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SEISMIC ANALYSIS OF STRUCTURE WITH VERTICAL IRREGULARITIES USING SOIL STRUCTURE INTERACTION

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ABSTRACT

The basic configuration used in buildings on slope is step back and set back configuration. When such constructions are present in seismically prone areas, it is exposed to shear and torsion at greater extent than other conventional buildings. Buildings on slopes have fluctuated setups and asymmetry of varied mass and stiffness distribution. Mostly the effects of soil-structure interaction are generally ignored in the designing of low-rise buildings resting on shallow foundations. Ignoring such effects can lead to unsafe seismic design. Interaction between foundation and soil takes place when the structure is subjected to earthquake excitation. It gradually changes the motion of ground. The movement of the whole ground structural system is influenced by type of soil as well as by the type of structure. An attempt has been made in this paper to study the response of multi storied building subjected to seismic forces with Flexible foundations subjected to seismic forces analysed under different soil conditions like hard, medium and soft and also with fixed base condition. Also, the present paper gives a detailed methodology of Time History analysis.

Keywords: Fixed base, Flexible base, Soil structure interaction, Step back, Step back-setback, Time history.

I. INTRODUCTION

Majority of the existing reinforced concrete structures in India do not meet the current seismic requirements as these are primarily designed for gravity loads only. However, during the earthquake, the behaviour of the buildings depends on many parameters such as type of soil that is supporting, stiffness of infill, etc. The building supported on medium stiff soil and stiff soil can resist certain amount of lateral forces due to earthquakes, however the same building may not be able to resist the minor earthquake supported on soft soil. [1]

A common design practice for dynamic loading assumes the building to be fixed at their bases. Although structures are supported on soils, most of the designers do not consider the effect of soil structure interaction on structures during earthquake. When a structure is subjected to an earthquake excitation, it interacts with the foundation and soil, and thus changes the motion of the ground. This means that the supporting soil medium allows moment of the whole ground. Structural system is influenced by the type of soil as well as the type of structure. The effect of soil structure interaction should be considered in the buildings which are located in the earthquake prone areas.

In a few parts of the world, especially the hilly areas are more prone to seismic movement; e.g. northeast region of India. There is a shortage of plain ground in hilly regions which constrains the construction or building activity on such a ground which is hilly. Hill building developed without complying with seismic codal

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procurements has demonstrated risky and brought about heavy death toll and property when subjected to ground movements due earthquake. Because of hilly slopes these building ventures back towards the slope and in the meantime they may have setback as well, having unequal statures at the same floor level. During the activity of a earthquake these unpredictable and asymmetrical building usually come across lateral shears and torsional moments and thus unable to withstand the twisting minutes and pivotal powers created by static loads in isolation.[2] A discontinuity in the medium of wave's propagation is encountered at the interface of soil and structural foundations which leads to scattering, diffraction, reflection and refraction of the seismic waves at the soil foundation interface their by changing the nature of ground motion at that point.[3]

II. SOIL STRUCTURE INTERACTION

Most of the civil engineering structures involve direct contact of structure with the ground. When subjected to earthquake ground motions, the structural response and the ground displacements are not independent of each other. Seismic waves are transmitted from the bedrock through the soil medium to a structure. The difference in ground motion is due to interaction between the soil geological medium including soil and the structure, also known as soil-structure interaction.

A seismic soil-structure interaction analysis evaluates the collective response of the structure, the foundation and the geologic media underlying and surrounding the foundation, to a specified free-field ground motion. The term *free-field* refers to motions that are not affected by structural vibrations or the scattering of waves at and around the foundation. SSI effects are absent for the theoretical condition of a rigid foundation supported on rigid soil. Accordingly, SSI accounts for the difference between the actual response of the structure and the response of the theoretical, rigid base condition.

III. NONLINEAR TIME HISTORY (TH) METHOD

Nonlinear time-history analysis is the most comprehensive method for seismic analysis. At the base of the structure the earthquake record in the form of acceleration time history is input. At each second for the entire duration of an earthquake the response of the structure is computed. This method differs from response spectrum analysis because the effect of time is considered. That is, stresses and deformations in the structure at an instant are considered as an initial boundary condition for computation of stresses in the next step. Furthermore, nonlinearities that commonly occur during an earthquake can be included in the time-history analysis. Unlike the response spectrum method, nonlinear time-history analysis does not assume a specific method for mode combination. [4]

Hence, results are realistic and not conservative. In this analysis, all types of nonlinearities can be accounted for. This could be very important when seismic retrofit involves energy dissipation using yielding of members or plastic hinge rotation. The Input earthquake is never known with certainty. Hence, three to five different histories should be used. For nonlinear seismic analyses, a total seismic mass including self-weight and floor cover "Dead Load; *DL*" plus 25% of Live Load "*LL*" ($1.0DL + 0.25LL$) should be considered.

For buildings on hill slopes or sloping ground, two types of configuration are considered. These configurations are step back and step back-set back.

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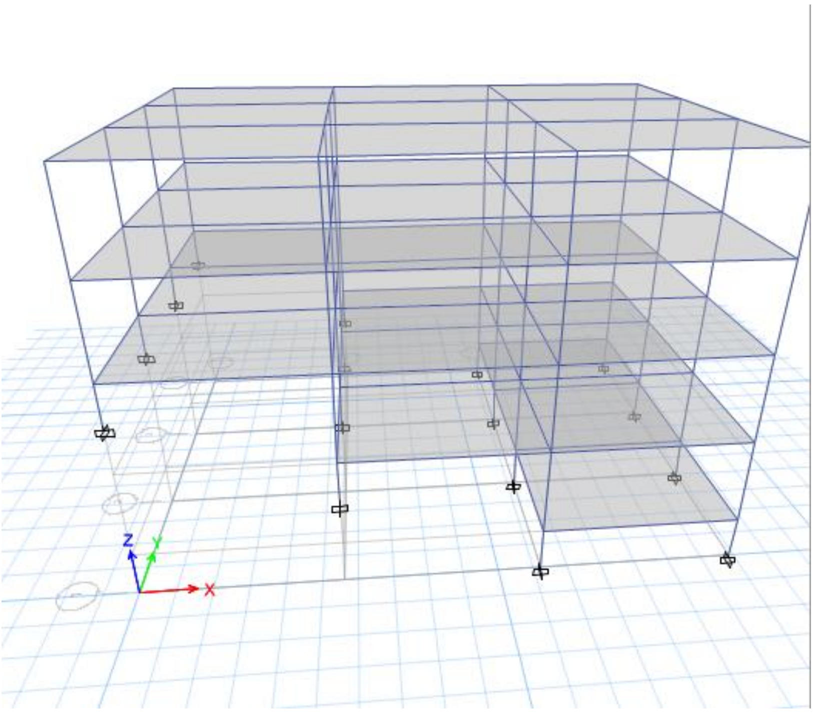

Fig. 1: **4 Storey Step Back Building**

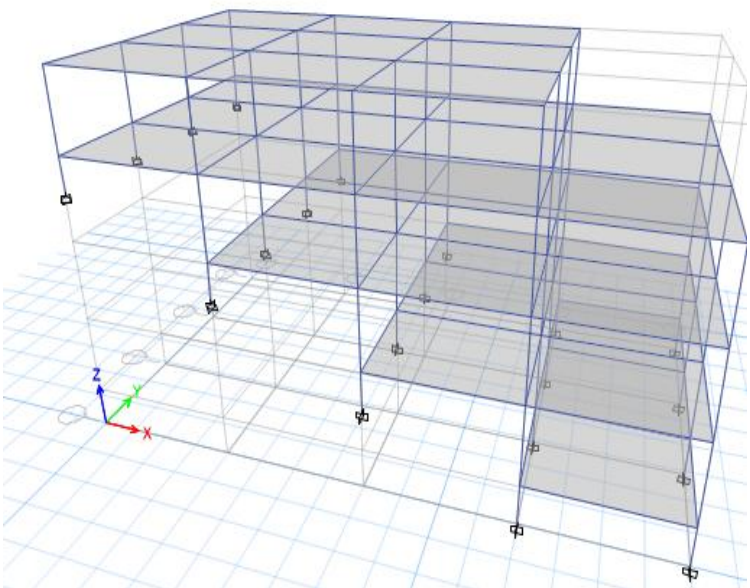

Fig. 2: **4 Storey Step Back-Set Back Building**

The typical 4 storey step back and step back-set back configuration buildings are shown in figure (1) and (2)respectively

IV. DESCRIPTION OF THE BUILDING MODEL

A typical 4 storey step back configuration building lying on slope is considered for the study. The slope is considered at an angle of 27^{o}. The details of the building are as shown in the table 1.

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Table 1: details of the building model

Description	Value
Number of storeys	4
Typical storey height	3.5
Bottom storey height	1.75
Grade of steel	Fe415
Grade of concrete	M25
Beam size	300*600
Column Size	600*600
Zone	Zone III
Live load	Roof- 1.5 KN/m^2
	Floor-3KN/m^2
Finishes	Roof finish- 2 KN/m^2
	Floor finish- 1KN/m^2

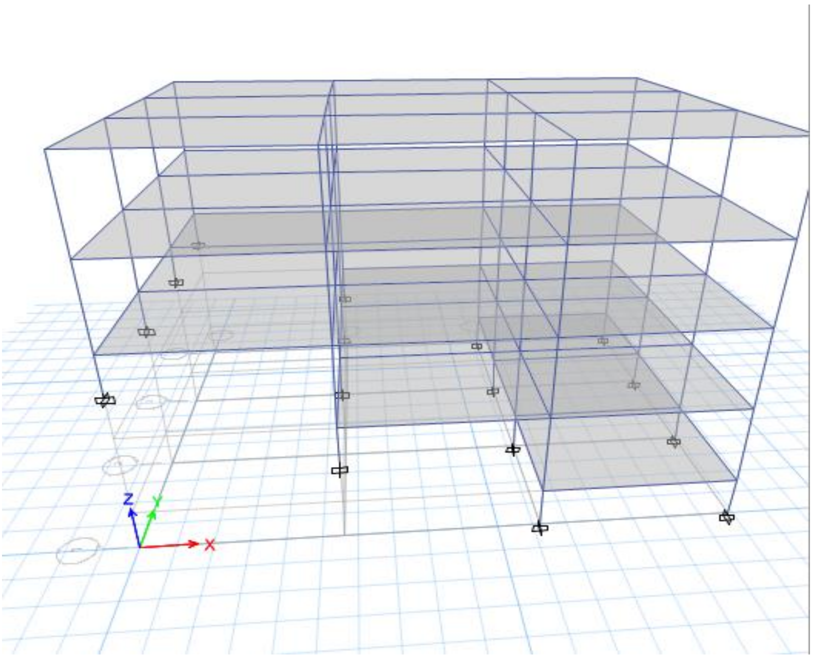

Fig. 3: 4 storey step back building

The frame is designed for seismic loads in ETABS 2015. Time History analysis is performed for the designed frame. Comparison of storey drift, storey shears and time period is studied further. The building is shown in figure 3.

For the inclusion of soil structure interaction in the given case, three types of soil, i.e., medium, soft and stiff soil and rigid base. All the three cases are analysed by Time History method.

V. RESULTS

The results obtained by the Time history analysis for the given building are as shown in figure 4.1, 4.2, 4.3.

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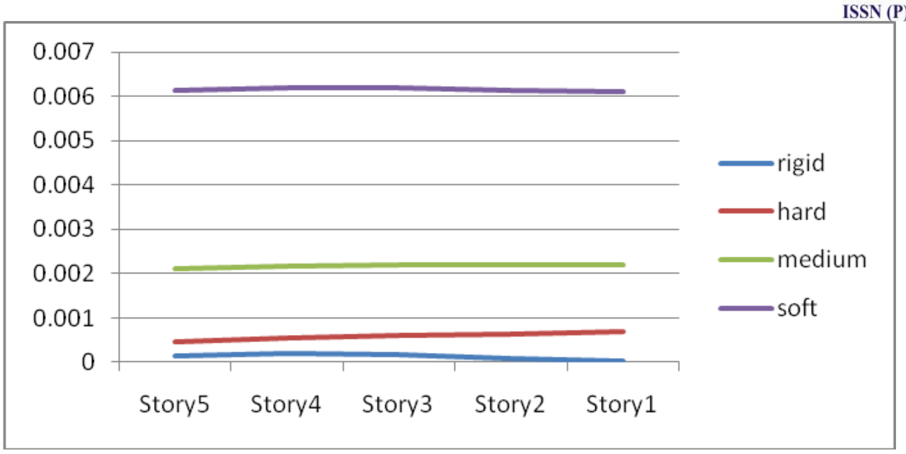

Figure 4.1 storey drift

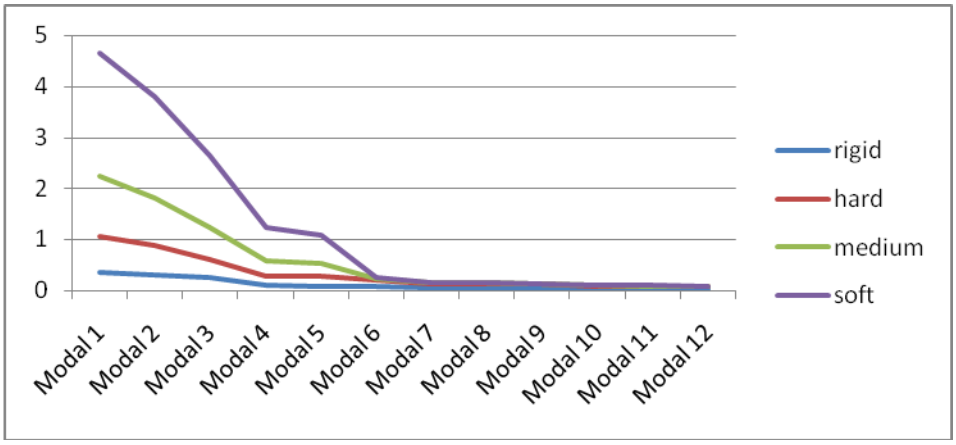

Figure 4.2 : Time Period

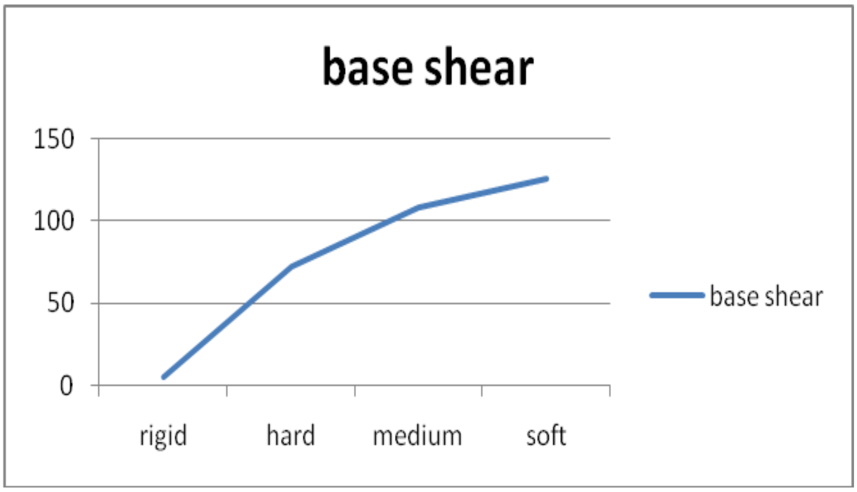

Figure 4.3: Base shear

VI. CONCLUSION

From the results shown with respect to the building models considered leads to the following conclusions:

1. It is observed that the fundamental natural frequencies increase with the increase of soil stiffness and this change is found more in soft soils.
2. The base shear is found to be increased with the increase of soil stiffness with more in soft soils.

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3. The storey drift increases when the soil changes from fixed base (rigid) to hard soil, hard to medium and then medium to soft.

4. Thus it can be said that Soil–structure interaction cannot be ignored while designing important structures like buildings, bridges, nuclear power plants, liquid retaining structures, dams, etc., against the expected earthquake forces.

5. The software used for nonlinear dynamic analysis ETABS 2015 having features of performing performance based analysis.

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