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Seismic Analysis and Design of Mono Column Structure using ETABS

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Abstract:
The design and analysis of RCC structure supported on single column is done in this project. The entire structure is supported by a single column (mono column), all other components function as cantilevers, with the mono column structure being the most important. These are one-of-a-kind constructions. Eccentric loading can induce structural twisting in either direction and system failure. ETABS is used to design and analyze buildings with diverse seismic zones. Geometric modelling, assigning sectional and material properties, setting supports and boundary conditions, assigning loads and load combinations, special commands, analytical specification, design command, and report were all processes in designing a Mono column building. The height of the structure is taken as 25.0 m. Structure is supported on a single column. It is a 4-storey building. Height of each storey is 4 m. First storey starts at a height of 5m above ground level. Single column keeps the building at a height of 5 m above ground level. Width and breadth of each storey is 16 m. Column is provided at the Centre of structure starting from ground level toa height of 21 m above ground. The process of designing and analyzing buildings with all seismic zones is supported by the use of applicable IS codes. Maximum stress, bending moment, node displacement, deflection, and storey drift are analyzed and compared, and the findings are provided in tabular and graphical form. Shear walls are being investigated for seismic fortification of the building. a single column the building is modelled in ETABS and given the necessary material attributes. A comparison of several seismic zone layouts is carried out. The results provide a graphical comparison of all seismic zones. Keywords: RCC Structure, ETABS, Single Column, Earth quake load etc.,

1.INTRODUCTION:

General:

Due to increase of population into urban cities there is a need to accommodate the influx in the urban cities. However, due to rapid increase of land cost. and limited availability of land the trend is to build multi storey building. A multi storey buildings is a building that has multiple floors above ground in the building. Multi-storey buildings aim to increase the floor area of the building without increasing the area of the land and saving money. These multi storey building s are sky scrapers are built not just for economy of space they are considered icons of a city's economic power and the city's identity. Various types of structural system have been used to facilitate the demand of high-rise structures. Thousands of multi storey building s is being built all over the world with steel as well as reinforced concrete. Many of the multi storey buildings s are designed with structural components consisting of various systems such as flat slab, flat plate system, including commercial and uses because the systems have various advantages. A single column provides better architectural view compared to structure supported on many columns. They save ground space as requires less area for providing foundation and provides more space for parking. They are also unique. Single column structure can be made either by using RCC or Steel. This structure supported on a mono column provides large serviceable floor space compared to structure supported on many columns. They save ground space as requires less area for providing foundation and provides more space for parking. Maximum space utilization is considered will serve its maximum serviceability. In this research describes planninq, structural analysis, design and drawings with various components and approximate cost of the whole buildings. This building consists of mono column i.e., Single column structural system (each floor in whole structure is supported independently by mono column at the center). Earlier, modeling and structural analysis of buildings were carried out using hand calculation method based on simplified assumptions and understanding the whole behavior of the structure. But it seems to be time consuming and complicated for high rise buildings. At present, computer hardware's and software's for modelling and analysis of structure is widely available. We need to know how the knowledge secured in the class room is applied in these practical sides of work. When we got this project, we come into practical field to collect construction techniques and to meet the various difficulties in the construction. Also, it is necessary to have sufficient knowledge regarding various software's currently used in planning analysis and design of and are not included during the design process of the primary structure. Since the 1990s specialist software has become available to aid in the 3 design of structure with the functionality to assist the drawing, analyzing and design of structures with maximum precisions, example includes AutoCAD, STAAD-Pro, ETABS, Proton, Revit structure, etc. Our main aim to complete an Analysis between a conventional multi-stored building & a single column building by using ETABS against all possible loading conditions and to full fill the function for which they have built in economical expenditure. Safety requirements must be met so that the structure is able to serve its purpose with the maintain cost. 1.2 Single Column Building Structure supported on a single column provides better architectural view compared to structure supported on many columns. They save ground space as requires less area for providing foundation and provides more space for parking. They are also unique. Single column structure can be made either by using RCC or Steel. RCC structures are more common now days in India. Reinforced concrete as a structural material is widely used in many types of structures. It is competitive with steel if economically designed and executed. It has a relatively high compressive strength and better fire

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resistance than steel. It has long service life with low maintenance cost.

Fig:-1

Structure supported on a single column provides better architectural view compared to structure supported on many columns. They save ground space as requires less area for providing foundation and provides more space for parking. They are also unique. Single column structure can be made either by using RCC or Steel. RCC structures are more common now days in India. Reinforced concrete as a structural material is widely used in many types of structures. It is competitive with steel if economically designed and executed. It has a relatively high compressive strength and better fire resistance than steel. It has long service life with low maintenance cost. It can be cast into any required shape.

Fig:-2

OBJECTIVE:

of the Project Following specific objectives has been made for the present study To develop, planning and analysis model of the High-rise mono column structure in ETABS. Comparison of analytical results of different seismic loads applied on the structure, To verify deflection, drift, storey shear, overturning moment, storey stiffness for mono-column structures. At different seismic zones, And To study the performance of lateral displacement at all zones.

METHODOLOGY:

General:

Seismic analysis or earthquake analysis is a subset of structural analysis and is the calculation of the response of a structure to the earthquakes. A structure has the potential to wave back and forth during an earthquake this is called the fundamental mode and is the lowest frequency of the structure response. However, buildings also have higher modes of response, which are uniquely activated during an earthquake. Once the structural model had been selected, it is possible to perform analysis to determine the seismically induced forces in the structure. They are different methods of analysis which provide different degrees of accuracy. The analysis process can be categorized on the basis of three factors, the type of externally applied loads, the behaviour of the structure or the structural material and the type of structural modalselected. Based on the type of external action and behaviour of structure, the analysiscan be further classified as linear static analysis, linear dynamic analysis and nonlineardynamic analysis. 3.2 Seismic zones of India: Geographical statistics of India show that

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almost 54% of the land is vulnerable to earthquakes. The earthquake zoning map of India divides India into 4 seismic zones (Zone II, III, IV and V) unlike its previous version which consisted of five or six zonesfor the country. According to the present zoning map, zone V expects highest level ofseismicity whereas zone II is associated with lowest level of seismicity. The characteristics (intensity, duration~ etc.) of seismic ground vibrations expected at any location depends upon the magnitude of earthquake, its depth of focus, distance from the epicenter, characteristics of the path through which the seismic waves travel, and the soil strata on which the structure stands. The random earthquake ground motions, which cause the structure to vibrate, can be resolved in any three mutually perpendicular directions. The predominant direction of ground vibration is usually horizontal. Earthquake-generated vertical inertia forces are to be considered in design unless checked and proven by specimen calculations to be not significant. Vertical acceleration should be considered in structures with large spans, those in which stability is a criterion for design, or for overall stability analysis of structures. Reduction in gravity force due to vertical component of ground motions can be particularly detrimental in cases of prestressed horizontal members and of cantilevered members. Hence, special attention should be paid to the effect of vertical component of the ground motion on prestressed or cantilevered beams, girders and slabs

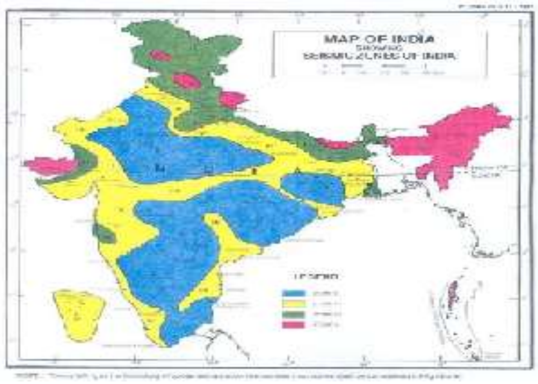
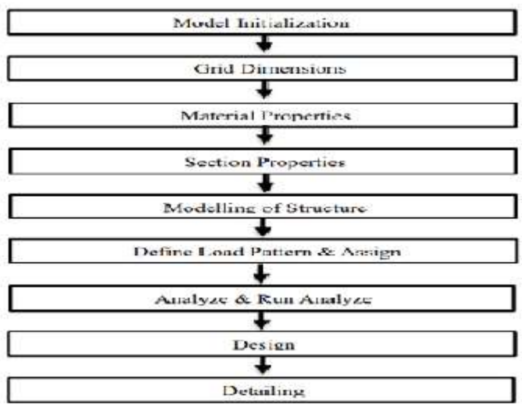


Fig:-3

Importance of seismic analysis The earthquakes are devastating at every level of social and economic lives are the most terrible consequence of earthquakes or loss of life. Hence the first task of earthquake protection is to reduce the loss of life from the data recorded the cases of death during an earthquake is due to collapse of structures. This is where the necessityarises for designing earthquake resistant structures such that they can,

- Resist minor level of earthquake ground motion without damage
- Resist moderate level of earthquake motion without structural damage, possible experience non-structural damage.
- Resist severe earthquake ground motion having intensity equal to the strongest Shaking experienced at the site, without collapse of structure as well-known as non structural damage.



Flow Chart:-

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PROPOSED STRUCTURE:

Designing a Mono column building. The height of the structure is taken as 18.0 m. Structure is supported on a single column. It is a 4-storey building. Height of each storey is 4 m. First storey starts at a height of 5m above ground level. Single column keeps the building at a height of 3 m above ground level. Width and breadth of each storey is 16 m. Column is provided at the Centre of structure starting from ground level toa height of 18 m above ground.

RESULTS:

MAXIMUM STORY DISPLACEMENT AT RSA AT X

Maximum story displacement at response spectrum analysis at x direction for all the models. Story displacement is the lateral displacement of the story relative to the base. The lateral force-resisting system can limit the excessive lateral displacement of the building. The maximum story displacement at seismic X direction for a mono column building will depend on several factors, such as the seismic hazard of the location, the structural design and detailing, and the characteristics of the ground on which the building is constructed. In general, the maximum story displacement can be estimated using the following formula:

$$Dx = (Sa/g) * (T/2\pi) * Cd * R * Ie$$

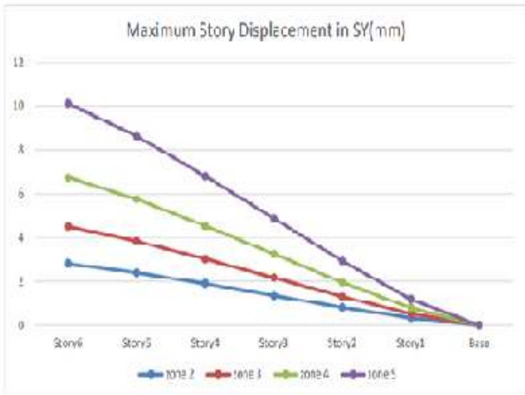
where Dx is the maximum story displacement in the seismic X direction, Sa is the spectral acceleration at the building site, g is the acceleration due to gravity, T is the fundamental period of the building, Cd is the deflection amplification factor, R is the seismic response coefficient, and Ie is the seismic importance factor.

Graph:-1

	zone 2	zone 3	zone 4	zone 5
Story6	2.891	4.626	6.939	10.408
Story5	4.307	6.891	10.336	15.504
Story4	3.418	5.469	8.204	12.306
Story3	2.463	3.941	5.911	8.866
Story2	1.507	2.411	3.616	5.424
Story1	0.685	1.097	1.645	2.468
Base	0	0	0	0

MAXIMUM STORY DISPLACEMENT AT RSA AT Y

Maximum story displacement at response spectrum analysis at y direction for all the models. Story displacement is the lateral displacement of the story relative to the base. The lateral force-resisting system can limit the excessive lateral displacement of the building.



Graph:-2

	zone 2	zone 3	zone 4	zone 5
Story6	2.811	4.498	6.747	10.12
Story5	2.397	3.835	5.752	8.629
Story4	1.891	3.025	4.538	6.807
Story3	1.356	2.17	3.255	4.883
Story2	0.814	1.303	1.955	2.932
Story1	0.33	0.527	0.791	1.187
Base	0	0	0	0

MAXIMUM STORY DRIFTS AT SEISMIC AT X

Maximum story drifts at response spectrum analysis at x direction for all the models. Storey Drift The storey drift in the structure due to the seismic effect for soft storey at different floor is decreasing floor wise. That means when irregularity is in Ground floor, drift is maximum and it decreases when the irregularity moves upward. As per Indian standard, Criteria for earthquake resistant design of structures, IS 1893(Part 1): 2016, the storey drift in any story shall not exceed 0.004 times storey height. In current analysis, all the storey drift satisfies the storey drift limitation as per IS code. It can be observed from the analysis that the location of irregularity has major contribution on the abrupt increase in the story drift of that particular story. From the result it is found that the irregularity in Ground floor yields highest inter-story drift of that particular storey. When ith story is irregular, the inter-story drift of that particular ith story is abruptly increases than that of regular frame.

Graph:-3

	zone 2	zone 3	zone 4	zone 5
Story6	0.000179	0.000286	0.00043	0.000644
Story5	0.000222	0.000355	0.000533	0.000799
Story4	0.000239	0.000382	0.000573	0.00086
Story3	0.000239	0.000383	0.000574	0.000861
Story2	0.000205	0.000328	0.000493	0.000739
Story1	0.000076	0.000121	0.000181	0.000272
Base	0	0	0	0

CONCLUSION:

• The stiffness of the structure appears to be consistent across all zones for each story. This suggests that the building is designed to have a uniform response to seismic forces.

• The overturning moment at seismic at X and Y is highest at the lower stories and decreases as the height increases. This is expected, as the lower stories have to resist a greater weight of the building and seismic forces. The base overturning moment is significantly higher than the overturning moments at each story. This indicates that the foundation of the building is designed to resist a large amount of the seismic force.The overturning moments increase as you move up the building, with the largest moments occurring at the top (Story1). This suggests that the lower stories are better able to resist lateral forces than the upper stories. The overturning moments are also larger in Zone 5 than in Zone 2, indicating that the building is subject to greater lateral forces in the direction perpendicular to Zone 2. The base overturning moments are positive, indicating that the foundation is resisting overturning forces, which is desirable for structural stability.

• The story shears at seismic at X and RSA at Y are highest at the top of Story 5 and gradually decrease towards the base. For

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both X and Y, the story shears are negative at the top and bottom of Story 6, indicating that the seismic forces are acting in the opposite direction. The story shears are also negative at the top and bottom of the Base, which indicates that the foundation is providing resistance against the seismic forces. The highest story shear values are observed in Zone 5, followed by Zone 4, Zone 3, and Zone 2. This indicates that the building experiences the highest seismic forces in Zone 5 and the lowest in Zone 2.

• Maximum story drifts at seismic at X and Y increase as we move from zone 2 to zone 5, and as we move from Story1 to Story6. This indicates that structures in higher seismic zones and upper stories experience greater lateral displacement under seismic loads.

• Maximum story displacements at RSA at X and Y also increase as we move from zone 2 to zone 5, and as we move from Story1 to Story6. However, the values are much lower compared to the maximum story drifts at seismic. This indicates that the building's response to seismic loads in terms of displacement is relatively smaller compared to the drift.

• Among all the stories, Story5 and Story6 experience the maximum story drifts and displacements at both seismic and RSA. This suggests that the upper stories of the building are more vulnerable to damage under seismic loads.

• The base of the building does not experience any displacement or drift under seismic loads or RSA, which is expected as the base is assumed to be fixed.

• Based on the design results, we can conclude that a square column with dimensions of 2.2m x 2.2m and reinforcement of 20T25 bars can safely withstand the applied loads and combinations. The design meets the requirements for strength, stability, and serviceability, as well as the constraints of maximum allowable deflection and steel stress. The use of M60 79 grade concrete and Fe 415 steel reinforcement is suitable for this application and provides a factor of safety of 1.5 against bending and axial loads. Overall, the design is reliable and can be used for construction.

• The area of steel required for the column is 5020 mm2 .

• The width and height of the rectangular column are 320 mm and 600 mm, respectively.

• The slenderness ratio of the column is 1.23.

• In comparison to other designs, we can say that the width and height of the rectangular column are relatively larger than what would be required for a column carrying an ultimate load of 2500kN. This means that the column is more robust and can withstand larger loads or have a higher safety factor. However, this also means that the column may be more expensive to build and may use more material than a column with smaller dimensions. Additionally, the slenderness ratio of 1.23 indicates that the column may be prone to buckling under compressive loads, so care should be taken to ensure that the column is adequately braced to prevent buckling.

• Based on the results presented, it appears that the maximum story drift and displacement values calculated using ETABs software and manual calculations are generally consistent, although there are some differences in the numerical values

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