Finite Element Analysis of Soil Bearing Capacity using Plaxis

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Abstract:**The bearing capacity of the foundation is a primary concern in the field of foundation engineering. The load at which the shear failure of the soil occurs is called the ultimate bearing capacity of the foundation.**

In this project a numerical model is developed using PLAXIS. Finite element analysis is carried out using Mohr-coulomb failure criteria to represent two dimensional soil model. Foundation is modelled as square footing and load increment is applied till the soil model fails. Ultimate bearing capacity is identified as that minimum pressure on footing at which the foundation soil experiences shear failure. The stress distribution in soil and displacement experienced at different locations are obtained. In plaxis effective stress is considered as a ultimate bearing capacity.

The preliminary investigation of black cotton soil was collected from crossroad which is six km away from Bhalki taluk, shows that it belongs to inorganic clays of high plasticity (CH) according to unified soil classification system(USCS).The ultimate bearing capacity for varying D/B ratio was computed by Terzaghi's equation by knowing the preliminary values of black cotton soil and loading frame which was successfully compared with Plaxis software.

Keywords: Bearing capacity, D/B Ratio, Expansive soil, Foundation, Plaxis, Soil model, Settlement.

I INTRODUCTION

1.1 General: The bearing capacity of the foundations is a primary concern in the field of foundation engineering. The self-weight of the structure and the applied loading such as: dead load, live load, wind load etc. are to be transferred to the soil safely and economically. The load at which the shear failure of the soil beneath the foundation occurs is called the ultimate bearing capacity of the foundation. The magnitude of the ultimate bearing capacity depends on the mechanical characteristics of the soil and the physical characteristics of the footing[1].

1.2 Importance of Study: Foundations are the most important components of any structures and any damage to either the foundation or the foundation results in catastrophic failure of super structure. Hence, focus should be on providing a strong base to any structure. Bearing capacity of soil is a parameter widely used in the design of foundation and the objective of design engineer to provide and proportion a found that keeps the stresses in foundation soil well within the limits of safe bearing capacity. It is well established that safe bearing capacity of soil is affected by various factors such as the depth of Ground water table (GWT), soil properties, layering of soils, size and shape of the foundation, depth of foundation etc. among many other factors [1].

1.3 Problem Statement: The present work focuses on numerical analysis using PLAXIS for evaluation of bearing capacity of ground under situations on ground adjacent to structure. Finite element analysis is carried out considering the soil to satisfy Mohr-Coulomb yield criteria. Parametric studies are made design tables and charts are presented to establish the effects of above mentioned factors on bearing capacity of soil [1].

1.4 Objectives of the Present Study:

1. To evaluate bearing capacity of soil using finite element analysis and Mohr-coulomb failure criteria.
2. To compare the results of evaluation of bearing capacity from PLAXIS and those from conventional theories.
3. To establish the bearing capacity of soil on ground from the present approach.

To perform parametric study and to identify the sensitivity of different factors influencing bearing capacity [22].

1.5 Scope of the Present Study

The present study focuses on the bearing capacity of a soil medium on ground by loadings of square footing which the stability of the foundations are analysed. Properties of soil considered in this geometric model simulation. Finite Element Method (FEM, PLAXIS 8.2) is used in the analysis where two dimensional footing is considered [1].

1. The present study is limited to 2D plain strain idealization. Hence only bearing capacity of soil supporting square footing is considered.
2. Study is restricted to homogeneous isotropic soil medium.
3. Study is limited to footing subjected to static loading only.
4 . Layered soils, soil with irregularities are not considered.
5. Effect of ground water table is not considered.
6. Soil is idealized to Mohr-coulomb yield criterion.
7. Initiation of failure at any location in soil medium is considered as bearing capacity failure.

II Material and methodology

2.1 Materials:

Black cotton soil: In this project the soil was collected from crossroad which is six km away from Bhalki taluk.

2.2 Methods:

1. In place density core cutter method
2. Specific gravity by pycnometer method
3. Grain size distribution
4. Liquid limit by casagrande method
5. Plastic limit
6. Standard proctar test(Compaction)
7. Direct shear test
8. Loading frame method

2.3 Index Properties:

The Specific Gravity (Gs) of the soil samples was determined as per IS: 2720 (part 3/Sec1) – 1980, Methods of test for soils: Determination of Specific Gravity, fine grained soils [2]. The clay and silt sized fractions of the soil specimen was determined as per IS: 2720 (part 4) - 1985, Methods of test for soils: Grain size analysis [3]. Atterberg's limits of the soil specimen was determined as per IS: 2720 (part 5) – 1985, Methods of test for soils: Determination of liquid and plastic limit [4].

2.4 Engineering properties:

The standard proctor compaction characteristics of the soil specimen was determined as per the IS: 2720 (part 7) – 1980, Methods of test for soils: Determination of water content-dry density using light compaction [5].

Direct shear test were carried out as per IS: 2720 (part 13) – 1986, Methods of test for soils: Determination of direct shear test [6].

Ultimate bearing capacity for square footing given by Terzaghi is

$$q_f = 1.3cN_c + \gamma DN_q + 0.4\gamma BN_\gamma$$

Where,
C=Cohesion
y=Unit weight of soil
D=Depth of footing
B=Breadth of footing
N_c, N_q, N_y=Bearing capacity factors.

III FIGURES AND TABLES

Black cotton soil: In this project the soil was collected from crossroad which is six km away from Bhalki taluka. These were obtained and tested to evaluate their basic characteristics, compaction and direct shear test. The soil samples thus obtained are oven dried, pulverized and subjected to different laboratory tests.

Table1:Properties of black cotton Soil

Sl. No.	Parameter	BC Soil
1	In situ density (kN/m^3)	16.48
2	In situ moisture content (%)	33.80
3	Specific gravity	2.62
4	Grain size distribution	Medium graded soil
5	Atterberg limits Liquid limit (%) Plastic limit (%) Plasticity index (%)	 60.83 35.415 25.415
6	Soil classification	CH
7	Compaction characteristics Maximum dry density (kN/m^3) Optimum moisture content (%)	 16.31 23.5
8	Cohesion (kN/m^2)	35.3
9	Angle of internal friction	0
10	Modulus of elasticity (kN/m^2)	20000
11	Poisson's ratio	0.4

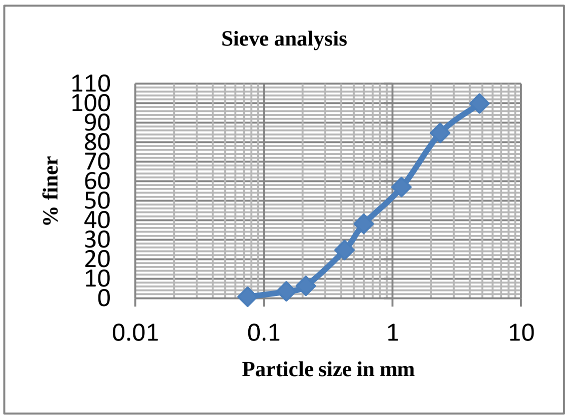

Fig 1

The above graph shows, as the particle size increase the percentage finer also increases. From graph the values of D_{10}, D_{30}, D_{60} are calculated and then the uniformity coefficient and curvature coefficient calculated. From above results the soil is the medium graded soil.

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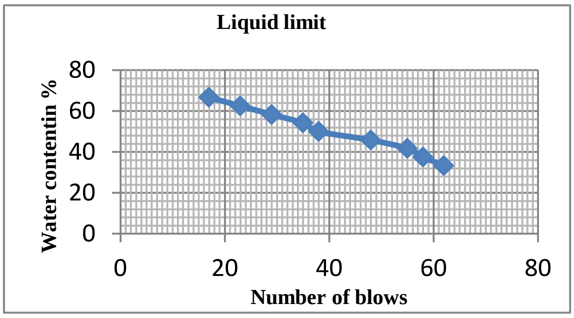

Fig 2

The above graph shows, as the water content increases the number of blows decreases. The liquid limit calculated from graph for 25 number of blows corresponding to water content.

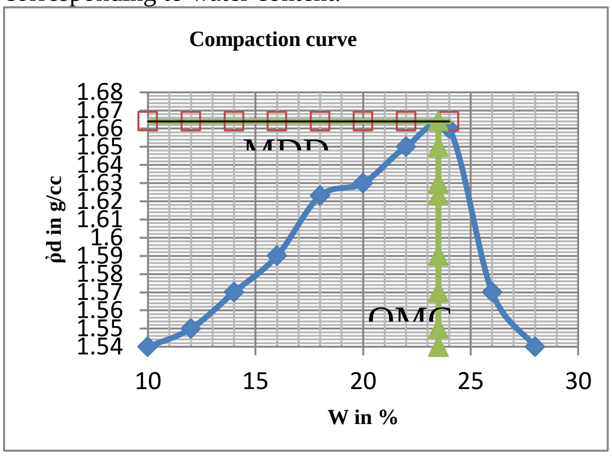

Fig 3

The above graph shows, as the water content increases the dry density increases upto a limit afterwards decreases. The optimum moisture content and the maximum dry density is calculated from graph.

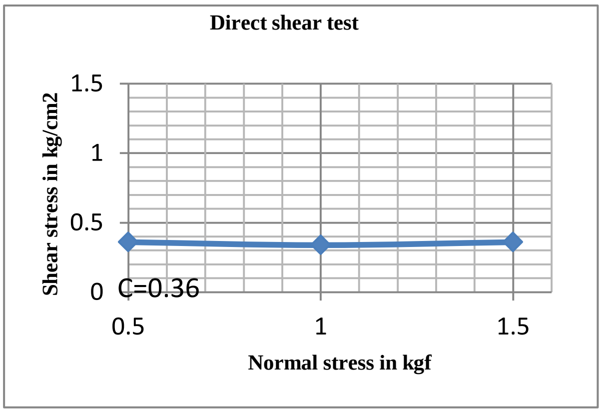

Fig 4

The above graph shows, as the normal stress increases the shear stress will not be increases. The tangent line shows the zero angle. The cohesion will be calculated from graph.

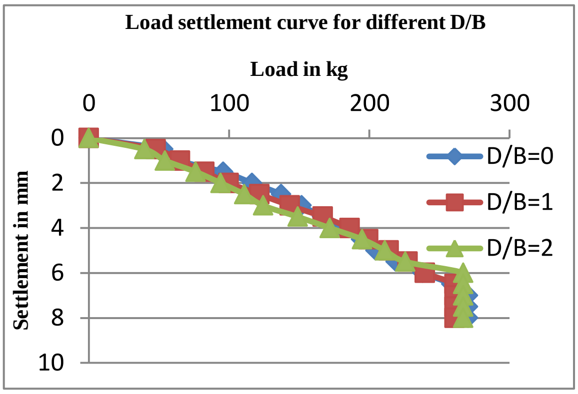

Fig 5: Load-settlement curve for varying D/B ratio by model test

The above graph shows the load settlement curve for black cotton soil for varying depth to breadth ratio (D/B).As the load increases the settlement also increases upto a limit after wards the settlement will be constant and the settlement will be reduced for D/B=2.The results obtained for D/B=2 is better than results obtained from D/B=0 because as the foundation in deep will be stiff therefore more settlement will not occure.

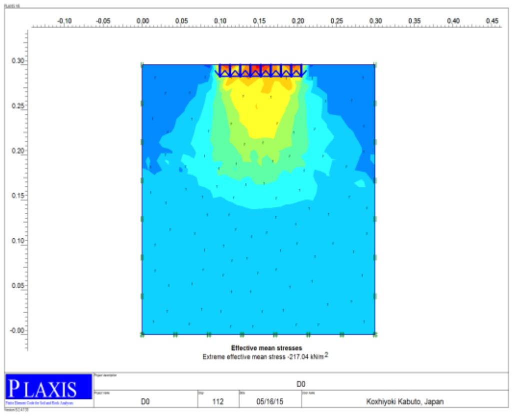

Fig 6: Ultimate bearing capacity for D/B=0 by plaxis

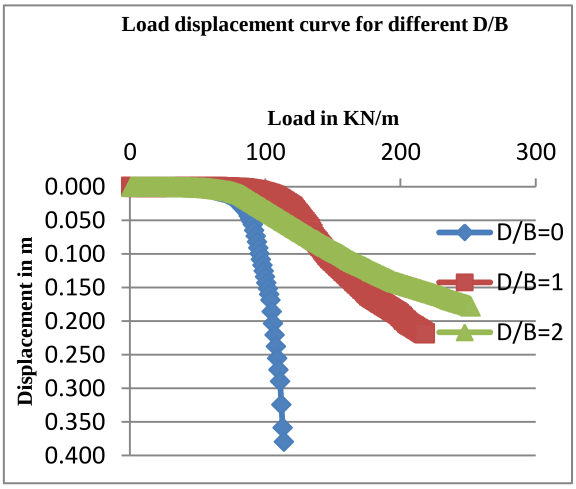

Fig 7

The above graph shows the load displacement curve obtained from plaxis for black cotton soil for varying depth to breadth ratio (D/B).As the load increases the displacement increases upto a limit and from plaxis the ultimate bearing capacity improves for varying D/B ratio. As the depth to breadth ratio (D/B) increases the displacement decreases.

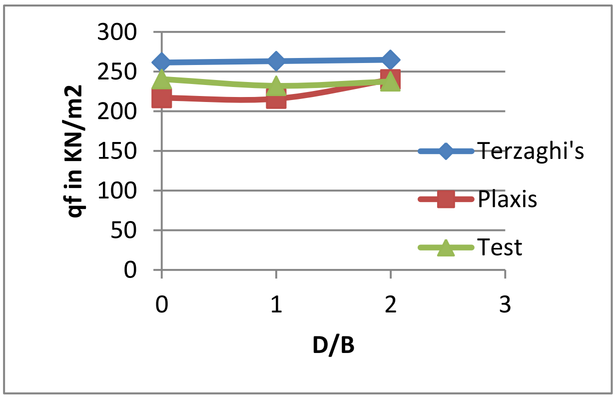

Fig 8: Ultimate bearing capacity from test, Terzaghi and plaxis for varying D/B ratio

The above graph shows the comparison between the results obtained from model test, terzaghi's equation and plaxis software. The results obtained from model test and terzaghi's equation and the results obtained from model test and plaxis software for varying depth to breadth ratio has been validated. The results obtained from plaxis are almost near to model test as compared to terzaghi's equation.

IV CONCLUSION

4.1 Conclusion

1. PLAXIS has been used to estimate the bearing capacity of soil with Mohr-Coulomb's failure idealization with considerable success.
2. Medium mesh generation is found to provide reasonably accurate results satisfying the desired convergence criteria.
3. The values of ultimate bearing capacity achieved by test and from terzaghi's equation are almost near.
4. For varying D/B ratio gives good ultimate bearing capacity. That is as the D/B ratio increases the bearing capacity also increases.
5. As the D/B ratio increases the settlement will be decreases.
6. The load displacement a curves show from plaxis has reduces displacement as the D/B ratio increases.
7. The values of ultimate bearing capacity is achieved by test is 237.68kN/m^2 and from plaxis is 240.12kN/m^2 for D/B=2.The results will show small variation. Hence the plaxis software is useful.
8. The variation of results obtained from model test and plaxis are 9.8%,7.32% and -1.02% for D/B=0,D/B=1 and D/B=2.Hence for D/B=2 shows very small variation which is negligible.
9. The plaxis software is useful for further work.

4.2 Scope for future work

1. The present study is limited to 2D plain strain idealization; it can be extended to 3D solution.
2. Study is restricted to homogeneous isotropic soil medium; other plastic models can be considered.
3. Work can be extended to layered soils, soil with irregularities.
4. Effect of ground water table can be considered.
5. Other shape of foundations can be considered.
6. Axisymmetry problems can be analyzed using PLAXIS.
7. Other than Mohr-Coulomb model, advanced soil models such as Hardening Soil model, Soft Soil Creep model and user defined models can be used.

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