SEISMIC BEHAVIOR OF REINFORCED CONCRETE BUILDING UNDER VARYING FREQUENCY CONTENTS

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Abstract The most important dynamic characteristics of earthquake are peak ground acceleration (PGA), frequency content, and duration. These characteristics play predominant rule in studying the behaviour of structures under seismic loads. The strength of ground motion is measured based on the PGA, frequency content and how long the shaking continues.

Ground motion has different frequency contents such as low, intermediate, and high. Present work deals with study of frequency content of ground motion on reinforced concrete (RC) buildings. Analysis is performed in structural analysis and design (ETABS) software. The proposed method is to study the response of G+12 building under different frequency content ground motions. The response of the buildings due to the ground motions in terms of story displacement, story velocity, story acceleration, and base shear are found. The responses of each ground motion for each type of building are studied 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 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 damage 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 behaviour 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. The structures designed in such a way that should have the capacity to resist minor levels of earthquake without damage, withstand moderate levels of earthquake without structural damage, yet probability of some non-structural damage, and withstand significant levels of ground motion without breakdown, yet with some structural and in addition non-structural damage.

In present work, two, six, and twenty-story regular as well as irregular RC buildings are subjected to six ground motions of low, intermediate, and high-frequency content. The buildings are modelled as three dimension and linear time history analysis is performed using structural analysis and design (STAAD Pro) software

Behaviour of RC Buildings under Seismic Load

A seismic design method taking into account performance principles for two discrete limit states is presented by Kappos & Manafpour [18], 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 [19], 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 modelling 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. They established good relationship between the calculated ideal envelopes of the dynamic analyses and static pushover results for a definite class of structure.

Pankaj & Lin [20] carried out material modelling in the seismic response analysis for the design of RC framed structures. They used two alike continuum plasticity material models to inspect the impact of material modelling on the seismic response of RC frame structures. In model one, reinforced concrete is modelled 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.

They compared the design nonlinear static analysis (NSA) and RHA responses for the two material models. Their works show that there can be important difference in local design response though the target deformation values at the control node are near. Likewise, the difference between the mean peak RHA response and the pushover response is dependent on the material model. Sarno [21] studied the effects of numerous earthquakes on inelastic structural response. Five stations are chosen to signify a set of sites exposed to several earthquakes of varying magnitudes and source-to-site distances. From the tens of records picked up at these five sites, three are chosen for each site to denote states of leading and lagging powerful ground motion.

RC frame analysis subjected to the same set of ground motions used for the response of the RC frame, not only verify that multiple earthquakes deserve broad and urgent studies, but also give signs of the levels of lack of conservatism in the safety of traditionally designed structures when subjected to various earthquakes. Cakir [3] studied the evaluation of the effect of earthquake frequency content on seismic behaviour of cantilever retaining wall involving soil-structure interaction.

A few researches are carried out to study the frequency content of the ground motion. The purpose of this project is to study the response of low, mid, and high rise RC buildings under low, intermediate, and high- frequency content ground motions in terms of story displacement, story velocity and story acceleration performing linear time-history analysis using structural analysis and design (Stadd.pro) software. The responses of RC buildings are strongly dependent on the frequency content of the ground motions.

2. LITERATURE REVIEWS

Sharoz et al [1990] investigated the seismic behaviour of reinforced concrete frames with setbacks using response of two small-scale models. The displacement, acceleration and shear responses of setback frames during earthquake simulations are compared with that of seven frames with uniform profiles. It is found that setback frames are not observed to be more susceptible to higher mode effects than the frames with uniform profile. They concluded that the response of setback structure is no different than that of the regular structures and hence it does not require different design considerations.

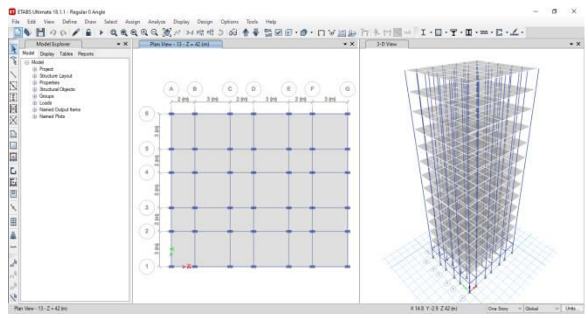
Eggert V Valmundasson et al [1997] studied the seismic response of building frames with vertical structuralstructure with irregularities in plan or vertical irregularities directly affects the whole structure in seismic action.The second defines the path effect of the earth as waves travel at some depth from the source to the spot. The third describes the effects of the upper hundreds of meters of rock and soil and the surface topography at the location. Powerful ground motions cause serious damages to made-up amenities and unluckily, From time to time, induce losses of human lives.

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 storey's and it is very negligible when only gravity loading exists on the structure.

PROBLEM STATEMENT

The following are the basic data considered for analysis

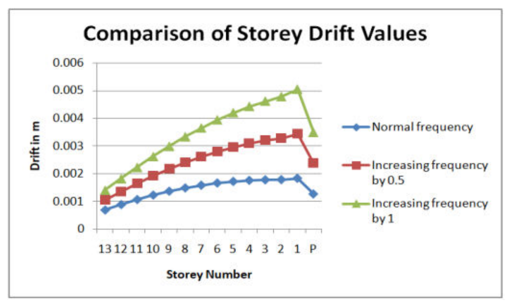
1. Height of typical Storey = 3 m
2. Height of ground Storey = 3 m
3. Length of the building = 15 m
4. Width of the building = 13 m
5. Height of the building = 39 m
6. Number of stores (G+12) = 13
7. Wall thickness = 230 mm
8. Slab Thickness = 150 mm
9. Grade of concrete = M30
10. Grade of the steel = 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

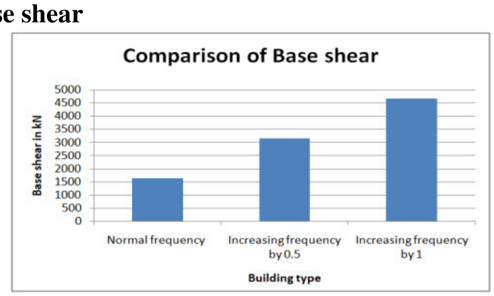
RESULTS AND ANALYSIS

Drift values



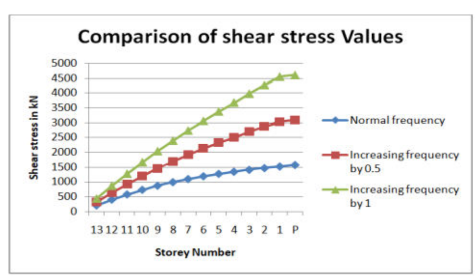
Graph 1: Comparison of storey drift values

Base shear



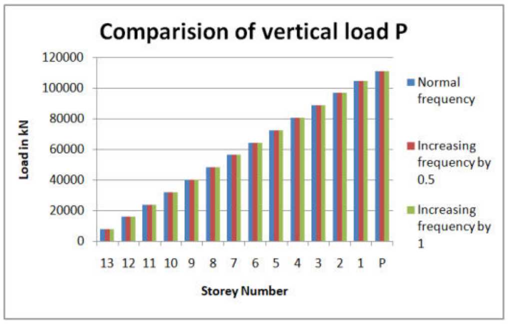
Graph 2: Comparison of Base shear values

Storey shear



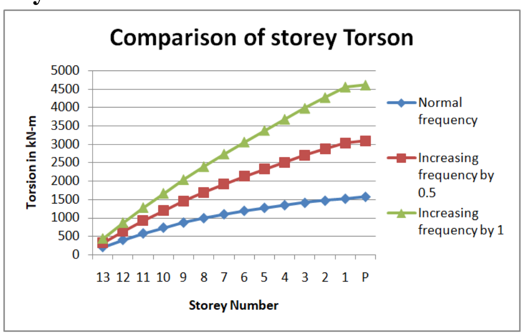
Graph 3: Comparison of storey shear values

Vertical load P



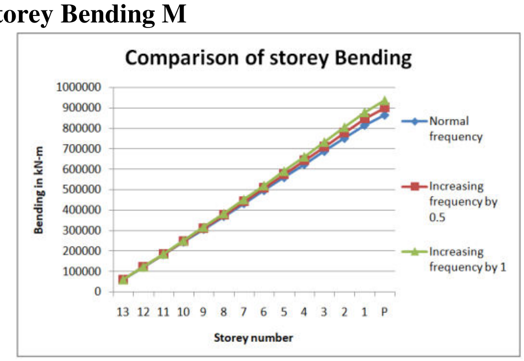
Graph 4: Comparison of vertical load P values

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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