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Soil Structure Interaction Effect on Dynamic Behavior of a Building

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***Abstract*- Dynamic Soil Structure Interaction (SSI) is a collection of phenomena in the response of structures caused by the flexibility of the foundation soils, as well as in the free field response of soils media caused by the presence of structures. The effects of this phenomenon in dynamic behavior of building structures can be changed by embedment of foundation. The attempt of this study is to evaluate the seismic response characteristics of surface and embedded model buildings using finite element analyses. In recent years, many works have been done on dynamic soil structure interaction for different types of structures, especially for heavy and massive structures, such as nuclear power plants, dams, coastal platforms, bridges and tall structures on the soft soil. For high rise building there still have exist a demand for more sophisticated methods of analysis.**

An attempt has been made here to carry out the interactive analysis of the building frame having ten storeys resting on typical raft foundation. The building will be design considering a zone with specified soil condition in India. A detailed approach is made by the help of ANSYS software using finite element method. The building is analyzed for various load cases, mainly dead load and live load and lateral loads. Analysis is carried out by using staad pro v8i. The comparison of these models for different parameters like Storey Displacement, Column Bending moments and Time period are presented.

Keywords—Soil-structure interaction, response-spectrum analysis, finite element method.

INTRODUCTION:

In design offices the base of multi-storey buildings are taken as fixed and analyzed for earthquake response using provisions of IS 1893-2002 with the aid of response spectrum given for soft, medium and hard soils in foundation. But in reality, the type of soil present in and around the foundation structure also participates in the seismic response and the assumption of fixed base becomes conservative. Soil structure interaction usually carried out for soft, medium and hard soil. This study is mainly concentrated on in situ clayey soil conditions.

The main objective of this research is to contribute to the understanding of the seismic performance of superstructure considering the complex dynamic interaction between superstructure, the raft foundation and the soil. As the dynamic response of the structure and the foundation to large extent is inelastic, the primary focus is on studying the behavior of superstructure by modeling the nonlinearities of soil. To address this problem, a Finite Element Method is used to model soil structure interaction analysis of framed structures by programming in MATLAB using Direct Method. The study has also used the finite element tools ETABS for modeling and SAP2000 for SSI analysis. Finite element method is one such amongst them in view of the afore-mentioned observations, the interaction analyses have been reported to quantify the effect of soil-structure interaction on the response of the building frame resting on raft foundation.

Using analytical calculation of soil structure interaction also the main object of this paper is to find out the probability of an earthquake of larger magnitude if occur in that model building then what happens in that structure. Among the physical phenomena investigated, the effects caused by local topography, the interaction with other structures and the dissipation of dynamic energy through the soil medium were described by exact series solution.

MODEL SPECIFICATION:

SSI effects have been found to be important, when a group of identical structures with same dynamic characteristics are present. The middle structures are attracting more displacements because of trapping of seismic waves. In case of group of structures with variable height, while considering SSI there is a decrease in response for 15 storey structure when compared to 10 storey structure which is not observed in fixed base system. In case of response of structures of variable shape the top floors will attract more displacement because of reduced stiffness on top floors but in conventional fixed base case opposite behavior is observed.

In present study G+10 building are modeled.

The material properties considered are:

Young's modulus of M25 concrete, E=25×106 kN/m², Density of Reinforced Concrete =25 kN/m³, Density of brick masonry =20 kN/m³, Dead load intensities like Floor finishes =1.0 kN/m², Roof finishes =2.0 kN/m², Live load intensities on Roof =1.5 kN/m² and on Floor=3.0 kN/m²

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Fig1: Fixed Base Model in ANSYS

Modal Analysis

Modal analysis is performed in ANSYS in order to obtain the natural frequencies corresponding to various mode numbers. Results from the modal analysis are then used to perform Response Spectrum Analysis (RSA) for the same structures.

TABLE V

FUNDAMENTAL FREQUENCY FOR DIFFERENT MODELS

Number of Storeys	Fundamental Frequency			
	Fixed Base	Hard Soil	Medium Soil	Soft Soil
G+10	0.330617	0.408806	0.404932	0.39093

RESULTS AND DISCUSSIONS

The results obtained for the building system from RSA of various based models are represented in tables.

TABLE VI
BUILDING RESPONSES OF FIXED BASE MODEL

No. of Storeys	Max. Deformation (m)	Max. Velocity (m/s)	Max. Acceleration (m/s2)	Max. Shear Stress x 10^7 (Pa)	Max. Elastic Shear Strain (m/m)
G+10	0.38862	1.4279	5.6868	1.9564	0.000728

TABLE VII
BUILDING RESPONSES OF SSI MODEL IN MEDIUM SOIL

No. of Storeys	Max. Deformation (m)	Max. Velocity (m/s)	Max. Acceleration (m/s2)	Max. Shear Stress x 107 (Pa)	Max. Elastic Shear Strain (m/m)
G+10	0.82851	2.2351	22.956	2.5331	0.001993

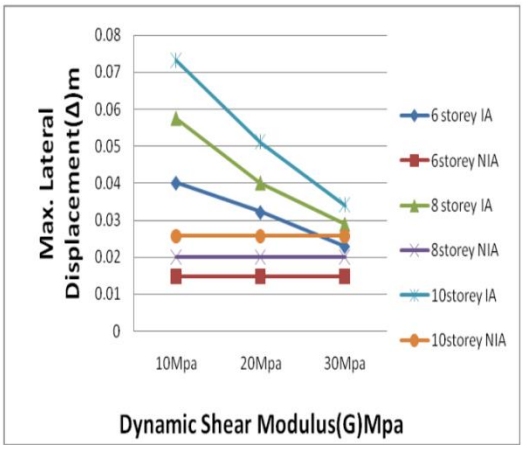

Fig2: Variation of Max. Lateral Displacement with Shear Modulus of Soil

CONCLUSION

The study leads to the following broad conclusions:

FUNDAMENTAL NATURAL PERIOD

The fundamental natural period of a specific structure considering interaction is more than that of non-interaction investigation furthermore it increments as the shear modulus of the soil declines. With expansion in number of stories fundamental natural period increments.

BASE SHEAR

Base shear values for interaction case is more than that of non-interaction case, as the shear modulus of the soil abatements base shear increments. With expansion in number of stories base shear increments.

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