Effect of Soil Structure Interaction on Seismic Response of Multistorey Building

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Abstract - *Seismic analysis of building is very much important in the present scenario. Conventional structural design methods neglect the Soil structure Interaction (SSI) effects. Ignoring of SSI is reasonable for light structures in relatively hard soil. The effect of SSI, however becomes very dangerous for heavy structures resting on relatively soft soils such as clay silt. In order to study the effect, a G+9 storey structure resting on piled raft foundation is modelled in ANSYS 21. The effect of soil structure interaction on seismic response of building resting on three different types of soil- stiff clay, silty sand and hard rock is compared with the response of building with fixed base(without soil).Static and dynamic(response spectrum) analysis were performed to evaluate the total deformation and equivalent stress. On comparing the values of total deformation and equivalent stress of the building it is found that the structure with soil shows greater deformation and equivalent stress than structure without soil and silty sand shows the greatest among them*.

Key Words: Soil Sturcuture interaction, Piled Raft foundation, Total deformation, Equivalent stress.

1. INTRODUCTION

In the seismic analysis of a structure resting on the ground, the response of the sub-soil affects the response of the structure and vice versa. Also, the structure displacements and the ground displacements are not independent of each other. This phenomenon is called soil-structure interaction (SSI). Thus the soil structure interaction can be defined as the process in which the response from the soil influences the motion of the structure and the motion of the given structure affects the response from the soil [1].

The present work emphasizes the importance of soil structure interaction in the analysis. The construction of high-rise building, medium height buildings are usually using the pile and raft foundations to support the structure under the soft grounds and reclaimed land. The study of soil structure Interaction is one of the beneficial effects on the seismic response of the building. It decreases the frequency of the building , and also it increases the flexibility of the building, story drift and lateral deflection compared to the corresponding rigidly supported structure.

2. PROBLEM STATEMENT

This paper analyses the effect of SSI on multi storey building under seismic loading. Aimed with the purpose, a G+9 building with piled raft foundation is analysed by Ansys 21 subjected to combination of gravity load and seismic load. Compare the same building using 3 types of soil with that of the building with fixed base.

3. OBJECTIVES

[1] To study the effect of SSI on seismic response of multi storey building using ANSYS software

[2] To compare the seismic response of multi storey building resting on different soil types with and without considering SSI using static analysis.

[3] To compare seismic response using dynamic analysis.

4. MODELLING

4.1 Geometry of the Building

For this study, 10 storey building with piled raft foundation has been considered. A simple structure with base dimension 12m x 12m was modeled. Cross-section properties of superstructure elements have been kept same for all floors, column – 300 x600mm, beam – 300x50mm & floor slab – 150mm and cross-section properties of foundation elements raft – 850mm, pile diameter – 750 mm & pile depth – 15m, all dimensions are as per design requirements. The soil plan area, was fixed such that, horizontal dimension should be at least five times the horizontal dimension of building and depth of soil should be at least three times depth of foundation, Therefore, soil volume modeled is 60x60x45m.

4.2 Finite Element Modelling

The building models are modelled as three dimensional structural solids with element types assigned automatically by FEA software, ANSYS 21. Mesh convergence study was done for building and used

3000mm element size and for soil a coarser mesh was used. No separation type contact was used between structure and soil elements and bonded contact type between structural elements. [2].

4.3 Boundary Conditions and Loading

Soil is modelled as rectangular solid around the foundation due to scope limit. Since soil is extended in infinity in actual case, we modelled it as finite sized solid and applied boundary conditions. Pressure applied is 1000Pa. For static analysis, cyclic loading was applied and for dynamic analysis El centro data was given.

Table -1: Material Properties of Concrete and Soil

Properties	Structure	Soil
Material	Concrete	Soft Soil
Young 's Modulus , E(Pa)	2.9×10^{10}	2.5×10^{7}
Poisson 's ratio ,ν	0.15	0.25
DENSITY, ρ (Kg/m³)	2500	1900

5. Methodology

G+9 RC frame structure supported by a piled raft foundations of two high rise buildings are designed by considering the with and without soil structure interaction subjected to a seismic forces. Static (Cylic loading) and dynamic (Response Spectrum) analysis were conducted using ANSYS 21. Seismic analysis was carried out by using El centro earthquake data.

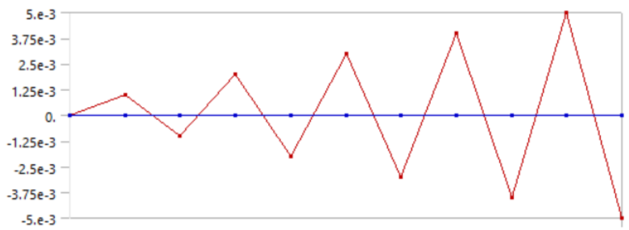

Figure: Seismic Cyclic loading

Table 2: El centro earthquake data

Frequency(Hz)	Displacement(m)
0.1998	0.02297
1.1428	0.02368
2.3991	0.02999
3.081	0.0341
4.2166	0.03285
5.2402	0.04617
6.3584	0.03904
7.0369	0.04171
8.1511	0.05372

6. RESULTS AND DISCUSSIONS

6.1. Static Analysis

A.) Total Deformation

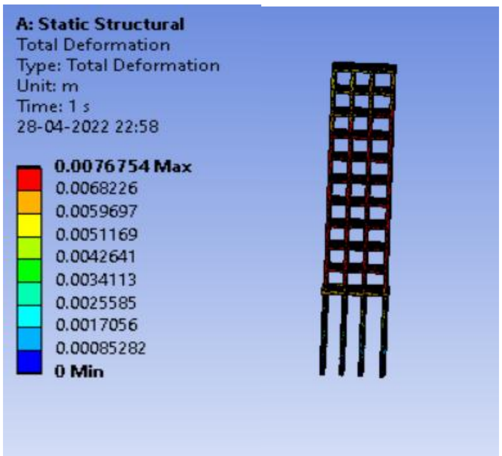

Fig : fixed base

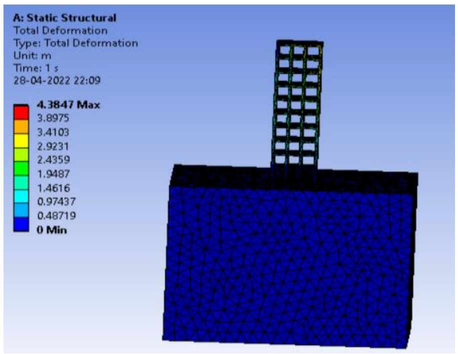

Fig : Stiff clay

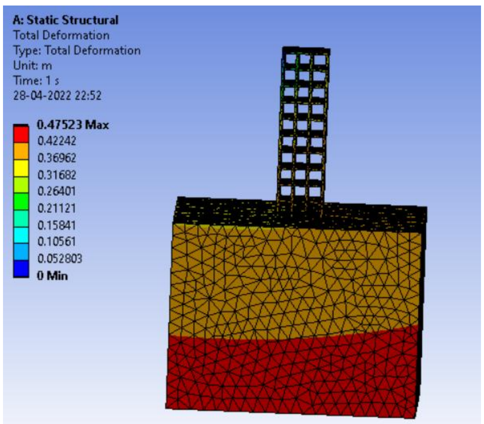

Fig: Hard rock

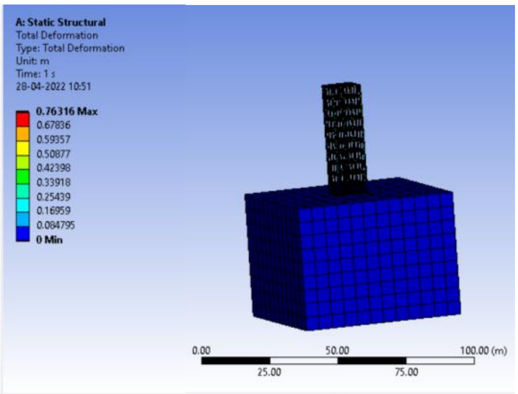

Fig : Silty sand

Total deformation occurred to the building under consideration is greater for flexible base than fixed base model and is greatest for building with stiff clay.

6.2 Dynamic Analysis

A.) Total deformation

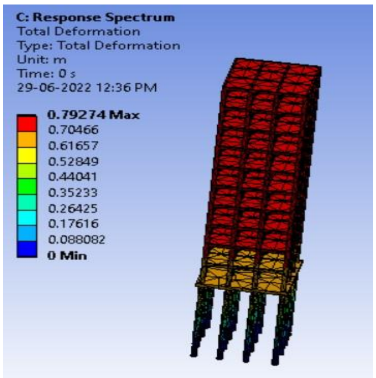

Fig : fixed base

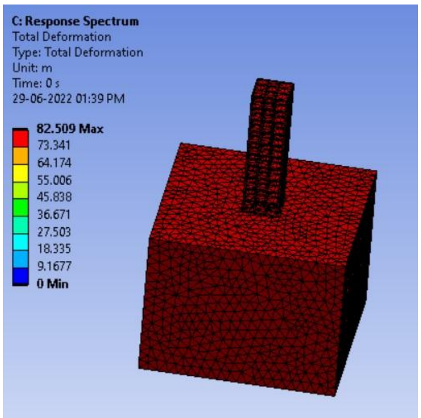

Fig : Stiff clay

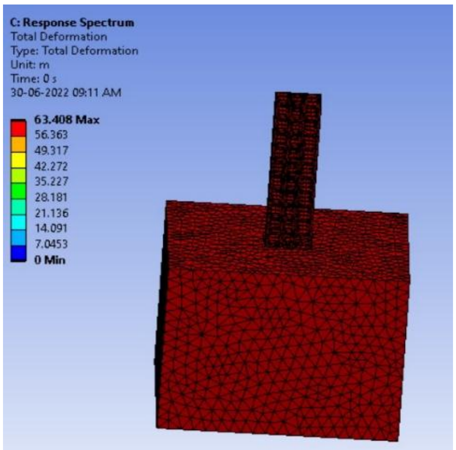

Fig : Silty sand

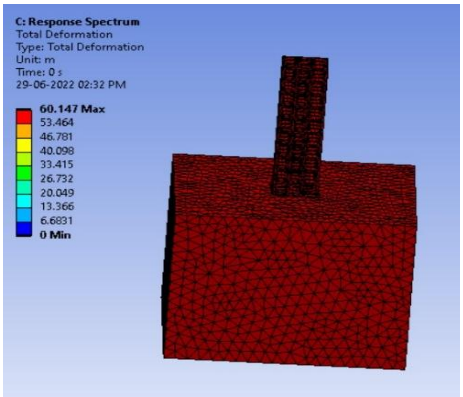

Fig: Hard rock

7.CONCLUSIONS

1. Total deformation vary considerably for different soil types and are decreasing from soft soil to hard rock.

2. Deformations under seismic loads are larger for building considering SSI effects than with fixed base

3. Total deformations under dynamic analysis are far greater than those under static analysis. Thus, dynamic analysis is preferred for buildings in earthquake prone areas.

4. Thus soil structure interactions need to be considered for seismic analysis of multistorey building.

8. REFERENCES

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