Seismic Analysis and Soil Structure Interaction of Multistoried Building with Different Types of Footing

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***Abstract:*-Seismic Analysis of building is very much important in the present scenario. Post earthquake study of the structures reveals an idea about the behaviour of the structure to seismic forces and their damage. Numerical Analysis is a powerful tool in the analysis of structures which predict the possible settlements and deflections related to seismic loads so as to design the structure safely. In addition it is seen that the interaction of soil and foundation plays a major role in the damage/response of structure. Foundation is that part of structure to transmit loads from structure in to the sub-soil. In order to study the effect various type of foundation in the behaviour of building to seismic forces, a thirteen storey structure is modeled in ANSYS 16. The structure is resting on three layers of soil such as sand, clay and stiff clay. Three types of foundation such as raft, pile and under reamed pile are considered for the comparison of the study keeping all other parameters constant. On comparing the values of total lateral deflection of the building it is found that the structure with raft foundation shows maximum lateral deflection, than pile foundation and minimum is with the under reamed pile foundation. The settlement of footing is also observed. The settlement obtained under raft foundation concrete is greater than that of pile foundation. The soil settlement under pile foundation is slightly higher than that of under reamed pile foundation.**

Key Words: Earthquake, Foundations, Ansys

INTRODUCTION

Designing and modelling of any structure crosses two engineering disciplines. There is the structural engineer who designs the structure and the geotechnical engineer who is concerned with the geotechnical aspects of the soil. The strength of building and foundation are the two things to be considered while studying the behaviour of the structure. Foundation is that part of structure to transmit loads from structure in to the sub-soil. Raft foundations are required on soil of low bearing capacity and are useful in reducing differential settlement.. It is commonly used beneath multistoried building, silo clusters, chimney etc. Pile foundations are used to transmit loads to deeper layer of soil. It is used both on land and underwater for supporting structures. The under reamed piles are best suited in soils where considerable ground movements occur due to seasonal variations, filled up grounds or in soft soil strata. A soil structure interaction study is very much important to assess the behaviour of soil and structure as a single system. Numerical Analysis of structures helps in analyzing the behaviour of structures and gives the designer an idea about the probable settlement and deflection. A realistic model of structure and soil interaction can lead to an optimal and economical structure.

The objective of this paper is to study the type of foundation on lateral deflection response of the building and also to study its impact on the settlement of footing. The finite element software ANSYS 16 is used to model the soil-structure behaviour and its interaction effects. The consistency in the modeling of the interaction between structures and soil is maintained throughout the analysis. A thirteen storey building is considered for the study and is analyzed for three different type of foundation such as Raft, pile and under reamed pile foundation. Soil and structure is modeled together to obtain the soil structure interaction effects during the seismic transient. The acceleration record of Kobe earthquake (1995) of magnitude 6.9 is given as transient input. The results obtained are presented in this paper.

METHODOLOGY

ANSYS 16 workbench is used to determine the total deformation of the building as well as the settlement of the footing. ANSYS finite element tool helps in simulating every structural aspect very efficiently. The results are made reliable by the wide variety of material models, the quality of the element available, and the ability to model every aspect. ANSYS provides Linear static analysis that simply provides stresses or deformations, Modal analysis that determines vibration characteristics, advanced transient nonlinear phenomena involving dynamic effects and complex behaviors.

In this paper a 3-D model of soil structure system is developed. The different materials are defined in the engineering data tab by inputting the values of young's modulus and poisons ratio. The soil and structure is modeled integrally with introducing appropriate interface material. Then the model is meshed defining the mesh refinement in the mesh tool. The maximum lateral deformation of the structure and soil settlement beneath the footing is taken from result tab. Maximum lateral displacement is always obtained at the top of the building.

MODELLING.

An asymmetrical type of building (L- shaped) is modeled for the study, a G+12 structure is created in the Ansys16 workbench geometry tab. The structure consists of 5 bays in X-direction and in order to impart asymmetry the number of bays in Y direction is maintained as 4 and 2 in opposite faces. The other details of the structure are given in the table -1.

Table 1 : Details of the structure

Sl.No	Details	Value
1	Floor height	3.5m
2	Span	3m
3	Beam size	0.4 × 0.6m
4	Column size	0.6 × 0.4m
5	Mat foundation	800mm thick
6	Soil volume	100 × 100 × 70 m

The soil is modeled as non linear element with a volume of 100 × 100 × 70 m. The horizontal boundary (H) was placed at 5 times the foundation length (5L) and the vertical boundary (V) is placed at 3 times the foundation length (3L).The structure is supported on three layers of soil such as stiff clays, clay and silty sand and the engineering properties of the soil are shown in Table.2

Table 2 : Soil properties.

Silty sand (6m thick)	$E=205e6\ N/m^2$, poissons ratio = 0.35, Density = $20e3\ N/m^3$
Clay (18m thick)	$E=16.5e6\ N/m^2$, poissons ratio = 0.45, Density = $16.4e3\ N/m^3$
Stiff clay	$E=60e6\ N/m^2$, poissons ratio = 0.39, Density = $19e3\ N/m^3$

Kobe earthquake of Japan (1995) is used here for the transient analysis. Measuring 6.8 on the moment magnitude scale, it was the worst earthquake to hit the country in the 20^{th} century with peak ground acceleration of 0.833g..The acceleration time history for the Kobe earthquake is shown in fig.1.

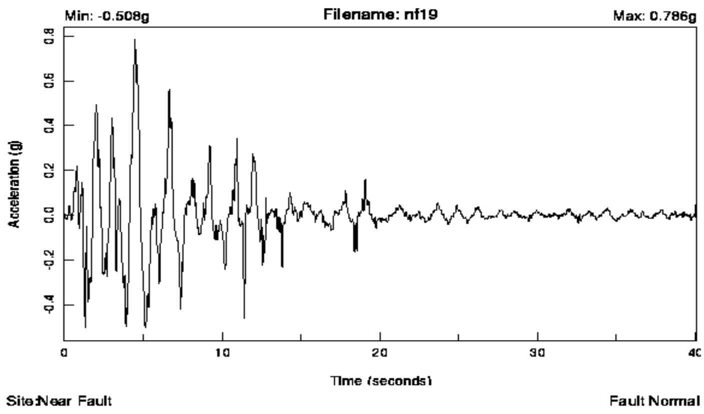

Figure 1: Acceleration time history [Kobe earthquake]

A thirteen storey building is considered for the study and is analyzed for three different type of foundation. At first the structure is modeled with raft foundation 80mm thick. Then the foundation is changed to pile foundation by giving piles of diameter 80cm and length 10m. The pile diameter and spacing are determined as per the Indian standard specifications. Then the structure foundation system is again modeled using under reamed pile foundation. The 50cm diameter pile of length 8m is given a under reamed shear bulb of 120cm at the end The deflection and soil settlement are noted. The modulus of elasticity is found out by using $5000(f_{ck})^{1/2}$. For M25 grade concrete E= 2.5e10Pa. Fig 2 and 3 shows the soil structure system and the corresponding mesh model respectively. 42817 nodes and 17429 elements are created for raft foundation structure.60705 nodes and 41410 elements are created for pile foundation structure. 70075 nodes and 52291 elements are created for under reamed pile structure.

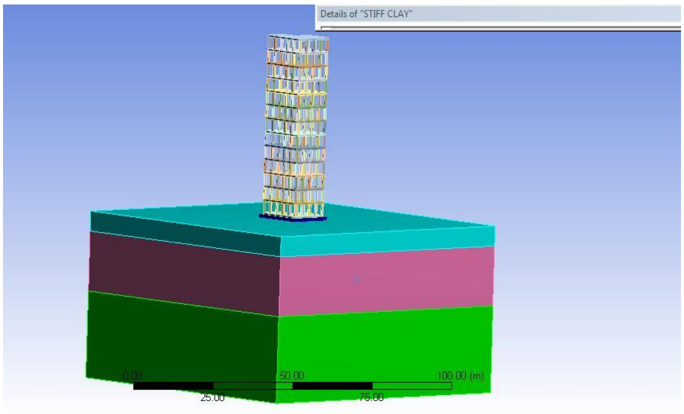

Figure 2: Model of the structure with raft foundation

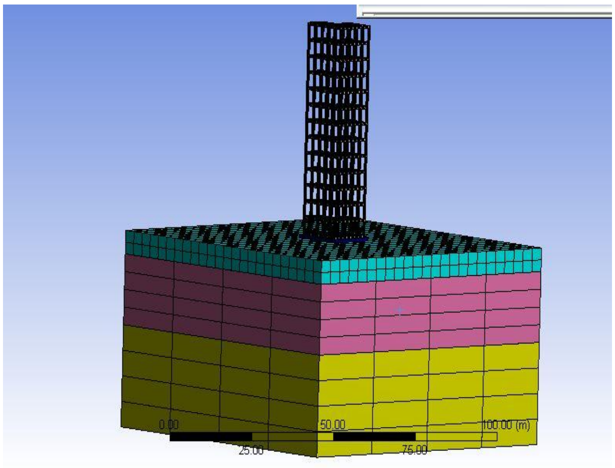

Figure 3: Mesh model of the structure with raft foundation

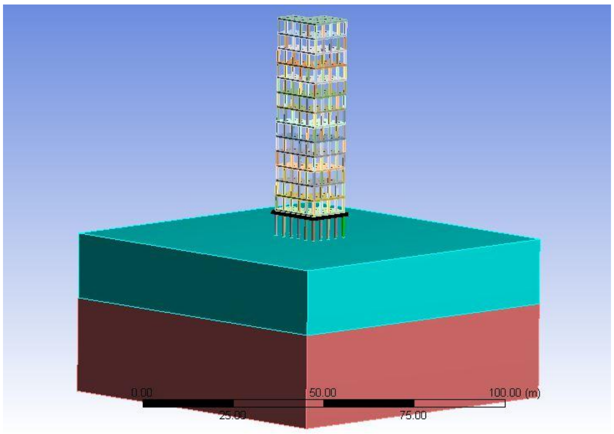

Figure 4: Model of the structure with pile foundation(hiding 1st layer of soil)

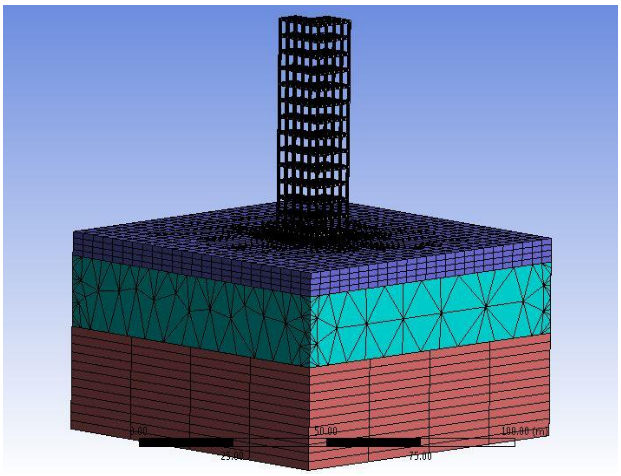

Figure 5: Mesh model of structure with pile foundation

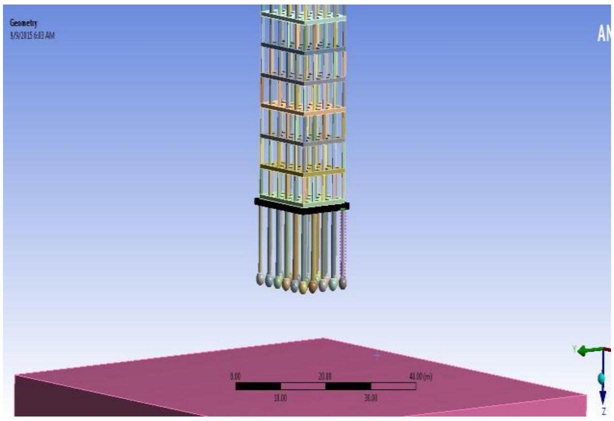

Figure 6: Model of the structure with under reamed pile foundation(hiding top two layer of soil)

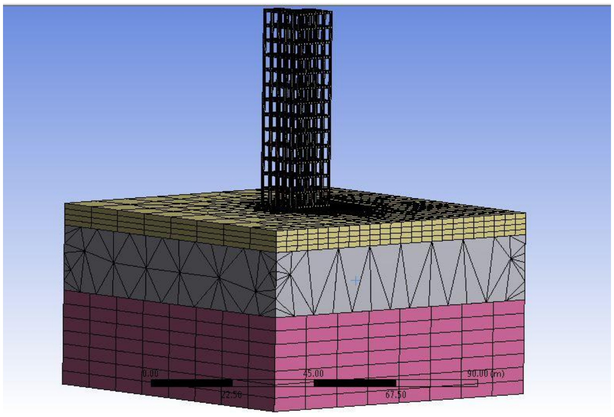

Figure 7: Mesh model of structure with under reamed pile footing

RESULTS AND DISCUSSIONS

The deformation versus time graph and soil settlement versus time graph is obtained for the three different foundation are given below. (In the graphs only positive side of deflection is shown for clarity)

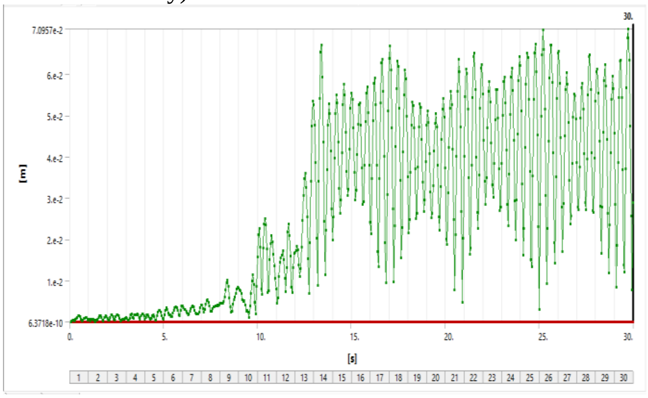

Figure 8: total lateral deformation Vs time graph for structure with raft foundation.

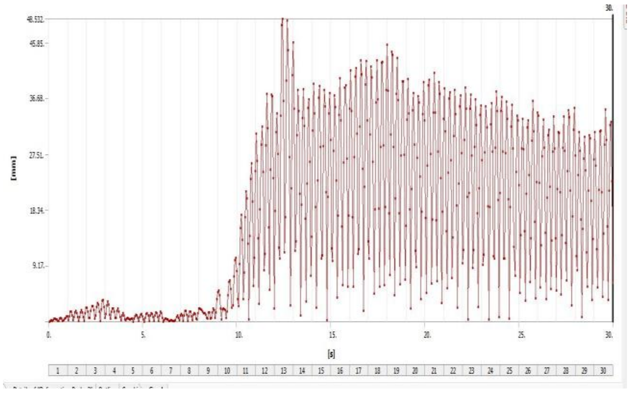

Figure 9 : Soil settlement Vs time graph for structure with raft foundation.

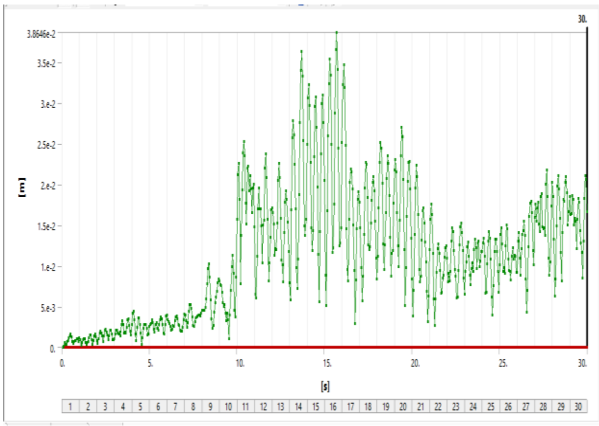

Figure 10:total deformation Vs time graph for structure with pile foundation

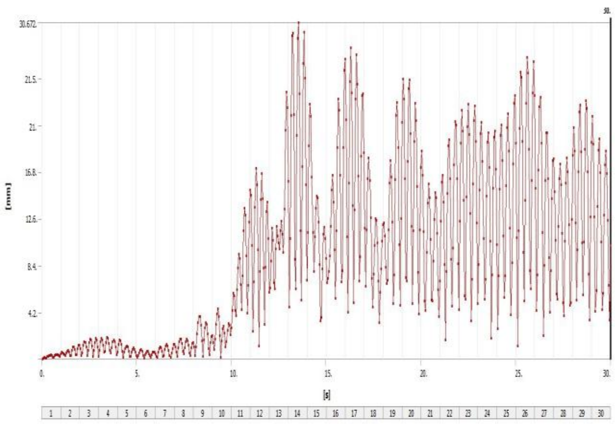

Figure 11 : Soil settlement Vs time graph for structure with pile foundation

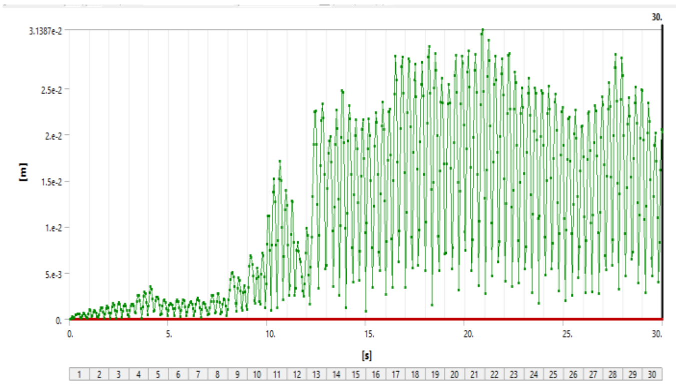

Figure 12:total deformation Vs time graph for structure with under reamed pile foundation

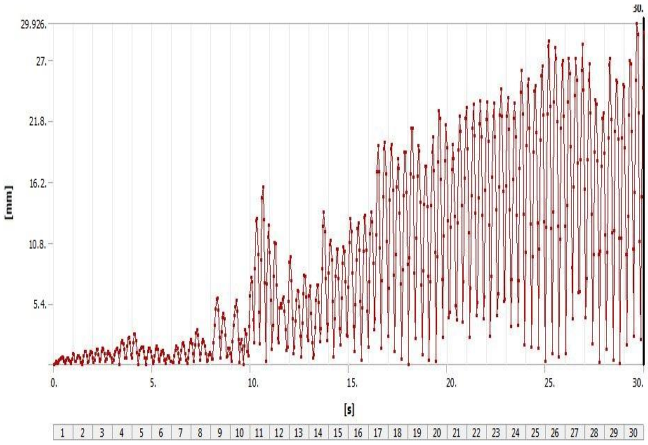

Figure 13 : Soil settlement Vs time graph for structure with under reamed pile foundation

Table 3 : comparison between various types of footing

G+12 structure	Raft foundation	Pile foundation	Under reamed pile foundation
Maximum lateral deformation(mm)	70.957	38.646	31.387
Soil settlement(mm)	48.532	30.672	29.926

CONCLUSION

In order to find out the seismic response and soil structure interaction of a multistoried building with varying type of foundation three different analysis have been carried out. G+12 storey structure is taken for the study with raft, pile and under reamed pile foundation systems. Three separate analysis is carried out for the same structure and same layered soil system. Three layers of soil with sand , clay and stiff clay is taken for the analysis. On analyzing the result it is found out that the deformation is higher for raft foundation and is about 70.9mm. When the raft is changed to pile foundation the deflection reduces considerably to 38.6mm. Thus deflection reduces to one half when raft footing is changed to pile footing. When the under reamed piles are provided instead of pile foundation the deflection again reduces to 31.387mm. The soil settlement under the raft foundation is remarkably higher than that of the pile and under reamed pile footing. But the soil settlement is only slightly more in case of pile foundation when compared to under reamed pile foundation. Thus out of the three foundation system under reamed pile foundation is found to be more effective when a seismic force is acted upon a structure.

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