Abstract

Foam as a soil conditioner in tunnelling: physical and mechanical properties of conditioned sands

A thesis submitted for the degree of Doctor of Philosophy at the University of Oxford
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St. Catherine's College, Trinity Term 2007.

Earth pressure balance (EPB) tunnelling machines are commonly used for the construction of tunnels in soft soils. These machines use the excavated soil in a pressurised head chamber to apply a support pressure to the tunnel face during excavation. How well an unstable face is supported in an EPB machine depends on effectively transferring a constant pressure from the support medium to the surface of the face. If the support pressure is not constant, but instead changes, the varying pressure inevitably leads to collapse of the face or heave on the surface ground. A machine may be designed to work in "Ideal ground" conditions. However, natural soils rarely have these properties, and conditioning of the soil is usually necessary to change its properties to suit the machine. Effective soil conditioning significantly improves the machine performance and control of the soil flow through the screw conveyor. However, for soil conditioning as commonly used in practice, the effects of different conditioning treatments on soil properties and the machine performance are not clearly understood, and problems with EPB machine operations related to the soil properties are often encountered.

This thesis presents experimental investigations of direct shear box tests on conditioned sands, compressibility tests on conditioned sands and a model EPB screw conveyor operating with sandy soils. Index tests were performed to investigate effects of foam and polymer conditioning treatments on the plastic fluidity of different Leighton Buzzard (L.B.) sands and Thanet sand. The index tests allowed assessment of conditioning treatments for sandy soils, and optimum ranges of treatments for Leighton Buzzard sand and Thanet sand are suggested.

In the series of shear box tests, performed on conditioned Thanet sand and conditioned L.B. sands, one of the most important findings was that the pore water pressure controls the strength of the sand foam mixtures. An increase in foam injection ratio (FIR) might produce an increase of pore water pressure and a decrease of shear stress.

In the series of compressibility tests, performed on conditioned Thanet sand and conditioned L.B. fine sand, one of the most important findings was that increasing FIR does not increase maximum gas expelled. The FIR and the initial relative density of the specimen have to be related to the capability of the specimen to retain the gas and establish a coexistence between grains of soil, water and gas bubbles.

Finally, from the series of model (1:10 scale), screw conveyor tests, performed on conditioned Thanet sand, conditioned L.B. fine sand and conditioned Garside sand, it can be concluded that the Oxford screw conveyor model can be used as a trial machine to study the effects of different operating conditions on conditioned sand specimens similar to those used on site. This can allow choice of conditioning methods to improve the performance of an EPB machine at a given site.