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A stochastic approach for determination of settlement under strip footings resting on loose granular media using fractals

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Abstract

From the viewpoint of the probabilistic mechanics of particulate media, settlement of granular soils is modeled by considering the diffusion of intergranular forces and the excess volume of voids, simultaneously. In this paper, fractal theory is applied to estimate the diffusion coefficient of displacements in the governing Fokker-Planck equation. A new random matrix model satisfying the particle size distribution and porosity of the granular media is used to calculate this coefficient. The theoretical modeling of the steady state deflection pattern under a rigid, strip footing resting on granular soils is found to be in good agreement with experimental data.

Keywords: Stochastic approach, fractal, granular soil, settlement.

1. INTRODUCTION

Settlement prediction like many geotechnical engineering problems is often affected by a considerable level of uncertainty. Such uncertainty may produce an unreliable estimation of the magnitude of settlement, while reliable settlement prediction is essential for design purposes. Traditional methods for predicting settlement of shallow foundations resting on granular soils were developed using the principles of continuum mechanics, in spite of discrete nature of such soils. In engineering practice, empirical procedures based on experimental correlations between observed foundation settlements and some in situ soil parameters are generally preferred. However, empirical methods generally suffer from the divergence between the stress conditions imposed by the in situ tests and those existing under actual foundation loading [1]. At any scale of observations a soil appears as a discrete collection of particles where heterogeneity, variability and disorder are the rule. Almost all natural soils are highly variable in their properties and are rarely homogeneous. The variability in soil properties and soil heterogeneity will have a significant effect on total and differential settlement of foundations. The response of loose cohesionless soils to surface applied loads can be investigated from the viewpoint of the probabilistic mechanics of particulate media. Based on the probabilistic viewpoint of the particulate media settlement of granular soil may be modeled by considering the diffusion of intergranular forces and an excess volume of voids simultaneously [2, 3]. A procedure that models the settlements of cohesionless soils as a transport phenomenon, can take into account the discontinuous and random nature of the material. It is assumed that soils are composed of very large number discrete particles and with the application of boundary loads, local change of porosity occur which then propagate in space and time through the medium; their accumulations act to produce observed boundary (macroscopic) settlements. This mechanism can be quantifiable through probabilistic arguments by solving the governing Fokker-Planck equations for the diffusion of intergranular force and displacement. The displacement form of Fokker-Planck equation has two coefficients of diffusion and convection that should be estimated. These coefficients are straightly related to the pore size distribution of the granular soil medium. The connectivity and heterogeneity characteristics of pores control the transport of voids through the porous media. Fractals offer new opportunities to quantify morphological properties of pore systems in porous media. In addition, it can also be used to address the relation between structure and a range of physical processes occurring in the porous medium. This ability to directly relate structure to function is one of the most important and beneficial features of fractal models. In many aspects, soil structure is a fractal medium and measuring fractal dimensions has become a common practice for describing structural properties of such a porous media. Depending on the object of interest, different features of the structure can be measured: solid matrix, pores, and the interface between them. A connection between geometry and transport can be facilitated by determining a set of parameters such as with a fractal model and assuming fractal scaling of various physical properties of soil [4].