International Journal of Advanced Technology in Engineering and Science
Vol. No.5, Issue No. 02, February 2017
www.ijates.com
ijates
ISSN 2348 - 7550

PUSHOVER ANALYSIS OVER A STRUCTURE WITH VERTICAL IRREGULARITIES USING SOIL STRUCTURE INTERACTION

Prajakta Barsinge[1], L. R. Wankhade[2]

[1]Research Scholar , [2]Professor, t Applied Mechanics Department,
Government College of Engineering, Amravati (India),

ABSTRACT

The hilly regions are mostly encountered with step-back-set-back configuration for buildings. The presence of such constructions in seismically prone areas makes them exposed to greater shears and torsion as compared to conventional construction. Multi-storeyed reinforced concrete buildings lay on slope slants in hilly areas. Building on slopes has fluctuated setups and asymmetry of variety in mass and stiffness distribution. The effects of soil-structure interaction are generally ignored in the designing of low-rise buildings resting on shallow foundations. It has been shown that ignoring such effects 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. It means that 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 storeyed building subjected to seismic forces with Flexible foundations subjected to seismic forces analysed under different soil conditions like hard, medium and soft. Also, the present paper gives a detailed methodology of Pushover analysis.

Keywords: Base Shear, Flexible Base, Natural Period, Soil Stiffness, Soil Structure Interaction, Storey Drift.

I INTRODUCTION

In India, as majority of the existing reinforced concrete structures in the seismic region are primarily designed for gravity loads only, they do not meet the current seismic requirements. The building to be fixed at its bases is assumed in common design practice for dynamic loading. The effect of soil structure interaction should be considered in the buildings which are located in the earthquake prone areas. The effect of soil structure interaction on structures during earthquake is not considered mostly, although structures are supported on soils. When a structure is subjected to an earthquake excitation, it interacts with the foundation and soil, and thus changes the motion of the ground. Supporting soil medium allows movement of the whole ground. Structural system is influenced by the type of soil as well as the type of structure. Certain amount of lateral forces due to earthquake can be resisted by the building supported on medium stiff soil and stiff soil , however the same building may not be able to resist the minor earthquake supported on soft soil.[1]

In many parts of the world, especially the hilly areas are more prone to seismic movement; for example, Northeast region of India. There is a minimal plain ground in hilly regions which constrains the construction on such a ground that is slant. Hill building developed with mud mortar/concrete mortar without complying with seismic codal requirements have demonstrated risky and brought about death toll and property damage when subjected to Earthquake. During an earthquake these unpredictable and asymmetrical building usually come across lateral shears and torsional moments thus unable to withstand the twisting 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] This leads to a subsequent increase in the natural periods of the structural system. Hence, the effect of soil-structure interaction on the structural system resting on isolated foundation needs a detailed investigation.

Simplified linear elastic methods are not adequate for the assessment of structural damage during earthquake. Therefore, a new generation of design philosophy that incorporates performance based design is required and it is changing from simplified linear elastic method to nonlinear technique i.e. Pushover analysis. [4]

The response of a structure subjected to seismicity depends on various parameters namely characteristics of ground motion, allowable deformation limits of the structure, strength of structural material, soil structure interaction and many others. Till date most of studies have been carried out by considering base of the structure as fixed, but this is not the ground reality. Therefore soil structure interaction effect is to be incorporated to study the seismic behaviour of the structure.

II NECESSITY

The behaviour of buildings during earthquake depends upon the distribution of mass and stiffness in both horizontal and vertical planes of the buildings, which vary in case of hilly buildings with irregularity and asymmetry due to step back and step back-set back configuration.

The presence of such constructions in seismically prone areas makes them exposed to greater shears and torsion as compared to conventional construction. In order to highlight the differences in behaviour, which may further be influenced by the characteristics of the locally available foundation material, current building codes including IS: 1893 (Part 1):2002 suggest detailed dynamic analysis of these types of buildings on different soil (hard, medium and soft soil) types.

To assess acceptability of the design, it is important to predict the force and deformation demands imposed on structures and their elements by severe ground motion by means of static pushover analysis.

The unsymmetrical buildings require great attention in the analysis and design under the action of seismic excitation. Past earthquakes in which, buildings located near the edge of a stretch of hills or on sloping ground suffered serious damages. The shorter column attracts more forces and undergoes damage, when subjected to earthquakes. The other problems associated with hill buildings are, additional lateral earth pressure at various levels, slope instability, different soil profile yielding unequal settlement of foundation. To capture the real behaviour of buildings on hill slope a 3D analysis of the building is required.

III PUSHOVER ANALYSIS

The recent advent of performance based design has brought the pushover analysis to the forefront. Pushover analysis is a static, nonlinear procedure in which the magnitude of the structural loading is incrementally increased in accordance with a certain predefined pattern. With the increase in the magnitude of the loading, weak links and failure modes of the structure are found out.

Static pushover analysis is an attempt to evaluate the real strength of the structure and a useful and effective tool for performance based design. Pushover analysis can determine the behaviour of a building, including the ultimate load and the maximum inelastic deflection. At each step, the base shear and the roof displacement can be plotted to generate the pushover curve. It gives an idea of the maximum base shear that the structure was capable of resisting at the time of the earthquake.

The material model used in the static Nonlinear pushover analysis is based on the procedures proposed by the documents, defining force – deformation criteria for the hinges which is used in the pushover analysis. Figure 1 describes the typical force-deformation relation proposed by those documents. Five points labeled A, B, C, D and E are used to define the force deflection behavior of the hinge. These points labelled as A to B – Elastic state, B to IO- below immediate occupancy, IO to LS – between immediate occupancy and life safety, LS to CP- between life safety to collapse prevention, CP to C – between collapse prevention and ultimate capacity, C to D- between C and residual strength, D to E- between D and collapse >E – collapse.[5]

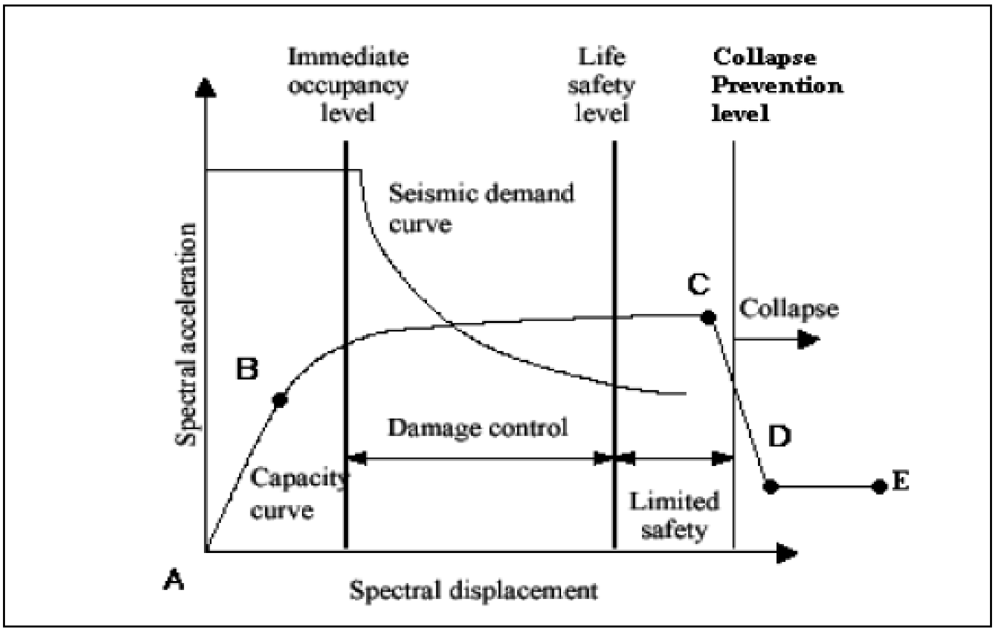

Fig. 1: Force- Deformation For Pushover Hinge With Levels

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.

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	300*500
Zone	Zone III
Live load	Roof- 1.5 KN/m^2
	Floor-3 KN/m^2
Finishes	Roof finish- 2 KN/m^2
	Floor finish- 1 KN/m^2

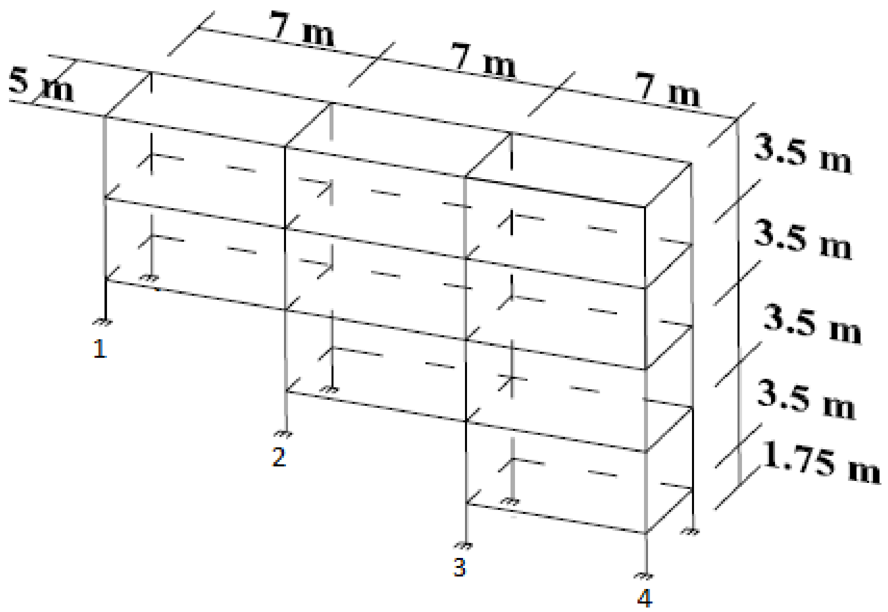

Fig. 2: 4 Storey Step Back Building

The frame is designed for seismic loads in ETABS 2015. Pushover analysis is performed for the designed frame. Comparison of storey drift, storey shears and time period is studied further.

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

IV RESULTS

The results obtained by the pushover analysis for the given building are as shown in figure 3.

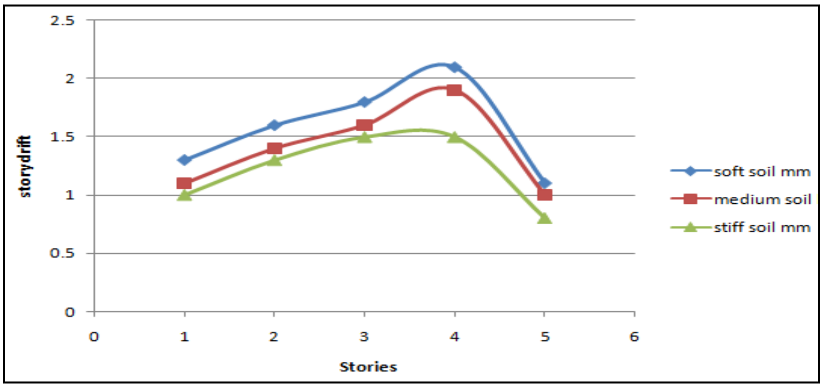

Fig.2: Storey Drift

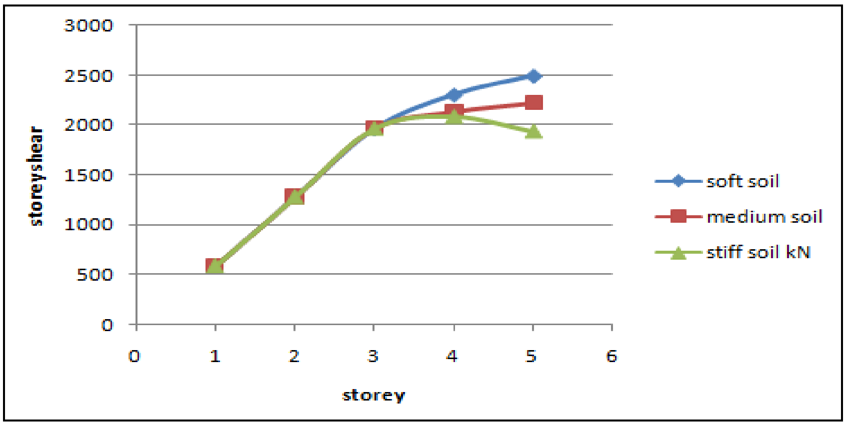

Fig. 3: Storey Shear

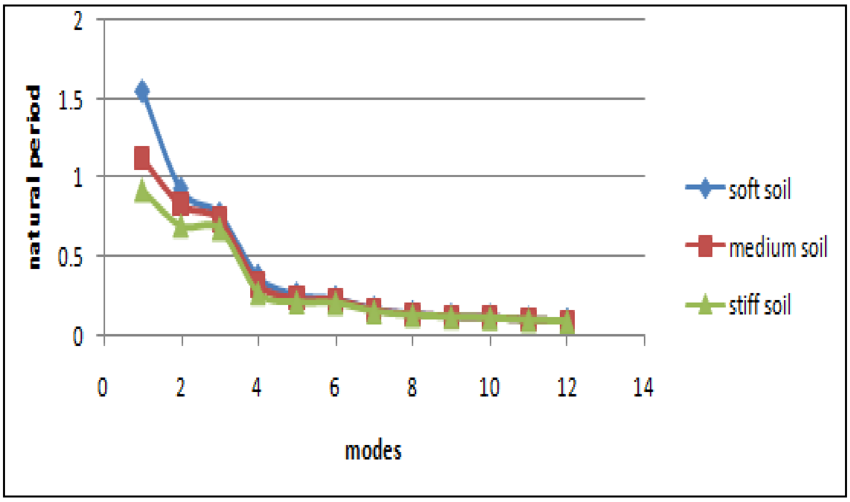

Fig 4: Fundamental Natural Period

V 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.
3. The storey drift increases when the soil changes from 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 static analysis ETABS 2015 having features of performing performance based analysis.

REFERENCES

[1] Ramesh Baragani, S.S.Dyavanal,"Seismic evaluation of multistorey rc buildings considering soil structure interaction with userdefined hinges", *Proceedings of 08th IRF International Conference,* 05th July-2014.

[2] Md. Aqeel, Rohan S. Gurav, "Influence of soil structure interaction in seismic behavior of buildings on hill slopes", *International Research Journal of Engineering and Technology, Volume 2, Issue 8,* Nov-2015,

[3] Amar R Chougule, S S Dyavanal,"Seismic Soil Structure Interaction of Buildings with Rigid and Flexible Foundation", *International Journal of Science and Research (IJSR), Volume 4, Issue 6,* 2013

[4] Halkude S.A , Kalyanshetti M.G and Kadlag V. A,"Pushover Analysis of R.C Frames Considering Soil Structure Interaction", *International Journal of Current Engineering and Technology, Volume 5, no. 1,* Jan 2015

[5] A. Vijayakumar, D. L. Venkatesh Babu," Pushover Analysis of Existing Reinforced Concrete Framed Structures", *European Journal of Scientific Research, Volume 71, no.2,* February 2012