landslides

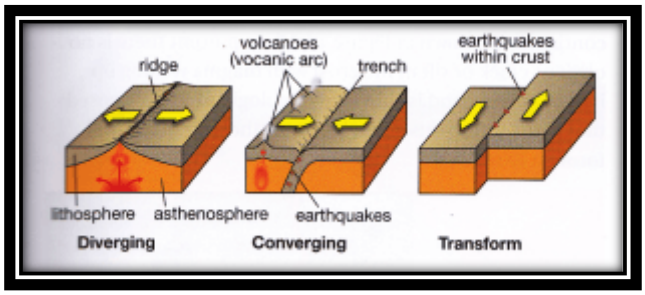
(b). Man-made/Anthropogenic Reasons

- Deep underground mining
- Blasting of rock by dynamites for construction purposes.
- Deep underground tunnel
- Nuclear explosion
- Reservoir Induced Seismicity (RIS) (E.g. Koyna Reservoir witnessed Earthquake in 1967 due to RIS)
- Hydrostatic pressure of man-made water bodies like reservoirs and lakes.

Plate tectonics provides the most logical explanation of volcanoes and earthquakes.
There are 3 types of plate boundaries along which earthquake occurs

1. Convergent
2. Divergent
3. Transform

Fig. no.- 2.3
Plate boundaries



*source- google image

Patna, located near Himalayan active seismic region has been subjected to destructive earthquakes such as 1803 and 1934 Bihar–Nepal earthquakes. Based on the past seismicity and earthquake damage distribution, linear sources and seismic events have been considered at radius of about 500 km around Patna district centre. Many important cities such as Patna, Meerut, Lucknow, Kanpur, Aligarh, Gorakhpur, Agra and Jhansi located in different parts of the Indo-Gangetic Basin (IGB) are susceptible to earthquake damages due to the proximity to seismically active Himalayan belt and situated on thick soil deposits. Also, IGB consists of many active tectonic features such as Munger–Saharsa Ridge Fault, East Patna Fault, West Patna Fault, Delhi–Haridwar Ridge, Delhi–Muzaffarabad Ridge and Faridabad Ridge. The major earthquakes such as 1833 Bihar, 1934 Bihar–Nepal, 1988 Bihar–Nepal and 2011 Delhi Earthquakes have occurred in IGB.

The study area is surrounded by several active faults and covered with thick soil deposits .Regional seismic records designate that deep regions of North Bihar Plains (area between 24.33 E–27.52 E latitude and 82.33 N–88.29 N longitude) are tectonically active. This part has documented more than 100 seismic events with 46 events of magnitude larger than 4.5 through the period of 1934–1993 (GSI 2000).

In the northeast Patna region, the key faults are West and East Patna Faults in the East Ganga basin . These faults are acknowledged as transverse faults, and the occurrence of seismic events is due to stimulus of fluvial dynamics in the North Patna plains transverse faults (Valdiya 1976; Dasgupta et al. 1987). The East Patna Fault (EPF) is considered to be the most active fault, and its interaction with Himalayan Frontal Thrust is characterized by a cluster of earthquakes (Banghar 1991; GSI 2000). This fault is located in the part of the city area. The Gandak River in the western basin of the Baghmati river basin is flowing along the Gandak Fault (Mohindra et al. 1992), which is also located near Patna district center (see Fig. 2). Dasgupta et al. (1993) ventured that all other faults between Motihari and Kishanganj have the same possibility of seismic hazard as they form a part of related fault system. Patna is near the above-mentioned fault.

Till date, the state of Bihar has faced a number of earthquakes, which include devastating earthquakes like 1934 Bihar–Nepal Earthquake, having a magnitude of 8.0, which killed nearly 10,700 people. Many earthquakes have also occurred during 1833, at Bihar–Nepal border. Various earthquakes like 1927 Madhya Pradesh earthquake, 1985 Rajauli area earthquake and 1988 Udaypur Gary earthquake have affected Patna in terms of the financial loss and loss of lives. Apart from the local seismic activity around Patna, the area

also located within a radial distance of approximately 250 km from Main Boundary Thrust (MBT) and the Main Central Thrust (MCT), where many major earthquakes have been reported . Considering the above seismic aspects of areas in and around Patna, Patna district center can be considered under a high seismic risk.

2.2 IMPACT OF EARTHQUAKE

The energy released from an earthquake can be up to 10,000 times more powerful than the first atomic bomb. Its side-effects can be:

Ground shaking

Shaking of the ground caused by the passage of seismic waves, especially surface waves near the epicentre of the earthquake are responsible for the most damage during an earthquake. The intensity of ground shaking depends on:

- conditions of the local geology influence events: solid bedrock is far less subject to intense shaking than loose sediment;
- duration and intensity of the earthquake are subject generally to the size of the earthquake;distance**:** the distance from the epicentre drops off so the intensity of the shaking decreases. This depends on the type of material underlying the area

Faulting and Ground Rupture

When an earthquake event occurs, ground rupture is only where the fault zone moves. Those constructions built adjacent to the fault will survive while structures built across these zones will collapse.

Landslides and ground subsidence

Avalanches, landslides, slumps and rock slides are triggered by ground shaking. These landslides are often more destructive than the earthquakes

Damage to man-made structures

Damage to man-made structures, such as roads, bridges, dams and buildings from ground motion depends on the type of construction:

- concrete and masonry structures are brittle and thus more susceptible to damage and collapse;
- damage to wood and steel structures is far less because of its flexibility

Fires

Fires, often associated with broken electrical and gas lines, is one of the common side effects of earthquakes. Gas is set free as gas lines are broken and a spark will start bringing "inferno". To complicate things water lines are broken and so there is no water to extinguish fire

Flooding

Flooding can come from many sources such as broken water main pipes, dams that fail due to the earthquake and earthquake-generated tsunamis. When an earthquake breaks a dam or levee along a river, the water from the river or the reservoir floods the area, damaging buildings and maybe sweeping away or drowning people. Small tsunamis, called seiches occur on lakes shaken by earthquakes and are usually just a few feet high. These small tsunamis are capable of destroying houses and uprooting trees.

Tsunamis

For sure, one of the most dangerous effects of an earthquake is a Tsunami. Tsunamis are giant waves that can cause floods and in some cases may reach up to 100 feet in height. These deadly waves strike a great distance from the epicentre. Tsunamis often result from sub-sea faulting of ocean floor sending seismic shocks through the water and creating large waves of low amplitude but of long period.

2.3 EARTHQUAKE MANAGEMENT

Measures against earthquakes

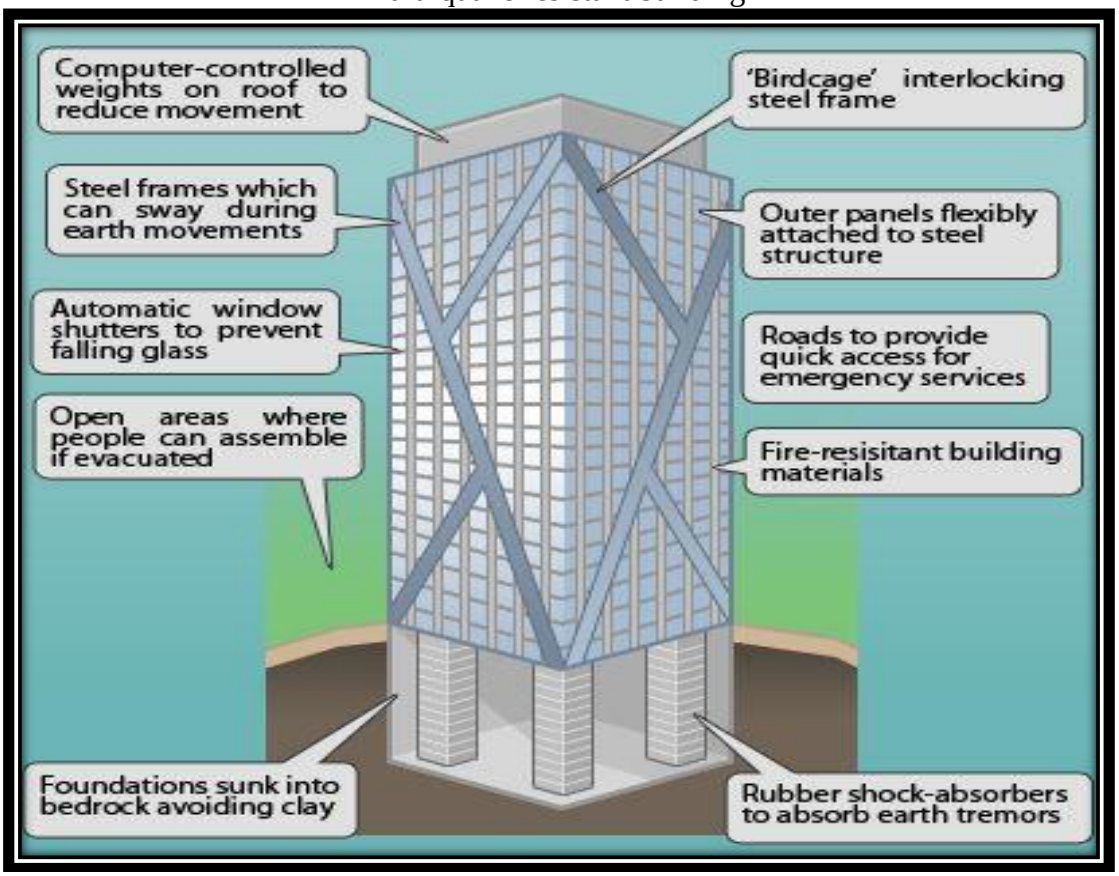
1.Personal measures

- Seek shelter under stable tables or under door frames.
- If outside, stay away from buildings, bridges and electricity pylons and move to open areas.
- Avoid areas at risk from secondary processes, such as landslides, rockfall and soil liquefaction.
- After an earthquake, check gas, water and electricity pipes and lines for damage.
- Listen to the radio and follow the instructions issued by the authorities.

2.Technical/biological measures

- No measures can be taken to prevent earthquakes themselves, however limited measures exist that can counteract their secondary effects like landslides, rockfall and soil liquefaction.
- Earthquake-proof planning and design of buildings
- The microzoning of the local geological substratum provides indicators of areas in which tremors will have a particularly strong or attenuated effect.

Fig. no.-2.4
Earthquake resistant building

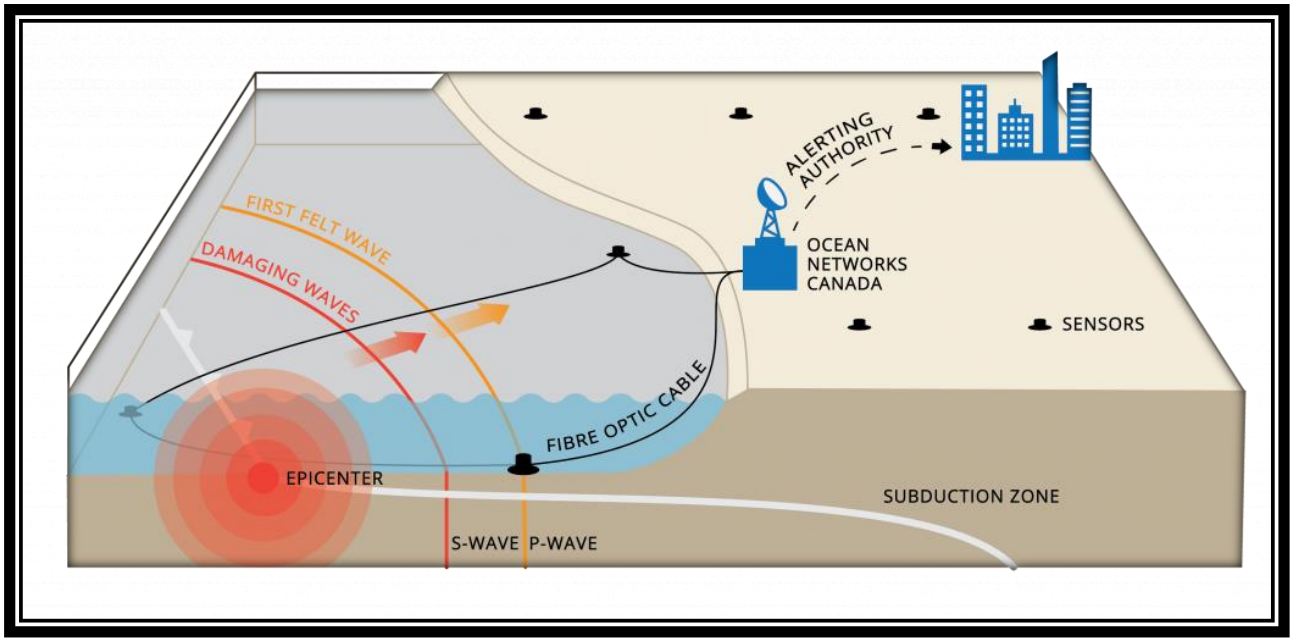


*source- google image

3.Organisational measures

At present, earthquake prediction is insufficiently precise to provide the public with sufficient advance warning. For this reason, adequate preparedness and assistance in catastrophes is extremely important in areas affected by earthquakes. Measures of this nature enable numbers of human lives to be saved.

Fig. no.-2.5
Technical measure



*source- google image

3. FEEDBACK FROM_EARTHQUAKE AFFECTED PEOPLE

The detailed study of earthquake in Patna district of Bihar covered through questionnaire that furnishes some important information regarding the same.All together 57 samples have been collected from Patna district . On the basis of this information , sets of primary data are created which are described in this chapter.

➢ GENERAL INFORMATION

Information related to age, sex ,education and occupation has been collected . The information about the age group of the respondents are summarized below.

Table 3.1
Earthquake in Patna : Age structure

Age group	Number	Percentage (%)
Below 25	37	65
25 – 35	12	21
35 -40	3	5
40 above	5	9
Total	57	100

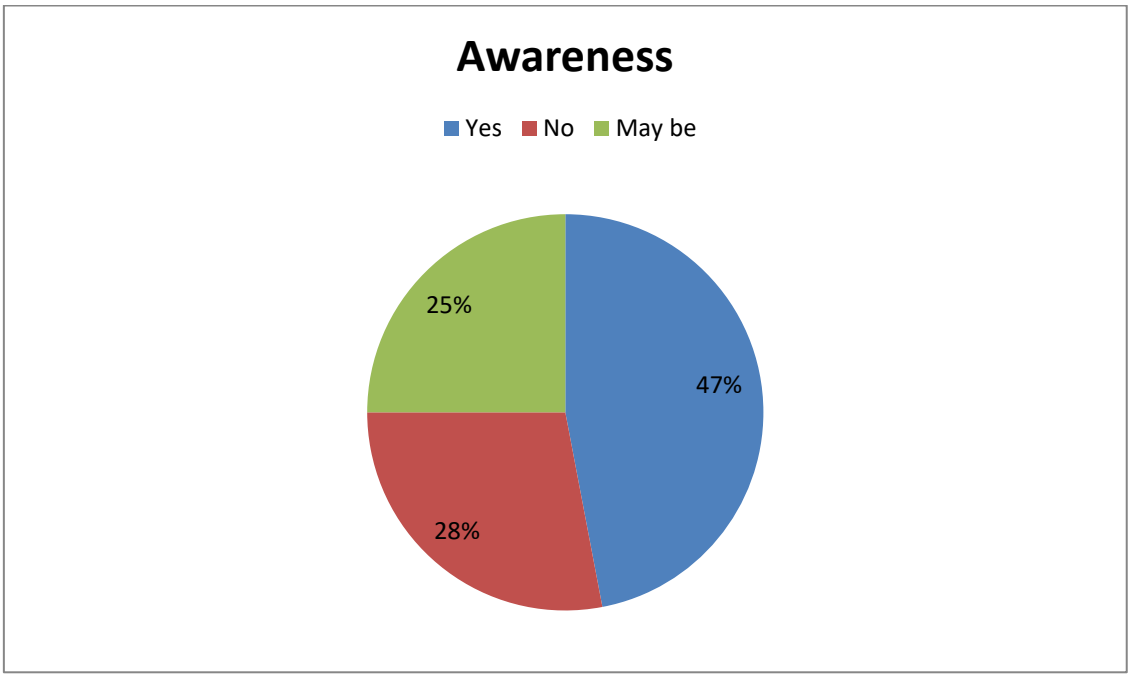
***Based on primary survey,2022**

The table 3.1 reveals that the majority of population belongs to the group of below 25 age whereas the percentage of 40 above age group is only 9%. So, the majority of the population belongs to young generation.

3.1 AWARENESS ABOUT EARTHQUAKE

The earthquake disaster management in India comprises pre-disaster and post-disaster management measures. Earthquake prevention, mitigation and preparedness are most significant aspects.

Chart-3.1
Awareness about earthquake management



***Based on primary survey,2022**

Table -3.2
Awareness about earthquake management

Awareness	Number	Percentage
Yes	27	47
No	16	28
May be	14	25
Total	57	100

***Based on primary survey,2022**

It is clear from the table 3.2 and figure 3.1 that 47% respondents are aware of the earthquake management. On the other hand 28% are not aware of it.

3.2 EARTHQUAKE RESISTANT BUILDING

The casualities are high because of collapse of buildings.

Table-3.3
Design of structure

Design of structure	Number	Percentage
Base isolation	1	02
Shock absorption	0	0
T-shaped	2	03
Pendulum power	0	0
Rocking core wall	0	0
L-shaped	6	11

Cross bracing	0	0
Inappropriate	48	84
Total	57	100

***Based on field survey,2022**

Table 3.3 depicts that 84% of the respondent agreed that their building structure is inappropriate as per earthquake resistance building norms . Base isolation building, T-shaped and L-shaped buildings were 2 % and 3% and 11% respectively.

Fig. no. -3.1

Earthquake resistant building- Sardar Patel Bhawan, Patna

*source- google image

3.3 SEVERITY OF EARTHQUAKE EXPERIENCE

Table -3.4

Earthquake in Patna : severity of earthquake experienced

Level of severity	Number	Percentage
Very serious	17	30
Moderate	33	58
Low	07	12
Total	57	100

*Based on primary survey,2022

From the table 3.4 it is observed that the severity of earthquake is 30%. The majority of the respondents i.e., 58% have experienced moderate earthquake and 7% of them experienced low earthquake.

3.4 LOSS SUFFERED IN FAMILY

Table 3.5

Earthquake in Patna : Loss suffered due to earthquake

Loss suffered	Number	Percentage
Death	01	02
Loss of property	28	49
Physical injury	08	14
Other	20	35
Total	57	100

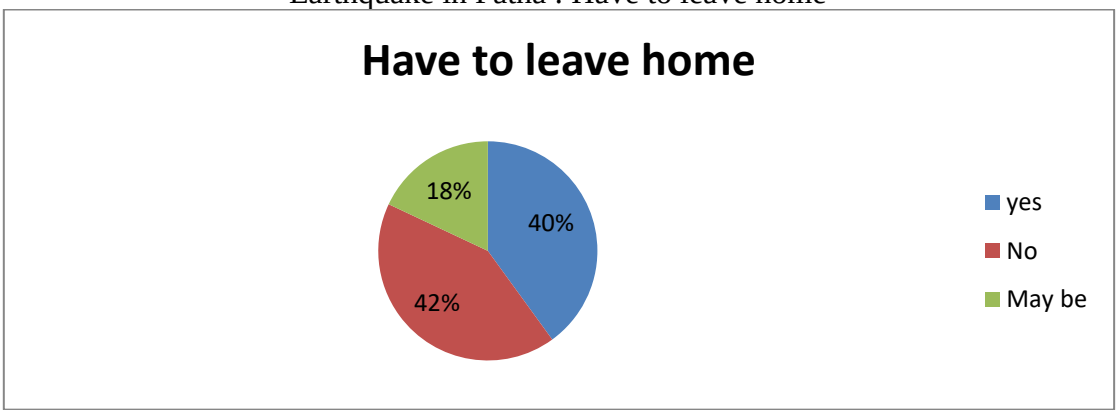
*Based on primary survey,2022

The level of severity is not much problematic but the loss caused by even moderate earthquake is comparatively high. It is observed from the table 3.5, that 49% of people have suffered property loss, 14% physical injury, 2% death and remaining 35% suffered other loss.

3.5 HAVE TO LEAVE HOME FOR SAFER PLACE

Chart – 3.2

Earthquake in Patna : Have to leave home



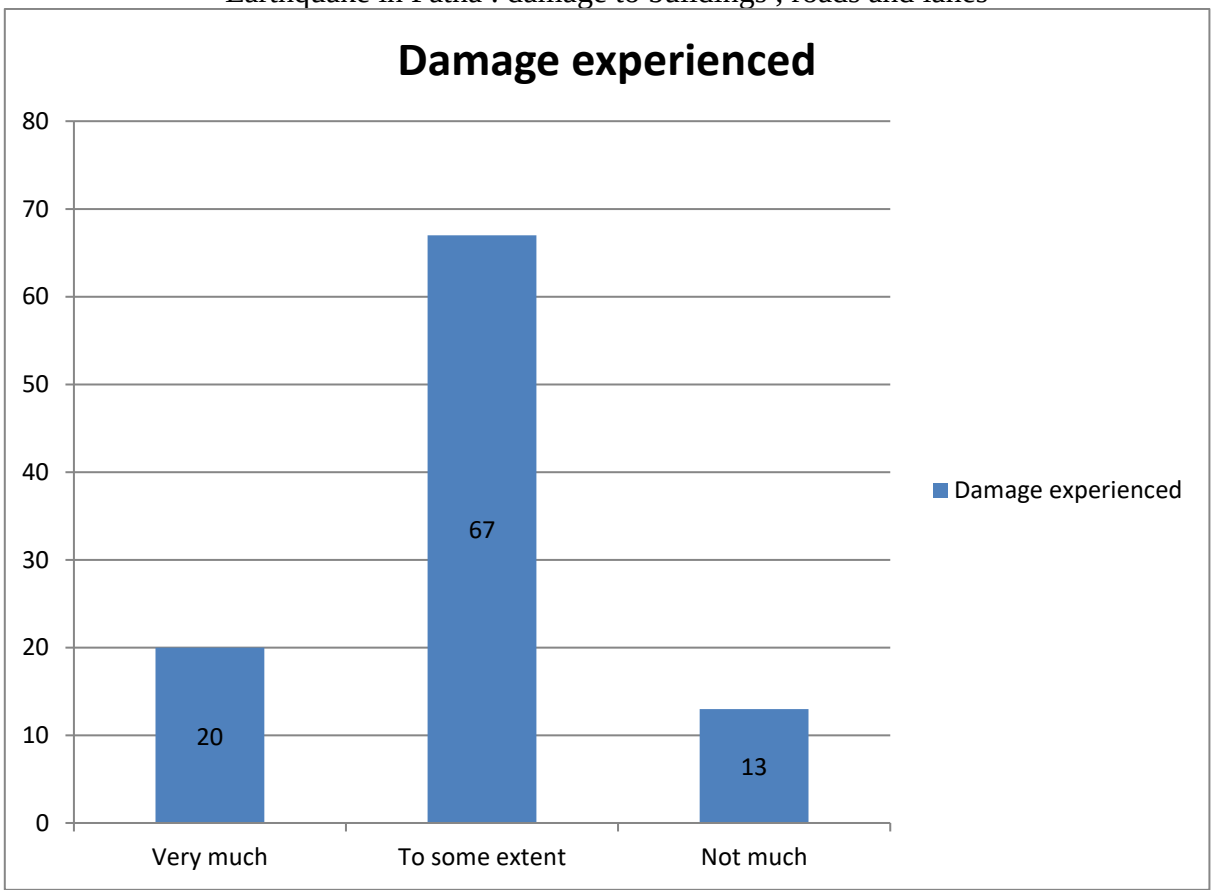
***Based on primary survey,2022**

Figure 3.2 shows that 40% of the respondents have to leave their home for safer place due to earthquake (temporarily). Although 42% have accepted that they have not shifted during earthquake . 18% are not sure about leaving their home.

3.6 DAMAGE TO BUILDINGS, ROADS AND LANES

Chart.3.3

Earthquake in Patna : damage to buildings , roads and lanes



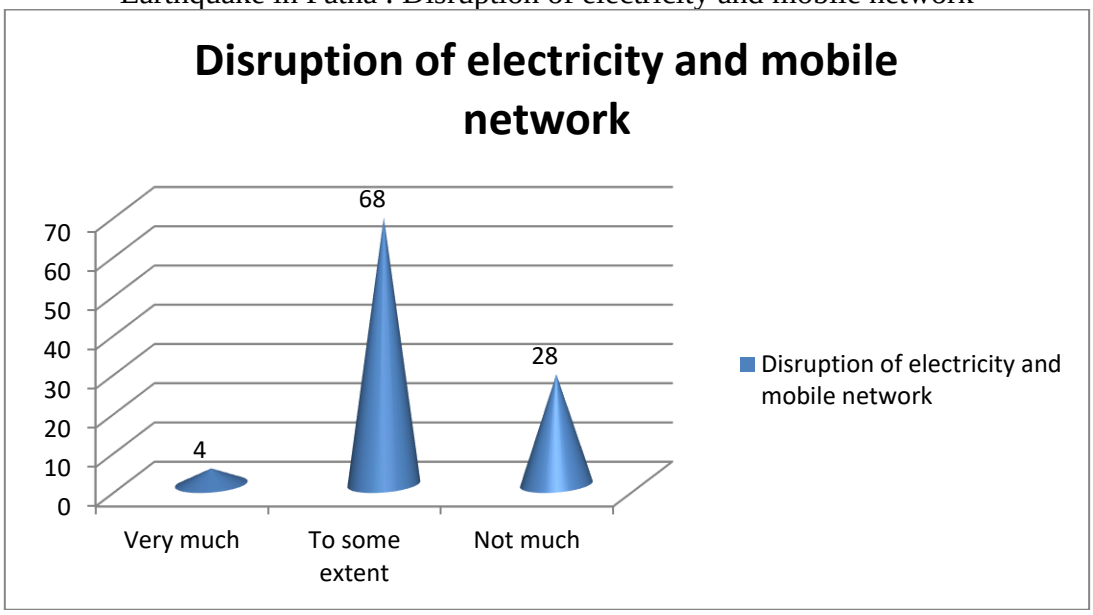
*Based on primary survey,2022

From figure 3.3 ,it is noted that 67 % people of the study area accepted that there was moderate damage to houses , roads and lanes while 20% agreed that there was severe damage to houses ,roads and lanes in the area.

3.7 DISRUPTION OF ELECTRICITY SUPPLY

Chart -3.4

Earthquake in Patna : Disruption of electricity and mobile network



*Based on primary survey,2022

Figure 3.3 represents that 68% of the respondents accepted thet there have been moderate disruption of electricity and mobile network in their locality whereas 28 % of the respondents said that there have not been much disruption . 4% accepted that they faces serious disruption issues.

3.8 SOURCE OF HELP DURING EARTHQUAKE

Table -3.6

Earthquake in Patna : Source of help during medical emergency

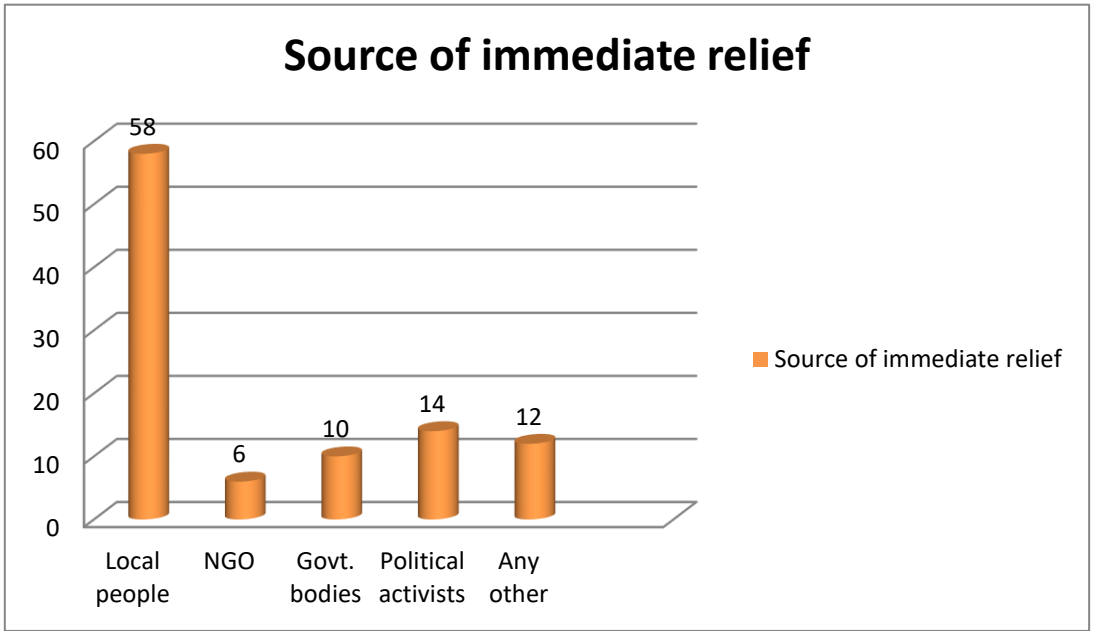
Got help from	Number	Percentage
Local doctors	23	41
Govt. hospital	16	28
Private hospital	15	26
Medical shop	03	05
Total	57	100

*Based on primary survey ,2022

Table 3.6 depicts that 41% of the respondents got help from local doctors and only 28 % got help from government hospitals. The lower percentage of help from government hospitals shows the failure of government in providing disaster related relief.

3.9 SOURCE OF IMMEDIATE RELIEF

Chart-3.5



*Based on primary survey,2022

From the above figure 3.4 , it is noted that 58% respondents got assistance from their neighbours while 6% people got immediate relief from NGOs. 12% have agreed that they got relief from other sources in which family members and relatives might be included.

Table -3.7

Earthquake in Patna : post-earthquake restoration

Pace of restoration	Number	Percentage
Fast	06	11
Not so fast	30	52
Slow	17	30
Very slow	04	07
Total	57	100

*Based on primary survey,2022

Table 3.5 is delineating that 52% of the respondents have agreed that the pace of return after the disaster is not so fast . 7 % people stated that the rehabilitation work is very slow.

3.10 MENTAL STATUS DURING AND AFTER EARTHQUAKE

Earthquake disturbs mentally and psychologically people of all ages. The aftershocks kept people in continuous mental dilemma of ground shaking that lead to distress, anxiety, depression and social dysfunction ,etc.

Table 3.8

Earthquake in Patna :Mental status during earthquake

Mental status	Number	Percentage
Agony	04	07
Panic	18	32
Fear	11	19
Insecurity	08	14
Trauma	04	07
Distress	04	07
Strong and stable	08	14
Total	57	100

*Based on primary survey,2022

It is clear from the table 3.6 that 32% of the respondents panicked during earthquake . 19% were fearful due to aftershocks and 14%were insecure.

3.11 THE LIFE AFTER EARTHQUAKE

Table 3.9
Earthquake in Patna :life after earthquake

Life after flood	Number	Percentage
Same as before	27	47
Better than before	10	18
Worse than before	20	35
Total	57	100

***Based on primary survey,2022**

Table 3.7 depicts that life after earthquake is not satisfactory . 47 % of the people accepts that their life after earthquake is same as earlier . on the other side 35% people are facing worse situation after earthquake.

4. FINDINGS AND CONCLUSION

The present study "**EARTHQUAKE IN PATNA :A FIELD STUDY"** reveals certain noticeable findings in order to inspect the overall socio-economic and psychological condition of earthquake affected population in Patna district . survey was carried out covering 57 samples from various localities of Patna district of Bihar.

4.1 SUMMARY OF THE FINDINGS

After the detailed analysis of data collected from the primary survey the following information are gathered-
It is observed that the majority of population belongs to the group of below 25 years of age whereas the percentage of 40 and above group is only 9%. So, the majority of the population belongs to young generation. Awareness about the disaster is an important aspect of any particular area. 47% of respondents are aware of the earthquake management but 28% are not aware of earthquake safety tips.

84% of the respondent agreed that their building structure is inappropriate as per earthquake resistance building norms . Base isolation building, T-shaped and L-shaped buildings were 2 % and 3% and 11% respectively

58% of the sample population agreed that the severity of earthquake was moderate but some of them i.e. 30% witnessed extreme level of severity. About 49% of respondents suffered from the loss of property whereas 14% were suffered physical injury and 35% were suffered from other problems. 40% of the interviewee had to shift themselves to safer place. . Damage of housing, roads, lanes and electricity and mobile network was moderate.

41% of the respondents got help from local doctors and only 28% people got help from government hospitals. The lower percentage of help from government hospitals shows the failure of government hospitals in health and wellbeing aspects in the Patna district. Source of immediate help was from local people i.e.58% and only 10% from government bodies. Only 14% of the sample population is satisfied to the role of government agencies. Majority of population stated that the retrofitting work is not so fast.

Earthquake affects people of all ages and it can leads to other challenges. Earthquake exposes people to several problems . Survivors of earthquake can experience longer-term psychological effects such as distress, anxiety, pain, depression and social dysfunction etc. 32% of the respondents panicked during earthquake. 14% felt insecurity due to earthquake in their locality while 19% was fearful. Life after earthquake disaster is not satisfactory. 47% of the respondents accepted that their life after earthquake is same as it was earlier. On the other side, 35% people are facing worse situation after the earthquake.

4.2 Conclusion

An earthquake is the shaking of the surface of the Earth, resulting from the sudden release of energy in the Earth's lithosphere that creates seismic waves. Earthquake is the form of energy of wave motion

transmitted through the surface layer of the earth.It may be due to faulting , folding, plate movement, volcaninc eruptions and anthropogenic factors like dams and reservoirs .Earthquake are by far the most unpredictable and highly distructive of all the natural disasters.Minor earth tremors caused by gentle waves of vibration within the earth's crust occur every few minutes while Major earthquakes usually caused by movement along faults, can be very disastrous particularly in densely populated areas.
More than 80% buildings in Patna are not earthquake resilient, experts said, and warned that they may not withstand a major tremor in future, causing huge loss of human lives and infrastructure. Bihar's capital city is one of the most vulnerable to earthquakes as per the National Centre of Seismology (NCS), India Meteorological Department (IMD). Patna falls under Zone IV, classified as a severe zone by the NCS.

The city receives aftershocks most times an earthquake shakes up Indo- Nepal border areas. On August 21, 1988, when a 6.9 magnitude quake hit Nepal near the Indian border, the entire north Bihar including Patna shook for 15 seconds and the tremors left behind cracks in thousands of buildings including the old secretariat in the capital.

In 2015, an earthquake of 7.8 magnitude on Richter scale hit the capital in April, followed by another earthquake of 7.3 magnitude in May, though their epicentre was in Nepal. These quakes damaged many old structures in the city.

4.3 SUGGESTIONS

Earthquake management is the organization and management of the resources and responsibilities for dealing with all humanitarian aspects of emergencies. The aim is to reduce the harmful effects of the hazards. The earthquake management includes steps from pre-earthquake risk reduction to post-earthquake recovery.

1. **Risk Recognition** – Certain areas are more vulnerable to earthquakes than others, so risk recognition is the first step.
2. **Earthquake monitoring system/Early warning system**– Making a precise forecast about the occurrence of an earthquake in a region is still a difficult proposition. Seismologists are increasingly concentrating on the aspect of earthquake forecasting.

- It will help in reducing the impact of upcoming disasters.
- **Example:** – Japan has an earthquake early warning system that uses electronic signals that reach faster than earthquake waves.

3. **Structural Solution**– Past earthquakes show that over 95% of the lives lost were due to the collapse of buildings that were not earthquake resistant. But, the construction of such quake-resistant buildings is more expensive than ordinary buildings. Therefore, a cost-effective solution remains a challenge for a country like India. Seismic strengthening can be done through prioritization of structures and to implement this, it is important to have an earthquake hazard map for various zones according to the vulnerability.

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APPENDIX
GEOG CC614
Earthquake in Patna: A Field Study

An Appeal: The present questionnaire is a part of research project on disaster undertaken by Semester-VI students (session 2019-22), Patna women's College, Patna. The study is going to be totally academic in nature and the given information will be used for academic purpose only.

QUSTIONNNAIRE

1. Email/ Name
2. City/ Town / Village
3. Age- Below 25/ 25-35/ 35-40/ 40 and above
4. Sex – male/ female/ others
5. Educational attainment- Pre matric/ Matric/ Post matric/ Graduation/ Post graduation
6. Occupation- Student/ Self- employed/ Government employee/ Home-maker/ Private job/ Other
7. Monthly income (if you are earing)- Below 25,000/ 25,000-50,000/ 50,000-100,000/ 100,000 & above
8. Are you aware about Earthquake management and safety tips- Yes/ No
9. Is your building/house earthquake resistant- yes/no
10. Severity of earthquake experience- Very serious/ moderately serious/ moderate
11. Loss suffered in family- Death/ loss of property/ physical injury/ other
12. Had to leave home for safer place- Yes/ No/ May be
13. Damage to housing, road or lanes- Yes, very much/ to some extent/ not much
14. Experienced disruption of electricity supply and mobile network- Very much/ to some extent/ not much
15. Types of building – T-shaped/L-shaped/other
16. Experienced any medical emergency- Yes/ no/ may be
17. If yes, got help from- Local doctors/ Govt. hospitals/ Pvt. Hospitals/ Medicine shop
18. Immediate relief provided by- Local people/ NGO/ Govt. bodies/ Any other
19. Are you aware of government initiative regarding earthquake retrofitting- Yes/ no/ may be
20. The post earthquake restoration of essential services concern by agencies- Fast/ Not so fast/ Slow/ Very slow
21. Mental status during flood- Agony/ Panic/ Fear/ Insecurity/ Trauma/ Distress/ Strong and stable
22. The life after earthquake disaster- Same as before/ Batter than before/ Worse than before

23.. Any Suggestions/ Observation/ Comment