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Safety assessment of a shallow foundation using the random finite element method

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A complex structure of soil and its random character are reasons why soil modeling is a cumbersome task. Heterogeneity of soil has to be considered even within a homogenous layer of soil. Therefore an estimation of shear strength parameters of soil for the purposes of a geotechnical analysis causes many problems. In applicable standards (Eurocode 7) there is not presented any explicit method of an evaluation of characteristic values of soil parameters. Only general guidelines can be found how these values should be estimated. Hence many approaches of an assessment of characteristic values of soil parameters are presented in literature and can be applied in practice.
In this paper, the reliability assessment of a shallow strip footing was conducted using a reliability index β. Therefore some approaches of an estimation of characteristic values of soil properties were compared by evaluating values of reliability index β which can be achieved by applying each of them. Method of Orr and Breysse, Duncan's method, Schneider's method, Schneider's method concerning influence of fluctuation scales and method included in Eurocode 7 were examined. Design values of the bearing capacity based on these approaches were referred to the stochastic bearing capacity estimated by the random finite element method (RFEM). Design values of the bearing capacity were conducted for various widths and depths of a foundation in conjunction with design approaches DA defined in Eurocode.
RFEM was presented by Griffiths and Fenton (1993). It combines deterministic finite element method, random field theory and Monte Carlo simulations. Random field theory allows to consider a random character of soil parameters within a homogenous layer of soil. For this purpose a soil property is considered as a separate random variable in every element of a mesh in the finite element method with proper correlation structure between points of given area. RFEM was applied to estimate which theoretical probability distribution fits the empirical probability distribution of bearing capacity basing on 3000 realizations. Assessed probability distribution was applied to compute design values of the bearing capacity and related reliability indices β. Conducted analysis were carried out for a cohesion soil. Hence a friction angle and a cohesion were defined as a random parameters and characterized by two dimensional random fields. A friction angle was described by a bounded distribution as it differs within limited range. While a lognormal distribution was applied in case of a cohesion. Other properties - Young's modulus, Poisson's ratio and unit weight were assumed as deterministic values because they have negligible influence on the stochastic bearing capacity.

Griffiths D. V., & Fenton G. A. (1993). Seepage beneath water retaining structures founded on spatially random soil. Géotechnique, 43(6), 577-587.