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Design and Analysis of a Multistory Reinforced Concrete Frame in Different Seismic Zone

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ABSTRACT

This study work focuses on the analysis of a structural system to determine the deformations and comparison of steel quantity of seismic zones. In this study, we have taken G+12 multi-storied RC moment-resisting framed structure building with the shear wall by analyzing the structure for gravity load, wind load and seismic loads for different cities. By Selecting four different cities on the basis of seismic zones (zone II, zone III, zone IV, zone V) and also considering that the basic wind speed. We have mainly focus on the structural system to determine the deformations and also forces induced by applied loads or ground excitation is an essential step in the design of a structure to resist earthquake. The analysis and design for all the cities are carried out using 'STAAD Pro' and 'STAAD Foundation' software which are industry standard software the world over. The wind-resistant design is carried out as per IS 875: (Part 3) 1987 and the earthquake-resistant design is carried out as per IS 1893: (Part 1) 2002. Analysis and design of beams, columns and shear wall have been done in STAAD Pro and the foundation is done in STAAD Foundation. We have also checked the design of some beams, columns, and footings manually and find correct. Design of RCC slabs is carried out manually for which an excel sheet is developed for working out moment coefficients for different edge conditions as per IS code. In this study work, we design and analyze a reinforced concrete frame structure in various seismic zones and we observing the variation in the behavior of the structure in various loading conditions.

KEYWORDS: *Biometrics, Automated Fingerprint Identification System, Huffman Code*

INTRODUCTION

Earth develops and discharges vitality. At the point when this happens, we have a quake, which is the shaking of the ground when shake beneath Earth's surface breaks. In the present scenario earthquake engineering attracts major attention of scientist because this is the event which cannot be accurately predicted it is the sadden event which happens due to various reasons such as;

1. Movement of tectonic plates.
2. Sudden slips at the faults.
3. The building of dams.
4. Volcanic earthquakes.
5. Due to explosive.
6. Due to mining etc.

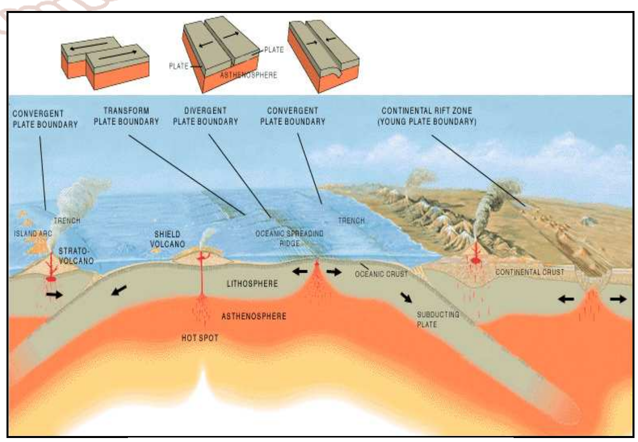


Figure1: Details of the earth crust

Many reaches have been conducted on this topic and still, it is continuing because more we try to learn more we can minimize the damages and save the lives. According to studies that have been made on the seismology about 90% earthquake happens due to tectonics. If we come to civil engineering an engineer's job is to provide maximum safety in the structures designed and maintain the economy. Whenever a structure is designed for a natural incident such as an earthquake we design it to behave limit states of serviceability, damageability and collapse.

Due to these reasons earthquake engineering gaining popularity. if we introduce the reinforcement in the structure we can increase the ductility of the structure But the incorporation of reinforcement in the structure mainly affects the economy of the structure.

In this project, we have taken G+12 multi-storied RC moment resisting framed structure building with the shear wall. We have analyzed the structure for gravity load, wind load and seismic loads for different cities. In selecting the cities, we have select four different cities on the basis of seismic zones and also considering that the basic wind speed should be different. We have select Bhopal for seismic zone II, Mumbai for seismic zone III, Delhi for seismic zone IV and Guwahati for Zone V.

After the analysis and design, we found that wind load is governing as compared to gravity load but it is not governing as compared to earthquake load. We have compared the volume of concrete and weight of reinforcement for all the loads in all cities and found the percentage variation in them with respect to gravity load.

We have then calculated the cost of RCC of the whole structure and compared to the gravity load in all seismic zones. Since the cost of the RCC is not the cost of the whole building so we have assumed that it is 50% of the total cost of the building. The main reason behind the cost comparisons is the removing of the myth that earthquake resistant building costs too much. For cost comparisons, we have taken the rate of each item from D.S.R. published by CPWD New Delhi.

Among the common perils, seismic tremors have the potential for making the best harms designed structures. Since quake powers are arbitrary in nature and flighty, the designing instruments should be honed for investigating structures under the activity of these powers. India has some of the world's most noteworthy tremors in the most recent century. Actually, more than 50% zone in the nation is viewed as inclined to harming seismic tremors. The northeastern locale of the nation and additionally the whole Himalayan belt is powerless to extraordinary seismic tremors of greatness more than 8.0.

Introduce examine comprises of (G+12) reinforced concrete frame structure symmetric in plan with settled construct resting various soil sorts.

Since quakes are the after effect of plate limit communications, it's nothing unexpected that most seismic tremors happen in only a couple of particular regions on Earth. Truth be told, these zones are known for quakes and volcanoes, which additionally have a tendency to happen where plates meet Components influencing seismic Design
1) The natural frequency of the building
2) The damping factor of the structure
3) Type of foundation of the structure
4) Importance of the building
5) Ductility of the structure

EARTHQUAKE TERMINOLOGY

Elastic wave:
A wave that is propagated by some kind of elastic deformation, leading to changes in shape that disappear when the forces are removed. A seismic wave is a type of elastic wave.

Epicenter:
It is the point on the surface of the Earth, vertically above the place of origin (Hypocenter or Focus) of an earthquake. This point is expressed by its geographical coordinates in terms of latitude and longitude.

Fault:
A fracture or fracture zone (a weak plane) in the Earth's crust or upper mantle, along which the two sides have been displaced relative to one another. Faults are caused by earthquakes and earthquakes are likely to recur on pre-existing faults, where stresses are accumulated. Far-field Observations made at large distances from the hypocenter, compared to the wave-length and/or the source dimension.

Fault slip:
The relative displacement of points on opposite sides of a fault, measured on the fault surface.

Focal mechanism:
A description of the orientation and sense of slip on the causative fault plane derived from the analysis of seismic waves.

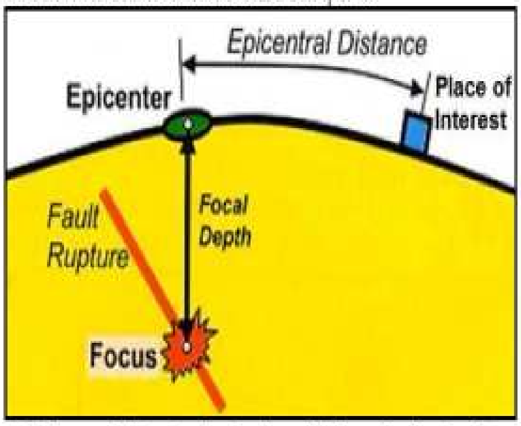
Focus (Hypocentre) / Focal Depth:
A point inside the Earth, where the rupture of the rocks takes place during an earthquake and seismic waves begin to radiate. Its position is usually determined from arrival times of seismic waves recorded by seismographs.

Foreshock:
A relatively small tremor (or an earthquake) that commonly precedes a relatively large magnitude earthquake (called the "main shock"), by seconds to weeks or months and originates in or near the rupture zone of the main shock.

Hazard (Earthquake /Seismic):
Earthquake hazard, H (X,t,T,I) in a region, area or site is represented by the percentage probability reckoned at the current epoch (t) with which the prescribed values (I) of ground motion (displacement, velocity, acceleration, spectral amplitudes) at the site (X), arising from any (or all) anticipated earthquakes in the region, will not exceed over a given time interval (T) of say 20, 50, 100, 500 years in the future. These are usually expressed as maps, showing contours of a specified ground-motion parameter, called "seismic hazard map".

Intensity:
A subjective measure of the effects of an earthquake at a particular place on humans, structures and (or) the land itself. The intensity at a point depends not only upon the strength of the earthquake (magnitude) but also on the distance from the earthquake to the point and the local geology at that point. Intensity grades are commonly given in Roman numerals (in the case of the Modified Mercalli Intensity Scale, from I for "not perceptible" to XII for "total destruction"). (See Modified Marcella Intensity Scale) 4 Inter-plate & Intra-plate earthquakes.

Focal Depth:-It is the vertical distance between the Focus and the epicenter.



The figure explains the related terminology used in the earthquake engineering

Seismic Waves: They are the waves of energy caused by the sudden breaking of rock within the earth or by an explosion. They carry the released energy and travel through the earth and are recorded on seismographs. There are many types of seismic waves, viz., body waves, surface waves, coda waves, etc.

Seismic Zone: A region in which earthquakes are known to occur. Bureau of Indian Standards [IS-1893 (Part-1): 2002], based on various scientific inputs from a number of agencies, has grouped the country into four seismic zones viz. Zone-II, -III, -IV and –V. Of these, Zone V is the most seismically active region, while zone II is the least. The Modified Mercalli (MM) intensity, which measures the impact of the earthquakes on the surface of the earth, broadly associated with various zones is as follows:

Seismic Zone Intensity
A. (Low-intensity zone)
B. (Moderate-intensity zone)
C. (Severe-intensity zone)
D. (Very severe-intensity zone) IX (and above)

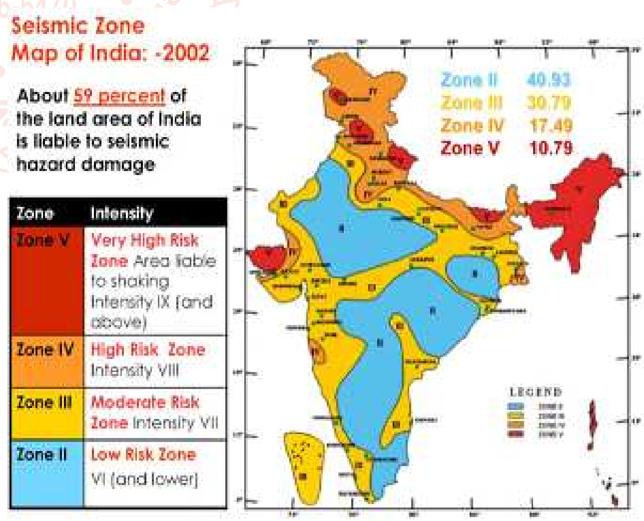
Seismicity Earthquake activity
Seismogram is a continuous written record of an earthquake recorded by a seismograph.

Glimpses of some of the earthquake related failures

Collapsing a building

A total collapse of a building

Fig. Apartment collapse in bhuj (2001)
Source: www.news.cn



List of earthquakes in India
The Indian subcontinent has a history of earthquakes. The reason for the intensity and high frequency of earthquakes is the Indian plate driving into Asia at a rate of approximately 47 mm/year.[1] The following is a list of major earthquakes which have occurred in India.

Table 1 list of earthquake in India

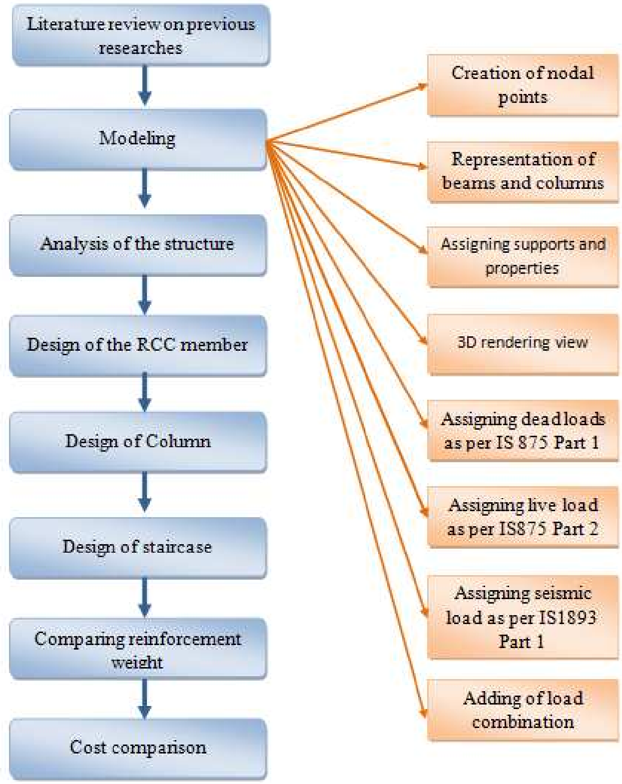
Date	Location	M		I	Deaths	Injuries	Total damage / notes	
2017-01-03	India, Bangladesh	5.7	Mw	V	3	8		
2016-01-04	India, Myanmar, Bangladesh	6.7	Mw	VII	11	200		
2015-10-26	Afghanistan, India, Pakistan	7.7	Mw	VII	399	2,536		
2015-05-12	Nepal, India	7.3	Mw	VIII	218	3,500+		
2015-04-25	Nepal, India	7.8	Mw	IX	8,964	21,952	$10 billion	
2013-05-01	Kashmir	5.7	Mw		3	90	$19.5 million	NGDC
2011-09-18	Gangtok, Sikkim	6.9	Mw	VII	>111			
2009-08-10	Andaman Islands	7.5	Mw	VIII			Tsunami warning issued	
2008-02-06	West Bengal	4.3	Mb		1	50	Buildings damaged	NGDC
2007-11-06	Gujarat	5.1	Mw	V	1	5	Buildings damaged	[2]
2006-03-07	Gujarat	5.5	Mw	VI		7	Buildings damaged	[3]
2006-02-14	Sikkim	5.3	Mw	V	2	2	Landslide	[4]
2005-12-14	Uttarakhand	5.1	Mw	VI	1	3	Building destroyed	[5]
2005-10-08	Kashmir	7.6	Mw	VIII	86,000–87,351	69,000–75,266	2.8 million displaced	
2005-03-15	Maharashtra	4.9	Mw	VII		45	Buildings damaged	[6]
2004-12-26	off northern Sumatra	9.1–9.3	Mw	IX	230,000–280,000		Destructive tsunami	
2002-09-13	Andaman Islands	6.5	Mw		2		Destructive tsunami	NGDC
2001-01-26	Gujarat	7.7	Mw	X	13,805–20,023	~166,800	Republic Day (India)	
1999-03-29	Chamoli district-Uttarakhand	6.8	Mw	VIII	~103			
1997-11-21	Bangladesh, India	6.1	Mw		23	200		
1997-05-22	Jabalpur, Madhya Pradesh	5.8	Mw	VIII	38–56	1,000–1,500	$37–143 million	
1993-09-30	Latur, Maharashtra	6.2	Mw	VIII	9,748	30,000		
1991-10-20	Uttarkashi, Uttarakhand	6.8	Mw	IX	768–2,000	1,383–1,800		
1988-08-21	Udayapur, Nepal	6.9	Mw	VIII	709–1,450			
1988-08-06	Myannmar, India	7.3	Mw	VII	3	12		[7]
1988-02-06	Bangladesh, India	5.9	Mw		2	100		[8]
1986-04-26	India, Pakistan	5.3	Ms		6	30	Severe damage	NGDC
1984-12-30	Cachar district	5.6	Mb		20	100	Severe damage	NGDC
1982-01-20	Little Nicobar	6.3	Ms			Some	Moderate damage	NGDC
1980-08-23	Kashmir	4.8	Ms		Few		Limited damage / doublet	NGDC

1980-08-23	Kashmir	4.9	Ms		15	40	Moderate damage / doublet	NGDC
1980-07-29	Nepal, Pithoragarh district	6.5	Ms		200	Many	$245 million	NGDC
1975-01-19	Himachal Pradesh	6.8	Ms	IX	47			
1970-03-23	Bharuch district	5.4	Mb		26	200	Moderate damage	NGDC
1967-12-11	Maharashtra	6.6	Mw	VIII	177–180	2,272	$400,000	
1966-08-15	North India	5.6	Unknown		15		Limited damage	NGDC
1966-06-27	Nepal, India	5.3	Ms	VIII	80	100	$1 million	NGDC
1963-09-02	Kashmir	5.3	Unknown		80		Moderate damage	NGDC
1960-08-27	North India						Moderate damage	NGDC
1956-07-21	Gujarat	6.1	Ms	IX	115	254		
1954-03-21	India, Myannmar	7.4	Ms				Moderate damage	NGDC
1950-08-15	Assam, Tibet	8.6	Mw	XI	1,500–3,300			
1947-07-29	India, China	7.3	Mw					
1941-06-26	Andaman Islands	7.7–8.1	Mw		8,000		Destructive tsunami	
1935-05-31	Quetta, Baluchistan	7.7	Mw	X	30,000–60,000			
1934-01-15	Nepal	8.0	Mw	XI	6,000–10,700			
1932-08-14	Assam, Myannmar	7.0	Ms				Moderate damage	NGDC
1905-04-04	Kangra	7.8	Ms	IX	>20,000			
1897-06-12	Shillong, India	8.0	Mw	X	1,542			
1885-06-06	Kashmir						Severe damage	NGDC
1885-05-30	Srinagar				3,000		Extreme damage	NGDC
1881-12-31	Andaman Islands	7.9	Mw	VII			Significant in seismology	
1869-01-10	Assam, Cachar	7.4	Mw	VII	2		Severe damage	
1845-06-19	Rann of Kutch	6.3	Ms	VIII	Few		Limited damage / tsunami	NGDC
1843-04-01	Deccan Plateau						Moderate damage	NGDC
1833-08-26	Bihar, Kathmandu	8.0	Ms				Severe damage	NGDC
1828-06-06	Kashmir				1,000		Severe damage	NGDC
1819-06-16	Gujarat	7.7–8.2	Mw	XI	>1,543		Formed the Allah Bund	
1618-05-26	Bombay			IX	2,000		Severe damage	NGDC
1505-06-06	Saldang, Karnali zone	8.2–8.8			6,000			
Note: The inclusion criteria for adding events are based on WikiProject Earthquakes' notability guideline that was developed for stand alone articles. The principles described also apply to lists. In summary, only damaging, injurious, or deadly events should be recorded.								

LITERATURE SURVEY

- Perla Karunakar the author put his efforts to find out the performance and variation in steel percentage and concrete quantities in various seismic zones and impact on the overall cost of construction. According to his analysis work, the quantity of concrete is increased in exterior and edge columns due to the increase in support reactions however variation is very small in interior column footings. Reinforcement variation for the whole RC frame structure between gravity and seismic loads are 12.96, 18.35, 41.39, 89.05%. The cost variation for ductile vs non ductile detailing is 4.06%.
- Purnachandra Saha, P.Prabhu Teja & P Vijay Kumar this research is mainly focused on variation in the percentage of steel when the building is designed for seismic zones. As per their research work, they concluded that percentage variation of steel in beams are not varying much as compared to columns. Variation is around 0.07% in columns and overall variation is around 0.91% from Zone II to Zone V.
- G Papa Rao and Kiran Kumar the author's researches on the changes in the percentage of steel and volume of concrete for the RCC framed structure for various seismic zones of India. They have designed the structure for gravity load and seismic forces which might be the effect on the building. According to him that the variation in support reactions for exterior columns increased from 11.59% to 41.71% and in case of edge columns it is 17.72% to 63.7% from Zone II to Zone V, and as in the case of interior columns it is very less. In case of total concrete quantities, the volume of concrete has been higher for exterior and edge columns from Zone III to Zone V because of higher values of support reactions with the effect of lateral forces and variation is very small in interior columns.
- Md Zubair Ahmed, Arshad, & Abdul Khadeer, the study was conducted to compare the percentage of steel quantities for buildings subjected to gravity loads, seismic forces. After the study of the whole frame structure, they got to the conclusion that Percentage of steel is more in outermost and edge columns in comparison to the interior columns and in case of beam external beams require less percentage of reinforcement compare to internal beams.
- J. C. Wason, V. Thiruvegadam, K. I. Prakash the study shows the cost modeling and quantity of a building foundation for RC multistoried structure designed for earthquake forces for various seismic zones of India. In this study, three types of foundations have been selected i.e. isolated foundation, pile foundation and raft foundation for various values of bearing pressures of the soils. The report gives the idea of foundation cost and structural quantities for the unit floor area of the structure located in various earthquake regions. According to this study following results are achieved. For isolated foundation, variations in concrete quantities are between 0.05 to 0.10 m3/m2 because of changes in allowable soil bearing pressure. The reinforcement changes from 3 to 9 kg/m2. Considering the case of pile foundation, the amount of concrete is 0.16m3/m2 and need of reinforcement changes between 10 to 13 kg/m2 because of variation in earthquake zones. In the raft foundation, the quantity of concrete also changes.

METHODOLOGY



MODELING

In the investigation work four models of the reinforced concrete frame.

Tall structure G+12 floors are made to know the reasonable conduct of working amid tremor.

The length of the building is 26m and width is 16m. The tallness of the individual story is 3m. The building is situated in zone II, III, IV & V. The building is created according to IS 456-2000. Concrete material of grade M25 is used, while steel Fe 415 and Fe 415 are utilized. Brick masonry having density 20 KN/m3 is utilized. Direct properties of the material are considered. For the investigation work staad pro. Software is utilized. The column sections are thought to be settled at the ground level.

Details of the structure:

Table 2 Details of the Structure

S.no.	Particulars	values
1	Size of beam	.6mx.5m
2	Size of column	.7mx.5m
3	Plan size	26mx16m
4	Height of structure	39m
5	Height of individual story	3m
6	The density of brick masonry	20kn/m3
7	Density of concrete	25kn/m3
8	Grade of concrete	M 25
9	Grade of steel	415
10	Soil condition	Medium soil
11	The thickness of the outer wall	.2m
12	The thickness of the inner wall	.1m
13	Seismic zones	ii, iii, iv, v
14	Thickness of slab	.15m
15	Importance factor	1

CONCLUSIONS

To understand the behavior of the reinforced concrete frame structure under the various type of seismic load applied in different seismic zones. The builder and constructors' should adopt the codal provisions in all the future constructions, as prevention is better than cure. On the light of avoiding the risk, this may not be an impossible task as earthquake resistant measures in building involve only 8%-10% additional cost depending upon the type of the building. The maximum story displacement, overturning moment obtained from the response spectrum method is lesser than those obtained by the equivalent static lateral force method.

ACKNOWLEDGEMENT

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[3] IS 456-2000 - Code of Practice for plain and reinforced concrete It is an Indian Standard code of practice for general structural use of plain and reinforced concrete. The latest revision of this standard was done in year 2000, reaffirmed 2005. This code uses the limit state design approach as well working stress design approach. It gives extensive information on the various aspects of concrete.

[4] IS 875 : Part 1 : 1987 Code for design loads (other than earthquake)for buildings and structures It deals with the dead loads, Unit weights of building material and stored materials

[5] IS 875: Part 2: 1987 Code for design loads (other than earthquake) for buildings and structures. It deals with the various types of imposed load that can come on different types of buildings.

[6] IS 1893 (Part 1):2002 Code of criteria for earthquake resistant design of structures.

[7] It deals with the Earthquake load that can come on different types of buildings in different seismic zone.

[8] "M 5.1, "M 5.5- Gujarat,", "M 5.3 - Sikkim". "M 5.1 - Uttaranchal, India" "M 4.9 - Maharashtra, India" "M 7.3 - Myanmar"."M 7.3 - Myanmar" "M 5.9 - India-Bangladesh border region". United States Geological Survey.

[9] "Dynamics of Structures: Applications to Earthquake Engineering" by A. K. Chopra This book is very suitable dynamics of structures and earthquake engineering. The book contains many topics that relate to the theory of structural dynamics and its application pertaining to the earthquake analysis, response and design of structures.

[10] "Dynamics of Structures" by R.W. Clough and J. Penzien This book teaches dynamics of structures to advanced in the field of civil engineering. The book demonstrates the state of art methods that are used to assess the seismic performance of foundation systems and contains information on earthquake engineering.