COMPARATIVE STUDY OF REINFORCED CONCRETE BUILDINGS SUBJECTED TO DIFFERENT SEISMIC FREQUENCY CONTENTS

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Abstract The primary dynamic properties of an earthquake are peak ground acceleration (PGA), frequency content, and duration. These properties play a pivotal role in analysing the behaviour of buildings under seismic stresses. The intensity of ground motion is assessed according to the Peak Ground Acceleration (PGA), frequency components, and duration of shaking.

Ground motion encompasses several frequency components, including low, midrange, and high frequencies. The current research examines the frequency content of ground motion in reinforced concrete (RC) structures. Analysis is conducted using ETABS software for structural analysis and design. The suggested approach is to analyse the reaction of a G+12 structure to ground vibrations with varying frequency content. The buildings' reaction to ground movements regarding story displacement, story velocity, story acceleration, and base shear has been determined. The reactions of each ground motion for every structure type are analysed and compared.

Keywords**:** Reinforced concrete building, ground motion, peak ground acceleration, frequency content, time history analysis, gravity load, building material properties.

1. INTRODUCTION

An earthquake occurs due to the rapid release of strain energy accumulated in the Earth's crust, which produces seismic waves. Structures are susceptible to seismic ground motion, resulting in damage to the edifices. To mitigate structural damage from ground motion, it is essential to understand the characteristics of the ground motion. The primary dynamic properties of an earthquake are peak ground acceleration (PGA), frequency content, and duration. These features play a pivotal role in analysing the behaviour of buildings subjected to earthquake ground motion.

Severe earthquakes occur seldom. Although it is theoretically feasible to design and construct buildings for these seismic occurrences, it is often seen as uneconomical and superfluous to undertake such efforts. The seismic design is conducted with the anticipation that a significant earthquake would cause considerable damage, and a seismic design philosophy based on this assumption has been developed throughout time. The aim of seismic design is to limit structural damage to an acceptable level. The structures are engineered to endure minor earthquakes without damage, withstand moderate earthquakes with potential non-structural damage, and resist significant ground motion while incurring both structural and non-structural damage.

This study examines two, six, and twenty-story regular and irregular reinforced concrete structures exposed to six ground movements with low, middle, and high-frequency characteristics. The structures are represented in three dimensions, and linear time history analysis is conducted using structural analysis and design (STAAD Pro) software.

Behaviour of RC Buildings under Seismic Load

Kappos & Manafpour [18] present a seismic design methodology that incorporates performance principles for two distinct limit states, featuring an analysis of a viable partial inelastic model of the structure through time history analysis with appropriately scaled input motions, as well as nonlinear static analysis (pushover analysis).

Mwafy and Elnashai [19] examined the comparative efficacy of static pushover analysis vs dynamic collapse analysis in reinforced concrete structures. The researchers analysed natural and artificial ground motion data applied to twelve reinforced concrete structures with varying features. The outcomes of more than one hundred nonlinear dynamic studies using a comprehensive 2D modelling technique for each of the 12 reinforced concrete structures are used to generate the dynamic pushover envelopes and to juxtapose them with the pushover results under varied loading patterns. They found a strong correlation between the computed ideal envelopes of the dynamic studies and the static pushover findings for a certain class of structures.

Pankaj and Lin [20] conducted material modelling in the seismic response analysis for the construction of reinforced concrete framed buildings. Two similar continuum plasticity material models were used to examine the influence of material modelling on the seismic response of reinforced concrete frame structures. In the first model, reinforced concrete is represented as a homogenised material using an isotropic Drucker-Prager yield criterion. Model two, similarly based on the Drucker-Prager criteria, incorporates concrete and reinforcement separately; the latter accounts for strain softening in tension. Their findings demonstrate that the design response derived from response history analyses (RHA) significantly differs between the two models.

They contrasted the nonlinear static analysis (NSA) and response history analysis (RHA) outcomes for the two material models. Their studies demonstrate that significant variations in local design response may occur, despite the desired deformation values at the control node being similar. The disparity between the mean peak RHA response and the pushover response is contingent upon the material model. Sarno [21] examined the impact of several earthquakes on inelastic structure behaviour. Five stations are selected to represent a collection of locations subjected to several earthquakes of differing magnitudes and source-to-site distances. From the many data collected at these five locations, three are selected from each site to represent states of dominant and subordinate ground motion.

The analysis of reinforced concrete (RC) frames subjected to identical ground motions utilised for their response not only confirms the necessity for extensive and immediate research on multiple earthquakes but also indicates the extent of non-conservatism in the safety of conventionally designed structures when exposed to diverse seismic events. Cakir [3] examined the impact of earthquake frequency content on the seismic behaviour of cantilever retaining walls, including soil-structure interaction.

Several studies are conducted to analyse the frequency content of ground motion. This project aims to examine the response of low, mid, and high-rise reinforced concrete buildings to low, intermediate, and high-frequency ground motions, focussing on story displacement, story velocity, and story acceleration through linear time-history analysis utilising Stadd.pro software for structural analysis and design. The reactions of reinforced concrete structures are significantly influenced by the frequency characteristics of ground movements.

2. LITERATURE REVIEWS

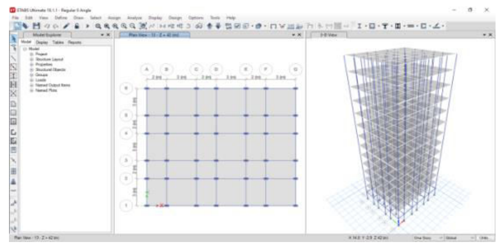
P V Dhanshetti et al [2015] investigated the action of P-Delta effect on multi-storey buildings. In this work, multi-storeyed reinforced concrete building models with different number of storeys were analyzed by using STAAD Pro V8i structural analysis software. The maximum response values in buildings in terms of storey drifts, column moments, beam moments, column shear and beam shear were investigated. It was observed that the P-Delta effect will be substantial when lateral forces exist on the structure and this increases with increase in number of storey. The P-Delta effect is not predominant on buildings up to seven storeys and it is very negligible when only gravity loading exists on the structure.

Manasa C. K et al [2016] examined the behaviour of reinforced concrete buildings under lateral loading. The focus of the study was to assess the P-Delta effect in tall RC buildings. Five building models with 10, 20, 30, 40 and 50 storey are analysed using non-linear static analysis method in ETABS 2015. The drift ratio is found out by considering P-Delta effect for all building models. The results demonstrated the effectiveness of P-Delta analysis in tall RC buildings. They concluded that the effect of P-Delta increases as the height of the building increases and it can be reduced up to certain extend by the construction of shear walls

PROBLEM STATEMENT

The following are the basic data considered for analysis

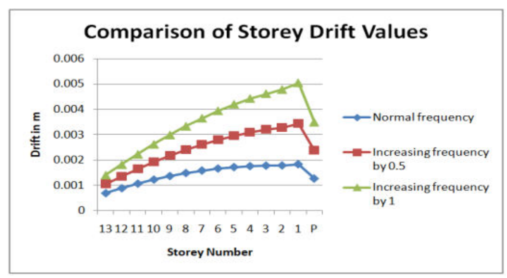
1. Height of typical Storey = 3 m
2. Height of ground Storey = 3 m
3. Length of the building = 15 m
4. Width of the building = 13 m
5. Height of the building = 39 m
6. Number of stores (G+12) = 13
7. Wall thickness = 230 mm
8. Slab Thickness = 150 mm
9. Grade of concrete = M30
10. Grade of the steel = Fe500
11. Support = Fixed
12. Column size = 460mmX230mm
13. Beam size = 350mmX230mm
14. Location of Building = India
15. Live load = 3 KN/m^2
16. Dead load = 2 KN/m^2
17. Density of concrete = 25 KN/m^3
18. Seismic Zones = Zone 5
19. Site type = II
20. Importance factor = 1.5
21. Response reduction factor = 5
22. Damping Ratio = 5%
23. Structure class = C
24. Basic wind speed = 44m/s
25. Risk coefficient (K1) = 1.08
26. Terrain size coefficient (K2) = 1.14
27. Topography factor (K3) = 1.36
28. Wind design code = IS 875: 2015 (Part 3)
29. RCC design code = IS 456:2000
30. Steel design code = IS 800: 2007
31. Earth quake design code =IS 1893: 2016



Building 3d model

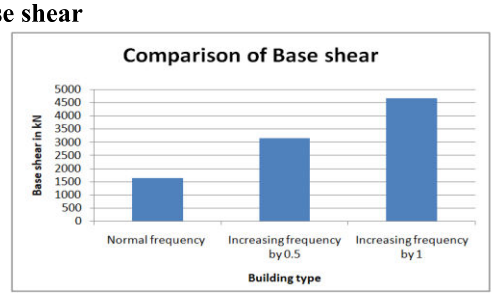
RESULTS AND ANALYSIS

Drift values



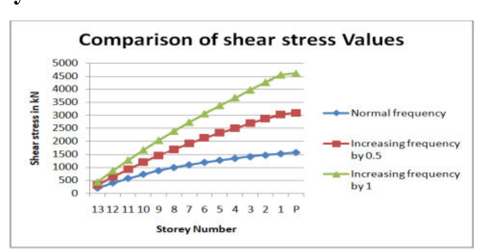
Graph 1: Comparison of storey drift values

Base shear



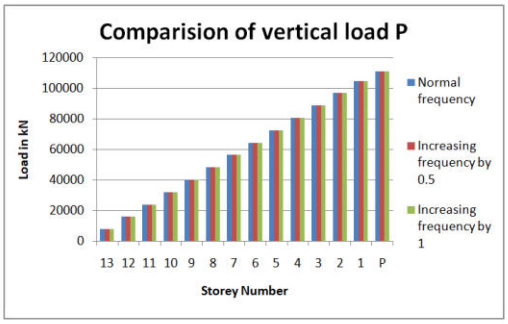
Graph 2: Comparison of Base shear values

Storey shear



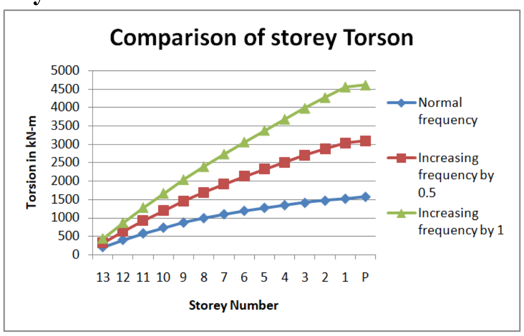
Graph 3: Comparison of storey shear values

Vertical load P



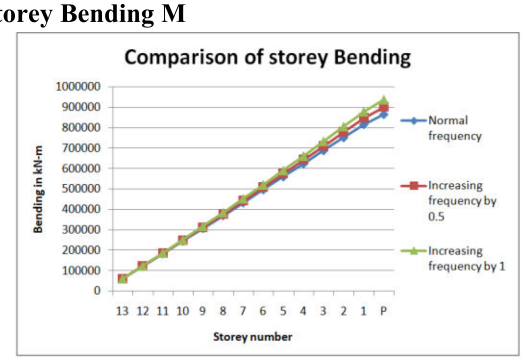
Graph 4: Comparison of vertical load P values

Storey Torsion T



Graph 5: Comparison of storey torsion T values

Storey Bending M



Graph 6: Comparison of storey bending M

CONCLUSIONS

Following conclusions can be drawn for 13 story regular RC buildings from the results obtained:

1. The response of regular three-dimension RC buildings under low, intermediate, and high-frequency content ground motions is studied by using ETABS software.
2. The seismic analysis of the building is done as per IS 1893:2016 code standard system
3. Regular RC building experiences minimum drift due to low-frequency content ground motion for 13 storey building.
4. Regular RC building experiences maximum story displacement due to high-frequency content ground motion in x and z-direction
5. Regular RC building experiences maximum story velocity due to high-frequency content ground motion.
6. Regular RC building experiences minimum story velocity due to high-frequency content ground motion.
7. Regular RC building experiences maximum base shear due to high frequency content ground motion.
8. Regular RC building experiences maximum base shear due to high frequency content ground motion.

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