To Analysis And Design Of Multistory Building from Earthquake Resistant

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ABSTRACT

The performance of a multi-story framed building during sturdy earthquake motions depends on the distribution of mass, stiffness, and strength in both the horizontal and vertical planes of the building. In multi-storied framed buildings, smash up from earthquake ground motion generally initiates at locations of structural weaknesses present in the lateral load resisting frames. A common type of discontinuity is vertical geometrical irregularity arising from the rapid drop of the height. STAAD.Pro has a very interactive user interface which allows the users to draw the frame and input the load values and dimensions. Then according to the specified criteria assigned it analyses the structure and designs the members with reinforcement details for RCC frames. STAAD. Pro provides us a fast, efficient, easy to use and accurate platform for analyzing and designing structures. Seismic load calculations were done following IS 1893-2000. Presence of infill walls in the frames alters the behavior of the building under lateral loads. However, it is common industry practice to ignore the stiffness of infill wall for analysis of framed building. Engineers believe that analysis without considering infill stiffness leads to a conservative design. But this may not be always true, especially for vertically irregular buildings with discontinuous infill walls. Hence, the modeling of infill walls in the seismic analysis of framed buildings is imperative. Indian Standard IS 1893: 2002 allows analysis of open ground story buildings without considering infill stiffness but with a multiplication factor 2.5 in compensation for the stiffness discontinuity.

Keyword :-*Seismic Loading, Manual Calculation, STAAD Pro., analysis, seismic effect, Programming tools.*

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1. INTRODUCTION

An earthquake is the result of a rapid release of strain energy stored in the earth's crust that generates seismic waves. Structures are vulnerable to earthquake ground motion and damages the structures. In order to take precaution for the damage of structures due to the ground motion, it is important to know the characteristics of the ground motion. The most important dynamic characteristics of earthquake are peak ground acceleration (PGA), frequency content, and duration. These characteristics play predominant rule in studying the behavior of structures under the earthquake ground motion. Severe earthquakes happen rarely. Even though it is technically conceivable to design and build structures for these earthquake events, it is for the most part considered uneconomical and redundant to do so. The seismic design is performed with the expectation that the severe earthquake would result in some destruction, and a seismic design philosophy on this premise has been created through the years. The objective of the seismic design is to constraint the damage in a structure to a worthy sum. An earthquake is the result of an unexpected release of energy in the Earth's crust that creates seismic waves. The seismicity or seismic action of an area refers to the frequency, type and size of earthquakes practiced over a period of time. At the Earth's surface, earthquakes manifest themselves by trembling and sometimes displacement of the ground. When the epicenter of a large earthquake is situated offshore, the seabed may be displaced adequately to cause a tsunami. Earthquakes can also trigger landslides, and occasionally volcanic movement. The seismic design is performed with the expectation that the severe earthquake would result in some destruction, and a seismic design philosophy on this premise has been created through the years. The objective of the seismic design is to constraint the damage in a structure to a worthy sum.

OBJECTIVE AND SCOPE

The purpose of this project is to study the response of low, mid, and high-rise regular as well as irregular three-dimension RC buildings under low, intermediate, and high-frequency content ground motions in terms of story displacement, story velocity, story acceleration and base shear performing linear time-history analysis using STAAD Pro software. From the three dynamic characteristics of ground motion, which are PGA, duration, and frequency content, keeping PGA and duration constant and changing only the frequency content to see how low, mid, and high-rise reinforced concrete buildings behave under low, intermediate, and high-frequency content ground motions

2. LITERATURE REVIEW

Cakir et.al [1] Studied the evaluation of the effect of earthquake frequency content on seismic behavior of cantilever retaining wall involving soil-structure interaction. Also, seismic behavior of partially filled rigid rectangular tank with bottom-mounted submerged block are studied under low, intermediate, and high-frequency content ground motions. No research work is done on seismic behavior of RC buildings under low, intermediate, and high-frequency content ground motions**.**

Rathje, et.al. [2] Studied three simplified frequency content, which are mean period (Tm), predominant period (Tp), and smoothed spectral predominant period (Tp). They computed the frequency parameters for 306 motion records from twenty earthquakes. They used the data for developing a model to describe the site reliance, magnitude, and distance of the frequency

Chin-Hsun et.al. [3] Proposed a new stochastic model of ground excitation in which both frequency content intensity are time dependent. The proposed ground motion model can be effectively employed in simulations as well as random vibration and reliability studies of nonlinear structures. Responses of single-mass nonlinear systems and three-story space frames, with or without deterioration under the no stationary biaxial ground motion are found through the equivalent linearization method and Monte Carlo simulations. His results indicate that the time-varying frequency content and the dominant frequencies of ground motion are close to the structural natural frequency.

Pankaj & Lin [4] Carried out material modeling in the seismic response analysis for the design of RC framed structures. They used two a like continuum plasticity material models to inspect the impact of material modeling on the seismic response of RC frame structures. In model one, reinforced concrete is modeled as a homogenized material using an isotropic Drucker-Prager yield condition. In model two, also based on the Drucker-Prager criterion, concrete and reinforcement are included independently; the later considers strain softening in tension. Their results indicate that the design response from response history analyses (RHA) is considerably different for the two models.

Hao & Zhou [5] Worked on rigid structure response analysis to seismic and blast caused ground motions. Comparing to an earthquake ground motion, ground shock produced by underground or surface blast has very high amplitude, high-level frequency and short time. Furthermore, vertical component of a ground shock may be noticeably higher than the acceleration of gravity. This will result in the unfastened inflexible structure hop or fly into air. Subsequently.

Kappos & Manafpour [6], Including analysis of a feasible partial inelastic model of the structure using time - history analysis for properly scaled input motions, and nonlinear static analysis (pushover analysis).

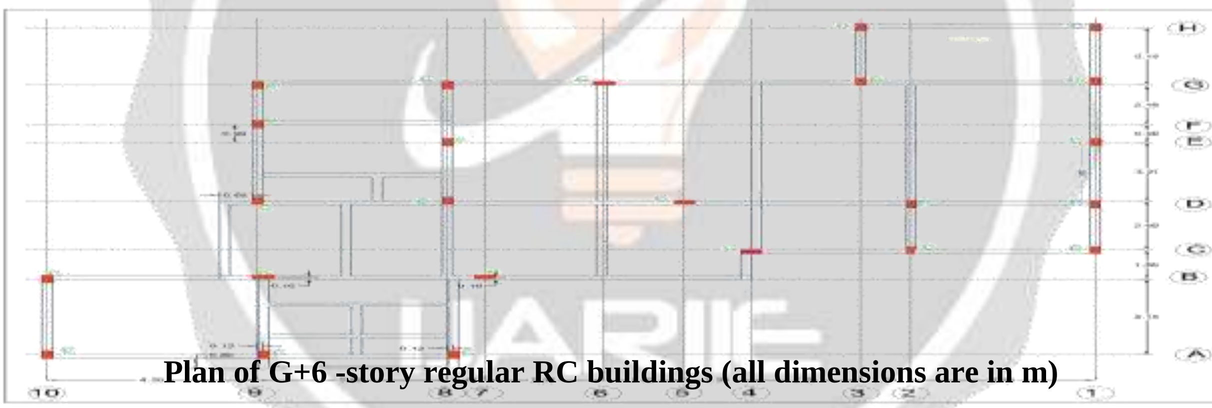
Mwafy & Elnashai [7], Studied static pushover vs. dynamic collapse analysis of RC buildings. They studied natural and artificial ground motion data imposed on twelve RC buildings of distinct characteristics. The responses of over one hundred nonlinear dynamic analyses using a detailed 2D modeling approach for each of the 12 RC buildings are used to create the dynamic pushover envelopes and compare them with the pushover results with various load patterns.

Pankaj & Lin [8] Carried out material modeling in the seismic response analysis for the design of RC framed structures. They used two a like continuum plasticity material models to inspect the impact of material modeling on the seismic response of RC frame structures. In model one, reinforced concrete is modeled as a homogenized material using an isotropic Drucker-Prager yield condition. In model two, also based on the Drucker-Prager criterion, concrete and reinforcement are included independently; the later considers strain softening in tension.

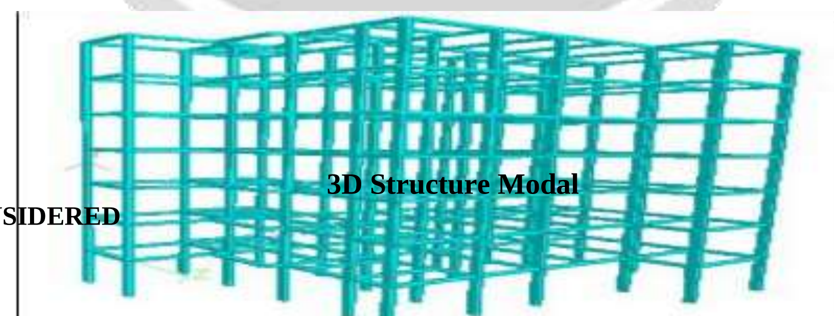
3. METHODOLOGY

Concrete is the most widely used material for construction. It is strong in compression, but weak in tension, hence steel, which is strong in tension as well as compression, is used to increase the tensile capacity of concrete forming a composite construction named reinforced cement concrete. RC buildings are made from structural members, which are constructed from reinforced concrete, which is formed from concrete and steel. Tension forces are resisted by steel and compression forces are resisted by concrete. The word structural concrete illustrates all types of concrete used in structural applications. In this chapter, building description is presented. The plan, elevation of G+6 -story regular reinforced concrete buildings of low, mid, and high-rise. The plan and elevation of the G+6-story irregular reinforced concrete buildings which are considered as low, mid, and high-rise buildings are shown.

Beam and columns are modeled by 3D frame elements. Beams and columns are modeled by giving end -offsets to the frame elements, to obtain the bending moments and forces at the beam and column faces. Beams-Column joints are assumed to be rigid. Beams and columns in present study were modeled as frame elements with centre lines joined at the nodes using commercial STAAD-Pro Software. Rigid beam-column joints were modeled by using end offsets at the joints. Floor slabs were assumed to act as diaphragms, which ensure integral action of all vertical lateral load resisting elements.



Plan of G+6 -story regular RC buildings (all dimensions are in m)



3D Structure Modal

3.1. LOADS CONSIDERED

DEAD LOADS:

All permanent constructions of the structure form the dead loads. The dead load comprises of the weights of walls, partitions floor finishes, false ceilings, false floors and the other permanent constructions in the buildings. The dead load loads may be calculated from the dimensions of various members and their unit weights. the unit weights of plain concrete and reinforced concrete made with sand and gravel or crushed natural stone aggregate may be taken as 24 kN/m” and 25 kN/m” respectively.

IMPOSED LOADS:

Imposed load is produced by the intended use or occupancy of a building including the weight of movable partitions, distributed and concentrated loads, load due to impact and vibration and dust loads. Imposed loads do not include loads due to wind, seismic activity, snow, and loads imposed due to temperature changes to which the structure will be subjected to, creep and shrinkage of the structure, the differential settlements to which the structure may undergo.

SEISMIC LOAD:

Design Lateral Force :- The design lateral force shall first be computed for the building as a whole. This design lateral force shall then be distributed to the various floor levels. The overall design seismic force thus obtained at each floor level shall then be distributed to individual lateral load resisting elements depending on the floor diaphragm action. Design Seismic Base Shear :-The total design lateral force or design seismic base shear

Properties of Concrete and Steel bar as per IS 456[7]

`		**Steel Bar Properties**	
Unit weight (γ_c)	**25 kN/m**	**Unit weight (γ_s)**	**76.33 kN/m**
Modulus of elasticity	21718.8MPa	Modulus of elasticity	2x10 MPa
Poisson ratio (νc)	0.17	Poisson ratio (ν_s)	0.3
Thermal coefficient (α_c)	1x10	Thermal coefficient (α_s)	1.2x10
Shear modulus (ς_c)	9316.95MPa	Shear modulus (ς_s)	76.8195MPa
Damping ratio (ς_c)	.5%	Yield strength	415MPa
Compressive strength (F_c)	25MPa	Compressive strength (F_s)	485MPa

4. RESULTS ANALYSIS

This type of analysis will be carried out for regular and low rise buildings and this method will give good results for this type of buildings. Dynamic analysis will be carried out for the building as specified by code IS 1893-2002 (part1).Dynamic analysis will be carried out either by Response spectrum method or site specific Time history method.

Following methods are adopted to carry out the analysis procedure.

a. Equivalent Static Analysis

b. Response Spectrum Method

c. Time History Analysis.

A.EQUIVALENT STATIC ANALYSIS: The equivalent static analysis procedure is essentially an elastic design technique. It is, however, simple to apply than the multi-model response method, with the absolute simplifying assumptions being arguably more consistent with other assumptions absolute elsewhere in the design procedure.

B.RESPONSE SPECTRUM ANALYSIS: This approach permits the multiple modes of response of a building to be taken into account. This is required in many building codes for all except for very simple or very complex structures. The structural response can be defined as a combination of many modes. Computer analysis can be used to determine these modes for a structure. For each mode, a response is obtained from the design spectrum, corresponding to the modal frequency and the modal mass, and then they are combined to estimate the total response of the structure. In this the magnitude of forces in all 1directions is calculated and then effects on the building is observed.

C.TIME HISTORY ANALYSIS: Time history analysis techniques involve the stepwise solution in the time domain of the multi degree-of-freedom equations of motion which represent the actual response of a building. It is the most sophisticated analysis method available to a structural engineer. Its solution is a direct function of the earthquake ground motion selected as an input parameter for a specific building. This analysis technique is usually limited to checking the suitability of assumptions made during the design of important structures rather than a method of assigning lateral forces

5. RESULTS AND DISCUSSION

Ductility in the structures results from inelastic material behavior and reinforcement detailing such that brittle fracture is prevented and ductility is introduced by allowing steel to yield in a controlled manner. Thus the chief task is to ensure that building has adequate ductility to withstand the effects of earth quakes, which is likely to be experienced by the structure during its lifetime. Ductility of the structure acts as a shock absorber and reduces the transmitted forces to the structure. the ductility of a structure can assessed by-

1.Displacement ductility

2.Rotational and Curvature ductility

3.Structural ductility

Ductility is the capability of a material to undergo deformation after its initial yield without any significant reduction in yield strength.
The factors which affect the ductility of a structure are as follows-

o Ductility increases with increase in shear strength of concrete for small axial compressive stress between 0-1MPa.The variation is linear in nature.
o Ductility varies linearly up to the point when axial compressive stress becomes equal to the compressive stress at balanced failure.
o The ductility factor increases with increase in ultimate strain of concrete. Thus confinement of concrete increases ductility.
o The ductility increases with increase in concrete strength and decreases with the increase in yield strength of steel.

o The effect of lateral reinforcement is to enhance the ductility by preventing the shear failure .It also restrains the compression reinforcement from buckling.

6. CONCLUSIONS

i) IS code gives a value of 2.5 to be multiplied to the ground storey beam and column forces when a building has to be designed as open ground storey building or stilt building. The ratio of IR values for columns and Demand Capacity Ratio (DCR) values of beams for both the support conditions and building models were found out using Equivalent Static Analysis (ESA) and Response Spectrum Analysis (RSA) and both the analyses supports that a factor of 2.5 is too high to be multiplied to the beam and column forces of the ground storey. This is particularly true for low-rise buildings.

ii) Capacity based earthquake resistant design is futuristic approach to design of reinforced concrete structures especially for multi-bay multi storied reinforced concrete buildings.

iii) This concept is to restrict the formation of plastic hinges in the beams only hence collapse occurs through the beam mechanism only, which localize the failure and hence leads to less destruction and loss of lives.

iv) Collapse due to sway mechanism can cause failure of a storey or whole frame. As its approach is to eliminate sway mechanism by making columns stronger than beams, this method is very effective in design of soft-storey frames.

7. REFERENCES

- T. Cakir, "Evaluation of the effect of earthquake frequency content on seismic behaviour of cantiliver retaining wall including soil-structure interaction," Soil Dynamics and Earthquake Engineering, vol. 45, pp. 96-111, 2018.
- IS1893 (Part1), Indian Standard CRITERIA FOR EARTHQUAKE RESISTANT DESIGN OF STRUCTURES PART 1, 6.1 ed., New Delhi 110002: Bureau of Indian Standards, 2002.
- E. M. Rathje, N. A. Abrahamson and J. D. Bray, "Simplified Frequency Content Estimates of Earthquake Ground Motions," Journal of Geotechnical & Geo environmental Engineering, no. 124, pp. 150-159, 1998.
- E. M. Rathje, F. Faraj , S. Russell and J. D. Bray, "Empirical Relationships for Frequency Content Parameters of Earthquake Ground Motions," Earthquake Spectra, vol. 20, no. 1, pp. 119-144, February 2018.
- Y. Chin-Hsun, "Modeling of nonstationary ground motion and analysis of inelastic structural response," Structural Safety, vol. 8, no. 1-4, pp. 281-298, July 1990
- E. kafka and A. Frankel, "Effects of Ground Motion Characteristics on the Response of Base-Isolated Structures," in Eleventh World Conference on Earthquake Engineering , Illinois, 1996.
- "Pacific Earthquake Engineering Research Center: NGA Database,"2005.[Online].
- Available: http://peer.berkeley.edu/nga/data?doi=NGA0023. [Accessed 2013].
- J. Kappos and A. Manafpour, "Seismic Design of RC buildings with the aid of advanced analytical techniques," Engineering Structures, pp. 319-332, 2001.
- M. Mwafy and A. S. Elnashai, "Static pushover versus dynamic collapse analysis of RC buildings," Engineering Structures, vol. 23, pp. 407-424, 2001.
- P. Pankaj and E. Lin, "Material modelling in the seismic response analysis for the design of RC framed structures," Engineering Structures, vol. 27, pp. 1014-1023, 2005.

- L. D. Sarno, "Effects of multiple earthquakes on inelastic structural response," Engineering Structures, vol. 56, pp. 673-681, 2013. M. D. Stefano and B. Pintucchi, "A review of research on seismic beavior of irregular building structures since 2002," Bull Earthquake Engineering, vol. 6, pp. 285-308, 2008.

- T. Cakir, "Evaluation of the effect of earthquake frequency content on seismic behaviour of cantiliver retaining wall including soil-structure interaction," Soil Dynamics and Earthquake Engineering, vol. 45, pp. 96-111, 2013.