SEISMIC ANALYSIS OF RC STRUCTURE BY CONSIDERING SOIL STRUCTURE INTERACTION (SSI)

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Abstract - *During the past years, researchers have investigated the behavior of structural response during earthquake with soil structure interaction (SSI). Accordingly, basic consideration of fixed-base condition analysis by neglecting the effect of soil behavior is carried out for seismic design of structure. Therefore, the effect of soil behavior is an important thing for the design considerations. The basic concept is known as the structure is resting on various types of soil underlying as the base for the foundation of that structure. For evaluate the natural behavior of building with soil interaction effect for the various types of soils and different layers of soil need to be considered for investigation. Accordingly, in this paper the seismic behavior of the RC structures for different types of soil individually and different soils in layer are carried out. For the study 3 different types of soil was tested for fundamental properties of that soil. The results after the analysis indicate that the storey deformation in individual soil increases. While the time period of building increases up to 61% for SSI model. Therefore neglecting SSI effect could be dangerous during earthquake.*

Key Words: Soil Structure Interaction, different location soil, layered soil.

1. INTRODUCTION

A large portion of the structural building includes some sort of basic component with coordinate contact with ground. At the point when the earthquake forces (i.e. external forces), acts on these frameworks, the results are depends on relation between structural displacements and ground motion. Within the evaluation of structure subjected to earthquake force, it is generally assumed that the base of structure is conventionally fixed. The analytical formulations for the interaction between BI and SSI reported that stiffness ratio between period elongation and structures damping is increase[1]. As per Forcellini, the structural behaviour changes as base isolation is incorporated with SSI, it affect as change in lateral deflection and floor drift. The effect of the mutual behavior between the structure, the foundations and the soil in the various directions is studied using 3D numerical models and fragility curves for probability-based approach are described 0. Site amplification and soil structure interaction combine effect on fragility curve for different load resisting frame structure and different soil material 0. For the open ground story effect with SSI is studies precisely, Seismic assessment of irregular building by beam on nonlinear Winkler foundation with soil structure interaction on tall ground story building0. Seismic ponding effect by considering soil structure interaction is performed and which results in increase in displacement demand for ponding and significant changes in story drift demand reduction0. The series of shake table experiment for understanding seismic response of Nuclear Power Plant with soil raft foundation in clay on scale down model for same foundations0. Study on effect of soil structure interaction on building with braced system for near and far field earthquake is studied along with different types of bracing methods, there are 49 types of strong back system is design for SSI effect[7]. The story drift for both the field earthquakes are investigated. Comparison between conventional and base isolation using soil structure interaction studied and results as increase in Storey drift 0. The effect of seismic isolators on steel asymmetric structure by considering SSI was studied by Radkia et al. and they observed the base isolators reduces the effect of SSI 0. Three types of soil were considered for soil modeling with base isolators. Base isolation on soft soil with layers is considered for steel structure for pile model, isolation model and pile plus isolators combinations. The effects of soil structure interaction for soil from different location in layered condition have not been considered. In this present study, G+10, G+15 and G+20-story structures for fixed base and flexible base condition developed using SAP 20000 with soft soil. The whole model is have been analyzed, under the various soil condition like soft clay from different locations considering in different layers.

1.1METHODOLOGY

In this study used the finite element method(FEM), specifically SAP 20000 software, to analyse the behavior of symmetric Ordinary RC moment resisting frame (OMRF) structure models. The models of G+10, G+15, G+20 will be generated by considering soil mass. Total 15 models are there for different type of considerations. The structural models are generated as per IS codes 00. Soil sample from 3 different locations is collected and tested to obtain the soil properties which are required modeling the soil profile. Then all soil properties were used in 3 different layers with different models comparing with conventional type model i.e. without SSI. The models are prepared for the SSI effect.

1.2SRUCTURAL MODEL

1.2.1 RC Model

The models used in this study were generated as three-dimensional structures of ground plus 10, 15 and 20 storey. These models are assumed to be located in Pune region with the risk of a moderate earthquake. The geometry of these buildings has five spans in the X direction and five spans in Y direction. Each span is 4 m long with a story height of 3m. Square section selected for columns and for beam rectangular section is selected. These structural models are loaded under gravity load and consider as they have fixed bases. Table 1 shows the values of the live and wall loads and floor finished loads on the structures. The structural models are designed using SAP 2000 0, as per the IS 456 0. Nonlinear behavior of structural member was reflected as users define plastic hinges. Time history analysis were performed by using two real ground motion records of Bhuj earthquake India (2001) and Kobe earthquake Japan (1995).

1.2.2 Soil Model

The considered soil models aims to represent real soil profile of 3 layers with different properties. No water table was considered inside the soil mass. The 30m depth of soil with single homogenous layers of each sample and the 10m each soil sample of 30m depth for 3 layered soil (A-B-C) is considered with their properties (see Table 2). The foundation soil for all models is set to 8 nodded brick element. The soil surface is 100 m x 100 m with a depth of 30 m as per 0 with boundaries are far from the foundation to reduce the effects of boundary conditions as shown in Fig. 1.

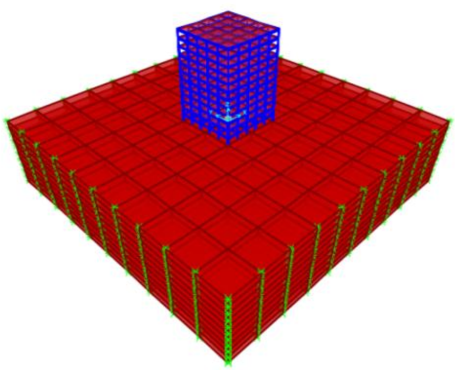

Fig -1: 3D view of G+10 model

Table -1: Loading Parameters

Properties	
Live load (kN/m2)	4
Floor finish (kN/m2)	1.5
Wall load (kN/m2)	15
Seismic Zone	III

Table -2: Soil properties

Properties	Sample A	Sample B	Sample C
Mass Density (kN/m³)	17.2	16.8	17.8
Modulus of Elasticity (kN/m²)	3.032×10^7	2.647×10^7	4.172×10^7
Shear Modulus (kN/m²)	1.166×10^7	1.018×10^7	1.604×10^7
Angle of Internal Friction (deg.)	32.2	31.8	32.8

2. RESULTS AND DISCUSSION

2.1 Time Period

The fundamental time period of structure for all four cases of fixed and flexible base are observed that the effect of soil foundation results in increase of fundamental time of structures. From the analysis G+10 model time period increase around 34% as base condition changes from fixed to flexible and increases as 27% for layered soil. Similarly for G+15 it is increase by 41%, 46% and 32% for sample A sample B and sample C respectively. For layered soil condition it is observed that 33 %. In G+20 model time period increases by 55%, 61% and 43% for sample A, B and C resp. For the layered soil time period increases by 44% is observed. Among all soil samples, sample C has lower value of increment in all type of structures.

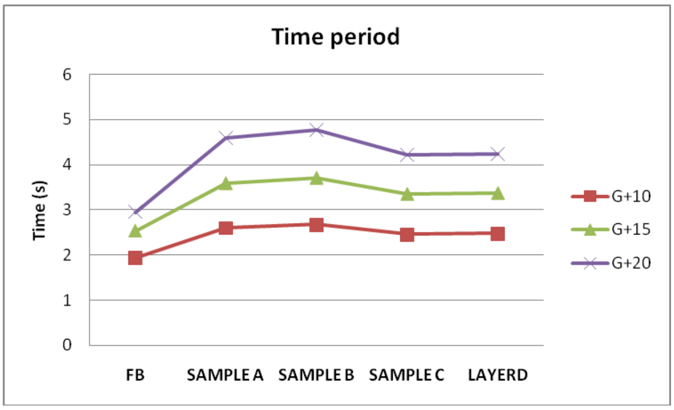

Chart -1: Variation in Time period

2.2 Storey Deformation

The Storey displacement is seen to be significantly influenced by the soil flexibility. The variations in storey displacement forG+10, G+15 and G+20 building frame are presented below.

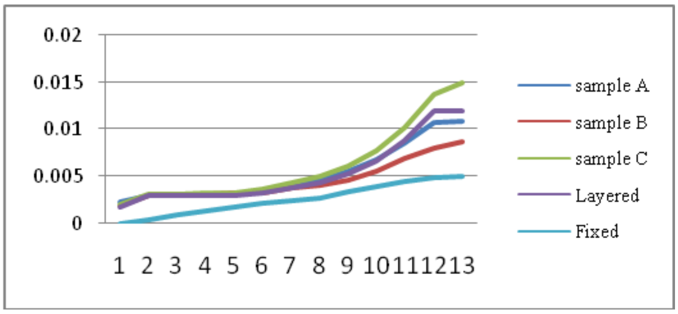

Chart -02: Storey Deformation in G+10 for Bhuj

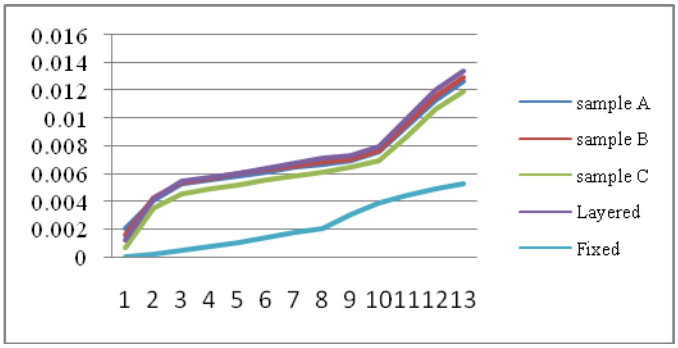

Chart -03: Storey Deformation in G+10 for Kobe

The displacement in G+10 building is to be significantly influenced by the soil flexibility. From Chart 2 and 3 it seems that the max Storey displacement 0.015m is observed in sample C in Bhuj. Also all samples have nearly 0.005m base displacement in Bhuj and Kobe. All samples have nearly same top story displacement in Kobe earthquake. Displacement of layered soil is in between sample B and sample C.

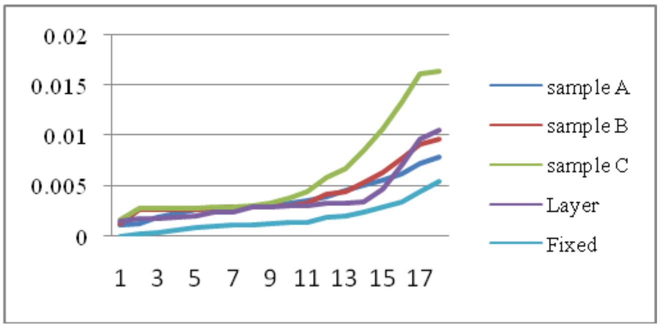

Chart -04: Storey Deformation in G+15 for Bhuj

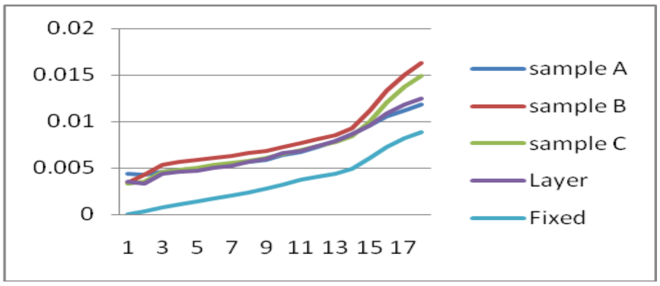

Chart -05: Storey Deformation in G+15 for Kobe

The displacement in G+15 building is to be significantly influenced by the soil flexibility. From chart 4 and 5 it is observed that the max Storey displacement 0.017m is observed in sample B in Kobe. Also all samples have nearly 0.004m base displacement in Kobe but in Bhuj the base displacement is nearly 0.002m for all building. Sample C is also having more displacement as compare to other sample in Bhuj equals to 0.0165m. In Kobe top story displacement is more in sample B. Displacement of layered soil is less than sample C and sample B but more than sample A.

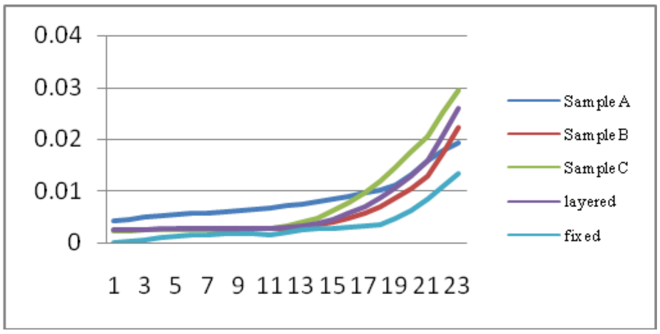

Chart -06: Storey Deformation in G+20 for Bhuj

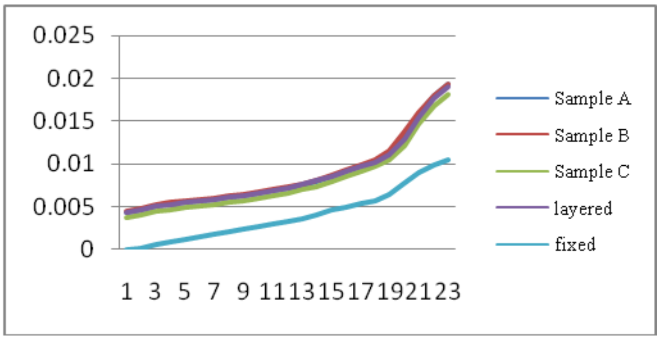

Chart -07: Storey Deformation in G+20 for Kobe

The displacement in G+20 building is to be significantly influenced by the soil flexibility. From chart 6 and 7 it is observed that the max Storey displacement 0.027m is observed in sample C in Bhuj. Also all samples have nearly 0.004m base displacement Kobe and less than 0.005m in Bhuj. All samples have nearly same top story displacement in Kobe. Displacement of layered soil is in between sample C and sample A for all earthquakes.

2.3 Soil Deformation

Deformation of soil due to external force that is earthquake is the effect after ground motion. Soils deformation is depend on intensity of earthquake or primarily known as peak ground acceleration (PGA).

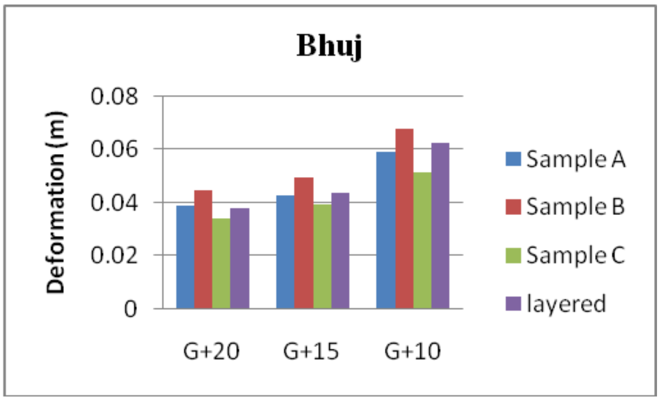

Chart -08: Soil Deformation for Bhuj

From chart 08 it is observed that deformation in soil for Bhuj is maximum in G+10 building which is 0.067m for sample B. Sample B have more deformation in all building. As the height of building goes down deformations are increases. For all building sample C is shows less deformation the any other sample. Deformation in layered soil is nearly equal to sample A.

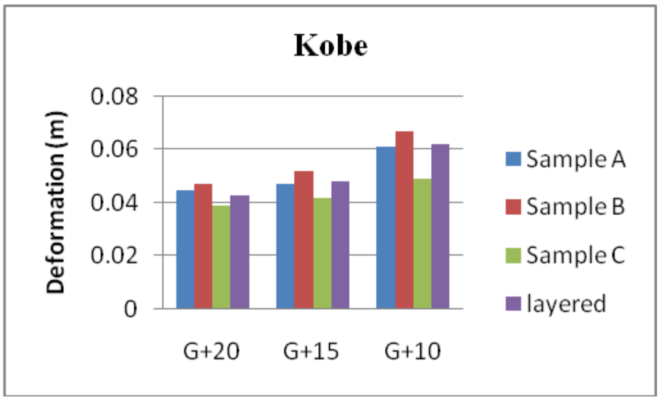

Chart -09: Soil Deformation for Bhuj

From chart-09 it is observed that deformation in soil for Kobe is maximum in G+10 building which is 0.065m for sample B. Sample B have more deformation in all building. As the height of building goes down deformations are increases. For all building sample C is shows less deformation the any other sample. Deformation in layered soil is nearly equal to sample A

3. CONCLUSIONS

In this study 15 numbers of models for various soil samples and fixed base were carried out to investigate effect of Soil Structure Interaction on the structure. The main conclusions are

1) As the base of structure changes from fixed to flexible the fundamental time period increases up to 61%. The sample C has less increment in time period in all category of building. The considerations of soil in layered condition decrease time period than soil considering individually.

2) The storey displacement increases as height of building increases. As the soil sample changes there is change in storey displacement. Displacement for soil sample depends on soil properties like shear modulus and density of soil.

3) Deformation in soil is more in less shear wave velocity soil sample. As sample C has more shear wave velocity it shows less deformation in all models.

ACKNOWLEDGEMENT

I would like to express my gratitude towards Dr. P. B. Nangare (HOD, Department of Civil Engineering) for providing me all the excellent academic facilities required to complete this work.

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