



SOIL INTERACTION OF BUILDING FRAME RESTING ON DENSE SAND: EFFECT OF CHANGE OF BAY LENGTH

Engineering

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ABSTRACT

The common practice of obtaining foundation loads from the structural analysis without allowance for foundation settlement may, therefore, result in extra cost that might have been avoided had the effect of soil–structure interaction been taken into account in determining the settlements. This requires that the engineers not only understand the properties of the ground but they also need to know how the building responds to deformation and what the consequences of such deformation will be to the function of the building. This paper presents the analysis of the single bay single storied building frame resting on dense sand. The numerical analysis is carried out using ANSYS by assuming that the base of the frame is resting on dense sand 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 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 25.27%. 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 69.34%, 23.03% 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

Dense Sand, Bay Length, Building Frame, Soil Interaction, Numerical Analysis, Conventional Method

1. INTRODUCTION

In the conventional method of analysis, a structure is analyzed assuming fixity at the base of the foundation and ignoring the effect of supporting soil media. The structure analyzed in this way does not provide the realistic behavior. In reality, the structure is generally supported on soil mass and there exists, the interaction between structure, foundation and soil mass. The flexibility of the foundation, the compressibility of the soil mass and other factors cause redistribution of bending moments and shear forces in the superstructure due to differential settlement of soil mass. Several studies have been made on the effect of soil–structure interaction problems to obtain more realistic analysis. They have quantified the effect of interaction behavior and established that there is redistribution of forces in the structure and soil mass. Hence, structures and their supporting soils should be considered as a single compatible unit. The interaction effects are found quite significant, particularly for the structures resting on highly compressible soils. The flexibility of soil mass causes the differential settlement and rotation of footings under the application of load. The relative stiffness of structure, foundation and soil influence the interaction behavior of structure foundation-soil system. The concept of soil–structure interaction was introduced, and the research methods were discussed by Prakash M. Yesane. (2016). Based on several documents, a systematic summary of the history and status of the soil–structure interaction research that considers adjacent structures was proposed as a reference for researchers. Jigyasa Chourasia(2018) made an attempt to find the effect of deep foundation (single under-reamed friction pile) with or without square footing on the displacement behavior of a four storied, one bay frame resting on different types of soil under dynamic loading. Reddy and Rao (2012) presented 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). 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 four storeyed, two bay frame resting on pile and embedded in the cohesive soil is examined by Janardhan Shanmugam (2015). For the purpose of the analysis, simplified idealizations made in the theory of finite elements are used. C. Ravi Kumar Reddy and T. D. Gunneswara Rao (2017) presented the experimental results of static vertical load tests on

a model building frame with geotextile as plinth beam supported by pile groups embedded in cohesionless soil (sand). A plane strain elastic interaction analysis of a strip footing resting on a reinforced soil bed has been made by using a combined analytical and finite element method (FEM) is discussed by K. Chandra shekharraa (1998). Reddy et al. (2015) presented the results of static vertical load tests carried out on model building frame supported on pile groups embedded in sand. 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 dense sand 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 that the base of the column to be resting on a rigid support which will not undergo any deformation. 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.

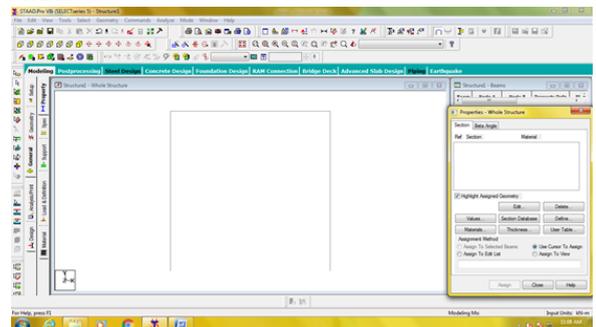


Fig 1: Modeled frame in STAAD

2.2 Finite element Analysis of Building Frame Using Ansys:

Using finite element analysis with the help of ANSYS software, the

effect of soil interaction on the design parameters is evaluated in a single bay single storied building frame as the bay length is changing from 3m to 10m. Figure 2 shows the Building frame modeled in ANSYS.

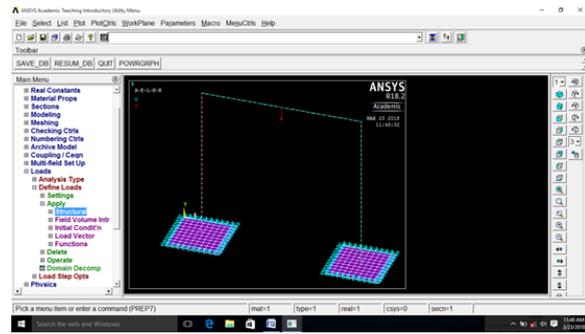


Fig 2: Modeled frame in ANSYS

3. RESULTS AND DISCUSSIONS

3.1 Axial load in column:

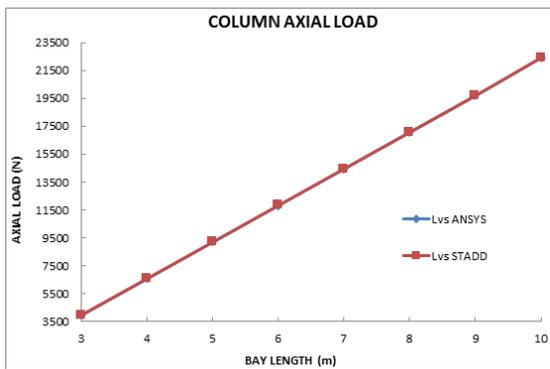


Fig 3: Axial load in column Vs Bay length

The figure 3 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 overlapped. Therefore there is negligible soil interaction effect in case of an axial load.

3.2 Shear force in column:

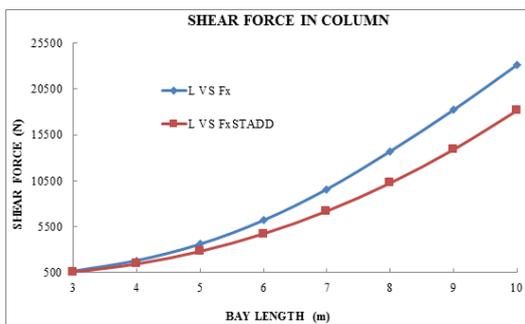


Fig 4: Shear force in column Vs Bay length

From the figure 4 it is clearly observed that the finite element analysis is giving higher value of shear force than the conventional method for all values of bay lengths. The percentage difference increases from 20.64% to 25.27% as the bay length increase from 3m to 10m. The figure 3 shows the plot between the bay length and shear force values in the column.

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 8.48 % to a maximum value of 69.34%.

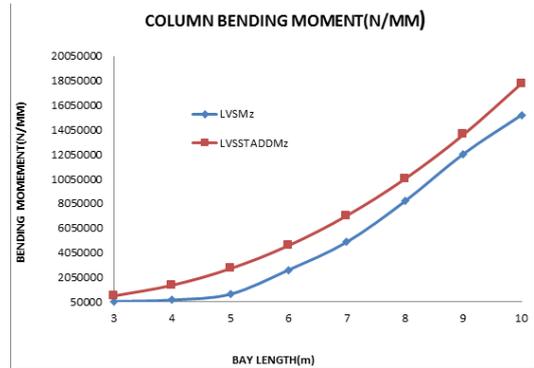


Fig 5: Bending moment in column Vs Bay length

3.4 Shear force in beam:

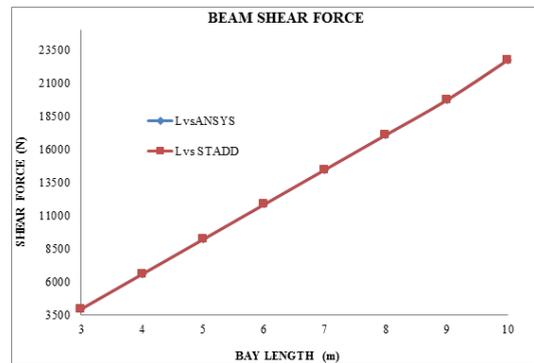


Fig 6: Shear force in beam

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

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 percentage difference varies from a minimum value of 17.63 % to a maximum value of 23.03%. 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.

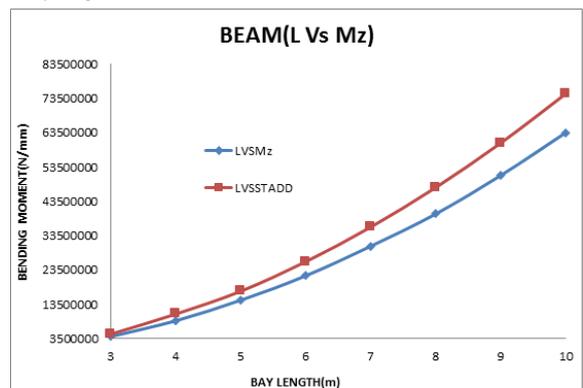


Fig 7: Bending moment in beam Vs Bay length

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 for footings resting on dense sand.

4 CONCLUSIONS:

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

- **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.
- **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 25.27%.
- **Bending moment in the column:** The maximum percentage difference in values of bending moment in the column from conventional and finite element analysis is 69.34%. 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 23.03%. 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:** In reality the footings undergo some settlement. But the conventional method assumes that the footing rests on a rigid medium hence footing settlements are zero. Hence the settlement values obtained from the finite element analysis will help the designer to satisfy the codal requirements on footing settlements for footings resting on dense sand.

References

1. PRAKASH.M.YESANE , Y.M. GHUGAL & R.L. WANKHADE " Study on soil structure interaction" International journal of engineering research , volume 5,issue 3,ISSN:2319-6890,2016,PP- 737-741.
2. JIGYASU CHOURASIA ,UMESH PENHARKAR &RAGHAVENDRA SINGH "Dynamic analysis of pile foundation with footing in different foundation soils" International research journal of engineering and technology(IRJET) ISSN online: 2395-0056, ISSN print : 2395-0075, volume 5. Issue 1, 2018.
3. Rakshaj.khare, H.S chore "interaction of building frame with pile" journal of electrical electronics & computer system. ISSN (online): 2347-2820 vol 1, issue 1, 2013 pp 27-32.
4. JANARDHAN SHANMUGAM, P.A. DODE & H.S. CHORE "Analysis of soil structure interaction in framed structures" International journal of computer application(0975-8887) international conference on quality up - gradation in engineering science and technology(ICQUEST) , 2015.
5. C. RAVIKUMAR REDDY , T. D. GUNNESWARA RAO "Experimental study of geotextile as plinth beam in a pile group supported modeled building frame" International advanced structural engineering (2017) 9: PP 353-363.
6. K. CHANDRA SHEKHARAA, S. JOSEPH ANTONYB & DEBASHISH "Semi - analytical finite element analysis of a strip footing on an elastic reinforced soil" Applied mathematical modeling, volume 22, issue 4-5,1998, pp 331-349.
7. RAKSHA KHARE & Dr. H.S. CHORE "Analysis of building frame considering soil structure interaction" International journal of modern trends in engineering and research (IJMTER) VOL. 03, issue 04,(2016) pp 1-21.
8. VIVEK GARG & M.S. HORA "A review on interaction behavior of structure - foundation - soil system" International journal of engineering research and applications (IJERA), volume 2, issue 6, 2012, pp 639-644.
9. MANJEET HORA "Elasto plastic soil structure interaction analysis of building frame soil system" International conference on case histories in geotechnical engineering, 2008, pp 1 -11.
10. VERNIKA SRIVASTAVA, H.S. CHORE, P.A. DODE "Interaction of building frame with pile foundation" Open journal of civil engineering 2016, volume 6, pp 195-202.
11. Rakshaj, khare, H.S .chore " Interaction of building frame " International journal of electrical, electronics & computer systems(IJEECS) ISSN: 2347- 2820, volume 1, issue 1, 2013, pp 27-32.
12. C. RAVI KUMAR REDDY & T.D. GUNNESWARA RAO " Experimental study of a modeled building frame supported by pile groups embedded in cohesion less soil" interaction and multi scale mechanics , volume 4, issue 4, 2011 pp - 321- 336.
13. C. RAVI KUMAR REDDY, M. ANJANEYA PRASAD , Y.V. BHAVANI SAI KUMAR, T. NARENDRA & Y. NAGA SATYESH "modeling of building frame on pile groups embedded in sand" International journal of applied engineering research, 10,3, 2015, pp - 2181-2183.
14. H. S. CHORE "Interactive analysis of building frame resting on pile foundation" Coupled system of mechanics, 3, 4, 2014, pp - 367-384.
15. R.SEN , T.G. DAVIES & P.K. BENERJEE "Dynamic analysis of piles and pile group embedded in homogeneous soils" The journal of the international association for earth quake engineering, volume 13, issue 1, 1985, pp - 53-65.

16. H.S.CHORE & R.K. INGLE "soil structure interaction analysis of pile supported building frame" AJSTD volume 24, issue 2, pp -457-467, 2008.
17. H.S CHORE, R.K. INGLE & V.A. SAWANT "Building frame- pile foundation- soil interaction analysis a parametric study" Interaction and multi scale mechanics, volume 3, issue 1, 2001, pp 55-79.
18. RAMAKANT AGARWAL & M.S.HORA "coupled finite infinite elements modeling of building frame soil interaction system" Asian research publishing network(ARPN) Journal of engineering and applied sciences, volume 4, issue 10, 2009, pp - 47- 54.
19. H.S.CHORE "Interactive analysis of building frame resting on pile foundation" Interaction and multi scale mechanics an international journal volume 6, issue 4, 2013.
20. VIVEK GARG & M.S. HORA "Analysis of space frame - strap footing - soil system to investigate column force under seismic loading" ARPN journal of engineering and applied science, volume 7, issue 12, 2012, pp - 1601-1613.