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EFFECT OF CHANGE OF BAY LENGTH ON SOIL INTERACTION OF BUILDING FRAME RESTING ON CLAY

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ABSTRACT

The framed structures are normally analyzed with their bases considered to be either completely rigid or hinged. However, the foundation resting on deformable soils also undergoes deformation depending on the relative rigidities of the foundation, superstructure and soil. This paper presents the analysis of the single bay single storied building frame resting on soil. The numerical analysis is carried out using ANSYS by assuming that the base of the frame is resting on soil when the length of the bay of the frame changes from 3m to 10m. The conventional analysis which assumes that the frame is resting on rigid support is carried out using STAAD by assuming the fixed base for the columns in the building frame when the bay length changes from 3m to 10m. From the numerical study, it is found that the shear force value in the column from conventional method is less than that of the value from finite element analysis. The percentage difference in shear force is 23.65%. The axial load values in the column and shear force values in the beam for various bay lengths of the frame obtained from both conventional and finite element analysis are not having considerable difference. The maximum percentage difference in values of bending moment in the column and beam from conventional and finite element analysis is 84.65%, 22.49% respectively. The conventional method of analysis is predicting higher values of bending moment in the column when compared to the finite element analysis which considers soil interaction. Hence neglecting soil interaction is uneconomical. The conventional method assumes that the footing rests on a rigid medium hence footing settlements are ZERO. But in reality the footings undergo some settlement. Hence the settlement values obtained from the finite element analysis will help the designer to satisfy the codal requirements on footing settlements.

Keywords: Bay length, Soil interaction, Building frame, Clay, Conventional method, Numerical analysis

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1. INTRODUCTION

In current design practice, structural engineers usually disregard any influence that the settlement of the supporting ground may have on the response of framed structures. Interactive analysis is, therefore, necessary for the correct assessment of the response of the superstructure. Foundation settlements may introduce new conditions of load distribution in the structure that cause distress and cracking of its elements, and may even lead to stress reversal. Soil settlement, on the other hand, is a function of the flexural rigidity of the superstructure. The structural stiffness can have a significant influence on the distribution of the column loads and moments transmitted to the foundation of the structure, and load redistribution may modify the pattern or mitigate settlements. Increase in stiffness of the frame generally reduces differential settlement, and when the soil is soft the interaction is beneficial. Previous studies have, however, indicated that the effect of interaction between soil and structure can be quite significant. The experimental results of static vertical load tests on a model building frame with geotextile as plinth beam supported by pile groups embedded in cohesion less soil (sand) is presented by Reddy and Rao (2017). The effect of the interaction between the pile cap and the soil underlying it is presented by H. S. Chore, et al. (2014) for a single-storey, two-bay space frame resting on a pile group embedded in the cohesive soil with flexible cap. The effect of soil-structure interaction on a four storeyed frame (G+3), two-bay frame resting on pile group embedded in the cohesive soil is examined by Raksha J, et al. (2013). The study by Varnika Srivastava et al. (2016) deals with physical modeling of a typical building frame resting on a pile group embedded in cohesive soil mass using complete three-dimensional finite element analysis. The results of static vertical load tests carried out on a model building frame with plinth beam supported by pile groups embedded in cohesionless soil (sand) by Reddy and Rao (2012). The effect of soil interaction on displacements and rotation at the column base and also the shears and bending moments in the building frame were investigated. The effect of rigidity of plinth beam on a model building frame supported by pile groups embedded in cohesionless soil (sand) through the results of static vertical load tests is presented by Reddy and Rao (2014). The results of static vertical load tests carried out on a model building frame supported by pile groups embedded in cohesionless soil (sand) is presented by Reddy and Rao (2011). The effect of soil-structure interaction on a single-storey, two-bay space frame resting on a pile group embedded in the cohesive soil (clay) with flexible cap is examined by Chore et al. (2010). The effect of the soil-structure interaction on the simple single storeyed and two bayed space frame resting on pile group of two piles with flexible cap is examined by resorting to more rational approach and realistic assumptions by Chore and Ingle (2008). Though much of the work is carried out on soil interaction of building frames, there is less light thrown in the direction of effect of bay length. Hence change of bay length of building frame resting on cay is taken for the present study.

2. METHODOLOGY

2.1. Conventional Method of Analysis of Building Frame using STAAD

A single bay single storied building frame is modeled and analysed using the software STAAD.Pro. The conventional method of analysing assumes the base of the column to be resting on a rigid medium which will not deform at all. Hence the columns in the building frame is provided with the fixed bases in the model generated using STAAD.Pro. Figure 1 show the Building frame modeled in STAAD.

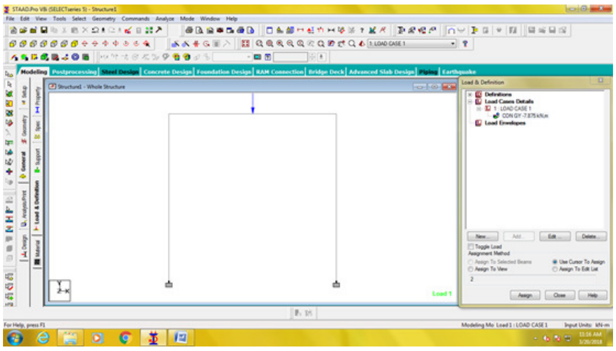

Figure 1 Building frame modeled in STAAD

2.2. Numerical Analysis of Building Frame Using Ansys

The effect of soil interaction on the design parameters in a single bay single storied building frame as the bay length is changing from 3m to 10m is evaluated by using finite element analysis with the help of ANSYS software. Figure 2 shows the Building frame modeled in ANSYS.

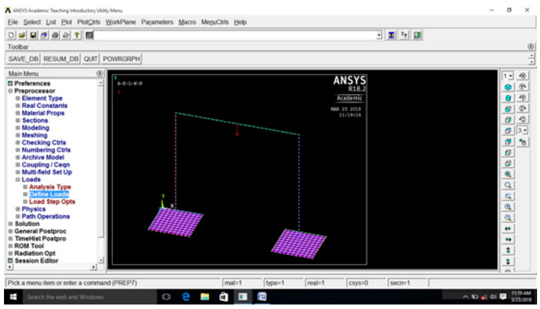

Figure 2 Building frame modeled in ANSYS

3. RESULTS AND DISCUSSIONS

3.1. Shear force in column

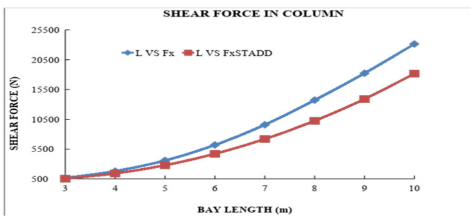

Figure 3 Shear force in column Vs Bay length

The figure 3 shows the graph between the bay length and shear force values in the column. From the figure it is clearly observed that soil interaction effect is present and it is giving higher value of shear force than the conventional method for all values of bay lengths presented in the graph. The percentage difference increases from 20.64% to 25.27%.

3.2. Axial load in column

The figure 4 shows the graph between bay length and axial load values in the column. The axial load values in the column from conventional method of analysis are varying linearly as the bay length of the frame increases. The linearity in the axial load values is also observed in the finite element analysis. The graph plotted between axial load and bay length of the frame is linear. From the figure it is clearly observed that the two lines are over lapped. Therefore there is negligible soil interaction effect in case of an axial load.

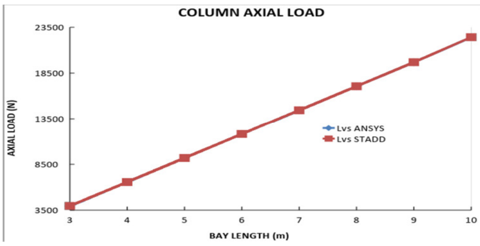

Figure 4 Axial load in column Vs Bay length

3.3. Bending moment in column

The figure 5 shows the graph between bay length and bending moment values in the column. The bending moment in the column from conventional method and finite element method of analysis is varying nonlinearly as bay length increases. From the figure it is clearly observed that soil interaction effect is present and it is giving lower value of bending moment than the conventional method for all values of bay lengths presented in the graph. The percentage difference varies from a minimum value of 8.28 % to a maximum value of 69.34%.

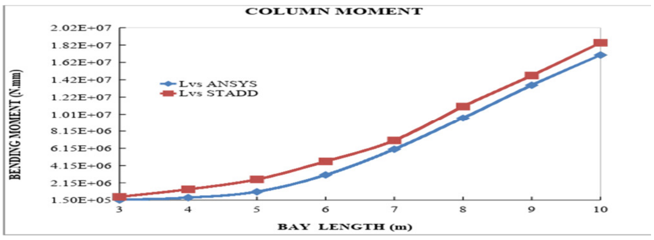

Figure 5 Bending moment in column Vs Bay length

3.4. Shear force in beam

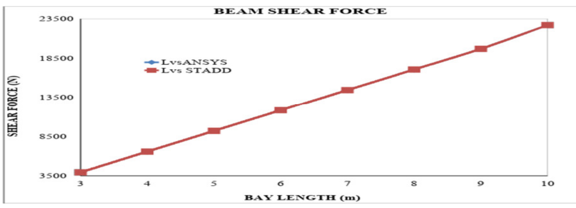

Figure 6 Shear force in beam

The figure 6 shows the graph between bay length and shear force values in the beam. The Shear force values in the beam from conventional method of analysis are varying linearly as the bay length of the frame increases. The linearity in the shear force values is also observed in the finite element analysis. The graph plotted between shear force and bay length of the frame is linear. From the figure it is clearly observed that the two lines are overlapped. Therefore there is negligible soil interaction effect in case of shear force in beam.

3.5. Bending moment in beam

The Figure 7 Shows the graph between bay length and bending moment values in the beam. The bending moment in the beam from conventional method of analysis is varying nonlinearly as bay length increases. The non-linearity in the bending moment is also observed in the finite element method of analysis. Initially, the bending moment plot is nearly linear then it is becoming steep curve. From the figure it is clearly observed that soil interaction effect is present and it is giving lower value of bending moment than the conventional method for all values of bay lengths presented in the graph. The percentage difference vary from a minimum value of 17.08 % to a maximum value of 22.49%

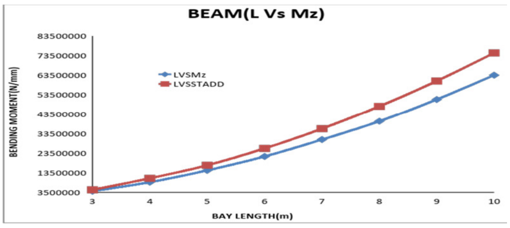

Figure 7 Bending moment in beam Vs Bay length

3.6. Footing settlement

The conventional method assumes that the footing rests on a rigid medium hence footing settlements are ZERO. But in reality the footings undergo some settlement. Hence the settlement values obtained from the finite element analysis will help the designer to satisfy the codal requirements on footing settlements.

4. CONCLUSIONS

The following conclusions have been drawn from the study mentioned herewith,

- **Shear Force in column**: The shear force value in the column from conventional method less than that of the value from finite element analysis. The percentage difference in shear force is 23.65%.
- **Axial load in column**: The axial load values in the column for various bay lengths of the frame obtained from both conventional and finite element analysis are not having much difference between them. Hence the effect of soil interaction in case of axial load in column is negligible.
- **Bending moment in the column**: The maximum percentage difference in values of bending moment in the column from conventional and finite element analysis is 85.68%. The conventional method of analysis is predicting higher values of bending moment in the column when compared to the finite element analysis which considers soil interaction. Hence neglecting soil interaction is uneconomical for this case.
- **Shear force in beam**: The shear force values from the conventional method of analysis and finite element analysis are not having much difference between them. Hence the effect of soil interaction on the shear force in the beam is negligible
- **Bending moment in beam**: The percentage difference in bending moment values in the beam obtained from conventional and finite element analysis is 22.49%. The

conventional method of analysis is predicting higher values of bending moment in the beam when compared to the finite element analysis which considers soil interaction. Hence neglecting soil interaction is uneconomical for this case.

- **Footing settlement**: The conventional method assumes that the footing rests on a rigid medium hence footing settlements are ZERO. But in reality the footings undergo some settlement. Hence the settlement values obtained from the finite element analysis will help the designer to satisfy the codal requirements on footing settlements.

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