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DISCUSSIONS

OBSERVATION OF DIFFERENTIAL SETTLEMENT IN OFFSHORE DEVELOPMENT PROJECT OF TOKYO INTERNATIONAL AIRPORT[i]

Discussion by TIEN H. WU[ii]

Detailed measurements of differential settlement were made during the 20 months after the start of construction. Based on the results, it was concluded that differential settlements 10 years after commencement of service would not cause damage to pavements and may cause minor damages to structures. Thus, the measurements supported the decision to forego expensive ground improvement prior to construction. This provides an excellent example of Terzaghi's "observational approach" (Terzaghi, 1961; Peck, 1969), in which observation of the performance of a structure is used to verify design assumptions.

In addition to satisfying the design and performance requirements, the authors have provided valuable data on differential settlement. Although differential settlement has been a major concern to geotechnical engineers for more than 50 years, observed performance reported in the journals are rarely as extensive as those reported here. Hence, the measured settlements are, by themselves, a valuable addition to our knowledge on settlement. Next, one may ask: how can the results from this site help us in estimating differential settlement in the future? In order to use these results in future designs, it is necessary to consider the theoretical model, for which the observed results can serve as calibration. This discussion addresses the differential settlement caused by non-uniformity in site conditions, which include the distribution of different soil types beneath the site and the properties of each soil type.

Deterministic methods for settlement prediction cannot be used to predict differential settlement because of our uncertainty about the non-uniformity in site conditions. However, probabilistic methods can be used to estimate the probability distribution of settlement due to the non-uniformity, which is also expressed in probabilistic terms. Krizek et al. (1977) calculated the probability density function (pdf) of settlement from the pdfs of load and compression ratio (C_c); spatial correlation was ignored. For the Atchafalaya Levee, Vanmarcke and Fuleihan (1975) used first order-second moment method (FOSM) to compute the variance of settlement from the variances of unit weight (γ), C_c, initial effective stress (σ_0') initial pore pressure (u_0), and applied stress ($\Delta\sigma$). Spatial correlation for γ was considered. Spatial correlation of C_c was assumed to be 1 within each compressible layer. Wu and Bao's (1986) analysis of the Northeast Test Embankment is similar to Vanmarcke and Fuleihan's, but considers the uncertainties about the preconsolidation pressure (σ_p) and the thickness of the compressible layers. The loads and initial stresses are assumed to be deterministic. In the analysis of the settlement of Bay Farm Island, Duncan et al. (1991) fitted a curve to the depth vs σ_p relation. The uncertainty about σ_p is represented by an uncertainty about the curve. The above models differ only in detail; the differences reflect largely which of the site characteristics were considered to be important.

A model similar to those described above can be used to estimate the probability distribution of the predicted settlement at Tokyo International Airport. The estimated probability distribution can be compared with the measured settlements to verify the model. In order to do this, one needs data on soil variability, in addition to those given in Figs. 3 and 5. Specifically, one needs the spatial correlation of C_c, e_0, and σ_p in vertical and horizontal directions. One also needs the soil profiles as observed in all the boreholes and the values of C_c, e_0, and σ_p of samples taken from these boreholes. At these locations, uncertainties about the means of C_c, e_0, and σ_p are due only to insufficient sampling. These may be expected to be small. Away from these locations, uncertainty due to spatial variations in thickness, C_c, e_0, and σ_p is expected to be large. The uncertainty can be estimated by a probabilistic model and used to derive the probability distribution of the settlement. It is suggested that the authors publish the necessary data in the discussion or a separate paper so that interested individuals can pursue this topic. If this information is included in Okumura and Tsuchida (1981), publication of the report in a journal will be worthwhile.

References

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