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Class 624.15 F26
No.

PROBABILISTIC ANALYSIS OF FOUNDATIONS AND EARTH RETAINING STRUCTURES

BY
M.P.W.S. FERNANDO

REFERENCE ONLY

A THESIS SUBMITTED FOR THE FULFILLMENT
OF THE DEGREE OF MASTER OF PHILOSOPHY AT
THE FACULTY OF ENGINEERING TECHNOLOGY
OF THE OPEN UNIVERSITY OF SRI LANKA

APRIL 1998

42071



ABSTRACT

The main emphasis of this study is to promote Civil Engineers to incorporate probabilistic concepts and methods in Soil Engineering. The current design practice is to use deterministic method and probabilistic methods are not applied. In this method additional mathematical computations are necessary, but with the help of powerful computing methods available today, numerous advantages could be obtained by this design philosophy in the field of soil engineering.

This research is related to the civil engineering works (Rural Roads and Buildings) under the six year Integrated Rural Development Project (IRDP), Kegalle District, Sri Lanka.

Soil Engineering problems are characterized by numerous uncertainties. Due to these uncertainties, soil variables can be treated as random variables and they are subjected to the analysis by probabilistic methods. In simple terms probabilistic techniques are the rules of uncertainty and these have to be used consciously to analyse uncertain soil Engineering systems. If an **uncertain system**, like a model for a soil engineering problem is analysed by '**certain rules**', in principle analysis is not precise and the final deterministic solution will not be reliable.

Probabilistic concepts are very useful as they can handle decision problems giving numerical answers to uncertainties, thus reducing the subjective personal element of design. They are based on mean[average], variance and distribution of uncertain variables, whereas deterministic methods incorporate only average values. By using only averages, data which are collected by extensive soil testing methods are not fully utilized in the analysis.

After deciding probabilistic methods are required to analyse an uncertain soil engineering problem, next step would be the formulation of probabilistic model. In this type of model, variables can be deterministic or probabilistic according to the extent of uncertainty associated with them. An important part of this exercise is the identification of the probabilistic variables in the model.

Next, this formulated model will operate on standard probabilistic concepts and laws and knowledge of these are essential to the Engineer to analyse the model. In addition to these rules, further he will have various sets of assumptions which simplify the mathematical computations involved in the analysis. These assumptions will reduce the complexity of the model. During the process of analysis these assumptions have to be tested for their accuracy using statistical tests. In recent past probabilistic methods have been included in various fields of Engineering. One example is the use of these methods in structural Engineering design codes. The latest British structural Code BS 8110, incorporates limit state design method which is based on probabilistic techniques. Here due to uncertainties present in the structural system, variables concrete and steel strengths are treated as random variables having probability

distributions. Also now it is accepted that no structure is completely safe and the difference between 'unsafe' and 'safe' design is only, latter is having an acceptable risk. making the earlier view that such a risk is completely removed is only a delusion. A main advantage of probabilistic analysis is, this risk can be calculated using reliability theory. Then for any limit state defined by the code, the actual risk that is associated with the structure should be within allowable limits.

In the second part of the dissertation, design of earth retaining structures are carried out using probabilistic approach. This study is related to 'Rural Roads Component' in IRDP, Kegalle District. Under this project 125 KMS of rural roads were constructed within the district, with total approximate cost of US\$ 1.15 M. Earth Retaining structures are essential structural elements on roads and they constitute high unit cost items in road construction. Hence, more careful design process is required for them. In this study probabilistic model is presented to satisfy this requirement. The numerical computations associated with the model are carried out by using the PRWSA (Probabilistic Retaining Wall Stability Analysis) computer programme designed for this purpose. In this model, Safety Margin (SM) concept is used and the factor of safety in deterministic method are replaced by the reliability. Also, a critical reliability that the structure can have for a particular design is computed. In addition to reliability, factor of safety are also evaluated for the purpose of comparison.

In the last part of the dissertation, the probabilistic analysis of bearing capacity of soils for foundations is discussed. This study is related to the buildings constructed for 'project management' component of IRDP (Kegalle). In the analysis, the variable Bearing Capacity (BC) is treated as a random variable having a distribution. By using the Safety Margin (SM) concept, reliability of foundation in respect of bearing can be computed. It is assumed that Safety Margin (SM) is normally distributed, and this assumption is tested using Chi-Square Goodness of fit test and found to be correct. Further applications which are related to Bearing Capacity, such as testing of randomness of soil data, finding suitable area to position foundation footings, computation of design load etc. are discussed.

Finally the reliability of a system of footings undergoing difference in settlement is analysed using random field theory. This type of settlement between parts of a structure is important for its stability than the magnitude of the total settlement. Serious cracking or even them, collapse of the structure can take place, if the difference in settlements is higher than allowable. A one of the main causes of this phenomenon is the , variations of soil properties under various parts of the structure. This variation is called spatial variability, which can be modelled by random field theory and reliability in respect to settlement difference can be deduced.