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Comparative Analysis of Regular and Horizontal Irregular Building on Sloping Ground with Shear Wall and Bracings as Structural Elements using ETABS

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ABSTRACT:Due to rapid urbanization and economic growth there is huge demand for construction of building. Since population density is high it led to construction of buildings on sloping ground, but this sloping grounds like hilly areas are more prone to earthquake which causes severe damage of life and property. The buildings constructed on hilly areas are different from buildings constructed on flat ground buildings on hilly areas have horizontal/plan, vertical, torsional, mass and many more irregularity. The structure irregularities are considered as one of the main fundamentals of its failure. Here we have done seismic analysis of a G+9 regular RCC building, C and I shape building of floor height 3m resting on sloping ground of horizontal angle of inclination 45° on zone II, Response spectrum analysis is done for three cases that is plain building and building with shear wall and bracings for all the three buildings, after analysis the response of the structures with respect to variation in the story drift, story displacement, base shear, story shear has been recorded and will be discussed and concluded.

KEYWORDS: Sloping ground, Response spectrum analysis, Horizontal irregularity, Vertical irregularity, Torsional irregularity, Mass irregularity.

I. INTRODUCTION

The enormous economic growth and swift urbanization has rushed the real estate development, which caused difficulty in excavate or levelling since it is very expensive lead to the construction of building on sloping ground, because to this population growth, population density in hillock has increased abruptly, in order to encounter the population problem construction of tall structure on hill slope is one of the major solution. Construction of Buildings on high ground are different from those in flat ground because it contains lot of irregularities like horizontal, vertical, torsional and so on and most of the high ground areas fall under seismic zones, hence they are vulnerable to earthquake. Despite all this problems Structural Engineers are seeking for the most efficient and economical design and serviceable for its design life time.

Building on sloping ground are subject to lateral earth pressure at many level in addition to more loads on flat ground, these loads transferred to slope foundation level may generate issue of slope instability and may lead to collapse of structure. The soil profile is not constant in high grounds bearing capacity, cohesion, angle of internal friction and other parameters can be dissimilar at different levels which leads to unequal settlement of foundation and local failure of the slope.

1.Irregularities

Irregularities can be categorized into two class Horizontal irregularity Vertical irregularity

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1.1.1Types of Horizontal/Plan irregularity

1.Torsional irregularity- Torsional irregularity is defined as the ratio of maximum horizontal displacement at one end to minimum horizontal displacement at the other is more than 1.2, then torsional irregularity exists as shown in fig 1.



Figure 1: Torsional irregularity

2.Re-entrant Corners-re-entrant corners occur in plan when, more than 15% of the overall plan dimension is projected in that direction by the structure layout. as shown in fig 2.



In a plan any inside corner forms an angle of 180 degree or less then re-entrant irregularity exists



Figure 2: Re-entrant Corners

3.Diaphragm Discontinuity- diaphragm discontinuity is the openings in slabs having excessive cut-out or variation of slab thickness, as a result, due to the frames or vertical members lateral translational stiffness, the lateral force is not shared by them, resulting in variations in stiffness and mass as shown in fig 3.



4.Out of plane offsets-In any story along the height of the building, the vertical parts like walls or frames are shifted out of plane. as shown in fig 4.



Figure 4: Out of plane offsets

5.Non-parallel systems-This kind irregularity exists If the principal orthogonal axes of the seismic force resisting system's vertical lateral force-resisting parts are not parallel as shown in fig 5.

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1.1.2 Type of Vertical Irregularity

1.Stiffness irregularity (**Soft Story**)- A soft story is a story whose lateral stiffness is less than that of the story above as shown in fig 6.



4A STIFFNESS IRREGULARITY (SOFT STOREY)

Figure 6: Stiffness irregularity (Soft Story)

2.Mass Irregularity-This occurs when the seismic weight of any floor is greater than 150% of that of floor below as in fig 7.



4B MASS IRREGULARITY

Figure 7: Mass irregularity

3.Vertical Geometric Irregularity-This occurs when, the horizontal dimension of the lateral force resisting system in any story is more than 125% of that in an adjacent story as in fig 8.



Figure 8: Vertical Geometric irregularity

4.Strength Irregularity (Weak Story) - A weak is story is one in which, the story lateral strength is less than that of the story above as in fig 9.

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4E STRENGTH IRREGULARITY (WEAK STOREY)

Figure 9: Strength Irregularity (Weak Story)

5.In-Plane Discontinuity in vertical elements resisting lateral forces-This irregularity exists when a lateral forceresisting element is present in one story but does not continue or is offset inside the plane of the element in the tale, this occurs in any major lateral force resisting system as shown in fig 10.



4D IN-PLANE DISCONTINUITY IN VERTICAL ELEMENTS RESISTING LATERAL FORCE

Figure 10: In-Plane Discontinuity in vertical elements resisting lateral forces

1.2 OBJECTIVES

- To study the seismic analysis of regular and horizontal irregular (C, I) building on sloping ground using ETBs 2018
- To study the seismic analysis of regular and horizontal irregular (C, I) building with shear wall and bracings on sloping ground using ETBs 2018
- To study the comparison between all the three systems considering story displacement, story drift, story shear and auto lateral loads

II. RELATED WORK

Anjeet Singh Chauhan, Rajiv Banerjee(2021)-In this paper they have studied G+10 RCC Step-back building having varying horizontal inclination of 20°,30°,40° and 45° on sloping ground in seismic zone V in ETABs by Response spectrum analysis. Here they made four models and checked Base shear, Story displacement, story drift and mode period of each models and concluded that as the angle of slope increases Base shear, displacement, drift and Mode period values increases in both directions but Story shear values decreases in both directions for increase in angle of slope.

Birendra Kumar Bohara (2021)-In this paper step-back building having fixed height on sloping ground having different structural elements like shear wall and bracings are used to determine seismic behavior of building using Response spectrum analysis in ETABs software. From the outcomes it is acknowledged that the shear wall placed at the corners gives better results. In bracings X concrete and X steel bracing gives good value compared to the other bracing system.

Satishkumar Guttedar, Sujeet Patil(2020)- Here, the study on seismic analysis of step-back, set-back, step-back setback building resting on sloping ground with bracings is carried out. The outcomes are the top story displacement and story drift of step back building is bit high than step back-set back buildings on sloping ground. Step Back-Set back building Configuration may be favored on sloping ground. Base shear increases when bracings where included this is because of increase in stiffness and x bracing shows least displacement compared to single diamond shape bracings and as the slope increase displacement and story drift increases.

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Syed Nizamuddin Khadri, Bypaneni Krishna Chaitanya et.al (2020)-In this paper study on seismic analysis of G+15 Skyscraper having different slope of $0,10^{\circ},20^{\circ},30^{\circ}$ consisting of shear wall at Centre of all four sides of building in different zones is carried out. The results are like the Fundamental Time period increases as the slope increases by providing the shear wall time period is reduced by 11% - 80%.

III. METHODOLOGY

PROCEDURE FOR MODELING

- 1. Open ETABs 2018 version and select grid only.
- 2. Define story data like number of stories, height between the stories and spacing in X and Y direction.
- 3. Select the desired code from option menu.
- 4. Define material property like concrete and steel from define menu.
- 5. Define section properties like beam, column etc from frame section.
- 6. Define slab from slab section in define menu.
- 7. Provide restraints at base or foundation level.
- 8. Apply load conditions.
- 9. After all the processes check the model if no errors are present run analysis

10. After analysis design check is done, if all the members are passed modelling is complete.

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Fig 11: RCC PLAN

Fig 12: C PLAN



Fig 13: I PLAN

IV. EXPERIMENTAL RESULTS

1 Displacement

	MODEL	X mm	Y mm
RCC	RCC	10.857	10.501
	RCC WITH SHEAR WALL	4.382	7.886
	RCC WITH BRACINGS	10.5	10.208
С	C SHAPE	8.684	7.729
	C WITH SHEAR WALL	4.666	6.054
	C WITH BRACINGS	8.242	7.508
Ι	I SHAPE	9.968	8.357
	I WITH SHEAR WALL	3.973	6.362
	I WITH BRACINGS	9.547	8.144

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2. Drift

	MODEL	X mm	Y mm
	RCC	0.000263	0.00034
RCC	RCC WITH SHEAR WALL	0.00019	0.00029
	RCC WITH BRACINGS	0.000223	0.0003
	C SHAPE	0.000213	0.00026
С	C WITH SHEAR WALL	0.000192	0.00021
	C WITH BRACINGS	0.000185	0.00024
	I SHAPE	0.000245	0.00029
Ι	I WITH SHEAR WALL	0.000183	0.00022
	I WITH BRACINGS	0.000231	0.00026



3.Story shear

	MODEL	X KN	Y KN
RCC	RCC	1373.473	1469.68
	RCC WITH SHEAR WALL	1560.736	1276.36
	RCC WITH BRACINGS	1399.119	1482.41
С	C SHAPE	845.0587	917.944
	C WITH SHEAR WALL	955.8801	746.812
	C WITH BRACINGS	871.9099	927.318
Ι	I SHAPE	849.6901	924.684
	I WITH SHEAR WALL	978.0332	739.847
	I WITH BRACINGS	871.646	934.412

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4. Auto lateral loads

	MODEL	X KN	Y KN
	RCC	2100.259	2100.26
RCC	RCC WITH SHEAR WALL	2082.335	2082.33
	RCC WITH BRACINGS	2124.355	2124.35
	C SHAPE	1536.551	1536.55
С	C WITH SHEAR WALL	1542.936	1542.94
	C WITH BRACINGS	1560.444	1560.44
Ι	I SHAPE	1542.936	1542.94
	I WITH SHEAR WALL	1336.055	1336.05
	I WITH BRACINGS	1377.704	1377.7



V. CONCLUSION

- 1. It is observed that the displacement is reduced by providing shear wall in all the three cases that is displacement in shear wall at corners is less than bracings at corners is less than plain building. (shear wall
sracings<plain building)
- 2. The Base shear value is more when provided with bracings, because the stiffness of building increases increasing base shear value
- 3. The story shear value increases in X direction when shear wall is provided in all the three models but shear value decreases in Y direction
- 4. The auto lateral loads are equal in X and Y direction in all the cases, we can say that providing of structural elements does not make any difference to auto lateral load
- 5. The drift is also less in case of building provided with shear wall than other two cases
- 6. The displacement in comparison with plain building to that of bracings does no show much difference

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7. C shape building shows least displacement compared to I shape and RCC building in all three cases

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