FEASIBILITY STUDIES ON PROACTIVE DISASTER PREVENTION IN FRAMES OF SLOPED REGIONS

Ahammed Salih V P[1], Shahla C P[2]

[1] PG Student, Civil Engineering Department, AWH Engineering College, Calicut, India
[2] Shahla C P, Assistant Professor, Civil Engineering Department, AWH Engineering College, Calicut, India

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Abstract - *The structures are usually constructed on flat ground, however, due to the lack of flat grounds usually hilly regions for construction task have been preferred. Since, construction of framed structures on sloping grounds gives variety of structural performance than the flat grounds, since these structures are unequal in universe consequently, attract huge amount of shear force and torsional moments and shows unsymmetrical distribution due to differing in column lengths. There are two types of configuration of building on sloping ground, the one is step back and the other is step back setback. In this existing study, performance of G+29 building on varying sloping angle i.e. 0°,15°, 30°, 45° to be studied. A comparison has been made with step back building with bracing system and the building resting on level ground (setback). The modeling and analysis of the RC framed structures has been done by using ETABS. The seismic analysis was done by Linear Dynamic method (i.e.Response Spectrum method) analysis have been carried out as per IS:1893 (part 1): 2002. The results to be obtain in form of Base Shear, Storey Displacement for all cases. The analyses showed that for construction of the building on slopy ground the step back- setback building configuration is suitable, However, step back building may be adopted by providing bracing system to control displacements and base shear.*

Key Words*: *Slope Angle, Base Shear, Story Displacement, Story Drift and ETABS

1. INTRODUCTION

In general, there are several natural disasters occurring the world causing various damages to life and property. Earthquakes are one such disasters which should be of major concern as it may cause huge destruction if they are of high magnitude. As per codal provisions, India has been divided into various zones depending on the severity of earthquakes which has to be considered in the Earthquake resistant design of structures. Due to scarcity of flat ground, it has become necessary to build structures in sloped regions. This may lead to varying effective heights of columns in the same storey. Such columns which are short compared to that of the regular columns are called Short columns. Short columns have more stiffness making them to attract more lateral load. This leads to highly susceptibility to earthquakes. This is known as "Short Column Effect". Hence RCC framed structures in sloped regions are of great importance. Proactive disaster prevention is the process of making necessary measures even before the disaster occurs, so that future damage and loss to human life as well as property can be prevented.

In sloping ground the height of the column is different at the bottom storey. It is asymmetric in plane and elevation. The short columns are most effects and damage occurs during the earthquake. Care should be taken for making this building earthquake resistance. The method used for the analysis is Linear Dynamic method (i.e. Response Spectrum method). Due to the asymmetry dynamic analysis must be used for seismic analysis of the building. In the response spectrum method the data such as zone factor, type of soil etc. are applied from I.S-1893.

1.1 Objectives

- To study the effects of top storey displacement, storey drift, storey stiffness and base shear of RC structures in varying sloped region (0 to 45 degree).
- The dynamic analysis is carried out using response spectrum method to the step back, step back-set back, step back with X-bracing and set back building frames.

2. MODELING AND ANALYSIS

In the present study, three building configurations are considered, which include step back buildings, step back set back buildings and set back buildings situated on sloping ground. Number of storey considered for each type of configurations is 30 storeys. Plan layout of each configuration includes 8 bays along the slope direction and 6 bays are considered across slope direction, which is kept same for all configurations of building frame. Earthquake analysis is carried out considering the 3D frames as per IS 1893:2016. Slopes of ground considered are 0°, 15 °, 30 ° and 45 ° with the horizontal. The columns are taken to be square to avoid the issues like orientation. The depth of footing below ground level is taken as 1.5 m where, the hard stratum is available. Typical plan, elevation and are shown in Fig 1 to Fig 5. RCC building data are given in table 1.

Table -1: RCC Building data

No.	Description	Value
1	Material used	M30 Concrete, Fe 500 steel
2	Unit weight of RCC	25 kN/m^3
3	Thickness of slab	0.125m
4	Column size	0.8x0.8m
5	Beam size	0.2x0.4m
6	Storey height	3m
7	Parapet height	1m
8	Height of structure	90m
9	Floor Area	768m^2
10	Live Load	3kN/m^2
11	Live Load on Roof	1.5kN/m^2
12	Floor finish	1.5kN/m^2
13	Mass source	1DL + 0.25LL
14	Number of floors	30
15	Soil type	Medium (II)
16	Code used	IS 1893:2016
17	Seismic Zones	V
18	Zone factor	0.36
19	Importance factor	1
20	Response reduction factor	5(SMRF)

2.1 Description of Various Building Models

2.1.1 Models of RC building in varying slopes

Model 1: RC Building in plain ground.
Model 2: RC Building with 15° slope.
Model 3: RC Building with 30° slope.
Model 4: RC Building with 45° slope.

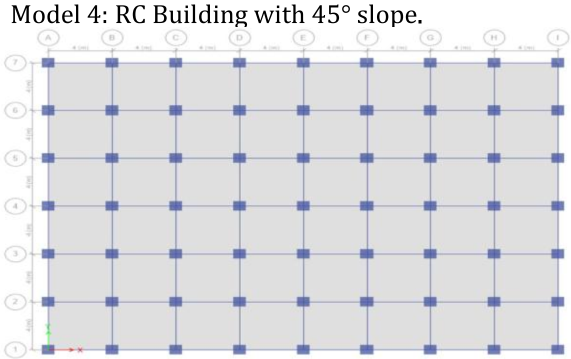

Fig-1: Plan

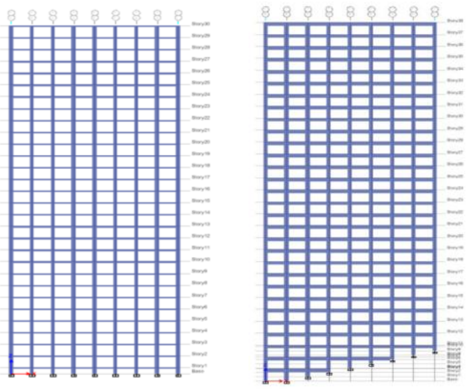

Fig -2: Elevation of RC building on plain and 15° ground

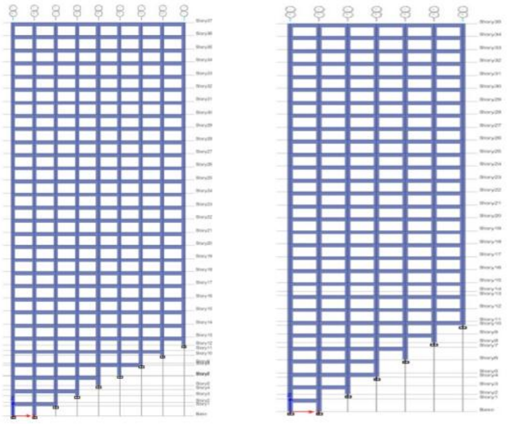

Fig -3: Elevation of RC building on 30° and 45° slope ground

2.1.1 Models of RC building having different configuration

Model 4: RC step back building.
Model 5: RC step back-set back building.
Model 6: RC step back building with X-bracing.
Model 7: RC set back Building.

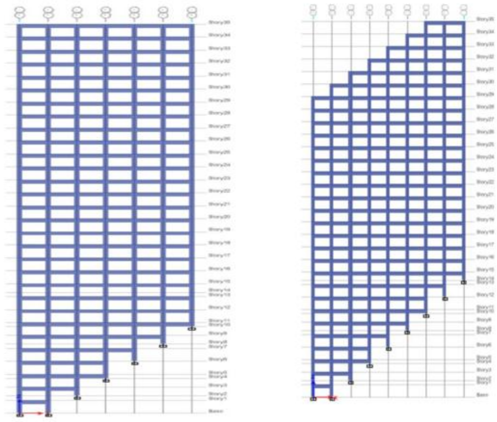

Fig -4: Elevation of step back and step back-set back building

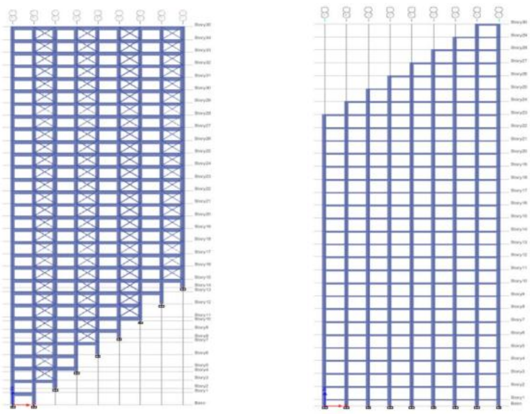

Fig -5: Elevation of step back with X-bracing and set back building

3. RESULTS AND DISCUSSION

RC building on plane ground as well as in sloped region with different configuration of building, with and without bracing system were analyzed and compared. Response spectrum analysis of seven building models is carried out to study the displacement and base shear of a G+29 irregular multi-storey building. This analysis aims to find out the performance of building in zone V.

3.1. Analytical results of RC building in varying sloped regions.

Table -2 Analytical results of top storey displacement of RC building in varying sloped regions

Sl. No.	Description	Maximum Displacement(mm)	
		X-Direction	Y-Direction
1	RC Building in plane ground (M1)	962.709	1006.892
2	RC Building with 15^0 slope (M2)	302.194	358.931
3	RC Building with 30^0 slope (M3)	269.962	333.979
4	RC Building with 45^0 slope (M4)	231.969	310.249

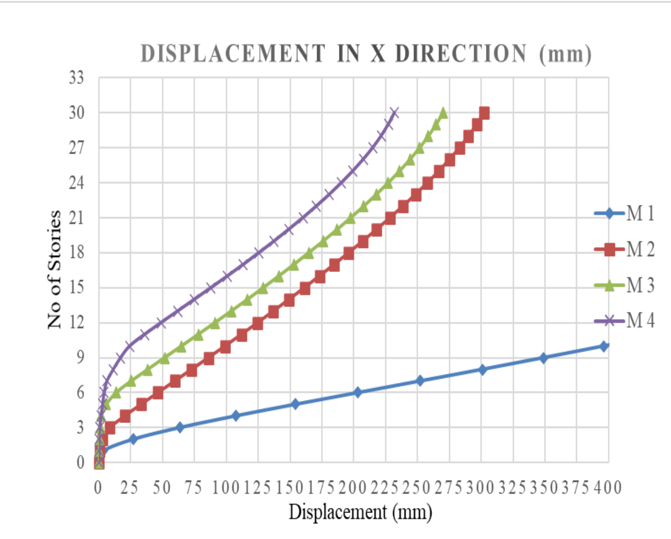

Fig -6: Variation of storey displacement in X- Direction of RC building in varying sloped regions

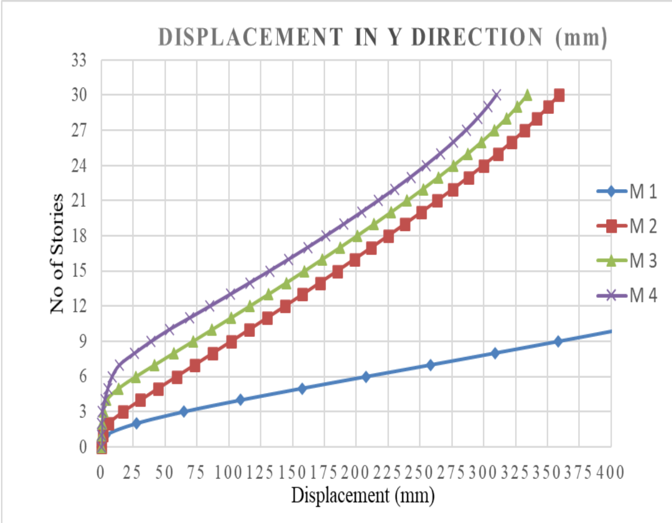

Fig -7: Variation of storey displacement in Y- Direction of RC building in varying sloped regions

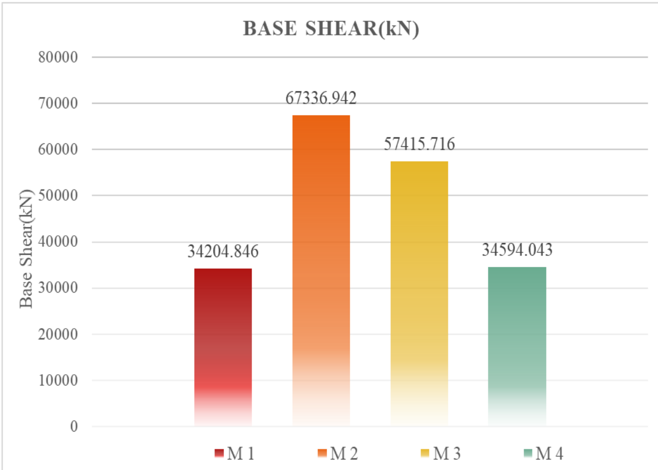

Fig -8: Variation in Base shear of RC building in varying sloped regions

Displacements in the direction of force (X-direction), increased along the storey height and reduced with the increment of the slope. In all the cases maximum displacement were obtained at top storey. There was a 12% reduction in displacement in X-direction and 7% reduction in displacement in Y-direction due to increment of slope.

Base Shear was reduced with the increment of the slope angle. It was seen that when slope angle increase from 0° to 15° there was 49.2% increase in base shear and on further increment of slope angle there was reduction in base shear value. There was a 14.72% reduction in base shear when slope angle changes from 15° to 30° and 39.7% reduction in base shear when slope angle changes from 30° to 45°.

3.2. Analytical results of RC building having different configuration

Table -3 Analytical results of top storey displacement of RC building having different configuration

Sl. No.	Description	Maximum Displacement(mm)	
		X-Direction	Y-Direction
1	RC Step Back building (M4)	231.969	310.249
2	RC Step Back - Set Back building (M5)	498.046	665.353
3	RC Step Back building with X-Bracing (M6)	213.841	283.05
4	RC Set Back buildings on Plane Ground. (M7)	1061.225	1326.237

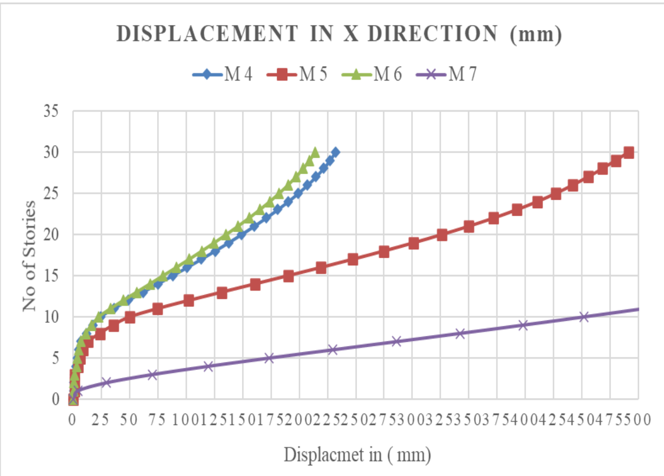

Fig -9: Variation of storey displacement in X- Direction of RC building having different configuration

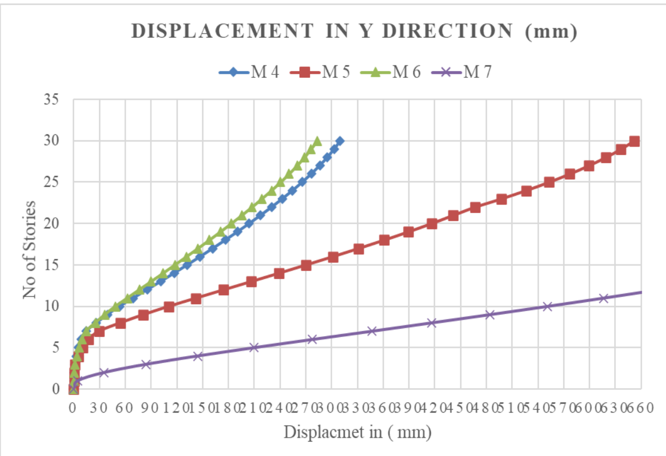

Fig -10: Variation of storey displacement in Y- Direction of RC building having different configuration

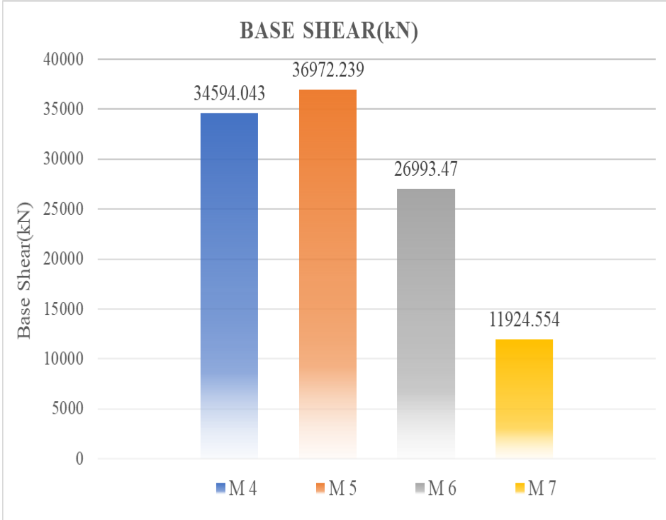

Fig -11: Variation in Base shear of RC building in varying sloped regions

In all the cases maximum displacement were obtained at top storey. There was a 9.72% decrease in displacement in X direction and 19.47% decrease in displacement in Y direction for step back-set back building than step back building without bracing. There was a 78.14% increase in displacement in X -direction and 76.61% increase in displacement in Y -direction for set back building than set back building. There was a 7.82% reduction in displacement in X-direction and 8.77% reduction in displacement in Y-direction for step back building with bracing than step back building without bracing.

Base Shear was reduced with provision of bracing in RC step back building. It was seen that 6.4% increase in base shear for step back-set back building than step back building without bracing. Whereas 21.9% reduction in base shear for step back building with bracing than step back building without bracing.

4. CONCLUSIONS

- Structures on the sloping ground were found as more vulnerable than the structures on the plain ground, and the degree of vulnerability increases with the increment of slope angle.
- As hill slopes increases from 0° to 45°, 12.4% of top storey displacement decreases.
- Frames in 15° sloped ground experiences maximum storey displacement due to low value of stiffness of short column while the frames in 45° sloped ground experiences minimum storey displacement.
- The step back building frames without bracings give higher values of top storey displacement as compared with step back & set back frames.
- Base shear is 6.87% higher for Step back-Setback building than Setback building.

- The performance of step back frames without bracings during seismic excitation can be effected more than other configurations of building frames. Hence, step back building frames without bracings on sloping ground are not desirable. However, it may be adopted by providing bracing system to control displacements.
- The analyses showed that for construction of the building on slopy ground the step back- setback building configuration is suitable, However, step back building may be adopted by providing bracing system to control displacements and base shear
- The columns of the setback buildings at the higher level of the slopes are subjected to higher bending moments so special measures should be taken during their design and construction.
- From the above conclusions it is clear that the use of irregular configuration will cause greater damage to the structure during earthquakes. Hence addition of steel bracings improves its lateral load carrying capacity.

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