EFFECT OF SOIL INTERACTION ON 3×3 BUILDING FRAME EMBEDDED IN MULTILAYERED SOIL

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ABSTRACT

Objectives: To study the effect of soil interaction on 3×3 building frame embedded in the multilayered soil. Methods/Analysis: A simple three storey three bay framed structure laying on the pile foundation is analyzed in ANSYS. The effect about soil structure interface on the displacement of columns in the structural frame is investigated. The investigational results are connected by means of those obtained on or after the soil structural analysis and the conservative method of analysis. Soil non-linearity inside the horizontal direction is performed by means of P-Y curves. Findings: These curves are developed using Matlock and API (American Petroleum Institute) equations. And the results shows that the values obtained from SSI for bending moment, shear force and deflection are more than that of without SSI. Applications: Effect of soil structure interaction on a building frame embedded in multilayered soil concept can be extended to different types of piles and number of bays and storeys can be increased further the analysis can be carried out for the different types of soils using ANSYS.

Key words: Soil structure interaction, Building frame, Multilayer soil, Experimental results, Nonlinearity.


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1. INTRODUCTION

Soil-structure interface (SSI) analysis is a very particular field of earthquake engineering. Generally, most of the buildings involve some types of structural elements with direct influence on earth. The peripheral forces like earthquakes result in these systems like structural displacements or ground displacements are not dependent on each other. The structural response to the earthquake vibrations influenced by the interaction between the foundations, structure, underneath and surrounding soils of the foundation. The past investigation reveals that the effect of soil with the structure can be considered relatively. The interface studies which were earlier discussed, accepted that resting on replica (model) pile foundation supported on a plane frame with different rigidity\(^1\). The building frame is subjected to CCL, UDL, ECL.
The end fallouts show that the BM & SF, which were drawn from the experimental examination, showed large drop with the reduction of rigidity of plinth beam. The explanation for the effect of the rigidity of the plinth beam on a building frame supported on a group of piles embedded in sandy soils by the result of static vertical load tests. The effect of the rigidity of plinth beam on displacements and rotation at the column base and also shears and bending moments in the building frame were investigated. In the analytical model, soil nonlinearity in the axial stated that stretchy pile caps laterally with rigidity must be measured and stiffness matrix of substructure needs to be drawn out by consideration of all the piles in a single group and also gave the explanation for a single-storeyed and two bayed space frame resting on group of piles with flexible cap by resorting to more rational approach and realistic assumptions. The effect of a single pile when it is fixed its reaction over the SSI on the response of super-structure. Analysis has been presented on pile foundation (single pile or pile group) and most of the work dealt with the analysis of a framed construction, which rests on the pile groups, and the explanation intended for SSI and group piles are exposed to lateral loads by using the ‘P-Y’ Curve.

2. OBJECTIVES
The main objective of the work is to analyze a framed structure supported on pile group embedded in multilayered soil considering Soil Structure Interaction (SSI) and compare the same with a structure analyzed without considering SSI.

1. Deriving the p-y curves as per the soil considered and by using the obtained values analyzing the structure in ANSYS.
2. Obtain BM, Deflection and SFD for the structure considered and comparing the obtained results with a structure analyzed with and without considering SSI.

3. METHODOLOGY
Bearing capacity is a major factor to be considered for a structure to withstand on a particular soil. So, my experimental investigation takes me to identify Structural behavior (Shear force, Bending Moment and Deflection) on different types of multilayered soils like Clayey soil and Sandy Soil to interact and compare with non-interaction of soil.

3.1. Derivation of P-Y Curve
P-Y curves for sandy soil and clayey soil are derived using Matlock equations and API equations.

Matlock equations method for soft clay

\[ P_u = 3 + (\gamma'/C_u) \times Z + (J/D) \times Z \times C_u \times D \]  
\[ Y_{50} = 2.5 \times \varepsilon_{50} \times D \]  
\[ P/P_u = 0.5 \times \left( y/y_{50} \right)^{0.15} \]

Where,

- \( P_u \) = ultimate soil resistance related to undrained shear strength of soil
- \( P \) = Horizontal soil resistance
- \( y \) = Horizontal pile deflection
- \( y_{50} \) = soil displacement at \( 1^{1/2} \) of maximum soil resistance
- \( D \) =Pile diameter
- \( \varepsilon_{50} \) = Strain at fifty percent above maximum shear stresses inside unconfined undrained triaxial test
- \( J = 0.5 \) for soft clay
- \( Z \) = Depth of soil  &  \( \gamma' \) = effective unit weight of the soil
The curve was shown in Figure 1.

**Figure 1** Matlock curve for soft clay

### API equation method for sandy soils

\[
P_{st} = (C_1Z + C_2D) \times \gamma' Z
\]

\[
P_{sd} = C_3D\gamma'Z
\]

\[
\bar{A}_s = [3 - 0.8(Z/D)] \geq 0.9
\]

\[
P = \bar{A}_p \text{tank } [(KZ/\bar{A}_p) \times Y]
\]

Where,
- \( P \) = soil resistance
- \( Y \) = pile displacement
- \( K \) = subgrade modulus
- \( P_u \) = ultimate bearing capacity of the soil
- \( \gamma' \) = unit weight of soil
- \( C_1, C_2, C_3 = \) correction factor

The curve was shown in Figure 2.

**Figure 2** API curve for sandy soils
3.2. Modeling and Analysis
Analysis of a 3×3 building frame is analyzed. Figure 3. Shows the view of frame model with pile foundation interacted in cohesive soil

![Figure 3 Analysis of a building frame with considering Soil Structure Interaction](image)

4. RESULTS AND COMPARISON
A graph is plotted between BM, Deflection, and SFD of the column for a framed structure embedded with pile foundation analyzed in ANSYS. An experimental investigation is majorly focused on structural behavior, therefore, the deflection, bending moment and shear force are evaluated by considering soil and without soil interaction. From the Figure 4. It is observed that column two and column four obtained more deflection in interaction and without interaction of soil compared to column one and column three. Column four has maximum deflection with soil interaction and column one has minimum deflection without soil interaction. Hence, the considered frame is more effective in multilayered soils.

From the Figure 5. it is observed that shear force is more effective in all column when interacted with soil compared to non-interaction. Column four has the maximum shear force with soil interaction and column two has minimum shear force without soil interaction. Hence, the considered frame is more effective in multilayered soils.

From the Figure 6. it is observed that bending moment has slight decrement from second column and fourth column and has more bending moment in columns with soil interaction. Therefore, the fourth column has more shear force and less bending moment. Column two has a maximum bending moment with soil interaction and column four has minimum bending moment without soil interaction, hence, the considered frame is more effective in multi-layered soils.
Figure 4 Deflection in UY-direction for with and without SSI

Figure 5 Shear force in FY-direction for with and without SSI

Figure 6 Bending moment in MZ-direction for with and without SSI
5. CONCLUSIONS
The deflection without considering SSI is 38% more than with considering SSI at column two. The shear force without considering SSI is 50% more than with considering SSI at column one. The bending moment without considering SSI is 13.9% more than with considering SSI at column two.

REFERENCES