Load-Settlement Behavior of Circular Footings Resting on Soil Mediums

Hiba Tul Shakoor[1], Harleen Kaur[2], Jaspander Singh[3]

[1]Prof. Hiba Tul Shakoor Department of Civil Engineering & Global Group of Institutes, Amritsar
[2]Prof. Harleen Kaur Department of Civil Engineering & Global Group of Institutes, Amritsar
[3]Prof. Jaspander Singh Department of Civil Engineering & Global Group of Institutes, Amritsar

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Abstract -Each foundation should provide a sufficient margin of safety against the greatest loading that it might withstand, even if this loading only occurs occasionally throughout the structure's lifetime. That is to say, an excessive burden or an incorrect assessment of the soil's qualities should only increase settling. PLAXIS is a finite element programme designed primarily for the investigation of deformation and stability in geotechnical engineering applications. The expanded output tools offer a detailed presentation of the computational findings, and the graphical input processes enable speedy production of complex finite element models. The computations are entirely automated and grounded in reliable numerical techniques. An accurate understanding of the load-settlement behaviour of the various types of soil beneath the footing is essential for foundation design. The major goal of this work is to use PLAXIS 2D to analyse the load-settlement behaviour of circular footings lying on soil mediums covering different types of soils. To do this, five models of various soil types bearing axial, inclined, and eccentric loads are taken into consideration. Each case's failure loads are noted, and comparisons for load-settlement are made for these soils. PLAXIS-2D.v.8.2 is the programme used for modelling and analysis. A 2d FEM analysis was conducted on rectangular and square footing carrying axial loads from an analytical research and compared with the results of the PLAXIS-2D analysis in order to validate the suggested model.

***Key Words*: PLAXIS-2D, FEM, Load-Settlement, Soil, Geotechnical investigations.**

1. INTRODUCTION

In a geotechnical structure, the stress distribution in the soil beneath is significant. The additional pressure caused by the external load on soil may depend on various factors, including assessment of the associated load, soil characteristics, and measurements of the stacked territory or laden area. One of the frequently discussed topics in geotechnical designing, for which several methodologies have been closely associated, is the bearing-capacity issue. These techniques might be applied logically or haphazardly. The slip line approach, limit balance approach, limit examination/analysis, numerical methodologies, and breaking point study combined with numerical methodologies are some examples of scientific strategies. Trial work includes full-scale and axis tests conducted in a research facility or on location. When complicated situations arise, such as when the establishment width proves to be extremely wide in comparison to the soil thickness or when the soil profile is not homogenous, the bearing-limit topic becomes even more challenging. It is a particular kind of isolated footing.

The circular footings, which are provided under each column separately, have a round shape. When surface soils are strong and stiff enough to handle the applied loads, these are utilised.

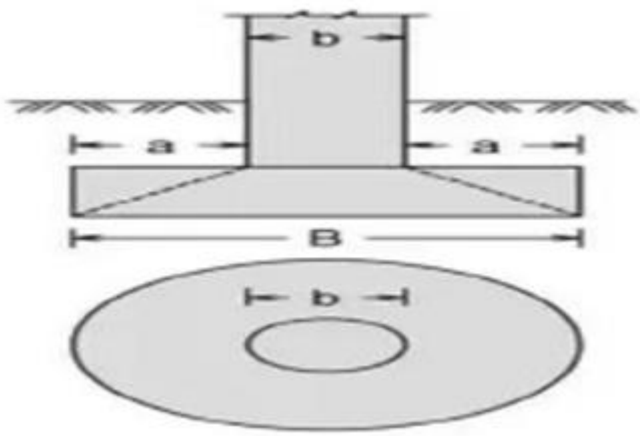

Figure1.2: Axial load model

2. Formulation & Result:

2.1 Methodology

A numerical method called the finite element method (FEM) is used to carry out finite element analysis on any given physical phenomenon. To fully comprehend and quantify any physical phenomenon, such as structural or fluid behaviour, thermal transport, wave propagation, or the development of biological cells, mathematics is required. PDEs are commonly used to characterise the majority of these processes. However, numerical methods have been developed over the past few decades, and one of the most well-known at the moment is the finite element method, which allows a computer to solve these PDEs.

In the current work, Plaxis-2D, a finite element programme, is used to evaluate the load-settlement behaviour of circular footing on five different types of soil media.

2.2 MOHR-COULOMB Analysis:

The Perfectly Plastic Linear Elastic Young's modulus E and Poisson's ratio (υ) for soil elasticity; cohesion c, friction angle (φ), and dilatancy angle (ψ) for soil plasticity; and five input parameters for the Mohr-Coulomb model. The Mohr-Coulomb model is a "first-order" approximation of the behaviour of soil or rock. It is advised to utilise this model for a preliminary analysis of the issue at hand. One calculates an average stiffness that is constant for each layer. This constant stiffness makes computations generally quick and allows for the first estimation of deformations.

2.3 Material Properties:

2.3.1 Material model is Mohr-Coulomb & material type is Drained soil.

Parameter	**Dense Sand**	**Sand**	**Sandy Clay**	**Stiff Clay**	**Soft Clay**
Unsaturated Unit Weight (γunsat) in kN/m^3	19.3	16	18	16.56	17
Saturated Unit Weight (γsat) in kN/m^3	22.12	17.12	21	19.4	15.6
Young‘s Modulus (E) in kN/m^2	18700	40000	46000	5400	5100
Poisson‘s Ratio (ν)	0.3	0.25	0.3	0.42	0.3
Cohesion (c) in kN/m^2	0	0	6	32	20
Angle of Internal Friction (υ)	44°	47°	22°	0°	0°

2.3.1 Material properties of circular footing:

Parameter	Value
Radius of Footing (r) in mm	0.25
Axial Stiffness (EA) in kN/m	43630000
Flexural Rigidity (EI) in kN/m2-m	544000
Equivalent Thickness of Plate (d) in m	0.433
Weight of Footing (w) in kN/m/m	9.837
Poison‘s Ratio (ν)	0.3

2.4 Software used:

The current t paper focuses on the load-settlement behaviour of circular footings using PLAXIS-2D. With the help of a single integrated software package and a wide range of advanced capabilities, PLAXIS-2D can model a variety of geotechnical issues. In a setting akin to Computer Aided Design, PLAXIS makes use of specified structural parts and loading types. This gives the user more control over the building of a model and gives them more time to understand the findings. The easy-to-use interface directs the user in effectively creating models using a geotechnical process. Users can define intricate soil profiles or geological cross-sections using boreholes. Structures mode allows for the definition of structural components such piles, anchors, geotextiles, and prescribed loads and displacements. CAD files can also be used to import geometry. A finite element mesh is almost quickly created by the automatic meshing technique. By activating and deactivating soil clusters and structural components during each calculation phase, users of staged construction can simulate the construction process with accuracy. Numerous geotechnical issues can be studied using calculation types for plastic, consolidation, and safety analysis. Simple linear to complex, highly non-linear constitutive models can be used to simulate the behaviour of soil and rocks.

2.5 Modelling

2.2 m radius flexible footing is modelled on several soil layer types for this research paper. In order to establish the footing on a soil model with soil parameters appropriate to the type of soil, material data sets were assigned to it. All soil models are based on a circular foundation. Using PLAXIS Professional 8.2, the modelling and analysis are completed. On c-soils to φ -soils carrying axial load, five distinct models were investigated.

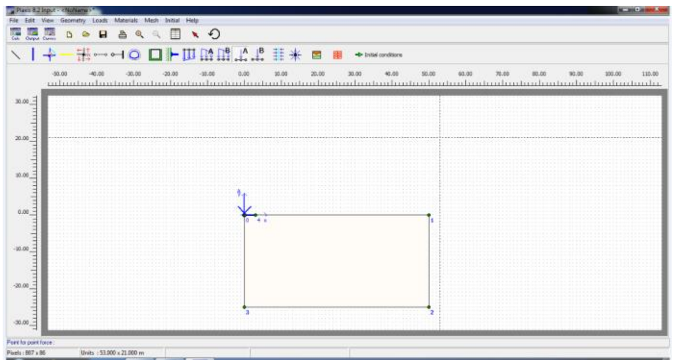

Figure1.2: Axial load model

2.6 Results:

2.6.1 THE RESULT OF LOAD-SETTLEMENT CURVES

In PLAXIS-2D, two columns—the x-axis and the y-axis—each have two combo boxes and radio buttons with multiple selections. For this curve, the x-axis represents the applied load, and the y-axis, the deformation. According to the needed settlement, the applied load intensity (kN/m) is converted for the entire area to give the total failure load (kN), and as the applied load is on one radian, 2r is taken into consideration for bearing capacity.

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If the settlement is 50 mm and the specified load intensity is 350 kN/m for a circular footing with a radius of 2.2 m, the total failure load is [(250*πr2)= 5321kN] load intensity times area of the footing. The radio button for x-axis displacement is selected in the output. As a result, the vertical displacement of point A (the footing's centre) is the quantity to be plotted on the x-axis. The amount of the specified adjustments that have been applied will be plotted on the y-axis when the multiplier radio button is selected in the y-axis. As a result, the value will fall between 0 and 1, indicating that the intended final condition has entirely been reached and 100% of the load intensity has been applied. The data is copied to MS-Excel and different load versus settlement curves are plotted using the Plaxis output when a load-displacement curve is generated in the curves window.

2.6.2 LOAD-SETTLEMENT CURVES UNDER AXIAL LOADING:

The figure 1.3 depicts the load-settlement behaviour of a circular foundation resting on several soil types, including dense sand, sand, sandy clay, stiff clay, and soft clay, respectively. It also depicts the failure loads on circular footings sitting on these soil mediums with a permitted settlement of about 50 mm. It can be seen that the failure loads drop as the soil medium changes from dense sand to soft clay, with dense sand having very high load intensity.

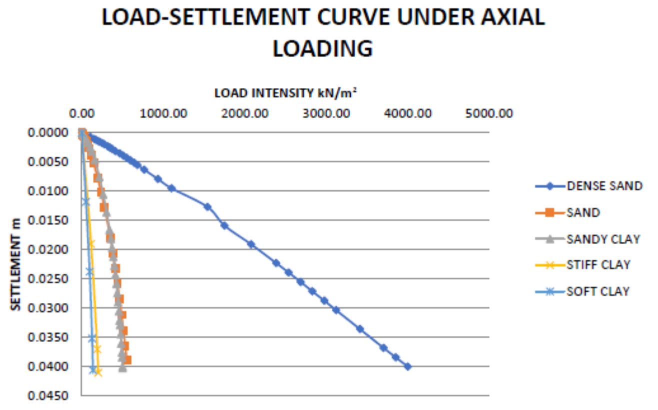

Figure 1.3: Load-Displacement curve for dense sand, sand, sandy clay, stiff clay and soft clay under axial load.

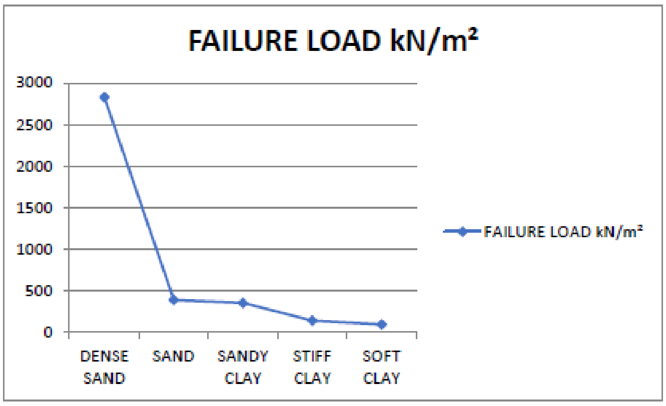

Figure 1.4: Failure load intensity graph for dense sand, sand, sandy clay, stiff clay and soft clay under axial load

2.7 VALIDATION OF MODEL:

A 2D FEM analysis was conducted on the test data collected from two analytical studies by the IS code approach in order to validate the suggested analysis. The output from Plaxis-2D was then obtained using the same properties and total load. Results from the PLAXIS software demonstrated the soil's approximate true behaviour under various loads.

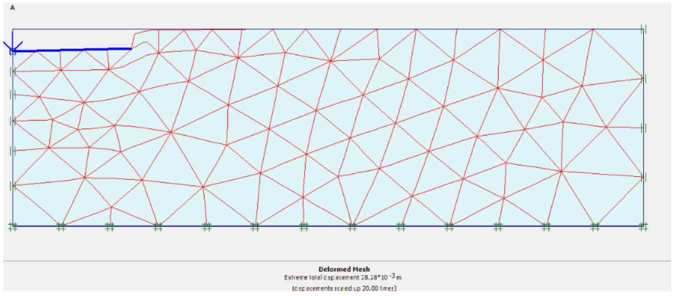

Figure 1.5: Mesh deformation for sandy soil having settlement of 31 mm

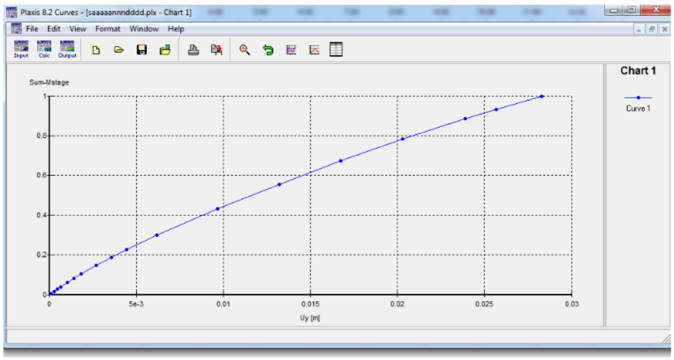

Figure 1.6: Load-displacement curve obtained for sandy soil

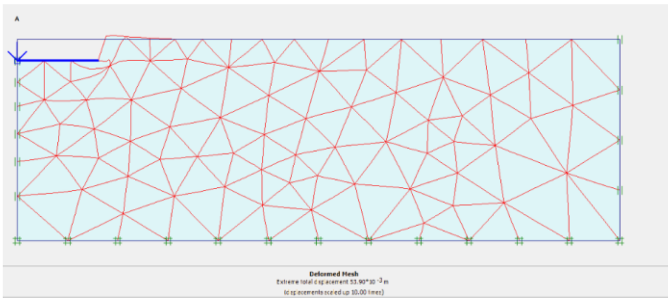

Figure 1.7: Mesh deformation for sandy clay having settlement of 57 mm

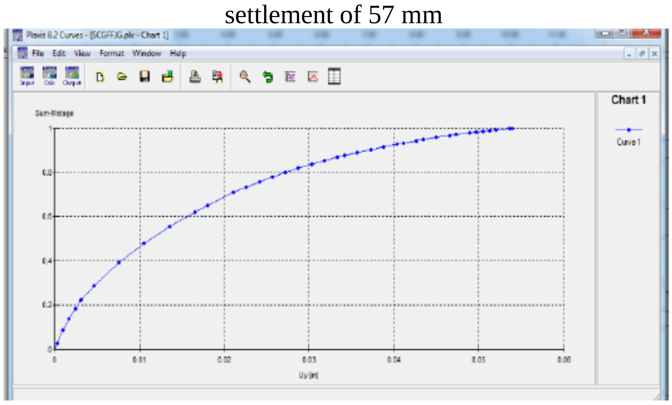

Figure 1.8: Load-Displacement curve obtained for Sandy Clay

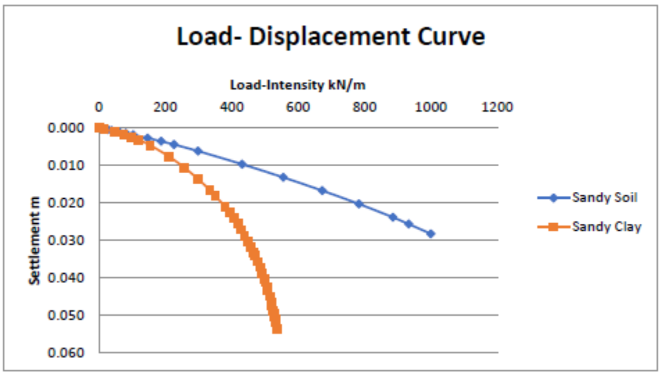

Figure 1.9: Curve from numerical study

Plaxis output result:
Table 1: Output from numerical study

Type of soil	Settlement m	Load-Intensity kN/m²
Sandy Soil	0.029	999
Sandy Clay	0.064	547.9

Comparison of analytical study and 2D FEM plaxis output:
Table 2: Comparison of results taken from analytical and numerical study

		Analytical Study		Numerical Study	
S.no.	Type of Soil	Settlement m	q kN/m²	Settlement m	Load Intensity kN/m²
1.	Sandy Soil	0.035	1000	0.031	1000
2.	Sandy Clay	0.050	536.8	0.054	536.8

2.8 Data Analysis
Table 3: Data validation

	Analytical Study Result	Numerical Study Result
Analytical study result	1	
Numerical study result	0.99888745	1

3.CONCLUSIONS

The results of several 2D finite element analyses on different soil media subjected to axial loads are presented in the current paper as a load-deformation curve. An analytical study comparison is used to validate the model. It is possible to draw the following inferences from the software's output results:

PLAXIS-2D may be utilised efficiently for modelling and analysis of flexible circular footings. In the case of axial loading, the failure loads decrease as the soil medium alters for all types of soil used in the investigation, ranging from hard sand to soft clay. The failure loads are maximal for the dense sand to sand, sandy clay, stiff clay, and minimum to soft clay for all types of loading while moving from dense sand to soft clay, as can be observed. However, the figures for failure loads are relatively high in the event of dense sand. The software's output, which uses diverse soil parameters to provide various forms of loads, aids in the research of soil-foundation interaction, particularly for shallow foundations. Wherever the value φ is higher, the soil's carrying capacity for a 2D FEM model, similar to an analytical research, is higher.

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