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Seismic Analysis of Irregular Buildings

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Abstract: *In countries like India where the mountains, hills and the plateaus form a significant part of its terrain. It is the increasing demand of the time to construct the RCC Buildings in hilly regions due to urbanization. The construction at hills is different from plains as they are more prone to seismic activities. As the buildings on sloping areas are having irregularities, the behavior of the building during earthquake depends upon the distribution of the mass and stiffness in both the horizontal and vertical direction. They are more susceptible to severe damage. Moreover, during earthquake, irregular buildings in hilly areas serve more damage. Dynamic response of hill buildings is somewhat different than the buildings on flat ground. Short column of RC frame building serves damage because of attracting more forces during earthquake. The RCC Buildings on the hilly regions are narrowed down to basic formats as step back and set back - step back and set back frames. The dynamic response i.e. fundamental time period, storey displacement and drift, and base shear action induced in buildings have been studied for buildings of different heights. The regular, set back and step back building frames are analyzed and compared in this study.*

Keywords: Seismic Analysis, RCC Building, Earthquake.

INTRODUCTION

A building is said to be setback, when it has step like recession while moving vertically/horizontally. Setbacks were initially used for the structural purpose; in ancient time it was used to increase the height of structures by distributing gravity load produced by the building material. Ancient example of setback techniques are step pyramids of Mesopotamia and ancient Egypt. But now a day's setbacks are often mandated by land use codes or are used for aesthetical reasons. There are many rules that apply to urban planning commission to use setback techniques to make sure that streets and yards are provided more open space and sufficient light and air.
Setback techniques also provide usable exterior space, which may be utilized for skyline views, gardening and outdoor dining. In addition, setbacks promote fire safety by spacing buildings and their protruding parts away from each other and allow for passage of firefighting apparatus between buildings. Some examples are: Empire State Building (New York), Willis (sears) tower (Chicago).
A building is said to be step-back, when it is founded on multiple supports at different levels while moving vertically/horizontally.
Step-back buildings are provided where a level foundation is not possible. This is sometimes the only option available in hilly regions.
Symmetrical buildings with uniform mass and stiffness distribution behave in a fairly predictable manner, whereas buildings that are asymmetrical or with areas of discontinuity or irregularity do not. For such buildings, dynamic analysis is used to determine significant response characteristics such as the effect of the structure's dynamic characteristics on the vertical distribution of lateral forces. Due to torsion effect and the influence of higher modes, story shears and deformations increase.

Static method specified in building codes are based on single-mode response with simple corrections for including higher mode effects. While appropriate for simple regular structures, the simplified procedures do not take into account the full range of seismic behaviour of complex structures. Therefore, dynamic analysis is the preferred method for the design of buildings with unusual or irregular geometry.

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LITERATURE REVIEW

Dr. Sanjaya Kumar Patro, Susanta Banerjee, Debasnana Jena, Sourav Kumar Das [1] reviewed a paper analyze the dynamic characteristics of these type of buildings with three different configuration such as a) Step back) Step back-Setback, and c) Setback.
B.G. Birajdar, S.S. Nalawade [2] considered two buildings on sloping ground and one building is on flat soil. The first two are step back buildings and step back-setback buildings; and third is the set back building. The slope is taken 27 degree with horizontal. Depth of footing was taken 1.75m below. Nagarjuna, Shivakumar B. Patil [3] studied step back, set-back buildings and set back buildings situated on sloping ground. Number of storey considered for each type of configurations is 10 storeys. Plan layout of each configuration includes 4 bays across the slope direction and 6 bays are considered along slope direction, which is kept same for all configurations of building frame. Slopes of ground considered are 10- 40 degree 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. He obtained the capacity curve and evaluates the performance with shear wall.
Shivanand.B, H.S.Vidyadhara [4] developed 3D analytical model of 12 storied building generated for symmetric and asymmetric Case. Building models are analyzed and designed by ETABS software to study the effect of influence of bracings, shear wall at different positions. Seismic analysis was done by linear static (ESA), linear dynamic (RSA) and non-linear static Analysis (Pushover analysis).
Chaitrali Arvind Deshpande, Prof. P.M.Mohite [5] analyzed G+6 multistoried building here with storey height of 3.1 m and hard Strata is available at 1.5 m below ground level, slope of ground are 26°, 28°, 30° building configurations are consider comparison of responses of stepback building and stepback-setback with and without bottom ties. G Suresh, Dr.E Arunakanthi [6] carried out three dimensional space frame analysis for two different configurations of buildings ranging from 8 to 10 storey's resting on sloping and plain ground under the action of seismic load and a comparison was made between the three frames i.e. step back, set back, set back and step back.

Y.Singh & Phani Gade [7] presented some observations about seismic behavior of hill buildings during the Sikkim earthquake of September 18, 2011. An analytical study is also performed to investigate the peculiar seismic behavior of hill buildings. Dynamic response of hill buildings is compared with that of regular buildings on flat ground in terms of fundamental period of vibration, pattern of inter-storey drift, column shear, and plastic hinge formation pattern. The seismic behavior of two typical configurations of hill buildings is investigated using linear and non-linear time history analysis. Mario de Stefan, Barbara Pintuuchi [8] reviewed research over seismic behavior of irregular buildings. This paper presents an overview of the progress in research regarding the seismic analysis of the irregular buildings- plan and vertical. Three areas were considered first the effect of plan irregularity second torsional effect and third the vertical irregular building.

Bahrain M. Shahrooz and Jack P. Moehle [9] evaluated effects of setbacks on the earthquake response of multistory building structures. As part of the study, they measured responses to simulated earthquakes of a ductile moment - resisting reinforced concrete test structures. The test structure is a one quarter scale model of a six storey, two bays by two bays building having a 50% setback at mid height. Joseph Penzine [10] presented the approximate method for the determination of the peak seismic response of certain irregular buildings while subjected to base acceleration. This method was based on the forced response of two degree of freedom system and is applied to lateral motion of the buildings having large setbacks coupled lateral torsional motion of the eccentric buildings.

MODELLING

Modeling of regular reinforced concrete building (R), set-back (S1) and step-back (S2) offset of the regular building (Figure 1 and 2) is carried out by Response Spectrum Analysis based on code IS1893:2002, Seismic Coefficient Method as well as Modal Analysis. The results for key parameter such as top storey node displacement, base shear, and base moment, modal responses etc. are tabulated. The results among key parameters are compared in tabular form.

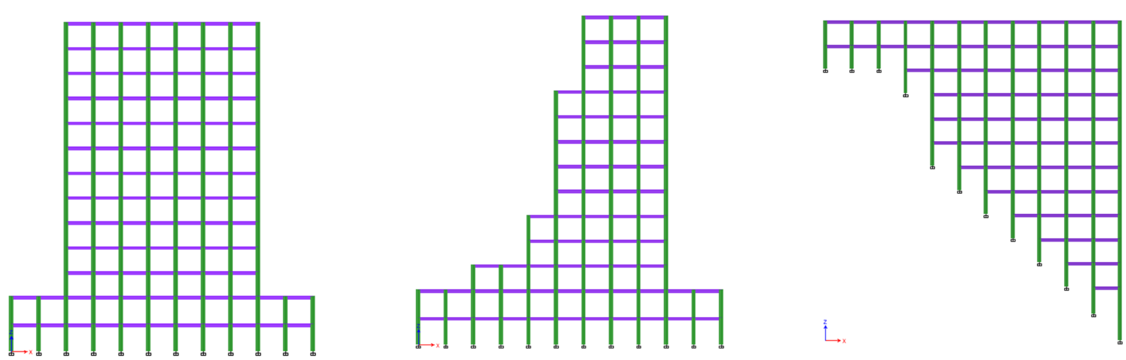

Figure 1. Elevation of the regular, set back and step back building

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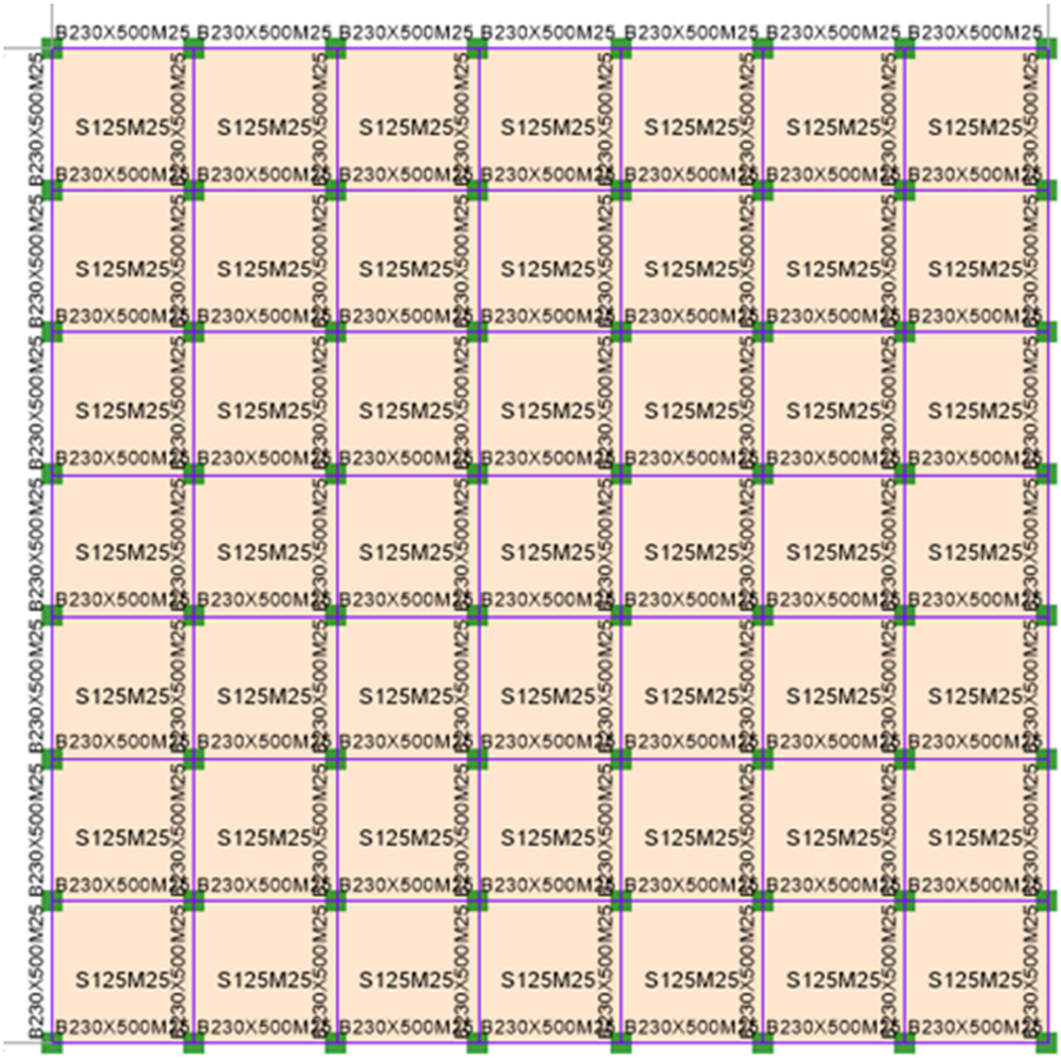

(Dimensions 20m X 28 m)

Figure 2. Floor plan

RESULTS AND DISCUSSION

The parameters for all the selected setback buildings as obtained from different methods available as tabulated below (Table 1 to 3) show that the buildings with same height and width may have different period depending on the amount of irregularity present in the setback buildings. Many empirical formulae suggested by codes do not take into account the irregularities present in buildings and thus they do not change for different type of irregularities.

TABLE 1
COMPARATIVE RESULTS – STOREY SHEAR

		Storey Shear (kN)		
Storey	Elevation (m)	R	S1	S2

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		EQX	EQY	EQX	EQY	EQX	EQY
TF	47.6	802.607	802.607	639.87	639.87	1105.88	1105.88
10F	44	753.932	753.932	604.706	604.706	1033.4	1033.4
9F	40.4	635.609	635.609	509.802	509.802	660.423	660.423
8F	36.8	527.379	527.379	493.723	493.723	474.197	474.197
7F	33.2	429.243	429.243	406.662	406.662	381.76	381.76
6F	29.6	341.201	341.201	323.252	323.252	303.457	303.457
5F	26	263.253	263.253	249.405	249.405	205.031	205.031
4F	22.4	195.399	195.399	185.12	185.12	128.672	128.672
3F	18.8	137.639	137.639	143.584	143.584	74.0754	74.0754
2F	15.2	89.9734	89.9734	94.5799	94.5799	37.5963	37.5963
1F	11.6	52.4014	52.4014	59.1001	59.1001	15.5913	15.5913
GF	8	56.945	56.945	64.5893	64.5893	4.4708	4.4708
UBF	4	15.0809	15.0809	17.1054	17.1054	0.3748	0.3748
Base	0	0	0	0	0	0	0

TABLE 2
COMPARATIVE RESULTS – BASE SHEAR (kN)

R	S1	S2
-4300.66	-3791.5	-4424.924

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TABLE 3
COMPARATIVE RESULTS – DEFLECTIONS

Storey	Elevation (m)	Deflections (mm)					
		R		S1		S2	
		SPECX	SPECY	SPECX	SPECY	SPECX	SPECY
Base	0	0	0	0	0	0	0
UBF	4	1.1	1.1	1	1	0.1	0.1
GF	8	2.9	2.9	2.9	2.9	0.3	0.3
1F	11.6	5.4	5.4	5.3	5.3	0.5	0.6
2F	15.2	8.4	8.4	8.5	8.5	0.7	1
3F	18.8	11.3	11.3	11.6	11.6	1	1.7
4F	22.4	14.1	14.1	14.5	14.5	1.4	2.6
5F	26	16.6	16.6	17.2	17.2	2.1	3.9
6F	29.6	18.8	18.8	19.6	19.6	3	5.4
7F	33.2	20.8	20.8	21.8	21.8	3.8	6.8
8F	36.8	22.5	22.5	23.7	23.7	3.7	7.6
9F	40.4	24	24	25.2	25.2	3.3	8
10F	44	25.1	25.1	26.4	26.4	3.4	8.6
TF	47.6	25.8	25.8	27.3	27.3	4.4	9.5

CONCLUSION

The following conclusions are drawn after the analysis:
1. Seismic behavior of set-back buildings is very much similar to regular buildings. Step-back buildings have completely different behavior.
2. Base shear is found to be maximum for step-back building, followed by regular and set-back buildings.
3. Storey displacements are much higher for regular and set-back buildings compared to step-back buildings.

REFERENCES

[1] Dr. Sanjaya Kumar Patro, Susanta Banerjee, Debasnana Jena, Sourav Kumar Das, "A Review on Seismic Analysis Of a Building on sloping ground"

[2] B.G. Birajdar, S.S. Nalawade," SEISMIC ANALYSIS OF BUILDINGS RESTING ON SLOPING GROUND"

[3] Nagarjuna, Shivakumar B. Patil," LATERAL STABILITY OF MULTISTOREY BUILDING ON SLOPING GROUND"

[4] Shivanand.B, H.S.Vidyadhara," DESIGN OF 3D RC FRAME ON SLOPING GROUND"

Cite this article as: Akil Ahmed. "Seismic Analysis of Irregular Buildings". *International Conference on Inter Disciplinary Research in Engineering and Technology (2016)*: 106-111. Print.

[5] Chaitrali Arvind Deshpande, Prof. P.M.Mohite," Effect of Sloping Ground on Step-Back And Setback Configurations of R.C.C.Frame Building"
[6] GSuresh1, Dr.E Arunakanthi2,"Seismic Analysis of Buildings Resting on sloping Ground and Considering Bracing System"
[7] Y.Singh & Phani Gade," Seismic Behavior of Buildings Located on Slopes An Analytical Study and Some Observations From Sikkim Earthquake of September 18, 2011."
[8] Mario de Stefan, Barbara pintuuchi," review of research over seismic behavior of irregular buildings"-
[9] Bahrain M. Shahrooz1 and Jack P. Moehle, "Seismic Response and Design of Setback Buildings"-
[10] Joseph penzine,"earthquake response of irregularly shaped building"-
[11] IS: 1893 (I)-2002. "Criteria for Earthquake Resistant Design of Structures" BIS, New Delhi.
[12] IS 456:2000,"Indian Standard Code of Practice for Plane and Reinforced concrete", Bureau of Indian Standards, New Delhi.

Cite this article as: Akil Ahmed. "Seismic Analysis of Irregular Buildings". *International Conference on Inter Disciplinary Research in Engineering and Technology (2016)*: 106-111. Print.