Ilkogretim Online - Elementary Education Online, 2021; Vol 20 (Issue 5): pp. 6701-6715
http://ilkogretim-online.org
doi: 10.17051/ilkonline.2021.05.759

STUDY ON SEISMIC PERFORMANCE OF REGULAR AND IRREGULAR BUILDINGS WITH AND WITHOUT VERTICAL SET BACK

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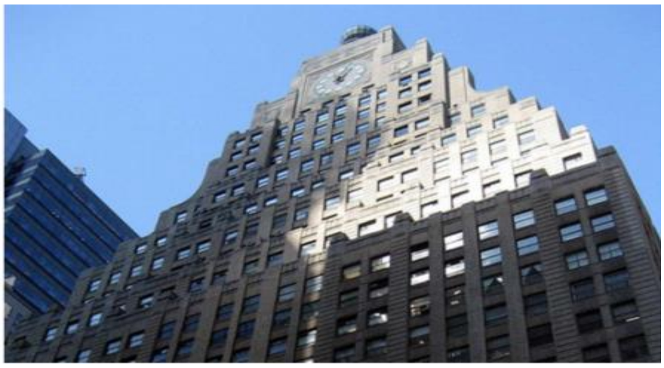
Abstract: These days performance of a high rise building during strong earthquake motions depends on the distribution of stiffness, strength and mass along both the vertical and horizontal directions. If there is discontinuity in stiffness, strength and mass between adjoining storey's of a building then such a building is known as irregular building. Modern residential structure are going higher and higher these days. The impact of lateral loads in the form of wind/Earthquakes affects the performance of these structures dramatically. It is often a common practice among structural engineers to use shear walls in place of columns. In the present study, review of G+10 multi-storey building with and without setback is carried out. Structural members are designed according to IS456-2000. The structure is analyzed by using ETABS v 9.7.1 software. Load consideration is based on Indian code. All necessary load combinations are considered in shear walls analysis and frame analysis. In addition wind load, seismic load is considered as external lateral load in the dynamic analysis. In dynamic analysis; Response Spectrum method is used. The values of story drift, story shear, story bending, time period, frequency and model stiffness values are compared for regular and irregular buildings.

Keywords: seismic, irregular buildings, vertical set back

I. INTRODUCTION

In multi-storeyed sealed buildings, damage incurred by quake ground movement often begins with areas of simple deficiency due to parallel loads of opposite sides. This behavior of multi-story encircled structures in the midst of solid tremor movements relies on the dispersion of mass, firmness and quality in both the flat and vertical plane of the structures. Now and again, these vulnerabilities could be caused by discontinuities in firmness, consistency or mass between neighboring storeys. These discontinuities between storeys are also correlated with abrupt changes in the geometry of the edges along the height. There are several examples of disappointment in systems in previous quakes owing to such vertical discontinuities. Auxiliary architects have built faith in the outline of systems in which the appropriations for mass, solidity and consistency are reasonably standardized. Be it as it can, there is less clarity about the construction of systems with unpredictable geometrical configurations. A common form of vertical geometric abnormality in building systems is the proximity of difficulties, i.e. the proximity of abrupt falls in horizontal dimensions of work at specific height levels. This building classification is referred to as 'difficulty building.' This building framework is increasingly becoming more prevalent in the new multi-storey building growth largely in view of its useful and tasteful architecture. Specifically, such a mishap offers satisfactory sunlight and airflow for the lower floors of a metropolitan environment with highly scattered tall buildings. In addition, this style of building system allows for continuity building by-law containment's associated with the 'floor zone proportion' (hone in India).


The paramount building at New York, United States [Source: https://untappedcities.com/]


Typical Setback building at India [Source: http://www.onlinejournal.in/IJIRV2I7/064.pdf]

Objectives study: The core goals of the project are as follows:

1. To investigate the seismic performance of multi-story buildings in IS 1893:2002.
2. To compare multi-story buildings with and without vertically stacked floors in both regular and irregular buildings.
3. To compare the effects of tale drift, shear force, bending moment, and construction torque for normal and unusual buildings, with and without vertical reverses.
4. To study test buildings in ETABS V9.7.4, a spectrum analysis was conducted.

II. LITERATURE REVIEW

Hema Venkata Sekhar presented analysis is carried out with G+7 Three building models with and without vertical set back models. From this study it was observed that the time history analysis will not give proper results when it compared with Response spectrum analysis. The major drawback of this research is that they only concentrated on Regular building models irregular models are not considered for analysis.

Aashish Kumar, Aman Malik, Neeraj Mehta presented study of vertical irregular building model is considered by using Time history analysis. From the results it was observed that by using Time history analysis the building is not getting accurate results as we compared with Response spectrum analysis case. The major advantage of this project is that vertical irregularity is considered for analysis.

Devesh P. Soni and Bharat B. Mistry study is to study the floating column building with vertical set back structure under the seismic loading condition. From this study it was taken point as when we increase the irregularity of the building by height it has higher values of deflection, shear, bending torsion values.

III. METHODOLOGY AND TYPES OF LOADS ON BUILDING

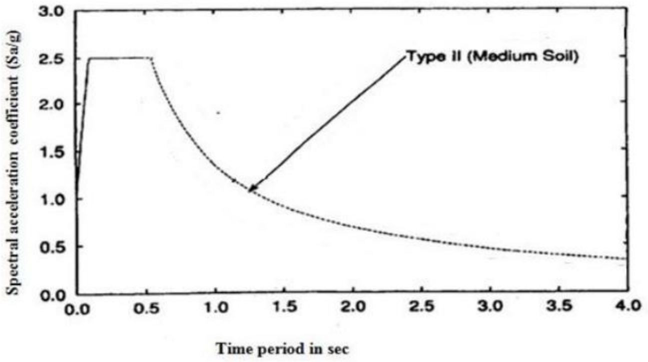
Response Spectrum Analysis:: For buildings without resistance to earthquakes, seismic analyses should be carried out. Seismic research considers complex results, which often makes precise analysis difficult.

However, a linear static analysis is appropriate for simple normal structures. This form of study for standard and low-cost buildings will be conducted and this approach will provide positive results for those buildings.

The construction will be dynamically analyzed in accordance with code IS 1893-2002. (part1). The dynamic analysis would be done using either the response continuum method or the time history method unique to the location. The analytical technique is followed by processes.

Response Spectrum Method

The idealized one-degree liberty system represents the maximum solution, supplying time and damping for earthquakes. This analysis is conducted according to the IS 1893-2002 code (part1). The seismic zone factor of IS 1893-2002 is to be entered in this kind of soil (part1). For the analysis in the 2013 ETABS software the fundamental response spectra for the type of soil considered are employed. The following diagram shows the typical response continuum for the medium soil type, which can be given in the form of time versus spectral acceleration coefficient (Sa/g).



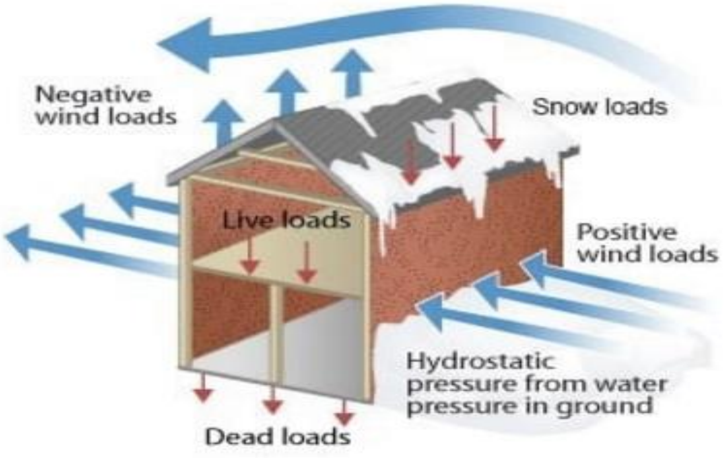
Response spectrum for medium soil type for 5% damping [Source: (http://www.scirp.org/journal/eng)

This approach takes into account the various modes of building reaction (in the frequency domain). All this, except for basic or complex buildings, is expected in some building codes. A compositional response can be defined as a combination of different modes, which correlate with the "harmonic" analysis of the unit in a vibrating string to choose these modes for a structure. The response is read from the architecture continuum and then is combined to provide an estimation of the total structure response based on the model frequency and modal mass. We ought to measure the magnitude of strength to see the impact on the house in both directions, i.e. X, Y and Z.
Methods for mixture include the following:

- Absolute - The full values are added together.
- Square root (SRSS) of the sum of squares
- Full quadratic mix (CQC) - a technique that boosts SRSS for closely spaced modes

Types of loads acting on the building:

The load forms acting on building structures and other structures can, as vertical charges, horizontal loads and longitudinal loads, be widely classified. Vertical loads are dead loads, living loads and loads of effect. Wind loads and earthquake loads have horizontal loads. In the special case of construction of the bridges, gateways etc., the longitudinal loads i.e. tractive and braking forces are considered.



Various types of loads acting on building [Source: https://theconstructor.org/structural-engg/types-of-loads-on-structure/1698/]

Types of loads acting on the structure are:

- Dead loads
- Imposed loads
- Wind loads
- Snow loads
- Earthquake loads
- Special loads

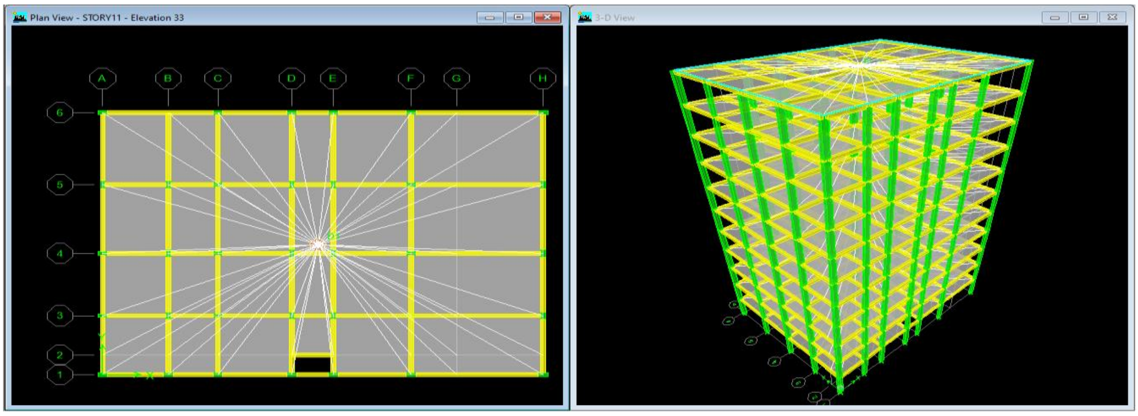
IV. MODELLING OF BUILDING STRUCTURES

In the present study, review of G+10 multi-storey building in zone V, with and without setback is carried out. 3D model is prepared in the framework of ETABS. Basic parameters considered for the analysis are

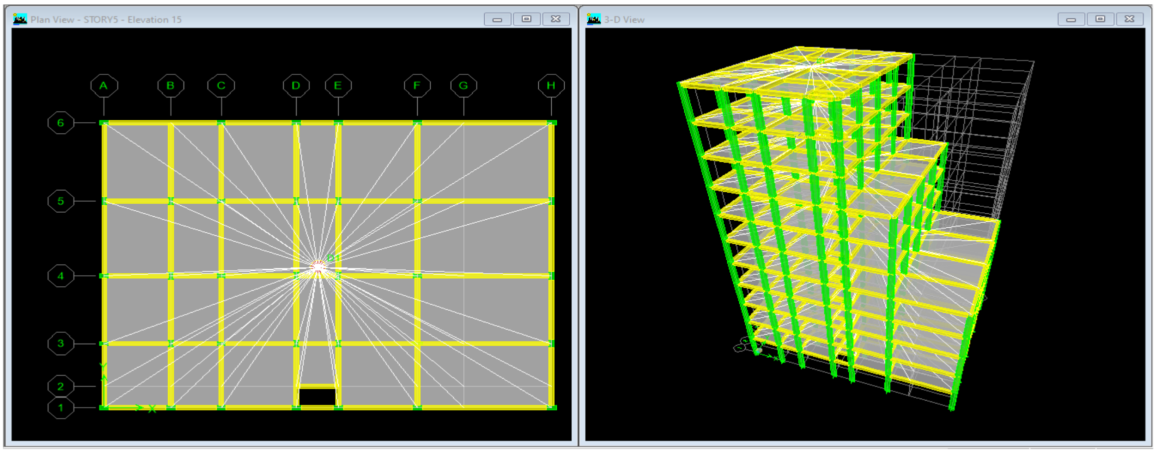
1. Utility of building : Residential building
2. Number of stories : G+10
3. Geometric details
a. Ground floor : 3m
b. floor to floor height : 3m
4. Material details
a. Concrete Grade : M40 (COLUMNS AND BEAMS)
b. All Steel Grades : HYSD reinforcement of Grade Fe550
c. Bearing Capacity of Soil : 200 KN/m^2
5. Type Of Construction : R.C.C FRAMED structure
6. Column : 0.4m X 0.8m
7. Beams : 0.8m X 0.8m
8. Slab : 0.150m
9. Thickness of Shear wall : 230 mm

MODELS IN ETABS V 9.7.4

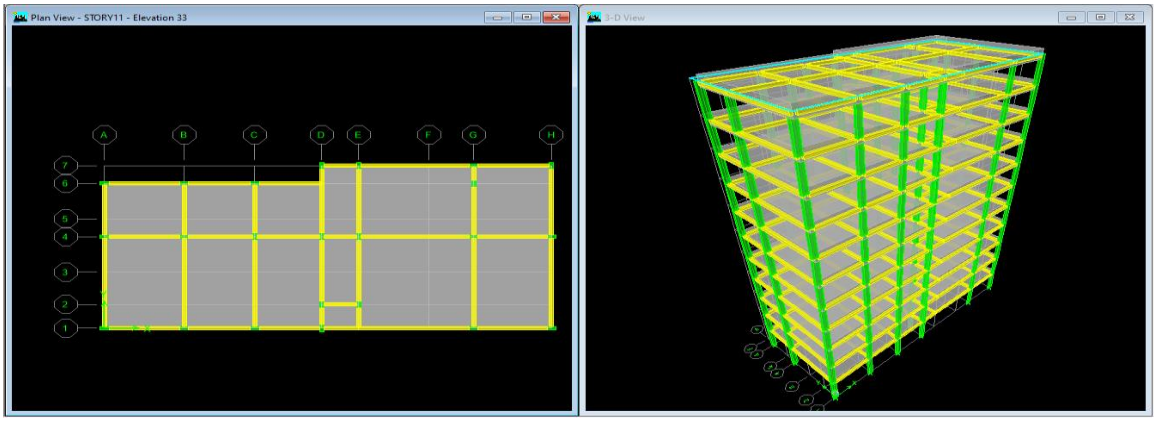
4.3.1 Regular model without set back



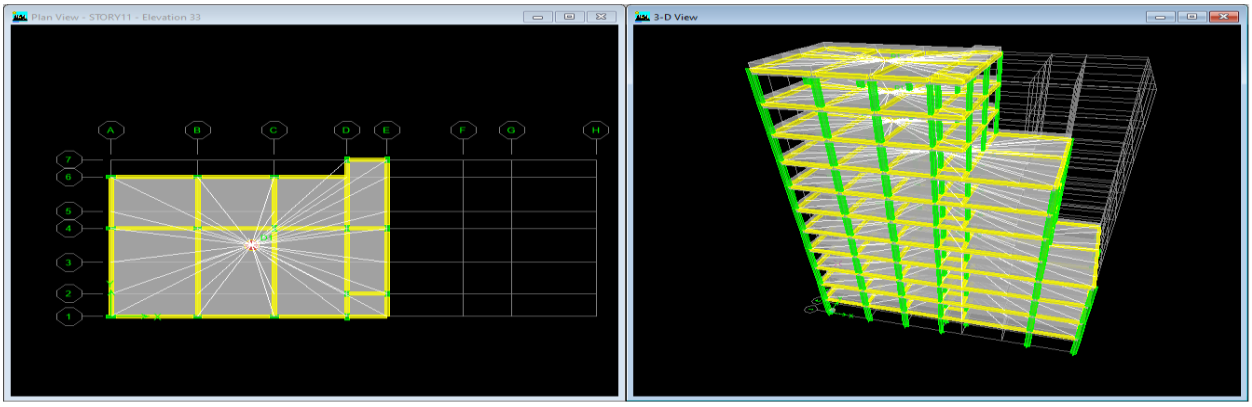
4.3.2 Regular model with set back



4.3.3 Irregular model without setback



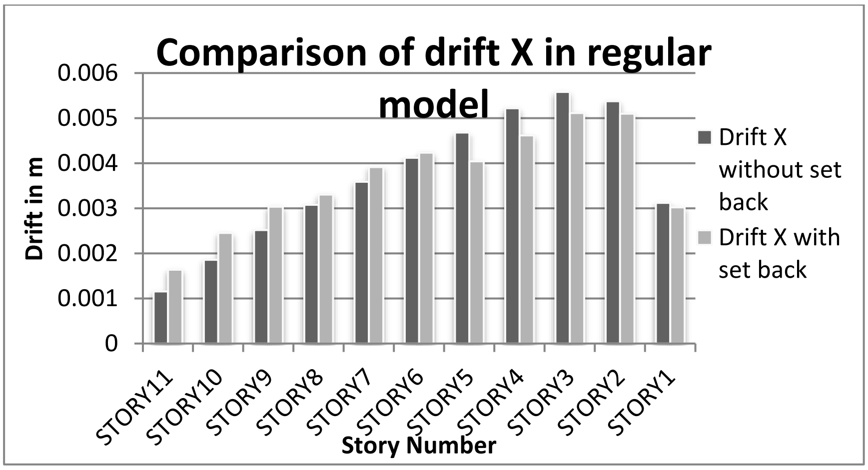
4.3.4 Irregular model with set back



V. RESULTS AND ANALYSIS

5.1 Regular

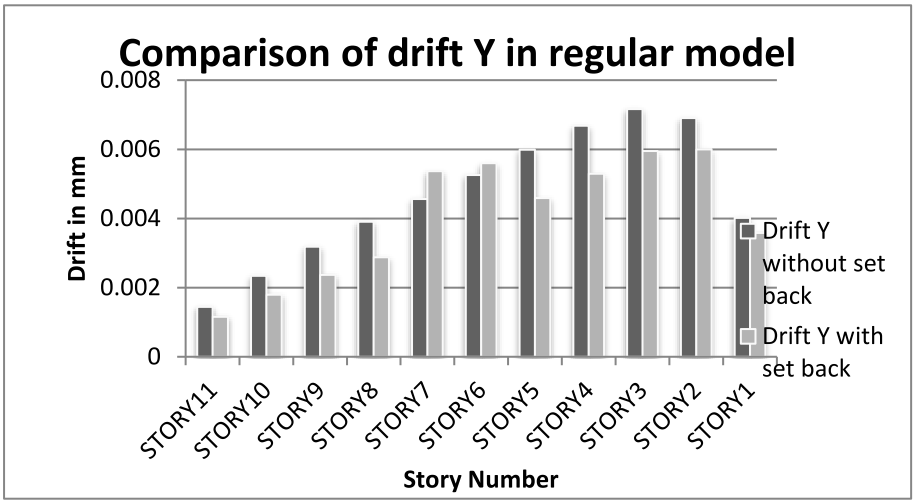
5.1.1 Story Drift in X direction



Graph 5.1 Comparison of Story Drift in X direction for regular building

The graph and table above reveals that the storage drift in X direction is less intensive than storage 11 to 6, without the backbone of an unmounted drift. And the worth of the reversal building from storey 5 is greater.

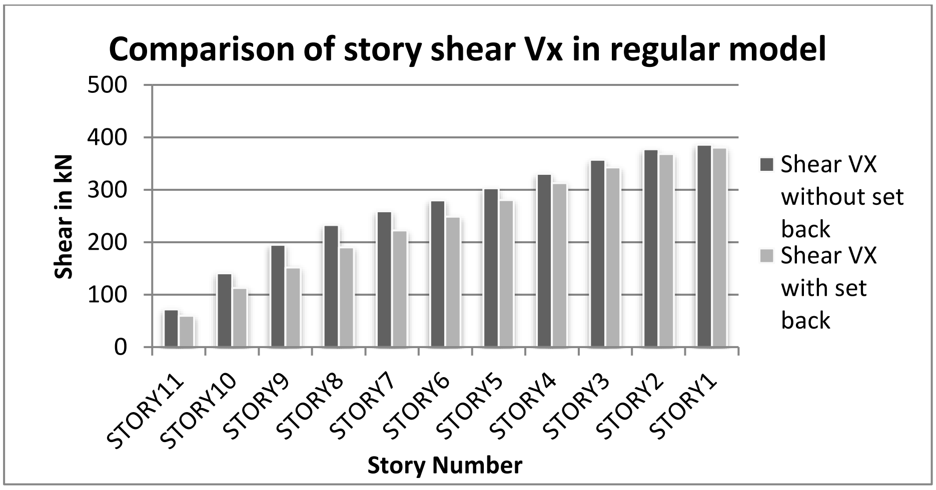
5.1.2 Story Drift in Y direction



Graph 5.2 Comparison of Story Drift in Y direction for regular building

The above graph and table shows the storey drift in Y direction from the results it was observed that drift value has less intensity from storey 11 to storey 6 for with setback building. And it has higher intensity of values for without setback building from storey 5.

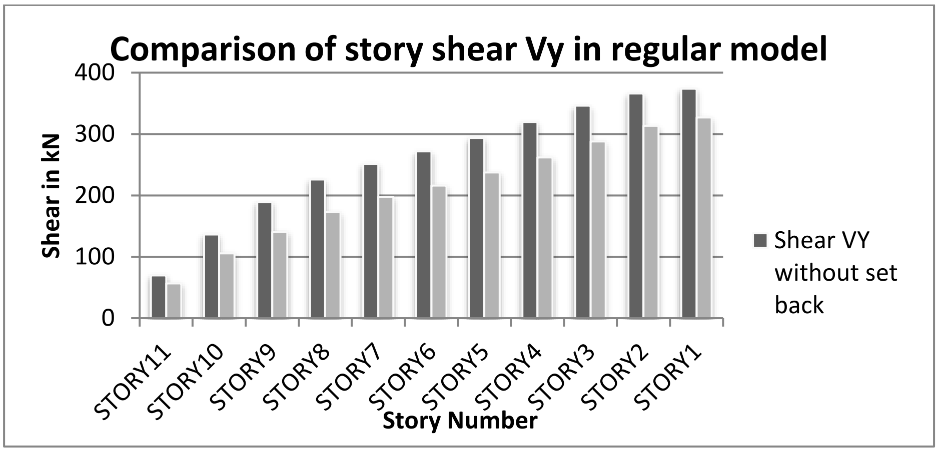
5.1.3 Story shear in X direction



Graph 5.3 Comparison of Story shear in X direction for regular building

The above graph and table shows the comparison of shear values from the above observation it is clearly shows that shear has less values for setback building models than without set back model for 11 storey's building structure.

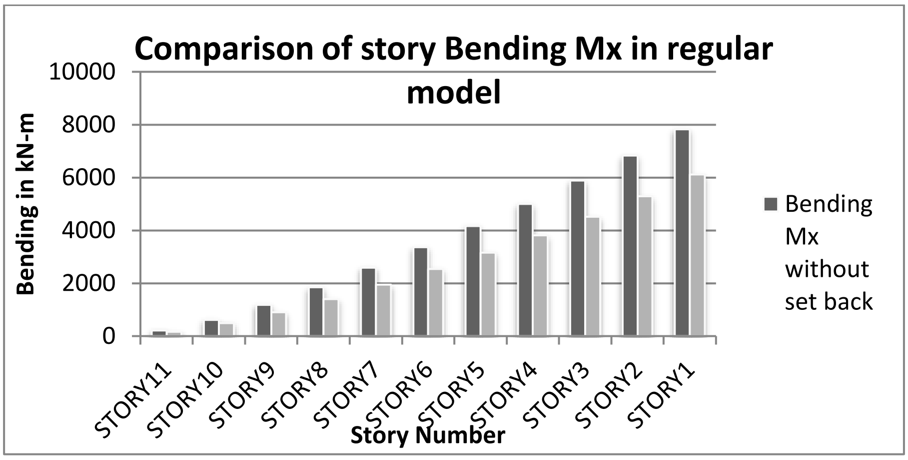
5.1.4 Story shear in Y direction



Graph 5.4 Comparison of Story shear in Y direction for regular building

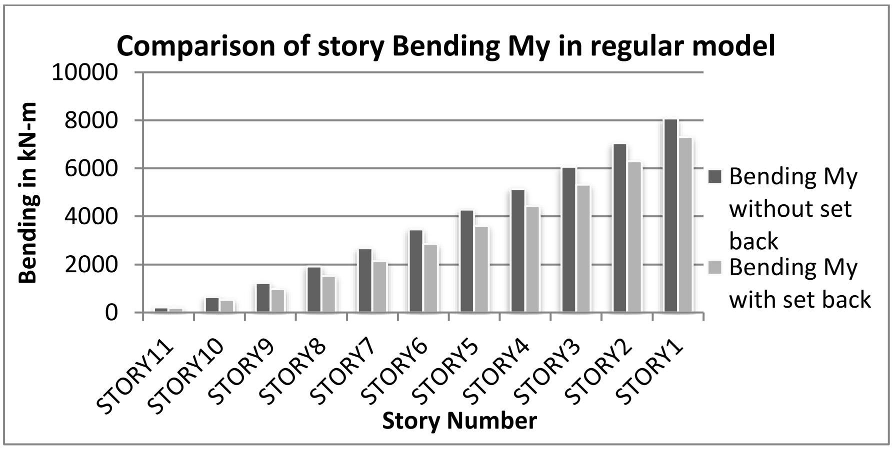
Due to the effect of lateral loads the shear in Y direction has higher intensity values for without setback model than with se back building model and the sheer force values are increases from storey 11 to storey 1.

5.1.5 Story Bending in X direction



Graph 5.5 Comparison of Story Bending in X direction for regular building

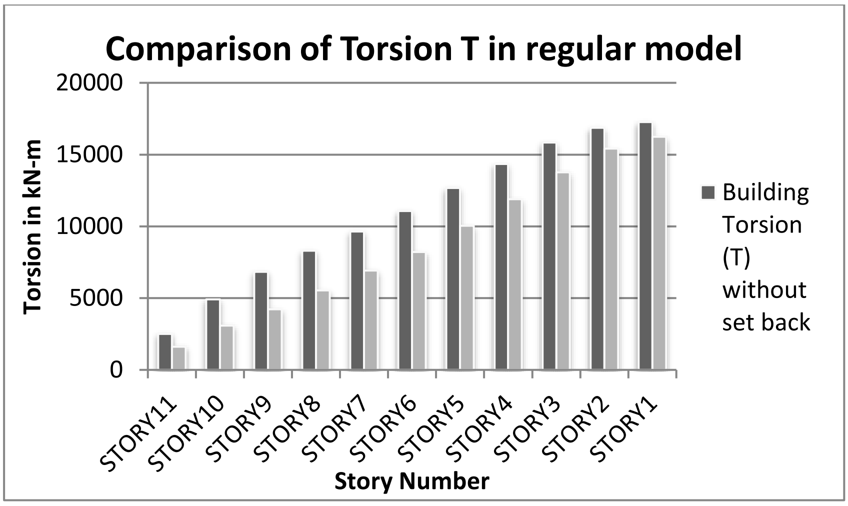
5.1.6 Story Bending in Y direction



Graph 5.6 Comparison of Story Bending in X direction for regular building

The above observations a show the bending comparison results for with set back and without set back building models the bending vi n Y direction values are increases from storey 11 to storey 1 it has higher values for without set back models due to the effect of lateral load cases.

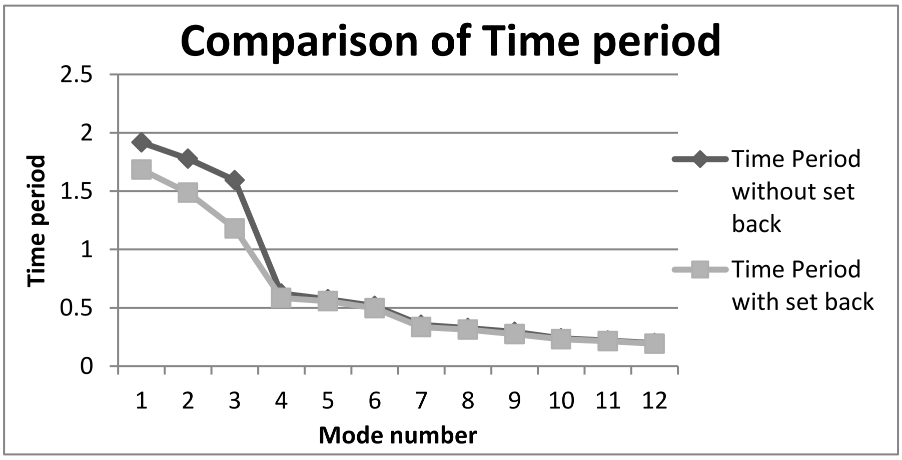
5.1.7 Building Torsion



Graph 5.7 Comparison of Building Torsion for regular building

Similar to the bending values the building torsion has higher values for building torsion and the values are increases from storey 11 to storey 1 due to the effect of lateral loads in models with and without set back.

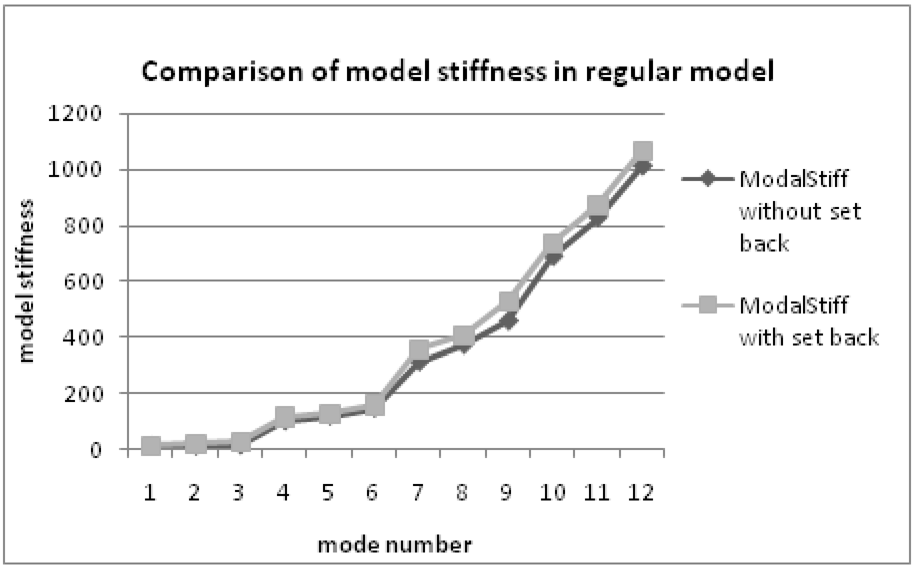
5.1.8 Time period



Graph 5.8 Comparison of time period for regular building

The above observations shows the time period values for setback building models for regular structure the time period values are decreases from mode 1 to mode 12 for both models.

5.1.9 Modal Stiffness

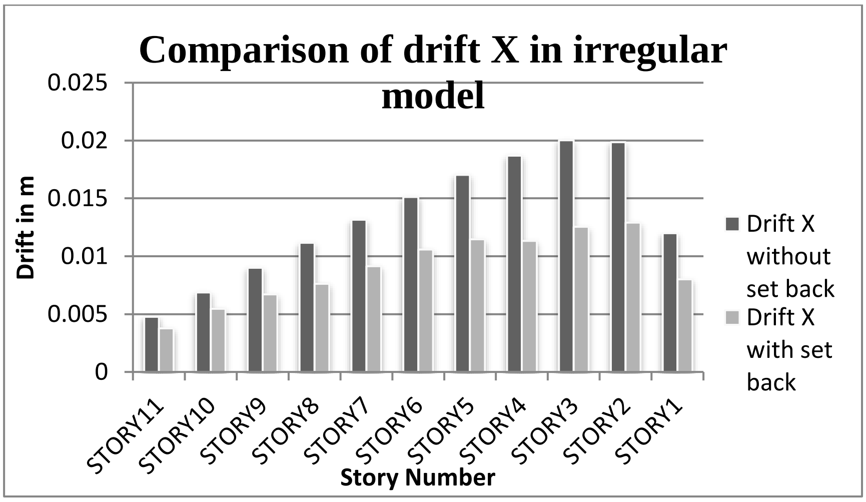


Graph 5.9 Comparison of time period for regular building

Model stiffness values are increases from mode 1 to mode 12 for both models it has almost same values which is shown in the above graph.

5.2 Irregular Results

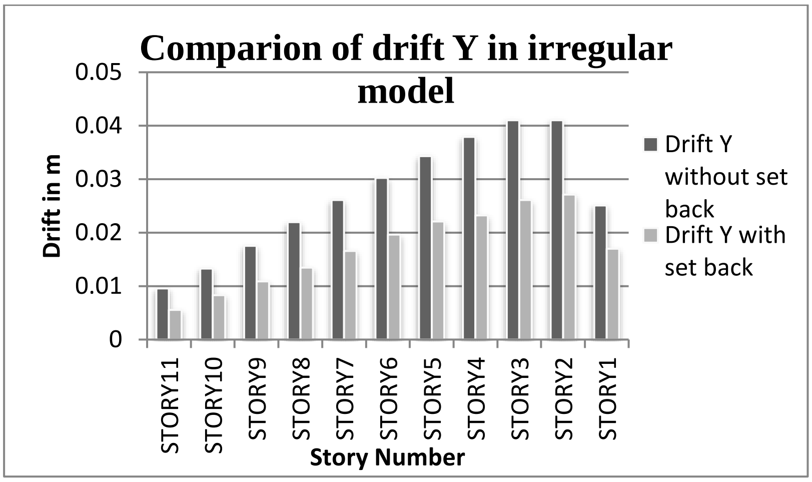
5.2.1 Story Drift in X direction



Graph 5.10 Comparison of Story Drift in X direction for irregular building

The above observations shows the comparison of drift X values for irregular models the value of drift has higher values for the without set back model than with setback models and it in increases gradually from storey 11 to storey 2.

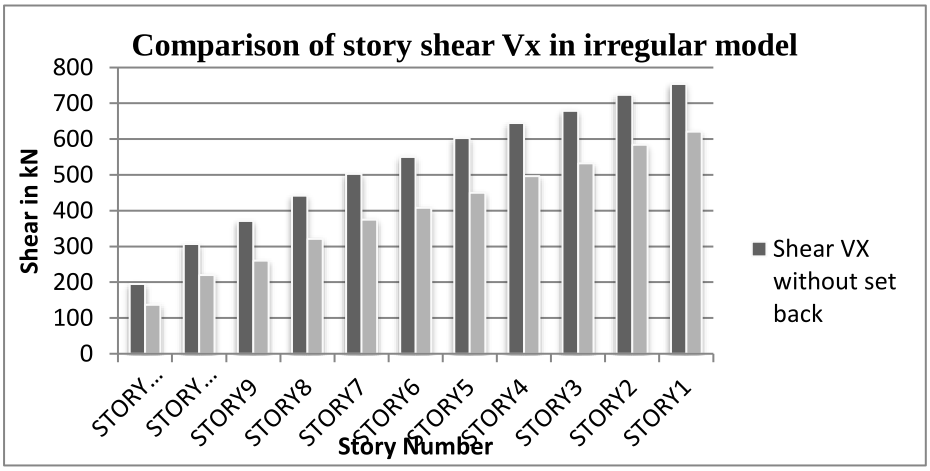
5.2.2 Story Drift in Y direction



Graph 5.11 Comparison of Story Drift in Y direction for irregular building

The comparison drift Y for irregular building models is shown in the above table and graph similar to the drift X values the intensity is high in case of without set back than with setback building models. And the values are increasing from storey 11 to storey 2.

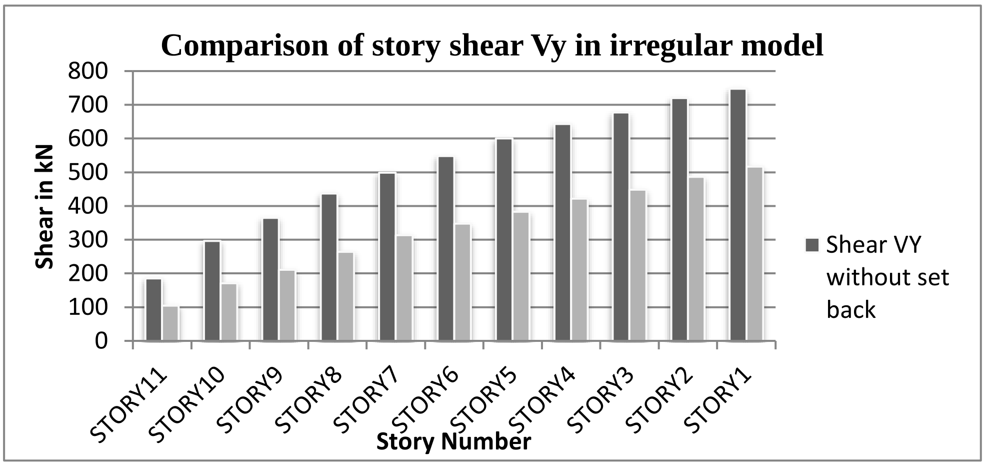
5.2.3 Story shear in X direction



Graph 5.12 Comparison of Story shear in X direction for irregular building

The values of shear in X direction for irregular building models of with and without set back are shown in above the intensity of shear increases from storey 11 to storey 1 and it has less values for with setback building structure.

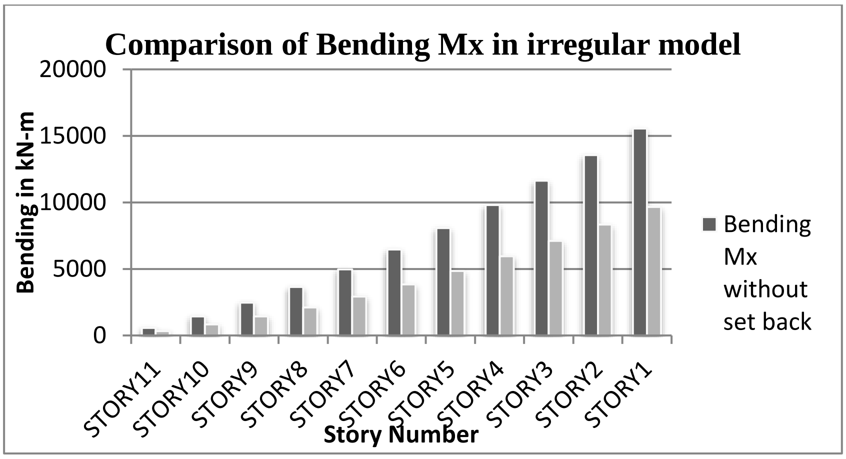
5.2.4 Story shear in Y direction



Graph 5.13 Comparison of Story shear in X direction for irregular building

Similar to that of Shear X The values of shear in Y direction for irregular building models of with and without set back are shown in above the intensity of shear increases from storey 11 to storey 1 and it has less values for with setback building structure.

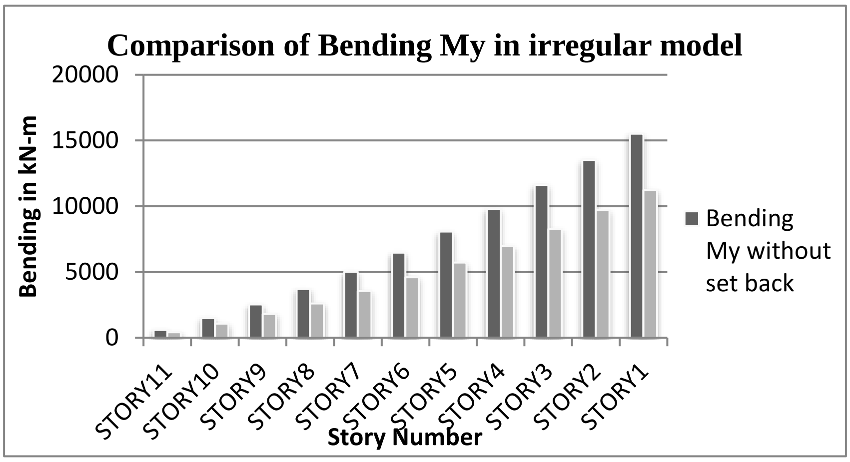
5.2.5 Story Bending in X direction



Graph 5.14 Comparison of Bending in X direction for irregular building

Bending moment value in X direction increases from storey 11 to storey 1 and it has higher values in case of without set back than with setback structure the effect of lateral loads is high in case of the without set back than with setback case.

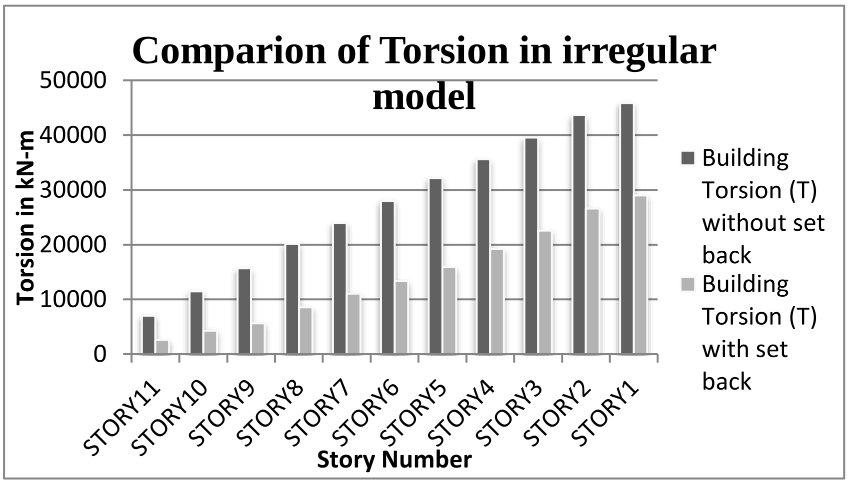
5.2.6 Story Bending in Y direction



Graph 5.15 Comparison of Bending in Y direction for irregular building

The above observation are related to the storey bending in Y similar to the direction the values of bending increases from storey 11 to storey 1 and it has higher values for without setback structures.

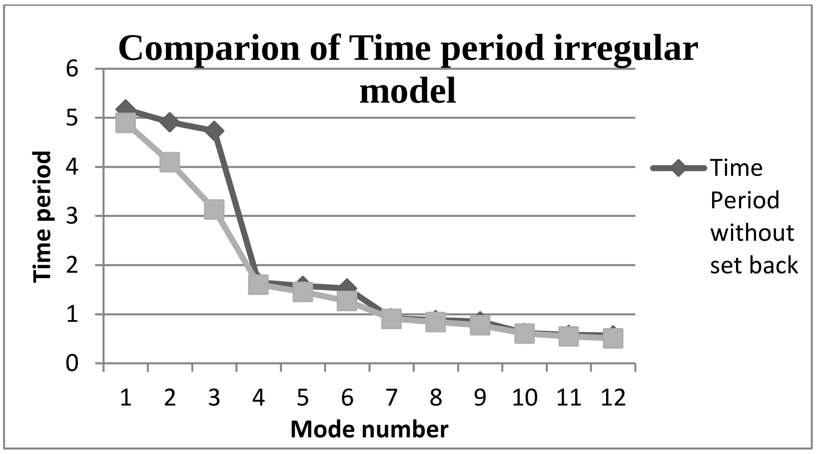
5.2.7 Building Torsion



Graph 5.16 Comparison of Building Torsion for irregular building

The values of torsion increases from storey 11 to storey 1 due to the effect of lateral loads the higher values are obtained for without setback models than with setback models.

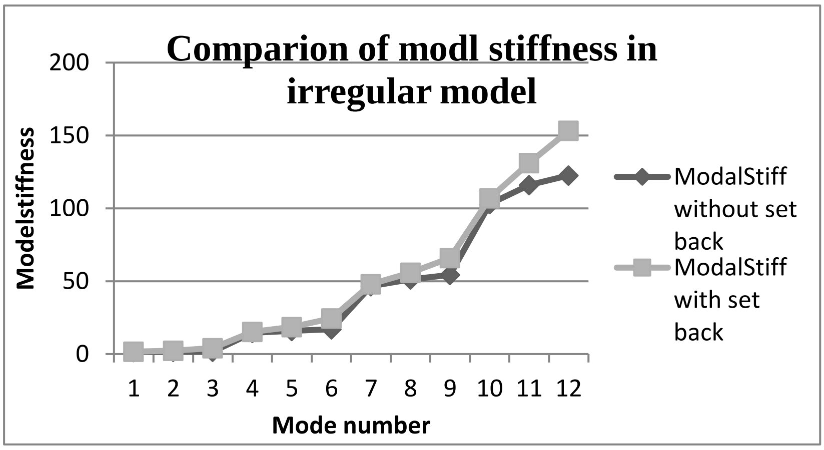
5.2.8 Time period



Graph 5.17 Comparison of Time period for irregular building

The comparison of time period for irregular buildings are shown in the above table and graph from those results it was concluded that the intensity of time period are almost same in both models due to setback the time period values are not changed.

5.2.9 Modal Stiffness



Graph 5.18: Comparison of Modal Stiffness for irregular building

The model stiffness values are increase from mode 1 to mode 12 in both models the irregular set back does not affects the model stiffness values for the models.

VI. CONCLUSION

The following point-wise ends can be drawn in the light of the work seen in this proposal:

1. In any case, it is found that the period of misfortune systems is not as much as the period of comparable customary construction. The core period of the misfortune systems varies with the paradox, regardless of whether the stature stays stable. Duration modification due to mishap phenomenon is not consistent with any of these criteria used in writing or configuration codes to characterize abnormality.
2. The Coding (IS 1893:2002) Observational Recipe shows the lower limits of the critical times resulting from the Modal Analysis and the Raleigh Process. As a consequence, it appears to be inferred that the code (IS 1893:2002) provides mild assessments of the key periods of complexity systems of 6 to

20 storeys. It can also be seen that Raleigh Approach thinks less about the key periods of complexity of the systems, something that is additionally traditional for the selected structures. At any rate, the degree of populism in the unfortunate building is not proportionate to that of the normal frameworks.

3. It has been discovered that the main time in an encircled building is not, as it were a building stature component. This analysis reveals that systems of the same generally speaking height which have distinctive basic phases with a broad range which are not subject to the exact conditions of the code.

4. As the condition of the triangular load example and the first mode form are comparable to the mid-ascent normal structures and similar to the skyscraper and misfortune structures, the resulting sucker bends are found to be comparable to almost all the buildings considered here.

5. FEMA 356 suggests that the weakling of investigations with a standardized and triangular loading example should relate each of the configurations associated with the base shear versus the roofing relocation of the customary structures. The findings introduced here help to render this announcement for ordinary systems. However this is not true for unfortunate structures, particularly for elevated structures with higher abnormalities (S3-type).

6. Mass corresponding uniform load configuration was found to be appropriate for completion of the weakling analysis of the Setback structures as the limit bend was carefully organized using this heap design by the reaction wrap acquired from nonlinear special investigations.

7. Upper bound weakling analysis significantly underestimates both the base shear ability of the setback and the regular construction frames.

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