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Effect of Frequency Content on Seismic Performance of RC Frames by Time History Analysis

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Abstract: Earthquake causes the random ground motions in all direction, radiating from the epicenter. These ground motions causes structure to vibrate and induces inertia forces in them. In India majority of the existing reinforced concrete structures in this seismic region do not meet the current seismic code requirements as these are primarily designed for gravity loads only. The performance of the existing buildings can be improved to perform better during the earthquakes, it must be analyzed and designed as per the Indian seismic code IS 1893 (Part 1) 2002. The impact of the event is most traumatic because it affects large area, occurs all on a sudden and unpredictable. They can cause large scale loss of life and property. Hundreds of small earthquake occurs around the world every day. Some of them are so minor that humans cannot feel them, but seismographs and other sensitive machines can record them. Buildings being one of the prime structures for mankind, Therefore, it is important to control structural response of symmetric and asymmetric buildings when subjected to earthquake ground motion. Behaviour of structures under seismic loads is influenced by the most important dynamic characteristics of earthquake viz. Peak Ground Acceleration (PGA), Peak Ground Velocity (PGV. The strength of ground motion is measured by frequency content which is defined as the ratio of PGA and PGV. High and low frequency contents are having PGA/PGV ratio greater than 1.2 and less than 0.8 respectively. Whereas, intermediate frequency content, PGA/PGV ratio lies in between these values.
Keywords: E-TABS, Ground Motion, Frequency Content, Non-linear Time History, Story Displacement, Story Drift, Story Shear.

I. INTRODUCTION

Earthquakes are one of the major natural hazards and responsible for the lives of thousands of people and the emission of seismic waves damages the structural buildings, roads and non-structural elements. Buildings being one of the prime structures for mankind, therefore necessary study should be carried out to know the earthquake acting on the structure and what will be the response of the structure. The damage on the structural element mainly depends on the magnitude and epicentre of the earthquake, and also on the type of structure. To minimize the damages on structural buildings due to earthquake loads, the structure should be analyzed and designed as per BIS (Bureau of Indian Standards) codes of practice. Seismic response controlled structures are being accepted as a fresh concept that can respond to the needs of a society in the new century. Structural control is one area of current research that looks promising in attaining reduce structural vibrations during loadings such as earthquakes and strong winds. The present study is to know the effect of frequency content on seismic performance of RC asymmetric and symmetric buildings.

II. OBJECTIVE OF THE PROJECT

A. To develop G+9 storied symmetric and asymmetric RC model.
B. To carryout time history analysis as per guidelines of IS 1893 (Part 1, 2002) on G+9 storied symmetric and asymmetric RC model considering the data of Barkot India (1999),Uttarkashi India (1999),Panimur India(1987),Ahmedabad India(2001), Chamoli India (1999) ,Srinagar India (1991) earthquakes with varying frequency contents.
C. To obtain the seismic parameters such as storey displacement, storey drift ratio and storey shear.
D. To evaluate the effect of time history analyses and varying frequency contents on seismic performance of G+10 storied symmetric and asymmetric RC model.
E. Checking for the results which structure model is better to consider for the construction feature, after getting the analysis results.

III. METHODOLOGY

The methodology, which was conducted, is briefly described as below:

A. To develop G+9 storied symmetric and asymmetric RC model
B. To collect Ground motion record. Barkot India(1999), Uttarkashi India (1999), Panimur India(1987), Ahmedabad India (2001), Chamoli India (1999), Srinagar India (1991).
C. To perform Time history analysis using E-TABS software.
D. Building response such as story displacement, story drift and story shear are found due to the ground motions.
E. The results of the R.C buildings are compared with respect to the varying frequency content ground motions data.

Table 3.1.Parameters for the development of G+9 storied RC frame model

Sl. No.	Description	Remarks
1	Type of structure	Residential
2	Total dimension	18.7 mX34 m
3	Number of stories	9
4	Each storey height	3.0 m
5	Dimension of columns	200x600 mm
6	Dimension of beams	200x500 mm
7	Thickness of slab	200 mm
8	Wall thickness	200 mm
9	Density of concrete	25 kN/m3
10	Grade of concrete	M30
11	Grade of steel	HYSD 550
12	Live load	2 kN/m^2
13	Floor finish	1kN/m^2
14	Seismic zone	III,IV,V

Table3.2 Ground motion characteristics of selected earthquakes Frequency content

Classification	Station	PGA (g)	PGV (m/s)	PGA/PGV
High	Barkot India(1999)	0.01689	0.0083	2.03
Intermediate	Panimur India(1987)	0.0172	0.168	1.02
Low	Chamoli India(1999)	0.06228	0.0894	0..69
High	Uttarkashi India(1999)	0.02222	0.0158	1.4
Intermediate	Ahmedabad India(2001)	0.04095	0.0377	1.08
Low	Srinagar India(1991)	0.0494	0.327	0.15

IV. ANALYSIS AND RESULTS

The FEM based structural software is used for modelling and analysis of the building. The analysis is carried out using ETABS (2016) software.
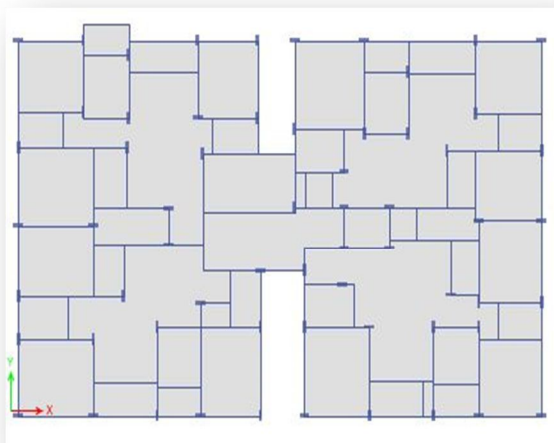

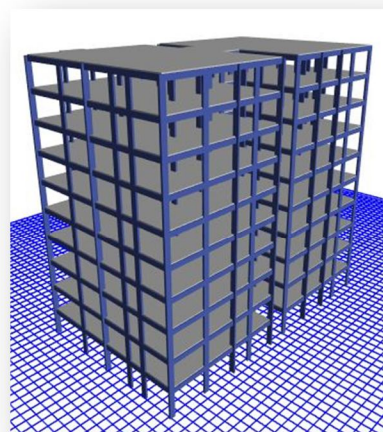Fig.1: Plan of G+9 storied RC bare frame model

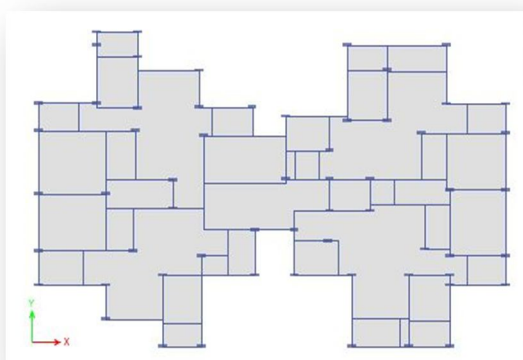Fig.2: 3D View of G+9 storied RC bare frame model

Fig.3: Plan of G+9 storied RC irregular model
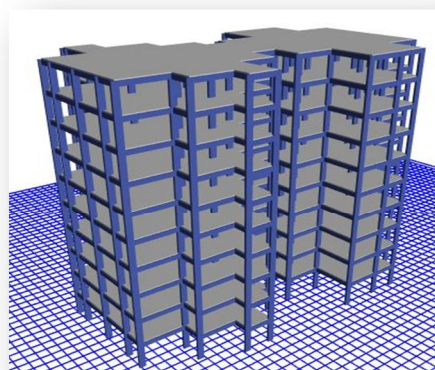

Fig.4: 3D View of G+9 storied RC irregular model

V. RESULTS

A. *Regular Structure*

Tables 4.1,4.2and4.3 and figure 5, 6 and 7 respectively show the maximum storey displacement (i.e. at top storey) in X and Y directions, obtained for the developed G+9 storied regular RC frame model by THA containing six earthquake data

1) *Story Displacement*

Table 4.1 Maximum story displacement in X and Y directions

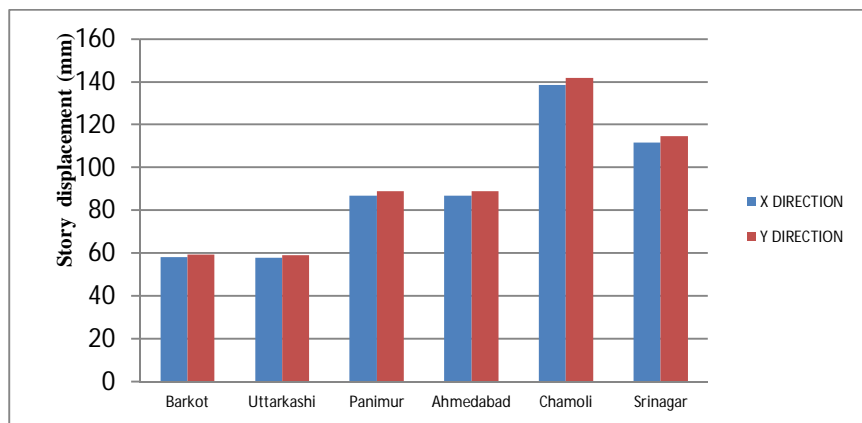| Model	X Dir (mm)	Y Dir (mm)
Barkot	57.926	59.242
Uttarkashi	57.701	59.022
Panimur	86.89	88.865
Ahmedabad	86.889	88.864
Chamoli	138.664	141.816
Srinagar	111.704	114.657

Fig.5: Maximum story displacement in X and Y directions

2) Story Drift

Table 4.2 Maximum story drift in X and Y directions

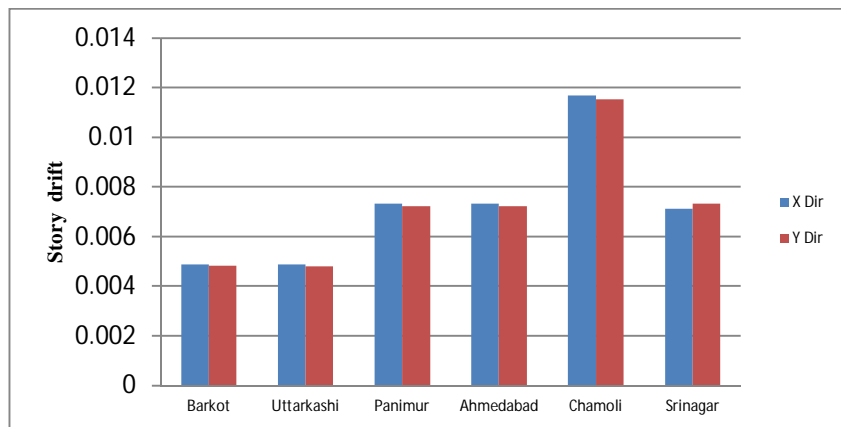| Model	**X Dir**	**Y Dir**
Barkot	0.004884	0.004812
Uttarkashi	0.004876	0.004811
Panimur	0.007325	0.007219
Ahmedabad	0.007325	0.007219
Chamoli	0.01169	0.01152
Srinagar	0.007115	0.007334

Fig.6: Maximum story drift in X and Y directions

3) Story Shear

Table 4.3 Maximum story shear in X and Y directions

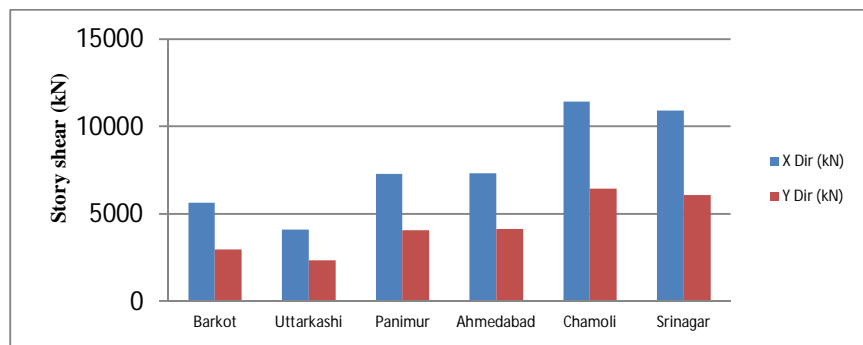| Model	X Dir (kN)	Y Dir (kN)
Barkot	5635.19	2976.46
Uttarkashi	4092.78	2336.05
Panimur	7278.33	4051.67
Ahmedabad	7320.89	4129.11
Chamoli	11438.90	6451.73
Srinagar	10917.49	6077.50

Fig.7: Maximum story shear in X and Y directions

B. Irregular Structure

Tables 4.4,4.5 and 4.6 and figure 8,9 and 10 respectively show the maximum storey displacement (i.e. at top storey) in X and Y directions, obtained for the developed G+9 storied irregular RC frame model by THA containing six earthquake data.

1) Story Displacement

Table 4.4 Maximum story displacement in X and Y directions

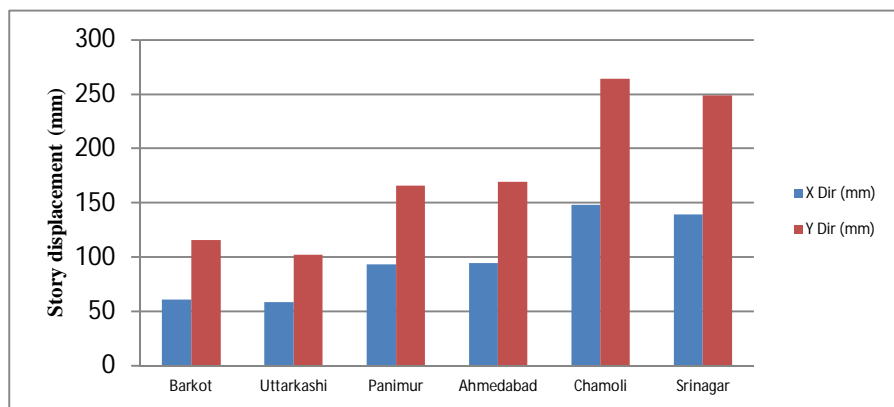| Model	X Dir (mm)	Y Dir (mm)
Barkot	60.63	115.33
Uttarkashi	58.43	102.074
Panimur	92.95	165.75
Ahmedabad	94.64	168.99
Chamoli	147.87	264.05
Srinagar	139.43	248.63

Fig.8: Maximum story displacement in X and Y directions

2) Story Drift

Table 4.5 Maximum story drift in X and Y directions

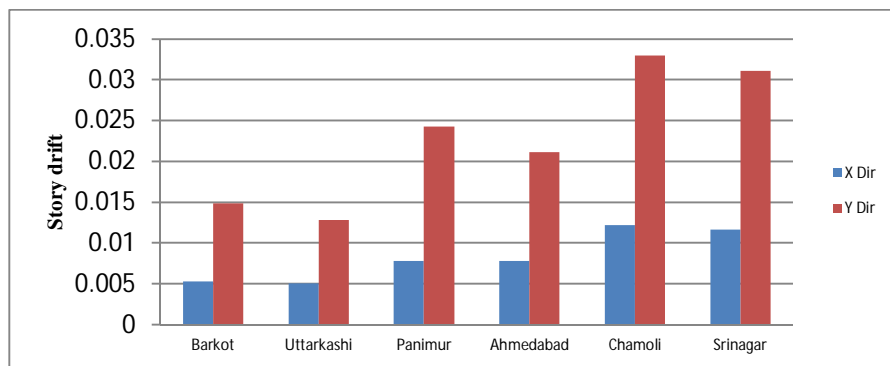| Model	X Dir	Y Dir
Barkot	0.005234	0.01483
Uttarkashi	0.00507	0.0128
Panimur	0.00127	0.00143
Ahmedabad	0.0078	0.0211
Chamoli	0.0122	0.033
Srinagar	0.0116	0.0311

Fig.9: Maximum story displacement in X and Y directions

3)   Story Shear

Table 4.6 Maximum story shear in X and Y directions

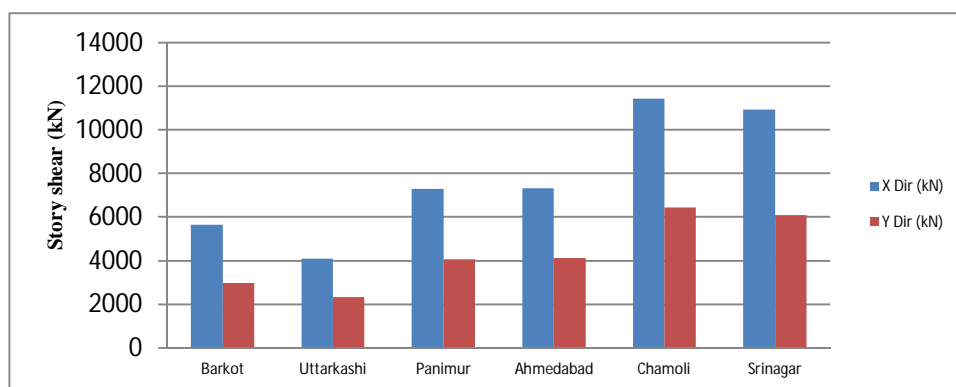| Model	X Dir (kN)	Y Dir (kN)
Barkot	5635.19	2976.46
Uttarkashi	4092.78	2336.05
Panimur	7278.33	4051.67
Ahmedabad	7320.89	4129.11
Chamoli	11438.90	6451.73
Srinagar	10917.49	6077.50

Fig.10: Maximum story displacement in X and Y directions

C.   Final Discussion

Tables 4.7,4.8 and 4.9 and figure 11,12 and 13 respectively show the maximum storey displacement (i.e. at top storey) obtained for the developed G+9 storied regular and irregula**r** RC frame model by THA containing six earthquake data.

1)   Story Displacement

Table 4.7 Maximum story displacement for regular and irregular structures

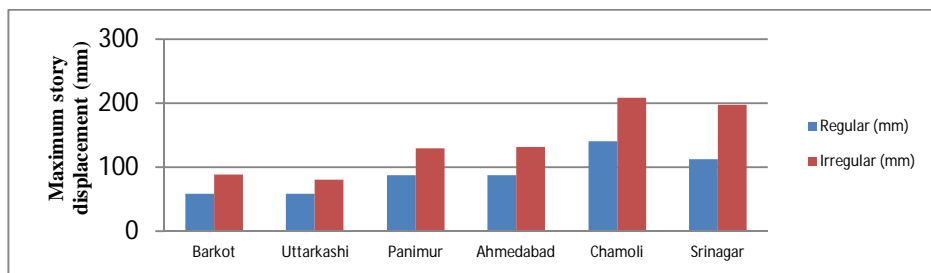| Model	Regular (mm)	Irregular (mm)
Barkot	58.584	87.98
Uttarkashi	58.3615	80.25
Panimur	87.877	129.35
Ahmedabad	87.8765	131.81
Chamoli	140.24	208.46
Srinagar	112.88	197.03

Fig.11: Maximum story displacement of regular and irregular structures

2) Story Drift

Table 4.2 Maximum story drift for regular and irregular structures

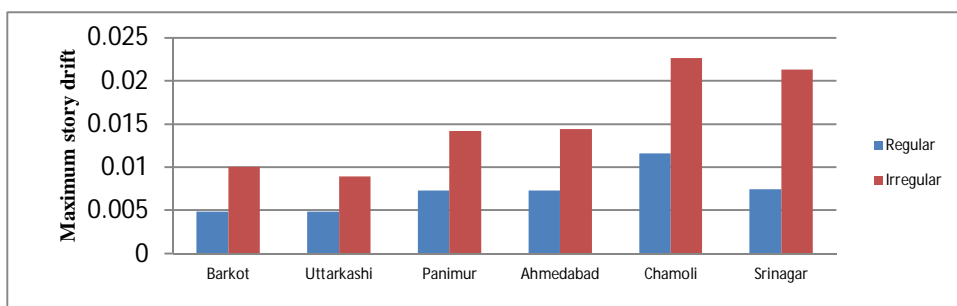| Model	Regular	Irregular
Barkot	0.004848	0.010
Uttarkashi	0.004843	0.0089
Panimur	0.007272	0.0142
Ahmedabad	0.007272	0.0144
Chamoli	0.011595	0.0226
Srinagar	0.007452	0.0213

Fig.13: Maximum story driftt of regular and irregular structures

3) Story Shear

Table 4.3 Maximum story shear for regular and irregular structures

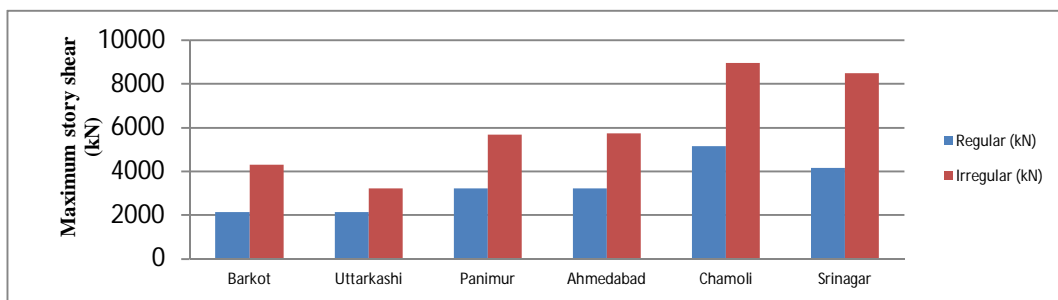| Model	Regular (kN)	Irregular (kN)
Barkot	2148.225	4305.82
Uttarkashi	2150.48	3214.41
Panimur	3222.375	5665
Ahmedabad	3222	5725
Chamoli	5142.78	8945.31
Srinagar	4169.79	8497.49

Fig.14: Maximum story shear of regular and irregular structures

VI. CONCLUSION

In the present study, G+9 storied RC residential, symmetrical and asymmetrical frame is modelled using ETABS software (Version 2016). Considering seismic zone III ,IV ,V of IS 1893 (Part 1, 2002), the developed model is subjected to Time History Analysis (THA) considering the data of Barkot (1999), Uttarkashi (1999) and Panimur (1987), Ahmedabad(2001), Chamoli(1999), Srinagar(1991) are carried out to study the seismic response of the model by determining seismic parameters such as storey displacement, storey drift ratio and storey shear. From the current study on effect of frequency content on seismic performance of RC frames, following conclusions are drawn.

A. Story displacement, story drift and story shear has significant effect for low frequency content (Chamoli an555d Srinagar),on both symmetrical and asymmetrical RC buildings than the high (Barkot and Uttarkashi) and medium frequency content (Panimur and Ahmedabad).

B. The displacement in Barkot is 33%,58.22% more than Panimur and Chamoli for symmetrical structure.

C. The drift in Barkot is 12.67%, 29.57% more than Panimur and Chamoli and the shear in Barkot is 50%, 58.22% more than Panimur and Chamoli.

D. The displacement in Uttarkashi is 50%, 58.38% more than Ahmedabad and Chamoli for asymmetrical structure.

E. The drift in Uttarkashi is 61.79,60.61% more than Ahmedabad and Chamoli and the shear in Uttarkashi is 78.10%, 64% more than Ahmedabad and Chamoli.

F. In both symmetry and asymmetry, chamoli (low frequency content) shows maximum values as compare to other locations.

G. Uttarkashi (high frequency content) shows well performance when compared to other locations in both symmetry and asymmetry.

H. Story displacement, story drift and story shear are minimum in Symmetrical structure, hence it is better to consider for the future construction work.

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