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Study of Soil Structure Interaction for Multistoried Framed Structure

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ABSTRACT: The structural behaviour depends on the types of soils, foundation type, length of span in the structure, storey number (10 storey and 15 storey) and load types to which is subjected to the frame structure. The differential settlement in buildings is responsible for changes in the forces in the framed structure and is an often lead to failures of the building. The settlement in clay soil soil is more prominent than any other soil like sand or stiff clay. So for the present study clay soil is selected for the settlement analysis of framed structure. In this present work finite element analysis of a 10 and 15 storey building was performed using geotechnical software Midas GTS NX in which soil is modeled as a continuum and structure software Midas GEN is used to model the framed structure. Study was performed using isolated and raft footing in the foundation. It is found that isolated footing is capable of reducing the immediate settlement up to some extent but it is not cost effective. The settlement results are compared with the theoretical methods of settlement calculation and found to be with in the permissible limit.

Keywords: Soil-Structure Interaction, settlements, stresses, Midas GEN, Midas GTS NX

INTRODUCTION

Conventional method of structural analysis adopted for practical design of most of the structures, ignores the effect of compressibility of soil and flexibility of foundation. Inclusion of soil and foundation in the analysis is likely to influence the computed values of stresses in the super structure members. The literature does not appear to provide much information regarding the magnitude of such influence and the effect of different parameters involved in the system. So, a comparative study of the stresses and settlement computed from such analysis with those obtained without including soil and foundation in the analysis is in this work would be very useful. Such a comprehensive parametric study to analyse the effect of various, material and geometric parameters involved in the system, has been attempted in the present work, to throw some light in the gray area in the literature. In the integrated analysis soil and foundation have also been included in the Finite Element Model, along with superstructure members. Soil foundation structure interaction (SFSI) is the interactions among the soil, foundation and structure. In general, the system of soil - foundation - superstructure may be of various geometrical configurations of complicated nature. With the development of Finite Element Method (FEM) and availability of computers, such an integrated system can be analyzed. But there are a number of parameters, which make such a parametric study unwieldy. A powerful numerical technique is being established by Finite Element Method (FEM) for general engineering analysis. In particular, geotechnical engineering problems involving complicated geometry and material behavior can be solved by FEM, without much effort, to handle such complications. So, to make such a parametric study possible, the superstructure configuration has been taken as plane frame with strip raft footing for each row of columns or isolated footing for each column. Also a few cases of plane frame with raft foundation and pile foundation have been studied. The superstructure members (beams and columns), foundation and soil have been modeled by three dimensional solid elements with three displacement degrees of freedom at each of their nodes. The superstructure and footing have been modeled using 20 noded isoperimetric quadratic solid elements. The soil is modeled with 20 noded and 10 noded solid elements with the same degrees of freedom. The connections between superstructure, footing and soil have been assumed to be adhesive satisfying M compatibility. In the present case, the framed structure of 10 and 15 storey is modeled in MIDAS GEN and MIDAS GTS software is used for the analysis of soil structure interaction. The comparative study of settlements in clay soil of 10 and 15 storey framed structure is done in terms of vertical loads with soil structure interaction effects. Live and dead load applied on the structure are according to IS: 875 part-I & part-II. Appropriate data are assumed whenever required. Settlement results from MIDAS GTS NX were compared with the manual calculation and found satisfactory. Isolated and raft footing are used in a coupled manner in MIDAS GTS NX to achieve the goal of the study. Mohr Coulomb clay soil model is used in this study for soil structure interaction analysis.

MATERIAL AND METHODOLOGY

The geometry consists of 10 and 15 Storeys framed structure with 4-bay spacing of each is 6m along X and Y direction. The frames are composed of beams and columns. There are three stages involved in the finite element analysis of frame structure interaction with soil, namely frame modeling in Midas Gen Software, exporting model to Midas GTS NX and analysis. Framed building of 10 and 15 storeys are modeled in MIDAS GEN software. Reaction force at footing is extracted in GEN and building is exported in MIDAS GTS NX software for post processing. In GTS NX building is analysed and reaction force are compared to check the building is successfully imported to GTS NX software with all loads and material properties applied in GEN software. Now a mohr coulomb caly soil model is used in MIDAS GTS NX to make the soil mass for footing analysis. Isolated and raft footing are used for the settlement and stress analysis of the structure. The material properties used in the design of framed structure are given below-

Table 1 Details of RCC Frame

S.No.	Property	Dimensions	Grade of Concrete
1.	Building Height 10 Storey 15 Storey	 30m 45m	
2.	Storey Height	3m	
3.	Beam	250mm X 450mm	M25
4.	Columns	250mm X 450mm	M25
5.	Slab	150mm	M25
6.	Isolated Footing	2m X 3m X 1m	M25
7.	Raft Footing	24m X 24m X 1m	M25

Table 2 Details of Dead and Live Loads

S. No.	Type	Load
1.	External walls	12 KN/m^2
2.	Internal walls	6 KN/m^2
3.	Slab Dead Load	4.75 KN/m^2
4.	Slab Live Load	3 KN/m^2
5.	Parapet wall Load	4 KN/m^2

Frame Modeling in MIDAS GEN and Analysis

The steps involved in the modeling and analysis of structure in Midas GEN are as follows:

STEP II: Frame modeling,

STEP III: Property assigning,

STEP IV: Applying boundary condition and loads

STEP VI: Analysis and Results

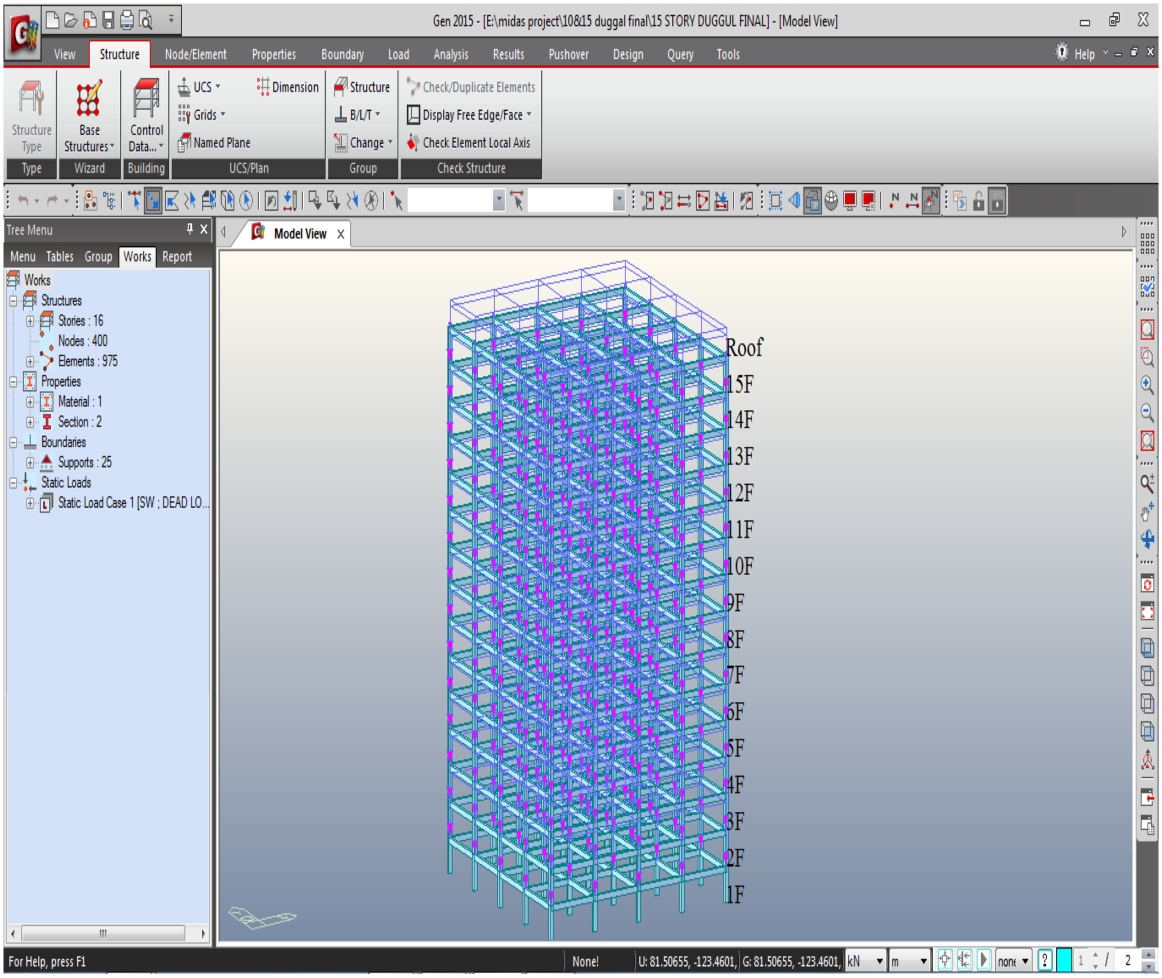

Figure 1 15 Storey Framed Building with applied loads in Midas GEN

Soil modeling in Midas GTS NX

The following steps are involved in the analysis of the structure in Midas GTS NX:

Step I: Geometry Modeling

Step II: Material Models

Step III: Mesh Generation

Step IV: Boundary Conditions

Step V: Perform Analysis

Step VI: Results Output and Report

In the present study 10 and 15 storey framed building was analysed in clay soil with isolated and raft footing for stress and settlement distribution in the vicinity of soil mass.

Case A: 10 storied framed building with clayey soil model with single layer of 10m depth
Case B: 15 storied framed building with clayey soil model with single layer of 10m depth

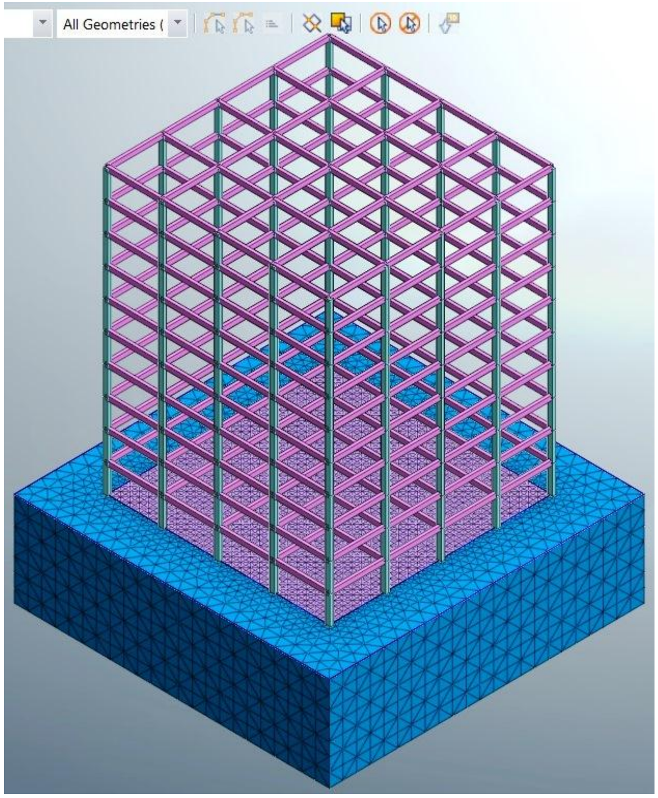

Figure 2 Meshed soil Layer with raft footing in Midas GTS NX

RESULTS

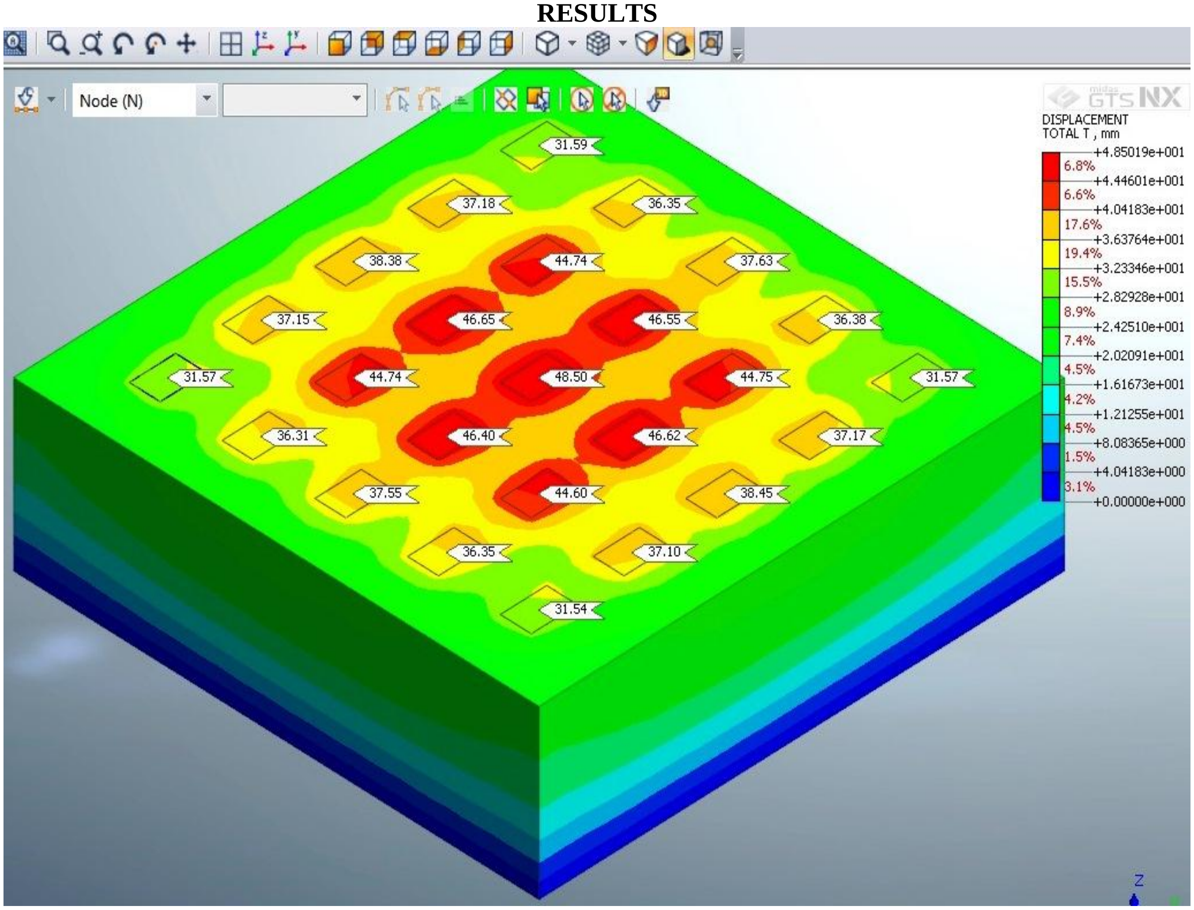

Figure 3 Settlements in Clay Soil with Isolated Footing in 10 storey framed building

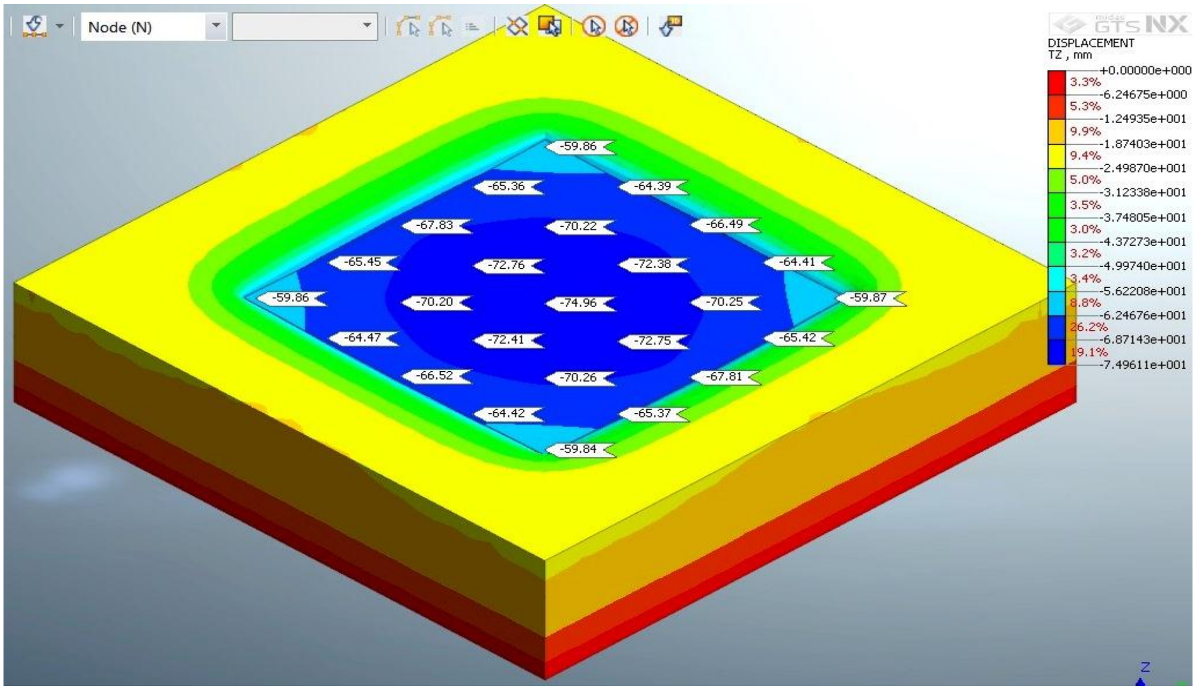

Figure 4 Settlement in clay Soil with raft footing in 15 storey building

Table 3 Percentage reduction in settlement with raft footing

Type of building	Isolated footing Settlement (mm)	Raft footing Settlement (mm)	% Reduction in settlement
10 Storey	48.50	44.47	8.30
15 Storey	89.82	74.96	16.54

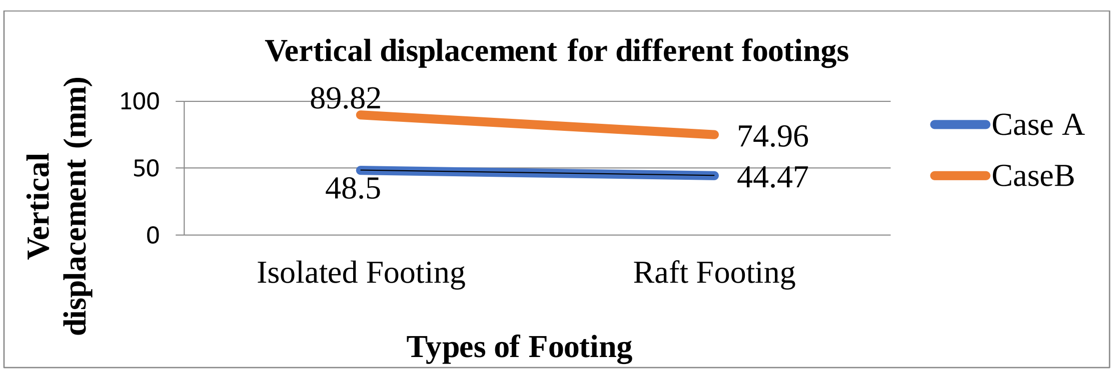

Figure 5 Comparison of settlement with different types of footing

Table 4 Comparison of settlements from GTS NX and Manual caalculation

Soil model	GTS NX Settlement (mm)		Manual Settlement (mm)	
	Case A	**Case B**	**Case A**	**Case B**
Isolated footing	48.50	89.82	52.21	86.87
Raft footing	44.47	74.96	47.31	72.16

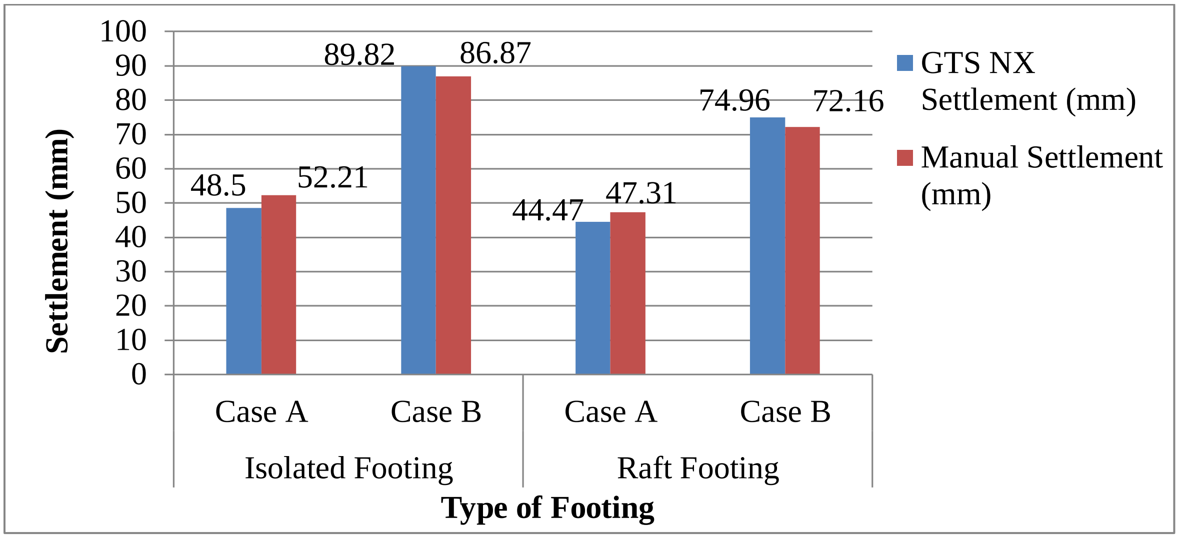

Figure 6 Comparison of settlement with different methods

CONCLUSIONS

From the study carried out following results are drawn:

1. From the study we conclude that raft footing is better than isolated footing to bring the settlement with in the limit.
2. It is observed that more stresses developed with isolated footing than raft footing in all the cases.
3. From the economic point of view raft footing can be expensive so the isolated footing is recommended with increased footing size.
4. From the study we found that there is minimal difference in settlements from Midas GTS NX and manual calculation

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