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Seismic Response of Irregular RC Building with Soft Storey at Different Levels

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Abstract: ***Vertical irregularities in buildings are very common feature in urban area, large number of vertical irregular buildings exist in modern urban infrastructures. Soft storey building is a multi-story building in which one storey is kept open for the purpose of vehicle parking, shops, commercial purposes etc. This paper deals with the study of seismic response of a building with soft storeys at different level. The study consists the modelling of a G+6 storied irregular RC building. The modeling of the whole building is carried out using the computer program STAAD.Pro V8i software. Parametric studies on displacement, inter storey drift and base shear have been carried out using equivalent static analysis to investigate the influence of these parameter on the seismic behavior of buildings with soft storey. The selected building is analyzed through five models and the comparison of result is carried out.***

Keywords: Irregular RC building, Equivalent Static Analysis, Lateral Displacement, Storey Drift, Base Shear

1. Introduction

Vertical irregularities in buildings are very common feature in urban area, large number of vertical irregular buildings exist in modern urban infrastructures. In most of situations, buildings become vertically irregular at the planning stage itself due to some architectural and functional reasons. This type of buildings shows more vulnerability in the past earthquakes. Open ground storey buildings are also called “open first storey buildings” or “pilotis”. Due to the scarcity of land, the ground storey is kept open for parking purpose and no infill walls are provided in ground storey but the storeys above it are provided with infill walls. This type of building shows comparatively a higher tendency to collapse during earthquake because of the soft storey effect. Large lateral displacements get induced at the first floor level of such buildings yielding large curvatures in the ground storey columns.

The energy developed during earthquake loading is dissipated by the vertical resisting elements of the ground storey resulting the occurrence of plastic deformations which transforms the ground storey into a mechanism, in which the collapse is unavoidable. The construction of open ground storey is very dangerous if not designed suitably and with proper care. A typical soft story building is an apartment building of three or more stories located over a ground level with large openings, such as a parking garage or series of retail businesses with large windows. This type of irregularities arises due to sudden reduction of stiffness or strength in a particular storey. For high seismic zone area, irregularity in building is perhaps a great challenge to a good structural engineer. Buildings are classified as having a "soft story" if that level is less than 70% as stiff as the floor immediately above it, or less than 80% as stiff as the average stiffness of the three floors above it. Soft storey buildings are vulnerable to collapse in a moderate to severe earthquake in a phenomenon known as soft story collapse.

Figure 1: Building with ground floor as soft storey

2. Objectives

1) To study the earthquake excitation of the building by varying soft storeys at different levels of G+ 6 T- shaped reinforced concrete building and to conduct seismic analysis of building located in seismic zone III, which is modelled in STAAD Pro.V8i software
2) To find out storey drift, lateral displacement, moment, shear force, deflection etc by using equivalent static analysis

3. Methodology

Methodology employed is equivalent static analysis.

3.1 Modelling of Building

Here the study is carried out for the behaviour of G+6 storied irregular R.C buildings with T shaped plan of soft storeys at different levels. Floor height provided as 3.4m and also properties are defined for the irregular R.C building modelled in STAAD. Pro V8i software. Here five models are created in which soft storey is provided at ground, first,

fourth, top floor and building model without soft storey. It is more user friendly and versatile program that offers a wide scope of features like static and dynamic analysis, non-linear dynamic analysis and non-linear static pushover analysis, etc.

3.1.1 Building Plan and Dimension Details

The following are the specification of G+ 6 storied irregular RC building located in seismic zone- III. Here the T shaped building is selected. For modelling in STAAD Pro.V8i software the first step is to specify nodal co-ordinate. Then beams, columns and plate elements to be modelled and assign the properties for beams, columns and the plates. After assigning the sectional property to the member it is important to assign it with member properties. Material properties include modulus of elasticity, poison's ratio, weight density, thermal coefficient, damping ratio and shear modulus.

The complete detail of the structure including modelling concepts is given below:

- General RC Building
- G+6 Building
- Height of each floor = 3.4m
- Medium Soil
- M20 and Fe415
- Column Size : 300mm x 450mm
- Beam size : 300mm x 380mm
- Zone III
- Dead Load : 25 kN/m^2
- Live Load : 3 kN/m^2

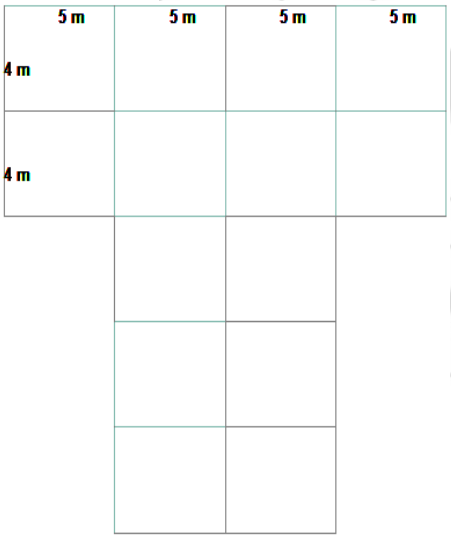

Figure 2: Plan of T shaped building

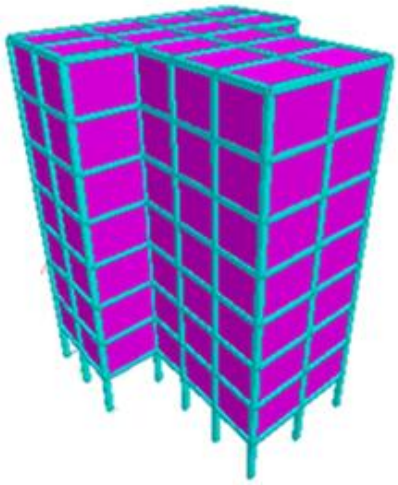

Figure 3: Three dimensional view of G+6 Building without soft storey

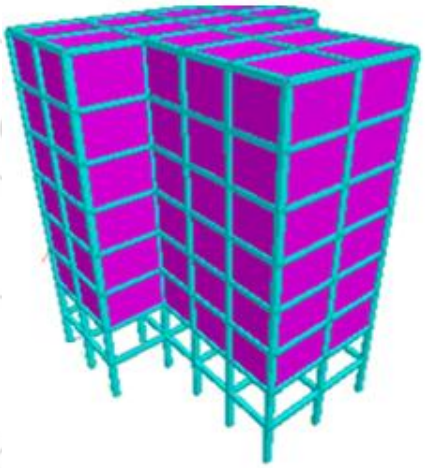

Figure 4: Three dimensional view of G+6 Building with ground floor as soft storey

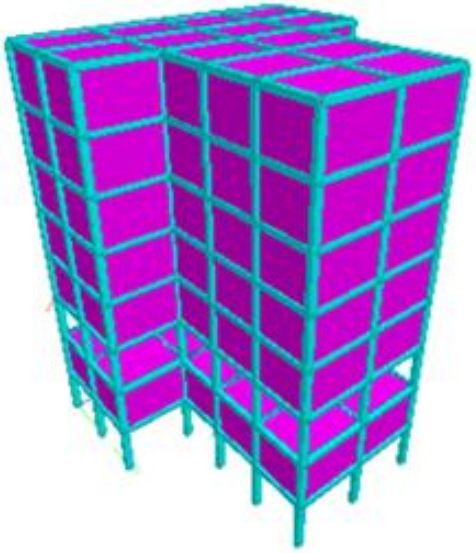

Figure 5: Three dimensional view of G+6 Building with first floor as soft storey

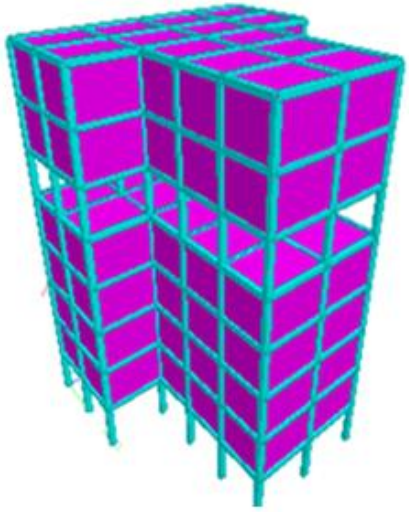

Figure 6: Three dimensional view of G+6 Building with fourth floor as soft storey

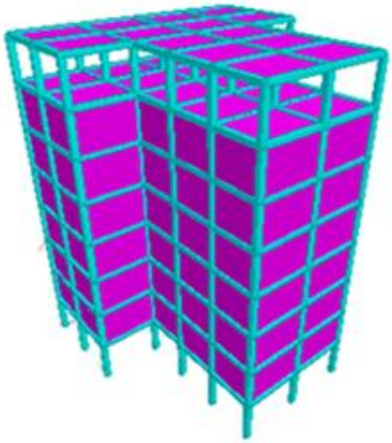

Figure 7: Three dimensional view of G+6 Building with top floor as soft storey

3.2 Load Formulation

The static loads are applied in all structures. The soft storey irregular buildings are designed for gravity loads and safe under gravity loads but these buildings are not designed for earthquake loads. Gravity loads and lateral loads are applied as per IS 1893(Part-I) 2002.

3.3 Analysis

The three dimensional reinforced concrete structures with G+6 storied building with soft storeys at different level are analyzed using STAAD Pro software. The main code for the analysis is IS 1893 (Part I) 2002 and provide the outline for calculating seismic design force. The method of analysis used is Equivalent static analysis to calculate displacement, base shear and storey drift. Among the different types of analysis, seismic analysis comes forward because of its optimal accuracy, efficiency and ease of use. Seismic analysis is done to evaluate the maximum shear force, bending moment and the dynamic results in the form of storey drift and lateral displacements. Equivalent Static Analysis defines a series of forces acting on a building to represent the effect of earthquake ground motion.

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4. Comparison of Results

After analysing the results obtained then it will be compared and find the seismic performance of the building with soft storey at different level.

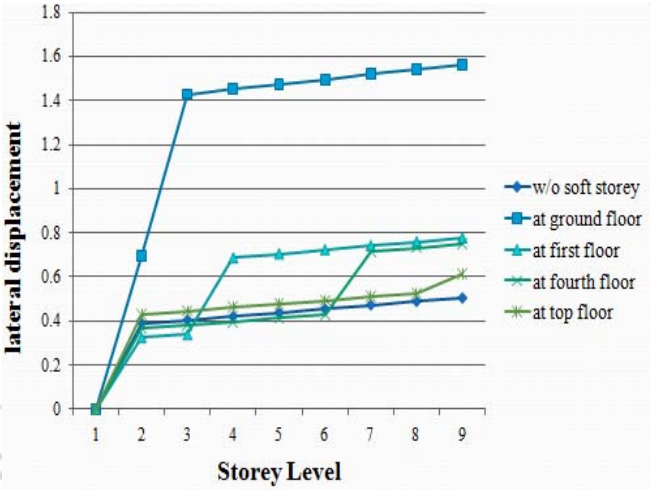

Figure 8: Lateral Displacement of G+6 Building with storey at different level (cm)

From Fig 8 it is understood that the lateral displacement is more when the soft storey is at ground level.

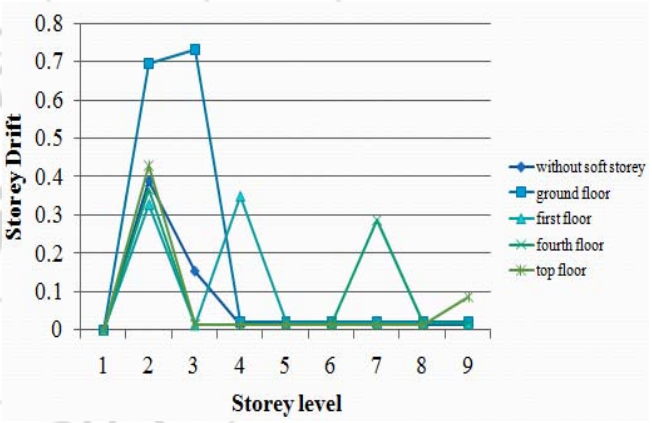

Figure 9: Storey Drift of G+6 Building with soft storey at different level

From fig 9 it is understood that the storey drift is more when the soft storey at ground floor. +

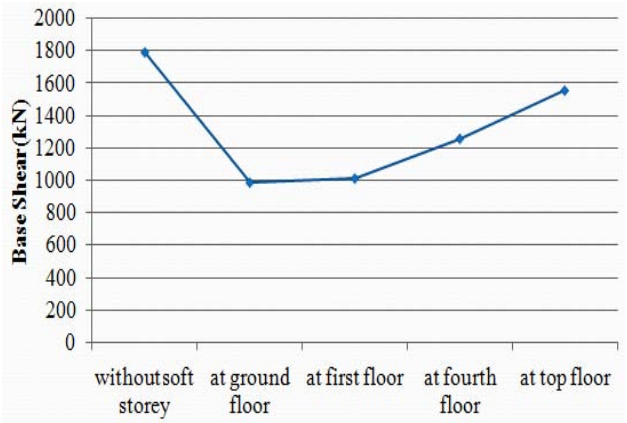

Figure 10: Base Shear of G+6 Building with soft storey at different level.

From Fig 10 Base Shear of building without soft storey and building with top floor as soft storey have near values. Therefore it can conclude that the soft storey providing at top floor is safer than at any other levels.

5. Conclusions

In this paper the study done to found the seismic response of an irregular RC building of G+6 with soft storey at different levels. After analysis the conclusions which obtained are as follows:

- Soft storey at ground level is a typical feature in the modern multistorey constructions in urban India. Such features are highly undesirable in buildings built in seismically active areas this has been verified in numerous experiences of strong shaking during the past earthquakes.
- Though multistoreyed buildings with open (soft) ground floor are inherently vulnerable to collapse due to earthquake load.
- In buildings with soft first storey, the upper storeys being stiff, undergo smaller inter-storey drifts. However, the inter-storey drift in the soft first storey is large.
- The displacement and storey drift of an irregular RC building with G + 6 storey is maximum when soft storey is at ground level.
- The displacement of an irregular building with soft storey at top floor is approximately near values of a building without soft storey.
- Base shear is maximum when soft storey is at top floor and it can be concluded that soft storey at top floor is safer.
- The decrease in base shear leads to the failure of building.

6. Future Scope

- Vertically irregular buildings with shear walls and plinth beams are not considered in this study. The present methodology can be extended to such buildings also.
- Irregular building with torsional effect also to be considered
- Analysis can be carried out in steel framed buildings and setback buildings.
- In the present study, building is considered in zone-III. It can extend to other zones.

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