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Seismic Analysis of Building with Shear Wall on Sloping Ground

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***Abstract**:*

This study investigates the seismic performance of shear wall building on sloping ground. The main objective is to understand the behavior of the building on sloping ground for various positions of shear walls and to study the effectiveness of shear wall on sloping ground. The performance of building has been studied with the help of four mathematical models. Model one is of frame type structural system and other three models are of dual type (shear wall - frame interaction) structural system with three different positions of shear walls. Response spectrum analysis is carried out by using finite element software SAP 2000. The performance of building with respect to displacement, story drift and maximum forces in columns has been presented in this paper.

Keywords

Sloping ground, Shear wall, Position, Performance, Earthquake analysis, Effectiveness.

1. Introduction

Shear walls are one of the most efficient lateral force resisting elements in multistoried buildings. Many modern constructions use shear wall as main source for lateral force resistance, and can also be used for seismic rehabilitation of existing buildings. Since plastic hinges forms in the beams and not in the wall shear wall frame interaction system is more reliable. In addition, benefit of reducing lateral sway in the building under seismic loading can be available using shear wall.

The economic growth and rapid urbanization in hilly region has accelerated the real estate development and resulted in increase in population density in the hilly region enormously. Therefore, there is popular and pressing demand for the construction of multistory buildings in that region. A scarcity of plain ground in hilly area compels the construction activity on sloping ground. Now days due to increasing demand of space certain building will have to be constructed without disturbing the existing geological profile. The multistoried building situated on slopping ground can effectively reduce the cost of foundation. When shear walls are provided at a proper location in a building they can prove to be very efficient at the same time they can act as a partion wall. When the building is situated on a sloping ground short column effect arise in a building. When these columns are not properly designed for such a huge force the building can suffer a considerable damage due to earthquake. The building on sloping ground is unsymmetrical about one of the principle axis and hence location of shear wall becomes crucial. It is important to select a position of shear wall that will offer the best resistance against the lateral forces.

2. Building Discription

Building considered for a study purpose is a G + 7 residential building situated in seismic zone IV. Structural plan of the building is shown in fig. 1, and other analysis data is as shown in table 1.

Table I: Analysis Data

Response reduction factor	5
Response reduction factor	1
Importance factor	Hard
Soil condition	17.5mX17.5m
Plan size	1.5m
Depth of foundation	200mm
Thickness of shear wall	120mm
Depth of slab	3.1m
Floor to floor height	500X500mm
Size of column	300X450mm

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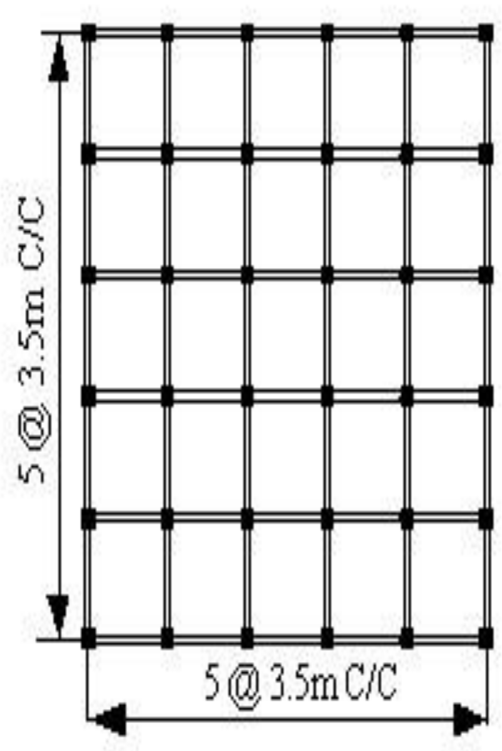
Size of beam	Fe 415
Grade of steel	M 20
Grade of concrete	3 KN/m^2
Live load	1:3 (18'26")
Slope of ground	5
Grade of steel	1
Grade of concrete	Hard
Live load	17.5mX17.5m
Slope of ground	1.5m

3. Modelling And Analysis

Building is modelled by using finite element software SAP 2000. Beams and columns are modelled as two nodded beam elements with six DOF at each node. Slab and shear wall is modelled by using shell element. Walls are modelled by equivalent strut approach. The thickness of strut is same as thickness of brick infill wall and only width of the strut is derived. Four models for the building are prepared as shown in figure 1 and 2. Model one is of frame type structural system and other three models are of shear wall frame interaction system. Total four shear walls are provided two on sloping



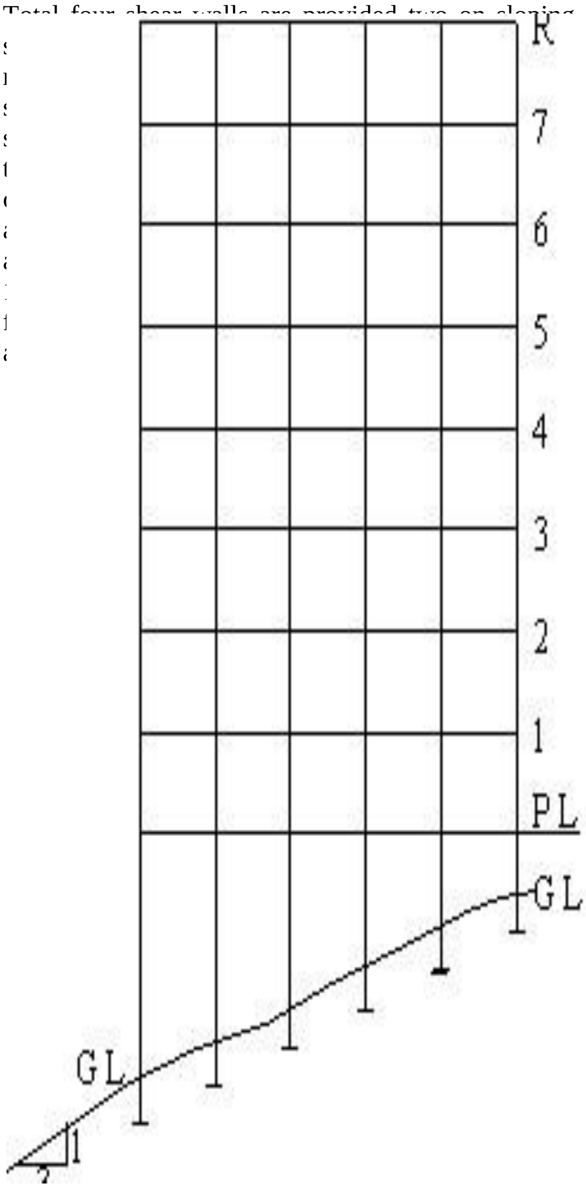


Fig. 1: Plan of building **Fig. 2: Elevation of building**

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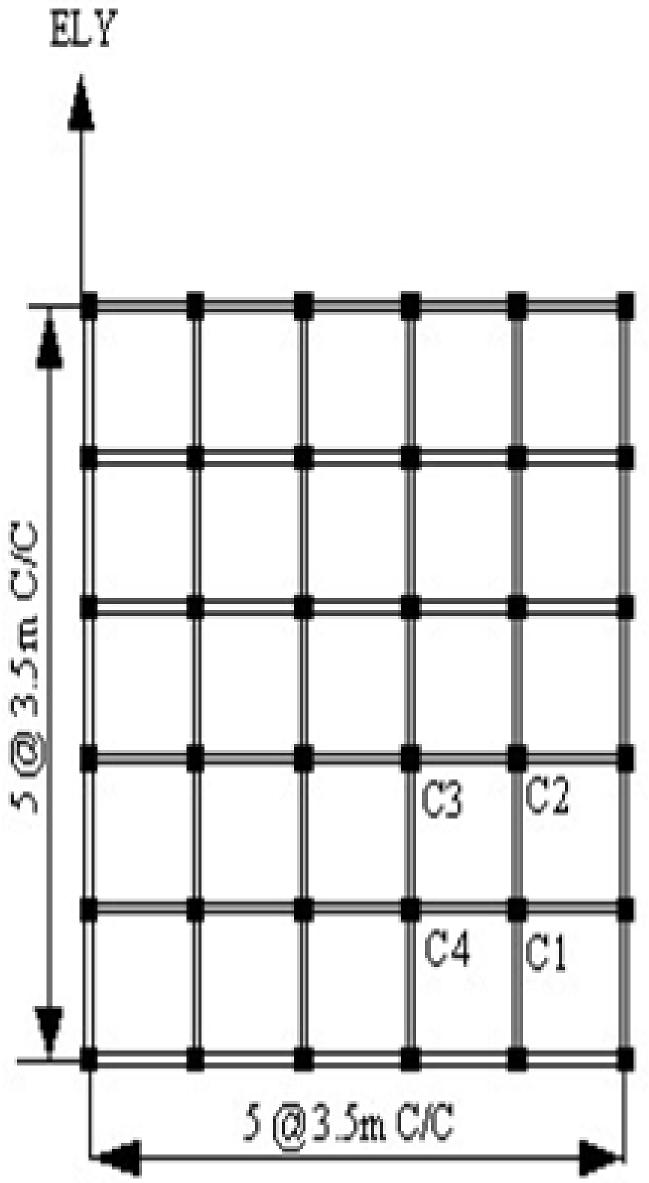


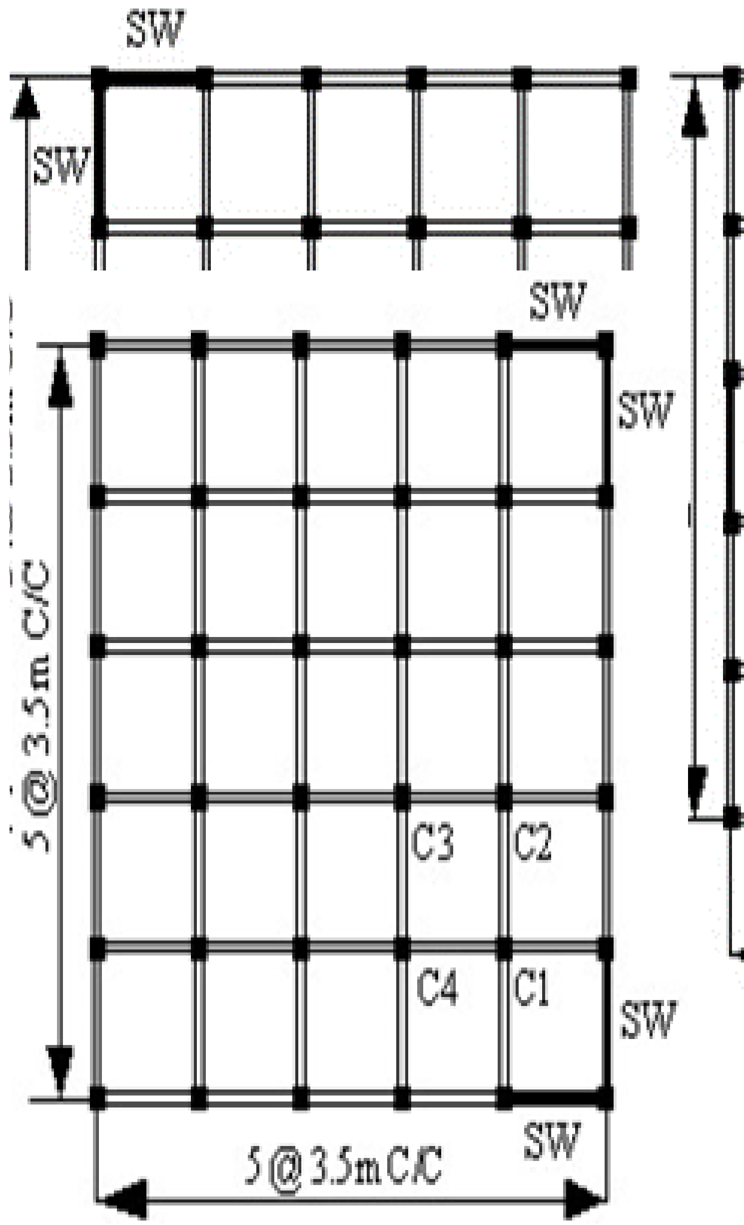
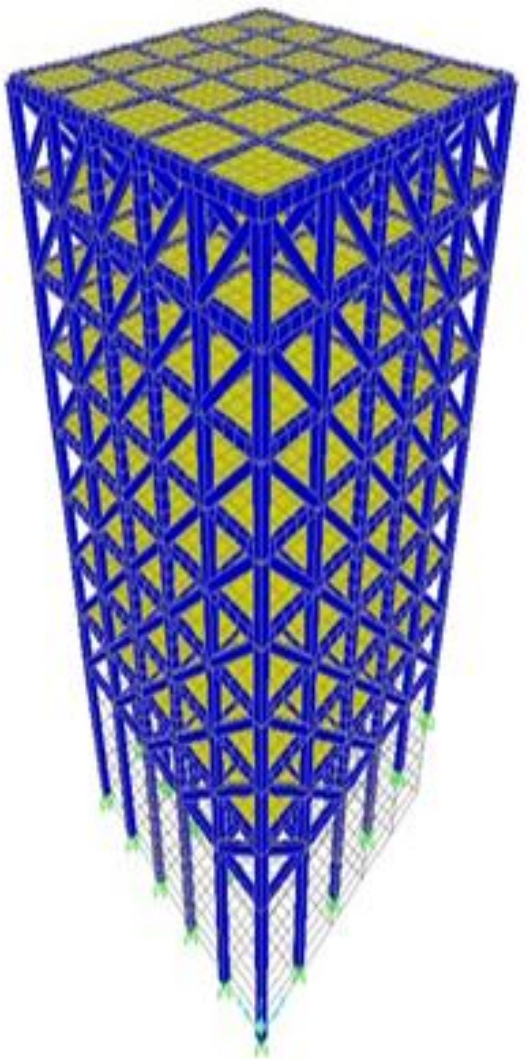


Fig. 3: Model I **Fig. 4: Model II**



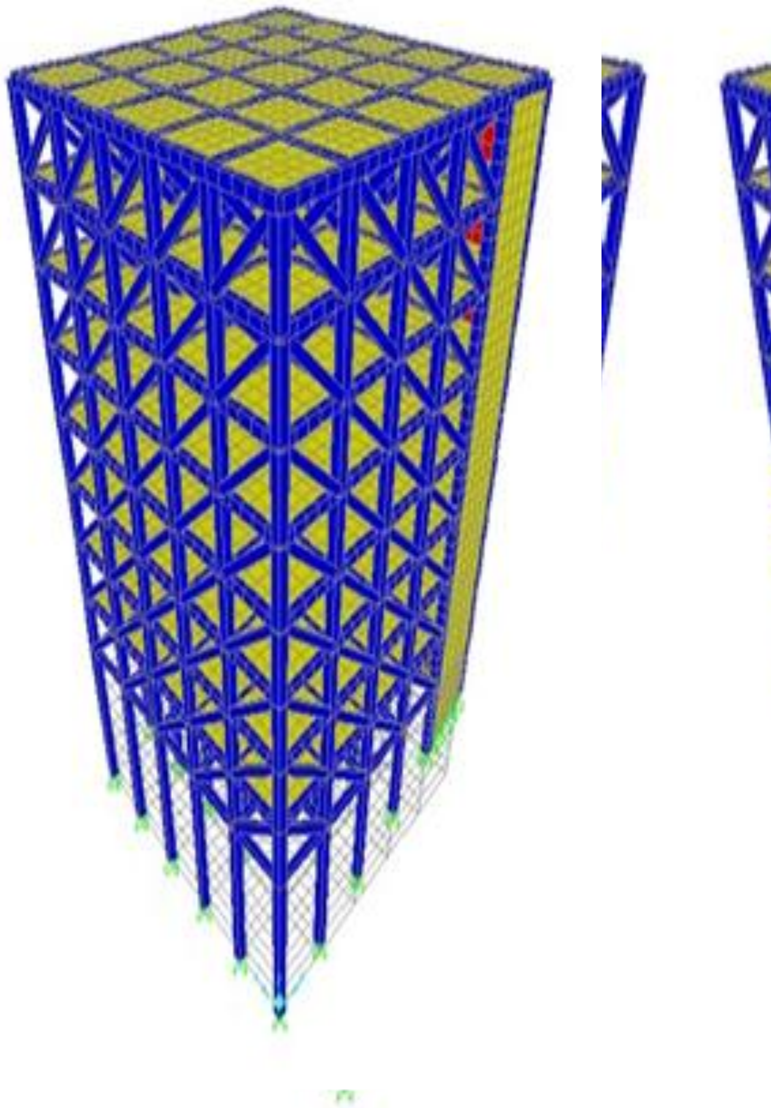


Fig. 7: Mathematical Model I

Fig. 8: Mathematical Model II

Fig. 9: Mathematical Model III

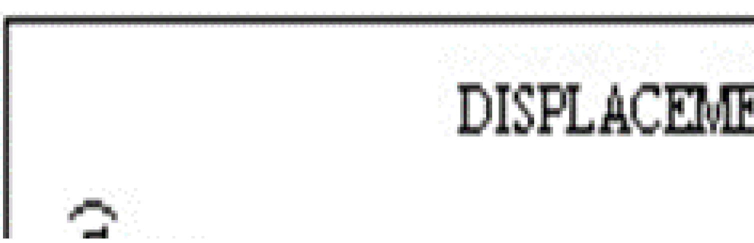
Fig. 10: Mathematical Model IV

4. Results And Discussion

Results of response spectrum analysis as per IS 1893:2002 (Part I) on the above four models with respect to displacement, storey drift and maximum forces in columns C1, C2, C3 and C4 are shown below. Percentage reduction in bending moment, shear force and torsional forces as compared with frame type structural system is also represented.

A) Displacement

Displacement profile for above models along both the principle directions are shown in fig. 11 and 12. In the direction of ground slope displacement is found to be minimum in model III (Shear wall provided towards long column side). The roof displacement for model III is reduced up to 43.62% as compared with model I and about 43.38% as compared with model II. In other direction where ground profile is flat Model IV gives minimum displacement. It is reduced by 33.23% as compared with model I and about 14.7% as compared with model III.



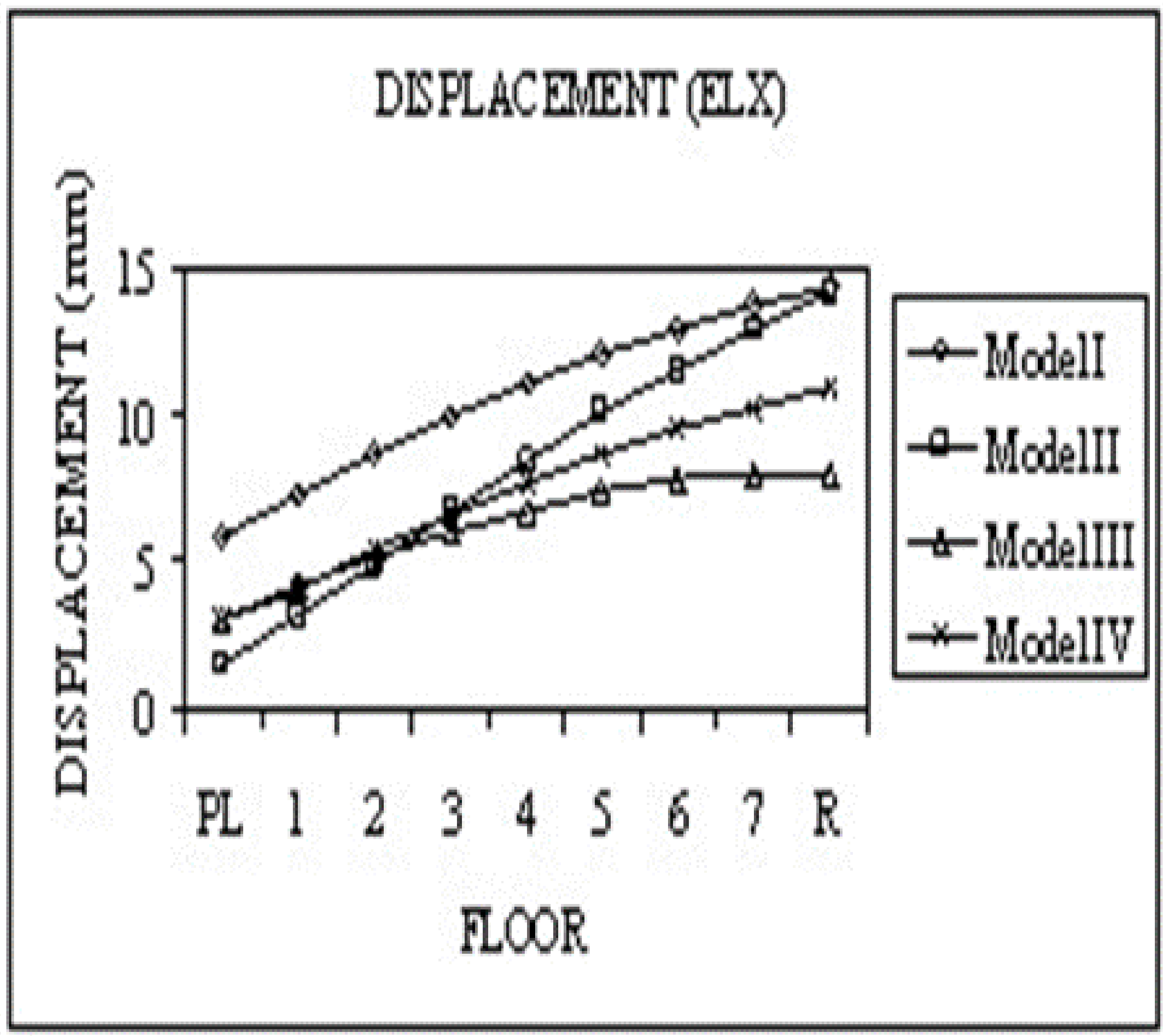


Fig. 11: Displacement along X

wall frame interaction system is more than frame type structural system along other side of building this may be because of stiffness irregularity. On sloping side top storey drift for model III is reduced up to 94.615% as compared with model II.

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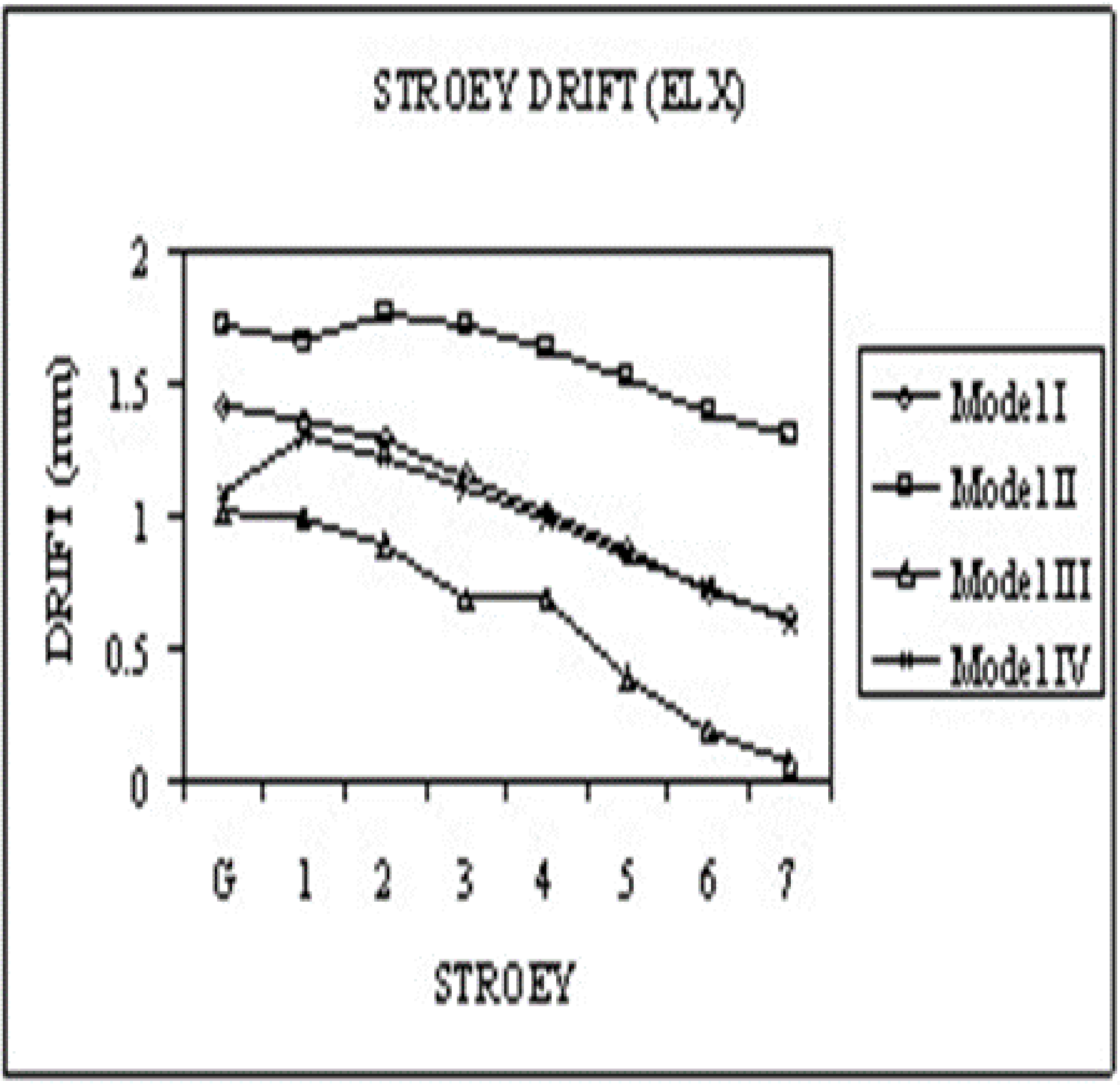

Fig. 13: Storey drift Along X

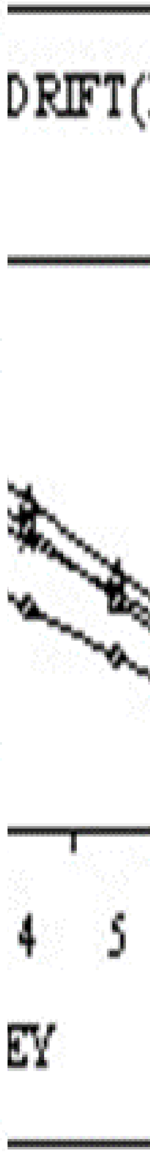

Fig. 14: Storey drift Along Y

C) Maximum forces

Comparisons of forces for columns are shown in figure 15 to 21 below. Percentage reduction in bending moment and shear force is represented in figure 16 to 19. Shear wall provided towards shorter column side (model II) gives minimum shear force and bending moment as compared with other two positions but torsional forces on column is found to be maximum for model II (shear wall towards shorter column). Shear force and bending moment is found to be maximum for model III (Shear walls on longer column side). Percentage reduction in shear force and bending moment for shear wall fame interaction system as compared with frame type structural system is represented in figure 22 and 23.

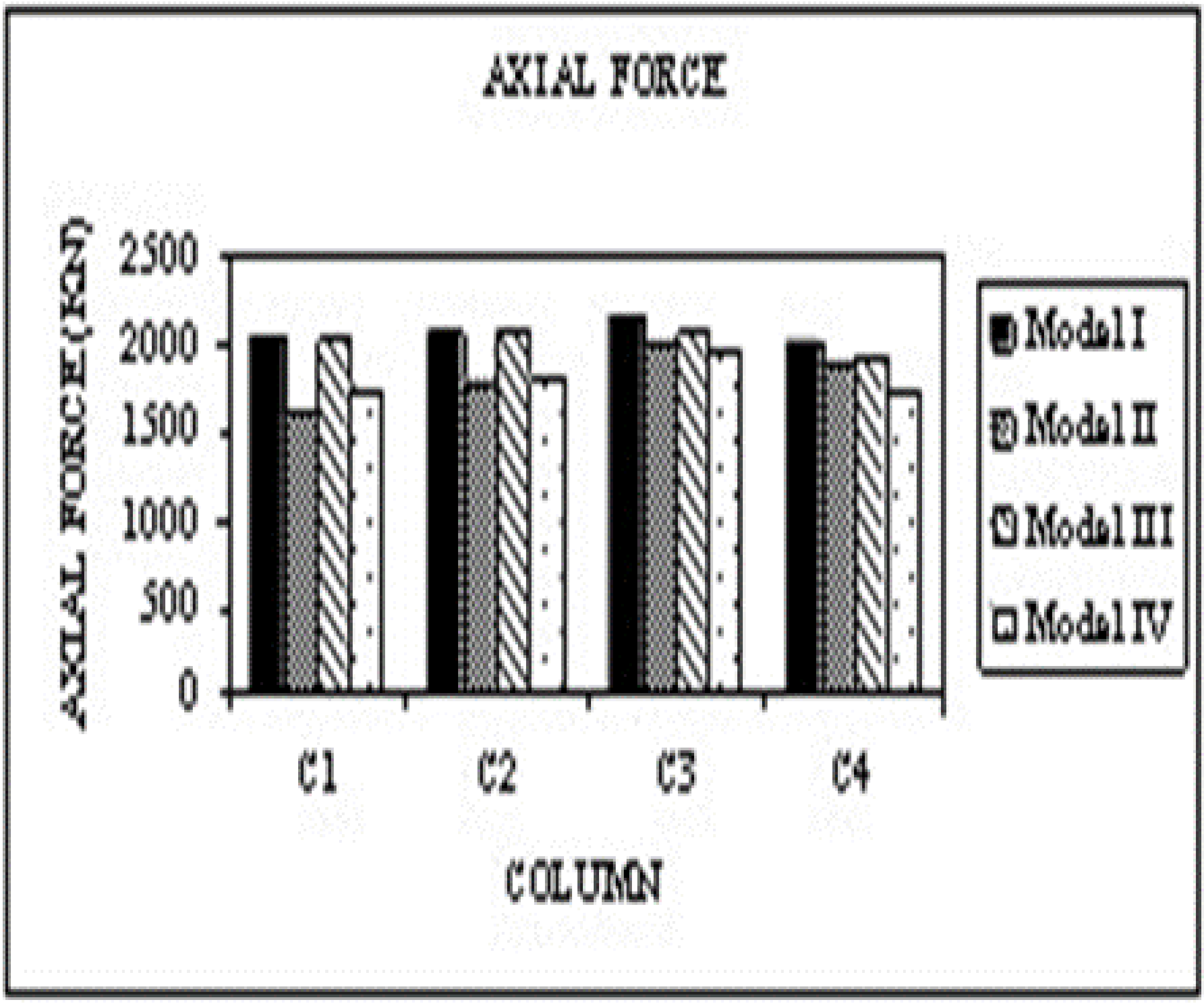

Fig. 15: Axial Force

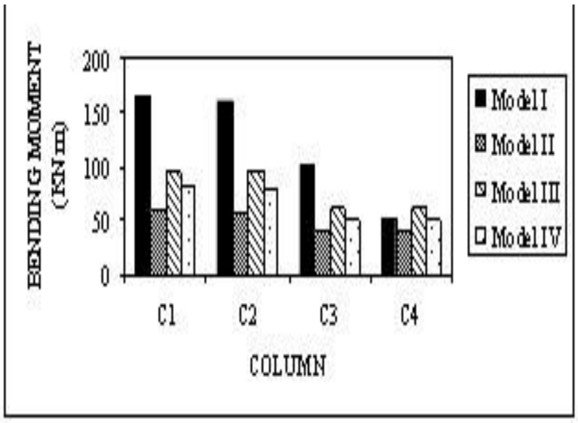

Fig. 18: Bending Moment along X

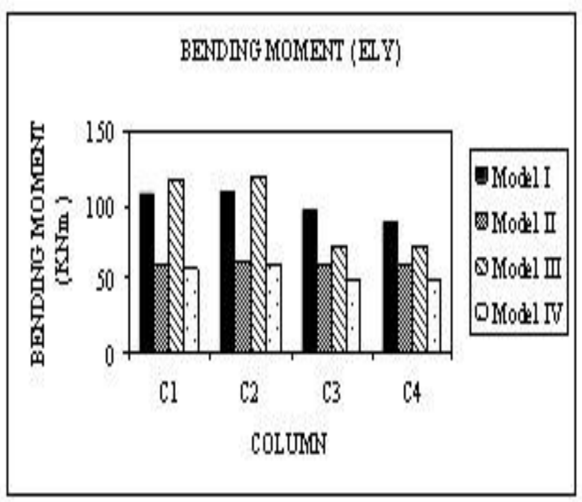

Fig. 19: Bending Moment along Y

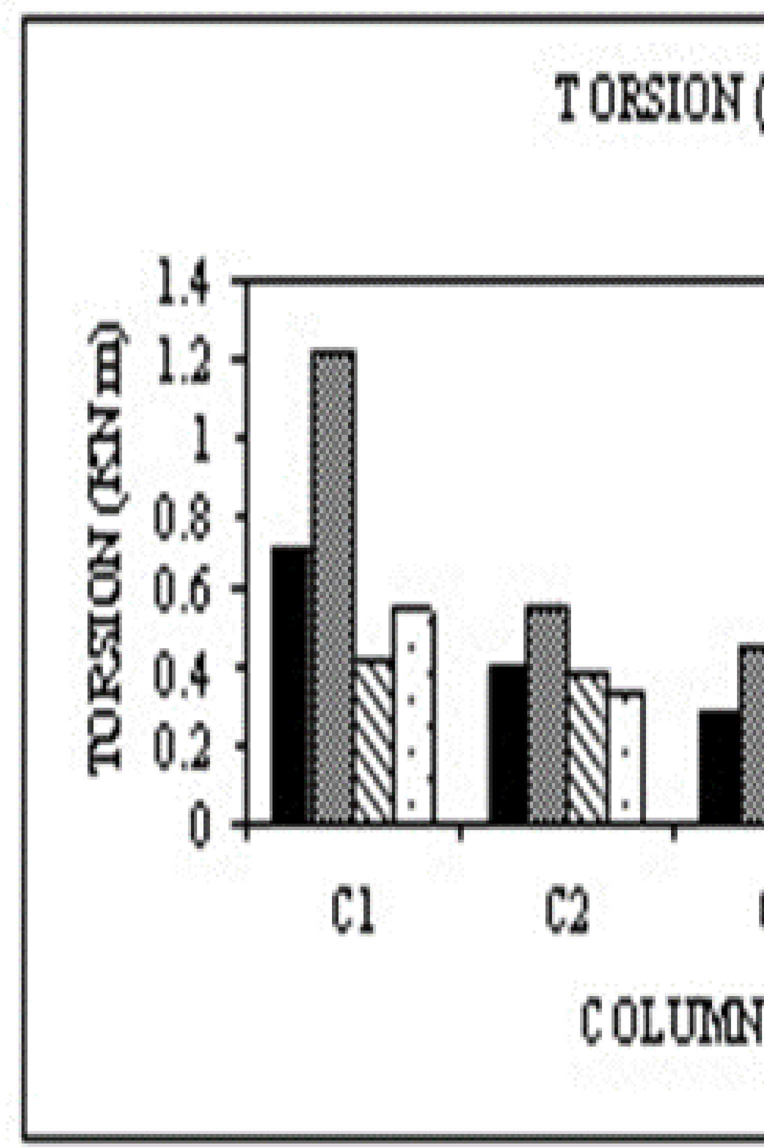

Fig. 20: Torsion along X

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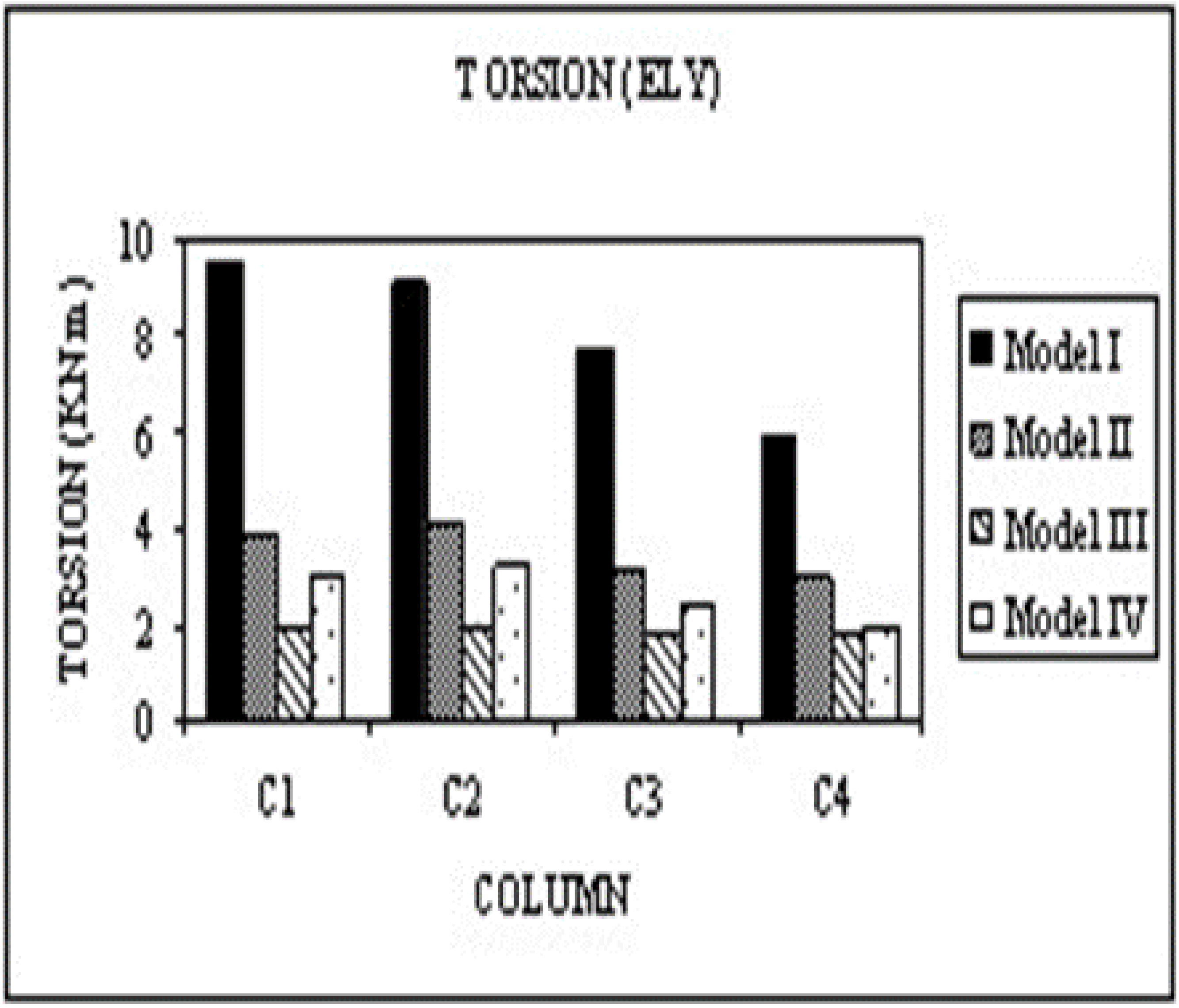

Fig. 21: Torsion along Y

Fig. 22: Percentage reduction in BM along X

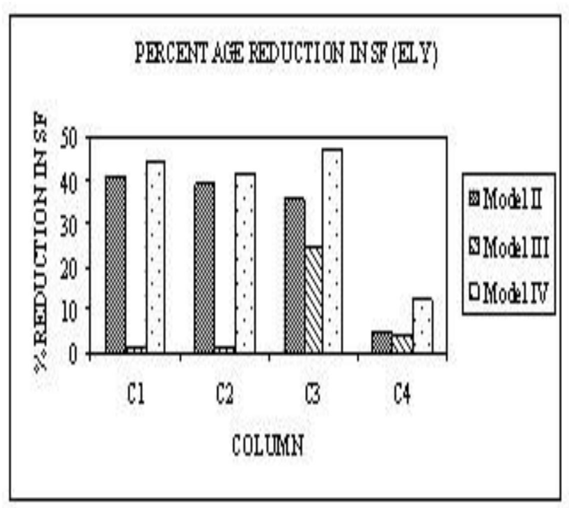

Fig. 23: Percentage reduction in BM along Y

Time period and frequency of vibration

Time period and frequency of vibration for the above four models are shown in table II, III and comparison of tine period is represented in figure 24.

Table II: Time Period and Frequency of Vibration in Model I and Model II

Mode	Model I		Model II	
	Time period (Sec)	Frequency (Cyc/sec)	Time period (Sec)	Frequency (Cyc/sec)
1	1.056	0.9467	0.632	1.581
2	0.808	1.2366	0.492	2.031
3	0.614	1.6286	0.320	3.120
4	0.227	4.3939	0.185	5.403
5	0.222	4.4991	0.164	6.078
6	0.158	6.3233	0.107	9.327
7	0.113	8.8119	0.104	9.607
8	0.103	9.6524	0.092	10.76
9	0.102	9.7163	0.088	11.24
10	0.089	11.209	0.084	11.85
11	0.088	11.357	0.081	12.32
12	0.084	11.844	0.068	14.59

Table III: Time Period and Frequency of Vibration in Model III Model IV

Mode	Model III		Model IV	
	Time period (Sec)	Frequency (Cyc/sec)	Time period (Sec)	Frequency (Cyc/sec)
1	0.6434	1.5542	0.5760	1.736
2	0.5993	1.6686	0.5535	1.8066
3	0.3876	2.5798	0.3678	2.7183
4	0.1904	5.2502	0.1766	5.66
5	0.1779	5.6209	0.1727	5.7878
6	0.115	8.6843	0.1137	8.7895
7	0.1062	9.4087	0.1025	9.7483
8	0.0941	10.623	0.0927	10.786
9	0.0901	11.089	0.0894	11.182
10	0.083	11.975	0.085	11.758
11	0.082	12.191	0.080	12.474
12	0.073	13.574	0.079	12.643

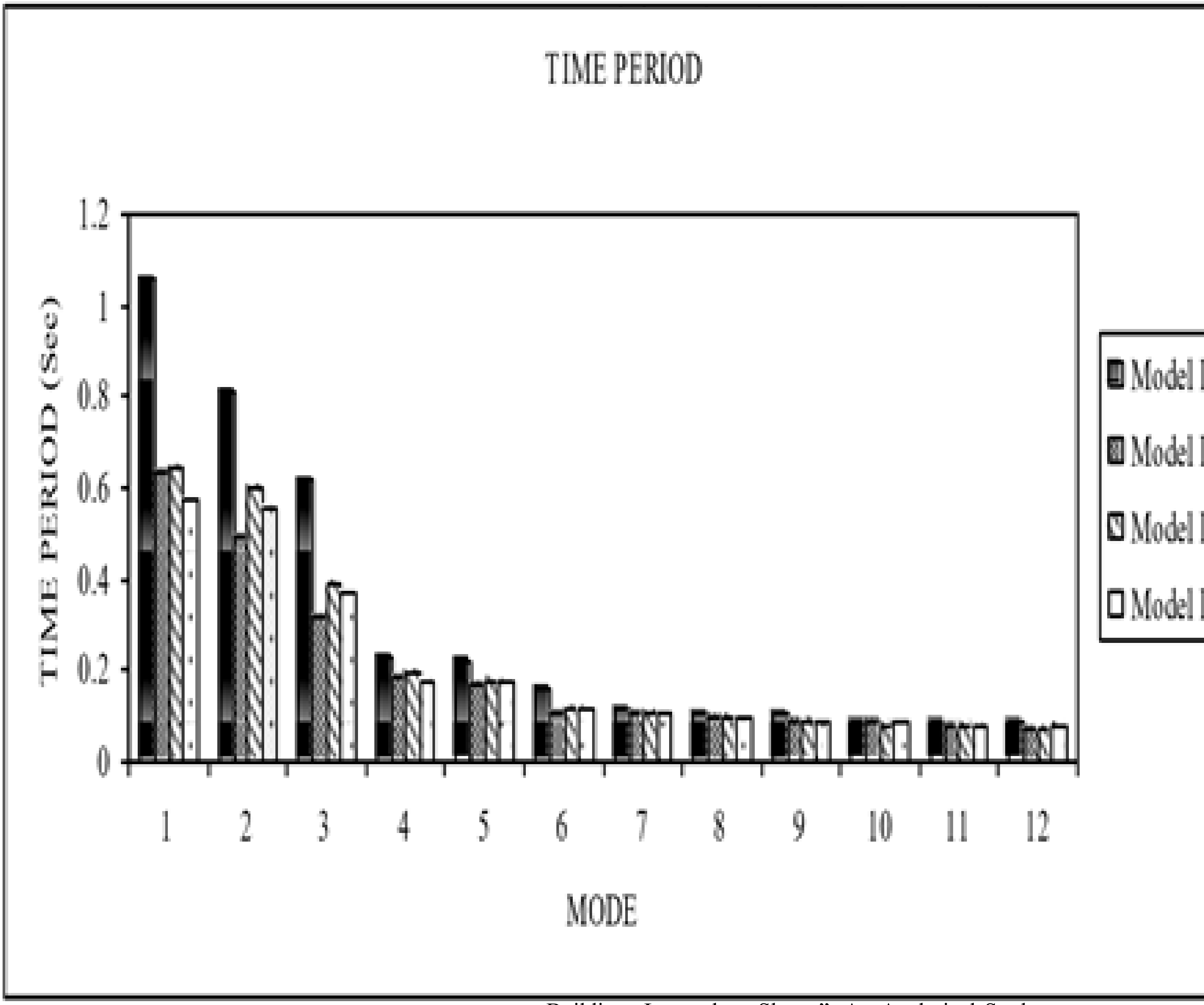

Figure 24: Time period of vibration

5. Conclusion

For the buildings on the sloping ground location of shear walls are very important for resisting earthquake forces.

The straight shape (or rectangular) shear walls configuration proves to be better among all configurations for resisting the lateral displacement.

Short columns are the most critical member for the building on sloping ground. To have a good control over the forces such as shear force and bending moment it is preferable to locate the shear wall towards the shorter column side.

Displacement and storey drift along sloping side is found to be minimum for model II where as on other side model III gives minimum displacement and drift. Good control over the displacement and

Buildings Located on Slopes", An Analytical Study and Some Observations from Sikkim Earthquake of September 18, 2011. 15th World Conference on Earthquake Engineering Journal, (2012).

S.M. Nagargoje and K.S. Sable, "Seismic performance of multistoried building on sloping ground", Elixir International Journal, (2012).

Dr. S. A. Halkude et al, "Seismic Analysis of Buildings Resting on Sloping Ground with Varying Number of Bays and Hill Slopes", International Journal of Engineering Research and Technology ISSN:2278-0181, (2013).

S. K. Jain and C. V. R. Murthy, "Seismic design of reinforced concrete buildings", Indian Institute of Technology, Kanpur, (1999).

Dr. S. M. A. Kazimi, "Analysis of Shear walled Buildings", Tor Steel Research Foundation in India, (1976).

Prashant D, Dr. Jagadish Kori G, "Seismic Response of one-way slope RC frame building with soft storey", International Journal of Emerging Trends in Engineering and Development, (2013).