Abstract

The assessment of ageing tunnels requires a deeper understanding of the long-term behaviour of twin tunnels, whilst lack of permeability data limits the accuracy of long-term predictions. This thesis therefore investigates long-term twin-tunnel behaviour through finite-element parametric analyses, and provides additional permeability data through laboratory studies.

Permeability tests are performed on fissured London Clay, exploring the effect of isotropic stress cycles on the permeability of fissures. A model explaining the permeability–stress relationship is proposed to explain irrecoverable changes observed in fissure permeability, and is formulated mathematically for numerical implementation.

Laboratory investigations are performed on grout from the London Underground tunnels, investigating permeability, porosity, microstructure and composition. A deterioration process is proposed to explain observations, consisting of acid attack and leaching. The deterioration had appeared to transform the grout from impermeable to permeable relative to the soil. The change in grout permeability with time would strongly influence long-term movements.

The long-term behaviour of single tunnels is investigated in a finite-element parametric study. A new method is formulated to predict long-term horizontal and vertical surface displacements after excavation of a single tunnel, and incorporates an improved measure of relative soil-lining permeability. The study also predicts significant surface movements during the consolidation period, contradicting the lack of further building damage observed in the field.

A further parametric study also investigates the long-term behaviour of twin tunnels. Key interaction mechanisms are identified, leading to the postulation of the long-term interaction behaviour under different tunnelling conditions. Long-term interaction is found to be complex and significant, and should be accounted for in numerical simulations.