iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** VIII **Month of publication:** August 2020

DOI: https://doi.org/10.22214/ijraset.2020.31152

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue VIII Aug 2020- Available at www.ijraset.com

Comparative Study of Braced RC Building Resting on various Angle of Sloping to Horizontal Ground

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Abstract: ***The structures situated in sloping areas are subjected to more affect by seismic activity with the structures that are situated in level locales. Structures on slants vary from different structures since they are unpredictable both vertically and horizontally consequently torsionally coupled and are vulnerable to serious harm when exposed to seismic activity. In present study, the behavior of G+11 stories RC building with Unbraced and Braced configuration is analyzed for Response Spectrum Analysis with different slope angles i.e., 0°, 10°, 20° and 30° using structural analysis tool ETABS 16. By performing Response Spectrum analysis have been carried out as per IS: 1893 (part 1): 2002. The results were obtained in the form of top storey displacement, maximum story Drift Ratio, Fundamental time period of first 12 modes and base shear. It observed that the fundamental time period of structure are decreasing due to increasing of angle of sloping. And the analyses showed that for construction of the building on sloping ground the bracing building configuration is suitable.***
Keyword: Sloping Area, Unbraced and Braced Configuration, Displacement, Drift Ratio and Base shear.

I. INTRODUCTION

Multistoried R.C. framed structures are getting trend in sloppy regions due to increment in land cost and under unavoidable conditions because of lack of land in urban area. Therefore, a considerable lot of them are developed on sloping areas. Mixes of step back and setback structures are additionally normal on hilly slope. At the area of setback stress focus is normal when the structure is oppressed to seismic vibration. These are commonly not balanced because of difficulty as well as step back and result into serious torsion under a quake excitation. Current construction standard proposes point by point dynamic investigation for these sorts of structures. Structures in uneven area are irregular and asymmetric, in this manner are exposed to extreme torsion notwithstanding horizontal forces under the activity of seismic vibration. Numerous structures on slope slants are upheld by sections of various statures. The shorter segments drawn in more forces as the stiffness of the short sections is more and experience harm when exposed to seismic tremors. Structures in uneven zones are exposed to horizontal earth pressure at different levels moreover to other ordinary loads as indicated on expanding on level grounds. Building loads transmitted at the establishment level to an incline make issue of slant shakiness and may result into breakdown of the structure. The dirt profile is non uniform on the uneven slants and result into absolute breakdown of the structure. The bearing limit, union, point of inward grinding, and so forth may be distinctive at various levels. It might result into inconsistent settlement of establishments and nearby disappointment of the slope.

II. SEISMIC ANALYSIS & BEHAVIOR OF BUILDING ON SLOPE

Structural analysis characterize as the arrangement of Standards rules and science required to examine and predicts the conduct of structures. Basic examination can be seen all the more uniquely as a strategy to drive the building configuration process or demonstrate the sufficiency of a structure without a dependence on directly testing it. To perform an exact analysis a structural engineer must decide such data as basic loads, geometry, support conditions, and materials properties. The consequences of such an investigation commonly incorporate help responses, stresses and displacements. This data is then compares with standards that indicates the condition of failure.

The aim of design is the accomplishment of an adequate probably that structures being planned will perform satisfactorily during their expected life. With a suitable level of safety, they should support all the loads and deformations of typical development and utilize and have sufficient strength and satisfactory protection from the impacts of seismic and wind. Structure and structural components will regularly be designed by Limit State Method. Record should be taken of acknowledged speculations, test and experience and the need to structure for durability. Configuration, including design for durability, development and use in administration should be considered in general. The realization of design objectives requires compliance with obviously defined standards for materials, production, workmanship and furthermore support and utilization of structure in administration.

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The structural design of the building is needy upon the base necessities as recommended in the Indian Standard Codes. The base requirements relating to the structural safety of structures are being secured by method of setting down minimum design loads which have to be assumed for dead loads, imposed loads, and other external loads, the structure would be required to bear. Severe adjustment to stacking measures suggested in this code, it is trusted, won't just guarantee the basic safety of the structures which are being designed.

III. MODELING AND ANALYSIS

In present research study, the reinforced cement concrete braced and un-braced building of different symmetrical in plan area 750m^2 of G+11 Storied of 3.3 m each are Modeled with angle of sloping 0 degree, angle of sloping 10 degree, angle of sloping 20 degree and angle of sloping 30 degree respectively as shown in figures. The linear Static and Response Spectrum analyses are done on these R.C.C. building models using IS 456:2000 and IS 1893:2002 with the help of ETABS 2016 Software.

Table 01 – Different model

Model -1	Building at Plane Ground without Bracing
Model -2	Building Resting at 10 Degree Sloping Ground without Bracing
Model -3	Building Resting at 20 Degree Sloping Ground without Bracing
Model -4	Building Resting at 30 Degree Sloping Ground without Bracing
Model -5	Building at Plane Ground with Bracing
Model -6	Building Resting at 10 Degree Sloping Ground with Bracing
Model -7	Building Resting at 20 Degree Sloping Ground with Bracing
Model -8	Building Resting at 30 Degree Sloping Ground with Bracing

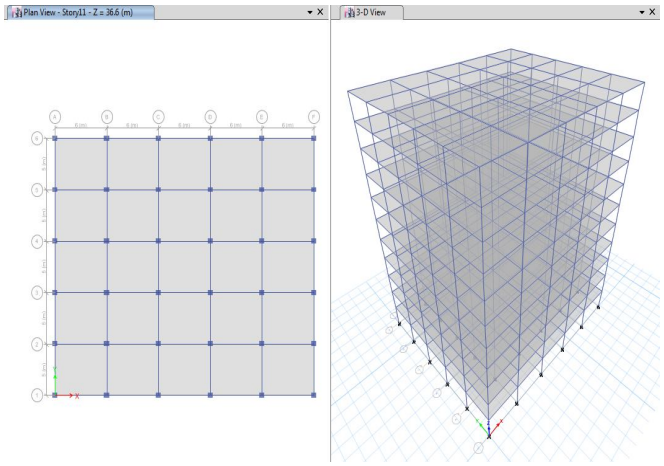

Figure 1 - Plan and 3D View of unbraced Building Model at 0 degree angle of sloping

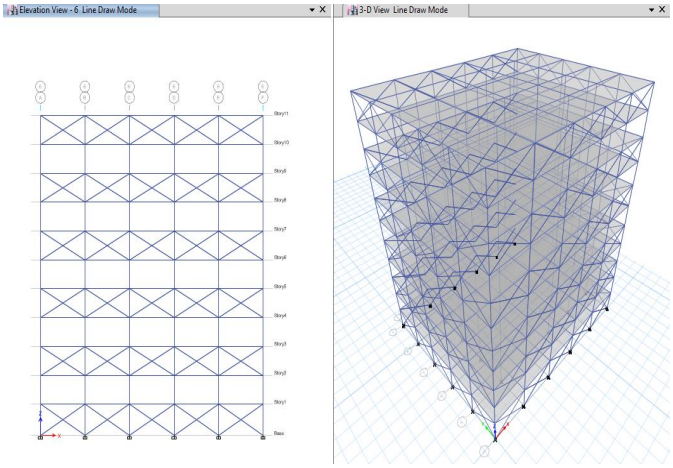

Figure 2 - Elevation and 3D View of braced Building Model at 0 degree angle of slopin

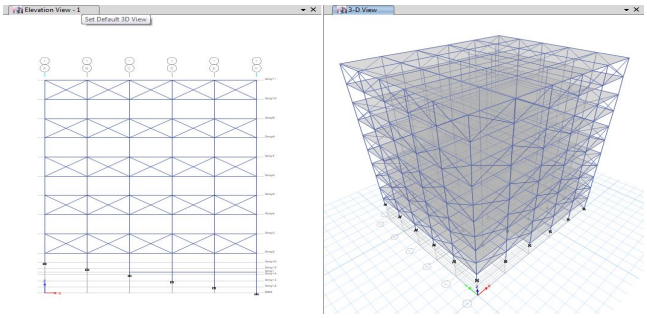

Figure 3 - Elevation and 3D View of braced Building Model at 20 degree angle of sloping

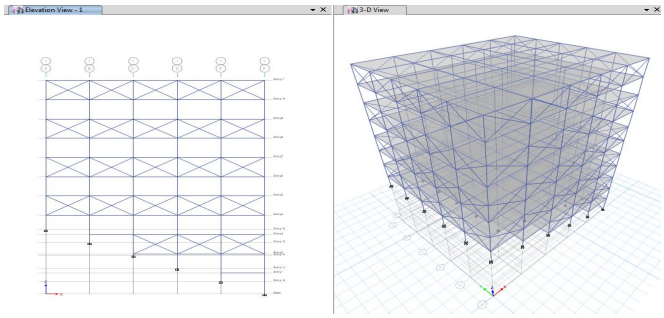

Figure 4 - Elevation and 3D View of braced Building Model at 30 degree angle of sloping

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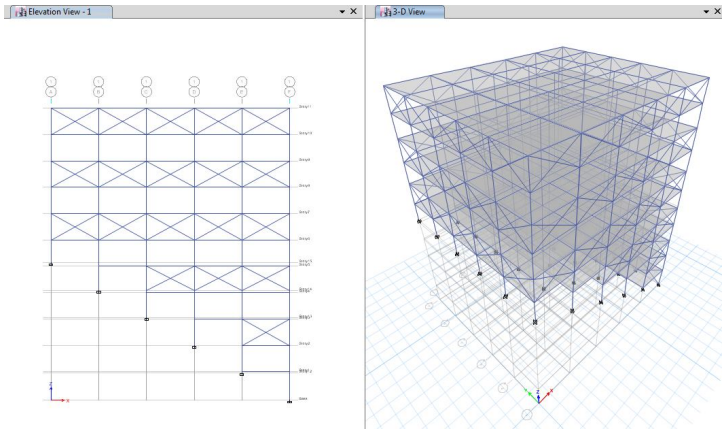

Figure 5 - Elevation and 3D View of braced Building Model at 30 degree angle of sloping

The general specification used in building for analysis shown in table 2.

Table 02 – Specification details

GENERAL PROPERTIES	
SIZE OF COLUMN	500mmX500mm
SIZE OF BEAM	300mmX500mm
SIZE OF BRACING	250x250
THICKNESS OF SLAB	125mm
MATERIAL PROPERTIES	
GRADE OF CONCRETE	M-30
GRADE OF STEEL	HYSD-500

The model given above are static analysis under earthquake for zone IV, have the importance factor 1.0 with response reduction factor 5 for RC frame building. And Response spectrum method of analysis shall be performed using the design spectrum specified as per IS 1893 (Part I): 2016. For the zone IV (one factor value is taken 0.24), medium type soil and special moment resisting frame (R = 5) the response spectrum graph are given as-

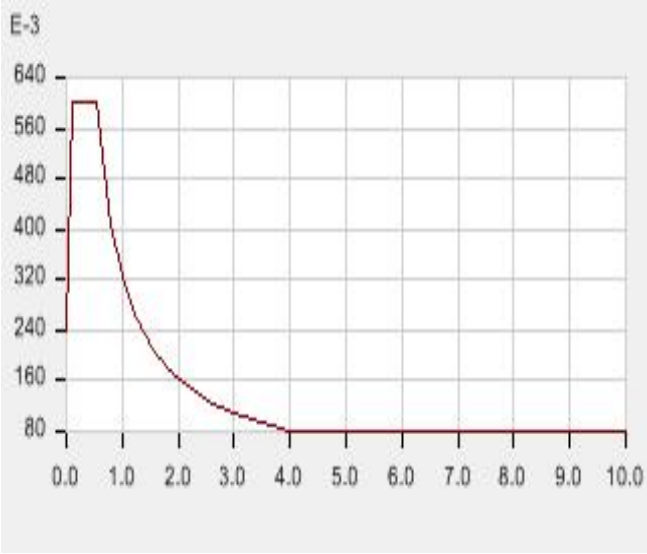

Figure 6 - Response Spectrum function as per IS 1893 (Part 1): 2002

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IV. RESULT AND DISCUSSION

The results free vibrational analysis, displacements and drift ratio due to static analysis, displacements and drift ratio due to response spectrum analysis and displacements and drifts from critical load combinations (1.5 DL + 1.5 EQX, 1.5 DL + 1.5 EQX, 1.5 DL +1.5 RSX, 1.5 DL+ 1.5 RSY) are compared for both braced and unbraced building model using various angle of sloping (0 degree,10 degree, 20 degree and 30 degree) in X and Y dictions.

A. Model Participation Time Period

Modal analysis is done for dynamic properties of building structure is generally depend on allover dimensions (length, width and height of building). It is used to determine the dynamic reaction of the structure during excitation.

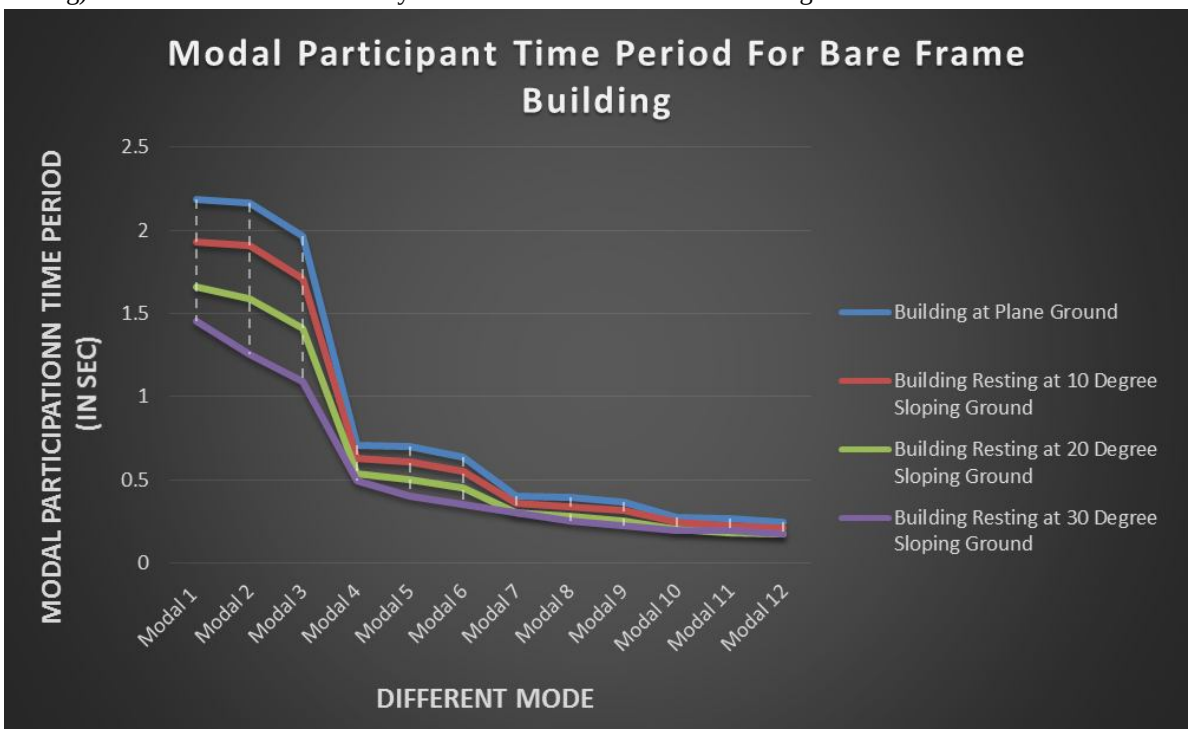

Figure 7 – Model Participation Time Period for different Unbraced Building

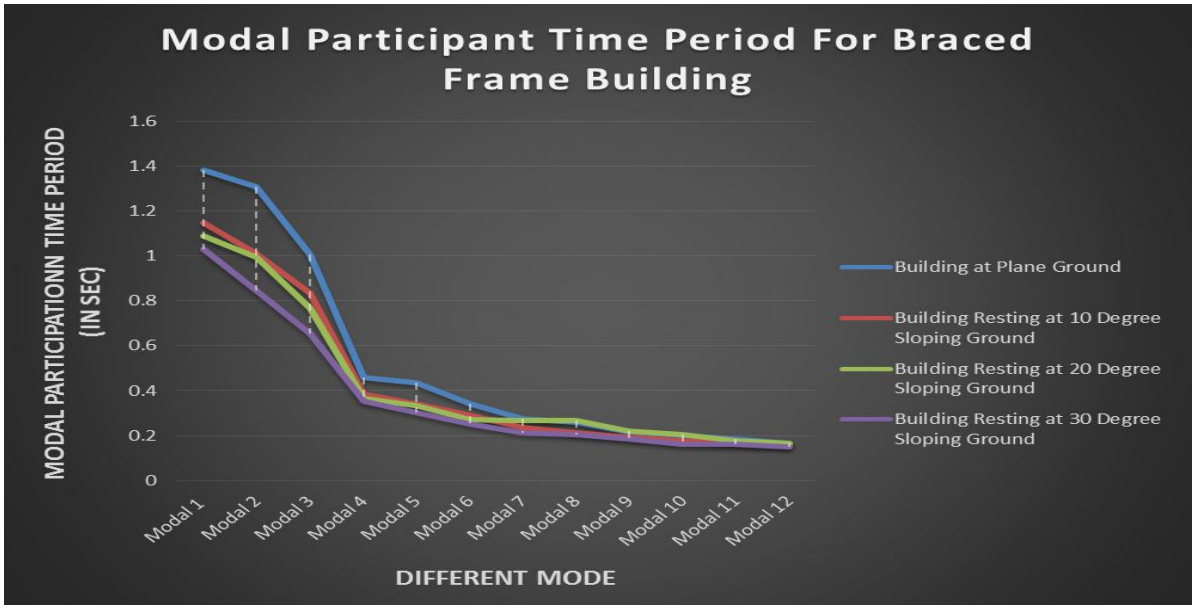

Figure 8 – Model Participation Time Period for different Braced Building

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B. Displacement of the Buildings

For the G+ 11 storey RC building with Unbraced and Braced configuration having various angle of sloping (0 degree, 10 degree, 20 degree and 30 degree) are analysis. The top displacement are reduced at increasing the value of angle for both Unbraced and Braced structure. The value of also reduced approximately up to 70% by using bracing system for all angle of sloping model. The value of top displacement for different load case are given below in Table 03.

Table 03 – Displacement at Top of the Building

	Building Without Bracing				Building With Bracing			
	Building at Plane Ground	Building Resting at 10 Degree Sloping Ground	Building Resting at 20 Degree Sloping Ground	Building Resting at 30 Degree Sloping Ground	Building at Plane Ground	Building Resting at 10 Degree Sloping Ground	Building Resting at 20 Degree Sloping Ground	Building Resting at 30 Degree Sloping Ground
EQX	32.503	29.538	23.569	17.591	19.552	15.655	14.297	10.825
EQY	32.06	30.283	24.809	19.633	20.862	18.378	16.257	13.15
RSX	25.781	22.365	18.662	15.045	15.37	11.922	11.648	10.141
RSY	25.77	26.214	23.824	22.017	16.297	15.403	15.002	15.036
1.5DL+1.5EQX	48.489	46.604	38.981	30.746	29.294	26.129	25.307	20.669
1.5DL+1.5EQY	48.06	45.471	37.261	29.558	31.403	27.577	24.464	19.8
1.5DL+1.5RSX	38.389	35.845	31.621	26.931	23.022	20.53	21.335	19.643
1.5DL+1.5RSY	38.626	39.368	35.783	33.135	24.555	23.115	22.582	19.643

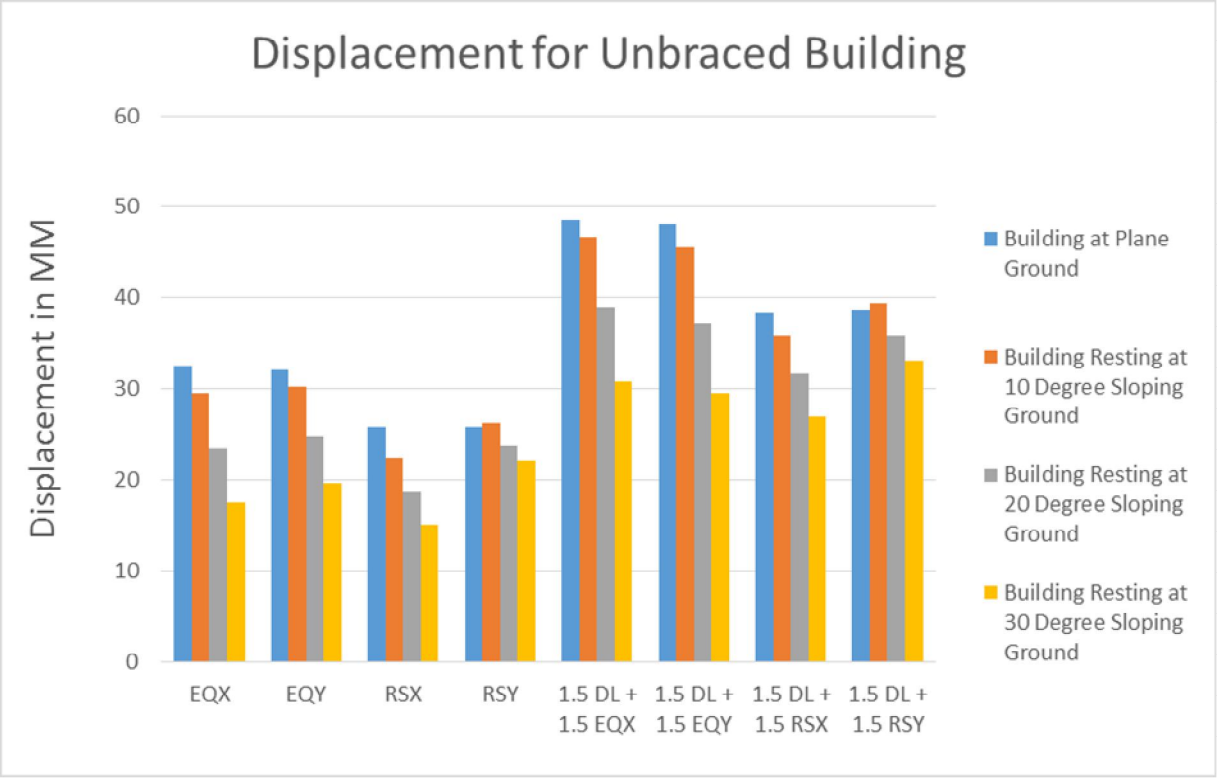

Figure 9 – Displacement for different Unbraced Building

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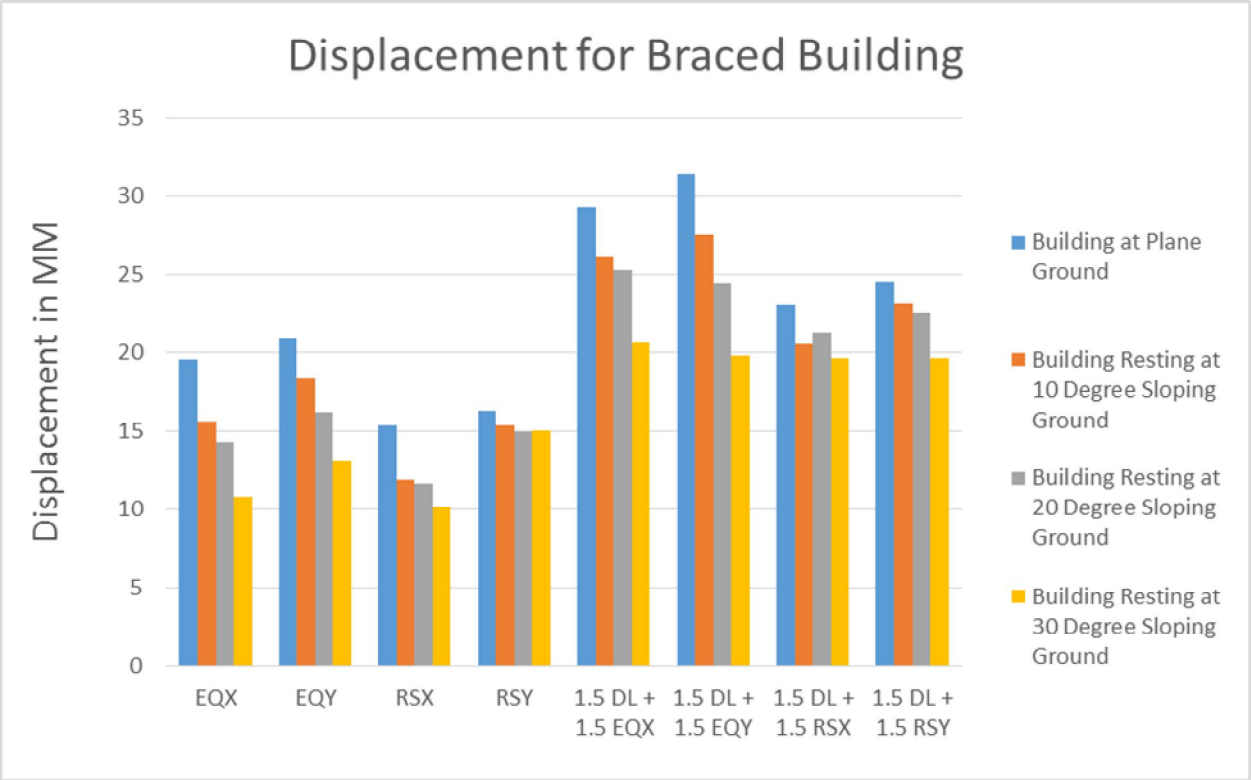

Figure 10 – Displacement for different Braced Building

C. Max. Drift Ratio of the Buildings

Table 04 – Maximum Drift Ratio of the Buildings

	Building Without Bracing				Building With Bracing			
	Building at Plane Ground	Building Resting at 10 Degree Sloping Ground	Building Resting at 20 Degree Sloping Ground	Building Resting at 30 Degree Sloping Ground	Building at Plane Ground	Building Resting at 10 Degree Sloping Ground	Building Resting at 20 Degree Sloping Ground	Building Resting at 30 Degree Sloping Ground
EQX	0.001178	0.001216	0.001147	0.001244	0.001007	0.001089	0.001043	0.001275
EQY	0.001196	0.001168	0.001083	0.000917	0.001124	0.001211	0.001026	0.000905
RSX	0.001059	0.001168	0.001018	0.001296	0.000934	0.000941	0.001024	0.001448
RSY	0.00109	0.001148	0.001179	0.001101	0.001042	0.000941	0.001075	0.000937

D. Base Shear of the Buildings

For an angle of hill slope, the base shear reduces with increase in value of angle of sloping for both unbraced and braced system. The base shear are also increases by using bracing configuration for all model. The values of base shear for different load cases and load combinations are given in table 05, figure 11 and figure 12.

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Table 05 – Base Shear of the Building

	Building Without Bracing				Building With Bracing			
	Building at Plane Ground	Building Resting at 10 Degree Sloping Ground	Building Resting at 20 Degree Sloping Ground	Building Resting at 30 Degree Sloping Ground	Building at Plane Ground	Building Resting at 10 Degree Sloping Ground	Building Resting at 20 Degree Sloping Ground	Building Resting at 30 Degree Sloping Ground
EQX	1777.60	1847.94	1770.76	1677.60	3023.04	3795.71	2883.49	2534.97
EQY	1792.51	1823.74	1698.95	1449.780	2855.29	3342.88	2630.94	2080.44
RSX	1775.35	1788.75	1805.42	2120.08	2865.02	3523.41	2897.15	3147.05
RSY	1797.50	1751.55	1695.16	1664.67	2704.71	3118.99	2688.14	2485.25
1.5DL+1.5EQX	2666.41	2771.91	2656.14	2516.406	4534.57	5693.57	4325.24	3802.46
1.5DL+1.5EQY	2688.77	2735.61	2548.43	2174.67	4282.93	5014.32	3946.41	3120.66
1.5DL+1.5RSX	2663.03	2683.13	2708.13	3180.127	4297.53	5285.12	4345.73	4720.58
1.5DL+1.5RSY	2696.24	2627.32	2542.75	2497.00	4057.07	4678.48	4032.22	3727.87

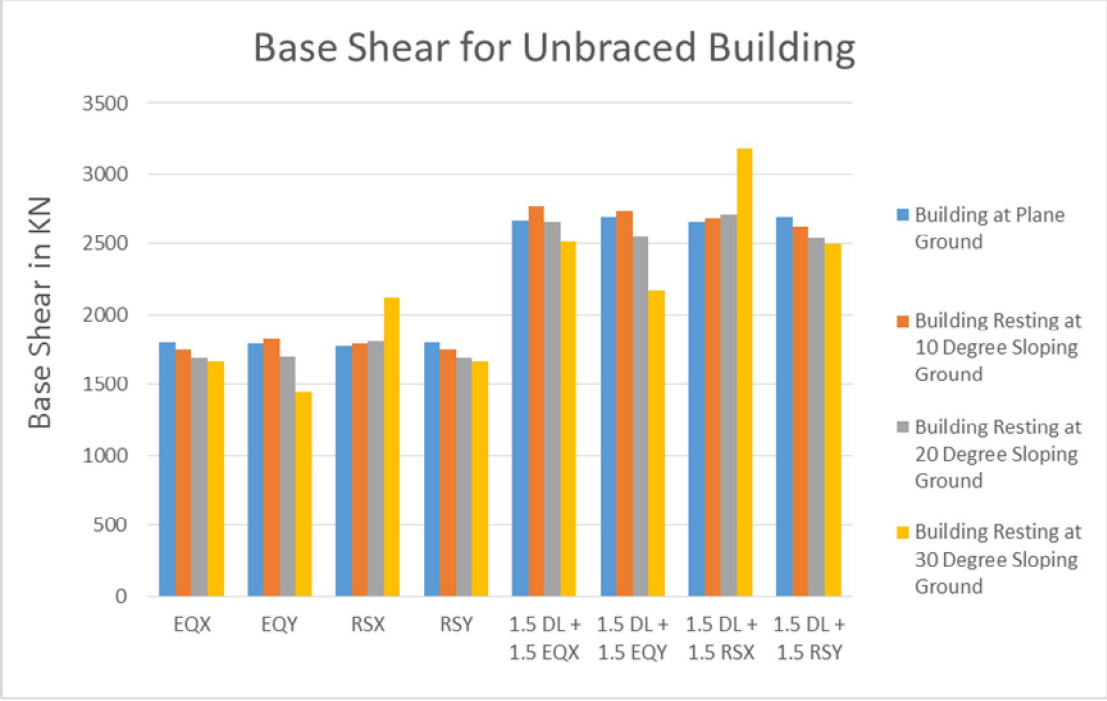

Figure 11 – Base Shear for Different Unbraced Building

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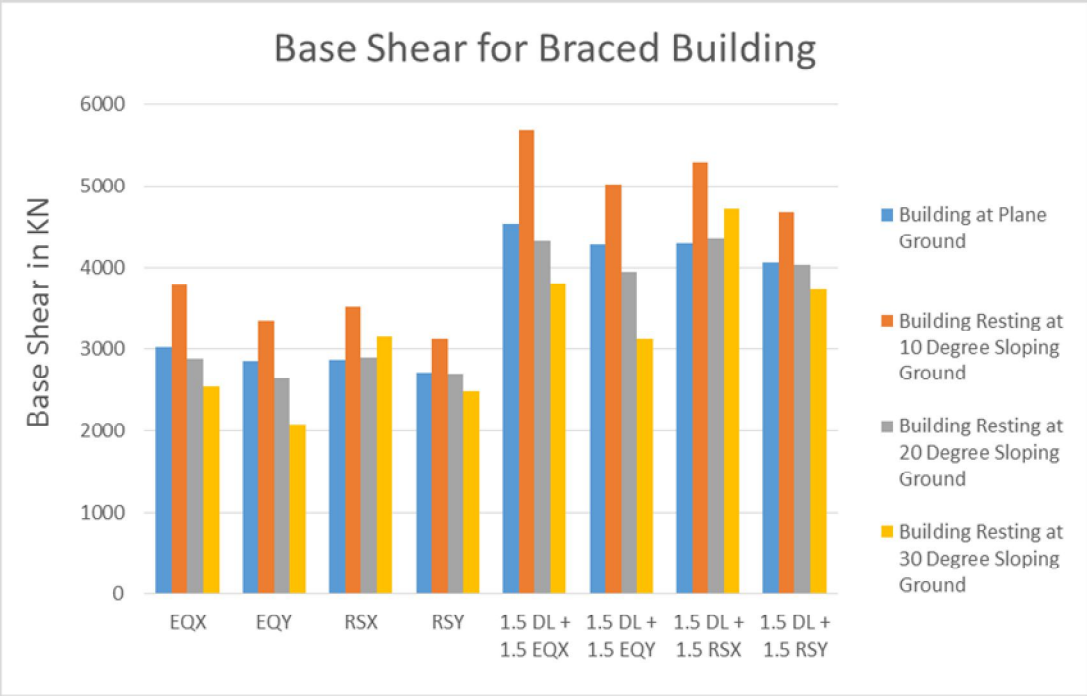

Figure 12 – Base Shear for Different Braced Building

V. CONCLUSION

After the analysis all the 8 building model of braced and unbraced structure at different angle of sloping (0 degree, 10 degree, 20 degree and 30 degree) are concluded followings

A. The Top storey displacement for both unbraced and braced buildings is found to be increase with increase in the sloping angles.
B. Comparing all 8 models, base shear of the 0 degree sloping building is found to be more for all load cases and load combinations both unbraced and braced building model.
C. Fundamental time period of the buildings is increased with a 2% with the increase in the angle of inclination.
D. Displacement of braced building is reduced than unbraced building for the all load cases and load combinations.
E. Maximum value of storey drift is found at middle height of the building, on an average it is found in the 4^{th} storey to 7^{th} storey in most of the models
F. Storey drift of the building increases as the angle of sloping are increases with respect to horizontal along the valley. And it also reduces when braced system placed than bare frame unbraced system.

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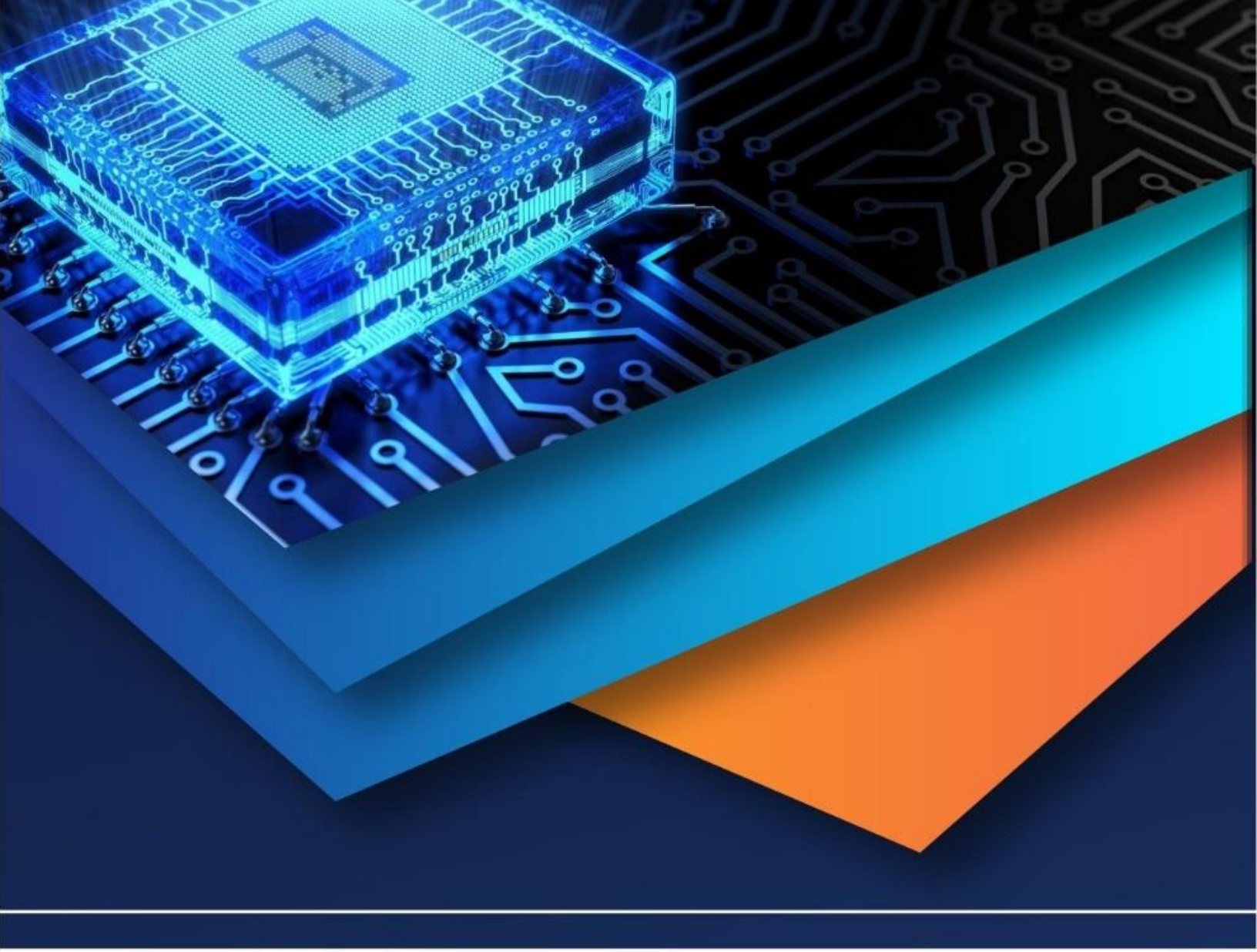

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