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Bearing capacity of reinforced foundations: Statistical approach and Sensitivity analysis

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Abstract

This paper pertains to a critical evaluation of two widely referred bearing capacity theories of reinforced foundation beds. An enhanced data-set (41 tests) have been used to carry out a refined linear and nonlinear multivariable regression analysis. The regression relations provide a statistical observational model for the prediction of bearing capacity of reinforced foundation beds. A sensitivity analysis is carried out to determine the measure of importance of the parameters towards the outcome of the model. It is found that the relative depth, number of layers of reinforcement and angle of internal friction of soil significantly influence the sensitivity of the system, while the other parameters have moderate influence. Relative length of reinforcement is found to affect the system negligibly.

*Keywords:*Bearing Capacity; Reinforced Foundation Beds; Multivariable Regression Analysis; Sensitivity Analysis.

1. General overview of the article

Bearing capacity of foundation beds is one of the inescapable interests for geotechnical engineers all over the world. Although widely studied, the vistas of further research and exploration to uncover the missing facts and interpretations seem to be endless. The problem of determination of appropriate bearing capacity becomes much more intricate for reinforced foundation beds. Reinforcing of soil can be achieved by embedding various types of materials such as metallic strips, geotextiles, geogrids and even rope fibers. The orientations of the inclusions can be horizontal, vertical or inclined, depending on the requirement for a particular problem. These inclusions result in significant modification of the failure zones of a foundation in respect to what observed for a foundation in a natural soil bed. In such circumstances, the bearing capacity theories (primarily developed for unreinforced foundations) fail to replicate the failure modes of reinforced foundation beds, and hence, needs substantial modification and refinement. In this aspect, too, a significant contribution has been provided by several researchers and bearing capacity theories for reinforced foundation beds have also been proposed. However, it has been observed that in several instances, even the refined bearing capacity theories fail to provide a reasonable prediction the bearing

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capacity as measured in the field [Binquet and Lee (1975)]. Failure surfaces determined from experimentations in in-situ and laboratory are found to differ largely with that as assumed in the theoretical analysis [Chummar (1972)].

For single- or multi-layered reinforced foundation beds, the failure surface is significantly affected by the interference of several physical elements of the system such as the relative length of the footing and reinforcement, relative depth of reinforcement beneath the footing, covering ratio of the reinforcement, number of layers of reinforcement, the tensile strength of the reinforcement, the unit weight and the angle of internal friction of the granular fill. Hence, for such cases, assuming a theoretical failure surface to predict the bearing capacity becomes even more complicated. The solution to such problem can be determined by two approaches – A conventional approach or a statistical approach. Studies reported by Michalowski (2004) and Huang and Menq (1997) belongs to the above mentioned categories respectively. In contrast to the calibration of the model in accordance to the output response as followed by Michalowski (2004), Huang and Menq (1997) expressed the bearing capacity as a function of the significant contributory parameters of the reinforced foundation bed.

This paper present a critical evaluation of the efficacy of the above two approaches. Based on the conclusions deduced from the critical study, a refined statistical model with an enhanced dataset is suggested for predicting the bearing capacity as a function of the statistically significant parameters. In order to achieve so, a revised linear and nonlinear multivariable regression analysis is carried out with the possible presence, detection and removal of outliers. Sensitivity analysis study is carried out using Local Perturbation Technique and also with the aid of SimLab sensitivity analysis package using Morris screening method, the variance based Fourier Amplitude Sensitivity Test (FAST) technique and Sobol's sensitivity analysis procedure. Results are reported to provide an insight to the significance of a contributory parameter in the predictions obtained from such an analysis. The following two figures depict the effect of the significant contributory parameters using the Perturbation technqiue and Sobol's sensitivity analysis, and is successful in providing a qualitative and quantitative contributions to the response.

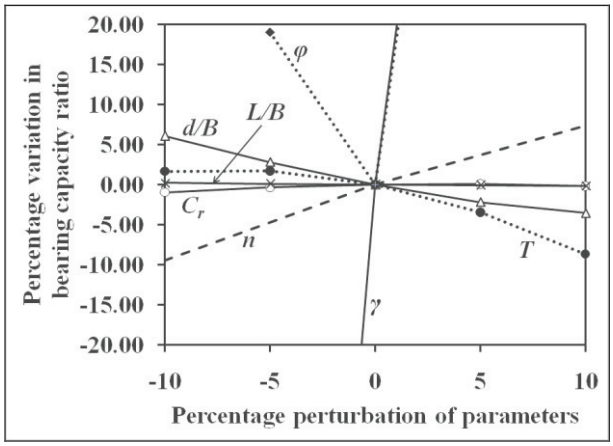

Figure 1. Result of Local Perturbation Technique on seven parameter regression model

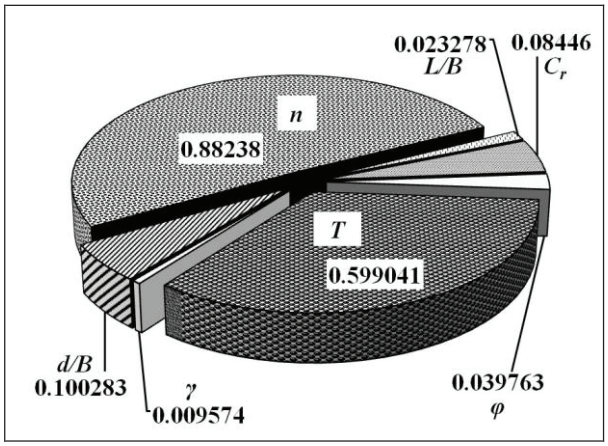

Figure 2. Result of sensitivity analysis by FAST method on seven parameter regression model

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