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Seismic Performance of Multi-Storey RCC building Resting on Sloping Ground

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***Abstract**: In our day to day life increases Population. So that there is increasing basic need of human being. I.e. Food, Clothing, Shelter. In this, Shelter is most required in recently situation for protected from environment. Mostly we use level or plain ground for construction of houses. However, now it is very less for utilization of level land. Therefore, required more land to use for fulfillment human need. I.e. required to use of land on sloping ground also. When we construct building on sloping ground, it is irregular; centre of gravity and mass does not match to vertical and horizontal plane. So, while construction of Multi storey building on sloping ground required proper design and analysis. For analysis we consider four types of building configuration step back, set back, step back and set back frames and regular building on plain ground. Also, 10 and 12 storey considered. In that, base shear, displacement and storey drift find out and compare same with other building configuration by using ETABS Software.*

Keywords: Etabs, Level Ground, Seismic Performance, Sloping ground.

I. INTRODUCTION

In the last 10 years, all fields had gone under fast modification for economic development. For construction of building on level ground, we use brick work, stone work either undressed or dressed. But level land in hilly region is very limited. So, it occurs more demand for construction of multistory building work on hill slopes also. Therefore to construct multistory reinforced concrete building on hill slope is the requirement for complete demand on hill slope for residential and commercial activities. Rapid growth of population has led to urbanization which has adversely affected environment. Due to population pressure, natural resources in the cities are depleted at a fast rate due to population pressure. One of the factors responsible for environment degradation is population growth or population density. In particular, population density plays the most important role in shaping the socio-economic environment. Its effects are felt on the natural environment also.

The aim of population control is not only to bring about a decline in fertility rates but also to improve the quality of life of the people. These are possible through rapid economic development. It is not an illusion to believe that a reduction in population growth will automatically raise living standards. In fact, an effective family planning policy should be integrated with measures to accelerate economic development.

It is proved from last observation regarding earthquakes, multistory buildings on hilly region has high damaged, collapsed though they have been designed for safety against natural hazards. So, while construction of building in hilly areas should be free from earthquakes.

When buildings located on hill slopes are mostly irregular, torsionally coupled hence susceptible to severe damage during the earthquake such buildings have mass & stiffness varying along the horizontal & vertical plane. The centre of mass & centre of rigidity do not coincide on various floors.

II. BUILDING CONFIGURATIONS

1. STEPBACK BUILDING

In step back multi-storied building configuration top at same level but base unequal of all bays. The floors of such buildings Step back towards the hill slope. Center of mass of all floors does not lie on one vertical axis.

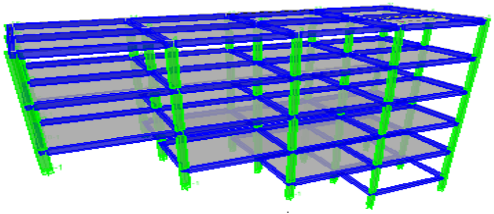

Fig. 1 Stepback Uilding

2. SETBACK BUILDING

In setback multi-storied building configuration top unequal but base equal level of all bays. The centre of mass of all the floors lies on the same vertical axis is true only for buildings which has symmetrical setback on all sides.

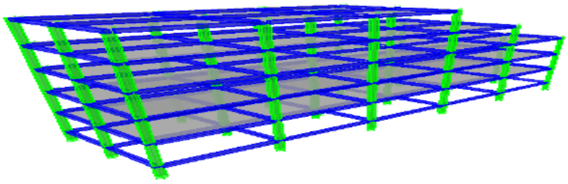

Fig.2 Setback Building

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3. STEPBACK-SETBACK BUILDING

In step back-Setback multi-storied building configuration top and base unequal of all bays. The floors of such buildings Step back towards and away the hill slope. Center of mass of all floors does not lie on one vertical axis.

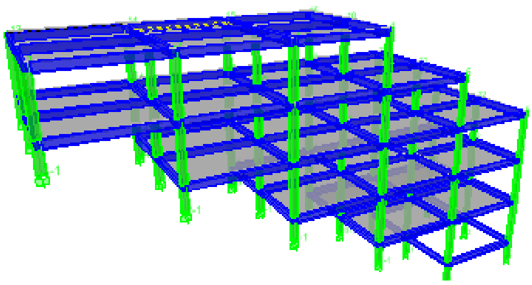

Fig.3 Stepback-Setback Building

4. REQULAR BUILDING ON PLAIN GROUND

In regular building on plain ground top and base equal. Building having simple and clear geometry having minimum damage as compare to other irregular building configuration. Also, it has uniformly distributed mass and stiffness throughout the building.

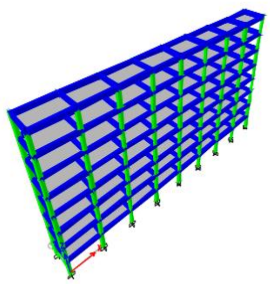

Fig.4 Reqular Building On Plain Ground

III. MODEL DECRIPTION

i. The slope of ground 27degree with horizontal, which is neither too steep nor too flat.
ii.The dynamic analysis is carried out using response spectrum method to the step back and set back , step back building , set back building and regular building on plain ground.
iii. The Size of block 7mx5mx3.5m .i.e. 7m in length , 5m in width both in horizontal direction and 3.5 m in height vertical direction.
iv. The depth of footing below ground level is taken as 1.8 m where, the hard stratum is available.
v. Basically model consists of one bay with four groups of building Configurations.
vi. Four different configuration of building ranges 10 and 12 stories on sloping ground 3D space frame analysis carried out by action of seismic load using Etabs software.

IV. GEOMETRICAL PROPERTIES OF MEMBERS

For analysis of seismic performance of Multi-Storeyed building on sloping ground considered following geometrical properties of members.

Table no: 1 Geometrical property of members for different configurations of Building

Building Configurations	**Number of storey's**	**Size of Column in mm**	**Size of Beam in mm**
Step back building	STEP10-STEP12	400X830	300 X530
Step back and Setback building	STEP-SET10-STEP-SET12	400X830	300X530
Set back building	SET10-SET12	400X830	300X530
Regular Building on Plain Ground	REG10 to REG12	400X830	300X530

V. FOLLOWINGS ARE ASSUMPTIONS FOR THE ANALYSIS:

i) Properties used for material is homogenous, isotropic and elastic.
ii) Structure Type: multi-storey rigid joined plane frame (special RC moment resisting frame)
iii) Number of Stories: different configurations of four buildings ranging from G+10, G+12.
iv) Infill wall: For all floors 230mm thick.
v) Specific weight of RCC: 25 KN/M3
vi) Properties of Material: Concrete grade is M25 and steel reinforcement is Fe500.
vii) Dynamic analysis is carried out using response spectrum method
viii) For all floors depth of slab is take as 225 mm thickness
ix) Parapet Height: 1.2M
x) Response Spectra: IS 1893 (Part 1) : 2002

VI. LOAD ANALYSIS:

1. Dead Load:

Dead loads can be defined as "It is self weight of structure present as permanent or stationary loads which are transferred to the structure or structural members throughout their life Span." Dead load is mainly due to self weight of structural members, permanent partition walls, fixed permanent equipment and fittings. The magnitude of dead load is calculated from the unit weight of different materials. It does depend upon unit weight of material.
The IS Code 875 (part-I)-1987, Page No.08 and Table 1 used for unit weight of building materials . From the table 1, the unit weight of concrete is taken as 25kN/m3, assuming 5% steel in the reinforced concrete.
Self-weight of the structural elements

a) Wall load on each floor beam = 13.66 kN/m
b) Wall load on roof beam = 5.22 kN/m and
c) Floor finish = 1.5 kN/m2

2. Live/Imposed Load:

Live load defined as "It is movable and temporary load on floors and roofs on the structure without any acceleration or impact."
These loads are assumed to be produced by the intended use or occupancy of the building including weight of movable partition or furniture etc. The imposed loads to be assumed in design of building are contained in IS: 875 (Part-2) 1987, Table 1.

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The floor slabs have to be designed to carry either uniformly distributed loads or concentrated loads, whichever produce greater stresses in the part under consideration. Since it is unlikely that at any one particular time all floors will be simultaneously carrying maximum loading, the code permits some reduction in loads in designing columns, load bearing walls, pier and their support and foundations. The imposed loads depend upon the use of building.

a) Live load on each floor = 4 kN/m2

b) Live load on roof floor =2 kN/m2

3. Seismic/Earthquake Load:

Earthquake loads depend upon the place where the building is located. As per IS 1893-2002 (Part-I) (General Provisions for Buildings), India is divided into four seismic zones. The code gives recommendations for earthquake resistant design of structures. Now, it is mandatory to follow these recommendations for design of structures.

As per IS 1893(Part I) -2002 following parameters considered for earthquake Load analysis.
1) Moderate seismic zone (III)
2) Zone factor 0.16
3) Importance factor 1.0
4) Response Reduction factor 5.0
5) Presuming special RC moment resisting frame for all configurations and height of building.
6) Average response acceleration coefficient for rock or soil sites.

Sa/g = 1+15 T when $0.00 \leq T \leq 0.10$ seconds
2.50 $0.10 \leq T \leq 0.40$ seconds
1/T $0.40 \leq T \leq 4.00$ seconds

4. Load Combination:

Four different load combinations considered as per the code (IS 1893PartI: 2002) which are as following
1)Combination 1 1.5(DL+LL)
2)Combination 2 1.2(DL+LL±EL)
3)Combination 3 1.5(DL ±EL)
4)Combination 4 0.9DL±1.5EL

VII. SEISMIC ANALYSIS

Since earthquake forces are random in nature and unpredictable, the static and dynamic analysis of the structures have become the primary concern of civil engineers. The main parameters of the seismic analysis of structures are load carrying capacity, ductility, stiffness, damping and mass. IS 1893-2002 is used to carry out the seismic analysis of multi-storey building. It is used to understand the response of buildings due to seismic excitations in a simpler manner. There are different types of seismic analysis methods. Some of them used in the project are
1. Equivalent Static or linear static Method.
2. Response Spectrum Method/ linear dynamic analysis.
3. Time History Method/Nonlinear Dynamic analysis.
4.Non-linear static method/Pushover method.

1 .Equivalent Static Lateral Force Method

The use of this method is restricted with respect o high seismic zones and height of the structure (low rise), buildings having higher modes of vibration than the fundamental mode, structures having significant discontinuities in mass and stiffness long the height. However, it accounts for the dynamics of building approximate manner.

2. Response Spectrum Method/ Linear Dynamic Analysis:

Dynamic analysis is carried by using response spectrum method. In this method peak response of a structure during an earthquake is obtained directly from earthquake response spectrum. Response spectrum method of analysis shall be performed using the design spectrum specified in Clause 6.4.2 or by a site specific design, spectrum mentioned in Clause 6.4.6 of IS 1893(Part 1):2002

3. Time History Method/Nonlinear Dynamic analysis:

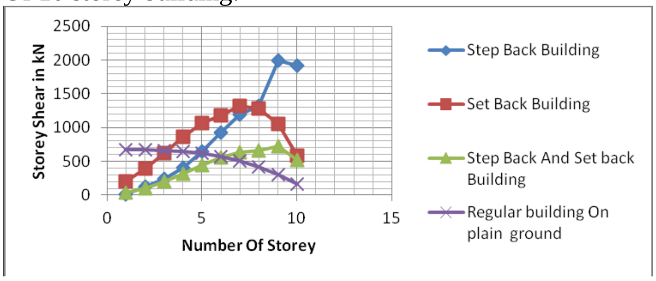
In this method, the mathematical model of the building is subjected to accelerations from earthquake records that represent the expected earthquake at the base of the structure. In elastic analysis the stiffness characteristics of the structure re assumed to be constant for the whole during o the structures. It is the most sophisticated analysis method available to a structural engineer. This method based on limited suitable assumptions made for design of structures. It considers the structure's non-linear properties over time, and therefore gives results that are relatively more reliable than other forms of seismic analysis.

4. Non-linear static (pushover) analysis:

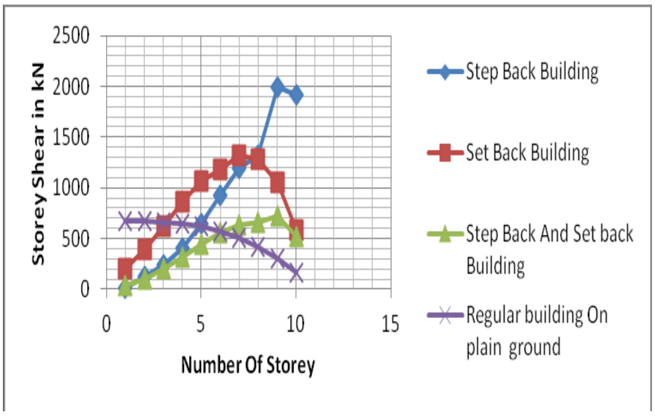
It applies calculated forces to the computer models that include non-linear properties — that is, doubling the force applied does not cause an equivalent increase in response, but either a greater or a lesser response.

VIII. RESULTS AND DISCUSSIONS

a) Comparison of storey shear step back building, Setback Building, Step back and Setback building And regular building on plain ground frames Of 10 storey building:



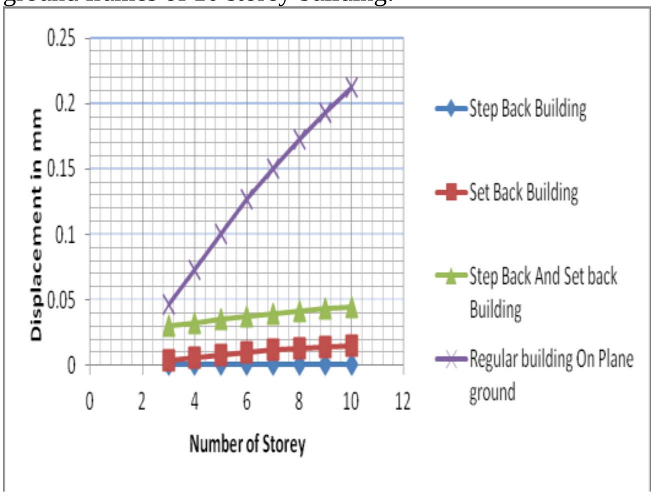
Graph 1 Storey Shear variation with respect to Number of Storey for 10 Storey



Graph 2 Displacement variations with respect to Number of Storey for 10 Storey

Result Conclusion: From the above graph storey shear for first stories step back building and Step-set back building are less than set back frames and regular building on plain ground.

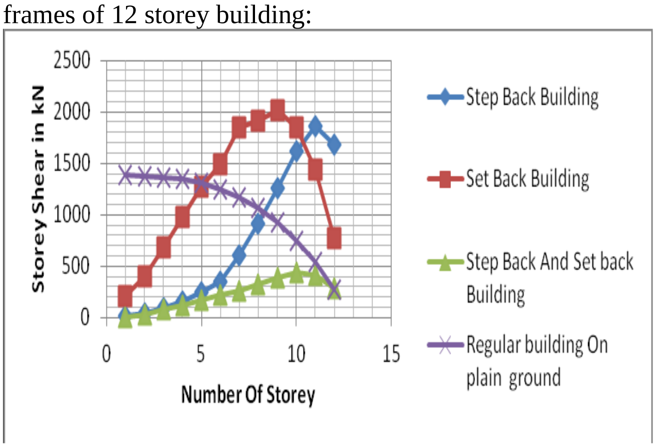
b)Comparison of displacement between step back , set back building , step back and set back and regular building on plain ground frames of 10 storey building:



Graph 3 Storey Drift with respect to Number of Storey for 10 Storey

Result Conclusion: from the above graph Storey Drift for Top stories step back and regular building on plain ground frames are more than step back and set back building frames and Set back building.

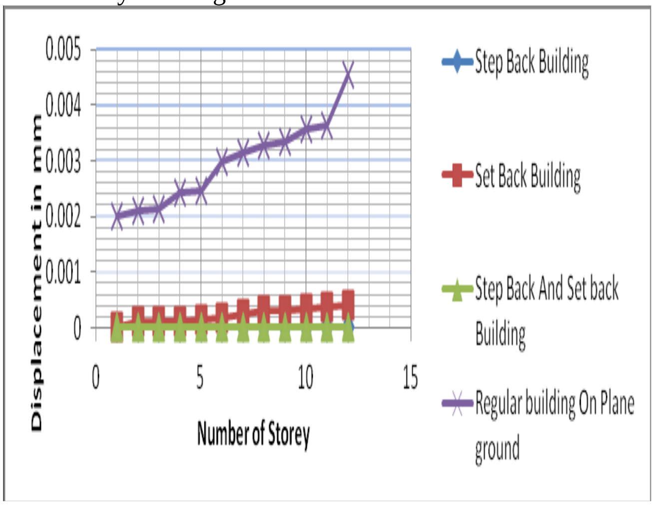
d) Comparison of storey shear between step back , set back , step back and set back and regular building on plain ground frames of 12 storey building:



Graph 4 Storey Shear variation with respect to Number of Storey

Result Conclusion: from the above graph storey shear for first stories step back and step-set frames are less than set back and Regular building on plain ground.

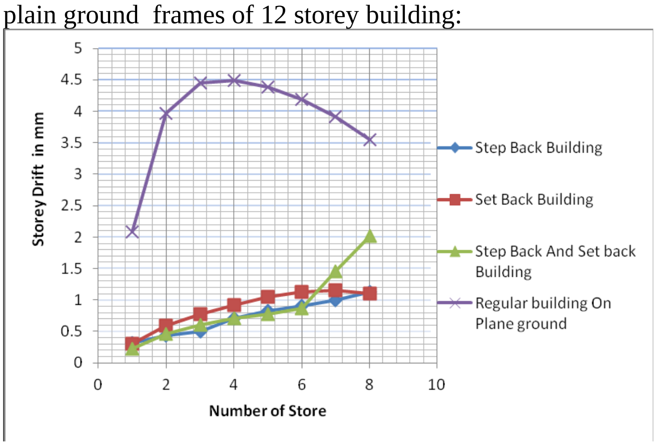
D)Comparison of displacement between step back without bracings, step back with bracings, step back and set back without bracing and regular building on plain ground frames of 12 storey building:



Graph 5 Displacement variations with respect to Number of Storey for 12 Storey

Result Conclusion: from the above graph displacement for Top stories set back and regular building on plain ground are more than step back building and Step-set back building.

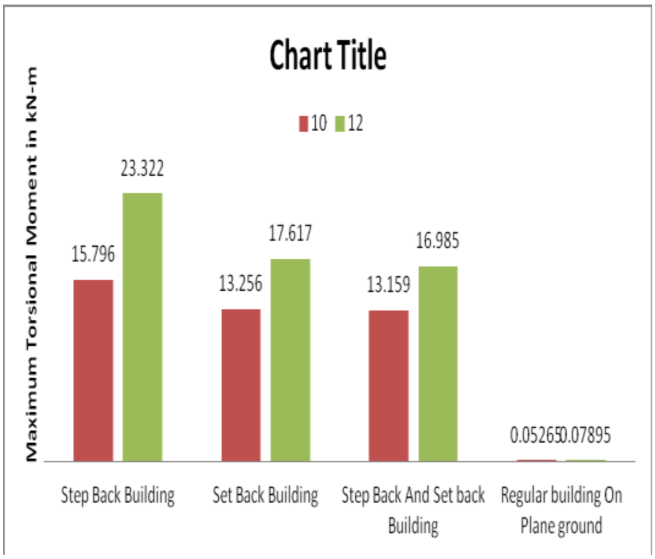
f) Comparison of Storey Drift between step back , set back , step back and set back and regular building on plain ground frames of 12 storey building:



Graph 6 Storey Drift with respect to Number of Storey for 12 Storey

Result Conclusion: from the above graph Storey drift for Top stories Set back building and step back building are less than regular building on plain ground frames and Step back and set back building frames.

g) Comparison of Maximum Torsionally Moment between step back , set back , step back and set back and regular building on plain ground frames of 10 and12 storey building:



Graph 7 Maximum Torsionally Moment of Building Configurations for 10 and 12 Storey

X. CONCLUSION:

The following conclusions have been drawn based on the results obtained from present study:

1. As per above comparison between four building configuration it can be concludes step back building performance during seismic excitation could prove more pregnable than other building configuration.
2. Also, as per comparison studies found that least in Step back-Setback and Setback building as compare to other configurations.
3. As number of storey increases top storey displacement is increased.
4. Step back-setback building may be Favored on Sloping ground.
5. In case of sloping ground has less base shear as compare to regular building on plain ground.

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