Seismic Response of RC Framed Building Resting on Sloping Ground

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***Abstract*:- Framed structures constructed on hill slopes show different structural behaviour than on the plain ground. Since these buildings are unsymmetrical in nature, hence attract large amount of shear forces and torsional moments, and show unequal distribution due to varying column lengths. In this study, two different configurations of hill buildings have been modelled and analysed using ETABS v 9.0 finite element code. A parametric study has been execute, in which hill buildings are geometrically varied in height and length. In all, eighteen analytical models have been subjected to seismic forces along and across hill slope direction and analysed by using Response Spectrum Method. The dynamic parameters obtained from analyses have been discussed in terms of shear forces induced in the columns at foundation level, fundamental time periods, maximum top storey displacements, storey drifts and storey shear in buildings, and compared within the considered configurations of hill buildings. At last, the suitability of different configurations of hill buildings has been suggested.As per analysis, as the number of bay increases seismic performance of the building increases. So in every cases it is not possible to increase the number of bays. So in order to overcome this problem, we are providing shear walls in every corner.A well designed system of shear wall in building frame improves seismic performance significantly.**

Key words: Hill buildings, Step-back and Step-back setback, Response Spectrum method, Earthquake analysis,Shear wall.

1. INTRODUCTION

In the last centuryEconomic development of hill areas has led to the re-examination of building style, optimum use of construction material and construction method. Due to scarcity of the plain land on hills, houses built on steep slopes, pose special structural and construction problems. RC framed structures constructed on hill slopes show different structural behaviour than on the plain ground. Because of steep slopes, buildings are constructed generally in step-back configuration, though a combination of step-back and setback buildingconfiguration is also common. There is a development of torsional moments due to the unsymmetrical nature of these buildings and eccentricity caused by the difference in the alignments of the centre of mass and stiffness at each floor. When the building is subjected to seismic forces an increase in the stress concentration has also been reported at the location of setbacks.A significant amount of research work has been done involving hill buildings. Past research have described different problems and suggested different techniques concerning mathematical modelling formulation and lateral load analysis of step-back and setback buildings.A shear wall structure is considered as one whose resistance to horizontal loading is provided entirely by shear walls. These shear walls have different applications such as a vertical cantilever in the form of separate planner walls and as non-planner assembles of connected walls around elevator, service shaft and stair. Shear walls have been the most common structural elements used for stabilizing the building structures against lateral forces. Their very high in-plane stiffness and strength makes them ideally suited for bracing tall buildings. The usefulness of shear walls in framing of buildings has long been accepted.In the present study three dimensional modelling of two different configurations of hill buildings has been undertaken and the effect of plan aspect ratio has been parametrically studied by varying plan dimensions and height of the models. Results have been discussed in terms of static and dynamic properties of buildings such as shear forces induced in the columns at foundation level, fundamental time period, maximum top storey displacements, storey drifts and storey shear in buildings and compared with in the considered configurations of hill buildings. And then shear walls are provided at the corners and compere the maximum top storey displacement.

2. METHOD OF ANALYSIS

Three dimensional space frame analyses of step-back setbackconfigurations of hill buildings involving the effect of plan aspect ratio have been carried out by parametrically varying plan and height of the models. The seismic analysis is carried out by using equivalent static approach and response spectrum method using finite element code ETABS v 9.0, and seismic parameters such fundamental time period, maximum top story displacement, story shear, story drift and column shear at ground level in each direction, i.e. along slope and across slope of hill, are determined using SRSS modal combination and compared within the considered configurations. Concrete, as constituent material, is assumed to be homogenous, isotropic and elastic in nature with modulus of elasticity and Poisson's ratio of concrete as 25000 N/mm2 and value of Poisson's ratio is 0.2. The yield stress of reinforcement steel is taken as 415 MPa. For seismic analysis, the floor system in the all the configurations is modelled as rigid frame diaphragm and beam and column members modelled as two node beam elements. The foundation in all the models is assumed to be fixed support system. The torsional effects and accidental eccentricity is considered in the analysis as per recommendations of Indian code IS 1893 (Part 1): 2002.

2.1 Geometrical properties

All the models have same geometrical and material properties, and rest on the same inclination of ground which is 26^0. The geometrical properties of the structural elements in the models with designation of different model types are given in Table 1. The inter-storey height is taken as 3 meters and foundation depth is 1.5 m in all the buildings. The thickness of the slab at all floors in all the models is contemplated as 125 mm. The building models are assorted in length along and across the slope, their heights will also be varied accordingly. Where as in step-back setback configurations the length along the slope is carried out from four bays (6 m each) to eight bays with an increment of one bays at each step by keeping width of building persistent to one bay across slope. After that the building length , across the slope is changed from one bay (5 m each) to five bays of same length at one bay at a time by keeping the same number of bays along slope and number of storey's in the structure. The thickness of shear wall is 250mm and M20 grade concrete is used.

Building configuration	STEP-BACK SETBACK	
Parametric variation	4 to 8 bays	1 to 5 bays
Designation of model	SETALS	SETACS
Column size (mm)	All: 400X400	All: 400X400
Beam size (mm)	Across slope : 300X450	

Table 1: Geometrical properties of hill buildings

2.2 Seismic parameters and loads

The seismic parameters considered in dynamic analysis of all the models are assumed as per IS 1893 (Part 1): 2002. The hill buildings are assumed to be in Zone V with the peak ground acceleration value of 0.36g. The importance factor, I is taken as 1.5 (for important building). Also, the response reduction factor R taken as 5 for SMRF system of the buildings. The soil strata beneath the foundation is assumed as medium soil. The gravity and imposed loads are taken as per IS 875 (Part 1 and 2): 1987, self-weight of the structure is calculated and imposed load is assumed to be 3 kN/m2 for a typical residential building. Since, the lateral load due to earth pressure on foundation columns does not take part in the seismic weight of the structure, thus its effect is neglected in the analysis to observe only the effect of lateral forces due to seismic loads. The effect of lateral earth pressure should be considered for design purposes. Then every models are designed, analysed and checked for any failure of members and hence the column size are varied accordingly as the height of the structure increases.

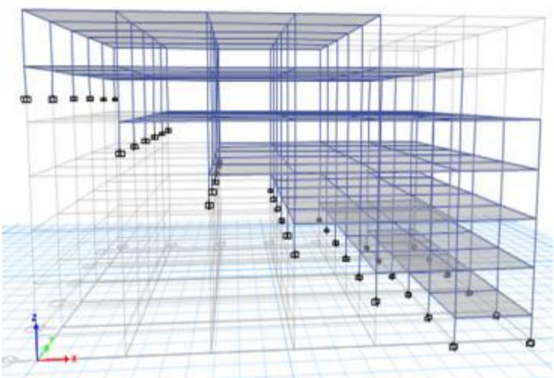

Fig.1 Step-back setback building

3. RESULT AND DISCUSSION

In this study, geometrical variations in the structure of step-back setback configurations with and without shear wall are performed by varying height and length of the buildings in along and across slope direction. In all, eight models of different lengths and widths have been analyzed for earthquake loads and accidental eccentricity as per codal provisions. The hill buildings are subjected to seismic loads independently in either direction viz., along and across slope of the hill. The results obtained in the analyses are discussed in terms of seismic parameters such as storey drift, fundamental time period (FTP), top storey displacement, storey shear and normalized base shear in columns at ground level and compared within the considered effects on hill buildings.

The values of maximum storey displacement, maximum storey drift and storey shear of each model is analysed. Fig 2, fig 3, fig 4 and fig 5 shows the 3-D model, maximum storey displacement, maximum storey drift and storey shear of step-back setback across 4 bays. Fig 6, fig 7, fig 8 and fig 9 shows the 3-D model, maximum storey displacement, maximum storey drift and storey shear of step-back setback across 4 with shear wall.

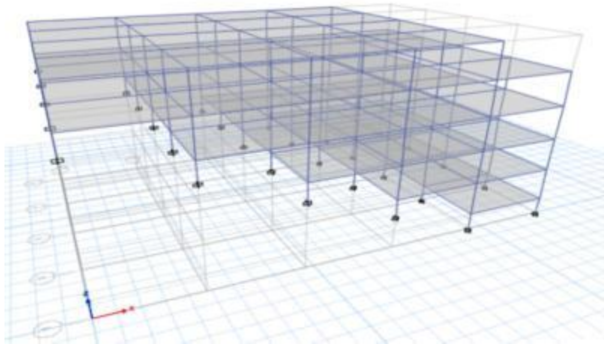

Fig.2 3-D Model of step-back setback across 4 (SETACS 4)

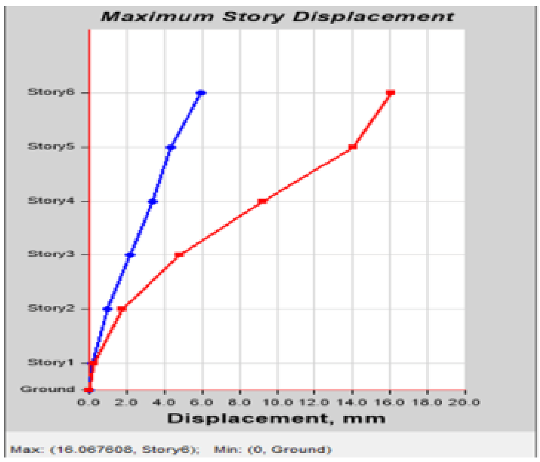

Fig.3 Max storey displacement for SETACS 4

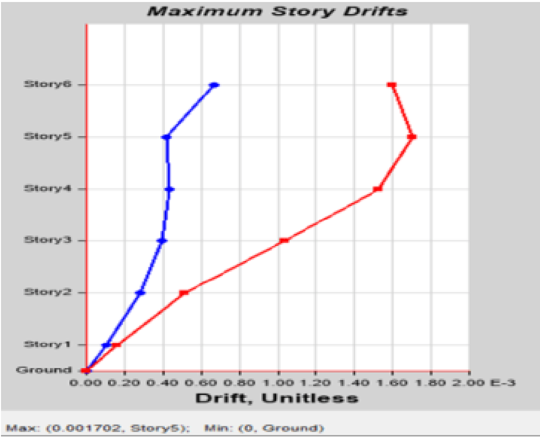

Fig.4 Max storey drift for SETACS 4

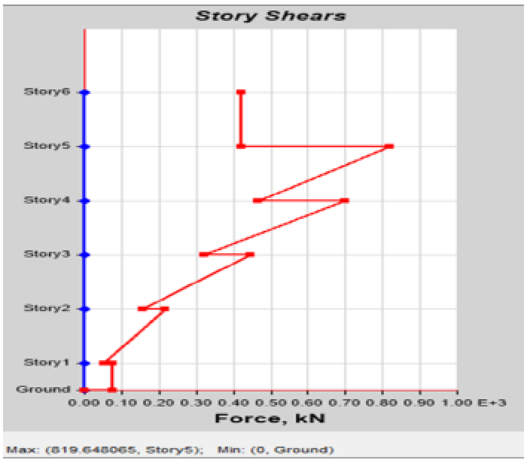

Fig.5 Storey shear for SETACS 4

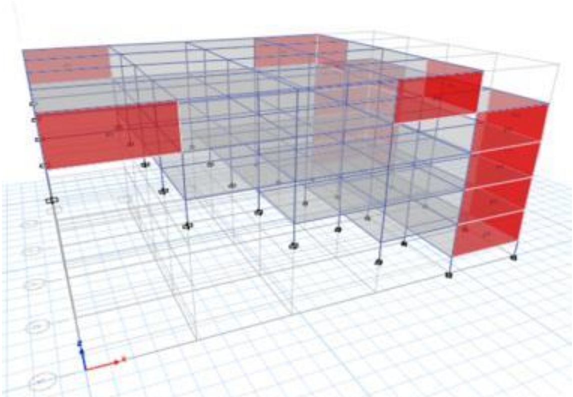

Fig.6 3-D Model of step-back setback across 4 with shear wall (SETACS 4 (SW))

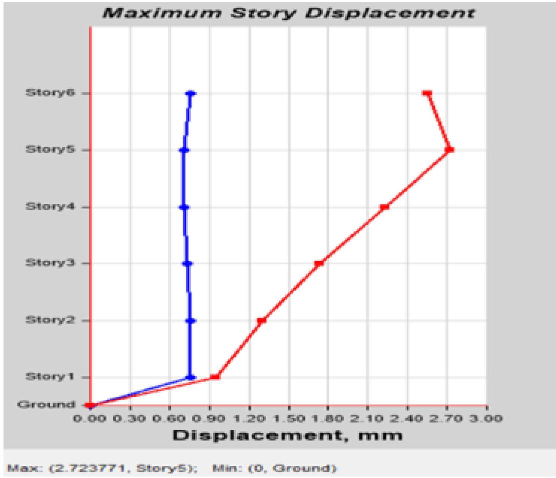

Fig.7 Max storey displacement of SETACS 4 (S W)

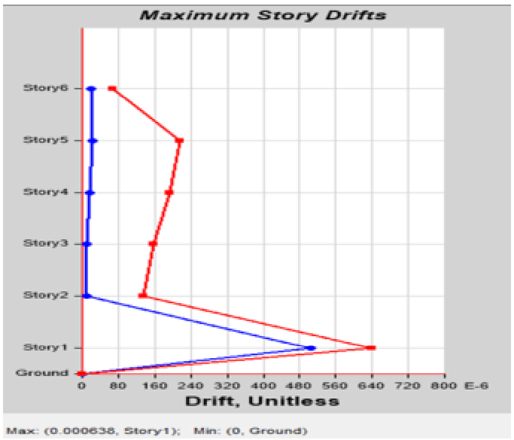

Fig.8 Max storey drift of SETACS 4 (S W)

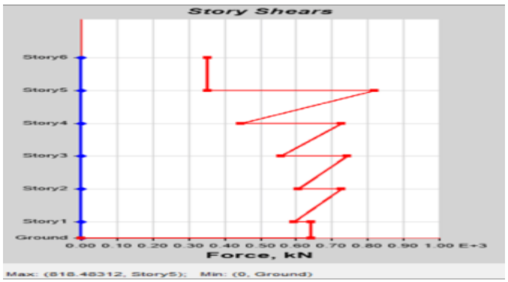

Fig.9 Storey shear of SETACS 4 (S W)

Table 2: comparative study

Models	Max storey displacement		Max storey drift		Storey shear	
	RSX	RSY	RSX	RSY	RSX	RSY
SETACS 4	6.334	16.067	0.0013	0.0017	837.127	819.648
SETACS 4(SW)	1.893	2.728	0.00028	0.00063	843.971	818.483
SETACS 5	6.535	14.641	0.0013	0.0016	1036.26	1034.71
SETACS 5(SW)	1.319	2.735	0.00029	0.00058	1039.28	1007.64
SETALS 6	3.781	8.880	0.00078	0.00094	908.422	890.422
AETALS 6(SW)	0.852	2.104	0.00014	0.00035	900.217	825.230
SETALS 7	3.114	7.710	0.0064	0.00078	747.007	797.109
SETALS 7(SW)	0.724	1.950	0.00011	0.0003	753.008	737.351

By comparing the above table it is observed that step-back setback across 4 has the maximum storey displacement that is 16.0676.By providing shear wall along the corners the displacement is reduced to 2.7287.

4. CONCLUSION

The set-back set back across with shear wall shows better seismic performance compared to without shear wall.

 The maximum storey displacement that is 16.067 is obtained for SETACS 4.

By providing shear wall along corners the displacement can bereduced .

SETACS 4 with shear wall has the lowest value of storey displacement.

By providing shear wall the storey displacement can be reduced to 83%.

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