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Design of Earthquake Resistant Residential Building (G+9)

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Abstract:-
Earthquakes are one of the most devastating forces on the planet. The seismic waves that travel through the ground can demolish buildings, kill people, and cost billions of dollars in damage and restoration. According to the National Earthquake Information Centre, there are over 20,000 earthquakes every year on average, including 16 major disasters. The damage was caused by the collapse of buildings with people inside, as in previous earthquakes, prompting the development of earthquake-resistant constructions. Constructions intended to withstand earthquakes are known as earthquake-resistant structures. While no structure can be completely safe from earthquake damage, earthquake-resistant construction aims to build structures that perform better than their conventional equivalents during seismic activity. Building rules state that earthquake-resistant constructions must be able to withstand the greatest earthquake with a reasonable chance of occurring at their site. There are now various design philosophies in earthquake engineering that use experimental results, computer models, and historical earthquake observations to provide the requisite performance for the seismic threat at the location of interest. In this article, we will deal with numerous techniques that can help improve a structure. Earthquake-resistant design of structures has developed into a genuine multidisciplinary field of designing wherein numerous energizing advancements are conceivable in the not so distant future. Most outstanding among these are: (a) an entire probabilistic examination and configuration approach; (b) execution based outline codes; (c) different yearly likelihood danger maps for reaction unearthly increasing velocities also, top ground increasing velocities with better portrayal of site soils, geology, close field impacts; (d) new basic frameworks and gadgets utilizing non-conventional structural designing materials and procedures; also, (e) new refined explanatory devices for solid expectation of basic reaction, including nonlinearity, quality and solidness debasement because of cyclic loads, geometry impacts and all the more critically, impacts of soil– structure connection. Some huge advancements that the coming years will witness are talked about in this Project.
Keywords: *Advanced Techniques, Earthquake, Effective Designs Process, Ideal Resistant Ratio, Structure failure seismology, and soil mechanism, vibration*

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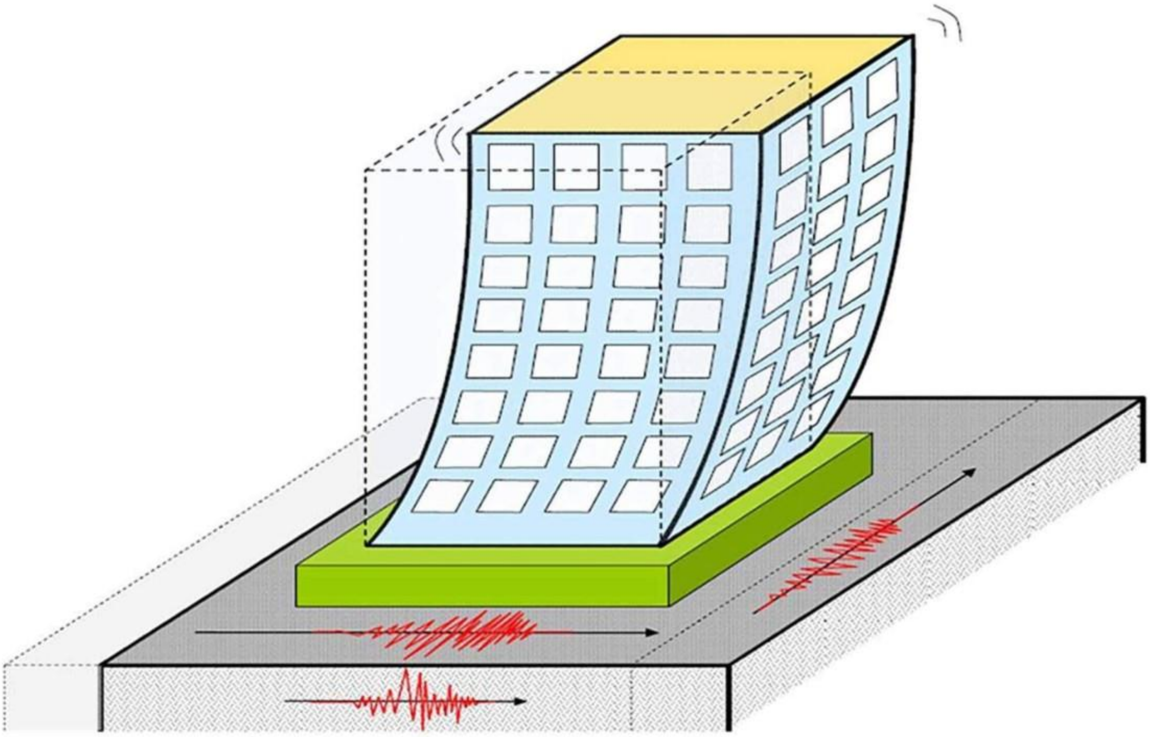
I. Introduction:-

An earthquake is the sudden shaking of the surface of the earth caused by the passage of seismic waves through the earth's crust. During the earthquake, vibrations occur in all directions radiating from the epicenter. The sudden release of energy cause structure to vibrate and inertia forces are acting on them. Most of the earthquakes are result from tectonic events, primarily movements on the faults, and remaining related to the manmade.The lack of earthquake knowledge and its incorporation in the building design and execution leads to the failure of structures. Some of the reasons behind building failures are



• Vertical and horizontal movement and the inertia of buildings cause frequent changes in buildings' weight.
• Use of poor-quality material. disaster. Earthquakes can create disasters of high magnitudes when they hit metropolitan areas of large population and infrastructure. India having vast territory, large population and unique geo climatic conditions, and the Indian sub continent is exposed to
• Massive structure (greater the mass of the structure, more the lateral force is exerted on the building).
• More the height of building, lesser its stability. There are 9 severe earthquakes has witnessed
by India in the last 3 decades between 1990 to 2020 and reports claim the number of causalities approx. 30500. Although, certain parts of the country are more prone to earthquakes (seismic zone V of IS 1893(Part 1)- 2016) than the others . No region can be considered free from earthquakes. In the Indian scenario, minor earthquakes are reported near the seduction zone (Himalayan belt) on a daily basis, whereas in the interpolate region (Deccan plateau) few major earthquakes have been observed over the years. The performance of the built environment during the past earthquakes has shown its brittle nature and has created an itch among the engineers and architects to move towards seismically efficient buildings. Analysis of earthquake resistant Design structures against natural earthquakes he said that buildings can effectively protect against earthquake using multiple design options.Load factors of earthquake designing structures where a number of options, details for earthquake types can be found. About 60 % of the Indian landmass, is susceptible to moderate to very severe earthquakes. A great earthquake in an unoccupied area may produce minimum damage when compared to a moderate earthquake in a densely populated area. All the field survey studies conducted after a major earthquake suggested that the maximum casualties reported were caused by structure collapse. The seismic performance of a building during an earthquake depends on its shape, size, geometry, and the nature of the load path. The aim of seismic design philosophy is to ensure the safety of structural components and human life. Design philosophies state that the load-bearing structural elements must suffer no damage in the case of a minor shaking, sustain repairable damage in the case of moderate shaking and sustain severe damage without collapse under strong shaking

SOME PAST EARTHQUAKE IN INDIA

Date	Event	Time	Magnitude	Max. Intensity	Deaths
16 June 1819	Kutch	11:00	8.3	IX	1,500
12 June 1897	Assam	17:11	8.7	XII	1,500
8 February 1900	Coimbatore	03:11	6.0	VII	Not Known
4 April 1905	Kangra	06:20	8.0	X	19,000
15 January 1934	Bihar-Nepal	14:13	8.3	X	11,000
15 August 1950	Assam	19:31	8.6	XII	1,530
21 July 1956	Anjar	21:02	6.1	IX	115
10 December 1967	Koyna	04:30	6.5	VIII	200
23 March 1970	Bharuch	20:56	5.2	VII	30
21 August 1988	Bihar-Nepal	04:39	6.6	IX	1,004
20 October 1991	Uttarkashi	02:53	6.4	IX	768
30 September 1993	Killari (Latur)	03:53	6.2	VIII	7,928
22 May 1997	Jabalpur	04:22	6.0	VIII	38
29 March 1999	Chamoli	00:35	6.6	VIII	63
26 January 2001	Bhuj	08:46	7.7	X	13,805

1. IS:875-1987 (Reaffirmed 2003)- Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures:

A building has to perform many functions satisfactorily. Amongst these functions are the utility of the building for the intended use and occupancy, structural safety, fire safety; and compliance with hygienic, sanitation, ventilation and daylight standards. The design of the building is dependent upon the minimum requirements prescribed for each of the above functions. The minimum requirements pertaining to the structural safety of the building are being covered in this code by way of laying down minimum designed load which have to be assumed for dead loads, imposed load, snow load and other external loads, the structure is required to bear. Strict conformity to loading standard recommended in this code claims to ensure the safety of the buildings and thereby reduced the hazards to life and property caused by unsafe structures as well as eliminates the wastage caused by the assumption of unnecessary heavy loading. This code is divided into five different parts for five different kinds of loadings. The different parts of the code are:

Part 1: Dead Loads- Unit Weight of Building Materials and Stored Materials:

This part deals with the dead load to be assumed in the design of the building. These loads are given in the form of unit weight of materials. The unit weight of the materials that are likely to be stored in the building are also given in the code for the purpose of the load calculation due to stored materials. This code covers the unit weight or mass of the materials and parts and components in the building that apply to the determination of the dead load in the design of building. Table I of this code covers unit weight of the building materials and Table 2 of the code covers the unit weight of the building parts or the components.

Part 2: Imposed Loads

Imposed load is the load assumed to be produced by the intended use or occupancy of a building including the weight of moveable partitions, distributed, concentrated loads, loads due to impact and vibrations and dust loads (Excluding wind, seismic, snow, load due to temperature change, creep, shrinkage, differential settlements etc.) This part of the code deals with imposed load of the building produced by the intended occupancy or use.

Minimum imposed load that should be taken into consideration for the purpose of structural safety of the buildings are given in the code but it do not cover the incidental to construction and special cases of vibration, such as moving machinery, heavy acceleration from cranes hoist etc.

Part 3: Wind Loads
This part deals with the wind load to be considered when desigining the building, structure and component thereof. This code gives the wind force and their effect (Static and Dynamic) that should be taken into account when designing buildings, structures and components
thereof. In the code wind load estimation is done by taking into account the random variation of the wind speed with time.

Part 4: Snow Loads
This part of the code deals with snow loads on roofs of buildings. Roofs should be designed for the actual load due to snow or the imposed load specified in Part 2 whichever is more sever. Since location of the building is within Kathmandu Valley, there is no possibility of snowfall. Hence the snow load is not considered in the design.

Part 5: Special Loads and Load Combinations
This code loads and loads effects (Except the loads covered in Part 1 to 4 and seismic load). due to temperature changes, internally generated stress due to creep shrinkage, differential settlement etc. in the building and its components, soil and hydrostatic pressures, accidental loads etc. This part also covers the guidance for the load combinations.

2. IS 1893 (Part 1): 2002 Criteria for Earthquake Resistant Design of Structures (General Provision and Building):

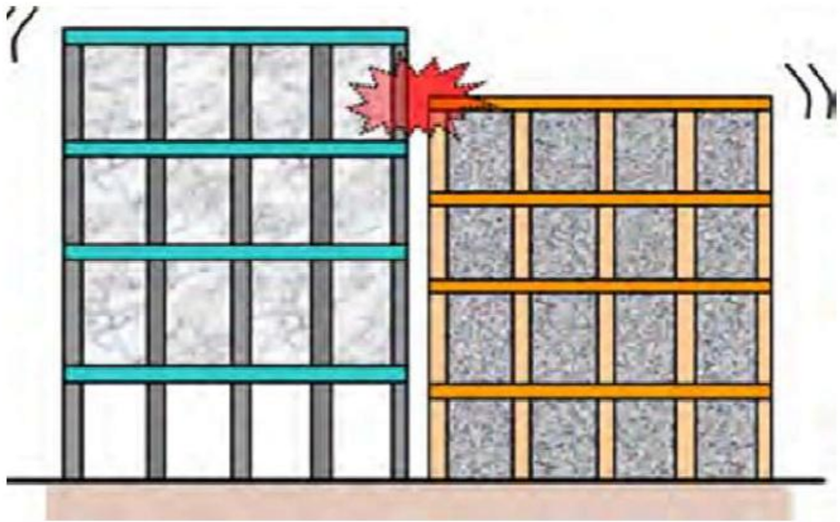
This code deals with the assessment of seismic loads on various structures and earthquake resistant design of buildings. Its basic provisions are applicable to buildings; elevated structures; industrial and stack like structures; bridges; concrete masonry and earth dams; embankment and retaining structures and other structures. Temporary supporting structures like scaffoldings etc. need not be considered for the seismic loads. It is concerned with the methods of determining seismic loads and the effects of various irregularities in a building can have upon its seismic response. This standard does not deal with the construction features relating to earthquake resistant design in building and other structures.

3. IS 13920: 1993 (Reaffirmed 2003) Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Force- Code of Practice:

This standard covers the requirements for designing and detailing of monolithic reinforced concrete buildings so as to give them adequate toughness and ductility to resist sever earthquake shock without collapse. The provision for the reinforced concrete construction given in the code are specifically to the monolithic reinforced concrete construction. For precast and prestressed concrete members, its use is limited only if they can provide the same level of ductility as that of monolithic reinforced concrete construction during or after earthquake. The code includes the detailing rules for flexural members, column and frame member subjected to bending and axial loads and shear walls.

4. IS 456: 2000 (Reaffirmed 2005) Plain and Reinforced Concrete - Code of Practice:

This Indian Standard code of practice deals with the general structural use of plain and reinforced concrete based on Limit State Design Method. According to the code, plain concrete structures referred to those structures where reinforcement if provided is ignored for last 20 years are 32 thousand, 25 million and 200 million respectively. On 26 January 2001, a very severe earthquake struck Bhuj and shook most parts of Gujarat, causing widespread damage and devastation. Over 13,805 persons lost their lives, 167,000 persons were injured, over a million homes were damaged or destroyed and there was large-scale damage to social and physical infrastructure.



. Figure 1.1. Pounding can occur in adjacent buildings located very close to each other due to earthquake-induced shaking (source: Murty 2005).

II. Literature Review :-

Building configuration play very important role in seismic response of structures normal irregular structure like L-shape and T-shape buildings are converted in to simple regular configuration by providing seismic joints. Brief Literature on the topic is presented in this chapter.

Proença, Carlos S. Oliveira and J.P. Almeida [1] Performance-Based Design, Seismic Assessment, Masonry Infilled Structures Early, pre-code, reinforced concrete structures present undetermined resistance to earthquakes. This situation is particularly unacceptable in the case of essential facilities, such as healthcare structures. Amongst these, the Santa Maria Hospital -finished in 1953 with a total area of 120,000 m² in Lisbon, was designed without explicit consideration for earthquake loading. Given the crucial importance of this healthcare facility in the case of a strong earthquake in the greater Lisbon metropolitan area, the Portuguese Health Ministry requested a seismic vulnerability assessment of the Hospital structure, as well as of the major non-structural components, medical equipment and basic infrastructure lifelines. The structural seismic vulnerability assessment stages comprised the development of linear dynamic and nonlinear static numerical models for some of the more representative building blocks. Nonlinear static analyses were conducted on one of the Hospital's most representative buildings according to displacement-based seismic design methodologies, A first nonlinear model was significantly modified through the introduction of diagonal struts, representing the stiffening effect of infill masonry walls, to match the experimentally determined fundamental frequencies. The analysis was carried out by means of two distinct nonlinear models, in terms of the load patterns. The first model (as described above) was used until all struts at a given intermediate storey collapsed, leading to a substantial change in the deformation and load pattern. The subsequent second model differed from the first model by the removal of the struts that had collapsed. A sensitivity analysis was carried out by changing the strength parameters of the diagonal struts. The final capacity curve was computed combining the former two capacity curves.

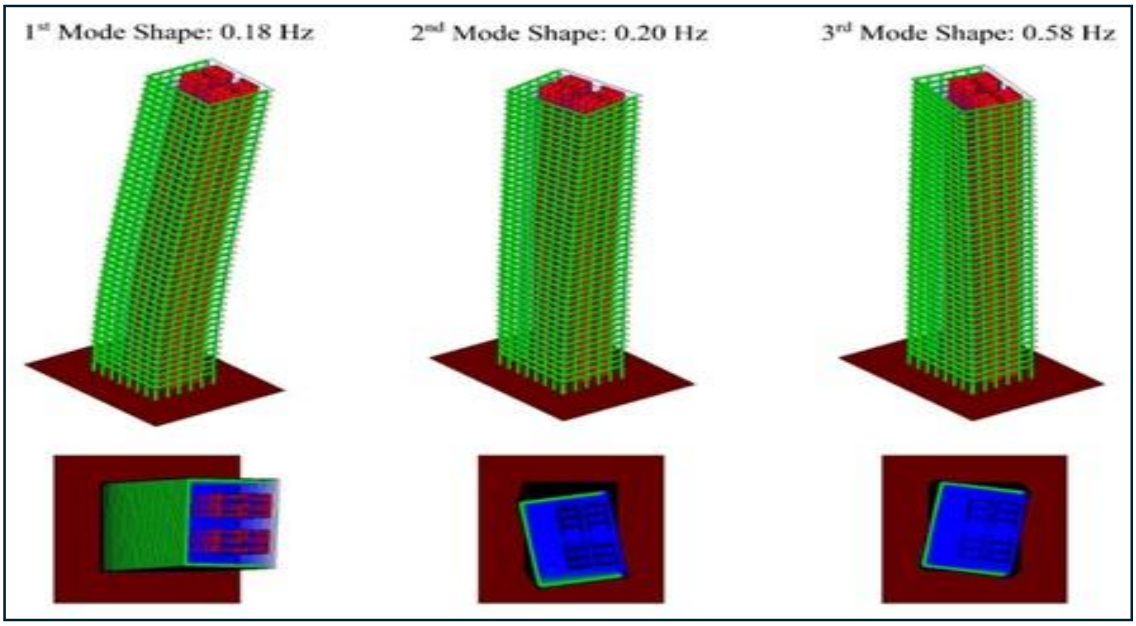
Sudhir Kumar Jain [2] It is important in seismically active areas to provide safe and economical protection for life and limb by making adequate provisions for earthquake resistance in buildings. For most ordinary buildings, it is sufficient to provide earthquake resistance in the building by means of a suitable building code. This usually involves static analysis of the building for the prescribed lateral forces, which take into account in an approximate manner the effects of building characteristics, soil characteristics, seismic risk in the area, importance of the building, etc. however, there are buildings that have some special characteristics, which make it difficult to model their dynamic behavior satisfactorily by a code type static analysis. Such buildings warrant detailed dynamic analysis for satisfactory answers to questions concerning the behaviour during earthquakes. Included in the category are high-rise buildings, buildings with extreme plan dimensions (e.g.; long and narrow buildings), building with eccentric centre of mass or stiffness, (this leads to coupled torsional and

Ugur Ersoy [3] Every year more than 300 000 earthquakes occur on the earth. Many of these are of small intensity and do not cause any damage to our structures. However, earthquakes of larger intensity in the vicinity of populated areas cause considerable damage and loss of life. It is estimated that on average 15000 people have been killed each year throughout the world because of earthquakes. The main objective of this paper is to lay down some basic principles for producing earthquake resistant reinforced concrete structures. These are simple principles and easy to apply. They have been developed in the light of analytical and experimental research done and on observations made from past earthquakes. Seismic resistance should be initiated at the architectural design stage. If the general configuration chosen by the architect is wrong, it is very difficult and expensive for the structural engineer to make the building seismic resistant. As a general principle the floor plan should be as symmetrical as possible. The length of wings (T, L, cross shaped buildings) causing re-entrant comers should not be large. If the length of the wings is not short, then a seismic Joint should separate these from the main building. The analysis was carried out by means of two distinct nonlinear models, in terms of the load patterns. The first model (as described above) was used until all struts at a given intermediate storey collapsed, leading to a substantial change in the deformation and load pattern. The subsequent second model differed from the first model by the removal of the struts that had collapsed. A sensitivity analysis was carried out by changing the strength parameters of the diagonal struts. The final capacity curve was computed combining the former two capacity curves, and the Sudhir Kumar Jain [10] It is important in seismically active areas to provide safe and economical protection for life and limb by making adequate provisions for earthquake resistance in buildings. For most ordinary buildings, it is sufficient to provide earthquake resistance in the building by means of a suitable building code

III. Objective :-

The main objective of this paper is to lay down some basic principles for producing earthquake resistant reinforced concrete structures. These are simple principles and easy to apply. They have been developed in the light of analytical and experimental research done and on observations made from past earthquakes. Seismic resistance should be initiated at the architectural design stage in this Design we Considered "T" shape irregularity is considered with 10, 20, 30 and 40 stories, for the seismic analysis. earthquake loading in X and Z directions. To make the configuration simpler, the "T" can be divided into two simple rectangles. Three cases are considered in the present analysis namely 1) Without any joint 2) Disjointed structure with gap between the rectangular shapes and With seismic joint providing Elastomer material. For above three cases study Maximum joint displacement, Axial force in columns, Bending moment (My and Mz) in columns and eccentricity.

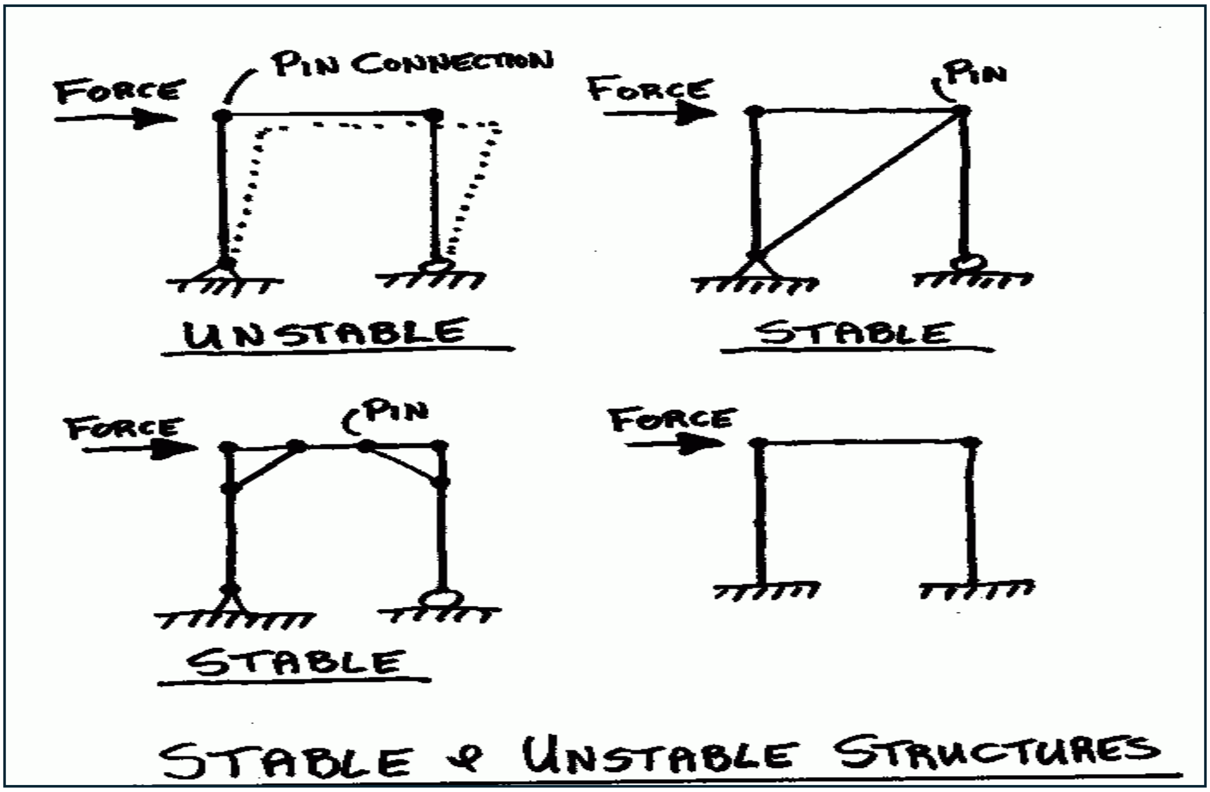
3.1 Analyze Seismic Effects: Evaluate the impact of seismic forces on a (G+9) residential building located in Seismic Zone III as per IS 1893:2016. Understanding seismic effects involves:



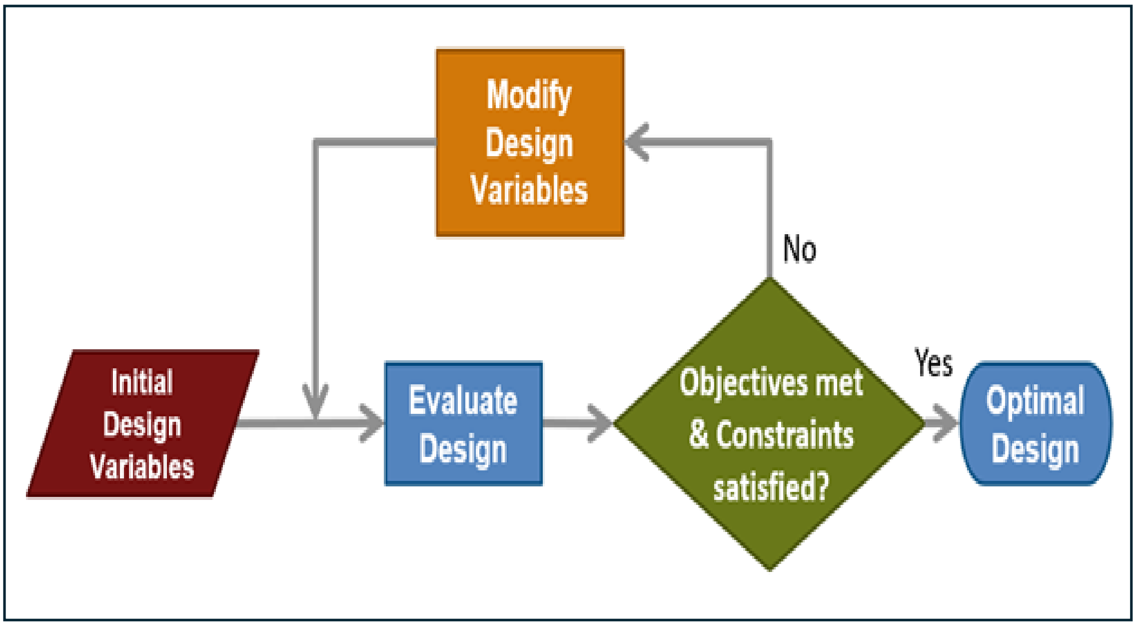
- Analyzing the nature and propagation of seismic waves.
- Assessing the site-specific soil conditions that may amplify or mitigate shaking.
- Evaluating the dynamic response of structures and incorporating appropriate engineering design strategies to reduce risk.
- Applying hazard assessment methods to plan for and mitigate the impacts of earthquakes.

By integrating seismological data with engineering principles, analysts can design safer structures and develop more resilient communities in earthquake-prone areas.

3.2 Structural Stability: Ensure stability and safety of the structure by considering lateral loads, base shear, and overturning moments. Structural stability is a multifaceted aspect of engineering that involves understanding material behavior, geometric configurations, and the effects of various loading conditions. By using analytical methods, simulation tools like FEM, and incorporating safety factors and redundancy, engineers can design structures that are not only strong but also resilient to dynamic and unforeseen events. This comprehensive approach ensures that structures remain safe throughout their intended lifespan, even under adverse conditions.

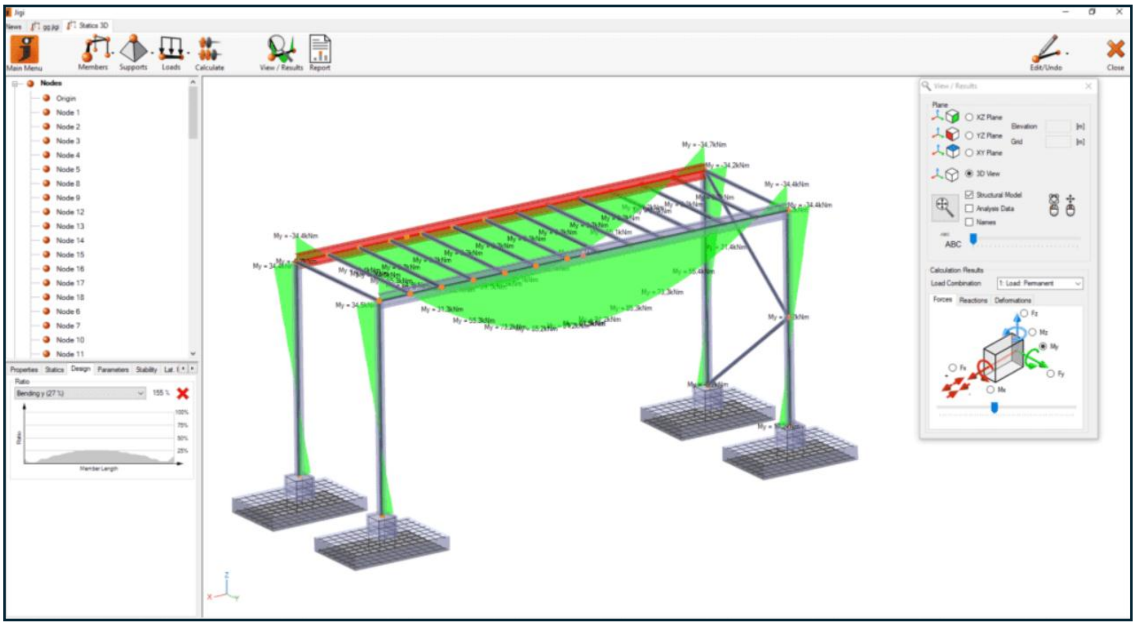


3.3 Design Optimization: Develop an efficient earthquake-resistant design that balances cost-effectiveness and structural integrity.



3.4 Material Selection: Choose suitable materials and reinforcement techniques to enhance the building's seismic performance.

3.5 Software Analysis: Utilize ETABS/SAP2000/STADD Pro for structural modeling and seismic response analysis.



3.6 Comparison of Structural Systems: Assess different structural configurations (shear walls, bracing, dampers) to determine the most effective design approach.
3.7 Compliance with Codes: Ensure adherence to Indian Standard (IS) codes, including IS 1893, IS 456, and IS 13920 for seismic detailing.
3.8 Performance Evaluation: Conduct response spectrum analysis or time history analysis to study the behaviour of the structure under seismic loads.
3.9 Mitigation Strategies: Propose retrofit techniques and damping mechanisms to enhance earthquake resistance.
3.10 Safety & Serviceability: Ensure the safety, durability, and functional efficiency of the building post-earthquake scenarios.

IV. Methodology:-

Each building has its own purposes and importance. Basically, buildings were constructed based on client requirement, geographical condition of the site, safety, privacy, available facilities, etc. and designed as:

4.1 Planning Phase

Planning of building is grouping and arrangement of different component of a building so as to form a homogenous body which can meet all its function and purposes. Proper orientation, safety, healthy, beautiful and economic construction are the main target of building planning. It is done based on the following criteria:

4.2 Functional Planning

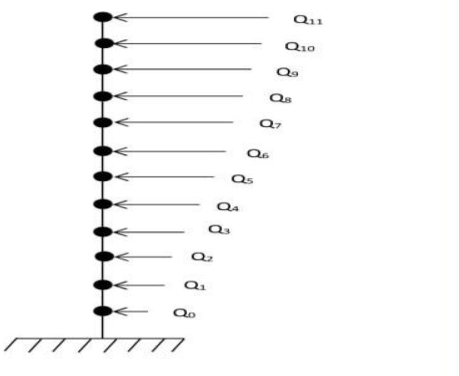
Client requirement is the main governing factor for the allocation of space required which is based upon its purposes. Thus, demand, economic status and taste of owner features the plan of building. Building design should Favor with the surrounding structures and weather.
Building is designed remaining within the periphery of building codes, municipal bylaws and guidelines.

4.3 Structural Planning

The structural arrangement of building is chosen so as to make it efficient in resisting vertical and horizontal load. The material of the structure for construction should be chosen in such a way that the total weight of structure will be reduced so that the structure will gain less inertial force (caused during earthquake). The regular geometrical shape building is designed as an earthquake resistant structure based on IS1893 (part1):2002.

4.4 Load Assessment

Once the detailed architectural drawing of building is drawn, the building subjected to different loads is found out and the calculation of load is done. The loads on building are categorized as below:

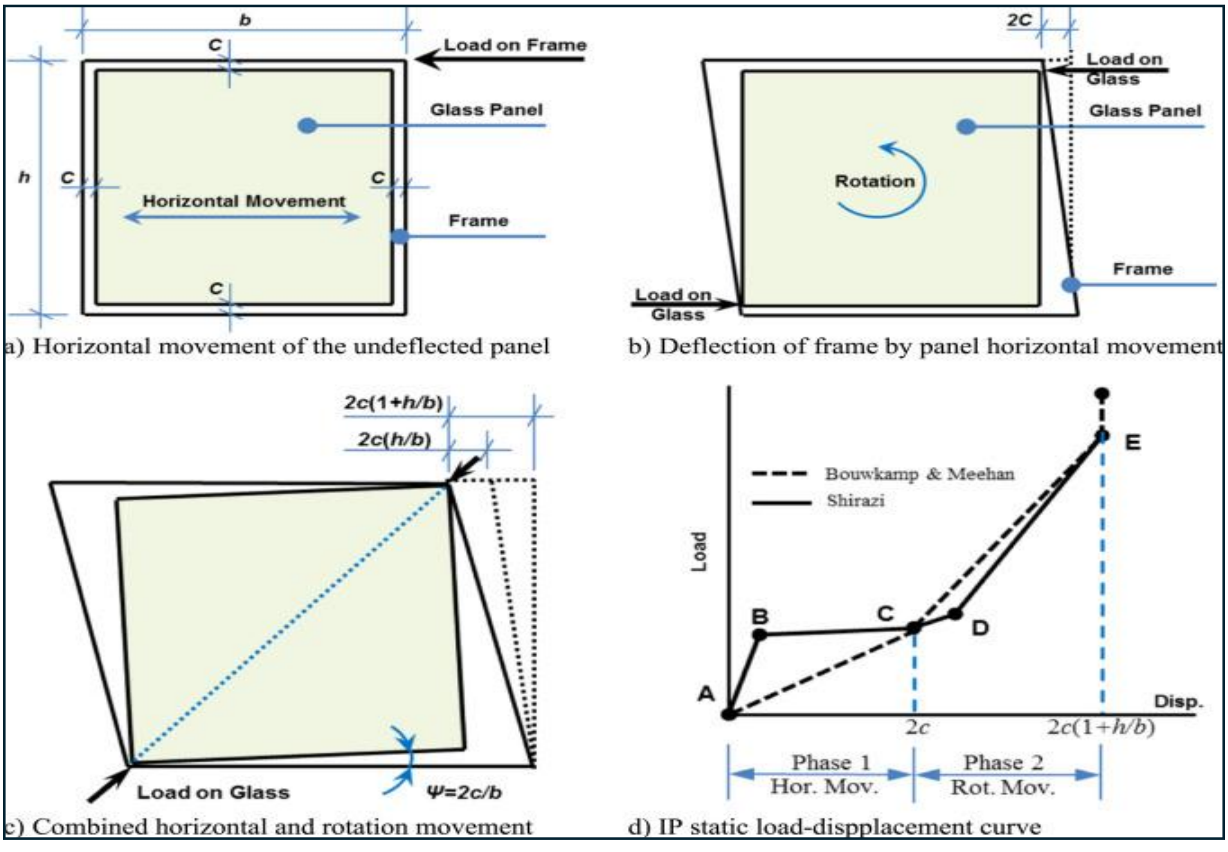


4.4 Gravity load
This includes the self-weight of the building such as structural weight, floor finish, partition wall, other household appliances, etc. To assess these loads, the materials to be used are chosen and their weights are determined based on Indian standard code of practice for design loads (other than earthquake) for buildings and structures:
IS 875 (part 1):1987 Dead Loads ii. IS 875 (part II): 1987 Imposed Loads

4.5 Lateral load
Lateral load includes wind load and earthquake load. Wind load acts on roof truss while an earthquake act over the entire structure. Wind load calculation is based on IS 875 (partIII):1987 and earthquake on IS 1893 (part 1):2002. The dominant load is taken into consideration for design.

4.6 Load Combination
Combination of different loads is based on IS 875 (part V):1987 Load combination.

4.7 Inter-Story Drift Measured
Inter-story drift is one of the particularly useful engineering response quantity and indicator of structural performance, especially for high-rise buildings. However, many researchers and engineers do not notice the difference between inter-story drift and harmful inter-story drift. Also, few programmers have considered the harmful inter-story drift in their structural analysis



procedure. So they may unreasonably use the inter-story drift as unique standard for structural behaviour judgment, which may eventually lead to unacceptable results and relatively conservative conclusions. As a result, considerable work has been done to investigate on the calculation methods and reasonable limit values of the inter-story drift for different structure types (Zhen and Xie, 2010; Deng et al., 2008; Wei and Wang, 2006; Xu,

$$\Delta u_i = (\Delta u_{si} + \Delta u_{bi}) + \Delta u_{si}^{'}$$

2005; Xin et al., 2000; Zhang et al., 1999). However, these methods focus on calculating the harmful displacement of structures predominated by global flexural or flexural shear deformation, such as shear wall and frame-shear wall structures. In addition, there are still no provisions in current codes in China about a reasonable and formal calculation method for the harmful displacement (GB50011, 2010). Therefore, it's urgent for researches to further study the inter-story deformation and put forward a simple and effective approach on harmful inter-story drift calculation equation.

4.8 Preliminary Design

Before proceeding for load calculation, Preliminary size of slabs, beams and columns and the type of material used are decided. Preliminary Design of structural member is based on the IS Code provisions for slab, beam, column, wall, staircase and footing of serviceability criteria for deflection control and failure criteria in critical stresses arising in the sections at ultimate limit state ie. Axial loads in the columns, Flexural loads in slab and beams, etc. Appropriate sizing is done with consideration to the fact that the preliminary design based on gravity loads is required to resist the lateral loads acting on the structure. Normally preliminary size will be decided considering following points:

Slab: The thickness of the slab is decided on the basis of span/d ratio assuming appropriate modification factor.

Beam: Generally, width is taken as that of wall ie. 230 or 300 mm. The depth is generally taken as 1/12-1/15 of the span.

Column: Size of column depends upon the moments from the both direction and the axial load. Preliminary Column size may be finalized by approximately calculation of axial load and moments.

4.8.1 Idealization of structure

4.8.2 Idealization of support

It deals with the fixity of the structure at the foundation level. In more detail terms, this idealization is adopted to assess the stiffness of soil bearing strata supporting the foundation. Although the stiffness of soil is finite in reality and elastic foundation design principles address this property to some extent, our adoption of rigid foundation overlooks it. Elastic property of soil is addressed by parameters like Modulus of Elasticity, Modulus of Subgrade reaction, etc.

4.8.1 Idealization of load

The load acting on the clear span of a beam should include floor or any types of load acting over the beam on the tributary areas bounded by 45º lines from the corner of the panel i.e. Yield line theory is followed. Thus, a triangular or trapezoidal type of load acts on the beam.

4.8.2 Idealization of structural system

Initially individual structural elements like beam, column, slab, staircase, footing, etc. are idealized. Once the individual members are idealized, the whole structural system is idealized to behave as theoretical approximation for first order linear analysis and corresponding design. The building is idealized as unbraced space frame. This 3D space As we are working with a computer based system, the importance of data input is as important as the result of output derived from analysis. Hence with possibility of garbage-in-garbage-out, we need to check our input parameters in explicit detail. Material properties are defined for elements in terms of their characteristic strep M25 for slabs, beams and M25 for columns. Also, section properties are de obtained from preliminary design. Loading values are input as obtained from Loading combination based on IS 875 (part V):1987 and IS 1893 (part 1):2002 for ultimate limit state and IS 456:2000 for serviceability limit state is prepared. An envelope load case of all load combinations is prepared to provide us with the envelope of stresses for design.

4.9 Design and Detailing

4.10 Design Philosophy

4.11 Limit State Method of Design for Reinforced Concrete Structures

Design of Reinforced Concrete Members is done based on the limit state method of design following IS 456:2000 as the code of practice. The basic philosophy of design is that the structure is designed for strength at the ultimate limit state of collapse and for performance at limit state of serviceability. A check for these two limit states is done based on code of practice to achieve safe, economic and efficient design

4.12 Working Stress Method of Design for Steel Truss Member

The design philosophy of working stress method of design is to use working loads at service state and design the members to perform at characteristic loads with minimum factor of safety in material strength. This approach makes the design conservative and deterministic and quite obsolete compared to more logical Limit State Method of Design. Hence by using different philosophy, the design of beam, column, footing, staircase and other structural component are done.

4.13 Detailing Principle for Reinforced Concrete and Steel Structures

4.13.1 Ductile Detailing of Reinforced Concrete Structure.

Ductile detailing of reinforced concrete structure is done based on IS 13920:2002 for the provision of compliance with earthquake resistant design philosophy. Special consideration is taken in detailing of linear frame elements (BEAMS & COLUMNS) to achieve ductility in the concrete to localize the formation of plastic hinge in beams and not columns to assure the capacity theory of STRONG COLUMN | WEAK BEAMS.

Detailing provisions of IS 13920:2002 and IS 456:2000 are used extensively for these members to comply with the relevant codes of practice.

4.13.2 Ordinary Detailing of Reinforced Concrete Structure

SP 34 detailing handbook for IS 456 is used extensively for reinforcement detailing of area. elements (SLABS & STAIRCASE). Defining the slabs to function as rigid floor diaphragm limits the necessity of special reinforcement provision for slabs eliminating the possibility of out-of-plane bending. Hence same follows for staircase slabs and detailing is done with the help of SP34.Detailing of Substructures (MAT FOUNDATION) is also done based on SP34 to comply with the design requirement of IS 456:2000.Reinforcement Detail drawings for typical representative elements are shown in detail in chapter 7 on structural drawings.

Thus, the detailing rules from different handbooks are followed along with enlisted codes of practice and then rebar arrangement is finalized. In this way, detailing of reinforcement is achieved to required specifications by code.

4.14 Codal References

The project report has been prepared in complete conformity with various stipulations in Indian Standards, Code of Practice for Plain and Reinforced Concrete IS 456:2000, Design Aids for Reinforced Concrete to IS 456:2000(SP-16), Criteria Earthquake Resistant Design Structures IS 1893 (Part 1):2002, Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces Code of Practice IS 13920:2002, Handbook on Concrete Reinforcement and Detailing SP-34. Use of these codes have emphasized on providing sufficient safety, economy, strength and ductility besides satisfactory serviceability requirements of cracking and deflection in concrete structures. These codes are based on principles of Limit State of Design.

4.15 Drawings

As specified in the requirement of the project assignment, the report also includes the following drawings: Architectural Plan of Typical floors, Elevation and Cross Section of the building.

2. Detailed Structural drawing of full size beam, full size column, slab, staircase and mat
foundation. Longitudinal and Cross section drawings are made to represent specifically the proper detailing of rebar in individual elements, at beam column joints, at the end support of slabs, in staircase and in the foundation.

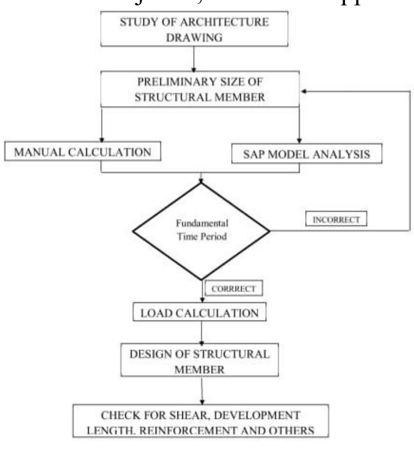


Fig.: Flowchart showing Method of design

V. Results And Discussions:-

The proposed constructive solution of the foundations of seismic resistant building is confirmed by the results of test of sandy soils at the base of a rigid stamp with dynamic (seismic) load, by construction experience, and the results of a survey of the load-bearing structures of rigid buildings after strong earthquakes. The construction of rigid buildings with foundations, in according with the proposed design scheme, will allow to exclude horizontal seismic impact on the vertical walls of the foundations (due to the absence of calming), and therefore horizontal seismic tremors on the building are also excluded.

VI. Design Results

a. FOR EARTHQUAKE RESISTANT RESIDENTIAL BUILDING(G+9)
b. Location:
a. Region: Central Development Region
b. Zone: III
c. State: UP
c. Type of Building: Residential Building (G+9))
d. Structural System: Special Moment Resisting Frame
e. Soil Type: ii (Medium)
f. Seismic zone: III
g. No of Storey: G+9
h. Dimension of building:
a. Maximum length: 30.0m
b. Maximum Breadth: 15.0m
i. Type of Staircase: Open Well
j. Type of foundation: Raft Foundation
k. Floor Height: 3.1m Each floor
a. Basement: YES
b. Typical:
c. Staircase cover: 2.8956m
l. Infill wall: Brick Masonry
a. Main wall: 0.2286m
b. Partition wall: 0.1143m
m. Design criteria: As per IS code
n. Size of structural elements:
a. Beam: 300*500mm
b. Column: 540mm*540mm in basement and 1, 2nd floor to top floor
c. Slab thickness: 150mm
o. No of columns:
a. Basement:
b. Typical:
c. Staircase cover
p. Number of lifts available: 2
q. Share Wall available : YES

6.1 Suggestions / Recommendations For Earthquake-Resistant Constructions in India

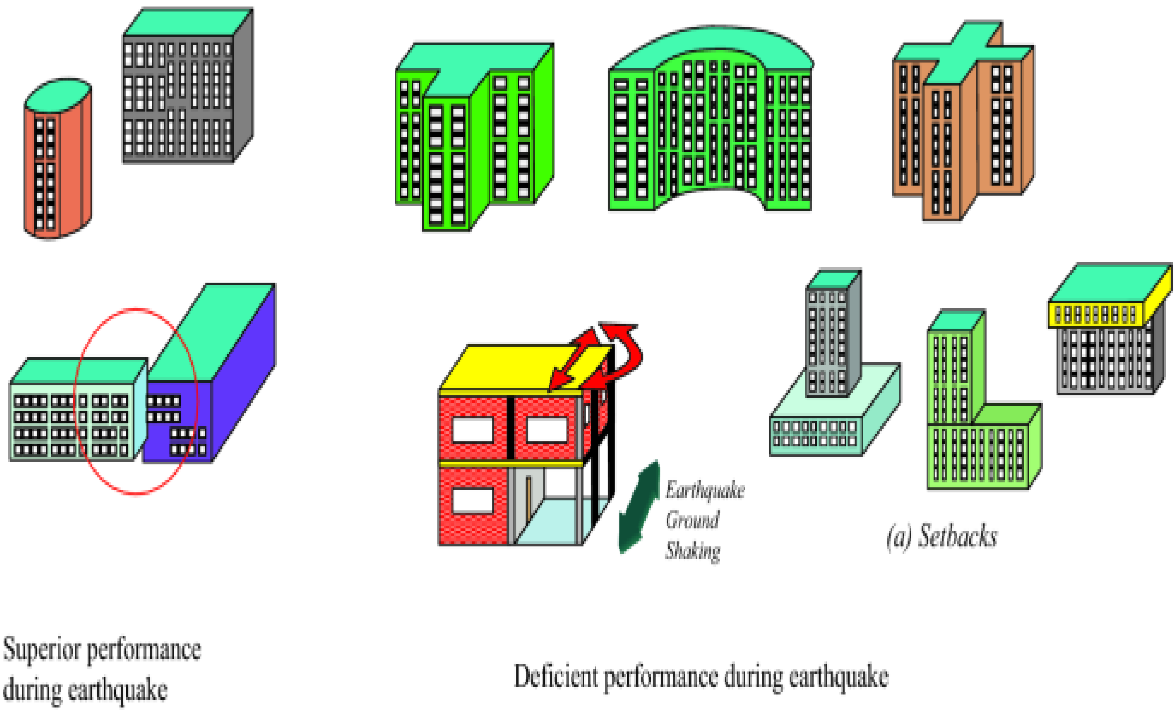
Engineered and Non-Engineered Constructions Most building constructions are non-engineered. However, formal education is imparted only on engineered constructions. Focus of discussions should also be placed on non-engineered constructions. Building Material Technology and Know-How There is a need for greater discussion on the different building materials and their utility for earthquake-resistant constructions in technical curriculum. Division of Responsibilities between Consultants, Contractors and Owners The consultant plays the most important role in realizing earthquake resistant constructions. The consultant has to educate the owner regarding the consequences of not providing earthquake- resistant features; this may motivate the owner to incur the extra costs for safety. The responsibility of adhering to the minimum requirements specified by the design codes shall remain with the consultant. The consultant also needs to ensure that the detailing provided is fully implemented by the contractor. Earthquake-Resistant Design Practice versus Traditional Design Practice Earthquake-resistant design and detailing should be considered under normal design situations. These should be an integral part of design process, even though these may not govern the final design in all cases. This situation

would then be similar to the current treatment of design for wind loads. This will d-mystify the myth of earthquake-resistant design
and construction being a special requirement. Code Provisions and Issues Design codes are the minimum specifications of the society's expectations of the structures. There is a need to ensure that the codal provisions are faithfully complied with. Since the building codes also fulfil a social obligation, the costs incurred by individuals involved in the code development should be provided. The code revisions sometime require technological up gradation or other major changes in the prevailing practices. Appropriate technological innovations and developments must take place in order to help the implementation of the difficult provisions. The code compliance in the country is currently very poor. This can be improved through necessary regulations and legal provisions. Introduction of tender specifications and changes in the city bylaws are some strategies for this. Also, there is a need for speedy action against defaulters to encourage compliance

VII. Conclusion:-

The fact that India lies in a hotspot for tectonic activities is a big factor to be accounted for in the design of any structure that aims to be safe, durable and serviceable. In this regard, the details of the structure we have designed for use as a residential apartment building, to the best of our team's knowledge, incorporate the required precautionary measures that allow it to overcome the perils that come with being situated in an earthquake prone zone along with the regular gravity loads that are expected in such a structure. Hence, we as the students of structural Engineering hope that this project meets the expectations of our respected supervisor and the rest of our teachers to whom we owe the sum total of our knowledge in this subject.

In the present work 'T' shape plan irregular building is considered for the analysis



(a) Continuous buildings
(b) Gap buildings
(c) Joint with Elastomer buildings
Based on the work carried out, the following conclusions are drawn.
For taller buildings (G+9 storeyed):
a) Provision of seismic joints with elastomers would reduce the column moments (Mz) by about 25% and (My) increasing 7% when compared to a continuous structure. But the axial forces are increasing by about 25%
b) Provision of seismic joints with elastomers would increase maximum joint displacement by 29% when compared to a continuous building
For shorter buildings (10storeyed):
a) Provision of seismic joints with elastomers would reduce the column moments (Mz) and(My) by about 4% when compared to a continuous structure. But the axial forces are increasing by about 5%

b) Provision of seismic joints with elastomers would increase maximum joint displacement by 10% when compared to a continuous building

VIII. Scope of Future Study

Other irregularities such as 'H', 'X', 'C' vertical and mass irregularities may be studied
2. Effect of seismic joints on irregular buildings with soft storey.
3. Irregular buildings may be analysed and compared the results of seismic coefficient method and response spectrum method.

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