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Seismic Analysis of RCC and Steel Building on Sloping Ground

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Abstract: It is necessary to design and analyse a structure to perform well under seismic loads and also endow with well strength, stability and ductility for seismic design. The seismic performance of high rise steel frame and RCC frame structure is analysed by equivalent static method. The advancement in building, Information, modelling has integrated design, detailing, and fabrication of steel which will result in high performance under earthquake loading. In present work various models were analysed with the help of Staad pro. And the results so obtained were plotted and compared.
Keyword: set back, step back, axial forces, displacement, slope

I. INTRODUCTION

In some parts of world, hilly area is more prone to seismic activity; e.g. northeast region of India. In this hilly regions, traditionally material like, the adobe, brunt brick, stone masonry and dressed stone masonry, timber reinforced concrete, bamboo, etc., which is locally available, is used for the construction of houses. A scarcity of plain ground in hilly area compels the construction activity on sloping ground. Hill buildings constructed in masonry with mud mortar/cement mortar without conforming to seismic codal provisions have proved unsafe and, resulted in loss of life and property when subjected to earthquake ground motions. The economic growth and rapid urbanization in hilly region has accelerated the real estate development. Due to this, population density in the hilly region has increased enormously. Therefore, there is popular and pressing demand for the construction of multi-storey buildings on hill slope in and around the cities.

II. OBJECTIVES OF PRESENT WORK

The objectives of project are as follows: -

A. To study behavior of RCC and Steel frame on sloping ground
B. To study behavior of RCC and Steel frame in various seismic zones.
C. To study the variation in material requirement for framing material.
D. To find the most vulnerable framing system amongst all frames conditions.
E. To find various parameters for all frames Such as, Axial forces, Bending Moments, Displacements and compare them.

III. METHODOLOGY AND CASE CONSIDERATION

A. Methodology

The study will be done in following steps:

1) Step-1 Introduction and Literature review

In some parts of world, hilly area is more prone to seismic activity; e.g. northeast region of India. In this hilly regions, traditionally material like, the adobe, brunt brick, stone masonry and dressed stone masonry, timber reinforced concrete, bamboo, etc., which is locally available, is used for the construction of houses. A scarcity of plain ground in hilly area compels the construction activity on sloping ground. Hill buildings constructed in masonry with mud mortar/cement mortar without conforming to seismic codal provisions have proved unsafe and, resulted in loss of life and property when subjected to earthquake ground motions. From study of various literatures, it is observed that there is need of detailed analysis and research work regarding behaviour of building located on sloping ground, also effect of framing material on seismic behaviour of building.

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2) Step-2 Selection of sloping angle of ground

Building sites in hilly areas are generally located on slopes and hill tops with roads girdling in between levels to provide access to the residences. Hill sides with less than 30" slope in general are noted to be stable as the gradient correspond to safe angle of repose of slope forming material. Stable slopes steeper than 30" with in-situ rock exposure are encountered in hilly terrain, if the discontinuity surfaces dip into the hill to prevent outward and downward movement of rock wedges. Building sites should in general be located on hill side with not more than 30^0 slope. None residential temporary buildings may be constructed on steeper slopes up to 45^0. From Study of IS 14243 (Part 2) : 1995 it is found that sloping angle cannot be greater than 30^0 therefore, angle of 10^0, 20^0, 30^0 were selected for analysis.

3) Step-3 Modelling and Structural Parameters

As per IS 14243 (Part 2) : 1995 Buildings in hilly areas should be so planned, oriented and designed but higher load comes on harder part of foundation soil. Since inner side of cut slope may have higher bearing capacity, building should be so oriented and planned that higher load may come on inner side. Width of developed land in hilly areas is often quite small and restricted because of cuttings. Therefore, longer buildings should be planned in view of above facts depending on the slope of ground and width of land available after cutting. Therefore, a rectangular shaped office building having 10 storey (G + 9 , Total height 33m) RCC and Steel framing will be analysed. Details about span and bays will be discussed later in respective chapter. Totally 12 models will be analysed 06 models (03 models having sloping angle of 10^0, 20^0, 30^0 in Zone-IV and 03 models having sloping angle of 10^0, 20^0, 30^0 in Zone-V) will be of steel framing and Similarly 06 models will of RCC framing

4) Step-4 Loading and Analysis

All loading will be considered as per IS 875 Part 1(Dead Load), IS 875 Part 2(Live Load),

And Seismic loads will be taken as per IS 1893 (Part 1) : 2002. As it is well known that combination of loads make more significant effect than single action of Load therefore, various loading combinations will be considered as per IS 1893 and results will be compared for most severe loading combinations. As the building is of height less than 40m so, according to clause 7.8.1 of IS 1893 (Part 1) : 2002 Static analysis method will be adopted. All models will be analysed using STAAD-Pro v8i software.

5) Step-5 Result Comparison And Conclusion

After analysing all above said models result comparison will be done to find the most efficient framing system in each zone, various comparisons will be made related to Base Shear Distribution, Maximum Displacement, Maximum Axial Forces, Maximum Moments. Finally based on all result comparison conclusions will be drafted.

B. Case Consideration

As discussed earlier totally 06 models will be analyzed details regarding those models is as per table given below

Table 1 Model Detail

Model Description	Label
RCC Framed model with 10^0 ground slope in Zone-IV	SR1
RCC Framed model with 20^0 ground slope in Zone-IV	SR2
RCC Framed model with 30^0 ground slope in Zone-IV	SR3
STEEL Framed model with 10^0 ground slope in Zone-IV	SS1
STEEL Framed model with 20^0 ground slope in Zone-IV	SS2
STEEL Framed model with 30^0 ground slope in Zone-IV	SS3

C. Material Constants

Table 2 Material Constants

Material	Concrete	Steel
Grade	M 30	Fe 500
Mass Density	2549.3	7849
Unit Weight	25	76.97
Modulus of Elasticity	25,000,000	20,000,000
Poisson's Ratio	0.15	0.3

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D. Structural Parameter

Table 3 Structural Parameters

Parameter	Value
Live load	3 kN/m2
Density of concrete	25 kN/m3
Thickness of slab	125 mm
Depth of beam	380 mm
Width of beam	230 mm
Dimension of Beam	ISMB-350
Dimension of column	300 x 450 mm (RCC Frame)
	ISHB-400 (Steel Frame)
Thickness of outside wall	230 mm
Thickness of inner side wall	100 mm
Height of floor	3.35 m
Earthquake zone	IV/V
Damping ratio	5% for RCC and Steel
Type of soil	II
Type of structure	Special moment resisting frame
Response reduction factor	5
Importance factor	1.20
Roof treatment	1 kN/m2
Floor finishing	1 kN/m2
Depth of Foundation	1.50 m

Optimize command will be used for buildings with Steel framing.

IV. MODELLING AND ANALYSIS

A. Modelling

In this section all details related to model i,e plan section and dimensions of storey and bay will be shown along with ground slope for better understanding

1) Plan and Elevation of model

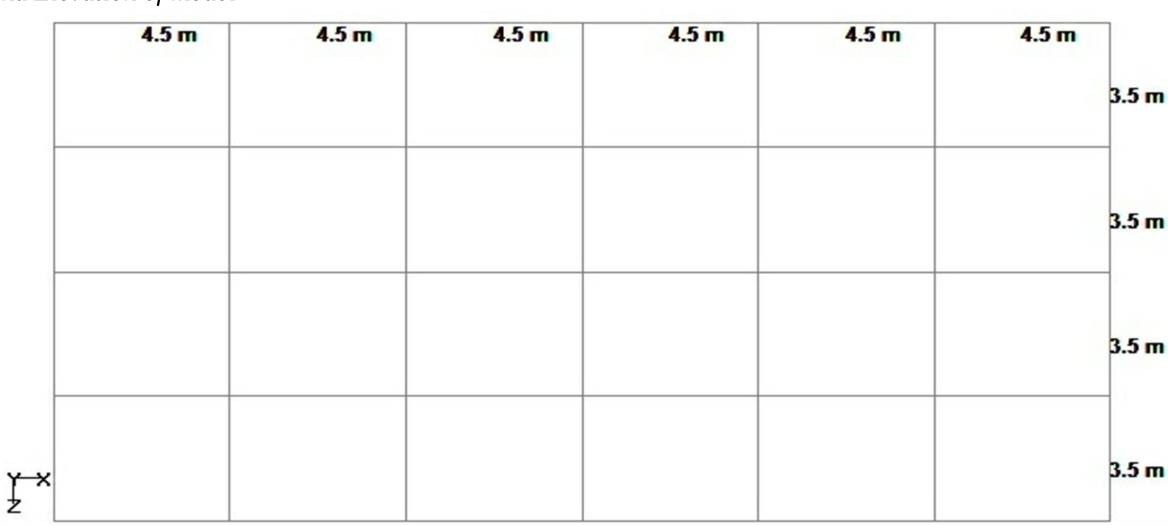

Fig 4.1 plan of model

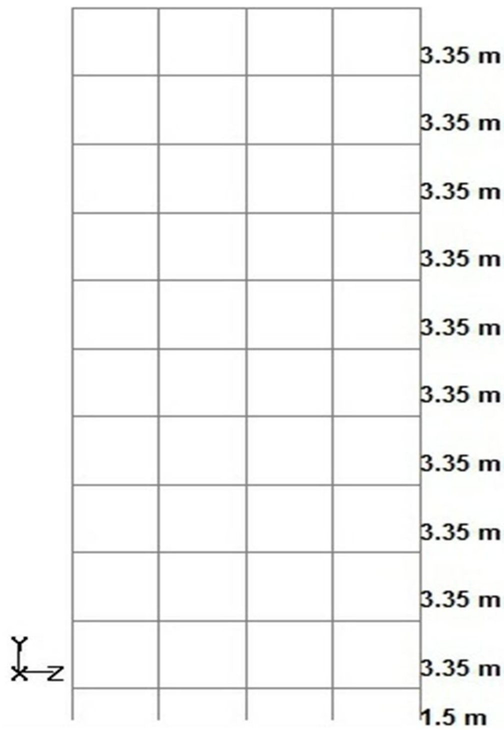

Fig 4.2 Elevation of model

2) Section of Frames with sloping ground

Fig 4.3 Section of model (10^0 slope)

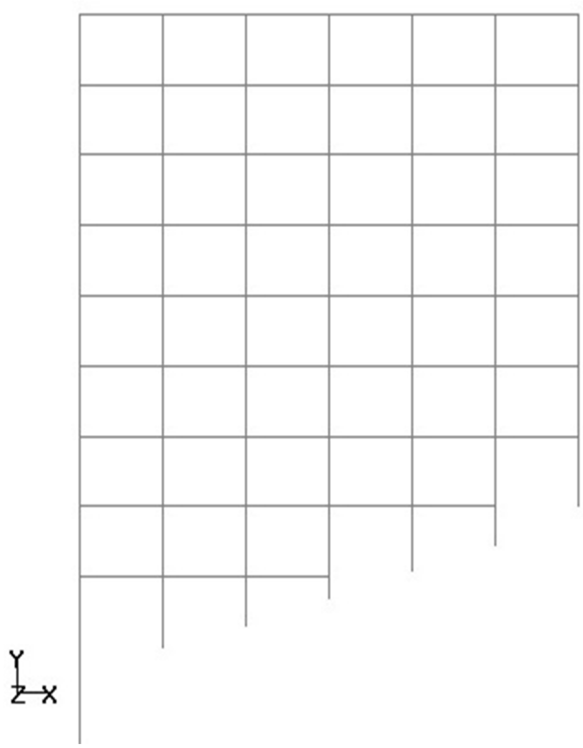

Fig 4.4 Section of model (20^0 slope)

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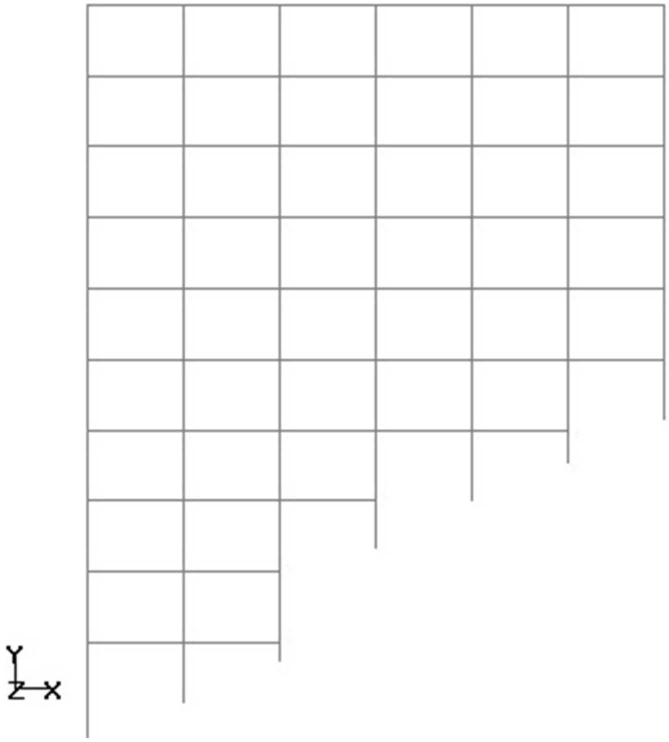

Fig 4.5 Section of model (30^0 slope)

3) 3D views of all models (RCC and Steel)

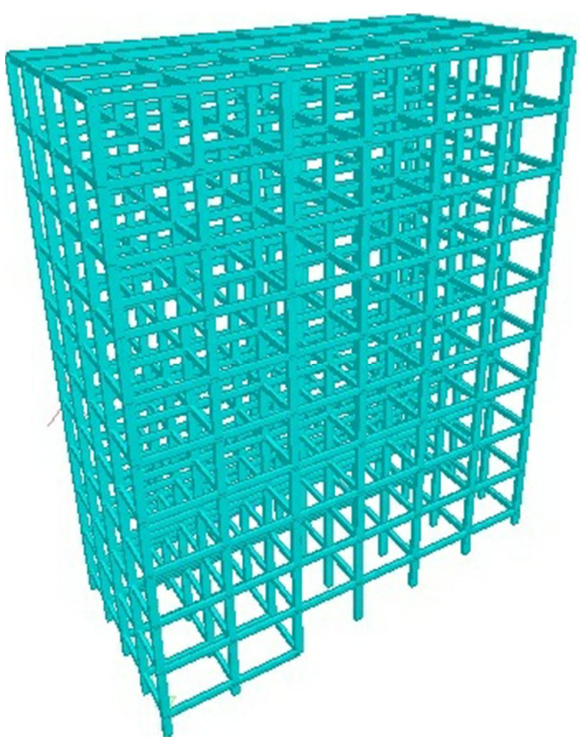

Fig 4.6 3D RCC model (10^0slope)

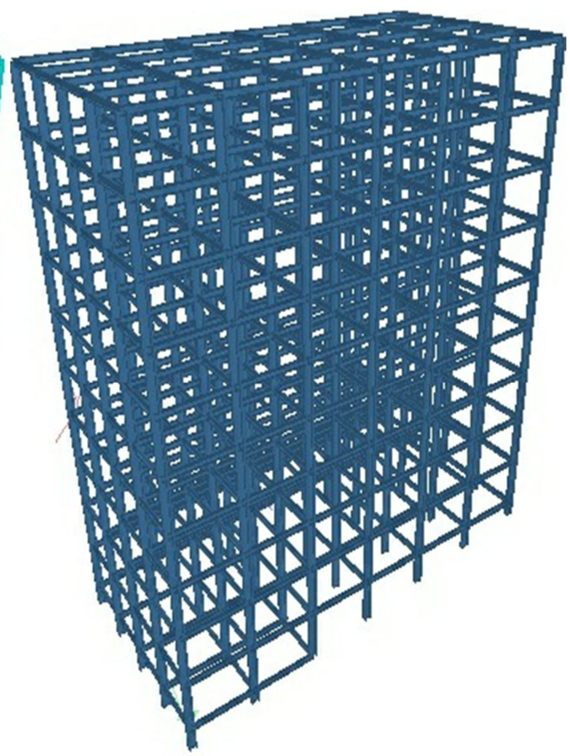

Fig 4.7 3D Steel model (10^0slope)

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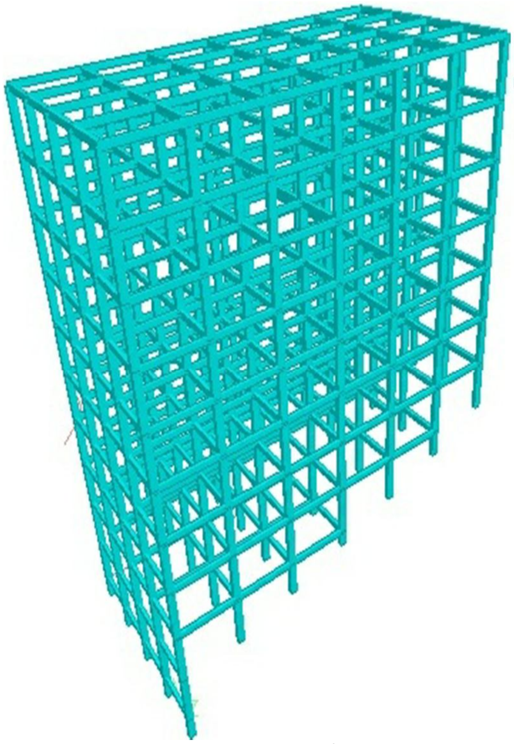


Fig 4.8 3D RCC model (20^0slope)

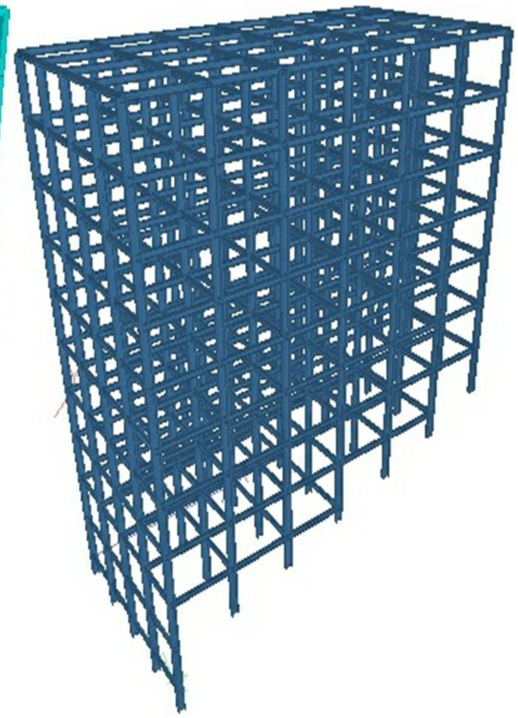


Fig 4.9 3D Steel model (20^0slope)

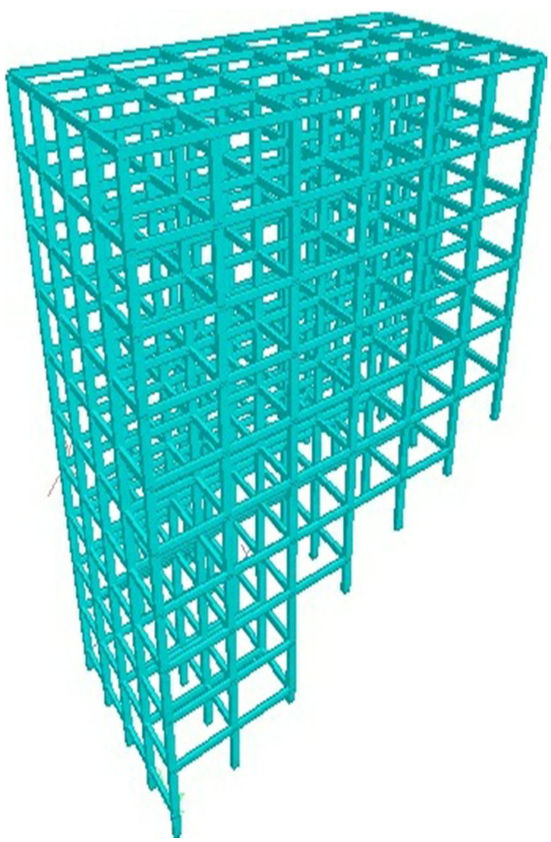


Fig 4.10 3D RCC model (30^0slope)

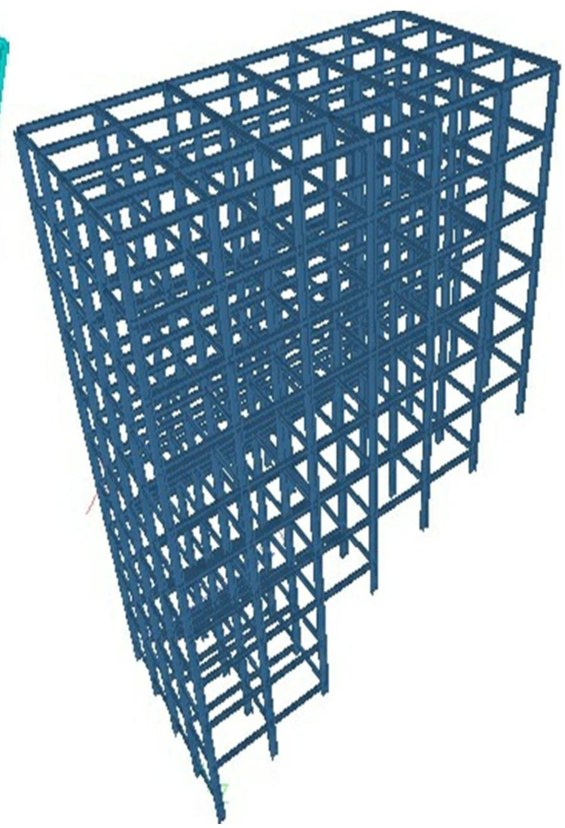


Fig 4.11 3D Steel model (30^0slope)

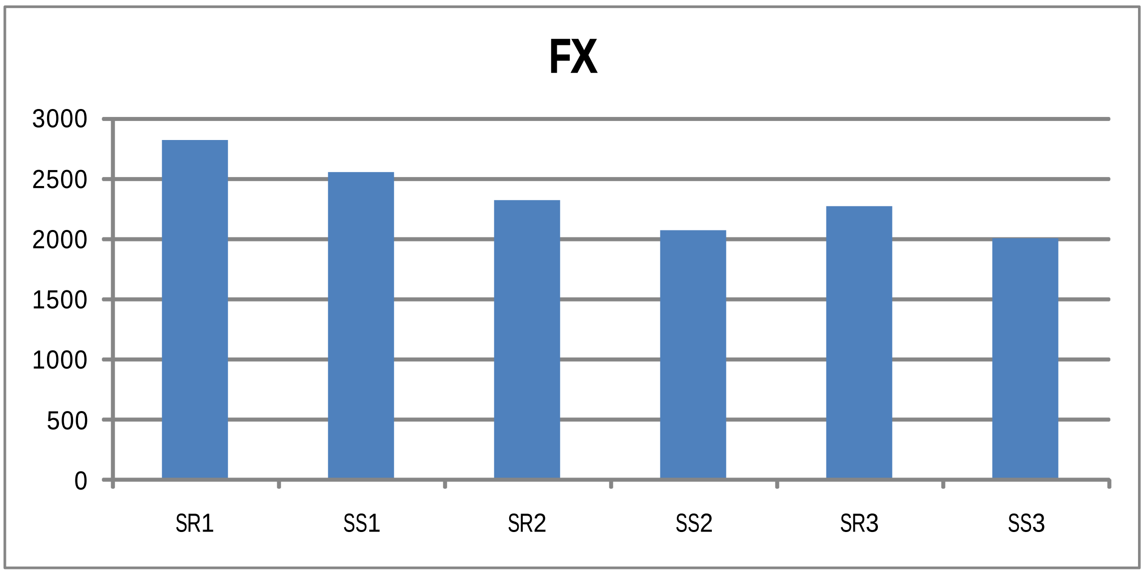
V. RESULTS AND COMPARISONS

A. *Comparison of Results for all models in Zone-IV*

1) Comparison for Maximum Axial Forces and Bending Moment

Table 5.1 Axial force and Bending moment comparison (Zone-IV)

Sr. No	Model	Max. Axial Force (KN)			Max. Bending Moment (KN.M)		
		FX	FY	FZ	MX	MY	MZ
1	SR1	2812.90	352.10	108.28	6.74	181.10	373.73
2	SR2	2319.03	196.10	94.99	13.39	180.74	309.43
3	SR3	2267.47	164.74	85.62	19.35	116.35	276.75
4	SS1	2559.51	257.95	94.14	0.13	138.11	465.72
5	SS2	2075.74	188.40	78.84	0.22	133.43	517.95
6	SS3	2013.09	170.55	73.62	0.37	104.85	474.38



Graph 5.1 Comparison of Axial forces in X – Direction (Zone-IV)

2) *Comparison for Maximum Reaction and Bending Moment*

Table 5.2 Maximum reaction and Bending moment comparison (Zone-IV)

Sr. No	Model	Max. Reaction (KN)			Max. Bending Moment (KN.M)		
		FX	FY	FZ	MX	MY	MZ
1	SR1	341.43	2812.90	108.28	185.24	7.95	363.64
2	SR2	190.15	2319.03	93.87	180.74	13.33	309.43
3	SR3	173.05	2267.47	85.62	116.18	19.35	251.38
4	SS1	247.84	2560.64	94.14	136.91	0.25	454.21
5	SS2	187.87	2075.74	77.64	133.43	0.22	517.95
6	SS3	175.55	2013.09	73.62	91.64	0.37	432.42

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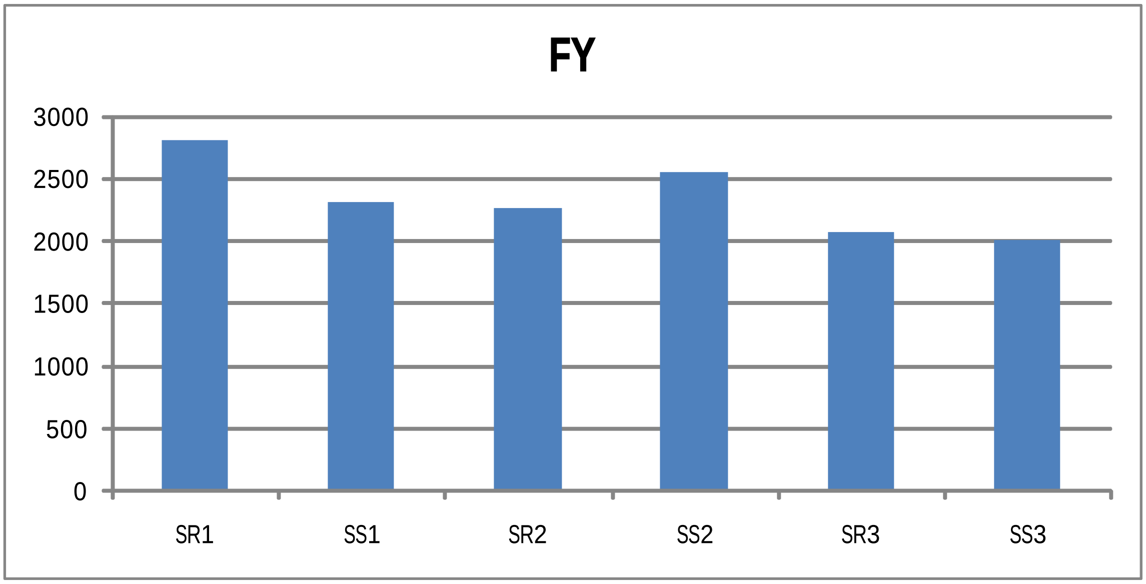
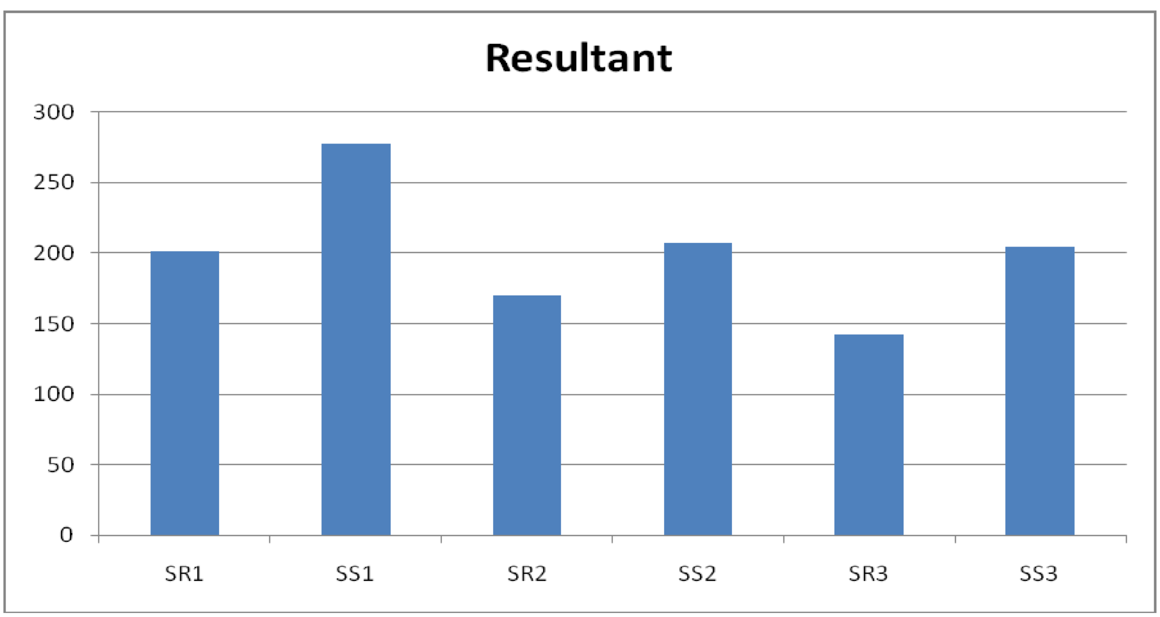


3) Comparison for Maximum Displacement

Table 5.3 Displacement Comparison (Zone-II)

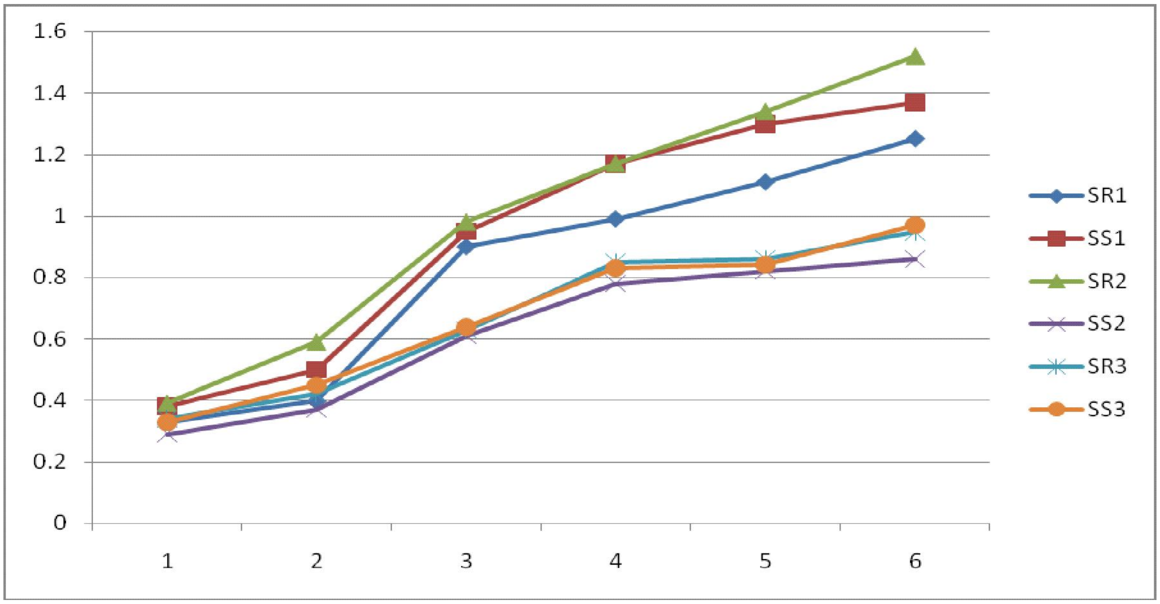
Sr. No	Model	Direction (MM)			Resultant
		X	Y	Z	
1	SR1	146.46	2.11	201.51	201.99
2	SR2	80.34	1.53	166.33	170.22
3	SR3	45.85	1.23	138.21	142.07
4	SS1	94.14	1.64	277.96	278.21
5	SS2	69.10	1.24	206.70	207.67
6	SS3	49.48	1.10	203.06	204.70



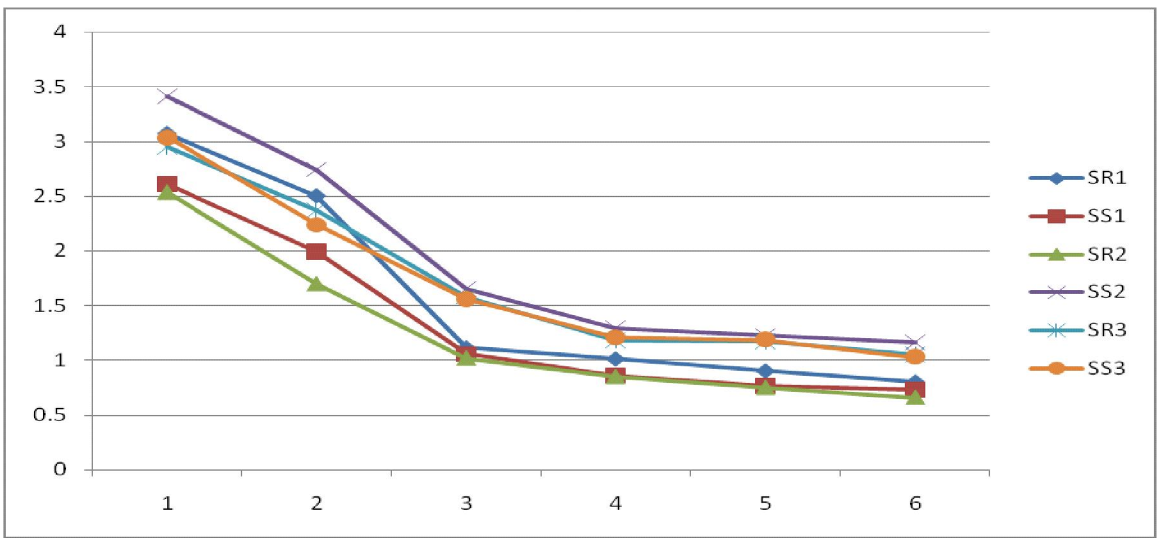
4) Modal Frequency and time Period for all Models (Zone-IV)

Table 5.4 modal frequency and time period for all models

Sr No	Mode	Frequency						Time Period					
		SR1	SR2	SR3	SS1	SS2	SS3	SR1	SR2	SR3	SS1	SS2	SS3
01	01	0.33	0.38	0.39	0.29	0.34	0.33	3.07	2.61	2.54	3.41	2.95	3.04
02	02	0.40	0.50	0.59	0.37	0.42	0.45	2.50	1.99	1.70	2.74	2.37	2.24
03	03	0.90	0.95	0.98	0.61	0.63	0.64	1.11	1.06	1.02	1.65	1.58	1.56
04	04	0.99	1.17	1.17	0.78	0.85	0.83	1.01	0.86	0.85	1.29	1.18	1.21
05	05	1.11	1.30	1.34	0.82	0.86	0.84	0.90	0.77	0.75	1.22	1.17	1.19
06	06	1.25	1.37	1.52	0.86	0.95	0.97	0.80	0.73	0.66	1.16	1.05	1.03



Graph 5.17 Comparison of Frequency (Zone-IV)



Graph 5.18 Comparison of Time period (Zone-IV)

VI. CONCLUSIONS

After analyzing various models following conclusions were found

A. On sloping ground steel structure gives lower values of axial forces compared to RCC structures
B. Compared to RCC structures steel structures gives1.5 time higher values of moments in beams and columns
C. Compared to steel structures, RCC structure gives almost 1.2 to 1.5 times lower values of displacement.
D. For 10^0 slope RCC structures behaves better than steel structures in both modes frequency and time period but as value of slope increases steel structures are more efficient than RCC structures.
E. For 20^0 and 30^0 ground slope steel structures can be prove more efficient and stable with some displacement control measures such as provisions of bracings.

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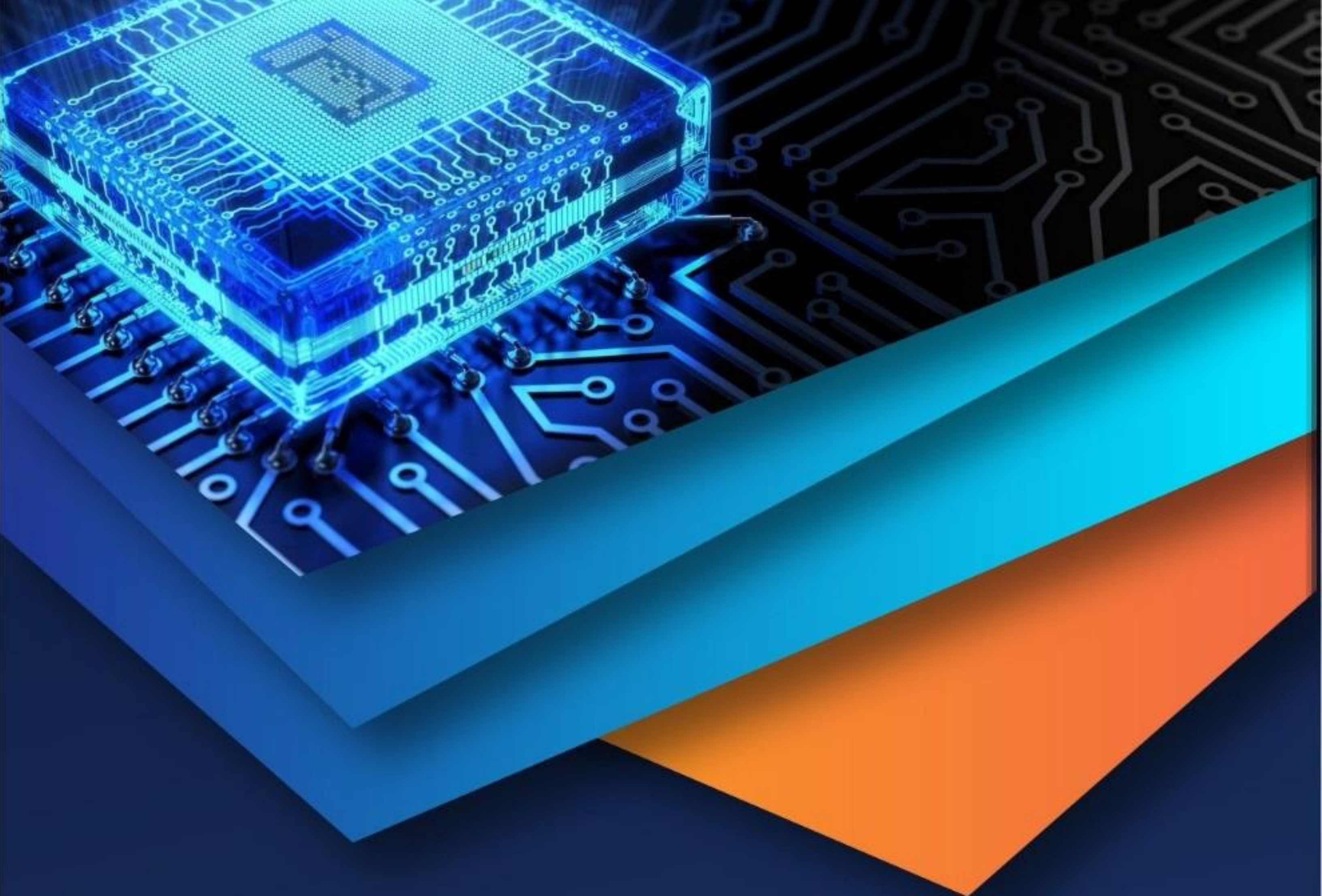

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