A NUMERICAL APPROACH TO PREDICT SOIL BEARING POTENTIAL FOR ISOLATED FOOTING

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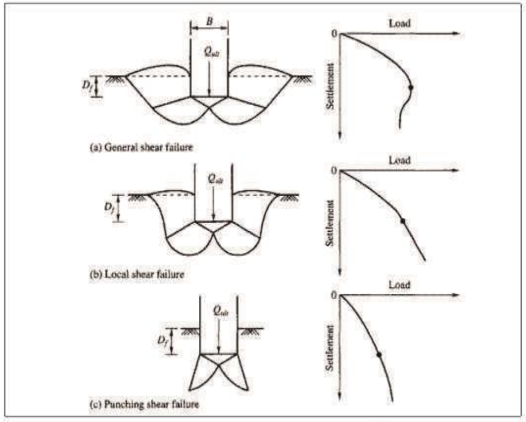
Bearing Capacity of Shallow Foundation

- **A foundation is required for distributing the loads of the superstructure on a large area.**
- **The foundation should be designed such that:**

  a) The soil below does not fail in shear &

  b) Settlement is within the safe limits.
- **The ultimate bearing capacity is the gross pressure at the base of the foundation at which soil fails in shear.**
- **Modes of shear Failure:**

  Vesic (1973) classified shear failure of soil under a foundation base into three categories depending on the type of soil & location of foundation



MODES OF SHEAR FAILURE

Bearing Capacity of Shallow Foundation

- **Terzaghi's Bearing capacity equation: $q_u = C^{/}Nc + \gamma\ D_f\ Nq + 0.5\ \gamma\ B\ N\ \gamma$**
- **UBC for Square & Circular footing:** Based on the experimental results, Terzaghi's suggested following equations:

  Square footing: $q_u = 1.2c^{/}\ N_c + \gamma\ D_f\ Nq + 0.4\ \gamma\ BN\gamma$

  Circular footing: $q_u = 1.2c^{/}Nc + \gamma\ D_f\ Nq + 0.3\ \gamma\ BN\gamma$

- **The Hansen's Bearing Capacity equation has been adopted by I.S. 6403 –1971 & may be used for general form as:**

(a) **For general share failure**, $q_{un} = c\ N_c\ S_c\ d_c\ i_c + \gamma\ D_f\ (N_q\text{-}1)\ S_q\ d_q\ i_q + 0.5\ \gamma\ B\ N_\gamma\ S_\gamma\ d_\gamma\ i_\gamma\ W^{/}$ ………………………….. (i)

(b) **For local share failure**, $q_{un} = \frac{2}{3}\ c\ N_c^{/}\ S_c\ d_c\ i_c + \gamma\ D_f\ (N_q^{/}\text{-}1)\ S_q\ d_q\ i_q + 0.5\ \gamma\ B\ N_\gamma^{/}\ S_\gamma\ d_\gamma\ i_\gamma\ W^{/}$ ……………………….. (ii)

- **Settlement of foundation:**

  The allowable maximum settlement depends upon the type of soil, the type of foundation & the structural framing system. I.S. 1904-1978 gives values of the maximum & differential settlements of different type of building.

Research Objective

- **Numerous numerical approaches have been proposed to estimate the foundation's bearing capacity value to avoid repetitive and expensive experimental work. All these models have their advantages and disadvantages. In this study, we compiled all the governing equations mentioned in Bureau of Indian standard IS: 6403-1981 and modify the equation for Ultimate Bearing Capacity.**
- **The aim of this study is to prepare a numerical model for the prediction of soil bearing capacity considering a specific shallow foundation type.**

Research Methodology

- The equations (i) & (ii) are joined together by introducing new parameters, K1 and K2, to simplify the mathematical code. These two parameters (K1 and K2) are selected as multiplying constant for the equation of ultimate bearing capacity of subsoil for general share failure case and local share failure case, respectively. Values of K1 and K2 for different failure condition are:
  - For general share failure condition, K1 = 1 and K2 = 0
  - For local share failure condition, K1 = 0 and K2 = 1
  - For transition zone between local and general share failure condition, K1 = 0.5 and K2 = 0.5

- The modified general equation of ultimate bearing capacity:

$$q_u = K_1 (c\, N_c\, S_c\, d_c\, i_c + \gamma^{/} D_f\, N_q\, S_q\, d_q\, i_q + 0.5\, \gamma\, B\, N_\gamma\, S_\gamma\, d_\gamma\, i_\gamma\, W^{/}) + K_2 (0.67\, c\, N_c^{/}\, S_c\, d_c^{/}\, i_c + \gamma^{/} D_f\, N_q^{/}\, S_q\, d_q^{/}\, i_q + 0.5\, \gamma\, B\, N_\gamma^{/}\, S_\gamma\, d_\gamma^{/}\, i_\gamma\, W^{/})$$

Numerical Model

ALGORITHM OF THE NUMERICAL MODEL

Considering length unit as meter and force unit as KN, the algorithm of the model is as follows:

Initialization:

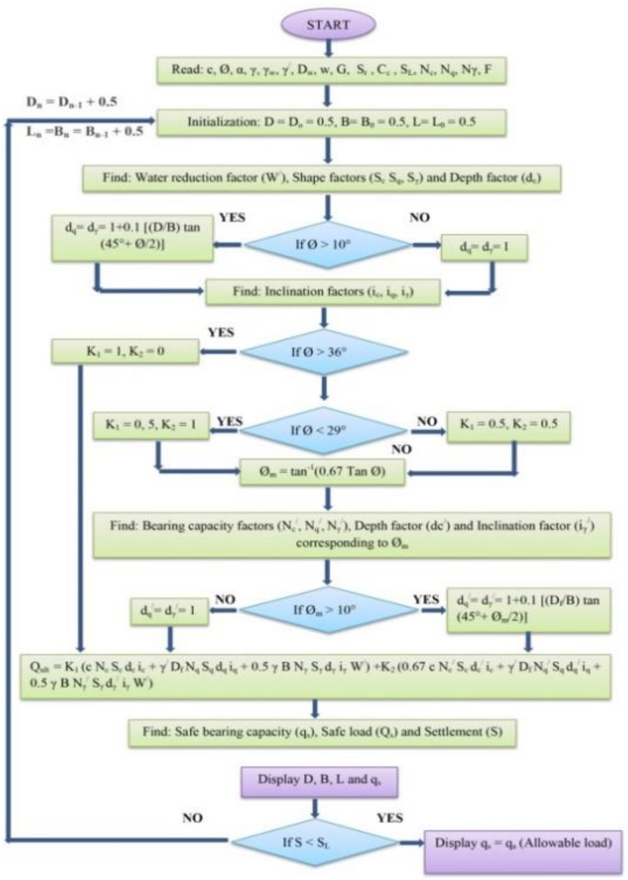
Depth of foundation, D_o = 0.5 m and varies as $D_n = D_{n-1} + 0.5$ till maximum value of D_n = 3m.

Width of foundation, B_o = 0.5 m and varies as $B_n = B_{n-1} + 0.5$ till maximum value of B_n = 3m

Length of foundation, $L_o = B_o$ and varies as $L_n = B_n$ (assuming square footing)

Input parameters into the model:

Soil cohesion (c), angle of shearing resistance (Ø), load inclination angle (α), bulk unit weight of soil (γ), unit weight of water (γ_w), effective unit weight of soil (γ'), depth of water table from the ground (D_w), natural moisture content (w), the specific gravity of soil solids (G), degree of saturation (S_r), compression index (C_c) permissible settlement in mm (S_L), bearing capacity factors(N_c, N_q, Nγ), the factor of safety (F).



Result Outcomes

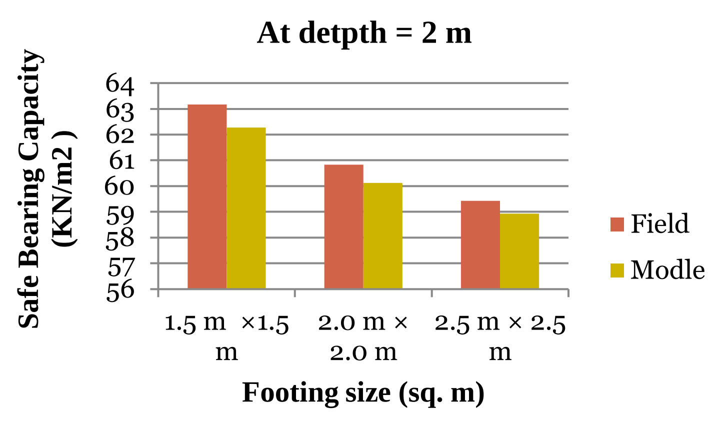
The program used for running the model was written in MATLAB language code and verified with the observed field data. Results indicate that:

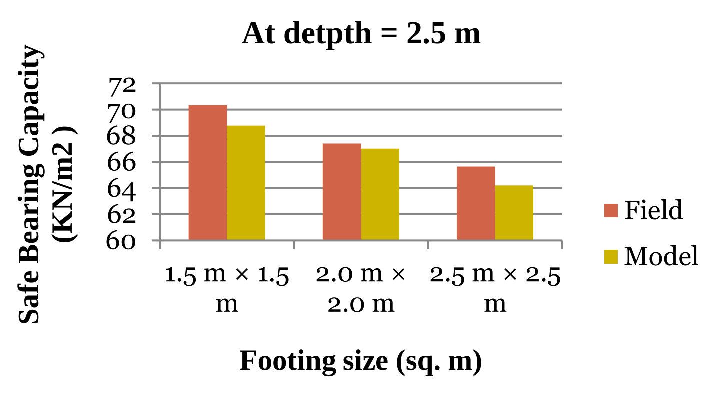
- **The proposed model accurately characterized the ultimate, safe, and allowable bearing capacity of a shallow footing at different depths.**
- **The correlation coefficients between the observed and model-predicted bearing capacity values for a 2m foundation depth with footing size of 1.5 ×1.5, 2.0 × 2.0, and 2.5 × 2.5 m are 0.95, 0.94, and 0.96.**
- **A similar result was noted for the other foundation depth and footing size. Findings show that the model can be used as a reliable tool for predicting the bearing capacity of shallow foundations at any given depth.**
- **Moreover, the formulated model can also be used for the transition zone between general and local shear failure conditions.**

The model output is compared with in-situ data and it is shown in the form of graphs

Table: Result output of field and model

Footing Type	Depth of foundation (m)	Footing Dimension (m)	Safe Bearing Capacity (KN/m^2)	
			Field	Model
Shallow Isolated	2.00	1.5 ×1.5	63.17	62.28
		2.0 × 2.0	60.83	60.12
		2.5 × 2.5	59.43	58.93
	2.50	1.5 × 1.5	70.35	68.77
		2.0 × 2.0	67.41	67.01
		2.5 × 2.5	65.66	64.21





Conclusion

- The main aim of this research is to propose a numerical model to simplify the process of prediction of bearing capacity of soil beneath a shallow foundation.
- The model is prepared using MATLAB software in such a manner that determination of bearing capacity of subsoil considering different virtual size footings at different depth is possible. The present work considers shallow square footing with sides ranges between 0.5 m to 3 m and depth varies up to 3 m below ground level.
- Comparing the numerical model with the real field data of a Geotechnical survey, it is found that the model gives nearly similar results and it is also observed that in both cases, for a particular depth the bearing capacity increases with the increase in contact surface area.
- As further extend, this model can be used for strip and circular foundation.

Thank You