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BEARING CAPACITY ANALYSIS AND ZONING OF KATHMANDU FOR SHALLOW FOUNDATIONS

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Abstract

The bearing capacity of foundation is the primary concern in the field of geotechnical engineering. In this study numerical models are developed for each of the secondary borehole data collected around Kathmandu valley. Finite element analysis (i.e. PLAXIS 2D) is carried out using Mohr-coulomb failure criteria to represent two dimensional soil models. Foundation is aimed to model as square footing and prescribed settlement of 10% of footing width is provided to obtain corresponding bearing capacity. In plaxis, effective stress is considered as an ultimate bearing capacity. Drained behavior with axisymmetical models have been considered for soil model in plaxis software. Various soil parameters like C (Cohesion), γ (unit weight), ϕ (Frictional angle), ν (Poison ratio), E (Elasticity) for each 1.5m and 3m depths have been considered in models and in theoretical approaches.

Keywords: *Bearing capacity, Various Depths, Shallow foundation, Plaxis, Soil Model, and Settlement.*

1. Background

The bearing capacity of foundation is primary need in the field of Geotechnical engineering. The loads from super structures are to be transferred to the underlying soils through foundation safely and economically. The load at which the shear failure of the soil beneath the foundation occurs is simply termed as ultimate bearing capacity of foundation. Foundation transfers the forces and moments from the super structure to the soil below such that the stresses in soil are within permissible limits and it provides stability against sliding and overturning to the super structure. It is a transition between the super structure and foundation soil. The job of a geotechnical engineer is to ensure that both foundation and soil below are safe against failure and do not experience excessive settlement.

In some other countries, bearing capacity zoning of highly urbanized cities has been done. But, in case of Nepal, no such proper maps have been prepared yet. Not only this, but also in the developed countries, people are using modern software for modeling through which calculations with more realistic results have been obtained during their researches. So, in order to apply numerical modeling as more realistic and quick approaches in this modern world for determining soil strengths, this study have been conceptualized.

In order to reduce the unplanned urbanization rate of Kathmandu valley and in order to provide planned settlement in the valley, the construction of tall and high rise buildings is being essential so, while constructing high rise and multi-storey buildings, bearing capacity of soil should be checked before construction to prevent form collapse and settlements. If bearing capacity zonation mapping could be provided then it will reduce the time and cost of project lapsed in investigations.

Bearing capacity zonation map at various depths could provide the clear view of strata encountered at various locations. Bearing capacity zonation map will facilitates the designer/Geotechnical engineer/geologist for preliminary design of foundation, feasibility study, planning of detail investigations of complex formations, estimates of future disasters related to soil failure etc., could be done. Geotechnical characteristics are obtained through detail investigations of the sites. Application

of numerical modeling for determining bearing capacity and other parameters would make the soil more predictable and computations would be easy along with complexities like ground water table, layer wise distribution of different formation of soil etc. could be obtained.

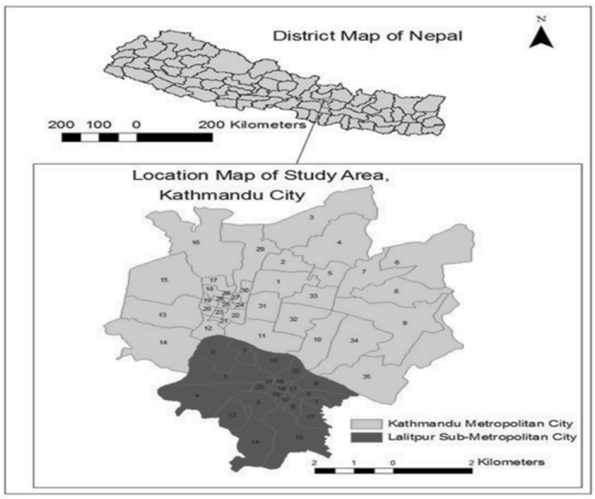

Fig.1: Borehole collection and study area

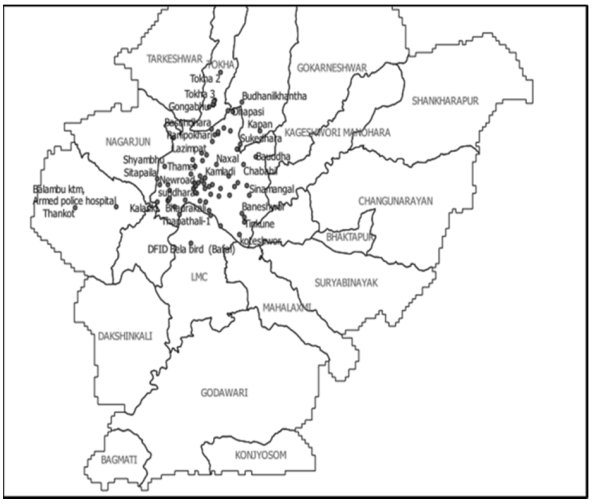

Fig.2: Digitized boreholes

The study area is Kathmandu Valley. Basically these areas are highly urbanized with high density of people. To prevent these areas from probable disasters caused by structural failures resting on soil, bearing capacity and other related parameters are evaluated.

2. Literature Review

The ultimate bearing capacity of shallow footings were given by traditional approaches from (Terzaghi, 1943: Meyerhof, 1951,1953,1963,1965 and 1967) including methods by Hansen (1961and 1970) and Vesic (1973) with modification by Bowles (1996).

PLAXIS 2D has been used to estimate the bearing capacity of soil with Mohr-Coulomb's failure criteria in which medium mesh were generated. For varying D/B ratio, bearing capacity was evaluated *(Fig-2),* with the increase of D/B ratio bearing capacity also increased and settlement decreased. Load settlement curve was generated for various D/B=0, 1, 2, [Prof. Moniuddin Md. Khajaand Mr. Vilas (2015)].

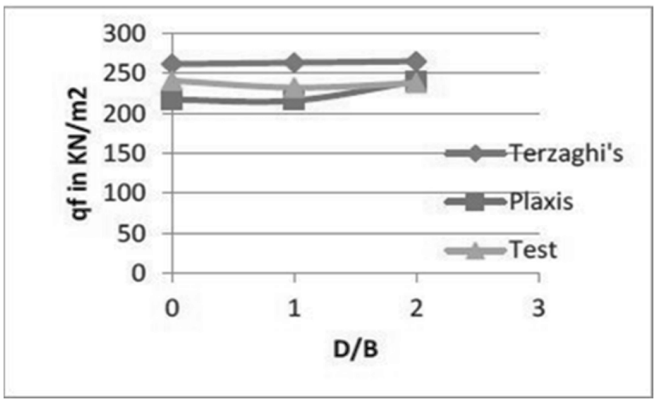

Fig. 2: Bearing Capacity from Plaxis and other approaches with varrying D/B ratios [Prof. Moniuddin Md. Khajaand Mr. Vilas (2015)].

Short term stability of footing was considered for analysis to evaluate bearing capacity of footing using FEM software, ABAQUS, citation [Mosadegh A, Nikraz H (2015)].

Bearing capacity of plain-strain footing were evaluated for various friction angles = 32º, 40º, 48º. [H.J.Burd and S.Fryman (1997)].

Mapping of soil bearing capacity with varying depth were carried out in Jakarta based on N-SPT value which was used in geotechnical design [Vidayanti D. and Widyawaty N. (2016)].

Bearing capacity zoning was done based on traditional approaches from different 145 bore hole data around Kathmandu and Lalitpur districts in I.O.E, MSG Thesis [Mahto S. K. (2012)].

3. Methodology and Materials

The methodology includes the secondary data collection and their analysis. In this research, several steps are taken to achieve the objectives of the study. The following points show the steps that are carried out to obtain results and output of the study field.

- Collection of Study Materials.
- Collection of data from different locations (Secondary Data).
- Filtering and Interpretation of data (SPT-N values, Soil parameters).
- Modeling in Plaxis-2D software for varying parameters. I.e. depth, WT.
- Calculations of Bearing Capacities from traditional approaches.
- Data analysis and plotting the results from GIS software.

3.1. Material Model

The failure criterion of the soil model used in the study is assumed as Mohr-Coulomb criterion. Axisymmetric model with square footing have been considered in the model. In The research total models were prepared with varying depths of 1.5m, 3m, & 4.5m with various properties but here only one model have been shown for sample.

3.1.1 Material model for soil (PLAXIS- 2D)

Material: Soil, Gray brown medium clayey of low plasticity (ML)
Failure Criteria = Mohr-coulomb
Elastic Properties:

Table 1: Model Parameters for ICT Pulchowk campus soil.

Parameter	Name	Value	Unit
Permeability in horizontal direction	K_x	1	m/day
Permeability in vertical direction	K_y	1	m/day
Modulus of Elasticity	E	12000	kN/m^2
Poisson's ratio	ϑ	0.3	-
Cohesion (constant)	C	20	KN/ m^2
Friction angle	Φ	23.72°	º
Dilatancy angle	ϕ	0	º
Mesh type	Fine mesh	15 Noded	
Parameter	Name	Value	Unit
Material model	Model	Mohr-coulomb	-
Type of material behaviour	Type	Drained	-
Soil dry unit weight	γ_{dry}	16.3	KN/m^3
Saturated unit weight	$\gamma_{saturated}$	19.3	KN/m^3

3.1.2 Numerical model

Various numerical models were prepared in PLAXIS-2D for different depths, different 80 locations and different types of soil around Kathmandu valley. Here sample model of only single depth 1.5m have been shown below in fig4 , fig 5 and fig 6

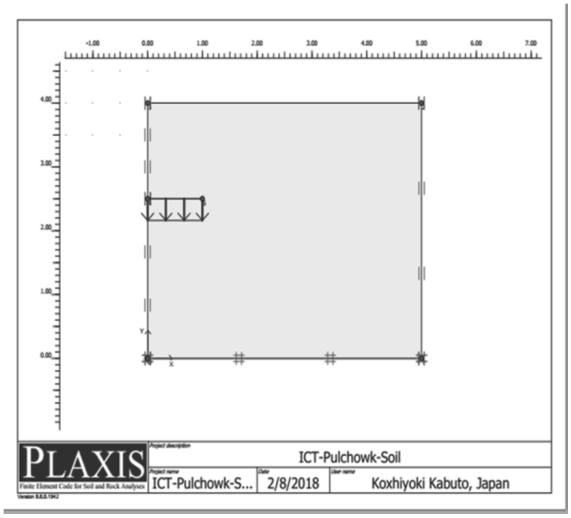

Fig: 4 Soil model at 1.5m depth in Plaxis-2D.

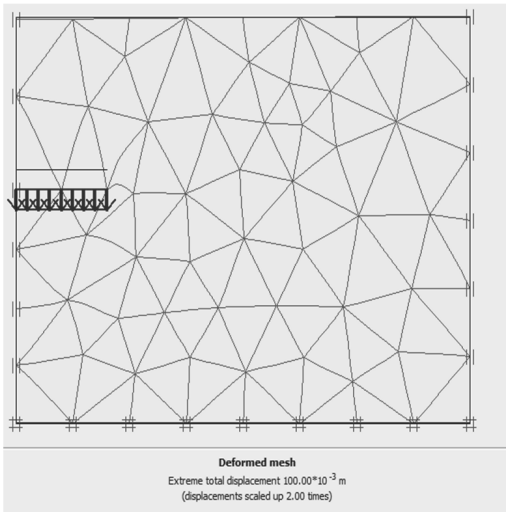

Fig. 5: Soil model obtained after deformations, deformed mesh in Plaxis-2D.

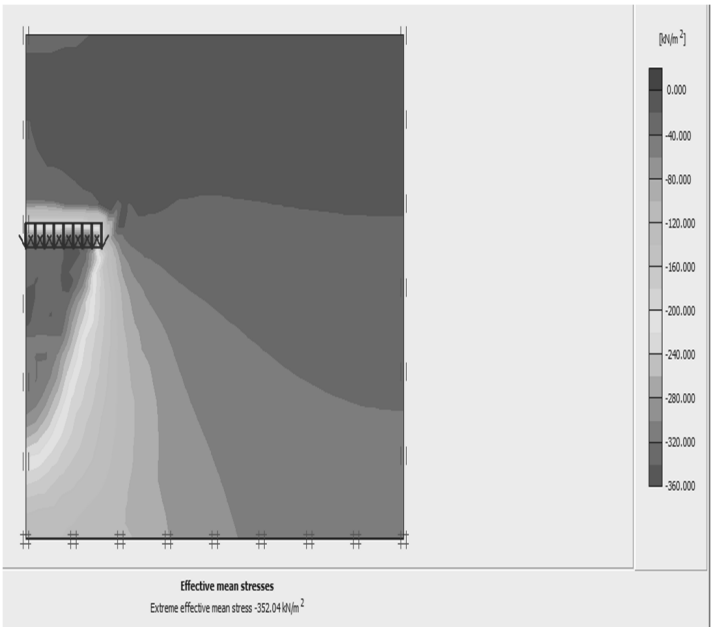

Fig. 6: Soil Model at 1.5m depth, Stress generated, Effective mean stress in Plaxis-2D

4. Results and Discussions

After the Bearing capacity were obtained from Models and Theoretical calculations. The least value obtained from three different methods was considered as the bearing capacity of the soil. For each two depths i.e. 1.5m and 3m the comparative curves were plotted to compare the values of bearing capacities with considering water table.

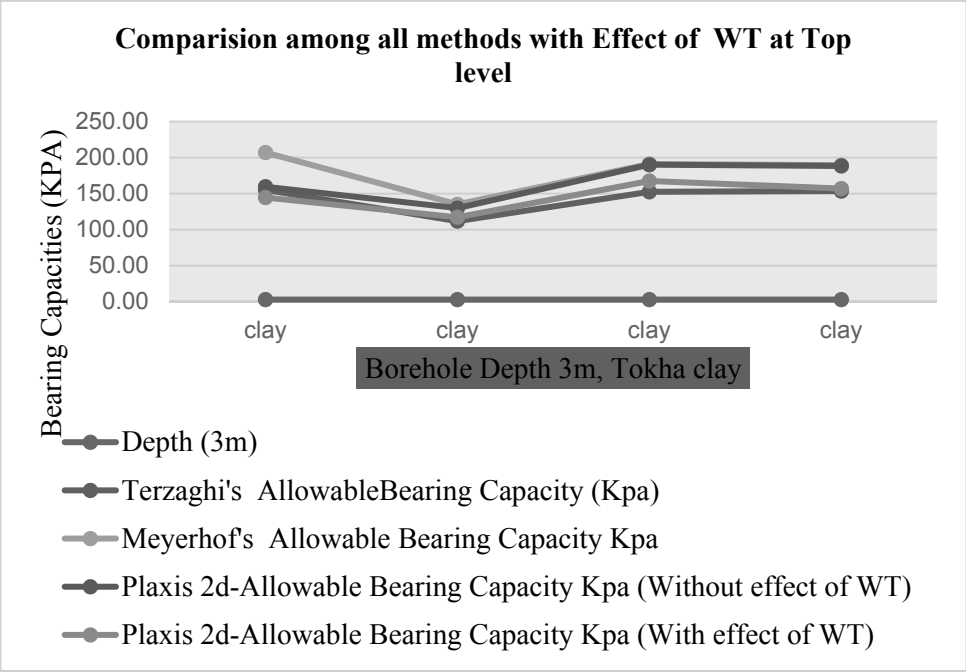

Fig 7: Comparison of bearing capacities at 3.0 m depth Tokha, from different methods.

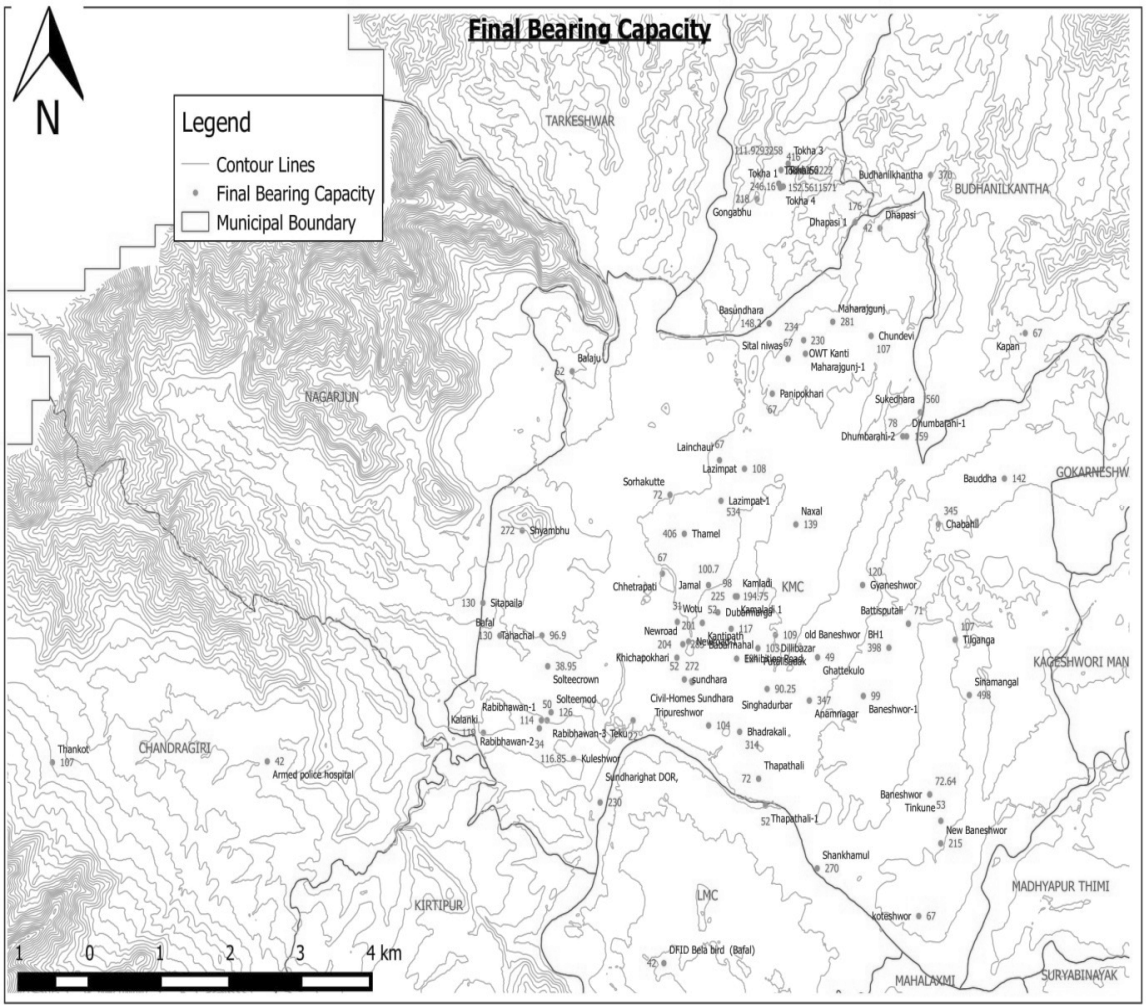

Fig. 8: Final Zonation of Bearing capacities

Based on above results Teku, Wotu-Ktm, Rabibhawan, Soltimood, Balambu, Dhapasi, Ghatekulosemms to have low bearing capacities (≤ 50 Kpa) which are the similar values to the hazard map produced by Department of Mines and Geology in 1998.

Additional to this some boreholes sites located near river banks seems to have low bearing capacities values and similar to those results produced by hazard map produced by Department of Mines and Geology in 1998.

5. Conclusions

Based on plotted results and comparisons with theoretical values of bearing capacities, all three values seem similar. Compared to theoretical values, numerical modeling values are also realistic as a result modeling gives the value of bearing capacities only in short duration and in easy manner so, numerical modeling could be used in the calculations. The variations in the result among theoretical and modeling values seem up to5 to 15% based on types of soil and location.

6. Recommendations

Based on the findings of the research, following recommendations are drawn for minimizing errors while obtaining bearing capacities.

For the realistic results ground water tables should be varied according to test results obtained in the borehole logs. Comparison of bearing capacities with more theoretical approaches could give more realistic results. In this research only depth has been varied but in future researches D/B ratio could be varied to obtain real scenarios of ground.

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