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Determining the Influence of Frequency Content of Ground Motion on RCC Building Response

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Abstract – *Various parameters of ground motion are peak ground acceleration (PGA), frequency content, and duration. The more common practice adopted by many seismic codes is to use peak acceleration as a single measure of ground motion intensity. Ground motion has different frequency contents such as low, intermediate, and high. These characteristics play predominant rule in studying the behaviour of structures under seismic loads. Present work deals with study of effect of varying frequency content of ground motion on reinforced concrete buildings. Modal analysis and Time-domain spectral matching should be performed in ETABS2015 software on RC buildings. The response of the buildings due to the ground motions in terms of storey displacement and base shear should be found out. The responses of each ground motion should be studied and compared.*

Key Words: **Ground Motion, Peak Ground Acceleration, Frequency Content, Time domain spectral matching, Base shear, Storey displacement**

1. INTRODUCTION

The earth vibrates continously at periods ranging from milliseconds to days. The amplitude of vibration vary from nanometers to meters. The motion of ground can be described in terms of displacement, velocity and acceleration. Peak ground acceleration, frequency content, duration etc are the important parameters of ground motion. The objective of earthquake engineering is to forsee the impact of earthquake on buildings and other sructures and to design such structures to minimize the risk of damage. Usually most seismic codes consider peak ground acceleration as a single measure of ground motion intensity. But other parameters such as frequency content, duration etc also has effect on the seismic response of structure. In this project we aim to study the seismic effect of various parameters of ground motion on the accelerogram is represented by Fourier spectrum, Power spectrum, and Response spectrum. Based on the frequency content, which is the ratio of PGA/PGV the ground motion records are classified into three categories

High –Frequency content PGA/PGV>1.2
Intermediate-frequency content 0.8≤PGA/PGV≤1.2
Low Frequency content PGA/PGV<0.8
In the present work we study the effect of varying frequency content of ground motion on the seismic response of building. The buildings are modelled as three dimension and linear time history analysis is performed using ETABS2015.

2. SOFTWARE USED

i, ETABS (Extended 3D (Three-Dimensional) Analysis of Building Systems).

ETABS is a structural analysis and design software. It can be used for linear, non-linear, static and dynamic analysis and for the design and detailing of any type of building and its components.

3. METHODOLOGY

1. Collecting 12 ground motion accelerograms from STRONG MOTION VIRTUAL DATA CENTRE.
2. Modelling the RCC building in ETABS.
3. Defining earthquake load for zone 3.
4. Modal analysis of the structure for more than 90% modal mass participation ratio.
5. Finding out the fundamental time period of the structure.
6. Creating Target Response Spectrum as per IS1893:PART-I.
7. Scaling of accelerograms for frequency content.
8. Generating Time History Plot from the scaled earthquake accelerograms.
9. Conducting Time-Domain Spectral Matching.
10. Comparing results.

4. MODELING

Table 1 shows different types of properties assigned in the models and Figure 1, figure 2, figure 3 and figure 4 shows the models created in ETABS 2015

Table-1: Details of models

Sl No	Particulars	Data
1	Grade of concrete	M30
2	Grade of steel	Fe 415
3	No. of storeys	10
4	No. of bays in x & y direction	4
5	Span of bays	4m

6	Beam size	300mmx400mm
7	Column Size Bottom 5 Storeys	600mmx600mm
8	Column Size Top 5 Storeys	400mmx400mm
9	Slab thickness	150mm
10	Dead Load On Beams	17.25KN/m
11	Live Load On Slabs	3KN/m^2
12	Floor Finish Load	1.5KN/m^2

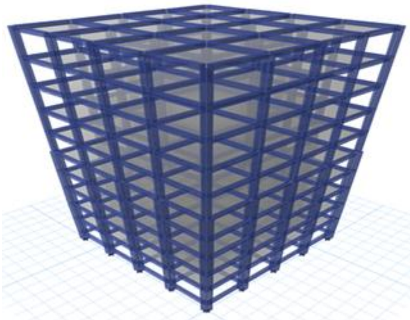

Fig-1: Model 1

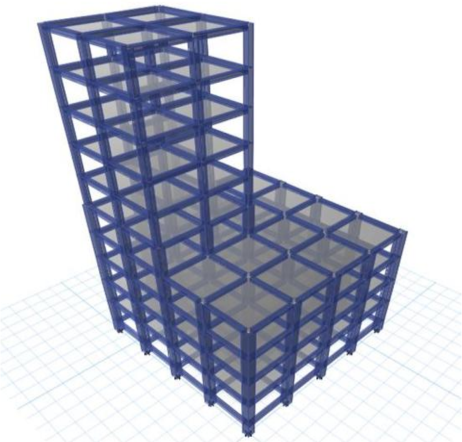

Fig-2: Model 2

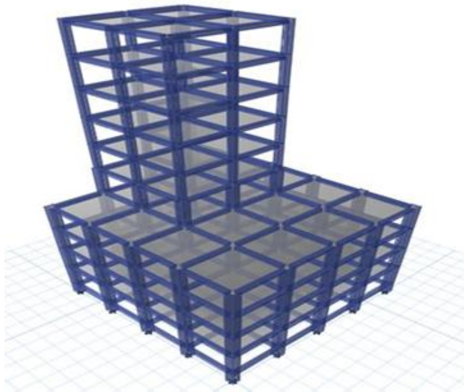

Fig-3: Model 3

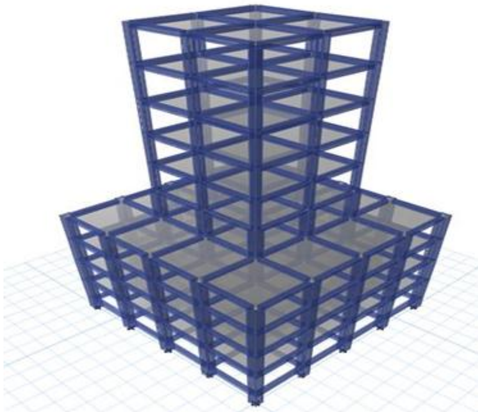

Fig-4: Model 4

5. TIME-DOMAIN SPECTRAL MATCHING

Time- domain spectral matching is a technique in earthquake engineering to obtain accelerograms for which the real earthquake accelogram is matched with the structures response spectrum. As per IS 1893:2018, the response reduction factor was taken as 5 for moment resisting frame and importance factor 1. The zone factor 0.16 was taken for the seismic zone 3.

6. RESULTS AND DISCUSSION

6.1 Irregularity Analysis

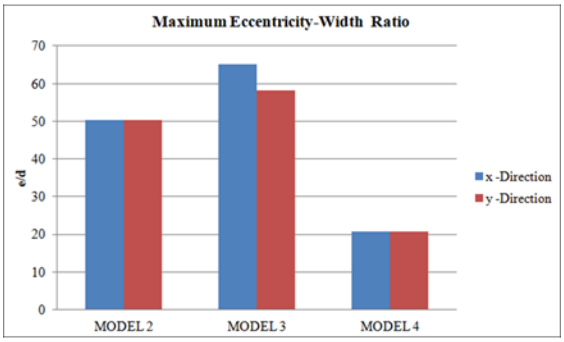

Chart-1: Vertical Geometric Irregularity

As per IS 1893 (Part I): 2016, Vertical Irregularity consist of vertical geometric irregularity, vertical stiffness irregularity and vertical mass Irregularity. Vertical geometric irregularity exists when eccentricity to width ratio is greater than 15%. Vertical stiffness irregularity exists when percentage increase of inter-storey stiffness ratio greater than 70%. Vertical mass irregularity exists when percentage increase of inter-storey mass ratio greater than 200% From chart 1, chart 2 & chart 3, it is clear that Vertical Geometric Irregularity is maximum for MODEL 3, stiffness Irregularity is maximum for MODEL 3, stiffness Ratio is maximum at 6th storey, Mass Irregularity is maximum for MODEL 3 and Mass Ratio is maximum at 6th storey.

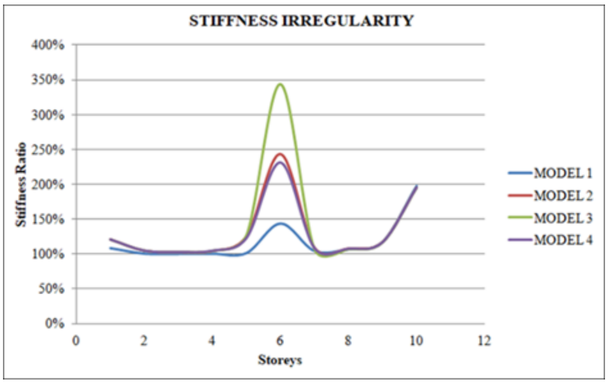

Chart-2: Stiffness irregularity

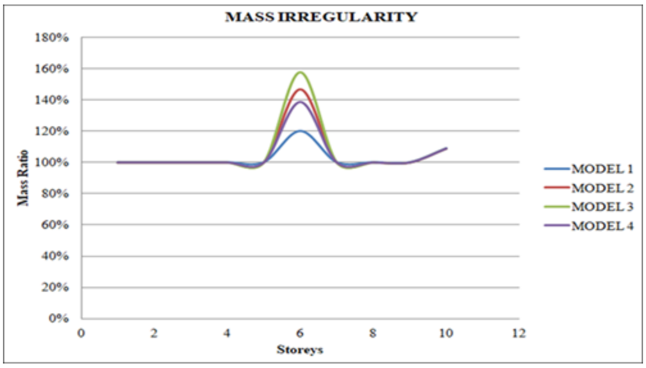

Chart -3: Mass irregularity

6.2 Fequency Content Estimation

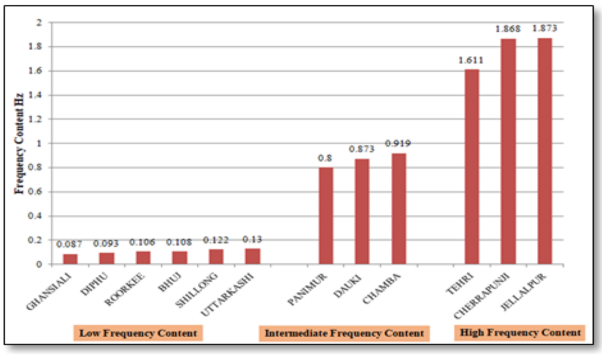

Chart-4: Frequency content of earthquake

Chart 4 shows the classification of ground motion into low, intermediate and high frequency content.

6.3 Base Shear

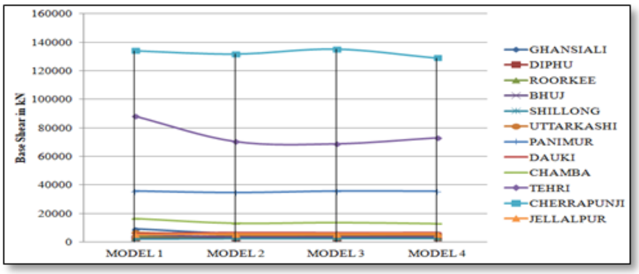

Chart -5: Base Shear

Chart 5 shows base shear is maximum for CHERRAPUNJI. TEHRI and PANIMUR Earthquakes. In regions of intermediate and high frequency content earthquakes, level of ductility of joints must be increased as per IS 13920:1993.

6.4 Torsional Response of Building

From chart 6 it is clear that Torsion is more for MODEL 3 because eccentricity-width ratio is high. No torsion for MODEL 1 & 4 since they both have symmetric plan. The maximum Torsion is created by CHAMBA & DAUKI Earthquakes. In regions of intermediate frequency content earthquakes, ensure symmetric plan for vertically irregular structures.

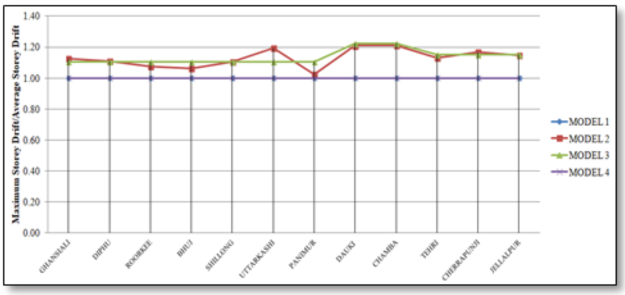

Chart -6: Torsional response

6.5 Maximum Inter Storey Drift

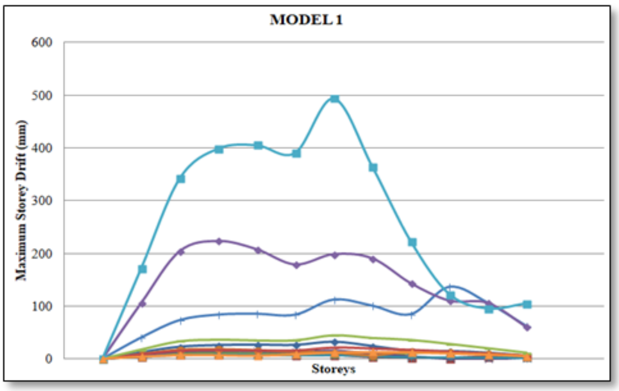

Chart -7: Storey drift of model 1

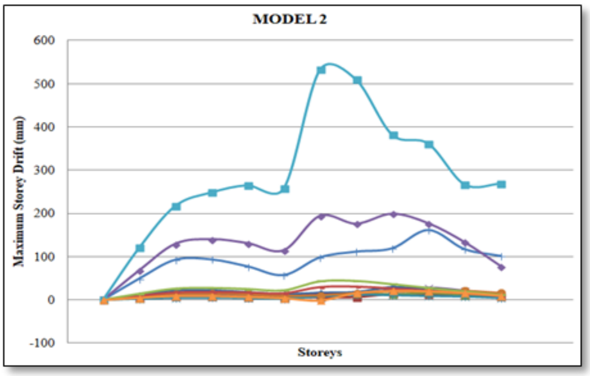

Chart -8: Storey drift of model 2

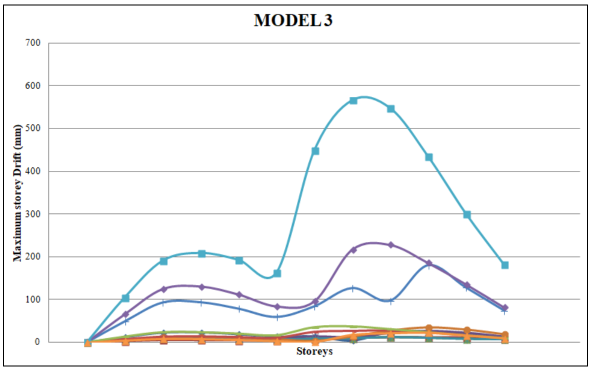

Chart -9: Storey drift of model 3

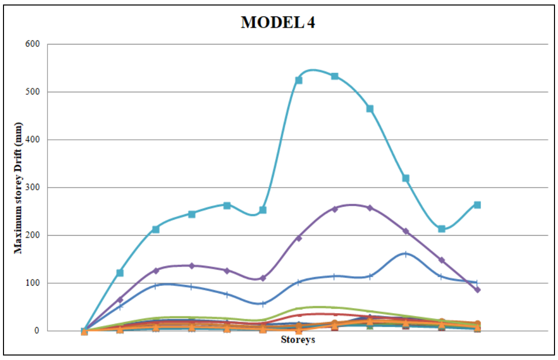

Chart -10: Storey drift of model 4

From chart 7, chart 8, chart9 & chart 10 it is clear that maximum Inter storey drift occurs for Model 3, since it has the highest stiffness irregularity. Maximum Inter Storey Drift is caused by CHERRAPUNJI, TEHRI and PANIMUR earthquakes. In regions of intermediate and high frequency content earthquakes, vertical irregular structure must be constructed avoiding soft storeys and column size reduction should be done gradually.

7. CONCLUSION

- From the analysis it is clear that Low Frequency Content Earthquakes don't have very much impact on the response of vertically irregular building
- Below are the things to consider when constructing a Vertically Irregular Building in regions of Intermediate Frequency Content and High Frequency Content Earthquakes
  1. The plan must be symmetric to avoid torsion
  2. Soft storeys must be avoided if maximum allowable drift exceeds
  3. Column size reduction must be done gradually in order to avoid high stiffness ratio
- The use of irregular structures in earthquake prone areas should be avoided if possible.
- But, if irregularities have to be introduced for any reason, they must be designed according to IS 1893 part 1:2016 and IS- 456: 2000, and joints should be made ductile as per IS 13920:1993

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