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Soil Structure Interaction of a Mid Rise Building frame for Seismic Load Considering Soft & Loamy Soil Condition using Analysis Tool SAP2000

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ABSTRACT

Now a day the human life and the environment have frequently been endangered by the natural hazards like earthquake, tsunami, flood, cyclone and landslides. As a consequence of which the human society and the nation's economy get hampered immediately after the occurrence of a natural disaster. In developing countries like India, where the population is very large and is increasing day by day, the social and economic factors force the people to live in vulnerable areas, due to which the effects of these natural disasters are catastrophic. Among all these threats, liquefaction of soil can be pointed out as one of the most disastrous seismic hazards. Hence evaluation of liquefaction susceptibility is an important aspect of geotechnical engineering. soil-structure interaction effect in the analysis and design of RC frame buildings is increasingly recognized but still not penetrated to the grass root level owing to various complexities involved. It is well established fact that the soil-structure interaction effect considerably influence the design of multi-storey buildings subjected to lateral seismic loads. In this study we are performing seismic assessment using Analytical tool SAP2000 over a mid rise building frame where we will provide lateral load for zone V (0.36) to determine soil structure interaction for lateral loads, for this study a mid rise symmetrical building of G+7 storey is considered.
Keywords: Soil Interaction, Analysis Tool, Mid Rise Building, Support Reaction, Forces.

I. INTRODUCTION

During the last century, it has been assessed that seismic danger accounts around 30% of all out setbacks and 60% of the all out property misfortune. However, soil liquefaction marvels have been perceived since long, it was all the more thoroughly brought to the consideration of designers, seismologists and academic network of the world by a few decimating earthquakes around the globe.

The traditional basic examination of a RC space casing is done expecting establishment laying on fixed end underpins. The investigation is completed by considering base part of the arrangement fixed and ignoring the impact of soil distortions.

Soil Structure Interaction:

The investigation of soil-structure interaction (SSI) is identified with the field of earthquake designing. It is imperative to take note of that the basic reaction is for the most part because of the soil-structure interaction powers that expedites an effect the structure. This is a form of seismic excitation.

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. This is a phenomenon in which the structural displacements and the ground displacements are independent to each other.

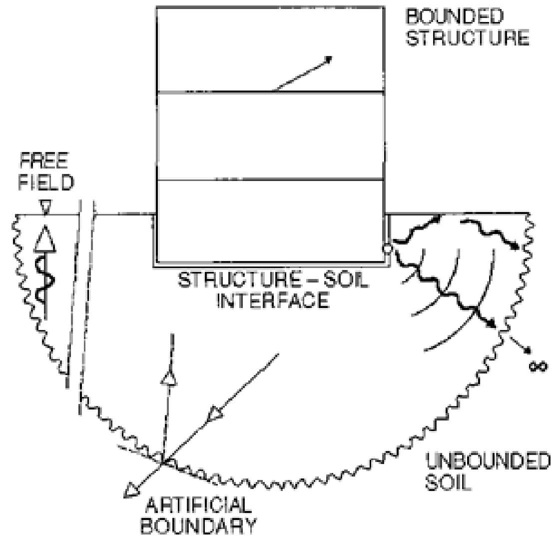

Figure 1 : Soil Structure interaction

Objectives of the study:

The primary objectives of this study is as follows:

1. To check the stability of soil - structure interaction in Seismic hazard.
2. To determine the effect of lateral load over two different soil type i.e. Loamy & Black cotton soil.
3. To determine the Utilization of Analytical tool SAP2000 in soil & Structure Interaction.
4. To determine the variation in forces, stability, displacement and other important criteria or safe structure.

II. LITERATURE REVIEW

Supriya and Reddy (2019) this research paper presented the effects of soil interaction on building frame design parameters as change of modulus of sub-grade reaction from 0.010 to 0.050 N/mm3 the analysis was done on parameters namely shear force, bending moment and settlements for different footing sizes of 1mx1m to 4.5mx4.5m the effect of SSI was quantified using finite element analysis. The conclusion derived from the research paper stated that the shear force and axial force value in the beam and column is constant from finite element analysis was not having considerable difference. The analysis was predicting that percentage difference in bending moment in beam, column and footings was at lower EFS value i.e 0.010N/mm3 at lower footing size 1mX1m was greater than when compared to higher EFS value i.e 0.050N/mm3 at higher footing size 4.5mX4.5m which considers soil interaction. But in case of the footings they undergo some settlement the percentage difference of settlement was 14.41% and 6.72% at lower EFS value i.e 0.010N/mm3 at lower footing size 1mx1m when compared to higher EFS value i.e 0.050N/mm3 at higher footing size 4.5mx4.5m respectively, which considers soil interaction.

Magade and Patankar J. P(2018) this research paper presented different parameter such as soil structure interaction, types of soil, stiffness of infill walls, and location of walls influences time period, displacement and base shear of building frame considerably. Hence it was important to consider to all these parameters in the analysis of structures. Shear walls located in the central part of the multistoried building gives lesser displacement and more base shear compared to other locations.

Kabtamu et. al. (2018) this research paper dynamic analysis of Soil Structure Interaction (SSI) effect on multi story reinforced concrete (RC) frame founded on soft soil (flexible base) and comparison was made with fixed base. Two model 2D RC frames with 7 and 12 story are selected for analysis. Winkler Spring and half space direct method models are used for flexible base for the frames founded on two types of soft soils with shear velocity Vs < 150 m/s Asper Seismic Codes of Chinese GB50011-2010 Soil IV and Ethiopian ES8-2015 soil D. The frames are subjected to strong ground motion matched to response spectrums of soft soil of Chinese GB50011-2010 and Ethiopian ES8-2015 for linear time history analysis. The dynamic analysis result showcased Spring and Fixed base mass participation 90% reaches in 2 or 3 modes but in direct method 11 to 30 modes for story 12 and 7 respectively.

The results led to the conclusion that SSI effect may not be always beneficial in multi-story RC frame compared to fixed base. Because the beneficial effect reduction in base shear may be smaller than detrimental effect of P-delta increment on vertical load carrying members. The results obtained in this study is limited to linear time history analysis regular 2D RC frame; however it is good indicator of SSI effect.

III. METHODOLOGY

Step-1 Select Geometrical data and modelling of structure using SAP2000.

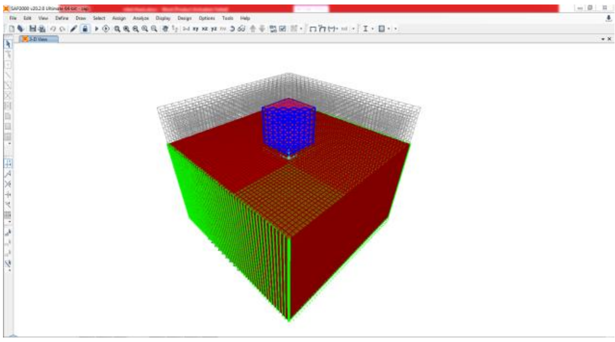

Figure 2 : Geometry of structure using SAP2000

Step-2: Defining material and soil property for study.
Step-3: Creating Soil Mass below the structure:
Step-4: Assigning Boundary Conditions
Step-5: Interacting RCC Structure over the soil

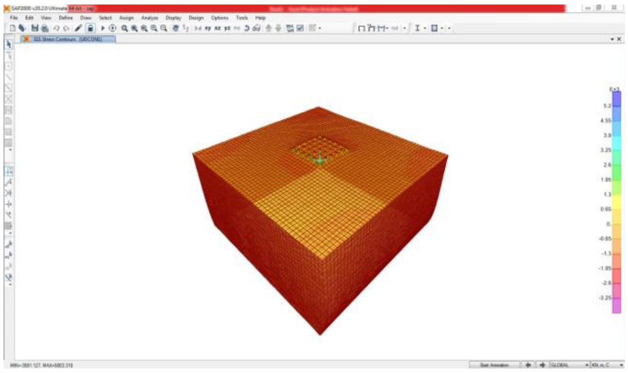

Figure 3 : Soil Structure interaction

Step-6: Load Combinations
Step-7: Interacting Soil and structure
Step-8: Comparative Analysis

Table 1 : Geometrical Data

Description	Value
HEIGHT OF BUILDING	24 m (G+7)
Length	18 m
width	20 m
column	0.5 x 0.4 m
Beam size (main)	0.4 x 0.4 m
Soil Type	Black cotton soil & Loamy
Soil Mass	80 x 80 x 80 meter
Support type	Fixed support

Table 2 : Soil Properties

S.No.	modulus of elasticity kN/m²	Poisons ratio	Unit weight kN/m³
Loam Soil	65000	0.3	18
Black cotton soil	15000	0.4	16

F.E.M. Analysis:

Finite element analysis, using the finite element strategy (FEM), is a result of the advanced age, going to the fore with the coming of computerized

PCs during the 1950s. F inite element analysis (FEA) is a modernized technique for foreseeing how an item responds to certifiable forces, vibration, heat, liquid stream and other physical impacts. Finite element analysis demonstrates whether an item will break, wear out or work the manner in which it was planned.

Soil Mass Analysis at Different Levels

Table 3 : Analysis of black cotton soil at top

Stressess at top of black cotton soil			
S11	**S22**	**S33**	**S12**
KN/m2	KN/m2	KN/m2	KN/m2
-3.37	2.49	-4.27	-0.0195
-3.37	2.47	-4.29	-0.0154
-4.48	2.5	-3.62	-0.0193
-4.48	2.49	-3.64	-0.0152
-6.11	-2.57	-4.26	-0.0257
-6.11	-2.59	-4.27	-0.0298
-7.27	-2.59	-3.64	-0.0259
-7.27	-2.61	-3.66	-0.03

Table 4 : Analysis of black cotton soil at mid 9m

Stressess at mid of black cotton soil			
S11	**S22**	**S33**	**S12**
KN/m2	KN/m2	KN/m2	KN/m2
-49.49	2.33	-155.39	0.05711
-49.49	2.37	-155.38	0.05209
-50.04	2.31	-152.1	0.05751
-50.04	2.36	-152.08	0.05249
-51.62	-1.56	-155.41	0.05005
-51.63	-1.52	-155.4	0.05507
-52.12	-1.54	-152.08	0.04966
-52.12	-1.5	-152.06	0.05468

Table 5 : Analysis of black cotton soil at Bottom 18 m

Stressess at Bottom of black cotton soil			
S11	**S22**	**S33**	**S12**
KN/m2	KN/m2	KN/m2	KN/m2
-75.98	1.54	-239.89	0.08414
-75.99	1.61	-239.87	0.08225
-80.8	1.53	-246.34	0.08427
-80.79	1.61	-246.3	0.08238
-77.4	-1.29	-239.9	0.08161
-77.41	-1.23	-239.88	0.0835
-82.19	-1.29	-246.33	0.08148
-82.18	-1.21	-246.29	0.08337

Table 6 : Analysis of Loamy soil at top

Stresses at top of loamy soil			
S11	**S22**	**S33**	**S12**
KN/m2	KN/m2	KN/m2	KN/m2
-13.37	1.88	-4.63	-0.09473
-13.36	1.85	-4.66	-0.08558
-13.68	1.9	-4.35	-0.0946
-13.68	1.86	-4.39	-0.08546
-15.19	-1.71	-4.61	-0.11
-15.19	-1.74	-4.65	-0.12
-15.57	-1.72	-4.36	-0.11
-15.57	-1.76	-4.4	-0.12

Table 7 : Analysis of Loamy soil at Mid 9m

Stresses at mid of loamy soil			
S11	**S22**	**S33**	**S12**
KN/m2	KN/m2	KN/m2	KN/m2
-48.81	1.91	-184.57	0.04682
-48.81	1.92	-184.59	0.03608
-49.36	1.89	-181.77	0.0472
-49.36	1.91	-181.78	0.03646
-50.62	-1.38	-184.59	0.03271
-50.62	-1.37	-184.61	0.04346
-51.1	-1.36	-181.75	0.03233
-51.1	-1.35	-181.76	0.04308

Table 8 : Analysis of Loamy soil at Bottom 18m

Stresses at bottom of loamy soil			
S11	**S22**	**S33**	**S12**
KN/m2	KN/m2	KN/m2	KN/m2
-48.81	1.91	-184.57	0.04682
-48.81	1.92	-184.59	0.03608
-49.36	1.89	-181.77	0.0472
-49.36	1.91	-181.78	0.03646
-50.62	-1.38	-184.59	0.03271
-50.62	-1.37	-184.61	0.04346
-51.1	-1.36	-181.75	0.03233
-51.1	-1.35	-181.76	0.04308

Column Analysis

In this research paper we are presenting analysis of a column joint from base to 7th storey. For analysis we are considering outer edge column C1

C1:

Axial Force

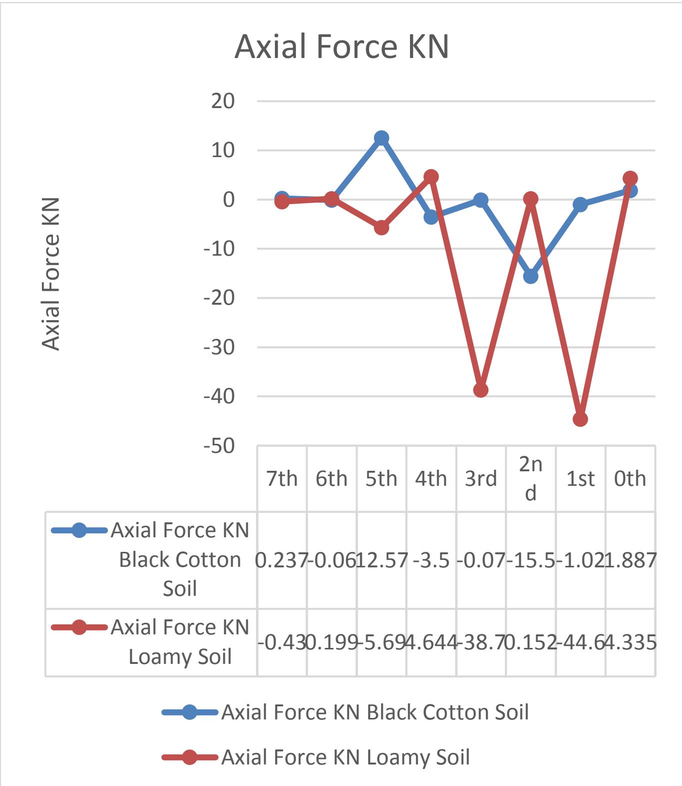

Figure 4 : Axial force

Shear Force

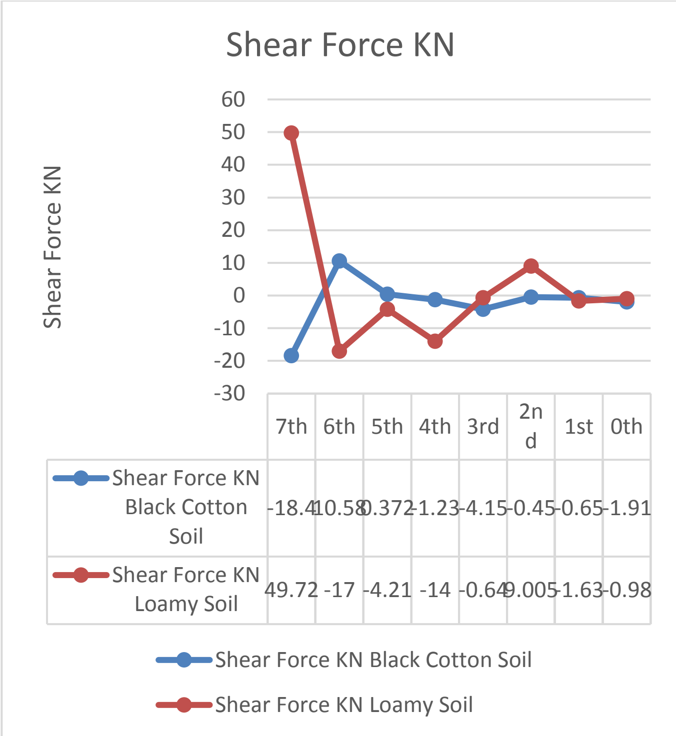

Figure 5 : Shear Force

Bending Moment

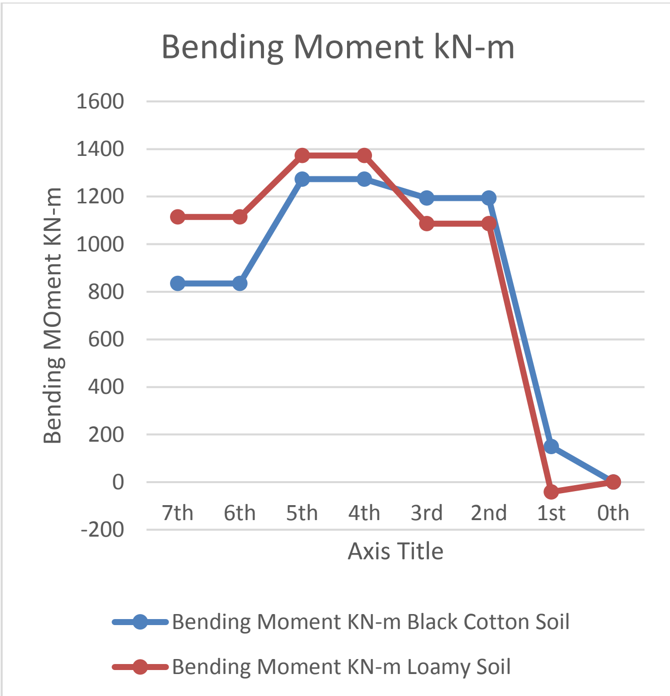

Figure 6 : Bending moment

IV.CONCLUSION

Following points are drawn from the comparative analysis are as follows:

- Vertical forces are distributive in both the cases but due to soil interaction effect on black cotton soil causes unsymmetrical distribution of loading.
- In terms of shear forces, it can be said that unbalanced forces are effecting both the cases due to lateral forces, in case of black cotton soil unbalance forces are generating more in comparison.
- In terms of bending moment it has been observed that moment is linear in both the direction as it is generated due to the vertical and lateral forces in structural member, it has less effect of soil.
- It is observed in the above analysis that loamy soil is 18.50 % more stable in resisting forces.
- It is observed that effect of lateral forces is more in black cotton soil as compared to loamy soil.
- It is observed that soil mass is meshed finitely in SAP2000 Which provide accurate and linear results.
- It can be concluded that there is variation in both the cases i.e. structure under black cotton soil and loamy soil, as forces and moment are varying by 16% and 14 % respectively.

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