Performance of Silty Sands and their Use in Flexible Airfield Pavement Design

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Abstract

Traditionally, flexible pavement design relies on past experience and semi-empirical methods developed through a combination of element testing and modelling. Element testing in this area especially, has centred on the performance of clean sands. This is in conflict with actual practice where a wide range of fines and soil gradations could be present in a real-world project. This research investigates the characteristics of natural sands and examines the influence of these marginal materials in pavement design using element testing and controlled modelling of an actual flexible pavement system.

The element tests concentrated on separate, natural soils sourced from Kazakhstan which had similar mineralogy, but varying amounts of fines. One of the key parameters examined was equivalent void ratio and its efficiency to account for the behaviour change in granular materials which comes from increased fines content. Starting with monotonic triaxial results combined with strength-dilatancy methods it was shown that prediction of shear strength in a silty-sand could be improved by 13%. Incorporating this finding into repeat load triaxial tests, the transitions between elastic, plastic, and ratcheting failure behaviours (i.e. shakedown boundaries), commonly used to help predict the lifespan of a flexible pavement, were examined. It was seen that cycling a silty-sand, the stress path and yield surface could change depending on the fines content.

The Cambridge Airfield Pavement Tester (APT) was designed and constructed to measure permanent subgrade deformation resulting from various surface loads. The number of input variables required to design flexible pavements is one of the most frequently stated problems in the field; variation of aircraft types, environmental conditions, and materials makes mechanistic design of the soil foundation problematic. Accordingly physical pavement modelling continues to be the only experimental method that allows input parameters and material characteristics to be examined simultaneously. Digital image correlation (DIC) was incorporated into the system; the first time this technology has been used in flexible pavement research. A Null Pressure System was also installed to measure soil stress distributions. It was observed that the critical failure mechanisms for thin and thick surficial layers are different, resulting in changes in the rates of surface rutting.

Finally, by combining element and APT results, knowledge of the causal relationships between subsurface deformation and failure mechanisms in flexible pavement were advanced. In-situ soils, which are frequently incorporated into subgrade designs, were found to have a substantial role in the serviceability of the pavement. Correlations between element tests and APT results highlighted the complicated loading and boundary conditions present in a pavement.